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Abstract Book

8th Annual International Conference on Chemistry

20-23 July 2020, Athens, Greece

Edited by
Gregory T. Papanikos

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Abstracts
8th Annual International Conference on Chemistry
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Preface

This book includes the abstracts of all the papers presented at the ***8th Annual International Conference on Chemistry*** *(20-23 July 2020)*, organized by the Athens Institute for Education and Research (ATINER).

A full conference program can be found before the relevant abstracts. In accordance with ATINER's Publication Policy, the papers presented during this conference will be considered for inclusion in one of ATINER's many publications.

The purpose of this abstract book is to provide members of ATINER and other academics around the world with a resource through which to discover colleagues and additional research relevant to their own work. This purpose is in congruence with the overall mission of the association. ATINER was established in 1995 as an independent academic organization with the mission to become a forum where academics and researchers from all over the world could meet to exchange ideas on their research and consider the future developments of their fields of study.

It is our hope that through ATINER's conferences and publications, Athens will become a place where academics and researchers from all over the world regularly meet to discuss the developments of their discipline and present their work. Since 1995, ATINER has organized more than 400 international conferences and has published nearly 200 books. Academically, the institute is organized into 6 divisions and 37 units. Each unit organizes at least one annual conference and undertakes various small and large research projects.

For each of these events, the involvement of multiple parties is crucial. I would like to thank all the participants, the members of the organizing and academic committees, and most importantly the administration staff of ATINER for putting this conference and its subsequent publications together. Specific individuals are listed on the following page.

Gregory T. Papanikos
President

8th Annual International Conference on Chemistry, 20-23 July 2020, Athens, Greece

Scientific Committee

All ATINER's conferences are organized by the Academic Council. This conference has been organized with the assistance of the following academic members of ATINER, who contributed by chairing the conference sessions and/or by reviewing the submitted abstracts and papers:

1. Gregory T. Papanikos, President, ATINER & Honorary Professor, University of Stirling, U.K.
2. Ellene Tratras Contis, Head, Chemistry Unit, ATINER & Professor of Chemistry, Eastern Michigan University, USA.
3. Nicolas Abatzoglou, Head, Environment Unit, ATINER & Professor, Department of Chemical & Biotechnological Engineering, Université de Sherbrooke, Canada; Chair Pfizer, Processes and Analytical Technologies in Pharmaceutical Engineering; Director of GRTP-C & P (Groupe de recherches sur les technologies et procédés de conversion et pharmaceutiques); Fellow of Canadian Academy of Engineering.
4. Isai Urasa, Academic Member, ATINER & Professor of Chemistry & Director, Water Chemistry Research Laboratory, Hampton University, USA.
5. Lampros Pyrgiotis, Research Fellow, ATINER.

FINAL CONFERENCE PROGRAM
8th Annual International Conference on Chemistry, 20-23 July 2020, Athens, Greece

PROGRAM

Monday 20 July 2020

09.00-09.30
Registration

09.30-10.00
Opening and Welcoming Remarks:

- **Gregory T. Papanikos**, President, ATINER.
- **Ellene Tratras Contis**, Professor, Eastern Michigan University, USA.
- **Bala Maheswaran**, Professor, Northeastern University, USA.

10.00-10.45
Zoran Bojkovic, Professor, University of Belgrade Serbia.
Dragorad Milovanovic, Lecturer, University of Belgrade, Serbia.
Title: *What 5G has been and what 5G+ towards 6G should be?*

10.45-11.00 Break

11.00-11.45
Gagik Shmavonyan, Professor, National Polytechnic University of Armenia, Armenia.
Title: *Unique Nanostripes and Sheets of 2D Atomic Materials Obtained by Substrates Rubbing Technology.*

11.45-12.00 Break

12.00-12.45
Fritz W. Bopp, Professor Emeritus, University of Siegen, Germany.
Title: *How to Avoid Absolute Determinism in Two Boundary Quantum Dynamics.*

12.45-13.00 Break

13.00-13.45
Nicolae Diga, Postdoctoral Researcher Engineer, Politehnica University of Bucharest, Romania.
Title: *Use of Modern Software Supports Specialized in Designing Induction Motors with Special Destinations.*

13.45-14.00 Break

14:00-14:45
Bala Maheswaran, Professor, Northeastern University, USA.
Title: *Experiential and Interactive Learning: A new Approach*

14.45-15.00 Break

15:00-15:45
Ethel Petrou, Professor and Chair, Department of Physics, Erie Community College, State University of New York, USA.
Title: *The Challenges of Lab Teaching during the COVID 19 Pandemic*

15.45-16.00 Break

16.00-16.45
Ellene Tratras Contis, Professor, Eastern Michigan University, USA.
Title: *Sustaining Solutions in Undergraduate STEM Education*

16.45-17.00 Break

17.00-17.45
Leslie Kerby, Assistant Professor, Idaho State University, USA
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18.00-20.30
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- **Priya Chouhan** & **Nikos J. Mourtos**, Aerospace Engineering, San Jose State University, USA. *The Conceptual Design of a General Aviation Electric Aircraft.*
- **Samneet Singh** & **Nikos J. Mourtos**, Aerospace Engineering, San Jose State University, USA. *Design of a Two-Seater, Electric Air Taxi.*
- **Shali Nidarsana Subramanian** & **Maria Chierichetti**, San Jose State University, USA. *Risk Identification and Qualitative Risk Assessment of Air Taxi Operations for Large Scale Urban Air Mobility.*
- **Rushikesh Badgujar** & **Nikos J. Mourtos**, San Jose State University, USA. *X-69 CargoSat for LEO Deliveries.*
- **Aysha Rehman**, **Calvin Nuttall**, **Joshua Kring**, **Christian Ancheta**, **Tyler Borda** & **Periklis Papadopoulos**, San Jose State University, USA. *Conceptual Design of Astrobee Surface Sampling Payload.*
- **Enrique Murcio Reyes** & **Maria Chierichetti**, San Jose State University, USA. *Image Processing Techniques for Crack Detection in Aerospace Structures.*

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09.45-10.00 Break

10.00-10.45
Tomoharu Miyanaga, Shibaura Institute of Technology, Japan.

Title: *Phase and Morphology Control of Organic-Inorganic Hybrid Network Polymer by Means of Hydrosilylation Reaction of Cubic Silsesquioxane or Cyclic Siloxane and Divinyl or Diallyl Compounds*

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Piotr Razniak, Assistant Professor, Pedagogical University of Cracow, Poland.
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12.00-12.45
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13.00-13.45
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Guillaume Thomann, Associate Professor, Université Grenoble Alpes, France.
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14.00-14.45
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15.00-15.45
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15.45-16.00 Break

16.00-16.45
Timothy M. Young, Professor and Graduate Director, The University of Tennessee, USA.
Title: *'Data Science' – The Revolution for Engineering Academic Programs.*

16.45-17.00 Break

17.00-17.45
Jeffrey Busch, Senior Consultant and Adjunct Professor, Portland State University, USA.
Title: *Agile-Stage-Gate Approach: Exploratory Research on the Structure, Roles, and Responsibilities.*

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18.00-20.30
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- **Tyler Borda**, United Airlines Technical Operations, USA, **Periklis Papadopoulos**, San Jose State University, USA & **Mark Guerrieri**, San Jose State University, USA. *Hybrid Air Breathing Rockets and their Potential.*
- **Richard Drossler**, San Jose State University, USA. *ARCH: Asteroid Redirection and Conversion to Habitat.*
- **Jordan Pollard**, **Kyle Stewart** & **Periklis Papadopoulos**, San Jose State University, USA. *The Design and Analysis of a Nuclear Thermal Propulsion Reactor for an Altitude Compensating Nozzle.*
- **Kyle Stewart** & **Periklis Papadopoulos**, San Jose State University, USA. *System Analysis of a Nuclear Thermal Rocket Engine with a Toroidal Aerospike Nozzle.*
- **Mark Lin** & **Periklis Papadopoulos**, San Jose State University, USA. *Parallel Processing of Computational Fluid Dynamics and the Resulting Numerical Uncertainty from Load Balancing.*
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Eman Alam
Lecturer, Al-Azhar University, Egypt

