

Exhibition: Discovery of space and the search for life in the space

Ben Maouia Naoufel¹, Snoussi Sarra² *, Titouhi Imen³

¹Tunis Sciences City, ²Tunis Sciences City, ³Tunis Sciences City

*naoufel.benmaouia@cst.rnu.tn, sarra.snoussi@cst.rnu.com,
titouhi.imen@live.fr*

Keywords: Exhibition, Space, Astronomy, CST

As part of the modernization of the equipment of the astronomy pavilion, Tunis Sciences City undertakes to completely renovate the Universe pavilion, both in its form and in its content thanks to a combination of a certain number of modern museographic and scenographic parameters which highlight the themes of Space and come to describe scientific experiments attractive, giving a role to the visitor to explore this vast and mysterious domain.

The objective of the renovation is mainly to address the various themes of space science and technology in a simple and understandable language in the form of interactive manipulations and illustrations based on new technologies. It is also a vision of the future on the evolution of space technology which is the origin of scientific discoveries.

This exhibition contains several areas that are complementary and independent dealing with the **Discovery of space and the search for life elsewhere**, with insertion in a transversal way of the history of astronomy and space with themes on the solar system, the astronomical phenomena, space missions and the great structures of the universe. It will talk also about astronomical news and future projects in astronomy.

On the other hand, this exhibition offers visitors experiences to live in a space center that allow them to discover its backstage and to understand the scientific and technical fundamentals necessary for any space mission. This center will be composed of a propulsion laboratory, a rocket center and a satellite center which illustrate the various stages useful in the design and production of the main space tools, namely launchers and satellites.

GIS-based Assessment of the Opa Reservoir Flooding, Ile-Ife, Nigeria

Wilson B. Gwanfogbe ^{1*}, Bolarinwa O. Balogun ¹, Guedjeo C. Suh ²

¹*Department of Remote Sensing and Geographic Information systems, African Regional Centre for Space Science and Technological Education in English (ARCSSTE-E), OAU Ile-Ife, Nigeria;*

²*Department of Geology, Higher Teacher's Training College, University of Bamenda, Bambili Cameroon.*

**bums_gwanfogbe@yahoo.com; bola.balogun@arcsstee.org.ng:*

Keywords: Ile-Ife, Weighted Analytical Hierarchy Process (WAHP), Geographic Information Systems, vulnerability map, risk map.

With the Earth's changing climatic situation, flooding is expected to rise with accompanying socio-economic and environmental impacts. During the months of July 2011 and 2018, catastrophic floods hit the town of Ile-Ife, rendering many homeless, submerged farmlands and destroyed student residences and properties. This was just one of the many flooding events during the rainy seasons that constitute a major concern to the Nigerian Government and the Osun Local Government in particular. Assessing the magnitude of such flooding events and the severity of impacts will require a more dynamic and robust approach, such as can be offered by satellite remote sensing and Geographic Information Systems. The use of these techniques in this study, provides information to support decision-making for emergency planning, mitigation and above all, sustainable development. Studying the Opa reservoir is crucial because denizens of the Obafemi Awolowo University (O.A.U) and Ile-Ife town depend on it as their main source of water for domestic and industrial purposes. The study aimed to delineate the Opa catchment area and determine the leading causes of flooding in the reservoir. The Weighted Analytical Hierarchy Process (WAHP) method was used to evaluate and weigh identified causal factors, integrated them with remote sensing; while geospatial techniques was used to map out flood risk areas.

Eight conditioning factors for flood risk including slope gradient, elevation, curvature, LULC, drainage density, vegetation index (NDVI), TWI and rainfall intensity were identified, and weighed to produce flood vulnerability and risk maps. Consolidating the various data layers in ArcGIS pro, the flood risk areas on the map were divided into four subclasses of risk: very high, high, moderate and low. From the WAHP method, approximately 31.9% of the total area is highly prone to floods, especially the riparian communities; 27.5% has high risk; 24.2% is of moderate risk; and, 16.4% is of low risk. The accuracy of this method was validated by identifying over 10 repeated flood-inundated locations based on the Damage and Needs Assessment Report of the 2011 flood by the Osun Local Government, ground-truthing field surveys, and interpretation of Landsat 8 and Google earth images.

The final flood risk map is considered an important tool for flood risk reduction planning, and provides vital information that links flood risk with social, economic and environmental policies. The findings of this study can be adopted by the Administration of O.A.U in formulating appropriate mitigation and preparedness measures, to minimize the impacts of prevailing and future floods.

Risk assessment for wild fires with remote sensing data

Ralf Löwner¹

¹ Hochschule Neubrandenburg, University of Applied Sciences, Landscape Sciences and Geomatics, Brodaer Straße 2, 17033 Neubrandenburg, Germany, Email: loewner@hs-nb.de;

Abstract

Due to climate developments, natural hazards represent an ever-increasing problem for the world population as a whole, and thus an enormous challenge for each individual country. A critical need to respond to these challenges is the analysis of the site parameters and thus potential risks of a given area. The results obtained are indispensable to increase the preparedness of the acting authorities as well as of the population. The data from current and previous remote sensing programs provide indispensable data for site analysis and monitoring.

As an example, the present work considers wildfires, which represent a relevant natural hazard, which causes very serious and widespread problems, especially for the Mediterranean area. The study areas include one region in Tunisia and one in Sicily. In both areas, a vulnerability analysis as well as a statistical hazard analysis are carried out in order to finally arrive at a risk assessment. For this purpose, only free available data are used, in particular remote sensing data from active and passive sensors of the Copernicus services of the European Space Agency (ESA) and from NASA's Landsat program. The results show the different risks of the individual landscapes and serve as a blueprint for a quick and easy risk assessment in other areas.

Due to significant improvement during the last years, sophisticated free geospatial software tools provide desktop solutions for data acquisition, management, and analysis (e.g.; QGIS, GRASS, SNAP etc.), spatial database management systems (e.g. PostgreSQL/PostGIS), and Internet map server applications (e.g. Leaflet, Geoserver, Mapserver, QWC2). The advantages of these Free and Open Source Software (FOSS) consist in the sustainability and a certain independence from further funding, licence problems or private enterprises and big corporations. Therefore, the present analyses and models are realized with FOSS implementing the standards of the Open Geospatial Consortium (OGC).

The analyses considered here originate in part from the modules of the international English-language Master's program "Geomatics" of the University of Applied Sciences in the City of Neubrandenburg, Germany, and the results obtained are also incorporated in teaching. Some high-ranking scientific

papers have already been published in this field of science. This ensures that sufficient specialists will continue to be available in Germany and abroad in the area of risk management in the future.

