U.S. BORDER PATROL

TECHNOLOGY DESIGN PRINCIPLES & STANDARDS FOR INTEROPERABILITY

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U.S. Customs and Border Protection

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1. PURPOSE

This document describes the technology design principles and standards that U.S. Border Patrol (USBP) acquisition programs of record will incorporate into their system requirements and design to support and promote consistency and interoperability. Consistent with the Program Management Office Directorate (PMOD) Capability Roadmap, USBP has identified interoperability between and among its ecosystem of sensors and supporting systems as a key enabling capability to achieve its goals for increased implementation of autonomous systems. Autonomy is not a single system but rather a design concept that defines how systems interact to achieve more powerful results. The design principles and standards in this document will serve as a foundation to support autonomy across USBP and drive USBP's shift toward achieving operational advantage.

2. BACKGROUND

Currently, most USBP sensor systems rely heavily on Border Patrol Agent (BPA) operators to manually detect, identify, classify, and track Items of Interest (IoI), including the need for BPA operators to continuously monitor and control the operation of those systems. USBP has a need to reduce dependency on BPAs monitoring systems and performing manual system functions. New solutions should autonomously provide alerts and usable data to reduce the number of BPAs required to monitor and operate surveillance systems, allowing more BPAs to focus on confirming and responding to threats. This need is described in the USBP Autonomous Surveillance Strategy and supported by the PMOD Capability Roadmap. Specifically, the PMOD Capability Roadmap cites standardization and interoperability as one of USBP's core enabling capabilities for integrating autonomous capabilities across the agency.

The implementation of standardization within this ecosystem enables effective interoperability through consistent technology standards and system design, engineering, and architecture principles. Systems built to consistent standards, especially data standards, allow more efficient and effective sharing between and among the data sources and stores within the USBP enterprise. It increases the speed and quality of system integration, reduces the time needed for data cleansing or preparation, and supports a common view of data across the USBP enterprise, including activities of both BPAs and illicit actors. The goal is to encourage an environment that supports "plug and play" integration to ensure effective data interchange for collaborative autonomy while increasing interoperability, reusability, portability, and operational capability and reducing development time, technical obsolescence, and lifecycle costs.

The design principles and standards of this document will provide the foundation for the implementation of broad scale autonomy that minimizes manual tasks and brings BPAs 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 entails formalizing standards for data and autonomy within USBP. As implementation progresses, goals will expand to drive industry innovation in alignment with the standards cited in this document, enabling autonomy for USBP and its BPAs at scale.

3. SCOPE

The current scope of this document is identifying mature, existing standards and engineering principles that promote technical interoperability of relevant sensors and command and control systems for the USBP operational space. These layers of interoperability have been described in a proposed interoperability reference model developed by Dr. Andreas Tolk for the 8th International Command and Control Research and Technology Symposium [1] (Section 12). The reference model in Figure 1 (next page) illustrates the full breadth of interoperability which includes the technical levels addressed in this document.

This document focuses on data/object model and protocol interoperability, which enables components and systems to exchange data with one another in standardized formats using standardized protocols. This allows cooperating components and systems to utilize the exchanged data for a common objective. This document also addresses physical interoperability standards where relevant and applicable.

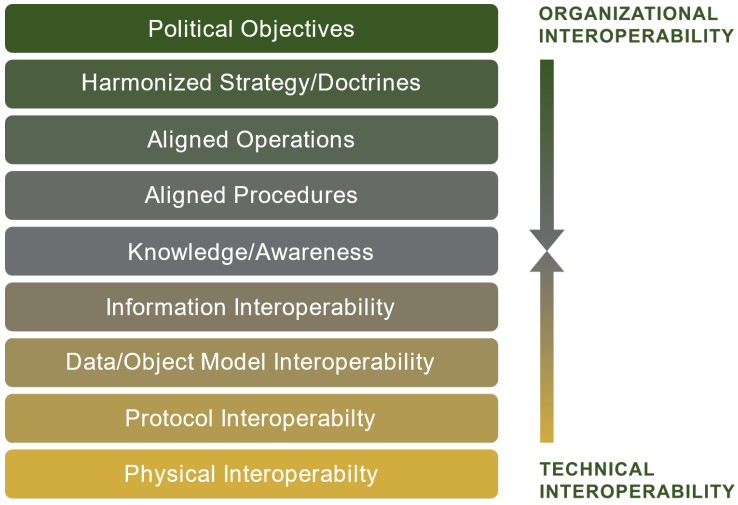

Figure 1: A Full Interoperabilty Model

This document will address the following elements within the technical interoperability layers:

