Prospective Development of Uhuru Spaceport

Obadiah Kegege[1], Allen Herbert[2,3], Kwesi Robotham[4], Robert Howard[1], Camille Alleyne[1], Enanga Fale[1], Edward Tunstel[1], Ousmane Diallo[1], Aisha Bowe[1]
[1]National Society of Black Engineers (NSBE) Space Special Interest Group (Space SIG), [2]Jaka Consulting, [3]Phezu Space LLC, [4]Futron Corporation

Abstract - *As satellite launches and space related research/technology advances, the Sub-Saharan Africa will need a spaceport. The concept of the East African Spaceport nicknamed "Uhuru," a Swahili word that means "freedom," was first suggested during the 2012 NSBE Aerospace Systems Conference in Los Angeles. A preliminary study followed during the 2013 Space Technology Session (STS-2013) and recommended establishing a permanent spaceport in East Africa, close to the Equator. This paper discusses the prospective sites and suggested phases of development of Uhuru Spaceport: Uhuru Earth research and education center, suborbital infrastructure development and suborbital space science center, and orbital launch and planetary development center. Also, this paper addresses some factors affecting the development and operation of Uhuru Spaceport; that could provide low cost, reliable access to space while stimulating African economic and technology advancement.*

Keywords: Space Launch, East Africa, Feasibility Study, Uhuru Spaceport, Equatorial Launch Site, Space Policy.

1 Introduction

Most African countries have developed or are in the process of developing their own satellites. However, in Sub-Saharan Africa, space launch is a major element of the space value chain that is currently missing from African capabilities (Figure 1). The concept of a spaceport located in Sub-Saharan Africa is not new. Between 1964 and 1988, the Italian Space Agency (ASI - Agenzia Spaziale Italiana) launched satellites from San Marco sea launch platform off the coast of Kenya. This launch platform is currently decommissioned. Filling in this blank would open doors to benefits of market, societal, and international relationships.

During the STS-2013, members of the National Society of Black Engineers (NSBE) Space Special Interest Group (Space SIG) worked to strategize the prospective development of an East African Spaceport (Uhuru). This working group proposed establishing a permanent spaceport in the East Africa region close to the Equator, accessible to the mainland and airports. The study recommended that this spaceport be developed in three phases: (1) Uhuru Earth research and education center, (2) suborbital infrastructure development and suborbital space science center, and (3) orbital launch and planetary development center.

This paper discusses possible sites for Uhuru Spaceport, geo-physical advantages, and suggested phases of spaceport development. As these investments proceed, a more holistic space value chain – covering science/research and technology advancement, manufacturing, operations, and usage of space systems applications will emerge into the mainstream of the African economy.

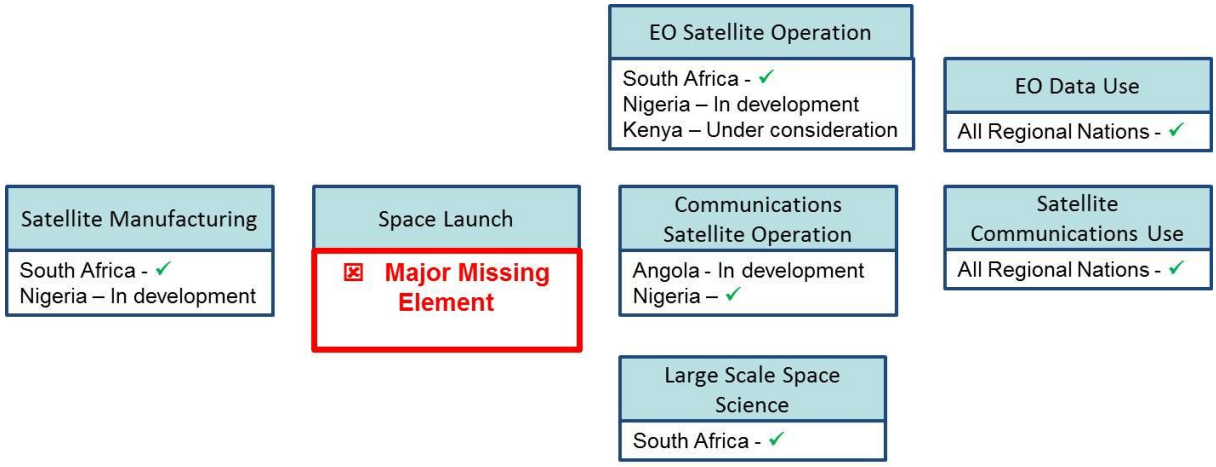

Figure 1. Elements of the space value chain present in sub-saharan Africa (EO refers to Earth Observation)