Pharmaceutical Biotechnology for the Production of Some Active Phytochemicals against Tropical Diseases from Some Wild Egyptian Medicinal Plants

Higher plants are rich source of bioactive constituents or phyto-pharmaceuticals used in pharmaceutical industry. Some of the plant derived natural products include drugs such as; morphine, codeine, cocaine, quinine, anticancer Catharanthus alkaloids, belladonna alkaloids, colchicines, phytostigminine, pilocarpine, reserpine, steroids like diosgenin, digoxin and digitoxin and other important active phytochemicals against many dangerous diseases such as tropical diseases etc. Many of these pharmaceuticals are still in use today and often no useful synthetic substitutes have been found that bosses the same efficacy and pharmacological specificity. Currently one-fourth of all prescribed pharmaceuticals in industrialized countries contain compounds that are directly or indirectly, via semi-synthesis, derived from plants. Furthermore, 11% of the 252 drugs considered as basic and essential by WHO are exclusively derived from flowering plants. Plant-derived drugs in western countries also represent a huge market value. Many plants containing high value compounds are difficult to cultivate or are becoming endangered because of overharvesting. Furthermore, the chemical synthesis of plant derived compounds is often not economically feasible because of their highly complex structures and the specific stereochemical requirements of the compounds. Traditionally the medicinal plants have been grown and then active components extracted and this is likely to remain the normal procedure. However the production of medicinal plants can present problems, which have led to the search of other ways to produce naturally occurring substances: 1- Production in the field is strongly dependent on season, weather, climate, diseases and pests etc. 2- Naturally occurring sources, especially in the tropics and subtropical zones are becoming limited and some medicinal plants are extremely scarce. 3- There may be technical and economic problems in production. 4- Production is labor intensive and therefore costs are high. 5- There may be political instability in the country where the plants are available resulting in an interrupted supply. The biotechnological production of valuable secondary metabolites in plant cell or organ cultures is an attractive alternative source to the extraction of whole plant material. However, the use of plant cell or organ

cultures has only limited commercial success. This is explained by the empirical nature of selecting high-yielding, stable cultures and the lack of understanding of how secondary metabolites are synthesized or how their synthesis is regulated. Many biotechnological strategies have been hypothesized and experimented to enhance the production of secondary metabolites from medicinal plants. Some of these include screening of high yielding cell line, media modification, precursor feeding, genetic transformation, metabolic engineering, elicitation, large scale cultivation in bioreactor system, hairy root culture, micropropagation, plant cell immobilization, biotransformation and others. Organ, tissue and cell cultures and other biotechnological techniques are useful ways to obtain biologically active constituents those play an important role in our life (they have pharmaceutical, medicinal and economic importance in our life). These ways (in vitro ways) of obtaining secondary metabolites are better than the classical methods since: 1- They are natural in origin, so they are of little toxic side effects compared with synthetic drugs. 2- They are safe sources and do not cause any environmental pollution as like as those occurred by applications of pesticides and insecticides to farm lands. 3- They are performed under controlled conditions (since the yield can be increased, with increasing replicates number and by using elicitors, fomenters and bioreactors in a large application scale), they are performed under aseptic conditions (this means that, they are system free of contaminating microbes " fungi and bacteria", consequently they are clean sources of drugs). 4- Using these techniques we can direct the culture for producing the organ that contains the highest amounts of the product we need (for example, root cultures can be produced using Agrobacterium rizogenesis to obtain substances that produced in root cells only). 5- Production cycle is smaller than that of normal culture in land (it takes little time), since callus cultures with short life cycle may be a good source for production of phytochemicals needed. 6- Using these methods we can conserve our natural resources (wild plants) instead of over-collection by herbalists. 7- Finally, the cost can be decreased if done on a large scale (instead of Fedens language "large areas" we use jars in small place = higher productivity of secondary metabolites). 8- Notably, in vitro studies using tobacco shoots had become desirable for an additional and particular reason (i.e., protection of diterpenes from degradation by microorganisms, as may occur with field growth material). The eight WHO tropical diseases are transmitted to humans by various means, but always include a vector that is generally a hematophagous insect. The designation "tropical diseases" was not invented by the WHO and has been part of the

medical vocabulary since the 19th century. Egyptian deserts have many medicinal plants, such as; Peganum spp., Tribulus spp., Zygophyllum spp., Balanites spp., Fagonia spp., Nigella spp,. Artemisia spp. and many other important medicinal plants. The target of this study is to highlight the effect of some Egyptian medicinal plants against some tropical diseases and against vectors of these diseases, additionally this review article will discuss the role of the pharmaceutical biotechnology in the production of many important phytochemicals (such as: flavonoids, alkaloids, saponins and many other important phenolic compounds) from these active plants against these tropical diseases.

Dimitris Argyropoulos
Finland Distinguished Professor of Chemistry, North Carolina State University, USA

Limitations in Creating Lignin-Derived Carbon Fibers

Single component lignin-derived carbon fibers have been under development for many years, but strength properties are still inferior to those of commercial carbon fibers. The extent of graphitization is an overlooked limitation to lignin-derived carbon fiber development, particularly for high-modulus fibers treated at high temperatures. The tensile moduli of commercial carbon fibers increase with temperature during graphitization, however, lignin-derived carbon fiber moduli stay the same or decrease. This review exposes the inability of lignin-derived carbon fibers to graphitize in a manner similar to commercial carbon fibers, thereby providing rationale for the aforementioned discrepancy in tensile moduli-temperature trends and offering possible tangible future areas of research and development.

Rushikesh Badgujar
Graduate Student, San Jose State University, USA
&
Nikos J. Mourtos
Professor and Chair, Aerospace Engineering, San Jose State University, USA

X-69 CargoSat for LEO Deliveries

Traditional rocket launch and delivery systems tend to be very expensive and are subject to schedule delays. On the other hand, CubeSats have allowed in recent years CubeSats drastic reductions in payload size. This project proposes the use of a high-performance spaceplane with a sophisticated and reliable mission profile to efficiently deliver CubeSats to at least 110 km altitude. The project presents the preliminary design of the X-69, a CargoSat Spaceplane concept, with a payload capacity of 1,500 kg. The X-69 could deliver up to 24 maximum-sized CubeSats (27U) to low earth orbit (LEO).

Launching from a spaceplane at high altitude will result in an environmentally friendly (less polluting) and time efficient approach, avoiding schedule delays, which tend to be common with traditional rockets. The project presents the conceptual and preliminary design of this spaceplane, which includes weight and performance sizing, fuselage design, wing and empennage design, landing gear design, weight and balance, stability and control analysis, drag polar estimation, cost analysis, environmental impact and final specifications. Since this spaceplane has a mid-air launch system using a mothership, it requires less fuel to climb from 45,000 ft altitude where the air resistance is very low, increasing the aerodynamic efficiency of the climb phase due to the much lower drag at higher altitudes. Re-entry and adverse deceleration during descent are also examined, considering the possibility for unpowered glide.

Zoran Bojkovic
Lecturer, University of Belgrade, Serbia
&
Dragorad Milovanovic
Lecturer, University of Belgrade, Serbia

What 5G Has Been and What 5G+ Towards 6G Should Be?

