KWARA STATE UNIVERSITY

THE FIRST (1ST) INAUGURAL LECTURE

AERONAUTICS AND ASTRONAUTICS: THE PARADIGM SHIFT IN NIGERIA'S FUTURE SPACE EXPLORATION AND DEVELOPMENT

By

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Distinguished Invited Guests,
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Great Kwasites,
Ladies and Gentlemen

Preamble:

I thank the Kwara State University for the opportunity given to me to deliver the first (1^{st}) inaugural lecture at the Kwara State University. I made excellent progress with my academic career, beginning from St. Aquinas College, Akure. I received an MSc in Mechanical and Aerospace Engineering in 1990 from Soviet Academy of Sciences,

National Technical University and PhD in Aerospace Engineering in 2000 from University of London-Imperial College/Queen Mary. While at Queen Mary as a Research Fellow from 1996 to 1999, I received recognition as an exemplary researcher at the UK Ministry of Defense - Defense Evaluation Research Agency, DERA. As ESA's Senior Research Scientist for Aeronautics and Astronautics from 2002 to 2004, I was responsible for ESA Future Launch Preparatory Programs (FLPP) and delivery of flight modules of European SOCRATES Reusable Launch Vehicle (RLV), for which I received several awards. I started a steady research career after a full-time research at CNRS in Dijon, France and Imperial College, obtained a PhD in 2000 on a project that was operated and sponsored jointly between Ministry of Defense, Defense Evaluation Research Agency (DERA) in UK, NASA in USA, and Engineering and Physical Science Research Council (EPSRC) at University of London. All my work has been in general area of aerospace advanced composites, launch vehicles (RLV and ELV) design and space propulsion.

I am an elected Fellow of the Royal Aeronautical Society, a Fellow of Institute of Materials, and Associate Fellow of the American Institute of Aeronautics and Astronautics. I serve as Technical Track Chair for Space Transportation Technical Committee. I am the chair of the AIAA Space Transportation Conference and Publications Committee, and also a member of Academic Affairs Committee. I serve as a member of the Scientific Study Section of Institute of Materials - A Scientific Study Committee of the UK Science Council,

Member-at-Large of the Committee of the British Composites Society. I am an author and editor of books and journals among which are AIAA Aerospace Materials and Engineering, and Aerospace Bio-inspired Materials and Engineering. I am strongly involved in an institutional leadership role that promotes inclusive excellence within a global framework of 21st century academic diversity, campus and community development. I love flying occasionally and as a hobby using my PPL.

This Inaugural paper briefly recounts the major events and history of aeronautics and astronautics from the days of the Wright Brother's achievement of manned, powered, heavier-than-air flight in 1903 and their later successes, described in 1908 issues of *Scientific American* and up till the establishment of the program in Nigeria in 2011 to the present. The paper provides information about some of the individuals who played significant roles in its development. The paper also describes the quest for human space exploration program elements, constellation and technology development which identifies and prioritizes the technology portfolio, space architecture, and launch vehicle design. The research centers on the application of genetic algorithms to design launch vehicles, missiles, design and prototyping of intelligent micro-aerial vehicles, experimental aerodynamics and fluid mechanics, applied structural dynamics, orbital mechanics, and modeling and simulation of flight vehicles and transportation systems. Even though much time is spent on pedagogy, the faculty members are all committed to providing excellence in research at all levels.

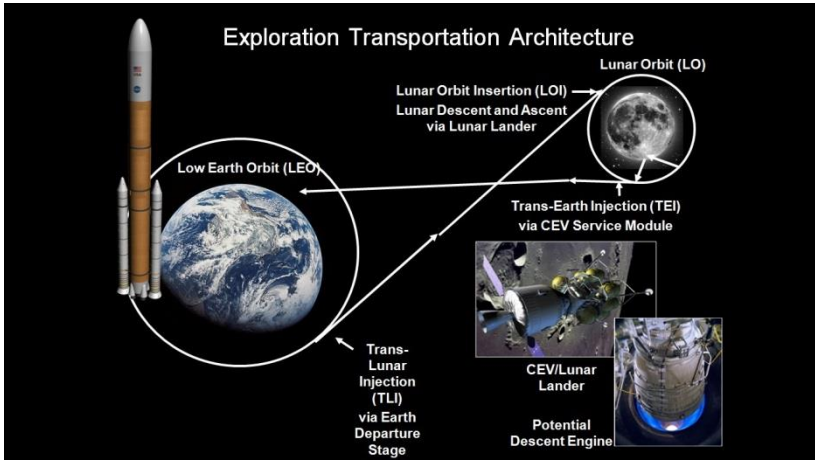


Fig 1: Vehicle and Space Exploration Transportation Architecture [NASA STL, 1]