Space-Based Earth Observation for Maritime Surveillance

Nadia Maaref¹, Vincent Kerbaol^{2*}, Béatrice Nhun Fat³

¹²³ *Collecte Localisation Satellites, Maritime Surveillance Unit*

nmaaref@groupcls.com, vkerbaol@groupcls.com, bnhunfat@groupcls.com

Keywords: maritime awareness, Earth Observation (EO), machine learning, data fusion, vessel profiling

Abstract:

The sheer vastness of the oceans has historically been a haven for those engaged in illegal activities. However even the most meticulous of these actors leave their traces. CLS Group has been collecting space-based maritime data for more than 30 years and believe that this contextual information is key to identifying vessels that are engaged in illicit activity. Indeed, for over 3 years, CLS has been developing and executing machine learning algorithms to expose anomalous vessel activities and generate consistently reliable leads on suspicious targets. As a result, our maritime domain awareness platform, MAS, has been designed as a Data Fusion & in-depth Analysis tool to help build the most comprehensive Maritime Picture and deliver Actionable Intelligence for end-users in their missions of Border Control, Detection of Illegal Fishing Activities (IUU), Detection of illegal activities at sea (smuggling, trafficking, transshipment).

Current sources of maritime information (reporting systems, information databases, near real time Earth Observation surveillance systems) produce huge quantities of data which cannot be directly exploited by the human operators in the various maritime control centers. At the same time, complementary and more innovative non-homogenous sources of vessel information become accessible. Traditional reporting systems are not enough by themselves to allow for a reliable detection of anomalies and to perform risk analysis on each individual vessel navigating in, or on its way to, European waters.

The objective of this presentation is to share about CLS' work to provide maritime authorities with a cutting-edge space-based maritime situational awareness platform, able to ingest and manage open or proprietary existing and innovative heterogeneous sources of information and to develop more precise, more robust and earlier detection of anomalies in the vessels profile (behavior at sea, registry, etc.) thanks to the big data capabilities and the innovative artificial intelligence algorithms, including deep learning. CLS will present practical results of this work in its MAS (Maritime Awareness System) platform allowing data ingestion and fusion between historical sources of information (AIS, VMS, LRIT, satellite EO imagery) and new types of data (ELINT).

COastal Management and MONitoring Network for tackling marine litter in Mediterranean sea

Sana Ben Ismail¹

¹*Institut National des Sciences et Technologies de la Mer, Carthage, Tunisia*

sana.benismail@instm.rnrt.tn,

Keywords: Marine Litter, Plastic pollution, Mediterranean Sea, ICZM, Monastir coast, Kuriat island

Marine litter is a growing environmental problem worldwide. It is threatening marine and coastal wildlife as well as causing loss of coastline aesthetic quality. It has a negative impact on the economy and on health. Tunisian Mediterranean coast is characterized by a rich diversity of natural, environmental, cultural and economic resources. Monastir city is considered as one of the most important commercial capital in Tunisia. During the last decades, it has reported an increase in urban density and industrial activities (textile, agri-business industry, fishing activity offshore fish farm, etc.). **COastal Management and MONitoring Network for tackling marine litter in Mediterranean sea (COMMON)** project is a three year funded project within the 2014-2020 ENI CBC “Mediterranean Sea Basin Programme”, the largest Cross-Border Cooperation (CBC) initiative implemented by the EU under the European Neighborhood Instrument (ENI). The consortium is composed of 7 partners from three Mediterranean countries (Italy, Lebanon and Tunisia). COMMON aims at applying the ICZM principles to the marine litter management in 5 pilot coastal areas through a local coordination and the Mediterranean networking among different stakeholders by testing an integrated strategy for marine litter management and disposal at coastal level that could be transferred to the whole Mediterranean area. COMMON will contribute to build multi-stakeholder networks at basin-level for tackling marine litter in a coordinate and integrated manner. The INSTM is a leader of work package Institutional capacity building in tackling marine litter throughout ICZM plan which will enhance the capacity of public authorities in 5 pilot areas to plan for sustainable management, use and monitoring marine litter sources, treatment and consequences, employing an effective participatory approach involving relevant stakeholders and local communities. The activities of the project will be presented by highlighting our training plan during next months and also it is occasion to present preliminary results about microplastics monitoring activities in Monastir and Kuriat Island the two pilot areas in Tunisia.

InSAR coherence Analysis for surface water mapping in the Lebna watershed in Tunisia

Riadh ABDELFAH
SUP'COM, University of Carthage
ITI department, IMT-Atlantique
riadh.abdelfattah@supcom.tn

The general objective of the work presented in this paper is the multitemporal monitoring of surface water evolution around the Lebna dam in northern Tunisia (Cap-Bon). This being in order to improve the spatio-temporal representation of surface hydrological processes developed in the framework of the PRIMA project, ALTOS. The ALTOS project is dealing with managing water resources within Mediterranean agrosystems by accounting for spatial structures and connectivities. It focusses on water resources management in Mediterranean agrosystems to achieve the interlinked Sustainable Development Goals (SDGs) by water issues.

Water resources are essential for the development of life on Earth. The majority of water is stored in the oceans (97.19%), the rest - fresh water - is distributed between frozen surfaces and glaciers (2.20%), groundwater (0.60%) and surface water which includes streams, lakes and soil moisture (about 0.01%). While water needs are generally associated with access to drinking water for the population, it is also essential for many industrial and agri-food sectors. The use of water has thus continuously intensified and diversified since the beginning of the 20th century, leading to an increased volumes of water used. Agriculture, which uses water for the irrigation of cultures, represents 3/4 of the current demand in the world: Mapping the distribution and persistence of surface water in a timely fashion has broad value for tracking dynamic events like flooding, and for monitoring the effects of climate and human activities on natural resource values and biodiversity.

The Lebna watershed, located in the Cap-Bon area in the north of Tunisia is an area of intensive vegetation growing. This region provides about 16% of national agricultural production, with only 4% of the country's total useful agricultural area. Then, identifying and understanding the problems posed by the transfer of water management to the Agricultural Development Groups (GDA) on the large irrigated perimeters of Lebna is crucial for an optimal monitoring. This inevitably passes through the identification of the different interaction mechanisms of surface water-groundwater. Thus, mapping and monitoring with precision the evolution of water surface related to a given watershed is essential.

We present in this work an analysis on the monitoring of the evolution of water surface related to the Lebna dam in the North of Tunisia based on optical and SAR (synthetic aperture radar) data from Sentinel 2 and 1. The InSAR (Interferometric SAR) coherence maps over the Lebna watershed, Tunisia (~210 km²) were generated using the Sentinel-1 data acquired from 2018 to 2022. Then, these maps simultaneously with the NDWI (Normalized Difference Water Index) extracted from the Sentinel-2 data were employed to assess the separability of different wetland types and their trends over time.

