SATELLITE DEVELOPMENT IN AFRICA: A SURVEY

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The number of African countries which have had satellites launched for their use has increased. Unfortunately, not many of these satellites have been designed and manufactured in Africa. Improving satellite development models in Africa is essential to a prosperous and self-sufficient African space industry. This requires an understanding of the current approach to satellite development, identification of international best practices and consideration of the policies necessary to implement such best practices. This paper details a survey completed by a wide array of space professionals and enthusiasts based within and outside Africa. The survey covers national, regional, and continental approaches to satellite development, financial and regulatory incentives, support for start-ups, capacity-building, and sustainability measures for satellite development on the continent. Part I provides a background on the space industry in Africa while Part II reports and analyses the survey results. Part III concludes by making recommendations which may be used by legislators, policymakers, space agencies and the African Union to design and implement satellite development policies that foster a sustainable and competitive African space industry.

Key Words: African space industry, satellites, science and technology, innovation, space law

1. Introduction

Whilst no African country can yet claim to be a space power, the African space industry is not negligible. Indeed, it is anticipated to exceed $10 billion by 2024.[1] Satellites, a key component of the space industry, have occasioned economic and social benefits globally. They have brought about a paradigm shift in critical spheres of human life such as communication, food security, disaster management, health, education, transportation and the provision of goods and services.[2]

The growth of the satellite sector has not escaped Africa. Since the first African satellite launch in 1999, 49 satellites owned by 13 African countries have been sent to space.[3] African nations have engaged in space-related collaborations with various countries. China, France, Japan and Russia, for example, have assisted in designing and manufacturing African satellites. Whilst such partnerships foster knowledge sharing and are welcomed under the right terms and conditions, they may also have undesirable consequences in that such partnerships may lead to dependency and socio-economic or political interference by foreign powers.

The World Economic Forum has reported that Africa's use of earth observation satellites will increase from $1.32 billion in 2019 to $1.8 billion by 2024.[4] Yet, data from 2019 found that African engineers had built only 40% of the then 35 African satellites, and not all of them had been built on African soil.[5] Significant effort must be made to "multiply African ownership - whether by the African Union (AU), African states individually or African companies - of African-built satellites.[6]

The African Union's *Agenda 2063* outlines an outer space programme that aims to foster an environment in which Africa will obtain its "rightful share" of the use of the global commons, which includes outer space.[7] Relatedly, the *African Space Strategy* seeks to transform Africa's resources-based economies into knowledge-based

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[1] Space in Africa, *African Space Industry Annual Report: Executive Summary* (Lagos, 2019) https://africanews.space/report/
[2] Timothy Kuhamba, *"We don't see them but we need them", Space in Africa,* 17 October 2018 https://africanews.space/we-dont-see-them-but-we-need-them/
[3] Space in Africa, *Angola Launches its Second Satellite, Angolasat-2, Today:* 12 October 2022 https://africanews.space/angola-launches-its-second-satellite-angosat-2-today/

[4] World Economic Forum, *Unlocking the potential of Earth Observation to address Africa's critical challenges,* 2021.
[5] Space in Africa, *African Space Industry Annual Report: Executive Summary* Lagos, 2019.
[6] Julia Selman Ayetey & Harold Ayetey, "Health from Above: Space-Based Healthcare Services in Africa" in Annette Froehlich, *Space Fostering African Societies (Southern Space Studies),* Springer, 2020.
[7] African Union, *The African Outer Space Program,* 2019

economies. The strategic objectives include, "accessing space services, developing regional and international markets, adopting good governance, promoting international cooperation, and coordinating the African space arena".[8] Increasing the design, development, manufacture and use of satellites by African nations is key to achieving these objectives.

This paper focuses provides the results of a survey on the satellite sector in Africa. It is hoped that the survey will contribute to further research which would provide an evidential basis for the development of satellites on the Continent.

