Response of The MITRE Corporation to the OSTP RFI on Research and Development Opportunities in Video and Image Analytics

September 5, 2022

For additional information about this response, please contact:
Duane Blackburn
Center for Data-Driven Policy
The MITRE Corporation
7596 Colshire Drive
McLean, VA 22102-7539

policy@mitre.org
(434) 964-5023

<<This page is intentionally blank.>>

About MITRE

MITRE is a not-for-profit company that works in the public interest to tackle difficult problems that challenge the safety, stability, security, and well-being of our nation. We operate multiple federally funded research and development centers (FFRDCs), participate in public-private partnerships across national security and civilian agency missions, and maintain an independent technology research program in areas such as artificial intelligence, intuitive data science, quantum information science, health informatics, policy and economic expertise, trustworthy autonomy, cyber threat sharing, and cyber resilience. MITRE's 9,000-plus employees work in the public interest to solve problems for a safer world, with scientific integrity being fundamental to our existence. We are prohibited from lobbying, do not develop or sell products, have no owners or shareholders, and do not compete with industry. Our multidisciplinary teams (including engineers, scientists, data analysts, organizational change specialists, policy professionals, and more) are thus free to dig into problems from all angles, with no political or commercial pressures to influence our decision making, technical findings, or policy recommendations.

MITRE has led the development and validation of a wide range of video and imaging technologies for multiple federal sponsors through our FFRDCs and independent research. Our sponsors and collaborators include all of those listed in Table 1 of the 2020 *Research and Development Opportunities in Video and Image Analytics* (2020 VIA Action Plan) - from DHS to USDA. Together, we have explored emerging imaging domains such as geospatial, multispectral, linear and non-linear optics, acoustics, and magnetic resonance. A common thread has been situational awareness, which is generally derived from real-time and/or post-processing of the image/video data—whether gathering intelligence or forming a diagnosis. We take pride in designing and optimizing image analysis for our nation's most unique and critical challenges. Furthermore, we act as an unbiased third party in testing, evaluating, and informing our sponsors' decisions on competing analysis approaches.

Introduction and Overarching Recommendations

Significantly Enhance the Strategic Approach

MITRE's overarching assessment of the 2020 VIA Action Plan is that it is fundamentally flawed and needs significant revision to drive the advancements the nation requires. The questions posed in this Request for Information (RFI) will primarily help fine-tune the prior Plan to better support a new administration's priorities rather than enhance the Plan so that it can drive needed impact.

National Science and Technology Council (NSTC) activities succeed when they identify common objectives and then state them in a manner that (a) drives interagency and public-private R&D[1] to meet specific and measurable objectives and (b) enables the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) to review agency plans to ensure they support those objectives.[2] This usually requires a vision of

[1] D. Blackburn and M. Garris. A National Science and Technology Council for the 21st Century. 2021. MITRE, https://www.mitre.org/sites/default/files/publications/pr-21-2388-national-science-technology-council.pdf.

[2] D. Blackburn. Interagency S&T Leadership. 2016. MITRE, https://www.mitre.org/sites/default/files/publications/pr-16-0916-interagency-s-and-t-leadership.pdf.

the desired end-state followed by a strategically developed collection of goals and objectives that need to be met for that vision to become reality. The NSTC can then develop more specific action plans to organize each year's work program to meet those collective goals.

The current Plan attempts to do all of the above in one succinct document, but fails in every case. The current vision statement has no end-state to aspire to reach and is decidedly unmeasurable. It merely states a desire to foster R&D activities related to VIA technologies. It then lists several proposed activities that are at the level expected of an action plan but are instead mislabeled as objectives. Note that many of the included activities are also unmeasurable and that this approach ignores the critical aspects of stating goals and objectives that drive the creation of activities necessary to collectively and systematically meet the vision. The approach in the current Plan allows agencies to claim success by merely doing some related activities while simultaneously not providing agencies, the NSTC, OMB, or OSTP the ability to holistically drive advancement or assess impact or progress. The current approach effectively neutralizes the NSTC's ability to drive progress or assess objectives.

