

FAA William J. Hughes Technical Center

2024 VERIFCATION AND VALIDATION SUMMIT FORUM WHITEPAPER

Operationalizing Advanced Concepts: Making It Happen

September 27, 2024

John Frederick, Verification and Validation Strategies and Concept Visualization Branch, ANG-E5A, FAA Columb Higgins, LS Technologies Angela Moore, LS Technologies

> WILLIAM J. HUGHES TECHNICAL CENTER ATLANTIC CITY INTERNATIONAL AIRPORT, NEW JERSEY 08405

TABLE OF CONTENTS

1	Intro	duction	1
2	Pres	entations	2
	2.1 Tech	Holistic Approach to Delivering Complex Solutions: Process, People, nology, Culture	3
	2.	1.1 Discussion	. 6
	2.2 Integ	National Background Investigation Services Program, A Case Study in ration of Agile Development with DOD-Mandated V&V	7
	2.3	Preparing for Advanced Air Mobility Through Modeling and Simulation	8
	2.3	3.1 Discussion	10
	2.4 Urba	Operational Concepts, Architecture, and Requirements Integration for the n Air Mobility System	10
	2.4	4.1 Discussion	12
3	Rour	ndtable Discussions: Exploring the Problem Space	12
	3.1	Barriers to Cultural Change	13
	3.2	Tools for Cultural Change	14
	3.3	Cultural Leadership	15
	3.4	Agile Culture and Shifting Left/Right	15
4	Cond	clusion	16

LIST OF FIGURES

Figure 1.	Where is culture in the picture?	3
Figure 2.	Subcultures/Countercultures in an Overall Organizational Culture	4
Figure 3.	Holistic Elements of Change	5
Figure 4.	Innovate 28 Near-Term Operations	9
Figure 5.	Where Faults are Introduced, Found, and Removed in Development	1

1 INTRODUCTION

This whitepaper is based on presentations and discussions held during the 19th Verification and Validation (V&V) Summit Forum. The FAA William J. Hughes Technical Center's (WJHTC) V&V Strategies and Concept Visualization Branch (ANG-E5A), in partnership with the Department of Transportation's (DOT) Highly Automated Systems Safety (HASS) Center of Excellence, conducted the V&V Summit Forum on May 8, 2024 at the National Aerospace Research and Technology Park (NARTP). Approximately 56 people were in attendance. Speakers addressed the summit's theme: "Operationalizing Advanced Concepts: Making It Happen," with a focus on the people, processes, tools/technology, and organizational culture that will be needed to evolve the national transportation system.

A critical objective of the summit forum was to expand perspectives and awareness on the theme and pursue interagency collaboration to move forward in addressing the many complex challenges of implementing a future vision for air transportation systems. Presentations addressed turning research and results into reality and how to balance the present and future—today's investments and tomorrow's innovation. Discussion focused on the challenges, strategies, and lessons learned for operationalizing investments, and the cultural changes that will be needed to implement these strategies.

Each of the forum's four presentations were followed by a brief question-and-answer session which sought discovery and clarification on the topic. After a break for lunch and networking, moderators reviewed the morning's presentations and led a roundtable dialogue on the challenges, problem statements, best practices, and lessons learned posed by each speaker.

John Frederick, Manager, ANG-E5A, moderated the summit forum. The following Subject Matter Experts (SMEs) made presentations:

- Crisanne Nolan, Agile Transformation Engineer, Carnegie Mellon University Software Engineering Institute (SEI)
- Dr. David Brown, Consulting Engineer and President, Chesapeake Systems Engineering
- Sherri Magyarits, Project Manager, FAA, Advanced Air Mobility (AAM) Strategy and Integration Branch (ANG-C23)
- Tom Rubino, Test Director, FAA, Innovate 28 AAM
- Dr. Ian Levitt, OCARI Team Manager, National Aeronautics and Space Administration (NASA), Air Mobility Pathfinders (AMP)

This white paper captures thoughts and suggestions made during summit forum presentations and discussion. Accordingly, this document does not represent official FAA policy or proposals for policy. Nor does it represent official policy of the SMEs' respective organizations.

2 PRESENTATIONS

Shelley Yak, Director, WJHTC, opened the summit forum and spoke about the theme, "Operationalizing Advanced Concepts." She said operationalizing means making it work, getting it done, but added that the future of the National Airspace System (NAS) is never done. It is continually evolving and modernizing. The NAS is growing to include diverse operations from Earth's surface to the lower stratosphere involving piloted, remote, and fully automated vehicles—both commercial and noncommercial—operating in airports, space ports, heliports, and vertiports across the nation. This will require various types of air traffic services using data sharing and advanced automation products. What people, processes, technology, and organizational culture do we need to make this vision a reality? Ms. Yak thanked John Frederick and the ANG-E5A branch for organizing the summit and this special forum. She said past summits addressed innovative methods, strategies, and V&V philosophies and principles to modernize the NAS. This year's theme takes us one step forward in operationalizing tomorrow's innovation.