2. Survey Design

2.1 The objective of the Survey

The primary purpose of the survey was to (a) elicit opinions of space professionals and enthusiasts as to the conditions necessary for a sustainable, prosperous and independent satellite industry and (b) make recommendations to space industry stakeholders such as legislators, policymakers, commercial entities and space agencies. The study did not Intend to provide conclusive results but rather to serve as a pilot for future research.

2.2 Methodology

The sample consisted of space professionals and enthusiasts, including space engineers, space lawyers, space scientists and space technology experts. A convenience sampling method was utilised to obtain a variety of opinions in a short duration of time. This method is also useful to generate hypotheses or identify issues that can be tested in a more rigorous manner in future research.[9]

The survey was open from 9 January 2021 to 1 April 2021 and was shared via social media networks: Facebook, LinkedIn and WhatsApp. Organised groups of space professionals in Africa on these social media platforms were also sent the survey. Additionally, emails were sent to national space agencies and representatives of space-related organisations in Africa. All questionnaires were self-administered.

The study utilised a mixed-method approach. The first eleven (11) questions were multiple choice, enabling quantitative analysis. The last question was open-ended and provided the basis for qualitative analysis.[10] Biodata was also collected during the survey.

3. Limitations of the Study

Convenience sampling results have a high incidence of bias, are not representative of the population and are generally unable to provide statistically significant conclusions.[11] The survey did not include any questions on law or policy. This is unfortunate given their relevance to the operation of telecommunication, remote sensing and navigation satellites.[12]

4. Survey Results and Discussion

There were 414 respondents. The respondents were nationals or residents of African countries or employees, members or students of companies, organisations or academic institutions based in thirty-one (31) African countries: Algeria, Angola, Botswana, Burkina Faso, Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Ethiopia, Gambia, Ghana, Kenya, Liberia, Malawi, Morocco, Mozambique, Namibia, Nigeria, Rwanda, Sierra Leone, Senegal, Somalia, South Africa, Sudan, Tanzania, Tunisia, Lesotho, Togo, Uganda, Zambia, and Zimbabwe.

The survey results and data analysis are reported below according to each survey question:

4.1 "**Do you think developing satellites as regional blocks (North Africa, East Africa (EAC), Central Africa (ECCA), West Africa (ECOWAS), Southern Africa (SADC) is the best model?**"
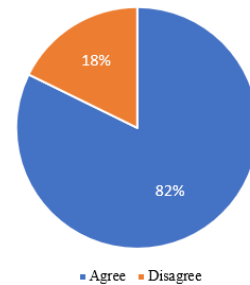

■ Agree ■ Disagree

Fig. 1. Best model for satellite development

Figure 1 shows that 82% (N=338) of respondents agreed that regional collaboration, while 18% (N=74) disagreed. [13]Respondents noted that 'Combining resources will lower the cost per region and operation of satellites.' Some countries cannot pool all resources required to get a satellite operational, but if they partner with others within regional blocks they may succeed together. The SADC region adopted a shared satellite system framework in

[8] African Union, *African Space Strategy: Towards Social, Political and Economic Integration*, HRST/STC-EST/Exp./16 (II) Second Ordinary Session for the Specialized Technical Committee Meeting on Education, Science and Technology, Cairo: Egypt, 2017.

[9] Alison Galloway, "Non-Probability Sampling" in (ed) Kimberly Kempf-Leonard, *Encyclopedia of Social Measurement*, Elsevier, 2005.

[10] Neither the results nor analysis pertaining to the qualitative question is included here as it will form the basis of a separate paper.

[11] Bill Albert, Tom Tullis and Donna Tedesco, "Planning the Study" in *Beyond the Usability Lab*, Morgan Kaufmann, 2010.

[12] For a general discussion see, Elina Morozova and Yaroslav Vasyanin, "International Space Law and Satellite Telecommunications", *Oxford Research Encyclopedia of Planetary Science*, Oxford University Press, 2019; Frans von der Dunk, "International Satellite Law" in *Oxford Research Encyclopedia of Planetary Science*, Oxford University Press, 2019.

[13] Two respondents did not answer this question.