- **Interoperability Design Goals and Principles:** The overall technology design goals and principles that should be incorporated into all USBP system designs to promote interoperability, reusability, and portability.
- **General Data Standards:** Standardized data formats that are to be applied across multiple technologies.
- **Technology-Specific Standards:** Data formats and protocols that are specific to a given technology category. These generally address the areas of sensor data and sensor control where applicable.
- **Communications Standards:** Common network and communications standards that USBP's operational technology must support for the transport of data.
- **Power Standards:** Standards for the generation and delivery of power to the operational systems and subsystems used by USBP.
- **Environmental Standards:** Standards related to the operational environment within which USBP systems must be viable.

When evaluating standards for adoption in the USBP ecosystem, the following characteristics were considered:[1]

- Discoverability
- Portability
- Scalability/Extensibility
- Simplicity
- Standard Maturity
- Technology Readiness
- Domain Compatibility
- Loose Coupling
- Maintainability
- Reliability
- Security

Standards described in this document will be labeled with one of the following statuses:

- **Pending:** A standard or standards area that is still under consideration.
- **Current:** A standard that is currently adopted for use by USBP.
- **Emerging:** A standard that is developing and may be adopted by USBP in the future.
- **Retiring:** A standard that was previously used by USBP but has been superseded.

[1] These characteristics are adapted from those considered in the *C-UAS Interoperability Analysis: Data/Object Layer Standards* developed by the Homeland Security Systems Engineering and Development Institute (HSSEDI) for the Department of Homeland Security (DHS) Science and Technology directorate (S&T) on December 16, 2021. As stated in that document, relevant characteristics "were selected from non-functional quality system attributes defined in engineering documents" such as the International Organization for Standardization (ISO) 9126.

4. INTENDED AUDIENCE

The primary audience for this document are the government teams that manage acquisition programs of record for the purchase, development, and integration of operation technology for USBP, including the engineering teams. Additional audiences may include those internal government groups responsible for portfolio management and program oversight. External industry partners may eventually be informed of this information, though the primary mechanism for communicating these principles and standards to external partners is through the description of program requirements.

5. INTENDED USE

This document should be used to inform and shape the requirements for the systems being developed. The principles should guide the teams' design decisions, and the standards should be used to shape their system requirements.

6. INTEROPERABILITY DESIGN GOALS AND PRINCIPLES

The goal of increasing interoperability is a "plug and play" technology environment that ensures effective data interchange for collaborative autonomy while increasing interoperability, reusability, portability, and operational capability and reducing development time, technical obsolescence, and lifecycle costs.

The design of USBP systems should adhere to certain principles that promote the desired environment. These design principles should be incorporated at all stages of the development of a USBP system, including the creation of initial concepts of operation and architectures, formulation of requirements, design and selection of system alternatives, and deployment and sustainment of the system. This includes general support for a Common Operating Picture (COP) as well as seamless, autonomous interchange of sensor and other system information.

6.1 System Design Principles

6.1.1 GENERAL DESIGN PRINCIPLES

- **USBP systems will favor the use of technology that adheres to common standards.**
  Interoperability is achieved by staying in sync with relevant national, international, and industry-wide standards. The procurement of standards-based, mature, non-developmental solutions promotes cost savings, standard interfaces, and sustainment efficiencies.

- **USBP systems will incorporate changes in technology as they become widely available.**
  The USBP technology enterprise will operate with a mindset of continuous improvement and incorporate new and emerging technologies to increase capabilities.

- **USBP systems will incorporate shared technology and infrastructure capabilities where available.**
  The design of USBP systems will incorporate agency- and department-shared capabilities, then federal partner-shared capabilities, and then non-federal partner-shared capabilities. If none of these are available, only then will a system design its own capability.

- **USBP systems will prioritize operational effectiveness when making selections among readily available technologies, features, and service delivery methods.**
  The design of USBP systems will prioritize the operational effectiveness of available technologies and services over other design considerations.

