

# Proceedings of the 2020 Cincinnati- Dayton INFORMS Symposium

January 31, 2020

Wright State University, Dayton, Ohio



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# 1. Introduction

## Conference Committee Message

*Now in our sixth year, the organizing committee welcomes you to our annual Cincinnati-Dayton INFORMS Symposium. The symposium is a forum to show the rich OR work being performed in our local area. We feel that the scientific and social exchange among symposium attendees will give us a much needed opportunity to interact in the Miami Valley area. For the 2019/2020 academic year, we moved the conference to January to facilitate more student involvement.*

*We have been pleased by the expansion of interest, volume and breadth of submissions and attendees since 2014. Our symposium has continued to gain traction every year and we have received more than a sufficient amount of submissions, ranging from Simulation to Medical Applications. The ability to accept online registrations saw an increase in the speed at which we had registrations. We had to work diligently to fit every talk into a single day.*

*We hope that you will thoroughly enjoy the day. Please do not hesitate to let us know if you need anything during your attendance and we hope to see you again at the 2021 Symposium. Additionally, please feel free to thank Wright State University's Biomedical, Industrial, and Human Factors Engineering Department and the Wright State University Raj Sooin College of Business. Without their sponsorship, our conference would be infeasible.*

-Cincy-Dayton INFORMS Conference Steering Committee

### 2020 Conference Steering Committee

Trevor Bihl, 2020 Chair Air Force Research Laboratory Trevor.Bihl.2@us.af.mil	Bruce Cox, 2020 Co-Chair Air Force Institute of Technology Bruce.Cox@afit.edu
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### Cincinnati-Dayton INFORMS Chapter and the Symposium

The Cincinnati-Dayton Chapter of INFORMS was established in 1995 as one of the regional chapters of INFORMS. Regional chapters are separate from student chapters and encourage interchanges between professionals, faculty, researchers, and students; regional chapters are relatively few in number and the Cincinnati-Dayton chapter is the only local regional INFORMS chapter in Ohio, Indiana, Kentucky or West Virginia. The Cincinnati-Dayton chapter has been successful in its mission by sponsoring the annual Arnoff lecture, offering chapter awards and social events, and encouraging facility tours, guest speakers and symposiums. Our chapter current has approximately 100 active members. By patronizing the symposium, you are both helping us to expand our chapter and facilitate needed technical interchanges in the Miami Valley area. More details can be found on our chapter webpage:

<https://www.informs.org/Community/Cincinnati-Dayton-Chapter>

## 2. Directions

The Berry Room is located immediately North of I-675 and North Fairfield Road (exit 17) at the corner of North Fairfield Road and Colonel Glenn Highway on the third floor of Wright State's Nutter Center. When facing the front entrance of Wright State's Nutter Center, the Berry Room is located on the far right.

To enter the Berry Room, it is advisable to park in Lot 1 and walk directly to the Administration/Berry Room door.

### Parking

Free parking is available in Lot 1, which is conveniently located on the same level as the Berry Room. Both the parking lot and the Berry Room are accessible to persons with physical disabilities.



## Sponsors

The Cincinnati/Dayton Chapter would like to thank the following sponsors

WRIGHT STATE UNIVERSITY

Raj Soin College of Business

*The Raj Soin College of Business has a long tradition of developing influential business leaders in the region and beyond. In 2000, the College was named the Raj Soin College of Business in honor of Rajesh K. Soin, an internationally recognized entrepreneur, business leader and community benefactor.*

*Through collaboration with the business community and alumni, the college continues to launch new academic programs, increase scholarship support and expand career opportunities for our students. This collaboration enriches our students' academic experience while helping area businesses excel.*

*With an enrollment of approximately 1,200 undergraduate students and 500 graduate students, we offer the benefits of a comprehensive business program and a diverse student body. At the same time our small class sizes and supportive faculty offer students the individual attention they need to excel.*

### **Contact information:**

100 Rike Hall  
Wright State University  
3640 Colonel Glenn Highway  
Dayton, Ohio, 45435  
<http://business.wright.edu/about>