2019.[14] The agreement includes the sharing of the satellite payload for broadcasting, communications and navigation amongst others. The framework will reduce the technological gaps in a region with only two countries, Angola and South Africa, that are satellite operators.

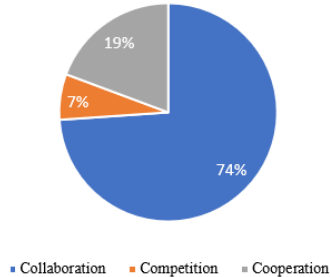## 4.2 What do you think will improve satellite development in African countries?

Fig. 2. Improving satellite development in Africa

Figure 2 shows that 74% (N=306) of the respondents were of the view that collaboration will improve satellite development, 19% (N=79) selected cooperation whilst 7% (N=29) thought competition would most improve satellite development. It has been said that 'Cooperation takes time, it is much slower, and Competition is faster. Competition accelerates innovation'.[15] It is suggested that collaboration and cooperation would be most suitable for African countries at the current time as there face similar problems to avoid duplication of efforts. Satellite payload can be shared which saves money for all involved and helps start-ups to flourish.[16] Countries have been collaborating as regional bodies for example in the use of the radio frequency spectrum to ensure harmonisation of radio frequency use.[17] The same approach can be used in the development of regional satellites.

4.3 Which type of satellite must African regions develop?
Figure 3 shows that, in terms of priority, 59% (N=244) of respondents believed that African regions must develop communication satellites, 26% (N=107) were of the opinion that environmental satellites must be developed,5% (N=21) recommended the development of navigation satellites,5% (N=21) recommended Broadcasting satellites whilst 5% (N=21) selected all the choices.
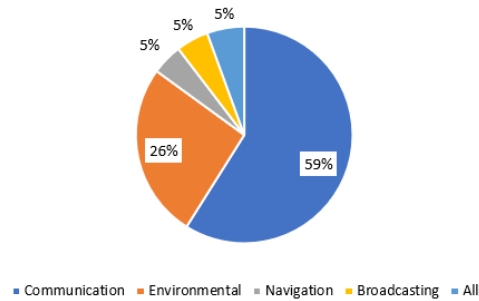

Fig. 3. Type of satellite Africa must develop

The UN's *World Social Report 2021* noted that a significant proportion of the population of African countries resides in rural areas.[18] Internet connectivity is often poor in such areas for a variety of reasons. Technological advancement means that non-geostationary orbits can be used by satellites to provide rural areas with internet services.[19] According to a UN report Africa has 30% of the world's mineral reserves, 8% of natural gas and 12% of the world's oil reserves.[20] Environmental satellites can be used more frequently to enhance mineral, natural gas and oil exploration on the continent.

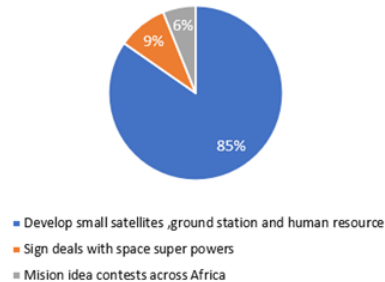## 4.4 What is the best model for Africa's satellite development?

Fig.4. Best model for satellite development

Figure 4 shows that 85% (N=349) of the respondents agreed with the development of small satellites, creating ground station capabilities, and creating human resources, 9% (N=37) agreed with space superpowers building satellites on behalf of them whilst 6% (N=25) were satisfied with organising mission idea contests.[21]

[14] Space in Africa, *Data Sharing: SADC to Implement Shared Satellite Framework,* 5 March 2020 https://africanews.space/data-sharing-sadc-to-implement-shared-satellite-framework/

[15] Unisec Global, Cho Mengu, *When Collaboration works more than competition*,12 September 2020 http://www.unisec-global.org/virtual-meeting.html

[16] European Space Agency, *Sharing the Satellite,* 22 June 2011 https://www.esa.int/Applications/Telecommunications_Integrated_Applications/Sharing_the_satellite