- **USBP systems will promote operational readiness (capability and availability) at best cost.**
  In accordance with Department of Homeland Security (DHS) Directive 5225-03 policies and directives, cost-wise readiness will be instituted throughout all materiel lifecycle phases to optimize availability, reliability, downtime, and ownership costs.

- **USBP systems will use open architectures that incorporate considerations for continuous innovation.**
  Architectures and designs adopted for USBP systems will enable adaptation to evolving requirements and threats. They will avoid technology obsolescence, proprietary or vendor-unique technology, and reliance on single sources

of supply over the life of the system. They will facilitate system reconfiguration and integration and promote system vendor independence, portability, maintainability, technology insertion, reusability, scalability, interoperability, upgradeability, and long-term supportability.

6.1.2 SENSOR SYSTEMS DESIGN PRINCIPLES

- USBP sensor systems will expose raw sensor data in USBP/U.S. Customs and Border Protection (CBP) defined formats.
- USBP sensor systems will support full integration with a cloud-based USBP COP that provides sensor fusion and correlation, sensor command and control, video storage, and the application of AI/ML algorithms to sensor data.
- USBP sensor systems will provide a USBP COP operator the ability to manage and control each sensor, including:
    - Taking control of the sensor and sensor sub-components (e.g., camera, Radio Detection and Ranging [Radar], illumination), when applicable;
    - Assessing the operational status (health) of the sensor and its sub-components;
    - Providing the ability to adjust sensor settings (e.g., radar sensitivity, illumination, camera pan/focus/zoom), when applicable, based on environmental and operational conditions; and,
    - Interfacing with centralized technology operations centers to monitor and report on the health and status of the sensor system and perform basic maintenance functions.
- USBP sensor systems will allow customization of automated capabilities to meet operational needs or comply with USBP standard operating procedures.
- USBP sensor systems will publish and maintain Interface Control Documents (ICD), Application Programming Interfaces (API), and Software Development Kits (SDK) to continuously modernize integration through the life of both the sensor system and the COP.

6.2 Recommended Functional/System Requirements Language

The following statements listed below provide recommended requirements to include in relevant acquisition documents to support USBP's interoperability goals:

- The System shall adopt common industry information technology, communications, and data standards identified in [*cite relevant document section*] to improve USBP's effectiveness.
- The System shall apply the Cursor-on-Target (CoT) standard for Machine-to-Machine (M2M) communications with the COP.
- The System shall include hardware interfaces which allow for modularity and reusability.
- The System shall include software interfaces which allow for modularity and reusability.
- The System shall have an open architecture with open data standards that can accommodate AI and ML algorithms.
- The System functional software upgrades shall be structured as non-destructive updates to the previous software version.
- The sensor and system software shall come with published APIs, SDKs, and ICDs as applicable.
- The System design shall follow modular open systems architecture (MOSA) guidelines.

7. GENERAL DATA STANDARDS

The standards described in this section are applied across multiple technologies to promote consistent, autonomous communication between systems in multiple domains. This currently includes machine to machine (M2M) messaging, Motion Imagery (MI), and still imagery.

M2M messaging is the autonomous interaction between devices to perform activities without human intervention or supervision. Data standards can support M2M communication by defining data fields, message formats, communications protocols, encryption schemes, and other standard components. M2M standards allow transmitting machines to properly package and transmit messages to be received and accurately interpreted by recipient machines.

7.1 Cursor-on-Target – Current

USBP has adopted CoT as its M2M messaging standard (current version 2.0 released in 2004). CoT is a mature data standard that uses an XML-based message format with an initial small message size that has the flexibility to support larger messages depending on the system requirement. The messages are event-based and contain time-sensitive geospatial information (i.e., "what," "when," and "where") and event type information with additional event descriptors. CoT is relatively easy to implement and supports message transmission over bandwidth limited links. Documentation for the CoT standard is openly available to any user with Department of Defense (DoD) sponsorship.

The adoption of CoT as USBP's M2M messaging standard supports the increased use of the Team Awareness Kit (TAK) as an essential system for shared tactical situational awareness. CoT is the messaging standard used by TAK for exchanging data.