### 3. Schedule: Friday January 31, 2020

Time	
0830-0900	<b>Registration and Coffee</b>
0900-0910	<i>Welcome and Agenda</i> <b>Authors:</b> Bruce Cox, <a href="#">AFRL</a>
	<b>Morning Session</b>
0910-0930	<i>Bi-objective optimal scheduling of F-15 fleet modernization</i> <b>Presenter:</b> Richard Danaher (AFIT) <b>Abstract-1</b>
0930-0950	<i>Value Focused Thinking Approach to Restore War Torn Countries: A case study of SSTRO Effort in Afghanistan in light of Pashtunwali Doctrine</i> <b>Presenter:</b> Muhammad Riaz (AFIT/PAF), Richard Deckro (AFIT), Matthew Robbins (AFIT) <b>Abstract-2</b>
0950-1010	<i>Piloting an Undergraduate Engineering Mentoring Program to Enhance Gender Diversity</i> <b>Presenter:</b> Beth Hart (UD), Sandy Furterer (UD), Andrea Mott (UD) <b>Abstract-3</b>
1010-1030	<b>Coffee Break</b>
1030-1050	<i>Multi-Objective Decision Analysis applied to Voting Bodies</i> <b>Presenter:</b> Connor Crandall (AFIT) <b>Abstract-4</b>
1050-1110	<i>Systems Engineering Concept Generation Technique in a Systems Engineering Course</i> <b>Presenter:</b> Sandra Furterer (UD), Taylor Zehring (UD) <b>Abstract-5</b>
1110-1130	<i>Optimizing part time student staffing for a university international office</i> <b>Presenter:</b> Ahmed Abualrahi (WSU) Trevor Bihl (WSU) <b>Abstract-6</b>
1130-1150	<i>Approximate Dynamic Programming for the Military Aeromedical Evacuation Dispatching, Preemption-Rerouting, and Redeployment problem</i> <b>Presenter:</b> Phillip Jenkins (AFIT), Matthew Robbins (AFIT), Brian Lunday (AFIT) <b>Abstract-7</b>
	<b>Luncheon</b>
1200-1320	<i>Keynote Speaker (1220 – 1320)</i> Michael Gorman <a href="#">UD</a> -- <i>From Theory to Practice: Bridging Gaps and Finding Opportunities for the Application of OR/MS Research</i> <b>Abstract-K</b>
	<b>Afternoon Session</b>
1320-1340	<i>ARIMA modeling by Mathematical Programming</i> <b>Presenter:</b> George Polak (WSU) Bogdan Bichescu (UT Knoxville) <b>Abstract-8</b>
1340-1400	<i>Lightning Forecasting at Cape Canaveral using Wavelet Methods and Semiparametric Modeling</i> <b>Presenter:</b> Jared Nystrom (AFIT) <b>Abstract-9</b>
1400-1420	<i>Database Analyses for USTRANSCOM Workload Forecasting</i> <b>Presenter:</b> Kayla Tinucci (AFIT) <b>Abstract-10</b>
1420-1440	<i>Cramming Questions: Quiz Bowl Set Optimization</i> <b>Presenter:</b> Kara Combs (WSU) Trevor Bihl (WSU) <b>Abstract-11</b>
1440-1510	<b>Heavy Hors d'oeuvres</b>
1510-1530	<i>Analysis with Bayesian Networks Compared to Simulation</i> <b>Presenter:</b> Aaron Salazar (AFIT), Mark Gallagher (AFIT) <b>Abstract-12</b>
1530-1550	<i>Finite Source Queues: an optional method when Readiness Based Sparing (RBS) models are too 'greedy' on extremely expensive parts</i> <b>Presenter:</b> Greg Gehret (AFLCMC), Mike McClure (AFLCMC) <b>Abstract-13</b>
1550-1610	<i>Metaheuristic Approach to Optimal Receiver Placement for GPS-based Multi-static Radar Over the Caribbean Sea</i> <b>Presenter:</b> Brandon Hufstetler (AFIT) <b>Abstract-14</b>
1610-on	<b>Closing</b>

## 4. Keynote Address: Michael Gorman

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**Abstract-K Berry 1-2**      **From Theory to Practice: Bridging Gaps and Finding Opportunities for the Application of OR/MS Research**

1220-1320

Michael Gorman (University of Dayton)

### **Abstract**

It has often been said that academia in general, and research in OR/MS in particular, has become too remote and inaccessible to practitioners. At the same time, while researchers define 'impact' with a citation metric, often that research has less and less practical impact. I describe fundamental differences between academic and practitioner approaches to problem solving, with examples to my experience in applied research. I describe ways that researchers can better and more frequently bridge this gap. Opportunities for "practice based theoretical research" are discussed. Recommendations include how to make OR/MS researchers more productive and relevant.

