PMOD CAPABILITY ROADMAP

ENABLING A MORE AUTONOMOUS USBP

May 2023

U.S. Customs and Border Protection

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1.0
Introduction

The 2022–2026 United States Border Patrol (USBP) Strategy outlines three major organizational goals. The first of these goals calls for gaining operational advantage by building an operational capability that continuously meets or exceeds the depth and breadth of national security threats. The USBP Strategy envisions achieving this through multiple means, including leveraging modern technology. However, deployment of modern technology requires development of underlying capabilities - a foundation to connect, align, and support technology. To develop these underlying capabilities, the Program Management Office Directorate (PMOD) has created the following *PMOD Capability Roadmap*.

The purpose of the *PMOD Capability Roadmap* is to articulate the vision of implementing necessary technological capabilities that support autonomy across USBP and PMOD. Broad scale autonomy that minimizes manual tasks will bring badges back to the border. USBP will meet mission-critical needs in the field by providing a technical backbone to its surveillance operations that can evolve with current and future advances in artificial intelligence (AI), machine learning (ML), and commercial sensors.

In the immediate term, this will entail formalizing standards for data and autonomy within USBP, building comprehensive knowledge of existing data and mission processes, and fostering iterative development of innovative autonomous solutions. As implementation progresses, USBP's goals will expand to include driving industry innovation in alignment with USBP's autonomy standards, increasing the level of system autonomy, and furthering automation of key processes to reduce mission workload.

Successful implementation of this roadmap is not limited to incorporating technical solutions into USBP's operations. It also requires concurrent development of enabling capabilities within USBP's infrastructure. These range from strengthening supply chains to investing in the workforce. Additionally, this success hinges on integration with the Strategic Planning and Analysis Directorate (SPAD) and their Requirements Management Process (RMP), in order to most effectively trace to requirements, address capability gaps, and justify investment decisions.

Through automating redundant tasks such as persistent surveillance, the time agent-operators spend on such tasks can be reallocated back to the border. Autonomy will also enable greater situational awareness and consistency by promoting communication and interoperability across systems. Furthermore, by providing greater operational transparency to industry partners, USBP will be able to integrate innovative technologies into agency processes more quickly and effectively. These benefits will enhance operational decision-making, targeting, and resource deployment processes to anticipate, counter, and disrupt the threats the faced by the United States.

2.0
Background and Roadmap Purpose

BACKGROUND AND USBP STRATEGIC ALIGNMENT

USBP seeks to achieve operational advantage by building an operational capability that continually meets or exceeds the depth and breadth of national security threats. USBP's operational technology must continue to evolve to keep up with historic levels of encounters and to mitigate the risks caused by siloed systems, limited upgrades, and manpower-intensive technology that can be automated. Recent significant advances in technology provide a unique opportunity to increase mission advantage, integrate information, and relieve agents of burdensome tasks. In alignment with the select relevant components of the 2022-2026 USBP Strategy and USBP Autonomous Surveillance Strategy, as demonstrated in Figure 1.1, the *PMOD Capability Roadmap* outlines the necessary capabilities to increase situational awareness and integration between operational and back-end systems, while allowing agents greater availability to respond to and resolve illegal activity in the field. The Capability Roadmap can be used as an input to the USBP Requirements Management Process, which is Border Patrol's governing process for developing operational requirements that provide traceability to capability gaps and mission needs. The roadmap process will help identify candidate technology requirements for consideration, raising visibility of these candidate requirements to the RMP for validation and integration. This leads to mitigated capability gaps and improved mission effectiveness by providing agents with relevant, cutting-edge technologies that will enhance their safety and efficacy.

2022–2026 USBP Strategy

> **GOAL ONE**
> Gain operational advantage
>
> **GOAL THREE**
> Effective Public and Private Partnerships

USBP Autonomous Surveillance Strategy

> **PILLAR ONE**
> Enhance existing USBP surveillance systems to add autonomous functionality
>
> **PILLAR TWO**
> Ensure autonomy is a key design element of future systems

USBP Requirements Management Process

> **RMP STEPS**
> 1. Strategic Guidance
> 2. Mission Analysis
> 3. Planning
> 4. Programming & Budget
> 5. Execution
> 6. Assessment
> 7. Lifecycle Management

PMOD CAPABILITY ROADMAP

Figure 1.1 *USBP Strategic Alignment*

CAPABILITY ROADMAP PURPOSE

This document describes the underlying technological and enabling capabilities that will allow for increased automation across USBP's operations. It includes a description of how these capabilities work towards USBP's vision of autonomy, guiding principles for measuring progress towards goals, and capability roadmaps for implementation of PMOD's vision. The capabilities, milestones, and principles outlined in this roadmap are not meant to apply to every program within PMOD; areas of this roadmap will apply to each program in varying degrees.