DHS Science and Technology (S&T) has also published a U.S. Border Patrol Sensor System Cursor-on-Target (CoT) Implementation Guide Version 10a (April 22, 2020). This guide serves as a reference for developing requirements for sensor systems and creating system-specific implementation profiles for CoT messaging. It includes already-developed CoT message schemas for the following message types:

- *Radar track messages* for terrestrial sensor systems with radars that can identify a target and generate a track of its movements;
- *Platform position messages* for terrestrial mobile/relocatable sensor systems that do not have a permanent/fixed location (geo-referenced in existing systems);
- *Field of view (FOV) cone messages* for terrestrial sensor systems with imaging sensors (e.g., video cameras, radars) that can surveil an area;
- *Sensor point of interest (SPI) messages* for terrestrial sensor systems with sensors (e.g., laser range finder) capable of generating a geolocation for an IoI;
- *Unattended Ground Sensor (UGS) alarm messages* for range of UGS systems (e.g., acoustic, motion, or seismic, etc.) with sensors capable of detecting an IoI;
- *Situational awareness messages* for a range of BPA-based systems (e.g., mobile phone with Android TAK);
- *Small Unmanned Aircraft System (SUAS) surveillance messages* for a range of SUASs with sensors capable of detecting an IoI;
- *Circle shape messages* for a range of systems which enable the definition of shapes; and,
- *Polyline shape messages* for a range of systems which enable the definition of shapes.

CoT also supports the inclusion of links to video streams in the Details section of multiple message types. USBP will continue to expand the library of pre-defined message types as system-specific implementation profiles are developed to encourage the reuse and extension of existing message types, such as for video or still imagery metadata.

7.2 Machine-to-Machine Standing – Emerging

USBP will continue to monitor emerging M2M standards as they mature to evaluate their applicability and utility in the USBP ecosystem of operational technology. Emerging standards of interest to USBP are listed below:

- *Universal Command and Control:* A data standard framework developed to create reusable components that support DoD "any-sensor-any-shooter" concepts as well as peer-to-peer and autonomous systems.
- *National Information Exchange Model (NIEM):* An overarching data model, XML schema, and methodology abstracted and segmented to support multiple specific domains.
- *Integrated Sensor Architecture (ISA):* U.S. Army Service Oriented Architecture between sensors and platforms that identifies standards and protocols to support system of systems (SoS) integration.

7.3 Motion Imagery Standards – Current

As defined by the Motion Imagery Standards Board (MISB), MI "is a sequence of images, that when viewed (e.g., with a media player) must have the potential for providing informational or intelligence value" [2, p. 14] (Section 12). This definition implies the images composing the MI are generated from sensed data and related to each other both in time and in space [2, p. 14] (Section 12). MI systems "provide the functionality of collecting, encoding, processing, controlling, exploiting, viewing, and/or storing" MI [2, p. 15] (Section 12). These include MI sensors and processors, such as electro-optical systems (EO), infrared (IR) systems, synthetic aperture radar (SAR), light detection and ranging (LIDAR), multi-spectral imagery systems, and hyper-spectral imagery systems. These sensors and processors "are capable of measuring, computing, and embedding context information along with the Motion Imagery in the form of metadata" [2, p. 15] (Section 12).

MI metadata is embedded within an MI system that supports the intelligence, surveillance, and reconnaissance (ISR) capabilities of the MI system. This metadata can include geospatial information, such as the location and elevation of the MI system. It may also include information about the MI system's orientation and specifics about the MI system itself.

MISB, part of the Geospatial Intelligence Standards Working Group, defines the most inclusive and authoritative set of standards governing MI systems used within the federal domain. It is responsible for "reviewing and recommending standards for motion imagery, associated metadata, audio and other related systems for use within the Department of Defense, Intelligence Community, and United States Imagery and Geospatial System (DoD/IC/USIGS)" [3] (Section 12).

To be in conformance with the standards and practices recommended by MISB, an MI system must:

- Retain MI in a digital form within the workflow once it is in digital form;
- Produce a compliant Moving Picture Experts Group (MPEG)-2 Transport Stream (*Note: This does not apply to Joint Photographic Experts Group (JPEG) 2000-based systems or real-time protocol-based systems*);
- Use H.262 (MPEG-2), H.264 (AVC), H.265 (high-efficiency video coding [HEVC]), or JPEG 2000 compression technology;
- Produce non-destructive (not "burned in") metadata;
- Comply with the MISB Standard 0902.8 minimum metadata set; and,
- Add metadata elements as needed for the task.