Historical Background of Aeronautics and Astronautics

The aeronautics study began at the Massachusetts Institute of Technology six years prior to the Wright brothers' 1903 pioneering flight. In 1896, mechanical engineering student Albert J. Wells built a 30-square-inch wind tunnel as part of his thesis [1]. In 1909, the year that marked the founding of MIT's Tech Aero Club, U.S. Naval Academy graduate, Jerome C. Hunsaker, enrolled in MIT's graduate program in naval construction. Hunsaker developed a fascination with the aeronautical literature in MIT's library and became an aviation enthusiast. He spent the summer and fall of 1913 surveying aeronautical laboratories in Europe. In 1914, MIT offered the nation's (USA) first course in aeronautical engineering. To support the course, Hunsaker, and his assistant Donald Douglas, built a wind tunnel on Vassar Street, the first structure on MIT's new Cambridge campus.

The first person to complete the course, earning the first American master of science degree in Aeronautical Engineering, was Hou-Kun Chow.

In 1933, Hunsaker became Mechanical Engineering head. He updated the undergraduate aeronautical curriculum, emphasizing fluid dynamics, thermodynamics, and electrical engineering, and making room for more electives. Otto C. Koppen's graduate class in airplane design reflected contemporary thinking that saw the airplane as part of a larger technological system. Hunsaker led MIT's effort to acquire a state-of-the-art wind tunnel. Dedicated in 1938, the Wright Brothers Memorial Wind tunnel was the first of large-scale facilities for advanced aerodynamic research, and became a national center for aeronautics research and testing during World War II. Today, AeroAstro maintains three wind tunnels: the large Wright Brothers tunnel used for student instruction, vehicular, architectural, and sports equipment research; a smaller low-speed tunnel; and a tunnel capable of generating supersonic wind speeds.

In 1939, Aeronautics became a distinct department. Hunsaker remarked, "The total effect of our graduates on the airplane industry cannot be estimated. But it is of interest to note that MIT graduates include the chief engineers or engineering directors of Curtiss Wright, Glenn L. Martin, Pratt & Whitney, Vought, Hamilton Standard, Lockheed, Stearman, and Douglas, as well as the engineer officers of the Naval Aircraft Factory and of Wright Field." The early try-and-fly days of aviation were over. The era of the engineered aircraft had fully emerged. Charles Stark Draper joined the aeronautics staff as a research assistant in

1929. In the 1930s, he established a course of study in instrumentation and founded the Instrumentation Laboratory, which would become the world's foremost academic center for inertial guidance research and development.

During World War II, the Aeronautics Department expanded rapidly to meet the needs of the military. As in World War I, MIT gave special training to Army and Navy officers. Approximately 600 officers received aviation engineering training with specialization in structures or engines. The size and importance of the Instrumentation Lab increased dramatically. War-related research was also conducted in the Aeronautics Department's other laboratories. The Wright Brothers Wind Tunnel operated 24 hours a day, testing aircraft designs for Martin, Grumman, Lockheed, and other manufacturers.

MIT emerged from the war as the nation's largest nonindustrial defense contractor; almost all major research in MIT's Department of Aeronautics was performed for the military. The Gas Turbine Lab advanced the new technology of the gas turbine engine, and quickly grew into a top academic and research center. The Aero-elastic and Structures Laboratory led the design of aircraft structures for high-speed flight, virtually creating the modern specialty of aero-elasticity. The Naval Supersonic Laboratory achieved supersonic flow at Mach 2.0 and, through Project Meteor, helped develop a supersonic air-to-air missile.

From just after World War II until 1959, the aeronautical engineering program grew and branched into specializations. Draper and his colleagues on the faculty worked to compress the myriad areas of the field into a manageable, four-year course. In the process, they helped define the modern aerospace curriculum.

In 1957, the Soviet Union launched Sputnik, the world's first satellite, and the space race was on. The cold war, the space race, and massive government investment in missile technology led the AeroAstro to expand instruction and research in astronautics, instrumentation, and guidance. In 1961, President John F. Kennedy gave a landmark speech committing the US to landing astronauts on the moon by the end of the decade. The speech was based on a plan prepared by NASA Deputy Administrator Robert C. Seamans Jr. Seamans, who earned his first degree in Instrumentation under Draper in 1951, and continued until his death in 2008.

MIT AeroAstro department is particularly distinguished by its tremendous contributions to the Apollo program. The voyage to the moon and landing were made possible by guidance, navigation, and control systems developed by the Instrumentation Lab. Apollo 11 astronaut Buzz Aldrin a graduate from AeroAstro was the second man to set foot on the moon and one of four MIT Aero Astro graduates to walk on the moon. In the early 1970s, the AeroAstro Department developed the Unified Engineering curriculum. The challenging two-semester curriculum, which students take as sophomores, includes statics, solid mechanics, and materials; dynamics; fluid mechanics; thermodynamics and

propulsion; and linear systems. It examines connections among the disciplines and emphasizes aerospace engineering as a systems approach. It also emphasizes the idea that leaders in the field consider the interaction of technical solutions with economic, political, social, and environmental needs, and societal constraints.