Mr. Frederick welcomed attendees to the summit forum, noting that it marked the start of a relationship with the DOT HASS Center of Excellence. The 2025 V&V Summit will continue with this year's theme, using findings in this white paper to expand and elaborate on how we can operationalize advanced concepts. He said realizing the world of tomorrow will require a change in thinking. That has been a goal of past summits: increasing awareness, providing different perspectives, and exploring ways to move forward. Part of changing our thinking is providing a broader perspective.

Mr. Frederick said the national transportation system of the future will be increasingly complex, including multiple layers of air, water, rail, and surface travel. When we zoom in, the issues look complicated and hard. But zooming out, it looks even more complicated. All of these modes of travel are interconnected and interrelated in ways not fully managed or optimized. Future autonomous systems will have to interface across different platforms with different stakeholders and different services in an intentional way. V&V will be essential to understanding the relationships and integrating these new concepts. That doesn't just apply to V&V organizations. Everyone is involved with validating and understanding concepts, and ultimately adjusting to them.

How will our workforce prepare for these challenges? What are the processes and standards we will use? What are our technology requirements? The effectiveness of our people, processes, and tools will largely depend on a strong organizational culture (Peter Drucker: Culture eats strategy for breakfast). If we want to do something new, we have to stop doing something old. How do we move to the next level, progress, and do the new things? How do we change our culture in order to move forward? Mr. Frederick said the summit forum was organized to socialize those questions and, perhaps, start answering them.

Before presentations, Angela Moore, Program Analyst, LS Technologies, conducted a poll of attendees asking, "What innovation area do you feel is the most challenging when operationalizing advanced concepts?" The results are included below.

- 0% Cybersecurity and Safety
- 6% New entrants and vehicle modes

- 16% Artificial Intelligence and Machine Learning
- 19% Autonomous vehicles and operations
- 28% New and interrelated standards, policies, certifications, and operating procedures
- 31% Interconnected and interdependent systems, services, vehicles

Mr. Frederick said the poll question would be revisited after presentations to see whether perceptions change.

2.1 HOLISTIC APPROACH TO DELIVERING COMPLEX SOLUTIONS: PROCESS, PEOPLE, TECHNOLOGY, CULTURE

Crisanne Nolan is an Agile Transformation Engineer in the Continuous Delivery of Capability Directorate at the Carnegie Mellon University Software Engineering Institute (SEI). She contributes to SEI's transition of Agile research and practices into complex government programs fielding cyber-physical systems through strategic planning, process definition, facilitation, and Agile operations. Her research interests include adoption support for rapid capability delivery and human-centered design approaches for business agility. Ms. Nolan has a Master of Public Management degree from Carnegie Mellon University and co-chairs the SEI Agile Collaboration Group.

Ms. Nolan's presentation focused on the people, processes, technology, and culture necessary for organizations to operationalize state-of-the-art research and introduce new concepts and new innovations into complex ecosystems and systems of systems. Culture is always the hardest for an organization to tangibly address. She used an example of a software factory (see Figure 1).





3

People in the software factory are assigned to specific roles and responsibilities. Processes used by the factory serve to reduce friction and standardize operations. Technology and tools are used by people. But where in such a diagram is the culture? Is it in the background. Ms. Nolan said culture is sometimes described as a shadow in the picture. Culture is what is going on in the picture that is not drawn. Because it is not so easy to see or describe, it is also difficult to change.

To complicate matters, organizations usually do not have a single culture. Large organizations are broken down into agencies, divisions, teams, etc. Each unit has a variation of the overall organizational culture. Those subcultures, nested subcultures, cross-cutting cultures, and countercultures all interact with the larger organizational culture and with each other (see Figure 2). We may be separate from those cultures, but we are affected by them. Ms. Nolan used the example of a team hiring 10 new employees and then working in a whole new way. There will probably be effects rippling out to other cultures around them as a result.



Figure 2. Subcultures/Countercultures in an Overall Organizational Culture

Ms. Nolan quoted psychologist Edgar Schein describing culture as a pattern of shared assumptions that has served a group well and which they are ready to use into the future. Some cultures are driven by results, and no matter what they do, as long as they get results, they are going to continue to behave that way. In a hierarchical culture, a new member might have an idea but they have to run it up the chain of command before they suggest it to the group. In either case, the organizational culture is heavily influenced by how it did things before. If it worked well, everybody is liable to continue doing it that way, which is why cultural change can be so hard.