### **Bio**

Michael F. Gorman, PH.D. is the president of MFG Consulting, Inc., and a full Professor at the University of Dayton. Throughout his 20 years of corporate and consulting experience, he has focused on delivering value to the organizations for which he works.

He specializes in optimization, simulation and statistical analysis and forecasting. He has worked with dozens of clients on tough analytical problems that have netted them millions of dollars in savings with huge financial returns on his projects. His collaborative approach leverages internal domain expertise of his clients. His consulting work has been lauded as a finalist in two international competitions of INFORMS (the Institute for Management Science and Operations Research). He has over 70 publications and over 70 presentations on his research, much of which centers on applied projects with clients. He is on the editorial boards at 5 major journals.

Dr. Gorman graduated from Indiana University with a Ph.D. in Business and Economics in 1994. He has a Masters in Economics from Indiana, and a Bachelors Degree in Computer Science and Economics from Xavier University in Cincinnati.

## 5. Abstracts for Presentations and Papers

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**Abstract-1****Bi-objective optimal scheduling of F-15 fleet modernization**

Richard Danaher, Air Force Institute of Technology (AFIT)

0910-0930

**1. Abstract:**

*The F-15 weapons system is vital to the Air Force's efforts to obtain air supremacy during conflict. Originally designed and procured over 40 years ago, demand to improve the lethality and survivability of the F-15 against evolving threat systems persistently increases. Multiple extensive modernization efforts providing advanced technologies and service-life extending hardware provide the opportunity to continue F-15 deployment beyond 2040. This research balances the short-term tactical objective for quickly developing available modernized and updated airframes against the strategic need to modernize the entire fleet as soon as possible. Workflow, availability, and resource limitations are all included in model. The reported analysis delivers insight on not only a good schedule, but also identifies the best practices of modernization job sequencing for the F-15 Systems Program Office. Lessons learned employing scheduling theory on where and when to focus modernization efforts provides a more reliable and combat capable aircraft to the warfighter for training and counterair operations.*

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**Abstract-2****Value Focused Thinking Approach to Restore War Torn Countries:****A case study of SSTRO Effort in Afghanistan in light of Pashtunwali Doctrine**

Muhammad Sharjeel Riaz, Air Force Institute of Technology (AFIT/PAF)

Richard F Deckro, Air Force Institute of Technology (AFIT)

Mathew JD Robbins, Air Force Institute of Technology (AFIT)

0930-0950

**1. Abstract:**

*Since the dawn of time, mankind has suffered from the menace of conflicts and wars; today as we talk, war clouds loom over a significant region of the globe. After a conflict what is normally left behind is rubbles and plethora of destruction – physical, social, and mental. Afghanistan remains one such example where, despite global efforts, the desired results for Security Stability Transition & Reconstruction Operations have not been achieved. This presentation proposes a mathematical model for evaluating the nation building effort in Afghanistan. The difference from previous efforts is the focus from a local person's perspective in consonance with the Pashtunwali doctrine which is held in high esteem by many Afghans. The research develops a value hierarchy concerning areas that locals and the Allies feel need to be focused on. It is believed that efforts on improving such areas will have far more significant and immediate impact on the indigenous populations of the region. This, in turn will enable the fight against terrorism through educating and improving the situation of a people who until now often feel neglected. At the same time the humanitarian efforts will be in synchronization with Islamic and cultural principles of Afghanistan and not just appear to be imposed by outside powers.*

*The research employs value focused thinking to categorize the factors in descending order of priority that need focus on for nation building. This work adds a new dimension to the models already available in the field and is likely to be more readily embraced by the local people. Choosing the right areas through the scientific approach of value focused thinking with a Pashtun decision maker also helps in allocating weights for specific areas thus enabling development of sound policy and utilization of tax payers' money. The intent is to bring peace and prosperity more swiftly and facilitate building a more stable region.*

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**Abstract-3****Piloting an Undergraduate Engineering Mentoring Program to Enhance Gender Diversity**

Beth Hart, University of Dayton (UD)

Sandra Furterer, University of Dayton (UD)

Andrea Mott, University of Dayton (UD)