This document describes PMOD's approach for implementing capabilities that will enhance existing operations, reduce time spent on redundant tasks, and promote greater situational awareness. It also details the technological solutions and steps for implementation, as well as ways to engage industry partners to remain on the cutting edge of technology. See below for a greater understanding of the roadmap's application to pertinent stakeholders.
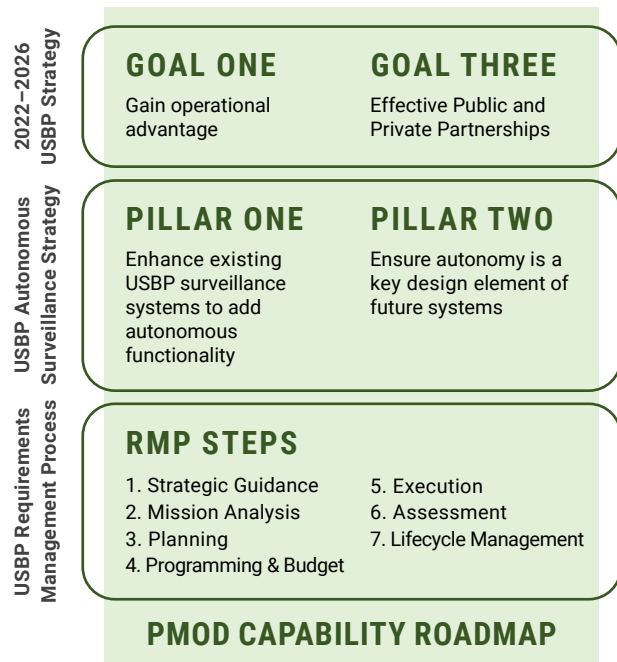
USBP Stakeholders

Portfolio Directors and Program Managers will use this roadmap to craft technology-specific roadmaps and Field Operators will use it to understand how new capabilities enhance existing capabilities.

CBP Stakeholders

The Office of Information and Technology, Office of Acquisition, and others will be critical in evaluating and implementing necessary.

Industry Stakeholders

USBP will develop standards for automation to inform technology-specific roadmaps in collaboration with industry that will drive accelerated development and integration of emerging technologies.

3.0
Vision

THE CASE FOR AUTONOMY AS A CAPABILITY

The past decade has seen unprecedented advances in AI / ML technologies. Both the public and private sectors are increasingly incorporating automation into their operations, from everyday individual tasks to organization-wide platforms. USBP must keep up with recent investments and research and development activities to enhance its surveillance mission and increase automation to provide opportunities for badges to redeploy back to the border.
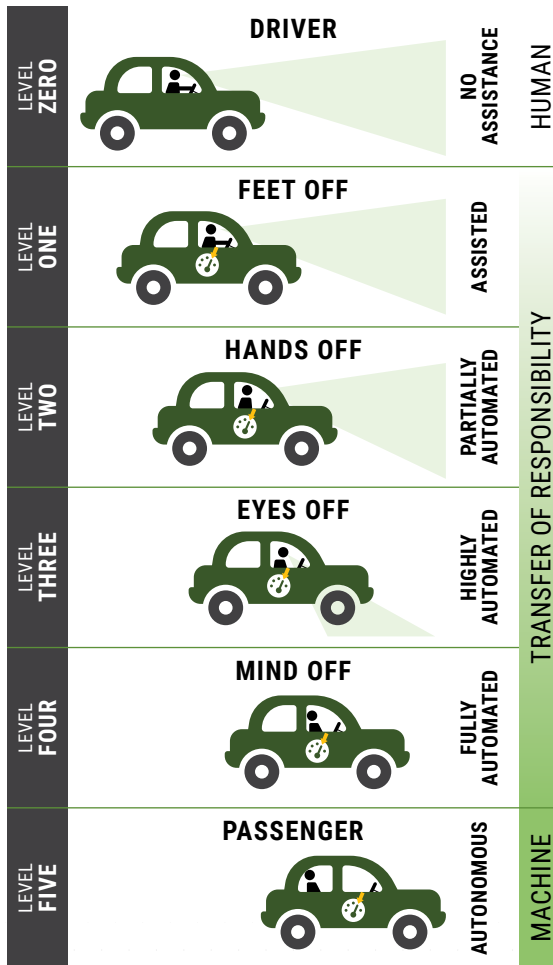
Definitions

Autonomy: the transformation of a function or process from a manual action performed by a human actor (e.g., a Border Patrol Agent) to a self-operating action performed mostly or wholly by technology with the overall goal of minimizing agent time spent on non-tactical activities.