Sometimes organizational cultures are influenced or defined by a mission statement or charter. Ms. Nolan said those can be helpful, but more often they are pictures of what a team is supposed to be doing, or what people think they should be doing, but they do not

describe real day-to-day activities. Some aspects of organizational culture are important to the system but may not appear in a document. You cannot look at an organizational chart and determine if a team is innovative. When thinking about and addressing organizational culture, it is important to see the reality on the ground. What do things actually look like? How do people really interact? It takes careful examination. If there is friction or misalignment caused by communication issues or interrelationships, how do we understand that and work past it? We are not going effect the cultural change alone. We will have to work with other people to make lasting change.

Cultural change can occur on different scales. On a smaller scale, procedures and skills are easier to change. By giving people the knowledge they need and the tools they need, they can operationalize a system or service. But on a larger scale, when you are changing the strategy of an ecosystem, or shifting the organizational mission that revolutionizes how the organization is structured, cultural shifts can take years. We are seeing that as Agile development matures. Developers and independent V&V analysts may no longer work individually for months on a particular artifact. They will team up and collaborate. As they continue to interact and experiment, they will decide how to work differently. Over months or years, that will become a cultural change.

Ms. Nolan closed by asking if we are prepared to accept change in our organizational cultures. It will require a holistic approach, including a well-communicated and consistent vision, resources, capable workforces, modifying day-to-day processes and strategies, and strong communication across groups. When any of these elements are missing, cultural change can fail (see Figure 3).



Figure 3. Holistic Elements of Change

2.1.1 DISCUSSION

Moderators opened discussion at the conclusion of the presentation. Attendees first participated in a poll asking, "In your experience, which element of change is most often missing when operationalizing advanced concepts?" The results are included below.

- 3% Incentives
- 3% Capable Processes
- 3% Action Plan
- 14% Capable Workforce
- 17% Vision
- 24% Resources
- 34% Organizational Culture

Mr. Frederick echoed Ms. Nolan's description of organizational culture as the shadow, perhaps unseen in Figure 1 but always there. When organizations are trying to accomplish something but failing, culture may be the reason. They have the technology and, in some cases, the resources, but they do not have an organizational culture built on the appropriate domains and relationships. In many cases, these domains and relationships did not exist before; therefore, organizations must adapt.

Attendees then participated in a poll asking, "In your experience, what have you observed contributes most to success when operationalizing advanced concepts?" The results are included below.

- 6% Vision
- 6% Incentives
- 9% Action Plan
- 9% Resources
- 16% Capable Processes
- 16% Organizational Culture
- 38% Capable Workforce

Ms. Nolan said the right culture can help the right processes "stick." A capable workforce is ready to pick up what is being developed and adapted because culture is not setting up barriers. The workforce knows more opportunities and more relationships will benefit them and they lean into the change. They are capably adaptable, looking toward the change and helping to lead the charge.

Mr. Frederick said it is hard to move the culture forward without a compelling vision. Often, we forget the power of a compelling vision. Vision leads to alignment. An organization can only stay in misalignment for so long if you know you have to achieve a shared vision together. It lights a fire and keeps everyone growing and vectored in the same direction. Learning is also important to changing organizational culture. Organizations need to value learning. If we are constantly learning, then we do not find ourselves in one stable position waiting for change. If we are looking forward and thinking about what comes next, incrementally experimenting, then we are constantly in a learning mindset. Ms. Nolan said it is important to build learning into the DNA of your organizational culture so you are ready for the complex systems coming down the line.

2.2 NATIONAL BACKGROUND INVESTIGATION SERVICES PROGRAM, A CASE STUDY IN INTEGRATION OF AGILE DEVELOPMENT WITH DOD-MANDATED V&V

Dr. C. David Brown is a consulting engineer and president of Chesapeake Systems Engineering supporting Department of Defense (DOD) Test and Evaluation (T&E) through the MITRE Corporation and the Institute for Defense Analyses. He also teaches graduate courses in program management and systems engineering for Johns Hopkins University. He is the former Deputy Assistant Secretary of Defense for Developmental T&E and Director of the DOD Test Resource Management Center. He has held a variety of positions throughout his almost 50-year career in T&E, including range instrumentation development, range test director, technology and range director, and test lead for a major Army acquisition program. He has a PhD in electrical engineering from the University of Delaware and an MS in National Security Policy from the Industrial College of the Armed Forces.

Dr. Brown said the DOD is increasing the use of Agile development for software and designated pilot programs, prompting a culture change in T&E. Some challenges during this culture change include scaling up agile teams to address large-scale development and integrating vendor-developed software into systems or systems of systems. To address this, he said government testers have been added into development teams and integration testing is being done in parallel with development so that there is continuous development, test, and delivery.