0950-1010

**1. Abstract:**

*Many female undergraduate Engineering students struggle during their first and second years of college with finding their place and questioning whether they belong in Engineering. It has been shown that mentoring programs can help encourage women to stay in STEM. The purpose of this study is to implement a women in science and engineering mentoring program within the STEM disciplines at the university. The focus of the initial pilot mentoring program includes: 1) orientation to the program, networking, community building and defining the program's goals; 2) understanding the imposter syndrome and strategies for dealing with it; 3) networking with female STEM faculty; and 4) planning your summer to target resume builders. The initial mentoring program design was developed through two Lean Six Sigma projects, where they collected voice of the customer (mentors and mentees)*

data, and designed the program. The program was piloted in Fall 2019, spearheaded by the Women Engineering Program in the School of Engineering, the director and a student graduate assistant. The success of the pilot program will be assessed in three ways: 1) number of mentor/mentee pairs starting the program, compared to the initial number interested; 2) retention of women in engineering and science during the program periods; and 3) through mentor and mentee reflections. In the initial voice of customer data collection, we identified 14 possible mentors, and in the pilot program, we had over 40 mentor/mentees paired for the program. This program will provide mentorship to women engineers throughout their college career as well as support them for a career in engineering in the workplace.

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**Abstract-4****Multi-Objective Decision Analysis applied to Voting Bodies**

Connor Crandall, Air Force Institute of Technology

1030-1050

**1. Abstract:**

Group decision making is a common area of study within Multiple-Objective Decision Analysis. Multiple techniques exist for aggregating preference parameters for multiple decision makers. It is currently common practice to attempt to evaluate available alternatives for the group as a collective and arrive at a single best solution. This work takes a different approach. Rather than trying to define the best solution, this effort seeks to narrow the solution space to alternatives that have a reasonable probability of being supported by a majority of decision makers in the group. Setting the stage for a decision based on a voting process. The process accomplishes this by evaluating alternatives based on the decision maker's individual preference parameters rather than an aggregated collective. By comparing available alternatives to the current state of the issue under analysis, the process can determine which alternatives are considered better or worse in the eyes of each decision maker.

A toy model demonstrates the proposed methodology when considering a simulated example that addresses the border security issue between the United State and Mexico. The example uses a simulated voting body of 20 decision makers considering multiple unique alternatives. Using the individual preference parameters for each decision maker, a deterministic analysis is run and a list of potentially viable alternatives is produced.

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**Abstract-5****Systems Engineering Concept Generation Technique in a Systems Engineering Course**

Sandra Furterer, University of Dayton (UD)

Taylor Zehring, University of Dayton (UD)

1050-1110

**INTRODUCTION:**

There is a need for engineering professionals to understand the benefits of following a sound systems engineering process. The Management of Engineering Systems graduate course addresses systems engineering concepts and processes, explaining activities and tools for developing systems solutions to meet customer needs. Using the online Systems Engineering Body of Knowledge as the foundational text, topics such as systems thinking, requirements analysis, testing, and life-cycle sustainment are discussed. The interdisciplinary and cross-functional nature of systems engineering is also emphasized.

**METHODS:**

We deployed active learning in a Management of Engineering Systems course to introduce a method for concept generation. This method integrated different systems areas and disciplines to generate systems concepts in the Concept of Operations phase in the Vee design lifecycle methodology. Class participants were organized into 9 topic (discipline) teams and were asked to generate ideas for each of the 9 available system planning topics. Participants had 9 available topic boards. On each board were 9 columns, for each team to place their ideas respectively. Teams were encouraged to generate ideas for other teams and to place them in the proper column on the proper board. The second action was for each team of participants to take their respective topic board, with the suggestions from other teams, and organize their ideas into correlated sub-topic groupings. Each team would then use the terms on their boards to generate an elevator pitch with respect to their discipline area. The Pugh Selection Technique was then used to prioritize the systems concepts.

**RESULTS AND DISCUSSION:**

The process of concept generation implemented yielded ideas that were later implemented in the system requirements, architecture and design phases. Additionally, this cross-topic concept generation established a working foundation and willingness between

teams to create integrated design concepts. Teams were more likely to plan their sub-system elements around the functional workings of another team to ensure that things integrated into the broader system architecture and design.

#### CONCLUSION:

Utilizing this system concept generation provides an opportunity for all parties, regardless of discipline or background, to be involved in the system conceptual planning that overall feeds back into the broader systems requirements and architecture phase. It provides the foundational understanding of the importance of cross-discipline involvement in early system planning phases. The method helped generate system concepts with relation to overall systems engineer conceptual design, planning, requirements and architecture development. The active learning provided an understanding of the value of cross-discipline interaction, trust, and transparency.