[17] International Telecommunication Union, *Spectrum Harmonization: How the Regional Organizations and Industry Associations can complement the ITU harmonisation efforts,* 11 April 2019

[18] United Nations, Department of Economic and Social Affairs (UNDESA), *World Social Report, 2021: Reconsidering Rural Development* https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2021/05/World-Social-Report-2021_web_FINAL.pdf

[19] International Telecommunication Union, *Non-Geostationary Satellite Systems*, 2021 https://www.itu.int/en/mediacentre/backgrounders/Pages/Non-geostationary-satellite-systems.aspx

[20] United Nations Environmental Programme, *Our work in Africa* https://www.unep.org/regions/africa/our-work-africa

[21] Three respondents did not answer this question.

4.5 Do you think financial and regulatory incentives from governments and market mechanisms facilitate satellite development by space start-up companies?
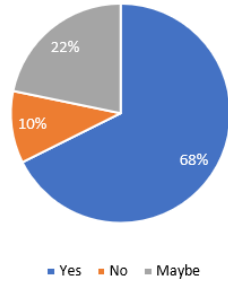

Fig. 5. Financial and regulatory incentives for space start-ups

Figure 5 shows that 68% (N=282) of the respondents believed the introduction of financial and regulatory incentives from governments and market mechanisms would aid satellite development by start-up companies, 10% (N=41) disagreed and 22% (N=91) noted that it might work.

The number of space start-ups have been growing in Africa.[22] However, many do not have sufficient funds to grow. Government grants can be a significant assistance in this regard.[23]

4.6 What needs to be done for policymakers to understand what to prioritise in the satellite development process?
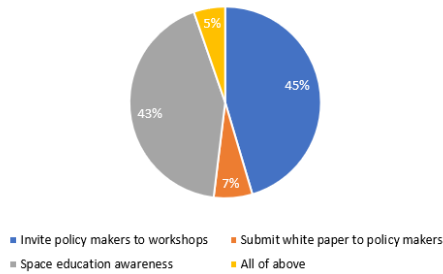

Fig. 6. Needs for African policymakers to understand the satellite development

Figure 6 shows that 45% (N=186) of the respondents agreed that inviting policymakers to workshops, 43% (N=178) were for space education awareness campaigns, 7% (N=29) were for submitting of white papers to policymakers whilst 5% (N=21) selected all the choices.[24]

4.7 What do you think needs to be done to develop enough human resources in satellite development?
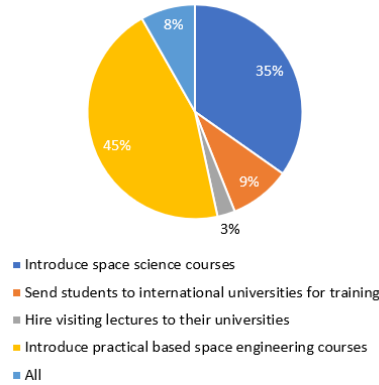

Fig. 7. Development of human resources in satellite development

Figure 7 shows that 45% (N=186) of respondents believed practice-based engineering courses into the educational curriculum, 35 % (N=145) thought the introduction of space science courses in universities would enhance human resources, whilst 9% (N=37) thought sending students to international universities for training was the best option. The hire of visiting lecturers for local universities was selected by 3% (N=12) of respondents, whilst 8% (N=33) thought all the choices were necessary to obtain sufficient human resources.

Engineering is vital to developing and constructing innovations that improve quality of life and sufficient Engineers are a necessary component for any thriving space industry. According to the Engineering for Sustainable Development Report 2021, Africa has the lowest number of engineering professionals per capita of all regions.[25] Doubling or even tripling the number of engineering graduates over the next few decades will be a determining factor in the advancement of (or lack thereof) the satellite sector in Africa.