SPACE SERVICES FOR FOOD SECURITY

Faiza Khebour Allouche^{1 & 2}, Alexandru Badea³ and Abdallah Gad⁴

¹ High institute of Agronomic Science of Chott Mariem, Department of Engineering and Landscape Planning, Sousse University, B.P 47.4042 Chott Meriem Sousse-Tunisia, *allouchekhebour@yahoo.fr*

² National Agronomic Institute of Tunis, Lr GREEN TEAM (LR17AGR01), Carthage University, B.P 43, Avenue Charles Nicolle 1082 Tunis Mahrajène-Tunisia.

³ Romanian Space Agency, Mendeleev Street nr21-25, 010362, Bucharest, Romania, *alexandru.badea@rosa.ro*

⁴ National Authority for Remote Sensing and Space Sciences (NARSS), 23, Josef Brows Tito, El-Nozha El-Gededa, Cairo, Egypt, *abdallagad1@gmail.com*

Corresponding author: *allouchekhebour@yahoo.fr*

Abstract : The war in Ukraine, supply chain disruptions, the severe 2022 drought in Europe and the continued economic fallout of the COVID-19 pandemic are reversing years of development gains and pushing food prices to all-time highs. Face to these crises, the World Bank is deploying short-and long-term responses to boost food and nutrition security, reduce risks, and strengthen food systems. This year, the World Bank Group has making up to A \$130 million loan for Tunisia, seeking to lessen the impact of the Ukraine war by financing vital soft wheat imports and providing emergency support to cover barley imports for dairy production and seeds for smallholder farmers for the upcoming planting season. Food security is become pressing global challenges and promoting sustainable agriculture has been recognized collectively as a core sustainable development goal. Achieving this goal will require concerted global actions and advanced IT/AI tools and solutions to eradicate hunger and guarantee food and nutrition security for all, as well as to promote, enhance and support more sustainable agriculture while conserving land, water, plant and animal genetic resources, biodiversity and ecosystems. Such tools are offered by space science, technology and applications, which help in the characterization, assessment and the monitoring of crops, livestock, forestry, fisheries and aquaculture. Depending on its resolution, space-derived imagery can provide information used in direct approaches (species composition, land cover) and indirect approaches (primary productivity: chlorophyll, ocean color; climate: rainfall, soil moisture; habitat: digital elevation, biomass structure) for quantifying and modelling biodiversity. The combined use of geospatial information and participatory assessments provides an effective decision-making process for enhanced spatial planning (land use/land cover/territorial) sustainable land resource management among the various sectors/actors and monitoring of transportation chains.

Key words : space, food security, biodiversity, land cover, IT

SPACE STAR'22

Use of MODIS-based Vegetation Cover Index (VCI) for Monitoring Drought in the Tunisian Drylands

Bouajila Essifi¹ and Mohamed Ouessar²

^{1,2}*Laboratory of Eremology and Combatting Desertification. Institut des Régions Arides (IRA), 4119 Medenine. Tunisia.*

essifib@gmail.com

Keywords: Drought, Monitoring, MODIS, VCI, Tunisia

Drought monitoring is an important component for integrated spatial decision-making and early warning systems in agroecosystems of Tunisian drylands. Based on the UN-Spider recommended practice and recent advances in geo-informatics and remote sensing data and tools, this work aims to contribute to the monitoring impacts of meteorological drought on natural vegetation through a multi-temporal analysis of MODIS-based Vegetation Cover Index (VCI). Meteorological drought is often defined by a period of substantially diminished precipitation duration and/or intensity. The commonly used definition of meteorological drought is an interval of time, generally on the order of months or years, during which the actual moisture supply at a given place falls below the climatically appropriate moisture supply.

The input data are the two weeks composites of NDVI (MVC: Maximum Value Compositing) from MODIS Satellite Imagery of the years 2000 to 2021 of March and April, the highest vegetation growth. The images are at a spatial resolution of 250 meters. We used the Copernicus Landcover map (2015) of Shrub cover using the Land Cover Classification System (LCCS) developed by FAO. The results show the spatial distribution of drought over twenty years in different regions of Tunisia with a focus on the dry areas in the southern part of the country

Observation from space of some changes in Tunisian coastal zones

Mehdi Ben Haj^{1*}, Mohamed Ali Briki²

^{1&2}Tunisian Littoral Protection and Planning Agency
m.benhaj@apal.nat.tn, briki4000@hotmail.fr

Keywords: Coastal zones, observation, satellite, change detection.

Earth observation from space is very useful in order to identify and analyse changes especially in coastal zones. In fact, coastal zones are home to unique ecosystems, where complex ecological processes take place through the interaction of terrestrial, aquatic, atmospheric, and human landscapes. That's why coastal zones present different evolutions in time/space scales caused by anthropogenic and/or natural pressures.

However, there are considerable knowledge and data gaps in achieving effective and future change-proof sustainable management of coastal zones around the world due to both technical and social barriers, as well as governance challenges.

In Tunisia, the littoral Protection and Planning Agency use to observe and follow the coastal zones with satellite images from different dates and origins in order to detect changes and particularly hotspots. Satellite images allow historical analysis and current status mapping, and offers the advantage of global coverage.

The realized observations showed a lot of anomalies compared to the natural situations and significantly contribute to understand the sources of the problems and search solutions.

This paper discusses how coastal zones observations with remote sensing techniques can and permit the analysis and survey of different phenomenon progresses.



Image1: Algal bloom in Sfax coastal waters

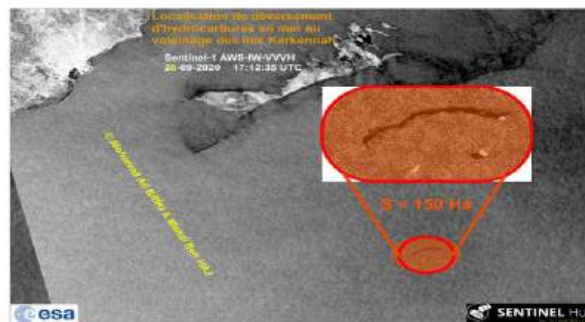


Image2: Oil spill in the offshore of kerkennah islands

SBAS for Africa and Indian Ocean

Louis Bakienon¹, Julien Lapie², Vivien Dovonon³
¹ASECNA, ²ASECNA; ³ASECNA

lapiejul@asecna.org, dovononviv@asecna.org

Keywords: Navigation, positioning, GPS, Augmentation, Satellite, ASECNA, Africa

The Agency for Air Navigation Safety in Africa and Madagascar (ASECNA) is committed to the provision of SBAS (Satellite-Based Augmentation System) services in the 16 million squared kilometres single sky airspace under its responsibility, and potentially beyond in Africa, as per the mandate given by its 18 Member States.

Its “SBAS for Africa & Indian Ocean” (A-SBAS) programme aims to provide airspace users with operational SBAS services from 2025, to improve the precision and boost the integrity, availability and continuity of the GPS and Galileo positioning and navigation solutions.