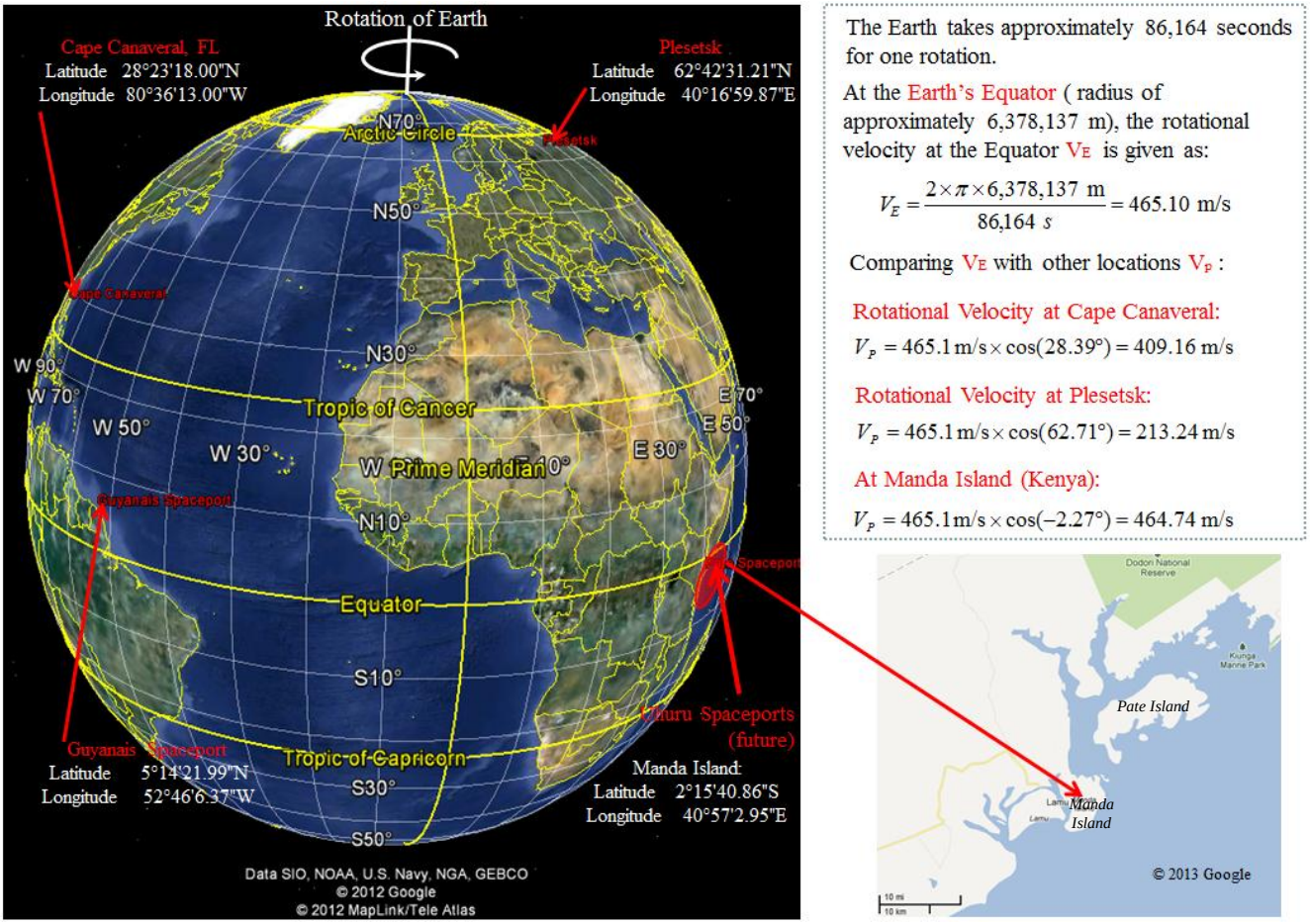

Figure 2. Geo-physical advantages and comparison of Manda Island with other spaceport orbital velocities