This work aims to provide the scientific community with a comprehensive overview of the most challenging aspects of 5G mobile networks and present latest research on 5G+ promising techniques in 6G evolution. 5G mobile telecommunications technology meet the required ITU-R IMT-2020 standard to support an all Internet Protocol (IP) network for faster data rates, higher connection density, and much lower latency than previous generations. With the completion of the first full set of standards in the past 5 years, the initial commercial deployment of 5G mobile networks has begun with full cruising speed, nowadays. Consumers and businesses are looking to a 5G wireless connection to enable faster downlink/uplink speeds and high quality of service (QoS) that's secure and reliable in new vertical applications of Smart transportation, industrial IoT, eHealth, Smart cities. As the commercial deployment of the 5G cellular networks is well underway, academia as well as industrial research organizations turn their attention to what comes next. 6G will focusing on the gap between beyond 2020 societal and business expectation driven by new technologies considered too immature or which are outside the defined scope of 5G. We identified three kinds of 5G+ core services for enhanced performance. Mobile broad bandwidth and low latency (mBBLL) service will provide a high-quality experience (QoE) in typical applications of mobile AR/VR and holographic teleconferencing. Next, massive broad bandwidth machine type (mBBMT) service enhances 5G mobile broadband and machine communication in typical application of tactile IoT. And finally, massive low latency machine type (mLLMT) service enhances ultra-reliable and low-latency communication in typical application of large scale industrial IoT. It was adopted a gradual evolution strategy and performance enhancement mechanisms based on investment in more spectral and hardware resources. However, we would point out current research progress towards 6G with some revolutionary technologies of wireless terahertz communications and artificial intelligence (AI). The advancement of wireless communications is highly restricted by basic sciences, especially mathematics and physics. Terahertz wireless

communications is a rapidly growing and the recent significant progress anticipates the THz wireless systems realizable in the near future. AI-empowered 6G would enable the transformation from cognitive radio to intelligent radio as well as series of new features of self-aggregation, context awareness, self-configuration and opportunistic set-up. To justify our vision of future networks, we point out the need for closer connection of academia, standardizing bodies, industrial organizations and governments in demand-oriented roadmap. Research activities in 6G should not simply aim at adding more functions without considering the value of the implemented service in real-world.

Fritz W. Bopp
Professor Emeritus, University of Siegen, Germany

How to Avoid Absolute Determinism in Two Boundary Quantum Dynamics

Arguments for a two boundary theory are briefly outlined. Plausible concepts of how in such a theory an approximate causal macroscopic theory can emerge are presented. A problem with simple implementations of the two boundary theory is that effective or real willful decisions cannot be added as there is no consecutive macroscopic time ordering. In the talk, we will present a somewhat drastic but beautiful way to avoid it.

Tyler Borda
Powerplant Engineer, San Jose State University/United Airlines Technical Operations, USA
Periklis Papadopoulos
Professor, San Jose State University, USA
&
Mark Guerrieri
Aerospace Engineer, San Jose State University, USA

Hybrid Air Breathing Rockets and their Potential

Research and analysis of proposed hybrid air-breathing rocket engines will take place to make determinations about their suitability for future use as a reusable commercially viable space-grade engine for human transport. We will go in-depth and discuss its theory of operation and mechanism of action specific to the Synergetic Air-Breathing Rocket Engine or SABRE as it is more commonly referred to.

This research is uniquely interesting and of relevance given recent public funding and interest in a revival of space exploration and commercialization of the industry. The SABRE developed by Reaction Engines is of specific importance as it is at the cutting edge of development in the field to which it belongs and could provide the gateway for modern expansion in the space. The concept of a hybrid air-breathing engine has never been done before. If successful the engine would allow a more conventional take-off and transition from low speed, to hypersonic, to out of atmospheric flight, unassisted. This is achieved by having a large precooler that feeds into a small core engine for subsonic flight. Once the craft reaches a speed of Mach 5 the engine switches to a conventional ramjet system to supply thrust to the upper atmosphere. Once there is no air left to compress efficiently for combustion the engine uses rocket propulsion to escape the earth's atmosphere. The advantages are apparent; among them is a reduced infrastructure dependence and a reduced onboarding of fuel. With that being said, itis important that academics are critical of the proposed concept engine to ensure that it is a sound scientific undertaking and not a potentially wasteful dead-end bound program.

To this end, we will be reviewing published information that is readily available on concept engines of this type and their related systems. By examining the general configurations of systems in these designs we hope to definitively conclude whether they are in fact the next evolution in space capable propulsions. Consultations of experts in the field as well as in academia will also be made when and where

possible. At the conclusion of these studies, we will attempt to verify optimum compromises that were made, by calculating our own theoretical design point.

Jeffrey Busch
Senior Consultant and Adjunct Professor, Portland State University, USA
&
Ali Eljayar
Portland State University, USA

Agile-Stage-Gate Approach: Exploratory Research on the Structure, Roles, and Responsibilities

One of the more prominent methodologies gaining recognition in recent years is the Agile-Stage-Gate approach. The relatively new hybrid model is a combination of the Stage-Gate and the Agile-Scrum models. A number of companies that are using the Stage-Gate process have recently adopted the Agile-Stage-Gate approach to improve their product development and project management practices. However, each of these companies made adjustments and modifications to the new approach in order to accommodate their specialized needs and to achieve the goals that are unique to their company. Therefore, no fixed structure or standardized features have been explicitly assigned to this hybrid approach. Instead, each company incorporated different features and manipulated the new approach to fit whatever needs that would arise from moment to moment along the way. This ambiguity leads to the question of whether the structure, roles, and responsibilities of this new approach can be defined and if so, how clear and consistent definitions could improve productivity, efficiency, communication and market response time. The purpose of this study was to explore the structure, roles, and responsibilities within this new approach and to identify patterns that emerge during the product development and project management processes. The research questions presented were administered and examined through a qualitative survey. Fifty-two complete responses were collected from experienced individuals who have varying degrees of experience with the Agile-Stage-Gate approach. These findings revealed many similarities and differences between the structure, roles, and responsibilities of this approach, many of which were also dependent on the product and project type being considered. The most apparent similarities between roles and responsibilities were found in the combined software development with the new product development projects. The findings support most of the research outcomes as outlined in the literature review. The study also revealed that the hybrid approach can also improve the management of stand-alone product development projects as well,

which is a very promising result for manufacturing firms that are willing to adopt this hybrid approach for their projects. Along with the significant and undeniable impact on team communication and performance, the Agile-Stage-Gate approach was shown to improve overall quality and productivity. Another important finding from this study is the significant benefit of the Agile-Scrum model that was not limited to a specific stage of typical product development life-cycles. Rather, manufacturing firms indicated that they can apply this integrated approach throughout all life-cycle stages within the Stage-Gate model. This research provides strong evidence that the hybrid approach is a promising model when it comes to managing in a combined manner, technology and new product development projects.

Priya Chouhan
Aerospace Engineer, San Jose State University, USA
&
Nikos J. Mourtos
Professor and Chair, Aerospace Engineering, San Jose State University, USA

The Conceptual Design of a General Aviation Electric Aircraft

Financial and environmental considerations continue to encourage aircraft manufacturers to consider alternate forms of aircraft propulsion. On the financial end, it is the continued rise in aviation fuel prices, as a result of an increasing demand for air travel, on one hand, and the depletion of fossil fuel resources, on the other. On the environmental end, it is concerns related to air pollution and global warming. New aircraft designs are being proposed using electrical or hybrid propulsion systems, as a way of tackling both the financial and environmental challenges associated with the continued use of fossil fuels.

While battery capabilities are evolving rapidly, the current state-of-the-art offers an energy density of ~ 250 Wh/kg. This is sufficient to power a small, general aviation electric airplane with a modest range no more than 200 km. This paper explores the possibility of a medium range (~ 800 km) electric, four-seat, FAR-23 certifiable general aviation aircraft, assuming an energy density of 1,500 Wh/kg, projected to be available in 2025. It presents the conceptual and preliminary design of such an aircraft, which includes weight and performance sizing, fuselage design, wing and high-lift system design, empennage design, landing gear design, weight and balance, stability and control analysis, drag polar estimation, cost analysis, environmental impact and final specifications. The results indicate that such an aircraft is indeed feasible, promising greener general aviation fleets around the world.

