Digital Engineering Center of Excellence: Advanced Air Mobility Focus Area White Paper: April 1, 2022

Background and Need: Recent years have seen the rapid development of Unmanned Aerial Systems (UAS) technologies, including the advancement of Urban Air Mobility (UAM), Regional Air Mobility (RAM), and Advanced Air Mobility (AAM) Concepts of Operations (CONOPS) through the efforts of the National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), and the Department of Defense (DoD). There have also been advances related to civil Type Certificate (TC), Airworthiness Certificate (AC), Production Certificate (PC), and maintenance requirements for unmanned and optionally manned systems, driven by research, regulatory development, and establishment of industry standards. Related to AAM, which is forecasted to be the next radical revolution in transportation, a broad range of emerging technologies are being designed to promote safety, cost-effectiveness, and consumer-friendliness. According to the Deloitte Advanced Air Mobility Survey (2021), by 2035 the industry will be valued at $115 billion and create over 280,000 high-paying jobs. As UAS in general, and larger electric Vertical-Takeoff-and-Landing (eVTOL) systems capable of significant cargo or passenger transport are designed, tested, and commercialized, approaches including digital engineering capabilities will quickly transition from obscure concepts to requirements for design, test, manufacture, and operation of certified systems.

The goal of Digital engineering is to change the order of the production process from design-build-test to design-test-build by moving much of the testing phase to the digital domain, providing an opportunity to optimize the design before investing resources to build a prototype or production model. It produces records for products that might otherwise not exist, or would not be as easily accessible, enabling review and approvals for certification or production and an ability to reliably manufacture at varied locations or times. These benefits result in massive savings of time and resources throughout the lifecycle of complex systems like those found in the aerospace industry. Digital engineering focuses on digital twins and digital threads modeling. Digital twins are computer models and relevant data associated with real objects that embody all physical attributes and are useful for computer simulated testing or other analyses across the lifecycle of an object. Digital threads can represent each individual decision that went into manufacturing a separate product, potentially including blockchain data, or managing an asset, preventing wasteful redundancy and enhancing communication between teams working on different aspects of the same project.

The development of aircraft and associated supporting technologies and systems able to enjoy the future benefits of AAM will necessitate a formalized and professionalized approach to UAS or eVTOL design, manufacture, and operations. The majority of such systems will require TC, AC, and PC approvals from the FAA through the guidance of the Title 14 CFR Part 21 regulations, or how they may be further modified to enable AAM capable aircraft. From design, testing, and production standpoints, this requires a high level of accuracy and professionalism in the initial design, documentation, manuals, and training requirements. Likewise, ongoing operations and maintenance of these systems will require the same level of rigor as commercial aircraft as it appears maintainers will be Maintenance, Repair, and Overhaul (MRO) services, as defined in the Title 14 CFR Part 145 regulations.

Solution: The formation of a ***Digital Engineering Center of Excellence*** (COE) with a focus on AAM is of paramount importance to ensure the complexities of digital engineering as related to this new domain of aviation are integrated from its foundation to ensure safety, efficiency, and compliance, while enabling economic development and commercial success. The State of Ohio generally, and southwest Ohio specifically, is uniquely suited to form and operate such a COE given existing world-class capabilities. The COE will provide a formalized structure through which existing resources will be organized, new capabilities will be created, and vital industry and government needs will be addressed.

Although it is east to only focus on the aircraft and integrated technologies (i.e., airframe, propulsion, navigation, sense and avoid), a holistic approach also considering integral support infrastructure including electrical charging or refueling solutions, launch and recovery facilities (e.g., vertiports), and ground-based Unmanned Traffic Management (UTM) solutions and other factors is required. To enable industry to meet current and future requirements of AAM capable systems, support mechanisms are needed to address multiple focuses including Research and Development, Commercialization, Testing and Certification, and Workforce Development. Each of these focuses are vital and part of an integrated whole that should be considered and supported together through a comprehensive and coordinated solution. The initial primary focuses as led by Sinclair College will center on Testing and Certification and Workforce Development.

Testing and Certification: As activities move past the research and development phase, testing and certification activities are required to validate technologies and ensure compliance with regulations and standards. Southwest Ohio is well positioned to support these activities through testing facilities and organizations including: *Sinclair College National UAS Training and Certification Center, Ohio Department of Transportation - Fly Ohio, Springfield-Beckley Municipal Airport, Dayton Aerospace,* and *ONEIL*. Having a robust ability to support ground and airborne testing, along with development of documentation (e.g. manuals, drawings) meeting regulations and standards is key, not only to produce quality and safe products, but also to meet the requirements for TC, AC, and PC from the FAA. Applying digital engineering best practices is necessary to ensure compliance and success in testing and certification efforts leading toward product commercialization.

Workforce Development: A strong workforce development capability able to address the requirements for AAM and associated digital engineering is critical. Institutions with leading capabilities for the development and implementation of salient academic certificate and degree programs, as well as non-academic credit workforce development training include: *Sinclair College National UAS Training and Certification Center, Wright State University, University of Cincinnati, University of Dayton,* and *The Ohio State University*. New academic programs and non-credit offerings must be developed and implemented to address the specific requirement of a digital engineering enabled workforce operating in aerospace and AAM domains. These institutions will take a leading role in the coordination of efforts, partnering with other academic, government, and industry organizations to ensure alignment.

Timeline and Next Steps: Many existing facilities and resources are already in place at the noted organizations that will support the COE and can be directly applied to envisioned activities, thereby reducing risk and overall costs. However, given the cutting-edge nature of AAM and digital engineering, investments are needed to not only create the structure of the COE and coordinate resources, but also develop new capabilities and content. The aims of the COE will be realized though a multi-phase approach beginning in 2023 with COE formation, establishment of partnerships and collaborations, documentation of requirements, and architecture of support services. From 2024-25, testing and certification, as well as academic and workforce training curriculum will be created and refined. Activities from 2026-29 will expand testing and certification capabilities and increase academic and workforce offerings and enrollments. Efforts will continue from 2030 to expand and mature in alignment with industry needs. Starting from the foundation of the COE, efforts will be coordinated with primary stakeholders to ensure alignment of requirements and outcomes, with partners having a direct role in contributing to COE success through their areas of specialized capability or support.