This continuum builds on the developmental T&E embedded in the Agile and Development, Security, and Operations (DevSecOps) processes. The majority of developmental testing (DT) is performed by the development team. For government acquisitions, some independent DT is required to ensure that government contract requirements are being upheld. Also, government acquisition mandates that the traditional Agile user demonstration be augmented by user acceptance testing and independent operational testing (OT). Dr. Brown said all of the testing is integrated as much as possible to eliminate unnecessary duplication.

Agile T&E principles and best practices include small, highly motivated and committed teams with user engagement. Agile teams are cross-functional, self-organizing entities that can define, build, test, and where applicable deploy increments of value. Teams are led by a Scrum master and include coders, testers, and a product owner. Teams are optimized for communication and value delivery.

Testing is integrated tightly with development and test scripts are derived from user stories. DevSecOps is a continuous process, with multiple steps conducted simultaneously— user demonstrations and limited user testing, limited formal OT and

cyber testing, automated vendor unit and component testing, intercomponent and system integration testing. Incremental capability is delivered as available. Fractionalized development can be difficult to integrate so properly addressing requirements often requires integration across multiple development teams. Dr. Brown said it helps to integrate V&V into the entire development stream. OT and Training (OTT) is beneficial as developers learn a lot about a product as they train people how to use it.

2.3 PREPARING FOR ADVANCED AIR MOBILITY THROUGH MODELING AND SIMULATION

Sherri Magyarits and Tom Rubino of the Innovate 28 Advanced Air Mobility (AAM) portfolio discussed their work integrating new types of electric Vertical Takeoff and Landing (eVTOL) aircraft into the NAS. Ms. Magyarits is a project manager and concept developer for New Entrant Concepts in the FAA's NextGen organization. In 2012, she architected the FAA's Concept of Operations for integrating Unmanned Aircraft Systems (UAS) into the NAS. Since that time, she has continued to develop and mature UAS concepts in collaboration with the FAA, NASA, and industry. Mr. Rubino serves as a systems engineer at the WJHTC. He has 35 years of experience in researching and testing new technologies and future concepts for inclusion in the NAS. Currently, he serves as the test director for the Innovate 2028 AAM portfolio and leads the Innovate 2028 AAM modeling and simulation effort.

Ms. Magyarits said new eVTOL aircraft with new capabilities will require new infrastructure and processes. Innovate 28 is a whole-of-government approach that has been using modeling and simulation capabilities at the WJHTC and elsewhere to help sites interested in AAM integration move forward. The FAA, DOT, NASA, and Department of Energy (DOE) are involved. Initially, Innovate 28 looked at Los Angeles airspace in preparation for the 2028 Olympics but the scope has broadened since then.

AAM is currently focused on eVTOL aircraft, with the first eVTOL models expected to be certified by 2025. The AAM market is predicted to be \$115 billion by 2035. Initial use cases include air taxi services, travel from airports into cities, and cargo and medical transport. Initially, AAM aircraft will be managed by air traffic control (ATC) and remotely piloted but will probably be autonomous in the future. Innovate 28 is working to integrate AAM operations in an ecosystem that also includes regional "vertiports," charging stations for aircraft, and automated routes. Innovation Teams, or iTeams, combine FAA and DOT personnel with local, state, and federal governments in partnership with industry and local communities to develop and define requirements. The aim is to ensure these aircraft are integrated safely and to create permanent and scalable AAM processes and procedures for aircraft certification, airspace management, environmental review, infrastructure, safety, and security at future sites (see Figure 4).



Figure 4. Innovate 28 Near-Term Operations

Ms. Magyarits said the FAA needs industry involvement to help develop solutions. AAM operators may be managing some of their own operations in the future so there will have to be processes through which they communicate with each other and ATC. One obstacle in understanding aircraft performance has been companies' reluctance to provide information on eVTOL aircraft characteristics. The FAA does have agreements with the U.S. Air Force and NASA to leverage their information when building models and simulations.

Mr. Rubino described the modeling and high-fidelity Human in the Loop (HITL) simulations conducted at the WJHTC and elsewhere. He said a diverse set of subject matter experts (SMEs) from iTeams, the FAA's Air Traffic Organization (ATO), and the National Air Traffic Controllers Association (NATCA) helped build simulations focused on AAM air space integration. The use case simulates how AAM operators would fly in and out of Los Angeles International Airport's (LAX) airspace for airport transfers (i.e., passengers flying from the city to the airport on eVTOL aircraft, or vice versa). This is a complicated airspace with multiple layers from smaller regional airports to LAX. Initial fast-time simulations were built on assumptions and surrogates (e.g., helicopters) to model eVTOL aircraft because some characteristics of these aircraft were still unknown. Later, refined fast-time simulations focused on what AAM fleet operations and vertiports would look like in these complicated areas. Finally, HITL simulations based mainly in the WJHTC investigated safety and operational performance in nominal and off-nominal scenarios.