#### REFERENCES:

No author, 2019, Mission Analysis and Concept of Operations, SEBoK, BKCASE Board of Governors by The Trustees of the Stevens Institute of Technology, [https://www.sebokwiki.org/wiki/Business\\_or\\_Mission\\_Analysis#Mission\\_Analysis\\_and\\_Concept\\_of\\_Operations](https://www.sebokwiki.org/wiki/Business_or_Mission_Analysis#Mission_Analysis_and_Concept_of_Operations).

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#### Abstract-6

#### Optimizing part time student staffing for a university international office

Ahmed Abualrahi, Wright State University (WSU)

1110-1130

Trevor Bihl, Wright State University (WSU)

##### 1. Abstract:

Student part-time staff at university international offices is beneficial to both the employed student and their peers using the services who can see them as peers with a similar experiential background. However, scheduling part time employment for multiple students, each with different class schedules, is a difficult task. In this project, optimization methods were used to solve part time student worker staffing at Wright State University's University Center for International Education (UCIE). Student availability and schedules change every semester, and sometimes during the semester. The current approach involves creating a schedule by hand; however, with multiple student employees and different and variable availability times this process is very complicated. To create an optimal schedule, the problem was set up with four workers and eight, one hour, shifts. The objective is to minimize how many students are present in total shift. Four constraints were added to this linear program: student availability, and max hours per week. Another constraint was that a maximum of two students can be working simultaneously, due to desk availability. In addition, a minimum of 1 student should always be present. Simplex was used to solve this linear program model, with the result being that out of a total 80 labor hours available per week, the optimized schedule results in only 4 unused hours whereas the current, manually created, schedule has 16 unused hours. Currently, UCIE is planning on implementing this solution and framework for future semesters.

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#### Abstract-7

#### Approximate Dynamic Programming for the Military Aeromedical Evacuation Dispatching, Preemption-Rerouting, and Redeployment problem

1130-1150

Phillip Jenkins, Air Force Institute of Technology

Matthew Robbins, Air Force Institute of Technology

Brian Lunday, Air Force Institute of Technology

##### 1. Abstract:

Military medical planners must consider how aeromedical evacuation (MEDEVAC) assets will be utilized when preparing for and supporting combat operations. This research examines the MEDEVAC dispatching, preemption-rerouting, and redeployment (DPR) problem. The intent of this research is to determine high-quality DPR policies that improve the performance of United States Army MEDEVAC systems and ultimately increase the combat casualty survivability rate. A discounted, infinite-horizon Markov decision process (MDP) model of the MEDEVAC DPR problem is formulated and solved via an approximate dynamic programming (ADP) strategy that utilizes a support vector regression value function approximation scheme within an approximate policy iteration algorithmic framework. The objective is to maximize the expected total discounted reward attained by the system. The applicability of the MDP model is examined via a notional, representative planning scenario based on high-intensity combat operations to defend Azerbaijan against a notional aggressor. Computational experimentation is performed to determine how selected problem features and algorithmic features affect the quality of solutions attained by the ADP-generated DPR policies and to assess the efficacy of the proposed solution methodology. The results from the computational experiments indicate the ADP-generated policies significantly outperform the two benchmark policies considered. Moreover, the results reveal that the average

service time of high-precedence, time-sensitive requests decreases when an ADP policy is adopted during high-intensity conflicts. As the rate at which requests enter the system increases, the performance gap between the ADP policy and the first benchmark policy (i.e., the currently practiced closest-available dispatching policy) increases substantially. Conversely, as the rate at which requests enter the system decreases, the ADP performance improvement over both benchmark policies decreases, indicating the ADP policy provides little-to-no benefit over a myopic approach (e.g., as utilized in the benchmark policies) when the intensity of a conflict is low. Ultimately, this research informs the development and implementation of future tactics, techniques, and procedures for military MEDEVAC operations.

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**Abstract-8****ARIMA modeling by Mathematical Programming**

1320-1340

George G. Polak, Raj Sooin College of Business, Wright State University  
Bogdan Bichescu, Haslam College of Business, The University of Tennessee, Knoxville**1. Abstract:**

We formulate a mathematical programming model for simultaneous selection of the lagged terms and evaluation of their coefficients in an Autoregressive Integrated Moving Average (ARIMA) model. The purpose is to optimally fit the ARIMA model to time series data while constraining the number of combined AR and MA terms, and seasonal terms as well, to achieve desired parsimony. The representation of white noise as a vector of decision variables serves as a stationary reference signal for determining the MA coefficients. Wavelets are employed to represent this reference signal, and reveal a binary characteristic which we exploit to linearize constraints.