Numerous aerospace accomplishments throughout the 1970s and '80s involved MIT AeroAstro alumni. A. Thomas Young was director of NASA's Viking I and II missions to Mars in 1976. The space shuttle program was led by James A. Abrahamson from 1981 to 1984. Beginning in 1983, Man Vehicle Laboratory experiments began accompanying Shuttle missions. Following the *Challenger* accident in 1986, AeroAstro Department Head Eugene E. Covert served on the accident investigations commission.

In 1988, a team of 40 MIT students and alumni set a world record for human-powered flight. Their craft, *Daedalus*, flew 74 miles from Crete to Santorini in a recreation of the mythological flight of the craft's namesake. In 1989, the Space Shuttle *Atlantis* launched the Magellan spacecraft to conduct a radar mapping of Venus. Building on MIT's extensive role in developing radar, an Institute team headed by Gordon H. Pettengill designed the radar instrument that mapped more than 98 percent of Venus's surface.

In the 21st century, AeroAstro faculty continues with ground-breaking research. For example, the Gas Turbine Lab is developing a "silent" jet aircraft that would produce no more noise than a tractor-trailer truck. The Space

Systems Lab has created a unique multiple micro-satellite system scheduled to be tested aboard the International Space Station, and is pioneering development of amagnetic propulsion/positioning system. Another AeroAstro group, together with NASA, is developing the spacecraft and support systems for future manned space missions. Experts in communications and software are researching a myriad of projects: from increasing robustness of aerospace software, to increasing autonomy of unmanned aerial vehicles.

The 21st Century marked the beginning of a new focus for Aeronautical and Astronautical Engineering. Industry and engineering education accrediting organizations had become concerned that engineering education was emphasizing engineering science at the expense of engineering practice. The Department embarked on an overhaul of its curriculum. After two years of exhaustive development, AeroAstro implemented an educational initiative, called CDIO (for Conceive-Design-Implement-Operate), that will have fundamental, long-lasting institutional impact at MIT, and more broadly, in university engineering education. Students continue to receive a thorough education in engineering fundamentals, but these are now interwoven with considerable hands-on projects, and exposure to a wide-range of topics and skills vital to 21st century engineering such as teamwork, ethics, and communications. The CDIO protocol, pioneered in AeroAstro, has been adopted by nearly 100 universities throughout the world [2].

KWASU Aeronautics and Astronautics

Aeronautics and Astronautics programs started in earnest in 2011 when I was brought in from MIT to become the pioneer Provost of College of Engineering and Technology. It was at this point I requested from the Vice Chancellor to separate what was then called Mechanical and Aerospace Engineering programs to Aeronautical and Astronautical Engineering. Aeronautical and Astronautical engineering involves the exciting challenge of designing and developing machines that can fly. The aeronautical engineering team is responsible for the creation of newer, safer and more energy-efficient, economical methods for travel including airplanes, helicopters, missiles, satellites, spacecraft, name it. They contribute to the amazing world of air travel where airplanes that weigh over half a million pounds can soar into the sky and spacecraft can travel 17,000 miles an hour.

AeroAstro engineering is the broad application of science and engineering to aerospace operations. Thus, the student is prepared for Air Force duty with specialization in research, design, development and analysis of space technology and aerospace system integrations. The program emphasizes structural, aerodynamic, guidance and control, and propulsion problems of aircraft and spacecraft.

Aeronautics and Astronautics is Nigeria's first and most respected program in Kwara State University. KWASU has a tradition of strong scholarship and solving industrial-strength problems. The AeroAstro community comprises of people whose careers have included ESA/NASA personnel,

retired eminent professors from University of Lagos and chief technologists, scientists, NAF, aerospace executives.

AeroAstro builds on humble beginning, scholarship, research development and implement reliable, safe, economically feasible, and environmentally responsible aerospace programs. Our university's contributions and collaborations are currently narrow, because this is the first time in Nigeria's history that aeronautics and astronautics is established. We are about graduating Aeronautical and Astronautical Engineers for the first time in the West African Coast. Nearly one-third of our current research collaborations are with Georgia Tech Faculty in the School of Aerospace Engineering, and approximately one-half are positioned with colleagues in professional practice like the Nigerian Air Force (NAF) government agencies, and overseas universities. We work closely with scientists and scholars at Space Agency, Korea Advance Institute of Science and Technology, International Aviation College, Ilorin, etc. Our educational programs are organized around three overlapping areas: space transportation, space systems and computation.