Automation: equipment or systems that work (mostly) by themselves with little or no direct human control

Autonomy = Automation + Learning + Trust

Autonomy is not a single system but rather a design concept that defines how systems interact to achieve more powerful results. Autonomy can be thought of in terms of the levels of human intervention required, ranging from fully human-led to fully autonomous. An analogy for this is the transition from manual driving to fully automating driving (see Figure 1.2). An example of simple autonomy is visualizing the same data on two systems without manually entering that data into both systems. More complex autonomy could include using machine-to-machine messaging from System 1 to trigger autonomous actions by System 2.

USBP is well-positioned to leverage industry relationships and innovations by taking an active approach to enhancing autonomy while collaborating on future technological solutions across CBP and DHS. USBP intends to develop an operational autonomous backbone that increases mission advantage, with the goal of reallocating agents' time towards responding and resolving in the field. In this future state, AI recommended actions will still require agent confirmation or rejection to ensure accuracy (Figure 1.3). This reduction of manpower-intensive surveillance and data entry will occur through automation within sensors, between sensors, and across systems. Autonomy will enhance operations across all 8 USBP Mission Essential Tasks (METs): Predict, Prevent, Detect, Identify, Classify, Track, Respond, and Resolve.

Figure 1.2 Levels of autonomy

Figure 1.3 Classify MET

3.0
Vision *(Continued)*

KEY THEMES FOR CAPABILITY IMPLEMENTATION

Standardization to Drive Industry and Innovation

Developing USBP standards for autonomy to enable better communication with industry partners and accelerate integration across current and emerging platforms.

Critical Actions

- Formalize and communicate USBP standards to government stakeholders.
- Align and utilize USBP standards across industry and acquisition community.

Data Management and Data Preparation for AI / ML

Understanding existing data and then developing trusted methods for automated data preparation to provide necessary inputs for successful capability implementation.

Critical Actions

- In coordination with SPAD, ensure USBP and key stakeholders have comprehensive knowledge of data inventory as data preparation begins.
- Integrate methods of data preparation into USBP's way of business.
- Automate common and trusted data preparation that reduces human workload.

Trust in Autonomy

Building enterprise trust in the platforms through the process of incremental testing and gradual incorporation of autonomous capabilities.

Critical Actions

- Inform autonomy architecture through incrementally delivered projects, non-traditional approaches (e.g., plugfests), market research, and lessons learned from current systems.
- Increase individual platform autonomy and level of trust in the field.
- Introduce autonomy gradually throughout the enterprise.

Unified Workflows

Optimizing and automating mission processes and integrating capabilities such as autonomy across systems.

Critical Actions

- Ensure mission processes are well-defined and understood by staff.
- Automate key processes to reduce mission workload.
- Introduce sensor and system cross-automation and autonomy.

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4.0
Guiding Principles for Defining Success

FUNDAMENTAL CHARACTERISTICS OF INTELLIGENT SYSTEMS

By assessing the following fundamental characteristics and potential examples of intelligent systems, USBP can determine benchmarks for success:

- Ability to perform tasks in unstructured environments. **USBP has the potential to leverage AI / ML technologies to extract and analyze information from unstructured data sources.**

- Ability to learn from experience. **Smart technology can develop more accurate algorithms to predict adversary movements, identify trends and patterns, and inform decision-making in the field.**

- Ability to solve complex problems with inductive and deductive reasoning. **USBP can use AI / ML in its data analytics processes to identify relevant patterns in interactions with immigrant populations.**

- Ability to transfer knowledge from one domain to another. **USBP can implement automated transfers of identified and confirmed migrant population patterns to other domains in the immigration ecosystem.**

5.0
Roadmap for Implementation

TECHNOLOGICAL CAPABILITY AREAS

To execute USBP's vision for autonomy, PMOD must make significant improvements in three Technological Capability Areas. These areas are Compute, Network & Connectivity, and AI & Data Analytics. These areas define the underpinning technologies needed at various planning horizons to meet mission-critical needs and automate redundant tasks. Roadmaps for each capability area are described in the following pages. Implementation of these technological capabilities will enable faster deployment, integrated/complementary systems, and reduced cost and technical risk over time. As technology advances, there may be opportunities to identify additional requirements that don't yet exist. In those circumstances, there may not be an immediate correlation to an existing gap or requirement. PMOD will bring candidate requirements through the RMP for adjudication as necessary and agreed upon.