There is a growing need for Low Earth Orbit (LEO) and Geostationary Orbit (GSO) access [2], [3], [4], and [5]. Launching from equatorial locations offers the most advantageous fuel usage for launches into GSO, allowing the maximum payload carrying capacity. GSO is the orbital domain most commonly used by commercial communications satellites – the most mature and commercially developed segment of space activity. Recent global launch forecasts issued by the U.S. Federal Aviation Administration (FAA) indicate that the trend for future GSO satellite payloads is toward higher mass satellites [5]. This suggests that launch mass efficiency (payload mass fraction) is an important consideration in the competitiveness of future launch sites. Launch sites for GSO need to be within about 5 degrees of the equator, because the delta-v (change in velocity) for orbital inclination plane change becomes 'too expensive' at higher latitudes [6].

Comparing the rotational velocity of Uhuru Spaceport versus other tropical spaceports (Figure 2), payloads launched from the Uhuru Spaceport can be delivered to space with lower fuel consumption rates. Currently there are only two active space launch facilities in equatorial regions : the European Space Agency's facility in Kourou, French Guiana and the commercial Sea Launch ocean-going launch platform; a third facility – the Alcantara Space Launch Center – is under development in Brazil. Thus, the prospective Uhuru Spaceport would be the fourth equatorial launch site in the world, and would be positioned to compete for internationally competed satellite launches. On the global launch market, the prospective Uhuru Spaceport holds a natural advantage – its equatorial location.

2 Sites for Future Uhuru Spaceport

Having the spaceport on an island helps in terms of testing, safety, and security. An island east of the equatorial African coastline also has the advantage of a flight path that is over water and not residential or commercial communities. Several islands in the East African region offer the best sites for spacecraft launches to LEO, Geostationary Earth Orbit (GEO), or interplanetary trajectories, due to their nearly equatorial locations. GEO is a circular GSO directly above the equator (i.e., zero inclination). As seen in Figure 3, there are several potential island locations for the East African Spaceport. The four major ones are: Pate Island (Kenya), Manda Island

(Kenya), Pemba Island (Tanzania), and Mafia Island (Tanzania).

Pate Island (approximate Latitude of 2° 5'55.78"S and Longitude 41° 5'22.53"E) and Manda Island (approximate Latitude of 2°15'40.86"S and Longitude 40°57'2.95"E) may offer the best locations for the future spaceport. Pate Island's rotational velocity is 464.79 m/s whereas Manda Island is 464.74 m/s. Although Pate Island is closer to the Equator than Manda Island, the tradeoff is Manda Island's accessibility to the mainland. It has an airport that could be expanded and is located near the new Kenyan port (Lamu) for the region. However, a future focused feasibility study will determine its particular suitability as a site for the spaceport.

Figure 3. Possible Sites for Uhuru Spaceport

There are other small Islands in Kenya and Tanzania that are not shown in Figure 3. The additional small Islands off the coast of Kenya include: Kiungamwina, Kui Island, Shakani, Kiwaiaya, Chundwa, Ndua Pate Island, and Mikiro. Also, the additional small Islands off the coast of Tanzania include: Mongo Island, Juani Island, Songo Songo Island, and Jbondo Island. These Islands should be included in a feasibility study to determine their potential for facilities supporting the Spaceport.

3 Notional Infrastructure of Elements

The NSBE Space SIG recommends that the development of Uhuru Spaceport take place in three phases: Uhuru Earth research and education center, suborbital infrastructure development and suborbital space science center, and orbital launch and planetary development center. This recommendation was based on preliminary feasibility analysis [1] and the review of the "Mombasa Declaration on Space and Africa's Development," a document which provided the basis for a shared vision for Space Access/Exploration in Africa [4]. The Mombasa declaration recognized "Space Science/Technology" and "Access to Space" as "major contribution to the well-being of humanity and specifically to the economic, social and cultural development of Africa in terms of Earth observation, satellite navigation and communications services that support, inter alia, education, health, environmental monitoring, management of natural resources, disaster management, meteorological forecasting and climate modelling" [4]. In addition to economic objectives, these phases of development were suggested by NSBE Space SIG to ensure the Uhuru Spaceport provides access to high-level education and training in space science and technology in the African continent.