In these scenarios, eVTOL pilots and air traffic controllers interact in the simulator using recorded data from LAX. Pilots use cockpit simulators at the Mike Monroney Aeronautical

9

Center and NASA while air traffic controllers at WJHTC use En Route Automation Modernization (ERAM), Standard Terminal Automation Replacement System (STARS), and voice communication systems identical to those in the tower.

The simulations help inform operations and future vertiport configurations. Where will vertiports be located? How can they provide equitable access to operators? What routes work best in a given airspace? Mr. Rubino said simulations can be repeated with specific eVTOL aircraft or at other locations as they become interested.

2.3.1 DISCUSSION

Mr. Rubino said original equipment manufacturers are not willing to share proprietary information at this point. That is an example of a culture barrier that would have to change as AAM matures. Innovate28 has been able to use NASA models, however, and aircraft certification SMEs have validated that they display flying characteristic similar to the eVTOLs being developed by industry.

In response to a question about traffic volume and demand, Mr. Rubino said the operational tempo of simulations can be increased or lowered as needed. The LAX simulation upped the tempo to 30 operations per hour at one vertipad. The team collectively thought that was too much and later HITL simulations used 12 operations per hour. Would that number of operations relieve highway traffic? No, but Ms. Magyarits said that these are initial entries. Operations will scale up in the future. Traffic management approaches will have to change as AAM use increases and there is still a discussion on how exactly that will happen. Modeling and simulators can validate different concepts so they will be integral to that effort. For instance, HITL simulations found this with potential vertipad locations at LAX: some locations that did not seem feasible ended up being manageable, while others seen as initially promising did not work out. As Innovate28 develops and matures these concepts, the team will have repeatable processes to use with new AAM locations such as Houston, Texas or Florida.

2.4 OPERATIONAL CONCEPTS, ARCHITECTURE, AND REQUIREMENTS INTEGRATION FOR THE URBAN AIR MOBILITY SYSTEM

Dr. Ian Levitt manages the Operational Concepts, Architecture, and Requirements Integration (OCARI) Team for NASA's Air Mobility Pathfinders (AMP) project, where his research focus is on the complex enterprise evolution of the NAS. Prior to joining NASA in 2020, he was with the FAA Office of NextGen's Portfolio Management & Technology Development Office (ANG-C). Dr. Levitt has led international standards for Automatic Dependent Surveillance-Broadcast (ADS-B) technologies and applications and has provided leadership for FAA's and NASA's capabilities for conducting Research, Development, Test, and Evaluation (RDT&E).

Dr. Levitt said the V&V Summit always provides for interesting topics of conversation. He said people, processes, tools, and culture all need to work together to integrate new concepts. The more complex systems become, the more important those four elements are to organizations. But we usually start in the wrong place—tools. That is where many organizations go first, but people and culture are just as important.

AAM and Urban Air Mobility (UAM) programs will be large systems of systems so organizations will need to ensure they have a workforce and culture capable of thinking and working differently to integrate these systems. An agile organizational culture will be able to use tools differently to do its job differently, possibly leading to breakthroughs. Dr. Levitt used the example of online whiteboards. Typically, leadership's inclination is to assemble a small, targeted group to make a decision. But online whiteboards can bring everyone to the table. He described the process as "crowd surfing" to a solution.

Storyboards are another important tool that allows organizations to do their jobs differently. Storyboards get everyone on the same page quickly so that people understand the problem. For increasingly complex systems, we have to bring in more and more diverse sets of perspectives so storyboards are an important starting point. Why are we doing what we are doing? What are we pushing for change? Dr. Levitt said HITL simulations are also helpful in taking the architecture or concept as it is and quickly pulling out research questions. "Do and learn" loops feed progress back into the system as part of a learning process. It is important that this process move quickly as the world is no longer set up for long, 2-year research and development (R&D) activities. By the time you are finished, industry has moved on and much of the work is overcome by events.

Tackling questions faster in an agile manner through do-and-learn loops will help organizations shift left/right on V&V. He referenced the V diagram, which shows where faults are introduced, found, and removed in the development process (see Figure 5).