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**Abstract-9****Lightning Forecasting at Cape Canaveral using Wavelet Methods and Semiparametric Modeling**

1340-1400

Jared Nystrom, Air Force Institute of Technology

**1. Abstract:**

The unique requirements for near real-time determination of lightning risk present a substantial challenge to weather operations at Kennedy Space Center and Cape Canaveral Air Force Station (KSC/CCAFS). This location experiences one of the world's highest incidences of lightning resulting in impacts to both the launch of space vehicles and daily support activity. Accurate lightning forecasts are essential for safe and efficient flight line operations, requiring the prediction of both lightning onset and cessation of lightning events following a storm. The accuracy of these forecasts is compounded by sensor data that is both inherently noisy and collected in time series. The KSC/CCAFS weather policy literature suggests current methodologies are far too conservative in nature and result in operational inefficiencies. This study proposes a method to apply a discrete wavelet transformation (DWT) and a semiparametric single-index model to time series weather sensor data to improve the timeliness and accuracy of lightning prediction for KSC/CCAFS.

A wide array of sensors are employed at KSC/CCAFS that provide readings over time to include the Lightning Detection and Ranging (LDAR) network, a network of electric field mills, and conventional weather data. Of primary interest for forecast development are readings from the system of electric field mills that measure the electromagnetic energy in the atmosphere throughout KSC/CCAFS. A DWT will be applied to a training set of historic data to develop a single-index model for lightning prediction. This semiparametric method is a generalization of many popular parametric models but without both distributional assumptions and the curse of dimensionality inherent in nonparametric techniques. This model will be designed to provide both the accuracy and timeliness required to effectively support operations at KSC/CCAFS.

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**Abstract-10****Multivariate Analysis of Human Performance STRONG Lab Data**

1400-1420

Kayla Tinucci, Air Force Institute of Technology

**1. Abstract:**

This study uses multivariate analysis methods to find relationships between nutrition and wellness and nutrition and performance. The nutrition, daily wellness, and weight and bodyfat data are from a study performed by the STRONG lab in the 711th Human Performance Wing. Electronically collected nutrition data along with survey data for 19 individuals over a 12-week study period are examined with a focus on health, fitness, and nutrition. Factor analysis and linear regression are performed and inferences are drawn regarding what effects calories and macronutrient intake have on subjects perceived wellness, weight, and body fat percentage. These insights are discussed in the context of past studies and nutrition subject matter expert opinions. The findings indicate that an increase in total calorie intake is associated with increased motivation, stronger feelings of recovery, increased

satiety, and increased body fat percentage. Increased stress and decreased sleep quality are associated with an increase in total calorie intake. An increase in total body weight is associated with an increased intake of fat and carbohydrates. Further conclusions and recommendations are offered.

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**Abstract-11****Cramming Questions: Quiz Bowl Set Optimization**

1420-1440

Kara Combs, Wright State University (WSU)  
Trevor Bihl, Wright State University (WSU)**1. Abstract:**

Quizbowl is an academic-based activity in which players test their knowledge against others by competing in tournaments. Tournaments can purchase questions from national organizations or produce a house-written set of questions. Quizbowl packet organization is a lengthy process that is often overlooked by a set's editor due to time constraints. Each packet has a predetermined number of questions, difficulty level, category distribution, and general heuristics that reduce question and/or clue duplication. Previous techniques to optimize question placement relied on manually edited databases and introduce a large chance of human error, which grows exponentially with the number of individual writers. Through the application of Excel's Simplex LP algorithm, the questions can be organized automatically with minimal human guidance given the several constraints mentioned previously. Ensuring minimal question and/or clue duplication is vital to all sets as it is the primary assessment of quality for a given set, its writers, and its editors. Further research could expand upon consideration for tiebreaker subjects, automatic question randomization of questions within a packet, and development of an easy to use GUI for the program.