USBP MI systems must meet these minimum conformance requirements to MISB standards and practices. This includes conformance to MISB Standard 0902.8 that defines the Motion Imagery Sensor Minimum Metadata Set, enabling the basic capabilities of situational awareness, discovery and retrieval, and cross-user/domain dissemination. Additional MI metadata as defined by other MISB standards should be included as appropriate for the mission application.

MISB publications are available at https://nsgreg.nga.mil/misb.jsp.

7.4 Motion Imagery Standards – Emerging

USBP will continue to monitor emerging MI standards as they mature and gain more use to evaluate their applicability and utility in the USBP ecosystem of operational technology. Emerging standards of interest to USBP includes:

- Alliance for Open Media (AOMedia) Video 1: An open, royalty-free video coding technology developed by the Codec Working Group of AOMedia. It is the successor to the VP9/VP10 video coding formats developed by Google.

7.5 Still Imagery Standards – Current

USBP will continue to monitor emerging MI standards as they mature and gain more use to evaluate their applicability and utility in the USBP ecosystem of operational technology. Current standards of interest to USBP include:

- JPEG File Interchange Format (.JPG);
- Portable Network Graphics (.PNG);
- Graphics Interchange Format, Version 89a (.GIF); and,
- Tag Image File Format (.TIF).

8. TECHNOLOGY SPECIFIC STANDARDS

The extensibility of the CoT messaging standard provides a broad base of support for most of the current interoperability needs of USBP. However, there may be specific sensor or technology systems that have mature and widely used data standards that allow for the communication of more detailed information specific to those technology domains. These types of standards will be adopted by USBP as needed to support the continued modernization and interoperability of its operational technology.

For sensor systems, these standards will apply in two areas:

1. *Sensor/technology data:* These standards apply to more detailed or sensor-specific data or metadata that is not part of a standard CoT message for this sensor or technology domain.
2. *Sensor/technology control:* These standards apply to formats or protocols for controlling characteristics of the sensor or technology itself.

These standards will also be applicable in their respective technology areas regardless of the physical platform used to deploy the technology (e.g., tower, land-based vehicle, aerial vehicle, person).

8.1 Optical Imaging Sensors

This category of sensors includes all sensors with optics components and the ability to convert light intensity into pixels. This includes electro-optical cameras and infrared cameras along with assisting technologies such as laser illuminators and laser range finders.

8.1.1 DATA STANDARD – PENDING

Optical imaging sensors include those that produce still imagery and those that produce MI. This section focuses on the protocols used to transmit or stream MI from an optical imaging sensor.

There are a variety of protocols used for streaming MI from an optical imaging sensor system. The appropriate protocol to use can vary depending on the source and destination of the MI. For traditional streaming of MI from an optical imaging sensor to a video/media server, USBP has adopted the Real-Time Transport Protocol/Real-Time Streaming Protocol (RTP/RTSP) as its standard, especially when using Internet Protocol (IP) optical imaging sensors. The current RTP standard is documented by the Internet Engineering Task Force (IETF) in Request for Comments (RFC) 3550. The current RTSP standard is documented in RFC 7826.

For delivery of streaming MI to playback clients, protocols should be selected as appropriate for the specific application using the following considerations:

- Playback scenario (e.g., live versus on demand);
- Playback support;
- Scalability;
- Latency;
- Quality; and,
- Security.

Protocol selection should also consider the general design principles, especially adherence to common, non-proprietary standards. Protocols to consider include HTTP Live Streaming, Dynamic Adaptive Streaming over HTTP (DASH or MPEG-DASH) (International Organization for Standardization [ISO]/International Electrotechnical Commission [IEC] 23009-1:2022), Secure Reliable Transport, and Web Real-Time Communication (WebRTC) (W3C Recommendation).

8.1.2 CONTROL STANDARD – CURRENT

USBP has adopted the use of Open Network Video Interface Forum (ONVIF) profiles for the control of optical imaging sensors where applicable. ONVIF is an open corporate forum that was founded to standardize the IP-based surveillance camera industry. It provides several profiles of compliance to make it easier for companies to create products that are compatible with other manufacturers. These profiles provide a set of mandatory and conditional features implemented in conformant devices to ensure that devices and clients that conform to the same profile will work with each other.