SBAS services will be used by aircraft for safety critical navigation applications for all phases of flight, from cruise operations down to precision landing. SBAS will improve flight safety and efficiency and will reduce their environmental impact. It will also benefit to many other areas of the economy, such as land, maritime and rail transport, as well as mass market applications, supporting user safety, cost-effectiveness, and sustainable development.

This programme is a key enabler to the implementation of the Space Policy and Strategy of the Africa Union. It is recognised by the International Civil Aviation Organisation (ICAO) and US GPS authorities.

The system definition and design are completed, and the development and deployment phases are on-going. Based on an indigenous African infrastructure, the system architecture comprises:

- A network of Navigation Reference Stations (NRS) deployed at various locations to collect GPS and Galileo data, which is scalable to support incremental service areas extension
- Two Mission Control Centres (MCC) composed of Navigation Processing Systems (NPS) to compute SBAS corrections and associated integrity bounds, and of Centralised Control Stations (CCS) for system control and monitoring
- Two Navigation Broadcast Stations (NBS) to uplink the signal carrying the SBAS messages to the navigation payload of the GEO satellite(s)
- A wide area transport network to ensure data communication between the various sub-systems
- A space segment composed of GEO satellite(s) broadcasting the SBAS messages to the users

In parallel, an SBAS demonstration service compliant to ICAO standards is provided in Western and Central Africa since September 2020. It is the first ever SBAS service to be provided in an equatorial region and constitutes an important technical achievement for Africa and even beyond for the global satellite navigation infrastructure, as it takes up the major technical challenge of SBAS operations in a region affected by important ionospheric disturbances.

The SBAS demonstration signal-in-space is generated and broadcasted from a fully-fledged test-bed infrastructure composed of a network of GNSS reference stations, a system prototype in Dakar (Senegal) using an advanced correction algorithm and processing set, an uplink station deployed in Abuja (Nigeria) and the navigation payload of the NigComSat-1R GEO satellite. Beyond technical tests, this service has been used to perform with partner airlines a series of aircraft and rotorcraft demonstrations to showcase on the field the benefits of SBAS operations. It has the potential to be extended in other regions of the continent, through additional reference stations.

Deficiencies in GNSS Based Timing Services in Africa.

Bedan Thendu^{1*}, Alou Aicha², Alex Wanda^{3*},
SatNav Africa –JPO¹; SatNav Africa –JPO¹; SatNav Africa –JPO¹
bedan.thendu@satnav-africa.com, aicha.alou@satnav-africa.com, alex.wanda@satnav-africa.com,

Keywords: Positioning, Navigation, Timing, UTC

For Global Navigation Satellite Systems, Positioning and Navigation services can be regarded as the primary services used on a mass scale, however GNSS can also provide the additional service of relaying accurate Coordinated Universal Time (UTC) time by acting as a precise time transfer infrastructure. One of the biggest challenges of ensuring that accurate and precise time is transferred from the source to the users is the channels used for this transfer. These channels very often cause additional delays before it reaches the end-user. GNSS provides a direct access to precise time (UTC) without delays

GNSS satellites provide time services that are accurate enough to fulfil requirements of applications in many domains because this time is built from accurate atomic clocks carried by the satellites. GNSS gives users access to UTC time with nanosecond-level (around 10ns) accuracy.

SatNav-Africa JPO conducted two studies (on behalf of AUC) on Positioning, Navigation and Timing (PNT) on the African continent. Both studies provided a survey and gap analysis on PNT Infrastructure and Technologies in Africa and this is in line with the objectives of the African Space Policy and Strategy, which seeks to address capability gaps in the continent through international partnerships, joint research and innovation strategies, as well as technology transfer, with a view to deploying space-derived products to improve the living conditions of African populations.

One of the studies focused on the use of GNSS as time dissemination infrastructure for the primary time standard known as UTC over the entire African continent. An assessment of the adoption of Timing and Synchronization (T&S) Technologies in different sectors in Africa based on number of GNSS receivers for Timing and Synchronization on the continent provided insight into the different sectors in Africa that are currently using precise Timing information disseminated to support their operations.

Regarding the T&S infrastructure, the study revealed that various infrastructures are required to support the provision of precise time information to the operators of critical infrastructure. This can be achieved through either timing service provider or directly from GNSS. At least Fourteen (14) African countries are either members or associate to the International Bureau of Weights and Measures (BIPM), in Paris, France. Three of them (South Africa, Egypt and Tunisia) contribute to the calculation of UTC with timing information from their national timing centers.

In general, precise time information reaches the majority of the critical infrastructure operators through either timing service provider (most especially using the internet) or directly from GNSS. Out of the 34 Countries with internet exchange points, 5 countries are known to host NTP services for the dissemination of UTC time sourced via GPS.

Main findings of the survey and gap analysis on GNSS Timing Technology and infrastructure were identified.

Analysis of DOP and its Preciseness in GNSS Position

Nissen Lazreg¹

¹*Center for Research on Microelectronic and Nanotechnology*

lazreg.nissen@yahoo.fr

Keywords: GNSS, DOP, Accuracy

Accurate positioning of objects is important for navigation applications which gives rise to many interesting and challenging mathematical problems. These problems involve the relationship between positioning accuracy and satellite geometry in accordance to the user's position.

Good precision GNSS satellite instantaneous code positioning demands good estimates of the distances from the transmitting satellites to the receiving antenna. But these good estimates do not always guarantee good positioning precision. This happens because the quality of the positioning is affected by the geometry of the observed satellites' constellation (the "satellites' geometry"), as seen from the GNSS receiver's antenna.

The impact of the satellites geometry in the positioning is accessed by the Dilution of precision DOP factors. It is an indicator of satellite geometry for constellation of satellites used to determine a position. These factors have the power to greatly amplify the impact of the uncertainties of the pseudoranges into the uncertainty of the solution found for the positioning problem.

Better the geometry, better the position accuracy. DOP describes the geometric strength of the visible satellites configuration on the GPS accuracy. Ideally, the visible satellites should be located at wide angles relative to each other.

The positioning accuracy is depends on the better satellite geometry. When the satellites are spread out in the sky, good satellite geometry is obtained. The receiver will be located at the intersection of the arcs of circles in which each has a radius equal to the receiver- satellite distance and a centre at the satellite itself. For a certain probability level, it is known from statistics that if the size of the uncertainty area is small, the computed receiver's position will be precise. When the satellites are far apart, the area of uncertainty will be small thus resulting good satellite geometry.

But when they are close to each other the uncertainty area is large and resulting in poor geometry. DOP number is varies with the relative receiver - satellite geometry, so it needs the availability of both the receiver and the satellite coordinates.