Nicolae Diga
Postdoctoral Researcher Engineer, Politehnica University of Bucharest, Romania
Valentin Navrapescu
Professor, Politehnica University of Bucharest, Romania
Silvia-Maria Diga
Professor, Politehnica University of Bucharest, Romania
&
Camelia Dina
EBU Technical Services Engineer, INAS S.A., Romania

Use of Modern Software Supports Specialized in Designing Induction Motors with Special Destinations

In this paper, the authors propose to approach the design of three-phase induction motors with special destinations, using the modern specialized software supports. In this respect, by creating and exemplifying clear procedures for defining and simulating the generic model of a three-phase induction motor with squirrel-cage rotor, it is possible to respond quickly to the demands of the beneficiaries and to provide them optimal constructive variants. In this study, the software support "ANSYS Electronics Desktop" was used for the modelling and simulation from the electromagnetic point of view of an induction motor with a squirrel-cage rotor of 6 kV medium voltage having the rated power 225 kW, intended for the electrical pumping systems. The motors of this type drive mineral oil pumps for starting boilers or heavy fuel oil transfer pumps, within the own services of a thermoelectric power station. Thus, it was used for the analysis of the studied motor, the product ANSYS RMxprt Design which is an additional software tool to the ANSYS Maxwell Design solution, dedicated to electric machines designers. The software generates as interfaces, the simulation results of the analysis performed on the studied motor (performances, complete detailed design data, curves). The performances of the studied motor will constitute the input data for the subsequent analysis of the electromagnetic field performed by the finite element method. The simulation is performed both in operating regime at rated load and no load, starting, running with blocked rotor, the software also providing the consumption of materials necessary for motor construction. The software generates a custom file with the design data of the analyzed three-phase induction drive motor, which contains: general data; stator data; rotor data; consumption of materials; operation at rated load; operation no load; starting; operation with

blocked rotor; detailed data when operating at rated load; the arrangement of the windings. With the help of this software product, the performances of the machine were calculated at different load levels in the domain (0.25 … 1.25)·PN. Due to the facilities offered by the "Optimetrics" module of the software product used, a number of technical characteristics could be compared, such as the variation as a function of speed of: efficiency, $\eta = f(n)$; power factor, $\cos\varphi = f(n)$; developed (useful) output power, $P2 = f(n)$; the developed couple, $M = f(n)$; the supply current from the stator winding, $I = f(n)$, etc. Thus recommendations could be made regarding the adoption of solutions to ensure the efficient operation of this motor in terms of loading regime.

Richard Drossler
MSAE Program Graduate, San Jose State University, USA

ARCH: Asteroid Redirection and Conversion to Habitat

This project provides a systematic approach to convert near-earth asteroids into habitats that transit between Earth and Mars. Payloads can rendezvous and depart the asteroid habitat ships, named ARCH (Asteroid Redirection and Conversion to Habitat), when they are nearby the planet of interest, and then transit in a ship whose scale would be impossible to launch from Earth.

This project begins with the selection of a cycler orbit for sustained transits between Earth and Mars. A method of nuclear thermal propulsion (NTP) is proposed to redirect the asteroid, which has an I_{sp} of 1147 seconds, and produces 1550 kN of thrust. A reference asteroid, 101955 Bennu, was chosen as a benchmark for modeling. Using this model and the NTP system, the characteristics of a range of asteroids 0.4-3 km in diameter (D_{ast}) and the corresponding ARCH are studied. A range of ΔV redirections from 2-25 km/s were investigated, showing ΔV maneuvers up to 7.8 km/s can be made using 50% of the asteroid mass as propellant.

Parametric studies of the ARCH habitat were carried out for D_{ast} and ΔV. These studies found that the population capacity ranges 4000-200,000 people in 93-6750 habitat acres. ARCH structural requirements are generally feasible, where a Bennu sized ARCH requires 10-18 MPa tensile strength throughout the shell structure. The ARCH shell will be constructed robotically using techniques such as sintering, additive manufacturing and assembly of digital materials. As with the propellant, these structural materials will come from in-situ resources.

Studies of the mining, processing, and availability of in-situ resources showed that cutting edge technologies will need to be developed to build ARCH systems. The best mining method is the use of Nd fiber lasers, which could extract the mass of Bennu in 1.5 months. The NTP reactors supply sufficient power for the ARCH system requirements. The processing systems to convert the asteroid regolith into usable material is the key technological hurdle. Extracting the volatiles of Bennu with microwave technologies requires 87 years, while refining the metals with molten regolith electrolysis would take over 13,000 years.

To increase the concentrations of volatile elements, off-loading and exporting half of the mineral mass of the ARCH candidate prior to redirection can significantly improve ΔV capabilities. One of the most

striking results is with the astronomical economic value of this exported ARCH asteroid material. Depending on D_{ast}, the mineral value is US$500 trillion-US$21,000 trillion for the ARCH asteroids and a "modest" US$365 trillion for Bennu.

The ARCH mission is a catalyst for invention and innovation, and a platform for human experimentation in the third millennium. The ARCH system can drive future research into numerous facets of its systems and subsystems. Most importantly, the ARCH platform can act as a foundation to weave together and build an interplanetary economy and society.

Dimitrios Goulias
Associate Professor, Director of Undergraduate Programs, Civil and Environmental Engineering Department, University of Maryland, USA

Engineering Education & Research Activities in the Global World & Covid-19

This presentation covered the engineering research and teaching activities in the global world and how are affected from Covid-19. Specifically, the transition and plans for either transitioning from person to person to online activities has been covered, as well as how a blended approach combining the two can be addressed. In this process innovative learning pedagogy alternatives were covered. Education abroad and international research cooperations were discussed from past, ongoing and future initiatives.

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Retropropulsion and GNC Strategies for Landing Scalable Payloads

This publication will demonstrate the design and application of technologies for touchdown landing systems. Guidance, navigation, and control strategies for landing scalable payloads will be presented. The primary subsystems include but are not limited to electrical, structural, mechanical, GNC, and propulsion. This publication will also demonstrate the feasibility of low-cost manufacturing methods. Primary points of the system our control optimization techniques with PID controllers and state feedback methods, the mechanical design of a gimbaled rocket motor, computer system integration with a Raspberry Pi 3B+. The secondary purpose is low-cost manufacturing utilizing 3D printing methods for landing technologies.

The electrical subsystem consists of one lithium-ion battery connected via USB-A to micro USB. The power available from the battery meets the system requirements of amperage and voltage for 30 minutes of continuous operation, exceeding the requirement with over a 30% margin. The batteries are compact, easily packaged, and are COTS technology.

The main structure consists of a three-inch diameter cylinder with roll stabilization fins and landing gear, that houses the avionics bay, gimbal, and servos. The retropropulsion motor is positioned below the avionics package. The avionics subsystem was designed to house the flight computer, battery, and navigation sensors while maintaining nearly zero radial center of gravity offset. Midbody fins are positioned at the center of gravity for roll control only, while pitch and yaw are controlled with gimbaled thrust. A mounting ring is strapped onto the

cylindrical airframe at the bottom where the landing gear will be attached. The landing gear is designed with struts to withstand landing forces of approximately 3.655 N. All of the components previously mentioned were 3D printed to reduce cost and improve iterability.

The mechanical subsystem consists of the gimbal and its two servo motor actuators. The 3D printable design of the gimbal was bought from BPS space to simplify the implementation of this technology into this touchdown system. The servo motors were chosen to fit inside the gimbal and withstand the maximum thrust force produced by the motor which is approximately 28 N.

The GNC subsystem is geared towards creating a landing system out of a standard rocket, utilizing a Raspberry Pi 3B+ as a flight computer. Navigation sensors detect rocket orientation, angular rates, and linear acceleration values. These two together create usable values for a control system to gimbal the thrust vector to correct the attitude of the rocket. The equations of motion were derived with Euler's equations and Kane's Method and are inherently nonlinear. A linearized and a nonlinear state-space system have been made to determine the more feasible of the two as a maximized control strategy. Note, guidance of any kind has been removed from these control strategies to avoid any legality issues. These strategies merely control the rocket's orientation which is fixed in the vertical.