Space Exploration and Development

For over 50 years, governments and companies invested billions of dollars to undertake space activities, whether for civilian, commercial, defense and security, manned and unmanned exploration purposes. Space is not "just a place" surrounding the Earth. Rather, it is a medium of decisive importance - meaning strategic - indispensable to achieve objectives of prime value [3]. It

is a medium of (hard and soft) power. Space has become paramount for political, diplomatic, military, economic and commercial achievements. It has dramatically transformed the society, significantly contributed to new knowledge, shaping and globalizing information and culture.

The Pervasiveness of Space

Space is now an essential part of the way we understand and influence our surroundings and shape our way of living, weather the focus is on Earth, the solar system or the distant universe [2, 3]. Space technologies have become an important part of everyday life and lifestyle through: earth observation, telecom and broadcasting, science and exploration; positioning and navigation, synchronization of networks and timing. The global space activities in 2012 are shown in figure 2.

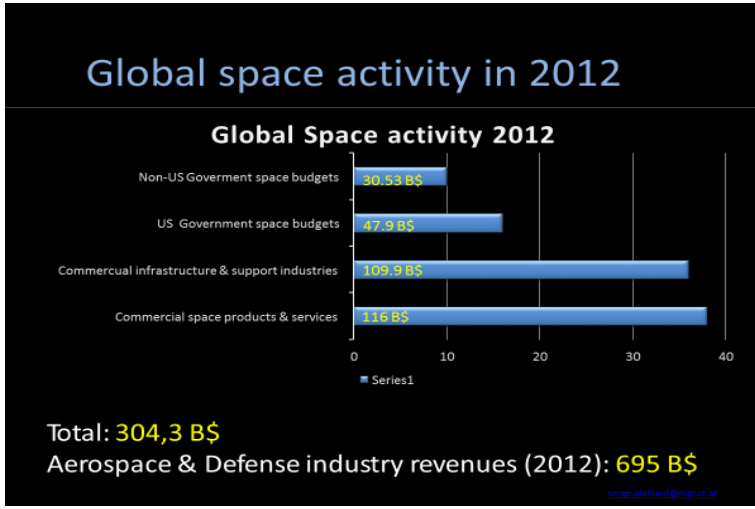


Fig. 2: Global Pace Activities in 2012 [3]

The global commercial space activity represents about 75% of the space economy. Broadcasting budget ($92.5 billion), geo-location and navigation ($81.1 billion), are by far the largest contributor to space revenues. Telecommunications revenue was $21.1 billion and Earth observation takes about $2.32 billion, while commercial infrastructure and support industries grew exponentially by 11% in 2012 from 2011, driven by the launch GNSS receivers. US space budget in 2012 was $47. 9billion. The European space budget was $8. 7 billion, including national and European Space Agency (ESA) and European Community (EC). Per capita contribution to civil space budgets: US $46, France $30, Germany $16, UK $6. Number of active satellites currently increased significantly to 1050. There were 333 commercial/national active GEO communication broadcast satellites, as of end of December 2013. Today, this has doubled. The value chain is depicted in figure 3.

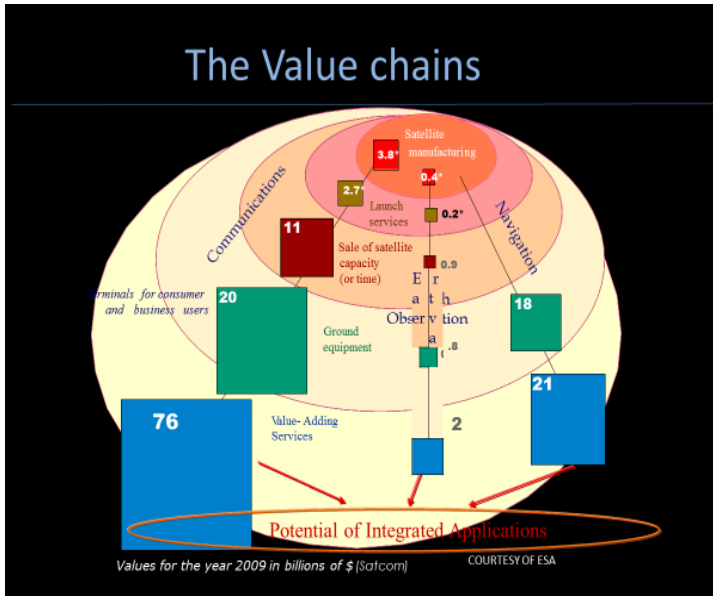


Fig. 3: The Value Chains in Global Space Activities [3]

Aeronautics and Astronautics has made it possible for meteorological satellite to gather data that is currently used by many different parts of society to ensure safety of the population, protect property, and increase economic performance and scientific knowledge. Figure 4 shows a typical example of the meteorological data collection in Low Earth orbit (LEO)