MITRE strongly recommends that the NSTC take a step back and develop an impactful strategy and implementation plan that will strategically drive federal activities and enable the Executive Office of the President (EOP) to assess individual activities and holistic progress toward the unifying VIA vision. It may help to use a strategic planning framework that is consistent with the Government Performance and Results Act (see Figure 1).

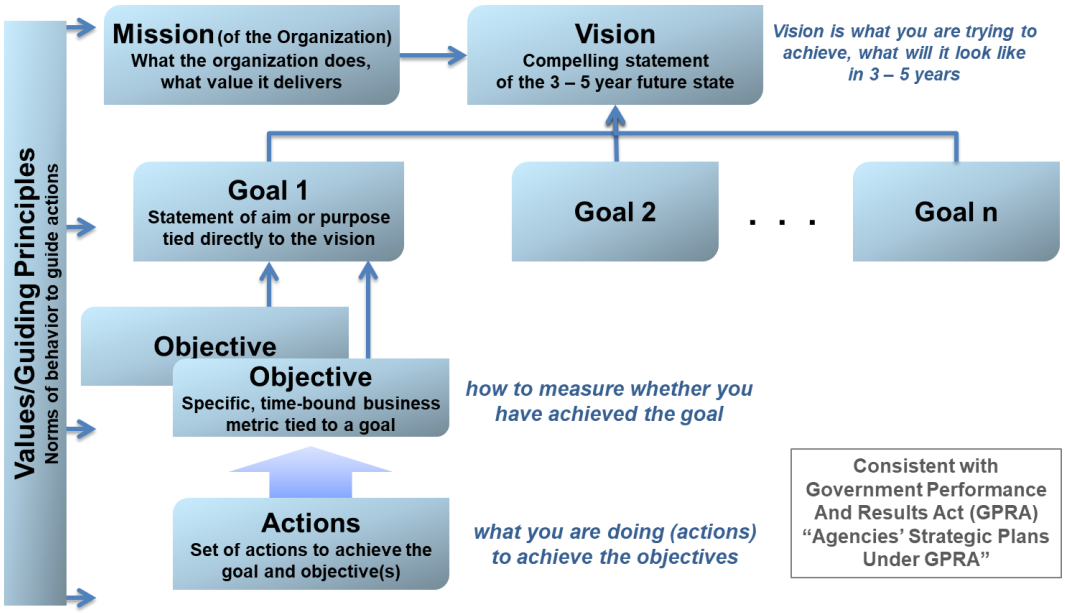

Figure 1. Strategic Planning Framework with Values/Guiding Principles

Such a structured planning framework provides:

- A set of values and principles that guides all subsequent activities
- A universal and compelling vision for the future of VIA research
- A series of goals that collectively enables the vision to be met

- Subordinate objectives and strategies that are specific and time-bound and that both help to drive activities so that they successfully meet the goals and provide the EOP the ability to measure progress

This is the approach used by most NSTC entities, and especially the most successful ones. We believe that this approach, as opposed to the original construct found within the existing Plan, will be much more comprehensive and greatly enhance the NSTC's ability to successfully drive intended outcomes.

For example, a potential vision statement could look something like this: *The United States is recognized as the world leader for both novel development of VIA technologies and the appropriate application of said technologies applied to the nation's security, economic, and citizenry well-being.* With that vision set, the NSTC could then look across its primary use cases (e.g., telemedicine, environment and climate, crop health and food security, intelligence) to determine the set of high-level goals that enable and equip federal agencies, both individually and collectively, to meet the NSTC vision. These goals should be written for VIA specifically, as opposed to the current goals, which are so generic that they apply to numerous Science and Technology (S&T) issues. This approach allows for capability development to target crosscutting technologies across the diverse application set while simultaneously fueling collaborative research to advance the state of the art.

Take a Systems Viewpoint

VIA technologies are becoming increasingly more sophisticated and interconnected, with interactions between components rather than each being leveraged in isolation. This trend will continue to grow into the future and should be recognized within the strategy.