The motor selected is an F-10 motor that has a burn time of 7.02 seconds and a maximum thrust value of 28 N. This motor was selected because of its degrading thrust curve and long burn time. The curve simulates throttleable retropropulsion required for landing a payload. The plateau in the curve is marginally lower than the weight which makes the rocket descend and eventually land with minimal velocity, approximately 4.214 m/s towards the ground. The long burn time is required for launch and landing within the same flight envelope and a full control system validation.

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Using Data Analytics to Improve Government Financial Efficiency

The goal of improving cost efficiencies is a constant endeavor of all organizations. This is especially true for governments, where public perception often has the ability to effect budget allocations. This paper explores the budget expenditures of the state of Idaho in the United States using data analytic techniques and suggests areas where improvements could be possible. Visualizations will be used extensively throughout the paper to illustrate results.

The data used in this analysis consisted of publicly available state expenditures from 2018 and 2019. The dataset contains over 2 million state expenditures across all state agencies. Analysis was performed using Python and the pandas library. Visualizations were created using the matplotlib and seaborn packages. The data exploration showed that Idaho's Departments of Health and Welfare, Education, and Transportation spent the most in this time period, with Health and Welfare spending the most by a large margin. This is of interest as health costs and insurance premiums have dramatically increased over the last 5 years and the future of this industry is uncertain. Changes in the year-to-year expenditures of the individual state agencies and vendors were investigated. In the area of health care, it was found that nearly all health districts in Idaho experienced a 3% average increase between 2018 and 2019. Assuming inflation cost on health care to be

between 1 and 2 percent, it appears the cost of state expenditures in health increased close to 1% above inflation. Analysis of Idaho's transportation costs shows that the state spent 40% of its transportation budget on out-of-state travel, with out-of-state lodging costing 88% more than in-state lodging and flight expenses costing nearly 34% more vs. in-state travel. Other areas of interest explored included university expenditures, corrections spending and computer technology expenses.

Data on Idaho's spending in education, health and transportation was compared to publicly available records for the states of Iowa, California, Arkansas and Texas to see how Idaho compares to other states. Initial analysis has shown that on a per capita basis, the state of Idaho spent significantly less on healthcare services than the states of Iowa and California, while spending more on education than Iowa, but less than California. In the area of transportation, Idaho's per capita spending is in line with both states. On a percentage basis, the initial analysis shows that Idaho has spent a larger portion of its budget on correction services than the state of Arkansas, and close to 30% more of its budget on transportation when compared to the state of Texas. Health care costs between Idaho and Arkansas are similar, with each state spending approximately 29% of its budget on health services. In education services, Idaho spent significantly less than both Texas and Arkansas. The analysis shows that Idaho spent less than 7% of its budget on education, while Arkansas and Texas spent 35% and 15%, respectively.

Cost efficiency in the area of transportation may be improved by increasing the use of video conferencing technology, providing incentives for workers to reduce travel expenses, capping personal vehicle reimbursement and considering contracts for out-of-state travel. Possible areas for improved efficiencies in health expenses include more accountability controls for redacted agents and the implementation of cost transparency standards for state approved providers. The analysis of Idaho's expenditures, as well as the comparison between Idaho and other state budgets, allows for areas of potential improvement or waste to be identified. The ability to do this effectively with free tools, such as pandas, could entice local governments to expand their data science and analytic capabilities, as the benefits could save potentially millions of tax dollars.

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The Integration of STEAM Facing New Paradigms in Material Selection, Manufacturing Processes and Design (SMPF&D)

The integration of STEAM domains (science, technology, engineering, arts and mathematics) is not an easy task, but it allows for greater stakeholder engagement, improved creativity, opportunities for innovation and tools for problem-solving and provides cognitive benefits for a holistic view of the situation. The ability to link these thematic areas and the sharing of these areas of knowledge allows for an improvement in teamwork skills, an incentive for critical thinking, a stimulation of interpersonal communication and adaptability (fundamental characteristics in the industry 4.0). It should also be noted that the union of these abilities illuminates the field of abstract thought, allows spatial resolution, openness to new ideas, experiences and new curiosities. The actions promoted by the STEAM concept give ideas a boost, stimulate risk taking and learn from mistakes. Experimentation of materials and manufacturing processes are mandatory in proposing new engineering ideas, as they carry the materiality of the product and / or system and thus the formal expression of the designer responsible for the project. Following the justification and relevance of this proposal, it is noteworthy that the interdependence between human and materials and process has made these incorporated into human culture becoming "substance of action" of civilizations over time. Just remember that the various ages through which man has gone through are characterized by the degree of development and utilization of materials and process: stone age (chipped and polished), bronze age, iron age; nowadays maybe we could say polymer age, composite age, multi-material age… What is certain is that knowledge of manufacturing processes and materials are almost always indispensable to materialize a conceptual project. In this sense, examples of integration between materials and manufacturing techniques notably in 3D printing and laser engraving and cutting will be presented and their relevance to materialize STEAM projects will be shown. The importance of STEAM concepts about personalization and industry 4.0 will also be discussed: can the STEAM approach be used in

the future to better answer the issue of personalized product demand? Can it give new paradigms to better answer some 4.0 issues? Given this scenario it can be concluded that STEAM theme combines transdisciplinary, interdisciplinarity, multidisciplinary and even cross-cutting disciplines and is with an Integration of science, technology, engineering, arts and mathematics facing new paradigms in material selection, manufacturing processes and design that we can move forward in new challenges of design research and industrial engineering in the coming days.

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Parallel Processing of Computational Fluid Dynamics and the Resulting Numerical Uncertainty from Load Balancing

Computational methods such as CFD traditionally have yielded a single output – a single number that is much like the result one would get if one were to perform an analytical hand calculation. However, this paper will attempt to show that computation methods create inherent uncertainty which should be reported as a data range along with a single mean value. In numerical computation, because many factors may affect the data collected, the data should be quoted in terms of standard deviations along with the average value to make data comparison meaningful. In cases where the difference in two data sets' average value is obscured by the uncertainty (error bars), then the two data sets are said to be indistinguishable. Similar analogy can be applied to computational methods. This will allow a meaningful comparison of datasets where the difference is small but is proven by physics.

A sample CFD problem pertaining to automotive aerodynamics is duplicated and computed on 29 identical computers in a university computer lab. The same problem was ran with the same setup so there was no perceivable difference from the user's standpoint. The expectation was that all 29 runs should return exactly the same result; unfortunately, while the difference was small the results were not the same. This is attributed to the parallelization scheme which partitioned the mesh to run in-parallel on multiple cores of the computer. The distribution of the computational load is hardware-driven and it depends on the available resource of each computer at the time. Things such as load-balancing among multicores using Message Passing Interface (MPI) is transparent to the user. Software algorithm such as METIS or JOSTLE is used to automatically divide up the load between different processor. As such, the user has no control over the outcome of the CFD calculation even when the same problem is computed repeatedly. Because of this, numerical uncertainty would arise from parallel multicore computation. One way to resolve this is to compute problems using a single core, without mesh repartitioning, which would take much longer than parallel computation; a more practical

way to deal with the numerical uncertainty that arises from parallel computation is to assign an error range to the final result to indicate the level of certainty. This way, minor differences from CFD output would not be interpreted as physical phenomenon but rather as apparitions of load-balancing among different cores. This method of representing CFD results with a mean value and a standard deviation, drawing an analogy to physical phenomena, is illustrated with example.

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Embedded Newtonian Stability Analysis of Flared Reentry Probes

The design process for aerospace vehicles is a lengthy, complicated process. This paper seeks to streamline one such aspect – stability-based design – through the usage of a MATLAB interface built upon an analytical approach to unsteady flow dynamics. This study will explore the creation of this interface as well as outline the direction and scope of future development capabilities.