Figure 5. Where Faults are Introduced, Found, and Removed in Development

The vast majority of erroneous assumptions are entered during the research phase but testers don't find them until they actually start implementing. Then it becomes so

expensive to fix that eventually the faults are not fixed. Developers find a workaround. Using a common basis architecture, executing many do-and-learn loops is one tool to squeeze assumptions out early in development. Dr. Levitt said organizational culture should look to shift left and shift right along the 'V' diagram. Practitioners usually involved with finding faults on the right side of the V need to be involved in the do-and-learn loops on the left. Conversely, researchers on the left need to be grounded with practitioners on the right so their research is informed.

Dr. Levitt said NASA built a UAM Airspace System Research Roadmap that organizes requirements, R&D, and planning efforts in a structured framework for progress and traceability. Recently, a Large Language Model (LLM) was used as a translator interface between users and the database. When users asked a question in plain English, the LLM converted the question into an equivalent cypher query and then responded with a large list of relevant data that the LLM interpreted and converted into an understandable response. Users found the LLM could predict connections to other requirements that should exist but were missed during the initial process of building the model. Dr. Levitt said there was a seven-fold increase in the rate that system engineers can navigate UAM requirements after the LLM was introduced. In some cases, the LLM was able to create requirements more creative than the user.

2.4.1 DISCUSSION

Attendees participated in a repeat poll asking, "After receiving the presentations, which innovation area do you feel is the most challenging when operationalizing advanced concepts?" The results are included below.

- 0% New entrants and vehicle modes
- 6% Cybersecurity and Safety
- 14% Artificial Intelligence and Machine Learning
- 14% Autonomous vehicles and operations
- 17% New and interrelated standards, policies, certifications, and operating procedures
- 50% Interconnected and interdependent systems, services, and vehicles

After considering the forum discussion, the poll responses indicated a near doubling of the "New and interrelated standards, policies, certifications, and operating procedures" from 28%. There was a significant decrease of those who selected "Interconnected and interdependent systems, services, vehicles" to 31%.

3 ROUNDTABLE DISCUSSIONS: EXPLORING THE PROBLEM SPACE

After a break for lunch, moderators reviewed the morning's presentations and led a roundtable dialogue on the challenges, problem statements, best practices, and lessons learned posed by each speaker. The major topics and challenges raised were:

- Agile and DevSecOps
- Shift-Left and Shift-Right are driving the need for cultural change

- How do we overcome the challenges and barriers to change?
- How can we optimize our organizational cultures to operationalize advanced concepts?

The moderators led a discussion to explore and define these problem areas.

3.1 BARRIERS TO CULTURAL CHANGE

Why is it so hard to change organization culture, or do a root cause analysis of the barrier to change? Mr. Frederick said it goes back to the picture in Figure 1. Culture is not explicitly shown. It is not as obvious as people, processes, and tools. There are various nested subcultures within organizations, creating extra hurdles to change. Moreover, there are multiple elements influencing culture (e.g., resources, vision, etc.) and multiple points of failure (see Figure 3). Missing just one element of cultural change can lead to failure. How do we ensure we are vectoring in the right direction to make the most out of our organizations?

Dr. Levitt said that existing organizational cultures typically have an allergic reaction to change. That is human nature. An overarching vision is needed for people to respond.

Ms. Nolan said change for change's sake is not fun for most people. We do not like changing what is working well. You can get a visceral reaction from people when pushing change. It has to be part of a vision and a plan. It is not change for change's sake. It is part of a whole vision to which you are contributing. The organization is finding new ways to succeed.

Dr. Brown said people are part of the organization. They create the culture. Change is typically disruptive and can be disruptive to the point of damage if it does not have these other components. Change has to come with a purpose and guidance. It needs to happen smoothly but also accomplish something.

Cultural change can also be more personal. An individual is being asked to change as part of this process. That include their values and belief system. They now have to align with an organizational culture that is different than what they are used to doing. Mr. Frederick said a certain mindset is needed to overcome the inertia of old behaviors to change culture for the good of the organization. People are used to operating in a certain way. A body in motion stays in motion until it is disrupted. Therefore, cultural change has to be purposeful. Positive disruption is sometimes necessary.

Dr. Brown said we usually wait too long to make change. We wait until our current way of doing things has proven to be bad or unproductive. In that case, change comes out of necessity. It is better to have someone with vision so we can get there before we need to. Ms. Nolan agreed, saying that is a common occurrence in government. There are bureaucratic steps involved, certifications involved, government guardrails in which we have to work that limit change. Cultural change agents have to navigate the world they live in and sometimes they have to be especially creative. Dr. Brown said democracy is similar. It is designed to be inefficient so that we move at a slow enough pace that we do not cause disruptive change. Ms. Nolan said the challenge is aligning that mindset and culture with engineering culture.

Mr. Frederick asked what the biggest challenges to cultural change concerning AAM will be in the near future. Is it integration? Is it getting manufacturers to be more forthcoming about their vehicles?