Across most, if not all, primary use cases, an end-to-end system of systems can be optimized to extract more actionable intelligence by improving each step in the process. Directly related to VIA are the imaging systems that form a chain originating from the source, propagating through optics and other media, before being measured by a sensor. This chain traditionally continues after image formation to encompass encoding, compression, and analysis or detection/classification/exploitation. When the system is holistically designed with the analysis method and desired final outcome in mind, the results can be impressive. As one example, compressive sensing illustrates that improved imaging speed and/or signal-to-noise ratio can be found by jointly devised signal acquisition and image reconstruction. Likewise, computational imaging integrates information extraction and filtering into imager design to produce enhanced output.

Since video analysis highlights dynamic behavior in a scene, it is inefficient to collect static information that is subsequently filtered. New detectors capable of event detection at the photonic level reduce data and data rates generated by imagers, which reduces computational burdens downstream. These imaging systems, called event-based or neuromorphic cameras, highlight that emerging imaging hardware often necessitates new VIA. Likewise, it is imperative that static information can still be analyzed with emerging analytics, algorithms, and technologies because the primary use cases do not always control the collection strategy, or source, due to their operating environment.

Additionally, basic parameters of video are the time interval over which measurements of a spatial area are made and the number of discrete temporal instances when measurements are made. Applications are distinguished by both. For example, situational awareness in defense and

security applications requires near-real-time observations and near-continuous data collection. In contrast, monitoring climate and agriculture requires long time periods, over years, but also longer periods between measurements (e.g., hourly, daily, monthly). Most applications are interested in establishing dynamic patterns that are stable over a defined time interval. In defense and security, in addition to identifying stable dynamic patterns, one may also be interested in noting anomalies in these patterns that stand out from random background activity. Observations over an extended period can improve classification, for example, distinguishing between male and female bodies through gait. Observation over an extended period may also enable classification of intent. For example, whereas a photo may allow one to identify the object held by a person as a baseball bat, observing actions over an extended period might lead one to conclude the bat is being used benignly to hit baseballs or being used as weapon to intimidate another person.

Questions Posed in the RFI

1. What R&D has taken place relevant to each goal since the VIA R&D Action Plan was published in March 2020? How does R&D reduce or change the need for the Federal Government to continue to pursue each goal?

As previously noted, the goals in the 2020 Plan are overly broad and unmeasurable. Any VIA R&D could claim alignment to the short- and long-term objectives of the original NTSC Plan, and it is not possible for the NSTC to measure overall progress or how these goals and related activities help to advance VIA capabilities within the federal government. Driving progress and enabling analysis will first require that the goals themselves be significantly enhanced.

2. What societal changes have taken place that would impact the need for the Federal Government to continue to pursue each goal?

Pandemic and Health Equity. One societal example that has been become apparent since 2020 and through the COVID-19 pandemic is healthcare equity, which has become a key issue for many Americans. Meanwhile, imaging and artificial intelligence (AI) technology have improved such that less expertise is needed to operate systems and interpret imagery. Recently, the U.S. Federal Drug Administration authorized a new class of AI-guided ultrasound imagers in which computer vision provides feedback to the ultrasound user in order to get optimal images in real time. VIA is a key component of telehealth and stands to limit the spread of disease, reduce healthcare costs, and empower patients.

Greater Usage of Open Source Data. Since 2020, the abundance of data available from the broad "open source" community has continued to expand (e.g., commercial imagery, social media data). As such, the government has increased both its utilization of and its reliance on this data to perform the aforementioned primary use cases for VIA. Despite these advances in reliance, there is an abundant amount of tension between the public and private sectors, most notably related to the appropriate application of data available in the open source domain within federal agency operations. Specific goals need to be laid out to achieve better public and private coordination, as well as a broad understanding of potential partnership use cases and, most importantly, their limitations.