4.8 What must be prioritised in the African satellite development process?

Figure 8 shows that 64% (N=265) of respondents believed that human resources development should be prioritised for satellite development in Africa, and 22% (N=91) thought investment in infrastructure was a priority. Only 6% (N=25) of respondents viewed the establishment of launch capabilities as a priority, which

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[22] Many of such companies focus on propulsion systems, weather monitoring or remote sensing technologies. They include, but are not limited to: DragonFly Aerospace, Eureka Geo, HyperNova, SCS Space, Geo Smart, Xina Box, NETLOXH, Luvhone Engineering and Consulting Partners, EYTSE CubeSCom, Omarichet, Simera Sense.

[23] World Economic Forum, *4 ways governments can support start-ups and save their economies,* 12 June 2020

https://www.weforum.org/agenda/2020/06/4-ways-governments-can-support-start-ups-and-save-their-economies/

[24] One respondent did not answer this question.

[25] United Nations Educational, Scientific and Cultural Organization (UNESCO), *Engineering for Sustainable Development*, 2021 https://en.unesco.org/reports/engineering

is equivalent to the number of respondents (6%, N=25) that thought all options were a priority. Just 2% (N=8) though offices for engineers should be prioritised. One respondent didn't answer this question.
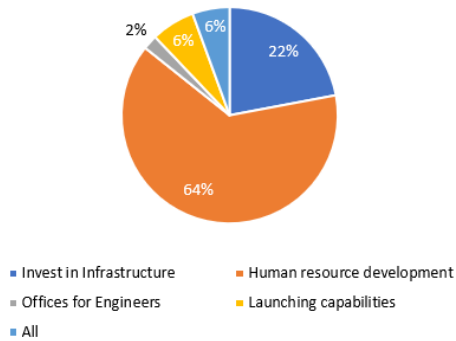

Fig. 8. Priorities in the African satellite development process

According to the UN Secretary General's *Human Resources Development Report*, building a critical mass of human resources is paramount to creating a sustainable development program.[26] Interestingly, this viewpoint aligns with the view of the majority of respondents.

4.9 What needs to be done to improve satellite engineering development in Africa?
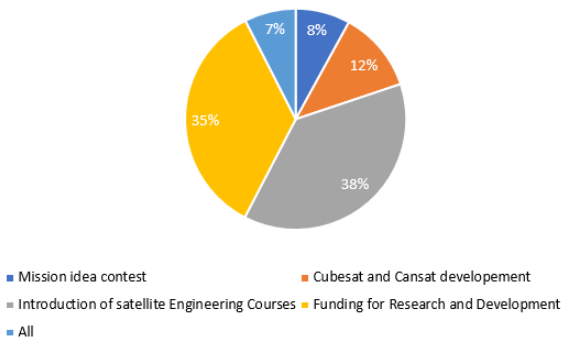

Fig. 9. Satellite Engineering development process

Figure 9 shows that 38% (N=157) of respondents agreed with the introduction of satellite engineering courses, 35% (N=145) were satisfied with the funding for research and development, 8% (N=33) agreed with having mission ideas contests,12%(N=50) selected CubeSats and CanSats, whilst 7% (N=29) agreed with all the choices.[27] Engineering education is key in enabling engineering for the attainment of sustainable

development goals. There is a need for more student-centred and problem-solving engineering in African universities'.[28]

4.10 What needs to be done to ensure the sustainability of satellite development?
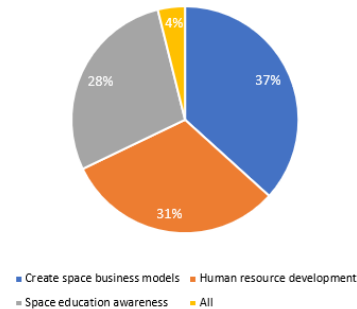

Fig. 10. Sustainability of the satellite development process

Figure 10 shows that 37% (N=153) thought the creation of space business models was necessary for the sustainability of satellite development in Africa, 31% (N=128) chose the training of human resources, 28% (N=116) chose the creation of space-related awareness programs, whilst 4% (N=17) agreed with all the choices.