USBP has adopted the following ONVIF profiles for relevant optical imaging sensors (devices) and the clients that control them:

- Profile G – For edge storage and retrieval;
- Profile M – Metadata and events for analytics applications;
- Profile S – For basic video streaming; and,
- Profile T – For advanced video streaming.

Additional information about ONVIF profiles and specifications can be found at https://www.onvif.org/profiles-add-ons-specifications/.

8.2 Radio Detection and Ranging Sensors

Radar sensors emit microwaves from an antenna in a specific direction, and another or the same antenna receives any reflected microwaves from an object at distance. Radars usually provide range, velocity, and angular direction of detected objects but can include advanced functions such as object size, object shape and components, moving parts analysis, and material composition analysis. This category includes both main types of radars, Frequency Modulated Continuous Wave Pulse Doppler, as well as monostatic and quasi-monostatic implementations of those radar types.

8.2.1 DATA STANDARD – CURRENT

USBP has adopted the All Purpose Structured EUROCONTROL Surveillance Information Exchange (ASTERIX) standard for radar data where applicable. This radar data standard was instrumental in integrating the air traffic control systems of Europe and has begun to be used by the Federal Aviation Administration for some of its systems, transitioning from the older Common Digitizer Mode 1 (CD1)/Mode 2 (CD2) standard. ASTERIX has also been adopted by a wide variety of surveillance systems, including the CBP Air and Marine Operations Surveillance System.

The full library of documentation for the ASTERIX standard is currently available at https://www.eurocontrol.int/asterix. The standards documents are separated into multiple categories. The current relevant categories/documents for radar data are CAT048 for “the message structure for the transmission of mono-radar target reports from a radar station (conventional Secondary Surveillance Radar (SSR), mono-pulse, Mode S, conventional primary radar or primary radar using Moving

Target Detection (MTD) processing), to one or more Surveillance Data Processing (SDP) Systems" and CAT062 "for the transmission of System Track Data to a user."

8.2.2 CONTROL STANDARD

No radar control standard has been identified.

8.3 Passive Radio Frequency Sensors

Passive Radio Frequency (RF) sensors use single or multiple RF receivers to receive and analyze RF signals from IoIs. The signals can be decoded and used to determine various characteristics of the IoIs, such as geolocation.

Appropriate standards for passive RF sensors are still being researched.

8.4 Optical Fiber Sensors

This category of sensors uses optical fiber cables to detect seismic, mechanical, and acoustic vibrations and display the location of the source and intensity of the vibrations. The characteristics and location of the detected vibrations can be used to further identify and classify its source.

Appropriate standards for optical fiber sensors are still being researched.

8.5 Ground Sensors

This is a broad category of sensors that includes seismic, acoustic, and magnetic sensors that can be accompanied by optical imaging sensors. This section only applies to the seismic, acoustic, or magnetic aspects of these sensors. All optical imaging sensors in this category must conform to the high-level imagery standards as well as any optical imaging standards, if applicable.

Appropriate standards for optical fiber sensors are still being researched.

8.6 Geographical Information Systems

USBP has traditionally followed the Federal Geographic Data Committee's (FGDC) guidance on the adoption of geospatial standards. The FGDC's authority comes from the Geospatial Data Act of 2018.

The list of FGDC geospatial standards is provided at https://www.fgdc.gov/standards/list and includes relevant standards from multiple sources, including ISO, the Open Geospatial Consortium, and DoD.

USBP does not have an executive responsibility for geospatial data production but does have a data production and data management responsibility to serve its internal workforce and partner agencies. As a result, standards related to data management and positional accuracy are important for new software implementations that may not use commercial products that typically already follow the FGDC standards.

USBP also produces both static and dynamic cartographic artifacts. Cartographic products are often governed by symbology and production guidelines. USBP is in the process of updating its cartographic symbology and production guidelines. These guidelines are mission-specific but are derived from the DHS Geospatial Management guidelines and the MIL-2525 standard. Cartographic guidelines are intended to be fit to purpose and specific projects should define and tailor these to fit the requirements of the specific task. Additionally, static and dynamic cartographic products, such as web browser-based mapping and geospatial tools, should endeavor to be Section 508 compliant, particularly with the colors of map features.