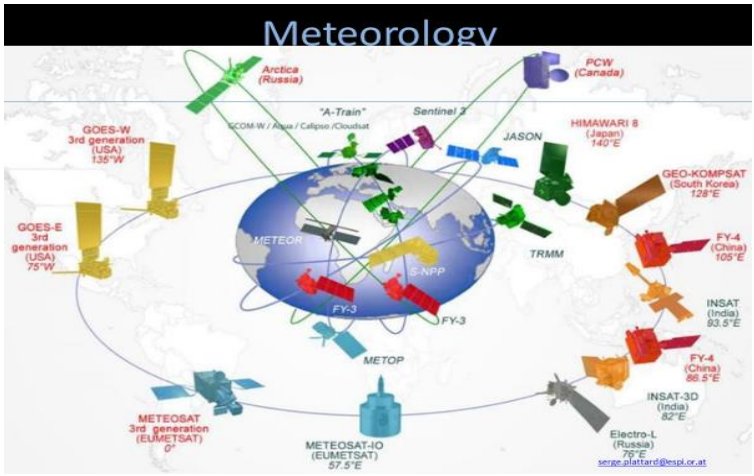


Fig. 4; The Meteorology map of space systems [3]

A Paradigm Shift

A paradigm shift to be implemented promptly is necessary to sustain public support to space exploration ventures.

This new vision should be:

1. Bold: to be inspirational for all people, requiring a commensurate level of sophisticated international cooperation;
2. Collective: the goal is to develop a common integrated space vision at the National level and link it to International Space Exploration Council.
3. Holistic: No *a priori* restrictions on the types of

missions. Best value for money and knowledge only;

4. Paved with realistic milestones: a) requiring an accepted common integrated vision, b) financial commitment, and, c) a "fail-safe" approach;
5. Sustainable: a) continuous commitment of the contributors in providing talented human resources, b) mission-wise tailored funding schemes, c) acceptance of an overall leadership on the exploration endeavor which will delegate managing responsibility to each mission.

The magnitude of this paradigm shift will require, for the first time in the history of Nigeria aerospace effort, a collective approach with a sense of common commitment open to every state in the federation able to contribute, and devoted to reaching a common goal of an impalpable New Frontier: A space nation in Africa for human space exploration and development.

My Humble Contributions to RLV and ELV Advanced Composites

For future reusable launch vehicle (RLV), Expendable Launch Vehicle (ELV) and space applications, there is a continued drive to improve the efficiency of structural designs not least in weight and cost [4, 5]. This has increasingly led to the use of fiber reinforced advanced composites to augment aluminium alloys as the primary structural materials. Those composites with a wide level of acceptance are carbon and aramid fibers reinforced with epoxy, bismaleimide and polyimide resins. There is an

increasing and foreseeable need for a range of lightweight structures capable of providing performance levels beyond those of conventional alloys and CFRP composites. These are emerging new advanced aerospace composites such as the carbon nanotube composites (CNT).

The development of advanced structural composites such as CFRP and hybrid composites is currently receiving considerable impetus. This stems from an increasing need within all aerospace activities to invoke: more weight efficient structures, improved aerodynamic characteristics and higher operating temperatures. In terms of structural composites aluminium alloys represent the traditional baseline with the 2000 and 7000 series alloys. Over the years, these have been substantially supplemented by structural composites based on thermosetting matrices with carbon, glass and aramid reinforcing fibers. Both aluminium alloys and epoxy composites have upper service temperature limitations of around 150 ºC. This has not placed serious restriction on development of cold structures RLV designs because operating temperatures in cold primary RLV structures have been modest.

ESA and NASA is studying new technologies associated with the application of CFRP or Hybrid composite materials structures for new generation of Reusable Launch Vehicle (RLV). Innovative designs, advanced materials foams and automated processes with the desired cost-savings potential are being pursued. This inaugural lecture addresses new advanced polymer composites and also the current ESA/NASA activities on experimental vehicles such as SOCRATES, issue related to materials structural

performance of the selected vehicle concepts, the quest for US space exploration for the design of RLV and ELV performance.

Design criteria are developed to ensure compliance with space regulatory requirements and ESA objectives. During selection of composite materials and design sizing, attempts are made to account for the most significant aspects of each selected materials and design. Existing and accurate analysis methods are selected and developed where practical, and conservative approaches are used where significant approximations are necessary. This design sizing activities supports subsequent development by providing representative design configurations for structural evaluation and by identifying the critical performance issues.

Significant research efforts are directed towards assessing structural performance predictive capability. The structural database collected to perform this assessment is intimately linked to the manufacturing scale-up activities to ensure inclusion of manufacturing-induced performance traits. Various mechanical testing conducted during FESTIP study which was used in this research effort to support the development and critical evaluation of analysis methods addressing all segments of RLV including fuselage internal loads, stability, ultimate strength, attachment and splice strength, and damage tolerance. These are evident in RLV Advanced Composite Technology Building Blocks ass shown in Figure 5.