AGENCE NATIONALE DES FREQUENCES

LES SERVICES DE COMMUNICATION SPATIALE, ROLES DE L'UIT ET DE L'ANF SPACE STAR'2022

Rôle du Département des services spatiaux (SSD) de l'Union Internationale des Télécommunications (UIT):

- Responsable des procédures de coordination et d'enregistrement des systèmes spatiaux et des stations terriennes.
- Garantir l'exploitation exempte de brouillages des systèmes de radiocommunication par l'application du Règlement des radiocommunications et d'accords régionaux.
- Elaborer et gérer les plans d'assignation et d'allotissement relatifs aux services spatiaux et fournit des mécanismes pour la mise au point de nouveaux services par satellite en identifiant des créneaux orbitaux adéquats.
- Faciliter la mise au point de tout nouveau service par satellite et permettre l'exploitation de manière sûre de ceux qui existent.

Rôle de l'Agence Nationale des Fréquences (ANF):

- Promouvoir les communications spatiales en Tunisie et contribuer aux études réglementaires.
- Autoriser les services par satellite en Tunisie suite à la réglementation en vigueur.
- Notifier et Coordonner les satellites et les stations terriennes.
- Contribuer aux conférences mondiales des radiocommunications et étudier les points d'ordre du jour relatifs aux services satellitaires.
- Mettre à jour la position orbitale tunisienne suite à la résolution 559.

Earth Observation: Status and Challenges

Thouraya SAHLI CHAHED¹(*), Wafa TALHAOUI¹, Bilel SELLITI¹

¹*National Center for Mapping and Remote Sensing*

cnct@defense.tn

Keywords: Earth observation, Remote sensing, Resources management, Sustainable development.

It is obvious that the use and exploitation of earth observation data have imposed themselves in everyday life with all spontaneity and without being behind a clear national policy. On the other hand, the National Center for mapping and Remote Sensing since its creation in July 1988 has been in charge of the promotion of earth observation products supported by international cooperation. Thus, awareness campaigns through workshops and the establishment of pilot projects have made it possible to reach the main sectors concerned with land use planning, natural resource management and development monitoring. Spatial data remained difficult to acquire and expensive in that time, which limited optimal and efficient use. Indeed, this has only hindered the adoption of remote sensing techniques in the methods and working tools of institutions, which are nevertheless very aware of the undeniable contribution.

The rapid evolution and improvement of space products and their availability around the world has thus enabled a wide audience to find themselves spontaneous users of earth observation data, particularly which are now available free of charge. Nevertheless, do the latter meet the growing needs anticipated in relation to the hazards facing our country? Achieving the objectives of sustainable development; disaster reduction; adaptation to climate change are now becoming the pillars of adequate management of resources that have become increasingly threatened.

It is with this in mind that it is essential to define a clear vision as to the implementation of a spatial strategy that goes hand in hand with sectorial orientations and strategies. The development of the field of earth observation remains largely linked to a strategy for the space sector as a whole. On the other hand, the CNCT is therefore working to establish a clear vision to ensure adequate development of remote sensing in all areas by integrating into the African strategy through the GMES & Africa initiative and at the regional level through the development of a draft space law as the basic text to be adopted for a national space law. Thus the involvement of CNCT experts in the work, particularly of the National Commission for Outer Space and its sub-committees, remains one of the pillars for moving towards adequate regulation with the assistance of all national actors.

Research In Outer Space: Facilitating access to space supporting scientific and technological advancement

Elena Giglio^{1*}, Matteo Bartolini²

¹*D-Orbit, Italy*; ²*D-Orbit, Italy*;

elena.giglio@dorbit.space; matteo.bartolini@dorbit.space

Keywords: microgravity, satellite, space_transportation, iod/iov

One of the biggest challenges in the research and innovation world is to address and push technology maturity by reducing time to market for the benefit of science and industry.

Launch and deployment costs of a space mission have pushed the upstream world to design satellites of reduced mass and size using, leveraging launch opportunities both for dedicated and rideshare missions.

These new satellites can be carried into orbit from existing launch vehicles, deployed into orbit and then operated from the ground control operation centre.

InOrbit NOW is a family of end-to-end solutions leveraging the ION Satellite Carrier, an orbital transfer vehicle able to transport satellites in orbit and accommodate multiple third-party payloads requiring a test in orbit over the course of the same mission.

ION can host sensors and scientific instruments integrated within the payload bay: ION Satellite Carrier will provide resources to the technology such as power, telecommunication, pointing, in-orbit storage and so forth. This kind of solution eases the process of reaching a TRL 9 because the technology owner needs to focus only on the development of the sensor, whereas D-Orbit with its ION Satellite Carrier will take care of all the rest such as operations, access to space, data retrieval and so forth.

ION features:

- Faster Time-To-Revenues and positioning in target orbit;
- Launch Cost Reduction: deploy a constellation in multiple orbits on a single mission;
- Faster Time-To-Space: ride on the first available launcher;
- Reduction In Number Of Satellites: ION replenishes constellations faster so there is less need for spare satellites;
- Lower Manufacturing Cost: reduced need for propulsion decreases costs.

ION advanced services:

- Backup Satellite for an existing constellation;
- Integrating Satellite Services via Payloads Hosted on ION;
- Satellite Communication Hub Services.
- In-Orbit Validation and Demonstration (IOD/IOV);

In-Orbit Demonstration/Validation (IOD/IOV) enables the space research community to develop space technologies and test them in real-world conditions, accelerating TRL and technology maturation.

Trends on Application of Quantum Technology in Space

Faten Ouaja Rziga¹, Khaoula Mbarek¹, Kamel Besbes^{1,2}

¹Microelectronics & Instrumentation Lab, Faculty of Sciences of Monastir, University of Monastir, Tunisia

²Centre for Research on Microelectronic & Nanotechnology (CRMN), Sousse Technopole, Tunisia

Abstract:

