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Energy-Constrained Vertiport Location Optimization for Advanced Air Mobility Emergency Logistics in Northeastern North Carolina

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Abstract

This paper formulates Advanced Air Mobility (AAM) emergency logistics infrastructure planning as an energy-constrained facility-location problem applied to the 21-county Northeastern North Carolina (NENC) region. A reduced-order physics-based energy model evaluates depot-to-county mission feasibility under battery capacity (40, 60, 80 kWh), payload (35 kg/77lbs and 113 kg/250lbs), mission type (one-way vs. round-trip), and wind conditions. The resulting binary coverage matrix drives three integer programming models: set covering, maximum coverage location (MCLP), and p-median assignment. An equity extension incorporates CDC Social Vulnerability Index weights. A dual-depot scenario pairing Elizabeth City with Edenton (Chowan County), drawn from a prior routing simulation in this research series, is also evaluated. Key findings: Elizabeth City as a single depot covers 66.7% of NENC counties under 40 kWh round-trip constraints, while an optimally placed single depot achieves 95.2%, missing only Vance County; two strategically placed vertiports achieve complete 100% coverage at 40 kWh round-trip, and a single depot suffices at 60 kWh; the Elizabeth City–Edenton dual-depot configuration achieves complete coverage under both one-way and round-trip missions at 60 kWh; under the tested NENC geography, uniform-wind assumption, and capped wind-energy model, battery capacity, not wind, is the dominant infrastructure lever. Equity analysis confirms that the optimized two-depot network covers all eight of the highest social-vulnerability counties, including Tyrrell (SVI = 0.96), Hyde (0.95), and Northampton (0.93), eliminating the equity gap present under the single-depot baseline, where these communities remain unserved. Results provide a quantitative foundation for phased AAM emergency logistics infrastructure planning in NENC.

Keywords
Advanced Air Mobility; Vertiport placement; Facility-location; Emergency logistics, Simulation-Based Optimization

Biographies

Dr. Kuldeep Rawat is currently the Thorpe endowed professor & dean of the School of Science, Aviation, Health, and Technology at Elizabeth City State University (ECSU). He earned an M.S. in Computer Science, an M.S. in Computer Engineering and a Ph.D. in Computer Engineering from the Center for Advanced Computer Studies (CACS) at the University of Louisiana-Lafayette. Dr. Rawat has served as Principal Investigator on numerous federally funded grants, including those from the US Department of Commerce, NASA, the Department of Energy, the National Institute of Justice, the Federal Highway Administration, and the Federal Aviation Administration. He is the ECSU lead for the NCDOT-funded Center of Excellence for Advanced Air Mobility and Unmanned Aircraft Systems. His areas of interest include embedded systems design, applied data science and machine learning, UAS applications research, optimization, and innovative uses of simulation techniques to solve engineering challenges. He is a member of IEEE, ASEE, and AUVSI. Dr. Rawat may be reached at ksrawat@ecsu.edu.

Dr. Kevin Kupietz is an associate professor and chair of the department of aviation and emergency management at Elizabeth City State University. He earned a BS in Fire Protection Engineering from UNC Charlotte, an MS in Occupational Safety from East Carolina University, and is a graduate of the National Executive Fire Officer Program. He earned a Ph.D. In Health Services from Capella University. Dr. Kupietz is a certified firefighter/Paramedic with more than 30 years of experience in emergency/disaster management. He has served as the Principal Investigator on many federally funded grants, including those from the Department of Homeland Security, the Department of State, the Office of Naval Research, and others. His areas of interest include building resilient communities from disasters, the use of drones in public safety, responder safety, and the use of advanced technologies in public safety. He is a member of NACON, IAEM, and NAEMT. Dr. Kupietz can be reached at kdkupietz@ecsu.edu.