The properties of CFRP or Hybrid are tailored to the specific requirements of reusable launch vehicle (RLV) in service. This tailoring offers a large number of variations of composites and processing methods. Development of new composites and combinations is thus initiated on a more target-oriented approach. Pros and cons of these fabric-reinforced plastics are mentioned. It is also shown, that a synergy between the "classical" plastics processing technology on the one hand and the composites technology on the other hand can boost new applications of structural polymer parts in a future RLV [5].

A design build approach is used in identifying materials and processes appropriate for use in RLV fuselage, wing and vertical tail applications. Carbon fibre reinforced polymers with epoxy is identified as a suitable candidate material for fuselage skins and stiffening elements and for the launch vehicle floor. Automated fibre placement (AFP) process is selected for fabrication of monolithic and sandwich skin panels. Pultrusion is selected for fabrication of floor beams and constant section stiffening elements. Drape forming is therefore chosen for stringers and other stiffening elements selected for fabrication of monolithic and sandwich skin panels. Circumferential frames braided through resin transfer molding are identified.

Development of selected materials and processes is pursued with the aid of literature survey and FESTIP studies. Significant efforts are expended on the development of AFP, braiding, and RTM processes. Innovation sandwich core materials and core edge close-out design concepts are evaluated for use in fuselage applications. Autoclave cure

processes are developed for stiffened skin and sandwich structures representatives of SOCRATES design concepts [6].

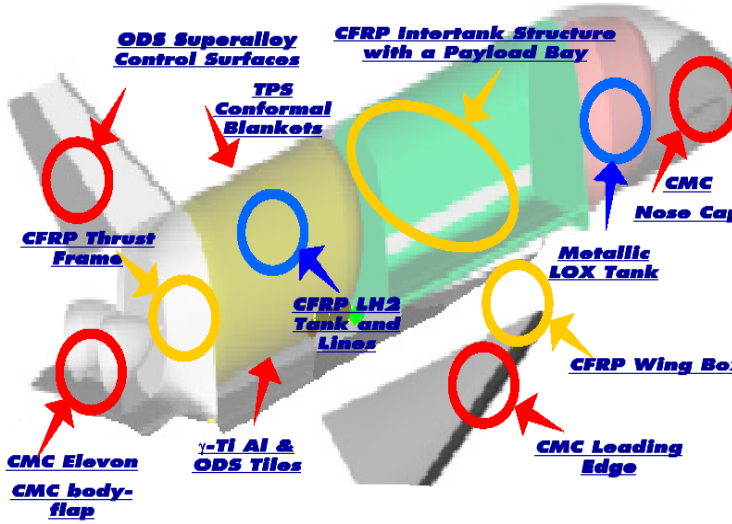


Figure 5: RLV Advanced Composite Technology Building Blocks [6].

The performance of selected materials in fuselage applications is investigated based on FESTIP studies and literature survey. The stiffness, strength, notch sensitivity, and bearing/bypass properties of fiber-placed skin materials and braided/RTM'd circumferential frame materials are evaluated. The strength and durability occurred and co-bonded joints are also evaluated. The impact damage resistance of stiffened skin and sandwich structures typical of fuselage panels is investigated. The mechanisms by

which fluids may penetrate and migrate through sandwich panels are studied. Finally, a cursory evaluation of the fire worthiness of composites structure is undertaken.

A three-step process is employed in this trade studies for initial development of the fuselage, wing and tail design and manufacturing process [6-10]. First, baseline concept is selected for crown, keel, and side panels, which had the greatest potential for cost and weight savings with acceptable development risk. The second is a trade evaluation of selected baseline and alternative concepts in which detailed designs and manufacturing plans are developed for cost and weight estimates. A globally optimized design is generated from the most attractive features of baseline and alternative concepts. The final step in design development involves detailed investigation and optimization of individual design elements. Selection, development, and characterization of materials and manufacturing processes are performed in parallel with the design development to leverage trade study results in directing these efforts. This integrated approach also served to provide the research effort with more refined information as the program progressed.

Future Aircraft Design

With the advent of technological revolutions, future aircraft will play an increasingly more important part of our lives. At AeroAstro department, faculty members, with students, are designing an aircraft that can fly using a car engine. A design and simulation tools, such as ANSYS and ABACUS, is used for a preliminary design and

evaluation of the future AeroAstro aircraft. Figure 6 depicts a typical future supersonic aircraft design.