In addition to broad data availability, the trustworthiness of data is continually in question. Altered imagery and synthetic videos of persons known as "deepfakes" are commonplace

occurrences in today's social environment. Continued and coordinated investments in VIA R&D to advance offensive (creation) and defensive (detection) capabilities are needed to establish methods to ascertain the integrity of the data available for exploitation. Synthetic data can be leveraged further to improve VIA as training data while minimizing risks to data privacy and lowering data collection costs.

These issues, previously considered outside the scope of VIA R&D, will become more and more in scope as VIA capabilities continue to further evolve into interconnected smart systems. Research that enables the country to be ahead of the wave is recommended.

Expanding the Workforce. Most recently, increased world tensions and conflicts demonstrate the need for a measurable objective to attract, develop, and retain a diverse technical workforce and researchers within the VIA community. This issue has been a high priority for the current administration's OSTP. A goal centered on helping ensure more broadly available access to VIA tools, educational opportunities, and training data, thus increasing the size, diversity, and topical experiences of the workforce, should be considered.

3. With R&D advances and changes in the socio-technical environment, what additional goal(s) should the Federal Government consider?

MITRE recommends that goals be crafted after defining the vision, with the goals then reflecting the top-level needs to be met for the vision to become reality. More specific objectives can then be developed to enable each individual goal to be met. Examples of objectives that support VIA goals could be:

- Invest in emerging imagers that can be codesigned with VIA, creating a reinforcing feedback loop between hardware and software/AI developments.
- Incorporate the human factor (i.e., psychology) into algorithm development for video analytics.

Additional data-driven insights that will help the Subcommittee follow.

AI Considerations

The application of AI and machine learning (ML) capabilities within VIA tooling has shifted from promising and emerging to purely dominant. While powerful, the appropriate application of these technologies and the benefits of their utilization can be amplified across missions by carefully considering ways to use VIA tooling to significantly improve—rather than replace—human decision making and psychology. Following this model, the implementation of sound human-machine teaming practices can both enhance the federal agency workforce as well as provide feedback loops to emerging VIA technologies. This process will incur temporary heartburn that prohibits full automation of capabilities, but likely will yield more resilient VIA systems. Human behavior is the heart of the problem, and the human element needs to be part of the solution. Although AI is a promising technology, it cannot be the center of the solution. Humans are at the center, with AI close to the center.

As use cases evolve, such as the application of VIA within telemedicine, the importance for equality of algorithms and analytics will become paramount. Throughout the stages of research, development, and implementation of VIA technologies, numerous design, workflow, decision,

and operational factors will affect the overall capability of VIA. It is imperative that appropriate frameworks and objectives are set forth that seek for continuous identification of gaps in performance and establish mechanisms for evaluation and improvement.

This drive toward more AI applications in VIA also leads to the necessity of incorporating trustworthiness into image and video exploitation algorithms. Our nation's adversaries will continue to attack our VIA systems using ever more powerful adversarial ML approaches. Defenses against these adversarial attacks will need to be continually developed and tested on real-world use cases. MITRE has been developing an adversarial attack framework, ATLAS (atlas.mitre.org), built on the successful MITRE ATT&CK® framework, with adversarial tactics and techniques described for a number of use cases, including VIA cases such as facial recognition systems and mobile camera applications. Any VIA strategy including AI/ML approaches will need to include research into discovering and defending against attacks on the nation's systems. We recommend that any research strategy in VIA includes putting into place oversight mechanisms and structures to ensure the responsible development and use of AI/ML technologies in order to address anticipated misuse, inequities, and potential privacy harms.

Labeling Data

Another research area is developing standards for labeling and archiving video data. Because the field of video analytics is evolving so rapidly, previously agreed-upon standards are likely to become obsolescent in short order. Additionally, commercial video analytic interests are likely to develop video labeling and archive services to obtain dominance in the market. It is in the best interest of the nation's health, safety, and security, while also promoting commerce, for the government or broader community to define and develop standards for video analytics that enable market players of all sizes to invest in R&D activities as the video analytics field continues to mature.