1. Compute

The Compute technological capability area describes the computing environment required to implement PMOD's vision. The computing environment will include a mix of cloud and edge computing, with increased processing occurring at or near the edge while leveraging on-demand, cloud-based high-performance computing for AI / ML model training.

2. Network & Connectivity

The Network & Connectivity technological capability area delivers the harmonized tactical and backhaul communications needed to support successful capability implementation. Connectivity will not consist of a universal modality, but rather a menu of integrated multi-modal, cost-effective options that can be tailored to geographic areas, bandwidth requirements, and mission need.

3. AI & Data Analytics

The AI & Data Analytics technological capability area consists of big data analytics, computer vision, and pattern recognition. Implementation of this capability area begins with data inventory and annotation, modeling updates, and iterative development of various technologies. Over time, AI and Data Analytics transitions to sensor fusion and automated recommendations of courses of action to interdict illegal activity.

5.1
Roadmap for Compute

	Autonomy		
	ENABLING TECHNOLOGICAL CAPABILITIES		
High-Performance Computing (HPC)	Centralized model training in cloud HPC	Streaming inference for complex AI	On-demand HPC for AI model updates that are distributed centrally and to the edge
Cloud / Hybrid Cloud	Cloud-based archiving and Video Management System	Streaming inference for fusion AI. Cloud-based Common Operating Picture (COP) integrates situational awareness	
Edge Computing	Edge intelligence integrated with sensors	BP-owned edge AI plus low-intelligence sensors for Detect, Identify, Classify, and Track METs (DICT)	Agent wearables or other tools enhance situational awareness and safety

(Row label for the above table: COMPUTE)

Impact

Achievement of the above targets will deliver the required computing environment to meet existing and future operational needs and further support technological capability implementation across the USBP ecosystem.

Immediate Term Objectives

USBP will focus on strengthening edge computing capabilities and transferring model training data into cloud-based platforms.

- This will enable centralized training of AI / ML models with large feature sets that can increase border surveillance coverage and border activity prediction.

Medium Term Objectives

Medium term goals center around developing streaming inference capabilities for complex and fusion AI / ML tools in centralized, cloud-based nodes and constructing a cloud-based COP.

- On-demand HPC will enable expansion and distribution of increasingly complex AI / ML models to maintain mission advantage and provide agents wearable technology or other tools to support their safety and activity in the field.

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5.2
Roadmap for Network & Connectivity

NETWORK & CONNECTIVITY	Autonomy		
	ENABLING TECHNOLOGICAL CAPABILITIES		
Network Architecture & Deployment	Harmonized and secure USBP comms architecture, spectrum optimization, and baseline equipment defined	Tactical voice data and video network build out begins Dark fiber and Low Orbit SATCOM backhaul	Unified and reliable tactical network that incorporates voice, video, and data covers as many border Areas of Operation as possible Mobile satellite communications (SATCOM) remains for the most austere locations
Data Transfer	Iterative development of bandwidth optimization	Bandwidth optimization deployment	

Impact

Updating the supporting network architecture will enhance agent situational awareness and ensure system security and responsiveness.

Immediate Term Objectives

Immediate term goals focus on a coordinated and secured USBP communications architecture, optimized spectrum, and defined baseline equipment to standardize operations across USBP.

- Iterative development of bandwidth optimization will help identify key partners for medium-term implementation.
- Additionally, these objectives will expand to building out a tactical voice, data, and video network for the purpose of enhancing the situational awareness and health monitoring of agents.

Medium Term Objectives

A unified and reliable tactical network that incorporates voice, video, and data will cover most border Areas of Operation to enable independent action by agents and in-field autonomous systems.

- In locations where it's too difficult or costly to implement this network infrastructure, mobile SATCOM voice and data technologies will be used to optimize operations.