3.1 Phase 1: Uhuru Earth Research and Education Center

Development of an Earth research center would require:

- Research facilities
- Balloon launch sites & a Sounding Rockets Center
- The Uhuru Institute for Space Research
- A Technology Incubator Center
- The Amateur Rocket Center and Testing Area
- The Astronomy Center
- Youth Space Camp
- An Education Center and a University Center to facilitate interaction from local and international university representatives and students, etc.

3.2 Phase 2: High Atmosphere and Suborbital Space Science Center

Suborbital infrastructure development would include:

- Launch Center & Launch Pads
- Facility Command Center
- Preparation Center
- Hazardous Material Building
- Maintenance Center
- Suborbital Payload Assembly Facility
- Aerospace Development Center
- Aviation Testing Facility
- Mission Control Center
- Horizontal Flight Landing Strip
- Command Tower etc.

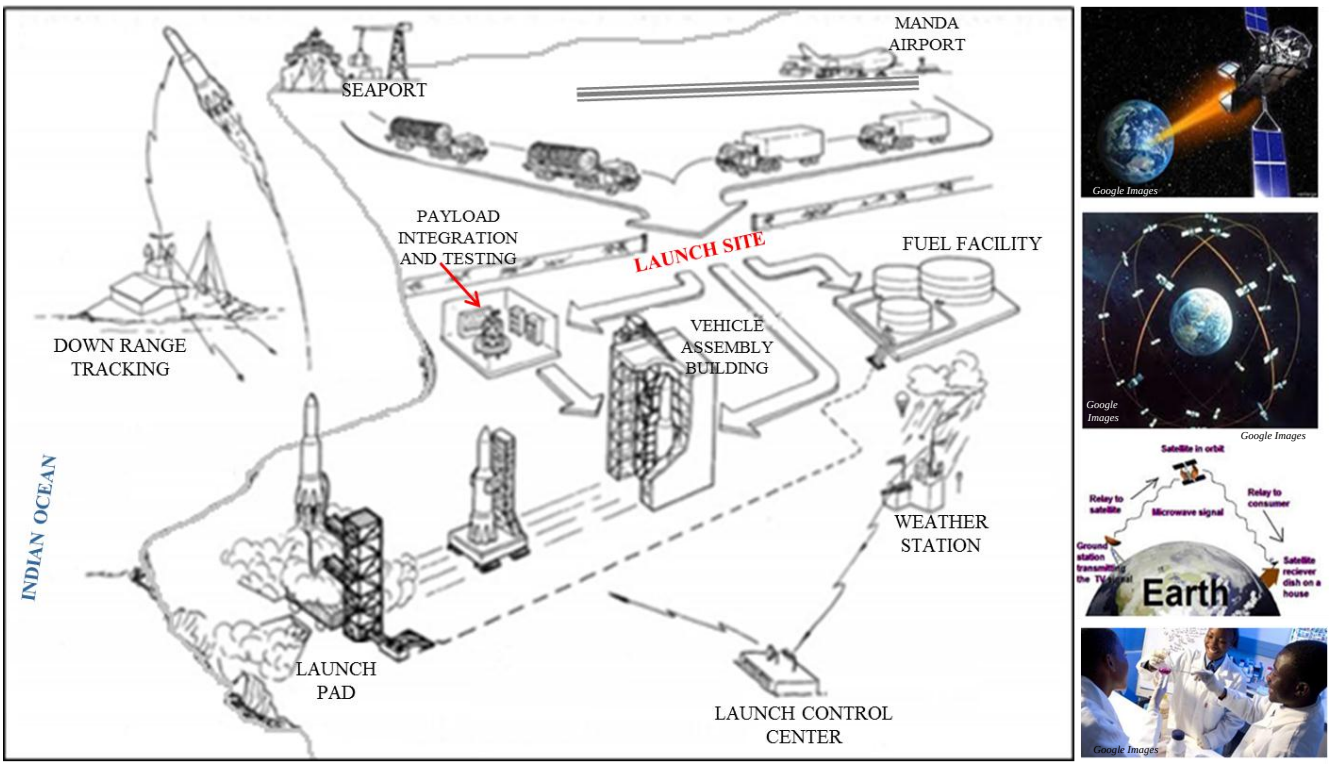

Figure 4. Notional vertical flight infrastructure of elements for Uhuru configuration