9. COMMUNICATIONS STANDARDS

Specific standards for communications are still being researched.

USBP currently relies on several disparate systems to support voice, video, and data communications across its technology enterprise. These include communications components for:

- Edge networks that connect end users to each other and/or a backhaul network;

- Backhaul networks that connect edge networks to the core or enterprise network; and,
- Combined edge and backhaul networks.

Currently, these networks reflect a history of being constructed incrementally without adherence to an overall architecture or design standard for the entire communications enterprise. The result is a mix of communications technologies as well as a mix of ownership and management of the resulting networks. Current systems and technologies include:

- Land Mobile Radio (LMR);
- Commercial/Private Cellular Systems;
- Satellite Systems;
- Wi-Fi;
- Mesh;
- Point to Point Systems (e.g., microwave and millimeter wave);
- Wired Systems; and,
- Other Systems (e.g., Bluetooth).

Each communications system type has relevant standards or sets of standards that should be considered when formulating requirements for their use, including:

- *LMR:*
  - Project 25 standards from the Telecommunications Industry Association. Homeland security-specific information can be found through the Project 25 Compliance Assessment Program (CAP) overseen by DHS S&T; and,
  - Emerging standards from the Alliance for Telecommunications Industry Solutions (ATIS).
- *Commercial/Private Cellular Systems*: Standards from the 3rd Generation Partnership Project (3GPP);
- *Satellite Systems*: DVB-S/S2 standard and other satellite communications standards from European Telecommunications Standards Institute;
- *Wi-Fi*: 802.11 standards from the Institute of Electrical and Electronics Engineers (IEEE);
- *Point to Point Systems* (e.g., microwave and millimeter wave): DVB-T/DVB-T2 from DVB; and,
- *Wired Systems:*
  - IEEE 802.3-2022 for Ethernet; and,
  - Standards from the Telecommunications Industry Association (TIA) Fiber Optic Tech Consortium for fiber optics.

Internet standards from the IETF must also be reviewed and considered.

In each of these areas, USBP should develop their informative standards, (i.e., best practice guidelines), for the normative standards, (i.e., specified requirements), which should be followed.

When determining appropriate communications standards, USBP will consider multiple layers of the Open Systems Interconnection (OSI) model **as illustrated in Table 1**, though the focus for standardization will more than likely be on the Transport Platform functional group (transport, network, data link, and physical layers).

	OSI Layer	Protocols	Data Units
Application Platform	**Layer 7** Application	DHCP, DNS, FTP, HTTP/HTTPS, IMAP, IRC, POP3, SMTP, SNMP, SSH	**Upper Layer Data**
	Layer 6 Presentation	SSL, TLS	
	Layer 5 Session	NetBIOS, RPC, RTCP, SAP, SMB, Handshaking connection	
Transport Platform	**Layer 4** Transport	TCP, UDP	**Data Segment**
	Layer 3 Network	ARP, IPv4, IPv6, ICMP, IPSec, NAT	**Data Packet**
	Layer 2 Data Link	802.1x, ARP, ATM, FDDI, Frame Relay, L2TP, MAC, PPP, VLAN	**Protocol Frame**
	Layer 1 Physical	10BaseT, 100BaseTX, 802.1x, DSL, ISDN, RS232, T1, Fiber Optics	**Bit/Symbol**

Table 1: The OSI Model with Example Protocols

10. POWER STANDARDS

This is a potential section of standards for consideration. No common, published standards could be identified for reuse, so these informative standards may have to be identified by USBP, especially for power transfer units and power distribution units.

11. ENVIRONMENTAL STANDARDS

Specific standards for environmental considerations are still being researched.

Most of the systems and operational technology used by USBP must operate in uncontrolled environments. For the materiel portion of USBP systems, programs should follow a standard for environmental testing process that results in realistic materiel designs that meet system performance requirements. An example standard to follow is MIL-STD-810H Environmental and Engineering Considerations and Laboratory Tests.

This section of standards should also reference any structural standards that are applicable to USBP systems, such as ANSI/TIA-322 and other standards from the TIA TR-14 Committee for communications structures.