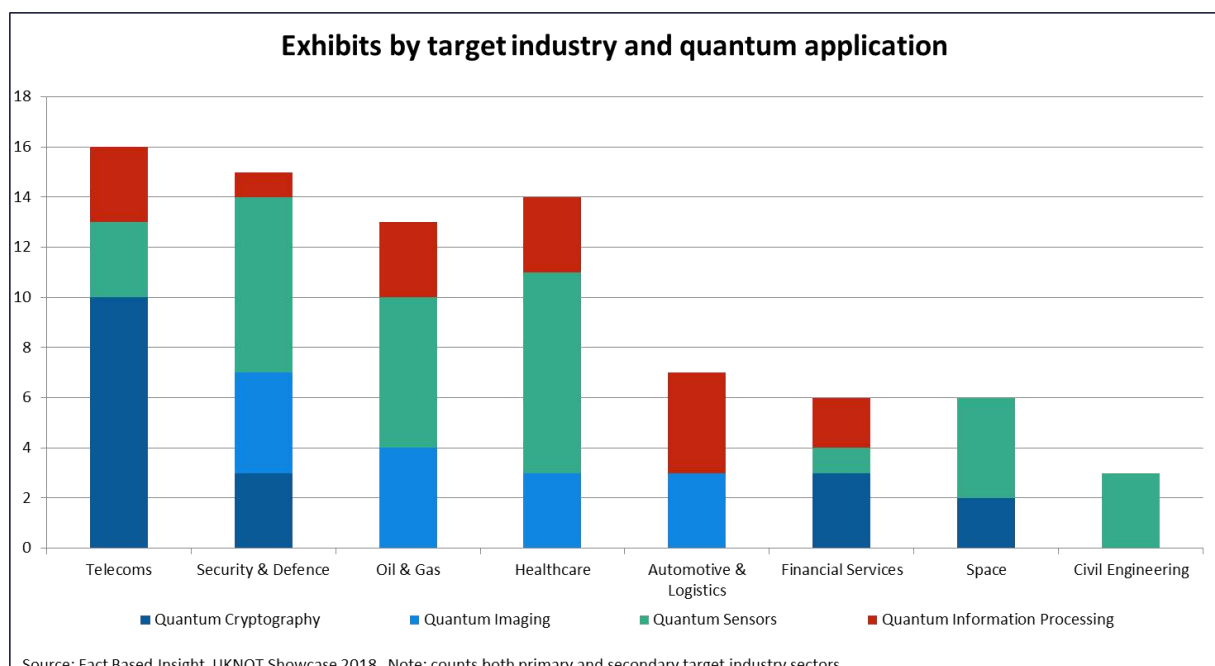
The popularity of applying quantum physics to space travel and measurement has increased. The limits and challenges faced by the current generation of technologies have prompted greater investment in promising emerging technologies, such as Quantum Technology (QT).

Hence, applications of Quantum Technology in Space (QTSpace) could lead to the potential development of a quantum internet, with encrypted and secure communications.

Here we aim to summarize the state of the art in the development of quantum technologies that have an impact in the field of space applications.

Our main focus is to study quantum gates and their implementation in quantum circuits, as well as the exploitation of quantum technology in space.

Moreover, in the field of quantum computing and more particularly in the quantum circuit computing model, a quantum logic gate is a basic quantum circuit operating on a small number of qubits. They are the building blocks of quantum circuits, as classical logic gates are for conventional digital circuits. We introduce in this work different quantum gates with 2, 3 qubits and their analogies with the logic gates, then we apply them in multiple applications.



FACT Project overview and major achievements

Samer Lahouar^{1,2}, Kamel Besbes^{1,2}

¹*Center for Research on Microelectronics and Nanotechnology, Sousse, Tunisia;* ²*Microelectronics and Instrumentation Laboratory, Faculty of Sciences of Monastir, University of Monastir, Tunisia*
samer.lahouar@crmn.rnrt.tn

Keywords: Space technologies, Space education, Space capacity building, Space infrastructure

The emergence of experimental nanosatellites, especially CubeSats, for space exploration and experimentation, gives low-cost space access to emerging countries such as Tunisia. In fact, CubeSats can be easily developed and fabricated since their components are widely available and are not very expensive. Moreover, CubeSats have versatile applications in different important domains, such as communications, remote sensing, border surveillance, environmental risks monitoring and mitigation, etc.

Furthermore, most space applications are within the scope of the Tunisian National Research Priorities. Actually, every space application involves one or more national priorities. As an example, space technologies and particularly CubeSats would help in the digital and industrial transition (development of CubeSat prototypes and subsystems); securing energy, water, and food (space surveillance); Education (new study fields). The space segment would also help in the implementation of new applications, such as smart cities, smart agriculture, smart transportation, IoT, without the dependence on other countries. For all these reasons, it was important for Tunisia to start its space journey by developing and testing CubeSats, which have a high Technology Readiness Level (TRL). This would also provide important capacity building in space technologies for students and engineers, which in turn would help in creating new jobs and new student profiles.

In this context, the project Fabrication and Applications of CubeSats in Tunisia (FACT) was launched since the end of 2018. The project is carried-out by a consortium of four institutions and is coordinated by the Center for Research on Microelectronics and Nanotechnology (CRMN) of Sousse, Tunisia. The project is expected to finish by the end of 2022 (4 years).

The purpose of this paper is to present the FACT project and its main outcomes. Specifically, the paper presents the main research and engineering activities carried-out by the researchers and students within the framework of the project to achieve its expected outcomes.

One of the major results of the FACT project is the installation of a CubeSat mounting facility, which is mainly composed of a class 1000 cleanroom and different workbenches with antistatic surfaces. This room can be used to construct and test the different CubeSat subsystems and mount them into a CubeSat without particles contamination. The second result of the project is the procurement of a thermal vacuum chamber that will be used to simulate space environment and ensure that the CubeSat can withstand harsh space without failure. The thermal vacuum chamber can accommodate a CubeSat of 6U or less.

More than fifteen (15) students, three (3) engineers, and eight (8) researchers participated in the execution of the different work packages of the FACT project. The students involved were from various fields, namely: electrical engineering, computer engineering, communication engineering, and electromechanical engineering. They were preparing diverse types of degrees ranging from License (BS equivalent) to Ph.D.

The research activities involved the design and optimization of different CubeSat subsystems such as the Electrical Power Subsystem (EPS), the communication subsystem, the attitude determination and control subsystem (ADCS), and the payload subsystem. On the other hand, the engineering activities concerned the design and implementation of different modules that can be used to test the CubeSat subsystems and assess their performance and proper functioning. Among these modules we can mention the frictionless air-bearing system and the Helmholtz cage that can be used to evaluate the performance of the ADCS. Also, we can cite the Solar Panels Simulator and the Battery Simulator that can be used to evaluate the performance of the EPS based on user-selected parameters, such as solar radiation power, panels' temperature, battery state of charge, and CubeSat mode of operation. All the modules were developed in-house by the students and were extensively tested to ensure their proper functioning.

Finally, it should be noted that theoretical and practical training courses in Space technologies, CubeSat development, and CanSat development are scheduled for fall 2022 as part of the FACT project. The aim of these training programs is to give a broad range of interested students an introduction about different space aspects and thus encouraging them to pursue their studies in the space field.

Acknowledgments: The FACT project was mainly financed by the Tunisian Ministry of Higher Education and Scientific Research in the framework of the PAQ Collabora projects.