Mr. Romano said every aspect on the chart in Figure 3 has to be considered. The more points of failure there are, the more challenging change becomes. Compound, complex systems are coming. It is our job to get out in front of them and make the systems interoperable. We are going to have to change some of our processes and the way we work together. That involves a whole-of-government approach, leveraging initiatives in the DOD and DOT to overcome technical barriers and scale up needed infrastructure. There has to be a vision/strategy phase and a tactical/execution phase.

AAM will require a culture change in terms of the public as well. How will people react to eVTOL aircraft flying over their homes or schools every day? How will the workforce react to ATC changes? There will have to be a wholistic approach to change. It has to be about the whole transportation system.

3.2 TOOLS FOR CULTURAL CHANGE

What are some tools or enablers for cultural change?

A shared vision throughout the organization is one critical element for change. Ms. Nolan pointed to the Innovate 28 portfolio—a focused team with a shared vision and organized support. She said it is important for these teams to get the right stakeholders together and then send them back where they came from to "inoculate" that group with visionary steps and prepare them for what is coming.

It is also about being nimble and learning. There is the possibility of having too much action plan, becoming overwhelmed by checklists of what you need to do to change while also doing your job. Ms. Nolan said it is similar to planning a military campaign. It is more than just assembling a group of soldiers. You need the right people with the right mindset and the right tools. They need to be able to learn and react to circumstances because no plan survives first contact with the enemy.

Mr. Frederick said there needs to be a network for getting information out and receiving feedback, and that network needs to be constantly maintained. An informational campaign should target multiple levels of the organization, both internally and externally. The network can communicate the vision to the organization, and the organization and vision continually evolve as that processes continues.

Ms. Nolan said the evolutionary aspect is so important to recognize in culture. We are comfortable understanding technological evolution and advancements, but social evolution can go unnoticed. What are people comfortable with now? What are they going to be comfortable with in 10 years? We have to leave ourselves the space to adapt and that requires careful planning up front. Mr. Frederick said an organization might have a strong vision at the start but later, as workforce turnover occurs, it can lose sight of the goal. An integrated implementation plan and strategy is needed for how you develop, maintain, evolve, communicate, get buy in, and follow up on the vision.

3.3 CULTURAL LEADERSHIP

Leadership has to be intentional about creating and maintaining a productive culture. Annie Augustin, Manager Air Traffic Systems T&E Services, noted that people do not learn culture by reading a book. It is communicated symbolically by actions, words, and constant observations of behaviors. Leadership has to constantly reinforce and communicate its vision. You only get so far by telling people what to do.

Ms. Nolan said it is leadership's job to espouse the vision, helping everyone to understand it at the highest level. There are also change leaders and influencers throughout the organization that leadership needs to have on their side. They may have a job that makes them influential, or sometimes they have a unique set of knowledge. Influencers can proliferate the culture in ways that a leader cannot.

Mr. Frederick said engineers are used to dealing with black and white instructions. If it is written down and briefed, we should be ready to go. But culture takes constant reinforcement and reassurance. In big organizations, leadership has to ensure that everyone sees their role and their contribution to the overall mission. Ms. Nolan said there is a push and pull. Change may not immediately make sense to an individual, but the organization has to find a way to evolve together.

Ms. Moore said it is leadership's job to communicate the why. Professionals understand what they have to do and the way they have to do it. But sometimes there is a gap in communicating the why. Communicating why something has to happen will enhance the vision. The why helps you understand why it is important.

A great group of people can accomplish anything. But that is not sustainable over the long term. How can leadership institutionalize and amplify its vision? Ms. Nolan said knowledge-sharing and new resources can help replicate success and take pressure off the first group that broke the ice. Leadership needs to communicate results. Organizations need to see some progress toward the objective. We are a little bit faster, a lit bit more resilient. We can do something new. Operationalizing the vision also has to leave some room for innovation. Too often, objectives get pushed down through the management structure and become just Jira tickets or Epics. Vision has to be more than checking the right boxes.

Mr. Frederick said there is value in measuring progress. Leadership cannot say that falling short of certain performance metrics by a certain time is a failure. Testers often think in terms of pass/fail. We can also look at the level of progress. Did we move the solution forward? Did we increase situational awareness? Progress should be incentivized and rewarded too.

3.4 AGILE CULTURE AND SHIFTING LEFT/RIGHT

The forum addressed numerous perspectives regarding agile development and agile acquisition. Ms. Nolan pointed out that systems engineers experimented with more agile testing methods instead of architecting a big plan. The learning cycle was agile in itself. However, there is a need to plan and formalize the methods to best migrate to agile development and acquisition in the agency. This formalization affects top-down understanding of the problem, the solution, and the timely implementation of the solution.