In order to fully model the stability characteristics of a hypersonic aerospace vehicle, complex computer-aided simulations are required. An analytical model can serve to reduce some of this complexity; this is accomplished through the utilization of an embedded, unsteady modification of Newtonian theory, in which segment contributions are considered on a piece-by-piece basis. The interface takes a user generated profile in conjunction with desired flow data and then calculates the resulting stability profile (for static and dynamic modes) in rapid fashion, allowing for ease of prototype modification. Current iterations of the tool are restricted to axisymmetric body profiles – its key advantages lie in its simplicity and piecewise structure. This allows for a somewhat more complex body to be broken down into smaller, simplified components, while still maintaining the ability to quickly determine full-profile stability properties. In addition, the tool can be adapted to work in tandem with CFD studies, thereby allowing for a higher-fidelity stability analysis of more complex body profiles.

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Experiential and Interactive Learning: A New Approach

Experiential and Interactive learning motivates students to grasp the concept and gain knowledge in the subject. It also helps them to use their skill for innovative outcomes. Experiential and Interactive based learning is an interesting concept and is in practice at several institutions. How much these activities influence learning is always met with varying opinions. We try to reform engineering education by moving away from the boundaries of traditional classroom based methods to project-based, concept-based, team-based, skill- and knowledge-integrated approaches using real world situations.

In my presentation, we will show innovative experiential learning approaches and their outcomes.

I will present the results of two experiential teaching techniques in two different locations; one is at the regular university environment and the other is at the high tech company's environment.

This includes sample students papers and projects published at peer-reviewed proceedings, and several learning activities used as part of the experiential education. This presentation will be beneficial to other educators to style their own experiential learning approaches.

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Phase and Morphology Control of Organic-Inorganic Hybrid Network Polymer by Means of Hydrosilylation Reaction of Cubic Silsesquioxane or Cyclic Siloxane and Divinyl or Diallyl Compounds

We reported synthesis of organic-inorganic hybrid gels by hydrosilylation reaction of cyclic siloxane compound or cage silsesquioxane compound, as a joint monomer, and α,ω-nonconjugated diene, as a linker monomer, using a Pt catalyst. The reactions successfully yielded transparent gels, and their mesh size measured by a scanning microscope light scattering device ranged from about 1 to 2 nm. We have controlled the affinity between the network structure and the organic solvent of the organic-inorganic hybrid gels, and found out some reaction systems, which can form porous polymers. In the present examination, mixed solvents of toluene and methanol (and acetone) were used to control solubility parameter (SP) of the solvents. Toluene is a good solvent, and methanol and acetone are poor solvents for the siloxane compound. In the process of forming a network structure by hydrosilylation, it is expected that a porous polymer will be formed when polymerization induce phase separation occurs via spinodal decomposition in the mixed solvents. We selected 1,3,5,7,9,11,13,15-octakis(dimethyl- -silyloxy)pentacyclo[9,5,1,1,1,1] octasilsesquioxane (POSS), or 2,4,6,8-tetramethylcyclotetrasiloxane (TMCTS), as the joint molecules, and 1,5-hexadiene, divinyl or diallylsilane compounds, as the linker monomer. In this report, effect of the reaction conditions, SP values of the solvent, molecular structure of the joint and linker monomers, and monomer concentration on the production state and morphology of the porous polymers was precisely studied. In the case of the reaction of POSS and HD, the production state changed from transparent gel to porous polymer by increasing the SP value using a mixed solvent of toluene and methanol. The monomer concentration in POSS-HD reaction system affected the morphology of the porous polymer, and changed from the particle linked structure to the particle linked structure with increasing of the monomer concentration, at the boundary of 10 wt%. The monomer concentration may influence the structure in the phase separation via spinodal decomposition and the subsequent immobilization. In the reaction systems using divinylsilane compounds, the difference in the side chain structure, methyl group or phenyl group, affected the porous structure of the polymer produced.

The reaction using divinyldiphenylsilane formed globules connected structure independent of the monomer concentrations, whereas the reaction using divinyldimethylsilane resulted porous polymer formed by small fine particles.

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Image Processing Techniques for Crack Detection in Aerospace Structures

The safety and structural integrity of aeronautical structures depends on the ability to detect cracks and defects (i.e., dents) in the structure before operation. After WWII, several accidents have occurred because of the inability to detect cracks in the fuselage of airplanes. Each pilot is generally expected to perform a walk-through of a vehicle before every departure, and maintenance crews periodically inspect the structure looking for cracks that might be growing to unsafe sizes. Still, cracks have gone undetected in the past. The aeronautical space is changing dramatically, and the vision for the city of the future is embedded in the Urban Air Mobility concept, in which fleets of autonomous air taxis will pick up and drop off passengers with no crews. With autonomy being the goal, structural inspections will also need to become as autonomous as possible, without compromising passengers' safety. The ability to autonomously detect cracks would therefore add a safety layer to maintain the structural integrity of aircrafts, which are nowadays made of metal (mainly aluminum alloys) and composite materials. Our goal is to embed crack detection algorithms using Unmanned Aerial Vehicle (UAV) to inspect airplane structures. Specifically, this paper investigates the use of image processing techniques to autonomously detect cracks and defects in metal and composite structures. A crack detection algorithm is generally divided in two parts: an initial preprocessing stage in which the image is analyzed to highlight the pixels at which a crack/defect occurs, and a detection stage in which the crack/defect is automatically detected and its features are extracted (i.e., depth, width, location). This paper will focus on the preprocessing stage of the algorithm, during which the crack is highlighted and enhanced to facilitate computer recognition. Several image processing techniques will be presented and compared. Algorithms such as edge detection algorithms, bottom hat transfers, thresholding techniques and their combinations will be compared starting from a grayscale transformation of the image with the crack/defect. Promising techniques will also be explored based on an HSV representation and filtering of the original image. It is expected

that this analysis will facilitate the maintenance procedure of aerospace fleets, saving time, lives and costs.

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Low Temperature EPR and Magnetic Susceptibility Studies of Cerium Nitrate-Triphenylphosphine Oxide and Cerium Vanadate Complexes

Phosphine oxide and orthovanadate complexes of rare earth ions have many potential technological applications in a wide array of fields, especially in materials physics, chemistry and biomedical engineering. Many of these applications are due to the unique magnetic properties of these complexes. The present work is focused on electron paramagnetic resonance (EPR) and magnetic susceptibility experiments we carried out on phosphine oxide and orthovanadate complexes of the rare earth ion Ce (III). Low temperature EPR measurements of Ce (III) doped in a La (III) nitrate complex with triphenylphosphine oxide and Ce (III) doped in La (III) vanadate have been carried out in order to gain a better understanding of the electronic properties of Ce in these compounds. The complexes Ce:La(NO3)3(Ph3PO)4(Me2CO) (1) and Ce:La(NO3)3(Ph3PO)2(EtOH) (2) have been synthesized using established methods such as the reaction of Ce/La nitrate hexahydrate and triphenylphosphine oxide in acetone (1) or ethanol (2) in air. Ce:LaVO4 solutions were prepared by reacting Ce/La nitrate hexahydrate (Ce/La(NO3)3·6H2O) and sodium orthovanadate (Na3VO4) in an aqueous environment. Single crystals of these complexes were grown under a variety of conditions to ensure that the crystals were free of defects and inclusions. X-band EPR spectra of the crystals were collected at liquid helium temperatures to allow the determination of the order and energy separation of the three Kramers doublets $|J=5/2; Jz=\pm 1/2\rangle$, $|J=5/2; Jz=\pm 3/2\rangle$ and $|J=5/2; Jz=\pm 5/2\rangle$ in the 2F5/2 ground state manifold of Ce (III). The information from EPR experiments, along with AC magnetic susceptibility measurements, will allow us to better understand how the crystal field influences the magnetic properties of these crystals. The EPR spectra and magnetic susceptibility measurements as well as the crystal synthesis techniques will be presented along with some potential applications of these interesting complexes.