Planar Antenna for UHF CubeSat Communication

Nozha Zalfani¹, Sabri Beldi ^{2*}, Samer Lahouar ¹³, Kamel Besbes ¹⁴

¹*Microelectronics & Instrumentation Lab, Faculty of Sciences of Monastir, University of Monastir, Tunisia*

²*Dept. of Physics, Microwave Electronics Research Laboratory, Faculty of Sciences of Tunis, University of Tunis El Manar, Tunis 2092, Tunisia*

³*Centre for Research on Microelectronic & Nanotechnology (CRMN), Sousse Technopole, Tunisia*

nozha.zalfani@gmail.com, beldi.sabri@gmail.com, samer.lahouar@crmn.rnrt.tn,
kamel.besbes@fsm.rnu.tn.

Keywords: Meander line antenna; UHF communication; FR-4; CubeSat; Long-range (LoRa); Internet of things (IoT)

The development of the CubeSat form, for communication applications in general and LoRa communication in particular, is currently increasing.

The linear wire deployable antennas are the most solution used for communication in this satellite form. However, deployable mechanical systems present the risk of failure during the mission and added an extra mass.

In fact, one-unit CubeSat geometry allows a very small space (10cm * 10cm * 0.06cm) for the antenna. Since the size of the antenna is proportional to wavelengths, the antenna size is a big problem for low frequencies, especially in the UHF band. For this reason, planar antennas are an attractive solution for CubeSat communications.

This work presents the method of testing a planar antenna working at a frequency of 920 MHz.

Development of a testbed for the ADCS subsystem of a CubeSat

Mounir Mansour^{1,3*}, Samer Lahouar^{2,3}

¹ Higher Institute of Applied Sciences and Technology of Sousse - University of Sousse-Tunisia;

²Center for Research on Microelectronics and Nanotechnology, Sousse, Tunisia;

³Microelectronics and Instrumentation Laboratory, Faculty of Sciences of Monastir, University of Monastir, Tunisia.

mounir.mansour@issatso.u-sousse.tn

Keywords: CubeSat, ADCS, Air bearing, Helmholtz Cage.

During the last two decades, nanosatellites became a widespread and significant trend. Due to low cost and several off-the-shelf components, the development of such satellites became common, especially among universities.

Despite their small size and standardized construction, CubeSats are useful to perform different tasks in different fields of space exploration: earth observation, communication, scientific missions, etc.

Several countries have entered the space race by launching programs to develop small satellites. Among the programs launched by Tunisia is the FACT project. This project is conducted by the CRMN of Sousse and aims to train students from Tunisian universities in the space sector.

All the systems required to operate CubeSats are similar to those of large satellites, but with strict size and mass constraints. Among the satellite components, the Attitude Determination and Control System (ADCS), has an important role during the CubeSat mission.

The failure of a single component of a system can lead to the failure of the entire satellite. In order to verify that the CubeSat is functioning properly and that its components are maintaining their proper operation in the space environment, ground tests shall be performed for each component and subsystem. One of the most challenging systems to test on ground is the ADCS.

Dynamic simulations of the space environment and the attitude of the CubeSat are necessary for the ADCS verification. There are several methods for allowing satellite motion in a low-torque environment. Each method has its benefits and drawbacks. The most extensively employed technique is the air bearing platform.

In this context, we present a testbed platform that allows to simulate the operation of an ADCS module. The system has been designed and implemented within the CRMN of Sousse as part of the FACT project. The testbed includes an air bearing platform and a Helmholtz cage.

The air bearing platform provides a frictionless low torque setting that simulates space environment. The Helmholtz cage allows creating a test environment in which the magnetic field produced can be controlled. The design of the testbed and preliminary test results are presented.

RF Circuits Addressing Power, Space Requirements and Re-configurability Challenges in Nano-satellite Applications

Mongia Mhiri^{1*}, Kamel Besbes^{1,2}

¹Laboratory of microelectronics and instrumentation at Faculty of Science in Monastir; ²Center of Research on Microelectronics and Nanotechnology
mongia.mhiri@fsm.rnu.tn

Keywords: Cubesat Communication, CMOS, Active Inductor, RF Filter, LC-Oscillator

Due to particular impellent, like low power, low encumbrance, radio frequency circuits for Nano-satellites applications need to be implemented with precaution. Apart of power and space, possibility of re-configurability offer them to be adapted to various transmit and receive systems and avoid implementing specific hardware for each application or to communicate with other Nano-satellites. In our research, we focus our activities on the application of some techniques and optimization approaches to enhance critical performances as power, space and re-configurability for transceivers operating in VHF, UHF, L, S and S2 frequency bands allocated. The main adopted techniques can be summarised in replacing the spiral inductor by an active inductor (AI) built with suitable multi-finger gate transistors. Key parts of a transceiver, as filters and oscillators, are designed using this approach.

It is well known that an active inductor is an active circuit that simulates an inductor in a specified frequency bandwidth. The active inductor is commonly designed as a gyrator-C that offers important characteristics as high quality factor, reduced area, and re-configurability when implemented using a CMOS conventional technology on Silicon. Three prototypes are designed, and simulated, among which one is fabricated in the ST CMOS 0.13 μm technology. The latter is a CMOS single access AI. It exhibits an inductor value of 3.41 to 31nH in the frequency band 1.2 to 3.26GHz with a maximum quality factor of 1467 at 2.52GHz. It occupies an area of 308.9 μm^2 and consumes a current between 2 and 3mA under a supply voltage of 1V. The second one is a floating AI, which main parameters are an inductor value of 80.7 to 520nH in the frequency band 0.785 to 3.25GHz, a maximum quality factor of 2672 at 1.49GHz. The third AI is implemented with a TSMC CMOS 90nm technology. Its inductor value varies from 3.55 to 26nH, and its highest quality factor is 895. It occupies an area of 600 μm^2 and consumes 0.515mW at 1V supply voltage.

In our work, we have implemented three prototypes of band-pass filters based on the above active inductors using 0.13 μm CMOS technology. The tuning of the centre frequency of each filter to meet the specifications dictated to VHF, UHF, L, S and S2 frequency bands is achieved through control voltages of the AI. All of the three filters expose competitive performances with the state of the art as a high quality factor, reduced power consumption and wide tuning range, which allow them to acquire an important FOM. One filter is single access with a centre frequency that can be tuned between 2 and 4.84GHz. It occupies an active area of 548 μm^2 and consumes less than 2.84mW. The two others are differential filters and are able to cover wider frequency-bands and have higher gain and better linearity at the cost of an unimportant increase of area and power consumption.