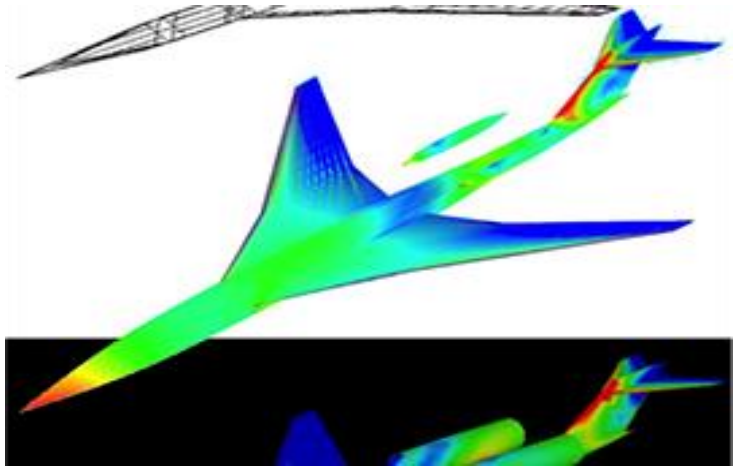


Fig. 6. Future Supersonic Aircraft Design Using ANSYS Simulation Tools [6]

From silent, efficient global transportation to personal or on-demand flight that frees us from roads, and to autonomous air vehicles for delivery of information and goods, the future of flight promises to look very different than today. In partnership with our government and industrial sponsors, our aircraft design research team focuses on these enabling technologies and their application to future flight concepts.

Autonomous Systems and Controls

Our fundamental and applied research efforts in the area of autonomous systems and controls focus on enabling

greater levels of autonomy on land, sea, sky, and space. Our current applications of interest include robotic transportation networks, mapping and navigation in extreme environments, planning and control for agile robotic systems, air traffic management, and space robotics, figure 7.



Fig. 7. Unmanned Aerial Vehicle (UAV) [2, 6]

KWASU Aero Astro students designed a similar UAV, which was demonstrated at exhibition in Abuja, figure 8. This is a milestone in the development of Aeronautical and Astronautical programs for the nation.



Fig. 8. AeroAstro Built UAV Flown around KWASU Main Building [11]

Cyber Safety for Transportation

This technology is now incorporated in road and rail transportation using integrated UAV systems for cyber safety. Transportation is changing dramatically. Soon, cars will drive while the enclosed humans snooze or send text messages. Trains will slow and speed, certain that they alone occupy the underlying track. Airborne drones will fly confidently between buildings to monitor air pollution and order in our cities [11, 12]. For all of this,

transportation will be safer and have much less impact on our environment. However, this new world of movement will need to be protected from cyber hackers.

Distributed Space Systems

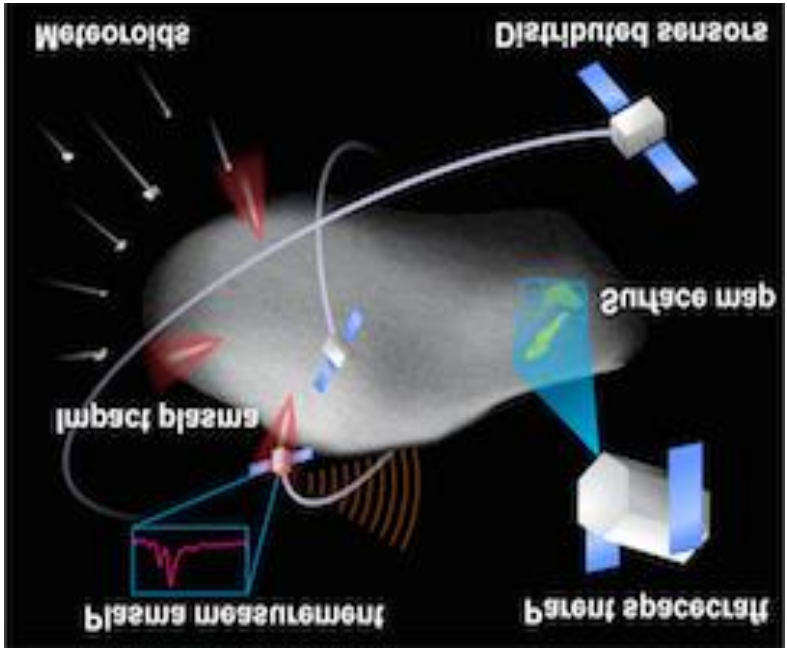


Fig. 9. Distributed Space Systems [12]

Distributed Space Systems (DSS) consist of two or more satellites that interact to accomplish scientific, commercial, or technological objectives that are otherwise very difficult if not impossible to achieve using a traditional monolithic spacecraft, figure 9. Key

applications of DSS include digital elevation modeling, gravity recovery, weather prediction, and disaster monitoring in the planetary science domain; gravitational wave detection, direct exoplanet, and star dust imaging in the space science domain; space debris removal and on-orbit inspection and servicing in the space situational awareness domain.