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The Challenges of Lab Teaching during the COVID 19 Pandemic

The COVID 19 pandemic emergency has imposed social distancing conditions that are depriving introductory natural sciences lab students of some of their learning experience. Available software does not address the entire spectrum of skills typically involved in inquiry-based, lab tasks.

However related educational research on student performance in such skills can inform lab instruction, even under these challenging conditions which don't allow students to meet in person and collect their own data. Labs can be modified to focus more on student planning and analytical skills by using provided lab data. This presentation discusses some of these research-based approaches. Most importantly teachers can make these changes by implementing desired lab modifications according to class level and abilities, so that students may fully benefit by their remote lab learning experience.

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The Design and Analysis of a Nuclear Thermal Propulsion Reactor for an Altitude Compensating Nozzle

The following research consists of the system design and analysis of a nuclear thermal propulsion reactor system. The reactor system is of a design explicitly for the use with an altitude compensating nozzle. The research consists of four sections, which will include, Advantages of The New Reactor System, System and Sub-system Design, Analysis through Computational Fluid Dynamics, and Conclusion of The Design and Analysis. The second section will consist of a systems engineering design approach to the reactor. At a moderate resolution level, the new reactor system consists of three primary systems, followed by five sub-primary systems. The primary systems and their sub-systems will be the focus of the design and systems engineering analysis. The Analysis through Computational Fluid Dynamics, section three, will mainly focus on the performance of the propellant interacting with the newly designed reactor system. The Computational Fluid Dynamic results will allow for a greater understanding of the behaviors of the exhausting propellant that may occur when interacting with an altitude compensating nozzle system. The knowledge and understanding gained from the research will aid in the coupling of a nuclear thermal propulsion reactor system with an altitude compensating nozzle system. Thus, the results may further enable humankind to explore their closest celestial neighbors and beyond.

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Conceptual Design of Astrobee Surface Sampling Payload

With the goals of sending humans to the moon and beyond by 2024 in order, the need for advanced research on long-term space flight travel is more urgent than ever. In order for humans to participate in long-duration interplanetary spaceflight, it's necessary to study the development and growth of microbiomes in manned spacecraft. This is going to be especially important in the future application of the NASA Lunar Gateway for the Artemis program; in essence, a smaller scale spacecraft akin to the ISS in which microbial monitoring will be paramount for astronaut health. Monitoring the microbiome of the International Space Station (ISS) is already a goal of National Aeronautics and Space Administration (NASA), and is achieved via the Microbial Tracking-2 Series (MT2).

MT2 is a data collection initiative on microbes in space, consisting of air samples, surface samples of ISS interior walls, and biological samples from the crew themselves [1]. This allows microbiologists on the ground to then study samples sent back to study the nature of pathogen growth on the ISS, as well as monitor astronaut health by tracking which microbes they're commonly exposed to. The study also has applications in studying comparisons between the space microbiome in closed systems and microbiomes present on Earth.

While sampling is tasked to astronauts to complete every 90-120 days, there are several challenges present that hinder consistent or ideal sample collection [3]. Samples are often mislabeled, damaged or simply lost, and the time expenditure for astronauts can better be used for research or more pressing tasks. This is where Astrobee comes in. Astrobee is a robotic free-flyer on the ISS designed to complete

automated tasks to save astronauts valuable working time on other projects or research [2].

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Unique Nanostripes and Sheets of 2D Atomic Materials Obtained by Substrates Rubbing Technology

2D atomic material unique nanostripes and sheets are obtained by substrates rubbing technology suggested by us. The substrates rubbing technology of making 2D atomic materials (atomic nanostripes, films, structures and devices) comprises putting pristine bulk (graphite, hexagonal boron nitride, molybdenum disulfide, etc.) layered material between two solid state (i.e. inorganic) substrates and rubbing the substrates against each other manually or mechanically in any direction, so that the crystalline powder uniformly spreads between them and covers the surfaces of two substrates with it. After a few circular rubbings of the powder with two substrates mono- and few layer nanostripes appear on the surfaces of both substrates. This technology for mass production of high quality and large-size mono- and few layer 2D materials has advantages over the similar technologies:

a) simple (one step), can be obtained even by hand, without using complicated nanotechnology equipment, hazardous toxic chemicals and high temperatures,
b) short-lasting (lasts a few tens of seconds),
c) cost-efficient (a few times, as no complicated nanotechnology equipment, hazardous toxic chemicals and high temperatures needed),
d) highly productive (production yield is almost 100% and production rate is a few tens of tons/year),
e) ecologically clean,
f) controllable,
g) universal and unique (any 2D material can be obtained by rubbing technology).

The substrates rubbed nanostripes are mono-, few- and multiple atomic layers of exfoliated flakes organized in self-assembled narrow bands of nano-sized quantum dots, which are reported for the first time. The nanostripes consist of arrays of quantum dots, while sheets consist of nanostripes, and 2D atomic devices consist of sheets with nanostripes. 2D material nanostripes are obtained by rubbing graphite or other layered bulk materials on dielectric, semiconducting and metallic substrates at atmospheric pressure conditions. The size, shape and density-controlled nanostripes, embedded in different devices, as well as other factors greatly affect the device performance.

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Design of a Two-Seater, Electric Air Taxi

Traffic congestion is now a major problem in every big city in the world. The problem is twofold: first, the loss of productivity and second and more important, the environmental impact associated with traffic gridlock endured on a daily basis. Sky taxis offer a very attractive solution to both of these problems as they promise a quick, efficient way to move people form point to point in large metropolitan areas and beyond. While the idea of air taxis is not new, earlier proposals featured noisy, polluting, conventional gas-powered engines, which would exacerbate current environmental concerns. This paper proposes a small electric sky taxi, which addresses not only the point-to-point efficiency but also the environmental concerns associated with the continued use of fossil fuels.

This paper explores the possibility of a medium range (750 km) electric, two-seat, air taxi, with a cruise altitude of 1.5 km. A battery energy density of 1,000 Wh/kg is assumed, which is projected to be available in 2025. The paper presents the conceptual and preliminary design of such an aircraft, which includes weight and performance sizing, fuselage design, wing and high-lift system design, empennage design, landing gear design, weight and balance, stability and control analysis, drag polar estimation, cost analysis, environmental impact and final specifications. The paper also examines the certification challenge of air taxis and their pilots, as the familiar rules of general aviation will not work well in and around large metropolitan areas, which present new hazards and challenges. The results indicate that small air taxis, like the one proposed in this project, may indeed be feasible in the near future, promising a more efficient and environmentally friendly way of moving people in large metropolitan areas.

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System Analysis of a Nuclear Thermal Rocket Engine with a Toroidal Aerospike Nozzle

The following research is on the system analysis needed for the coupling of a nuclear thermal rocket engine with a toroidal aerospike nozzle. The research consists of five main sections. The first being the establishment of the configuration of the new engine and the primary systems. The forming of a mission profile will follow to set the benchmarks of the new engine configuration as a complete system. The remaining sections will be the analysis of the systems and sub-systems of the new propulsion system. The analysis of the systems will allow for the establishment of a proof of concept for the overall design.

The coupling of the nuclear thermal rocket engine with the aerospike nozzle forms a system that is known as the Nuclear Thermal Propulsion System. Because of the uniqueness of this kind of Nuclear Thermal Propulsion System, the traditional configuration of the nuclear thermal rocket design had to be abandoned. This abandonment is due to the need for cooling of the cowling and spike of the nozzle. The redesigned nuclear thermal rocket engine is known as The Annulus Engine, which is in reference to the shape of the nuclear core, which is fashioned into a ring shape to allow for the inner coolant to pass through to cool the spike. This innovative design of the core will also allow for the redesign of the propellant feed system along with the integration of the propellant preheating with the regenerative coolant system. These redesigns and innovations have allowed for the potential for a concise high-thrust and high-efficiency Nuclear Thermal Propulsion System.