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**Abstract-12****Analysis with Bayesian Networks Compared to Simulation**

1510-1530

Aaron Salazar, Air Force Institute of Technology (AFIT)  
Mark Gallagher, Air Force Institute of Technology (AFIT)**1. Abstract:**

This research compares discrete-event and time-step simulations and dynamic Bayesian networks. We test the three approaches for accuracy on a queuing system with known theoretical values of the steady-state mean and variance of the number of entities in the system, along with the steady-state probabilities of each possible number in the entities in the system. We compare the accuracy of each approach in estimating these theoretical mean, variance, and probability values.

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**Abstract-13** **Finite Source Queues: an optional method when Readiness Based Sparing (RBS) models are too 'greedy' on extremely expensive parts**

1530-1550

Greg Gehret, Air Force Life Cycle Management Center (AFLCMC)  
Mike McClure, Air Force Life Cycle Management Center (AFLCMC)**1. Abstract:**

Many firms generate revenue by operating systems or fleets, such as welding robots, rental cars, aircraft, etc. The contribution of service parts to the availability of the system or fleet is well documented. Readiness-Based Sparing (RBS) models are often used to compute the spares levels for service parts, and unit price is a key input. When the unit price of a service part is extremely high, relative to the remaining service parts of the given system/fleet, the 'greedy' RBS model tends to set a very small level of spares. In this paper/presentation, we cover three areas. Firstly, we demonstrate how the typical RBS model determines spare parts levels on extremely expensive parts. Secondly, we touch on the current use of constraints, within the RBS models, designed to address the issue previously demonstrated. Thirdly, we highlight the finite source queue and show its utility. The finite source queue is not directly impacted by unit price. As such, it enables one to view the trade-space between spares levels and system performance without costs. Stated another way, it is not limited by marginal analysis. The implication is that the finite source queue may be a better methodology on extremely expensive items where managing the risk of part shortages is more important than the pure and/or constrained RBS solution on extremely expensive service part(s).

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**Abstract-14** **Metaheuristic Approach to Optimal Receiver Placement for GPS-based Multi-static Radar Over the Caribbean Sea**

1550-1610

Brandon Hufstetler, Air Force Institute of Technology (AFIT)

## 1. Abstract:

*In support of the US Coast Guard's mission to interdict illicit goods being trafficked from South America to the United States, this thesis proposes a Global Positioning System (GPS) based multi-static radar architecture to detect aircraft transiting the Caribbean Sea. The multi-static radar system developed in this thesis relies on the forward-scatter phenomenon in which a radar shadow is cast by a target in front of a transmitter creating a measurable difference in the signal amplitude at the receiver.*

*The forward-scatter radar shadow is detectable only within a narrow region outside of syzygy or the line-of-sight vector extending from the transmitter through the target. Thus, a receiver must be placed in a strategic location to maximize the probability of conjunction with the target and transmitter. This thesis determines the optimal placement of a collection of GPS receivers to maximize the probability of detection of any aircraft flying over the Caribbean Sea at 10,000 ft from South America towards known smuggling stop-over points in the Caribbean.*

*The solution space for this thesis is developed using the Systems Toolkit (STK) from Analytical Graphics, Inc. (AGI) scripted using the Python Programming Language and consolidated using the R Statistical Language.*

*There are two scenarios solved in this thesis. First is a minimal set-covering problem which answers the question: What is the fewest number of sensors required to detect all aircraft in the scenario and where should they be placed? The second is a maximal set-covering problem and answers the question: Where should a predetermined quantity of sensors be placed to maximize the number of aircraft detected in the scenario?*

*Set covering problems are known to be NP-Hard and the binary decisions made in the problems proposed in this thesis grow in computational complexity at a rate of  $O(2^n)$ . Therefore, the mathematical methods typically used to solve optimization problems are unable to determine the optimal solution in polynomial time. It is determined in this thesis that an exhaustive search of the solution space would take a computer nearly twelve billion times the age of the universe to complete.*

*Therefore, a genetic algorithm metaheuristic is developed and tuned to each problem. The genetic algorithms are validated on a subset of the data which has been solved to optimality using the International Business Machines Corporation's (IBM) C Programming Language Simplex (ILOG CPLEX) Optimization Programming Language Integrated Development Environment (OPLIDE). The metaheuristics are then employed in the R statistical programming language to answer the set-covering problems dened earlier.*

*The outputs of this thesis are solutions to the minimum and maximum set covering problems and a characterization of the solution space. The solution space characterization can be used to approximate the number of sensors required to employ a multi-static forward-scatter radar architecture elsewhere in the world with varying probability of detection requirements.*