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5.3
Roadmap for AI & Data Analytics

AI & DATA ANALYSIS	Autonomy			
	ENABLING TECHNOLOGICAL CAPABILITIES			
Big Data Analytics	Integrated DICT Solutions / MLOps for rapid model updates / Iterative progress with technical & contracting approaches / Learn from current iterative development	Data annotation: inventory data, plan and begin tagging, fill gaps	Analysis of anomalous activity based on patterns of life	Decision Analytics employed to improve automated decisions
Computer Vision (CV)			Continued refinement of CV algorithms and sensor collaboration	Sensor fusion coupled with path prediction for autonomous platform hand offs and multi-sensor DICT plus response overwatch
Pattern Recognition			Macro migration pattern analysis using proprietary and public data	

Impact

Implementation of AI & Data Analytics targets is essential for USBP to better analyze trends, improve prediction of movement patterns, and automate decision-making processes.

Immediate Term Objectives

A focus on integrated solutions for sensor processing and incrementally delivered programs will introduce new AI / ML solutions that enable a more autonomous analytical environment that provides advanced insights.

- For example, ML Operations provide USBP a means to counter rapidly evolving threats and incorporate new intelligence into models.

Medium Term Objectives

The aim will shift towards large-scale solutions that will improve USBP's ability to track movements, analyze patterns, and autonomously recommend and make decisions.

- For example, the collaboration of sensors and centralized AI / ML analysis could better track human trafficking and smuggling groups and reduce the time required to accurately document them.
- These solutions will lead towards putting more agents, equipped with real-time sensors and tools, in the field to perform their core tasks.

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5.4
Roadmap for Enabling Capabilities

ENABLING CAPABILITIES

Achieving PMOD's vision requires enabling capabilities beyond pure technical solutions to ensure the security and resiliency of USBP systems. These capabilities include:

- **Standardization & Interoperability:** Developing standards that lead to "plug and play" integration and simplified sparing strategies

- **Supply Chain:** Enhancing availability and competition in the supply chain while reducing risk

- **Power:** Reducing power demand of devices and expanding renewable and microgrid solutions at remote border sites

- **Training:** Developing Federal workforce skills to better understand and seamlessly interact with the implementation of autonomy in their operations

- **Platform Resilience:** Building in capabilities to address cybersecurity threats to develop resilient systems

- **Digital Engineering and Modeling:** Leveraging modern digital modeling capabilities across the technology lifecycle to accelerate the definition, design, development, acquisition, deployment, and sustainment of mission solutions to the field

6.0
Conclusion

Implementation of capabilities in this roadmap is integral to reducing the number of redundant tasks, returning personnel to operational roles, and supporting the establishment of a Common Operational Picture across USBP operations. To ensure this roadmap guides USBP in the right direction, several actions must occur in partnership with all stakeholders across CBP, including USBP, Office of Acquisition, Office of Information and Technology, and industry partners.

The first step for capability implementation involves an understanding of the current state of agency data and operations. To accomplish this, USBP will define Levels of Autonomy in collaboration with CBP and DHS stakeholders; develop approaches for harmonizing, annotating, and distributing data; and evaluate both existing autonomy implementation efforts and emerging capabilities in industry.

USBP's focus will then shift to integrating automated processes and technology. Business and mission process models for data preparation will be modified to meet capability standards and

platforms will incorporate autonomy in alignment with their operational profiles. The gradual rollout of automation throughout USBP operations will ease the transition to new and more efficient ways of working while increasing trust in autonomy among operators in the field.

The medium-term goal is to incorporate autonomy throughout all systems and align autonomy standards with industry and acquisition. This will entail automation of data preparation and gradual introduction of an enterprise model for mission planning and execution. USBP will work with internal and external stakeholders to develop technology-specific roadmaps for integrating the agency's autonomy standards across USBP operations.

USBP operations must keep pace with ever-evolving threats. By incorporating the capabilities outlined in this roadmap, USBP will leverage technology, automation, and innovation to enhance mission advantage, measure progress, and provide agents the tools they need to ensure national security.

Reference Documents

Booto Tokime, Roger, and Xavier Maldague. *Automatic Defect Detection for X-Ray Inspection: Identifying Defects with Deep Convolutional Network.* 2019.

Gartner Top Strategic Technology Trends for 2022. Gartner, 2022.

Greche, Latifa, and Najia ES-Sbai. *Automatic System for Facial Expression Recognition Based Histogram of Oriented Gradient and Normalized Cross Correlation.* Institute of Electrical and Electronics Engineer, 2016.

Hoeser, Thorsten, and Claudia Kuenzer. *Object Detection and Image Segmentation with Deep Learning on Earth Observation Data: A Review-Part I: Evolution and Recent Trends.* Multidisciplinary Digital Publishing Institute, 2020.