Multifunctional Composites and Intelligent Structures (MCIS)

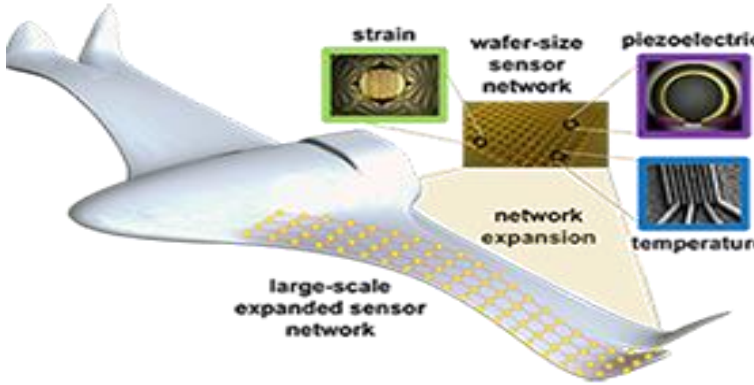


Fig. 10. Multifunctional Composites and Intelligent Structures (MCIS) [11, 12]

The Multifunctional Materials and Intelligent Structures group focuses on the design, manufacturing and experimental characterization of next generation composites and structures to be used in aircraft, space exploration, and automotive systems. Interests include

smart structures, structural health monitoring, lightweight composites, multi-functional materials, nanomaterials, micro- and nano-scale sensors, and harsh environment electronics, [11, 15] figure 10.

Multifunctional-Disciplinary Computational Aerospace

The research in computational aerosciences is driven by the daring technologies underlying next-generation aerospace systems, [15-22] figure 11. AeroAstro department is acquiring the software and equipment that will build on the experience developed at MIT. This spans from both extremes of the dimensionality spectrum: physics-based, high-fidelity computational models aimed at furthering our understanding of complex phenomena in turbulence, aeroacoustics, aerodynamics, aeroelasticity, aerothermomechanics, and many other multi-disciplinary areas relevant to aerospace engineering sciences; reduced-order models for all those pressing engineering problems that require real-time simulation responses such as, for example, the rapid exploration of a design space or optimal control [23 - 39].

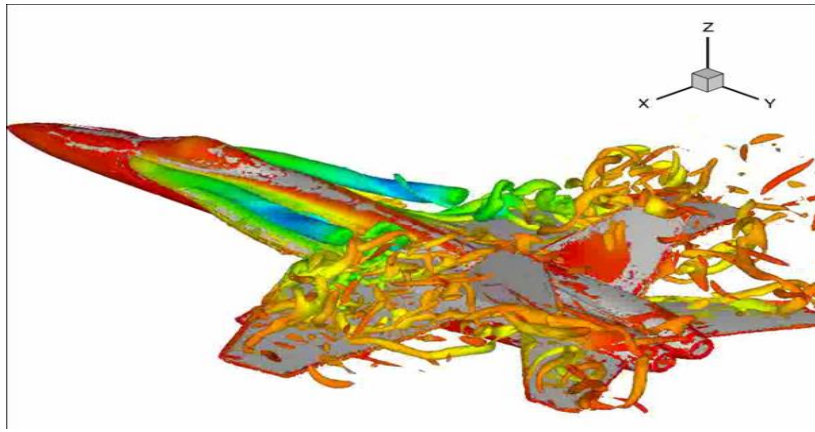


Fig. 11 Multifunctional-Disciplinary Computational Aerospace [12]

Conclusion

Mr. Vice Chancellor Sir, in the course of this inaugural lecture, I have been able to convince you and the audience why Nigeria needs Aeronautics and Astronautics program as a paradigm of future Nigeria's space exploration and development. On-Earth activities dependence on space will continue to increase, changing the way the human ecosystem works. Societal challenges will not be met without the use of space tools and systems. Institutional usages, which were dominant at the start are giving way to a democratization of space in:

- Telecom & Broadcasting
- Navigation and positioning

- Earth observation with a new wave of satellites and nanosats
- Intelligent Unmanned Aerial Vehicles (UAVs)
- Space related mass markets are raising new privacy issues
- Humans are bound to extend the technological sphere beyond the Earth limes
- KWASU is poised to make this dream of Aeronautics and Astronautics a reality in Nigeria

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Book/Journal Editorships/Board Membership

1. Associate Editor: Aerospace Materials Book, AIAA publishers
2. Author: Aerospace Bio-Inspired Structures, Cambridge University Press (in progress)
3. AIAA Spacecraft and Rocket Journal
4. AIAA Journal of Aircraft
5. Editorial Board Member: International Conference on Aerospace Composites/Nano Engineering
6. Associate Editor: Journal of "Metalurgija (Metallurgy MJoM).
7. AIAA Conference Chair for Space Transportation Committee

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