3.3 Phase 3: Orbital Launch and Planetary Development Center

Figure 4 shows the notional vertical flight infrastructure. A typical configuration of a Spaceport/orbital launch facility would consist of: launch pads, launch control center, vehicle assembly facility, payload integration and testing facility, fuel facility, seaport, communication and tracking assets, weather stations, airport, etc. The design of infrastructure in Phase 3 would need to be worked out in detail in the feasibility study. The configuration of a launch facility is highly dependent on the funding to build it and the type(s) of boosters to be launched there. For the GEO market case, heavy boosters would be required to deliver satellites to GEO. In this scenario, an orbital launch and planetary complex would have facilities such as launch complex with mission control, large vehicle assembly building, liquid oxygen plant, fire station, workshops and laboratories, and major transportation (ocean, seaport, railway, road to the mainland, and airport) to enable movement of pre-integrated larger launcher stages/spacecraft and payloads.

As mentioned in section 2, the location of a Spaceport should also consider the following: population density, weather, terrain, easy implementation of energy, and land ownership and rights of way, security, etc. Since the flight path (as shown in Figure 4) is towards the Indian Ocean, Uhuru Spaceport drop zones (for strap-on boosters, rocket stages, payload fairing halves, etc.) are predetermined to be in safe areas.

4 Conclusions

The development of Uhuru Spaceport would provide an opportunity for capacity building throughout the East African region. This includes cutting-edge technological innovations through space research, socio-economically relevant joint venture opportunities, and accelerated science/technology development. The accelerating demand for space access by the global community coupled with the current number of equatorially located spaceports clearly indicates a global supply gap [1], [3]. Also, the global demand for satellite services continues to be strong due to the increased globalization and interconnectivity of modern enterprise communications [5]. Uhuru Spaceport would provide the capability to narrow this gap. As discussed in section 2, the unique location at the Equator offers fuel consumption savings and good orientation for achieving geostationary orbit. Future Lunar and deep space missions/ interplanetary destinations may be tasked with assembly and launch of large spacecraft or other assets at GEO or LEO. In such cases, Equatorial Spaceports will be ideal for launching associated heavy payloads.

The most reasonable path towards the development of Uhuru Spaceport is in phases as highlighted in section 3. This would allow for gradual phased development of infrastructure necessary to support establishment of a Spaceport: roadway, railway, waterway, fueling, information technology/communications systems,

construction/manufacturing facilities, and operation facilities.

Acknowledgment

Authors would like to acknowledgment Jaka Consulting, Phezu Space LLC, and Futron Corporation for their collaboration in this effort.

References

[1] K. Robotham, J. Butler, I. Christensen, A. Herbert, R. Howard, O. Kegege, E. Tunstel, *"Feasibility of an East African Spaceport,"* 5th Annual KESSA Conference, Bowling Green, Ohio, September 7-8, 2012.

[2] D. Wood, A. Weigel, *"Capability building, partnership and development: Analysis of the space activities of equatorial countries,"* IAA/NASRDA Intl. Symp. on the Attributes and Characteristics of the Equatorial Plane, Abuja, Nigeria, 2010.

[3] A. Herbert, *"Commercial Opportunities in Africa's Emerging Space Markets,"* 15th Annual FAA Commercial Space Transportation Conference, Session on Minority Space Entrepreneurship, Washington, DC. February 15, 2012.

[4] United Nations Office for Outer Space Affairs, *"The Mombasa Declaration on Space and Africa's Development,"* 4th African Leadership Conference on Space Science and Technology for Sustainable Development, Mombasa, Kenya, September 2011. Retrieved from: http://www.unoosa.org/pdf/bst/ALC2010/Mombasa_Declaration_Final_final_28-10-2011.pdf

[5] *"2012 Commercial Space Transportation Forecasts,"* U.S. Federal Aviation Administration. Retrieved from: http://www.faa.gov/about/office_org/headquarters_offices/ast/media/NGSO-GSO_Draft_for_printing.pdf.

[6] M. Sonter, *"Equatorial low Earth orbit, an ideal orbit for in-space construction; and equatorial spaceports, as gateways for orbital construction,"* Space Future, 2005. Retrieved from: http://www.spacefuture.com/archive/equatorial_low_earth_orbit_an_ideal_orbit_for_in_space_construction.shtml