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ACRONYMS

Acronym	Definition
3GPP	3Rd Generation Partnership Project
AI	Artificial Intelligence
AMOSS	Air and Marine Operations Surveillance Systems
ANSI	American National Standards Institute
AOMedia	Alliance for Open Media
API	Application Programming Interface
ARP	Address Resolution Protocol
ATIS	Alliance for Telecommunications Industry Solutions
ATM	Asynchronous Transfer Mode
AV1	AOMedia Video 1
CAP	Compliance Assessment Program
CBP	U.S. Customs and Border Protection
CD1	Common Digitizer Mode 1
CD2	Common Digitizer Mode 2
COP	Common Operating Picture
CoT	Cursor on Target
C-UAS	Counter Unmanned Aircraft Systems
CWR	Cost-Wise Readiness
DASH	Dynamic Adaptive Streaming over HTTP
DHCP	Dynamic Host Configuration Protocol
DHS	Department of Homeland Security
DNS	Domain Name System
DoD	Department of Defense
DSL	Digital Subscriber Line

Acronym	Definition
DVB-S	Digital Video Broadcasting – Satellite
DVB-T	Digital Video Broadcasting – Terrestrial
EO	Electro-Optical
ETSI	European Telecommunications Standards Institute
FAA	Federal Aviation Administration
FDDI	Fiber Distributed Data Interface
FGDC	Federal Geographic Data Committee
FMCW	Frequency Modulated Continuous Wave
FOV	Field of View
FTP	File Transfer Protocol
GIS	Geographic Information Systems
GWG	Geospatial Intelligence Standards Working Group
HLS	HTTP Live Streaming
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IC	Intelligence Community
ICD	Interface Control Document
ICMP	Internet Control Message Protocol
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IMAP	Internet Mail Access Protocol
IP	Internet Protocol
IPSec	Internet Protocol Security
IR	Infrared
IRC	Internet Relay Chat
ISA	Integrated Sensor Architecture
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ISR	Intelligence, Surveillance, and Reconnaissance
JFIF	JPEG File Interchange Format
JPEG	Joint Photographic Experts Group
L2TP	Layer 2 Tunneling Protocol
LIDAR	Light Detection and Ranging

Acronym	Definition
LMR	Land Mobile Radio
M2M	Machine to Machine
MAC	Medium Access Control
MI	Motion Imagery
MISB	Motion Imagery Standards Board
MISMMS	Motion Imagery Sensor Minimum Metadata Set
ML	Machine Learning
MOSA	Modular Open Systems Architecture
MPEG	Moving Picture Experts Group
MTD	Moving Target Detection
NAT	Network Address Translation
NetBIOS	Network Basic Input-Output System
NIEM	National Information Exchange Model
OGC	Open Geospatial Consortium
OSI	Open Systems Interconnection
PDU	Power Distribution Unit
PMOD	Program Management Office Directorate
POP	Post Office Protocol
PPP	Point-to-Point Protocol
PTU	Power Transfer Unit
RADAR	Radio Detection and Ranging
RF	Radio Frequency
RFC	Request for Comments
RPC	Remote Procedure Protocol
RS-232	Recommended Standard 232
RTCP	Real-Time Control Protocol
RTP	Real-Time Transport Protocol
RTSP	Real-Time Streaming Protocol
S&T	Science and Technology Directorate
SA	Situational Awareness
SAP	Session Announcement Protocol
SAR	Synthetic Aperture Radar
SDK	Software Development Kit
SDP	Surveillance Data Processing

Acronym	Definition
SMB	Server Message Block
SMTP	Simple Mail Transfer Protocol
SNMP	Simple Network Management Protocol
SOP	Standard Operating Procedure
SoS	System of Systems
SPI	Sensor Point of Interest
SRT	Secure Reliable Transport
SSH	Secure Shell Protocol
SSL	Secure Sockets Layer
SSR	Secondary Surveillance Radar
SUAS	Small Unmanned Aircraft System
TAK	Team Awareness Kit
TCP	Transmission Control Protocol
TIA	Telecommunications Industry Association
TIFF	Tag Image File Format
TLS	Transport Layer Security
UC2	Universal Command and Control
UDP	User Datagram Protocol
UGS	Unattended Ground Sensor
USBP	U.S. Border Patrol
USIGS	United States Imagery and Geospatial System
TLS	Transport Layer Security
VLAN	Virtual Local Area Networking
W3C	World Wide Web Consortium
WebRTC	Web Real-Time Communication
XML	Extensible Markup Language