Huang, Hui-Min. "Autonomy Levels for Unmanned Systems." *National Institute of Standards and Technology,* 2016.
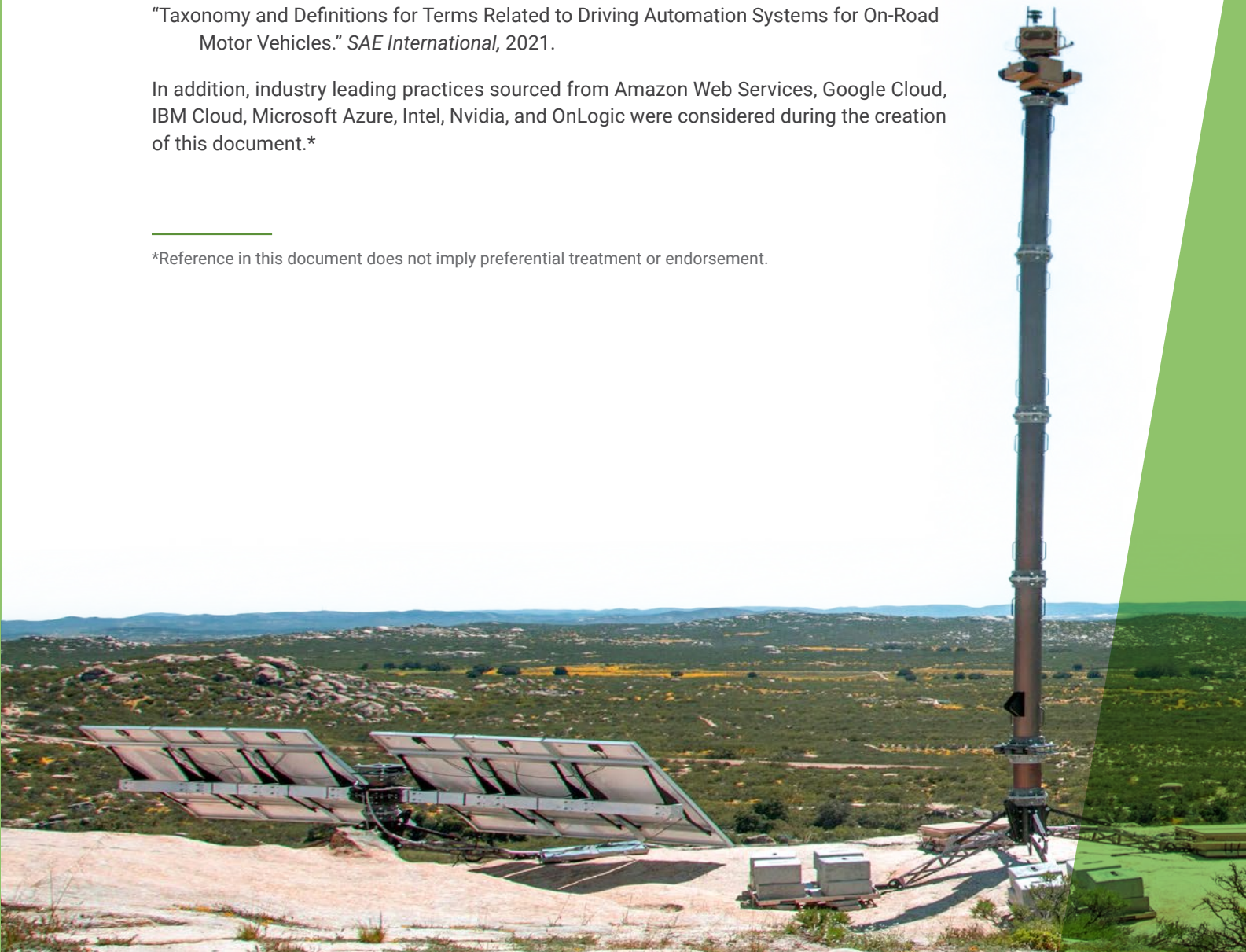
Meystel, A. *Measuring Performance of Systems with Autonomy: Metrics for Intelligence of Constructed Systems.* National Institute of Standards and Technology, 2001.

"Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles." *SAE International,* 2021.

In addition, industry leading practices sourced from Amazon Web Services, Google Cloud, IBM Cloud, Microsoft Azure, Intel, Nvidia, and OnLogic were considered during the creation of this document.*

*Reference in this document does not imply preferential treatment or endorsement.

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