There is a barrier of understanding at numerous levels, and entire business models must change significantly to adopt a new paradigm where we build a little, test a little, and collaborate with our developer. The risk and its mitigation are contractual matters to untangle.

Mr. Frederick said people are resistant to change when it comes to Agile. They are used to implementing in a set waterfall development where they define requirements at a certain stage and then move on. Applying agile principles and practices is difficult from a cultural perspective as many different stakeholders need to be involved to make it successful, especially with government acquisitions. How do you do contracting, requirements management, concept development in an agile way?

Ms. Nolan said SEI has spent a lot of time thinking about those questions. The answer may not necessarily be building Scrum teams or a DevSecOps pipeline throughout the federal government. But how can we be incremental? How can we build small pieces? How do we iterate on that to have a better small piece next time? Incremental progress could come in the form of a contract, or a Preliminary Design Review/Critical Design Review in which progress is demonstrated. She said we have to look at ways to break down big work.

Dr. Brown said Agile is not usually applicable to hardware development. Many systems are becoming a hardware shell with complex software inside. Ms. Nolan agreed but said 3D printers and additive manufacturing may change that. Modeling and simulations can help develop new hardware. We also need to leverage Artificial Intelligence and Machine Learning into our learning cycle to produce better hardware and software. Such work is easier said than done.

Mr. Frederick said shift-left seeks to move V&V of concepts and requirements as early as possible. This is critical to agile acquisition strategies. Human nature is to lock down requirements and not look back, but early V&V helps to narrow down the cone of uncertainty so we know what we actually need. Simulation and modeling tools can buy down risk similar to what Innovate 28 is doing in the AAM field. Shift-right is similar, except instead of shifting V&V to the left, it shifts research and concepts to the right so that implementation and integration are considered during development.

Shifting in either direction means bringing down existing barriers and promoting an agile culture with continuous learning. Mr. Frederick said we need to shift left but look right, providing resources for early V&V while remaining cognizant that the system or service will have to integrate with others. Researchers and implementers are typically siloed off from each other so there has to be a level of trust and knowledge-sharing between the groups. Also, when researchers complete one project they are often off to the next concept. To accomplish shift-right would require a culture change.

4 CONCLUSION

The purpose of the V&V Summit Forum was not to find immediate answers to some of these issues but rather to explore the challenges and gain an understanding and perspective of what it will take to operationalize advanced concepts into the national transportation system. The forum and this white paper will inform and help set the stage for the theme, presentations, and discussion at the V&V Summit planned for May 2025.

Many of the strategies and lessons learned to help operationalize new investments will involve understanding and changing organizational culture. Understanding organizational culture is challenging because it can be hard to see. It is not as easy as updating outdated tools and processes. There can be friction in even identifying the culture and needed changes before finding pathways to a solution.

Evolving organizational culture will require a shared vision, communication, resources, and a nimble approach among team members who are capable of creating or reacting to a situation. Does everyone have the same vision of the mission? Similar to members of a band, everyone needs to be playing to the same tune. A good band plays in unison, is agile and fluid. The band can change its tune based on a subtle look or movement. Sometimes the conductor can even walk away—the mission can change—but the band can play on. There is efficiency because information is moving instantaneously through the group; everyone experiences it and reacts to it. The group has the ability to react to something spontaneously, even in a disaster. There is the efficient ability to shift, pivot, and create.

Culture change will require everyone to think and act differently. We may see small, focused teams operating synergistically, with a sharing and movement of information, roles, and responsibilities. Trust between management and the workforce, as well as among teammates, will be essential. There will also need to be trust between organizations and outside stakeholders, such as eVTOL manufacturers, as teams work to implement and integrate new concepts. As organizations move toward more Agile development, testers will have to think of themselves differently. They are not just a critic. They are part of the team—they are in the band—and should treat testing not just as pass/fail but as moving toward a solution.

Finally, culture change has to be intentional. Leadership needs to offer a vision for change and an integrated implementation plan with buy in from the entire organization. The plan will most likely evolve, which means leadership must constantly reinforce the vision and reassure the people affected. It is not just about accomplishing the vision but making continual progress.

Operationalizing advanced concepts, integrating complex systems of systems, communicating with multiple stakeholders across an interconnected and interrelated transportation system—each of these goals would be hard to accomplish separately, but taken together they will require a culture change in how we plan, test, and implement. We will have to work across organizational and domain boundaries to understand relationships, develop trust between disparate groups with different missions, and provide necessary resources to model our vision for the future transportation system. In all of this, culture will have to be demonstrated in more than just a handbook or organizational chart. The necessary culture change will have to be accomplished through the actions and behavior of the organization from top down and bottom up.