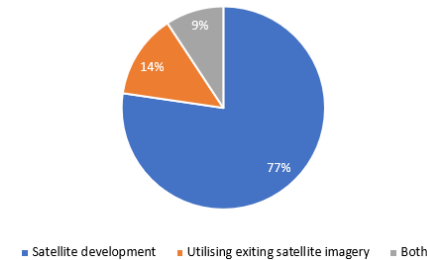**4.11 Which of the following should African Space Agencies focus on?**

Fig. 11. Sustainability of the satellite development process

Figure 11 shows that 77% (N=316) were of the view that Space Agencies focus on satellite development, 14% (N=57) favoured utilisation of the existing satellite imagery whilst 9% (N=37) opted for both choices. Four respondents didn't answer this question.

5.   Recommendations

This study suggests that the development of the satellite sector through regional blocks such as the EAC, SADC,

[26] United Nations, Department of Economic and Social Affairs, *Secretary General's Report on Human Resources Development (Agenda Item 23 [c])*, 17 October 2013 https://www.un.org/en/desa/sg%E2%80%99s-report-human-resources-development-agenda-item-23-c

[27] One respondent did not answer this question.
[28] United Nations Educational, Scientific and Cultural Organization (UNESCO), *Engineering for Sustainable Development*, 2021 https://en.unesco.org/reports/engineering

and ECOWAS should be further explored by national governments.

Investment in human resources was deemed more important than investment in infrastructure such as ground stations and satellite testing centres. Thus, the training of scientists and technicians at national science institutions, such as the Space Science and Technology Institutes of Ghana and Ethiopia, would assist in achieving this objective.[29] Additionally, the research found that almost half the respondents viewed awareness-raising as important.

The implementation of space science, space engineering and law competitions targeted at young African students could increase awareness of the importance of outer space to everyday life and foster interest in space-related careers. It is suggested that national space agencies and the African Union partner with organisations such as the African Space Leadership Institute or the African Air and Space Law Association in this regard.[30]

A further, more robust, study should be undertaken to provide data on the current state of the African satellite sector and further identify suggestions for strategic development. Further, an ancillary study of respondents formally representing African national space agencies and commercial enterprises would provide insight as to whether government and private industry plans across the continent are complementary to each other and in accord with the results of this baseline pilot study. Any such study should use statistical sampling techniques to avoid the limitations of convenience sampling.

It is important to note that many private entities and educational institutions are constructing and launching small satellites. Such activity may result in responsibility or liability for states under international law or be subject to registration requirements.[31] Whilst many African nations have signed and/or ratified international space law treaties, most do not have domestic space laws. The challenges arising from such a scenario and its likely impact on the growth or stagnation of the African satellite sector should be explored.

6.   Conclusion

The survey managed to gather opinions of over 400 space professionals and enthusiasts across Africa as to how to improve the development of satellites on the continent. Whether their views tally with the official strategies, policies and plans of African governments and private entities remains to be seen.

Any goal of transitioning to a self-sufficient African space industry will require the advancement of the satellite sector. Satellite collaboration with space powers should continue where it is conducive to knowledge -transfer and appropriate terms and conditions. However, such collaborations "must be augmented by African-owned and African-based" space science and technology companies.[32] This will foster local innovation, boost job creation and enhance national and regional security.

7. Disclosure

Acknowledgements

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UNESCO., *Engineering for Sustainable Development,2021* , pp. 147-149.

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[29] See, Ethiopian Space Science and Technology Institute http://etssti.org/establishment/; Ghana Space Science and Technology Institute https://gssti.gaecgh.org
[30] African Air and Space Law Association https://aadas.net
[31] See, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies,* 1967;

Convention on Registration of Objects Launched into Outer Space, 1976; *Convention on International Liability for Damage Caused by Space Objects,* 1972
[32] Julia Selman Ayetey, *"Ghana must use space for national development",* *The Daily Graphic,* 20 February 2019 https://www.graphic.com.gh/features/features/ghananews-ghana-must-use-outer-space-for-national-development-2.html