The reason for concern is that modern high thrust rocket engines all use the same two fundamental principles. The first being is that the engines use combustion as a means to add energy into the fluids contained in the plenum. The second principle is letting the highly energetic fluid to escape through an expanding bell-shaped nozzle in order to create thrust. These two fundamental principles of modern high thrust engines have reached their maximum theoretical potential. The technological plateau is due to the unwavering use of these two principles. Therefore, to overcome this plateau, a reassessment of these

principles must take place. In the reassessment of these principles, a fundamental parameter of rocket engines begins to show that it is critical in the surpassing of this current technological plateau. The critical parameter is specific impulse, more specifically a high specific impulse while maintaining high thrust. Therefore, with specific impulse being directly related to the molecular weight of the combusted exhausting fluid and indirectly related to the thrust optimization. Thus, affirming that molecular weight and thrust optimization are two of the limiting factors in achieving a high specific impulse while preserving high thrust. The proposed Nuclear Thermal Propulsion System has the potential for producing a high specific impulse while still being able to produce high thrust. Thus, the intended Nuclear Thermal Propulsion System would allow humanity to lift more and go further into space than ever before.

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Risk Identification and Qualitative Risk Assessment of Air Taxi Operations for Large Scale Urban Air Mobility

Urban Air Mobility (UAM) is a developing concept in the aviation industry that promises to deliver safe, efficient, and accessible on-demand air transportation within a metropolitan area. In this paper, we identify and assess the challenges and risks involved with this new, large-scale air transportation system. An on-demand air service, similar to ground on-demand transportation services, requires matching the customer location to the closest takeoff and landing area (TOLA) where they can travel in their reserved aircraft. Requirements for TOLA locations are that they need to be widespread and easily accessible within the metropolitan area, thus allowing the customer to onboard and offboard close to their destination. This novel concept requires creative air vehicle solutions to be developed for this unique mission profile, characterized by short/vertical takeoff and landing, short/medium-range cruise depending on the size of the metropolitan area, and small/medium payloads. The flexibility in mission design required by this novel concept can be achieved using electric air vehicles that will transport the customers to and from TOLAs, due to the recent advancements in battery technology and distributed electric propulsion (DEP). DEP allows more freedom in aircraft configuration design and can be used to accommodate a wider range of mission types. In particular, vertical takeoff and lift (VTOL), short takeoff and lift (STOL), and conventional takeoff and lift (CTOL) concepts are being explored in industry. The risk analysis of this on-demand air transportation system will begin by identifying and defining the risks involved with pre-flight, transportation, and post-flight phases of each mission for each type of aircraft configuration. It is crucial to identify and assess the impact of each challenge and prioritize risk mitigation planning, implementation, and progress monitoring early on to ensure that the issues that can hinder the successful implementation of a large-scale urban air mobility network are addressed. This paper will focus on identifying the risks that will have the greatest impact on air taxi operations. Then a risk assessment will be completed to identify the risks that are most critical to large scale urban air mobility projects

using air taxis. This assessment will take into account the probability and consequences of previously identified risk events. The final step of prioritizing the most critical risks will reveal what issues need more immediate attention.

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The Design of a Medium-Range, Hybrid Business Jet

Financial and environmental considerations continue to encourage aircraft manufacturers to consider alternate forms of aircraft propulsion. On the financial end, it is the continued rise in aviation fuel prices, as a result of an increasing demand for air travel, on one hand, and the depletion of fossil fuel resources, on the other. On the environmental end, it is concerns related to air pollution and global warming. New aircraft designs are being proposed using electrical or hybrid propulsion systems, as a way of tackling both the financial and environmental challenges associated with the continued use of fossil fuels.

While battery capabilities are evolving rapidly, the current state-of-the-art is only sufficient to power small, general aviation electric airplanes with minimal payload capacity and a modest range. For larger aircraft, a hybrid propulsion system is necessary. This paper explores the possibility of a medium range (7,000 km) hybrid-electric business jet. It presents the conceptual and preliminary design of such an aircraft, which includes weight and performance sizing, fuselage design, wing and high-lift system design, empennage design, landing gear design, weight and balance, stability and control analysis, drag polar estimation, cost analysis, environmental impact and final specifications. The results indicate that such an aircraft may indeed be feasible in 2030, promising a greener form of air transportation with a takeoff weight comparable to conventional business jets and competitive direct operating costs.

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Sustaining Solutions in Undergraduate STEM Education

Science, Technology, Engineering and Mathematics (STEM) programs that attract and sustain student interest feature learning that is experiential, investigative, hands-on, personally significant to both students and faculty, connected to other inquiries, and suggestive of practical application to students' lives. Such learning flourishes in a community in which faculty are committed equally to teaching, to maintaining their own intellectual vitality, and to partnering with students in learning, and in which institutional support for such a community exists. The CSIE (Creative Scientific Inquiry Experience) Program at Eastern Michigan University is involved in retaining and increasing the number of STEM graduates by including faculty professional development, student connectedness to the sciences and mathematics through academic service-learning, and curricular reform. Participants will share their own institutional experiences and strategies for recruiting and retaining their STEM majors, developing culturally relevant, community-based courses, and will explore ways for implementing such a program on their campuses.

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Significance of Firms in the Materials Sector in the Creation of the Command and Control Function of Cities

In the modern world the largest firms in the global economy noted on the Forbes Global 2000 list create the command and control function of cities. Of the ten possible sectors on the list, the materials sector was studied, which consists of firms in two subsectors: specialized chemicals and diversified chemicals. The materials sector is one of the weakest of the ten Forbes sectors. This is why it is important to examine the financial condition of firms in this sector, especially its largest firms. The purpose of the paper is to determine the financial rank of the largest firms in the materials sector noted on the Forbes Global 2000 list and their effects on the command and control function of cities. In this paper, we present a new comprehensive index of potential for selected cities based on revenue from sales, net profits, assets, and market value for selected sectors of the economy. A command control index (CCI) was created based on a comprehensive index of potential, number of sectors, and number of corporate headquarters. It has been shown that the materials sector is one of the weaker sectors among the largest world companies, both in terms of its totality and the financial performance of constituent firms, even though its value increased more than sixfold in the period 2006-2018. The materials sector is very often found in smaller cities – home to only one company generating their command and control function. This is very disadvantageous, as in the event of a crisis at this one company, the entire city may lose its command and control function. On the other hand, in large cities, its share is less than 10%. However, it is possible to identify cities where the significance of the materials sector has increased in the generation of the command and control function (Beijing, Shanghai, Hong Kong), and where it has substantially decreased (New York, Tokyo, London, Paris). A general increase in the significance of the sector has occurred in Asia, while a general decline has occurred in Western Europe and North America.

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'Data Science' – The Revolution for Engineering Academic Programs

Data science is revolutionizing the business world and the vast array of engineering applications in the context of Industrie 4.0. Industrie 4.0 promotes the evolution of cyber-physical systems in both the manufacturing and the service sectors with the goal of fully automating systems that require data mining, data fusion, and AI to accomplish tasks that were previously performed by humans. This new world of cyber-physical systems will require academic curriculums to be reevaluated and the evolution to meet the needs of the rapidly evolving business sectors. A key issue will be the assessment and reevaluation of quantitative and data science methods currently required in engineering curriculums. An engineering student's knowledge upon graduation will require at a minimum an understanding of database structures, automated data fusion, Total Data Quality Management (TQDM), machine learning, statistical algorithms, and elementary AI. This knowledge will include some familiarity of programming using analytical software such as Python, SQL and R. The requirement of an internship in the private sector is also critical for the engineering student's ability to understand application of the aforementioned concepts. This will ensure the long term success of students working in an environment of advanced cyber-physical systems in both the manufacturing and service sectors. Engineering schools should consider joint degree programs with computer science, statistics, and business analytics programs. A certificate program in 'data science' for engineering majors should also be considered.