The designed AIs are validated also through integrating broadband LC-oscillators. These oscillators using the third AI are simulated and implemented in 90nm CMOS process. Their performances demonstrate that they are well placed in the state of the art and exhibits a trade-off between area, power consumption and frequency band. A Voltage Controlled oscillator (VCO) is designed consisting of an LC tank and an NMOS cross-coupled pair. The VCO core occupies a small area of 1665 μm^2 and draws 3.3mA from 1V supply voltage. It achieves a phase noise lower than -105dBc/Hz at an offset frequency of 1MHz and a figure of merit FOM_A of -196dBc/Hz. An LC tuned digitally Controlled Oscillator exploits the AI with conjunction of a capacitive degeneration network. It occupies an area of 0.017mm² and consumes less than 5.2mW. It achieves a frequency resolution as accurate as 3kHz, a phase noise of -105.8dBc/Hz at 1MHz offset and it exhibits a FOM of -178dBc/Hz.

In our recent research work, reconfigurable RF circuits are designed and simulated promising robustness and improvement of sustainability. The main considered circuits are active inductors, filters and LC-oscillators dedicated to cubesat transceivers.

A New Method for Estimating Eclipse Duration on Low-Earth Orbit Satellites

Thameur Chebbi

Laboratory of Microelectronics and Instrumentation, Faculty of Science of Monastir, Tunisia

chebbythamer@gmail.com

keywords: eclipse, Low-Earth orbit, prediction, STK, CubeSat

Low-earth orbit satellites encounter eclipses when orbiting around Earth. The variation of eclipse duration can have a drastic effect on satellites, especially those with limited power sources. This paper investigates a new method to predict the eclipse period using an analytic approach. A satellite, in an ISS-like orbit, was considered to calculate eclipse periods over its lifetime. The results obtained are then compared with STK software (Satellite Tool Kit). It is shown that the analytical method has an accurate eclipse prediction compared to the results of the STK. This method can be a reliable solution for eclipse prediction onboard CubeSats, and for power budgeting analysis prior to launch.

In 2018, the CubeSat program FACT (Fabrication and Application of CubeSats in Tunisia) was initiated at the Center For Research of Microelectronics and Nanotechnology of Sousse, Tunisia. Apart from the ambition of designing and building a one-unit CubeSat platform, called TUNISIA-1, the main goal of the program was the hands-on education of undergraduate and graduate students.

The miniaturization of electronics has caused a revolution in all fields of technology, one of which now being space satellites, termed CubeSats. CubeSats are small satellites sized as small as 10x10x10 cm. and can weigh as little as 1.33 kg [1].

These CubeSats have been applied in a variety of fields to gain a better understanding of numerous subjects that impact human life. To complete its mission successfully, the nanosatellite must require an electrical power system (EPS), which is the most critical [2]. it encompasses both the power regulating electronics, power generation, and energy storage components within the standard 1U CubeSat (about 1 kg mass) operating in the nominal range of 3–5 W [3].

The size of the solar panels and batteries required is determined by the payload(s) and the mission's lifetime. However, due to the conventional form of CubeSat's limited weight and volume, electrical energy is confined, posing a fundamental difficulty to practically every CubeSat mission. Basically, this can be explained by the eclipse occurrence experienced by the satellite when it passes through the shadowed region created by the Earth[4], which limits the electrical power available in terms of solar energy harvested by solar panels and batteries capacity required during eclipse time and peak power demands.

Furthermore, eclipse events have an impact on the thermal regulation of satellite temperatures. It is critical that all CubeSat components remain operational, as temperatures in low Earth orbit (LEO) can range from -40°C to +85°C.[5], whereas, when in an eclipse area, this extremely low temperature is below the operational range of many components, particularly batteries, which can only survive at temperatures of approximately -10 ° C on average [6].

As a result, computing eclipse time becomes critical for sizing the elements of the electrical power subsystem (EPS) and improving CubeSat energy management. Whereas, onboard eclipse prediction is becoming increasingly important to improve CubeSat autonomous task management and control power distribution to different subsystems.

From the literature survey, it can be found that the shadow state prediction model falls into two categories namely; spherical Earth conical shadow model and cylindrical shadow model. Hence, several methods has been used to determine shadow occurrence for LEO satellites based on complex mathematical calculations [7], [8].

Despite the accuracy provided by these methods to achieve eclipse prediction, they required heavy computations with slow convergence time. Therefore, it makes them unsuitable for CubeSats to autonomously predict for eclipse occurrence.

In this paper, we present an analytical approach to predict eclipse in low-earth circular orbit. The results are then compared with STK results.

References:

- [1] C. D. S. Rev, "The CubeSat Program," *Cal Poly SLO Http://www.Cubesat.Org Date Appl. 109 2017*, vol. 13.
- [2] S. Dahbi, A. Aziz, S. Zouggar, N. Benazzi, H. Zahboune, and M. Elhafyani, "Design and sizing of electrical power source for a nanosatellite using photovoltaic cells," in *2015 3rd International Renewable and Sustainable Energy Conference (IRSEC)*, 2015, pp. 1–6.
- [3] A. Elbrecht, S. Dech, and A. Gottscheber, "1U CubeSat design for increased power generation," in *Proceedings of the 1st IAA Conference on University Satellite Missions*, 2011, pp. 1–7.
- [4] M. N. Ismail, A. Bakry, H. H. Selim, and M. H. Shehata, "Eclipse intervals for satellites in circular orbit under the effects of Earth's oblateness and solar radiation pressure," *NRIAG J. Astron. Geophys.*, vol. 4, no. 1, pp. 117–122, 2015.
- [5] E. Husni and N. Febrian, "Thermal validation testing of an automatic identification system (AIS) receiver for low earth orbit (LEO) CubeSat," in *Journal of Physics: Conference Series*, 2019, vol. 1152, no. 1, p. 012006.
- [6] "CubeSat Batteries and Satellite Power Systems | AAC Clyde Space." <https://www.aac-clyde.space/what-we-do/space-products-components/optimus-range> (accessed Feb. 18, 2022).
- [7] P. R. Escobal, *Methods of orbit determination*. Huntington, N.Y: R. E. Krieger Pub. Co., 1976.
- [8] D. A. Vallado, *Fundamentals of Astrodynamics and Applications (Space Technology Library) (Space Technology Library)*. Springer, 2007.

Space Engineering Systems

M. Jaidane¹

¹*The Polymath Company, Tunisia*

mohamed@polymath.company

Keywords: Systems Engineering, Aerospace

Systems Engineering is a discipline that has been theorised extensively for the last 70 years. And yet, it's rarely taught as a discipline. Engineering students and confirmed Engineers rarely grasp its value. It's often associated with large complex systems engineering with highly complicated development and use lifecycle. This holds true at the inception of Systems Engineering with The Appolo program and especially the Space Shuttle program during which thousands of suppliers with millions of parts and new technologies being invented concurrently to reach a single but exciting emergence. But the value of SE is unlimited and should be used for "simpler" projects to maximise the value the proposition of each product and efficiently achieve the mission statement of the project.

This simple presentation is an introduction to Systems Engineering with a focus on industrial application in Aerospace. It does not focus on SE techniques but mainly the ppsiyive outcomes of applying those techniques.