UGV Control Interoperability Profile (IOP) Version 0

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1 Scope

1.1 Purpose

This document defines guidelines for the specification of interoperable user interfaces and control hardware configurations. The guidelines in this document should be taken into account when designing Warfighter Machine Interfaces (WMI) and Operational Control Units (OCUs). Specified guidelines will include: look and feel, screen layouts, use interface navigation, operator control unit configuration, and common functions such as warnings, cautions, alerts (WCA's).

Wherever possible, existing standards will be used (Ex: Waypoint icon is provided in MIL STD 2525B). In some cases, existing standards may be used, but updated or expanded on to cover functionality that did not exist when the standard was created (Ex: traditional speedometer with autonomous navigation system max speed setting indicated).

All IOP compliant controllers will be capable of communicating with platforms using the JAUS-based message set contained within the other IOP documents. This Control IOP serves to provide additional guidance as to the design of controllers.

2 Source Documents

The following documents of the issue shown form a part of this specification to the extent specified.

2.1 Government Documents

MIL-STD-1472F	Military Standard, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities.
MIL-STD-2525C	Military Standard, Common Warfighting Symbology.

2.2 Non-Government Documents

- See Section 5

3 Warfighter Machine Interface (WMI)

3.1 Use of This Section

This section is to be utilized as guidance to aid system developers in the development and implementation of control and display systems for unmanned ground vehicle systems, providing a framework allowing system developers to effectively locate controls and information/status elements that are common across most unmanned vehicle platforms for specific functionality. The material developer shall specify specific ID(s) for each piece of functionality that a given system requires. The ID(s) are selected based on the specific mission requirements for that system. For, example section 3.11.2 (Sensors) lists a wide variety of sensors that may not all be required to accomplish the mission requirements for that specific system. The material developer shall select the particular ID(s) that align to the mission requirements for that specific system. Use of this guidance will also serve to drive consistency across unmanned platform programs through common placement, accessibility and graphic/control design (when applicable). This guidance does not preclude controller developers from using novel and innovative control techniques to meet overall system requirements.

The function tables included in this document are associated with a Microsoft Excel file with the same content. This file can be particularly efficient for the intended audience as it enables sorting and search capabilities.

HMI WG - Function Tables_052411.xlsx

3.1.1 Intended audience

This document is intended for systems engineers and designers engaged in the development of unmanned ground vehicle systems. This may be applied toward custom design solutions as well as off the shelf integrations.

3.1.2 Function Tables

The function tables provided in this document serve as guidelines for the implementation of common control capabilities and information/status elements of unmanned ground systems. While an extensive set of capabilities are referenced in the tables, it is intended for a system designer to select only the functions that are relevant to their system. Cells in the tables associated with this document which are blank will be left to the discretion of the implementer. (Note that tables will be periodically updated and updates will be released as needed)

The guidelines manifest themselves in the form of attributes associated with each control type and status element. These attributes include a common reference ID, a brief description of the function/task, a high level categorization, a Control vs Status determination, access level determination, and the presentation of a common widget/icon/graphic (when applicable). They are further described below.

ID
Provides an ID to each of the functions addressed in the document, allowing traceability between IOP documents as needed.

Example: CTRL-Mobility-1 (Identifies that this is in the Control IOP - is a mobility related function - number 1)

Function/task
Presents a brief description of the task or function associated with the ID (e.g. “select asset gear” and “switch between local and zulu time display”).

Category
Provides a high level indication of the type of function being described and possibly where it would be found in the system architecture. It is primarily present to allow sorting in the excel version of the function tables.

Control/Status
Indicates whether the element is a Control (C) (enabling functionality) or a Status (S) (providing information).

Levels of Information Accessibility

Specifying levels of information accessibility will allow a system designer to quickly identify where a control or function should be placed within the hardware and/or navigation scheme of the OCU human machine interface (HMI). This effort will not specify the exact location of the function or control within the interface but rather provide guidance on what common controls and status should be present within each layer of the navigation scheme.

Information Level		Description	Criteria
OCU Hardware Device	HW, HW-covered	Implementation would occur on a hardware input/output device. This includes buttons, switches, lights, etc located on the OCU enclosure, including the screen bezel, as well as joysticks, gamepads, trackball, keyboard, etc. that may be attached to the OCU with a cable or mounted to the OCU enclosure. A set of recommended joystick and gamepad input device mappings will also be provided as part of this effort. HW-covered is a switch or button with a protective cover to reduce the likelihood of accidental activation	(1) Mission Critical - immediate access is critical to mission success and/or crew safety (2) Frequency of Use - function is frequently used, must always be accessible to maintain reasonable crew performance (3) Sequence of Use - function is a required action/step in a mission critical or frequent task (4) Necessary for hardware use (example: OCU power button)
Software Level P – Persistent Status & Navigation	SWP	Persistent area(s) within the interface containing critical status/alert information and controls such as those for basic navigation. The size and arrangement of persistent area(s) are dependent on display size and desired content. The persistent area(s) are always present in the same location no matter where the user has navigated to in the interface.	
Software Level 1 – First Level	SW1	Implementation would occur one level in from any other part of the HMI, i.e., controls, status, imagery, etc at this level would always be accessible from high level basic navigation buttons (1-2 button presses or user commands *to get to* function depending on navigation scheme). Ex: Teleop functionality on a screen accessible from basic navigation buttons	
Software Level 2 – Second Level+	SW2	Functionality would be accessible from within software level 1. This would require 3+ button presses or user commands from anywhere else in navigation scheme *to get to* functionality. Ex: a menu or on a “child” screen to the “parent” main control screen	(1)not frequently used (2) not critical to mission capability

3.1.3 Common Widgets or Icons

Some elements will be associated with standard or generally accepted widgets or icons to communicate the information to the user (such as a dial being used to indicate speed in a commuter vehicle). When applicable, this column will indicate such a common solution. The system developer can find the recommended widget or icon in Widget & Symbol Library attachment, described below.

3.1.4 Reference

Presents any relevant standards, guidelines, etc. that may provide further guidance.

3.1.5 Capability Glossary Attachment

Full details of the capabilities used to create the content in the function tables, including description of and best practices for accommodating system capabilities (ex: handoff, shared control, mobility modes, teleoperation, leader follower, etc.)

3.1.6 Widget & Symbol Library Attachment

The Widget & Symbol Library defines common widgets, symbols, and icons for incorporation into Human Machine Interface (HMI) design. Widget definitions include capability/description, interaction (control and status), visual design, behavior, and scalability. Symbol/icon definitions include description, visual design, and scalability. For IOP V0, this lists contains only the potential necessary widgets and symbols for control HMI interoperability, but does not contain the widgets/symbols themselves. The future version of the attachment will give a detailed description of the widgets/symbols.

Widgets & Symbols List.docx

3.2 Controller Power & Authentication

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Pwr&Auth-1	start (power up) OCU hardware	OCU Power & Authentication	C	HW		
CTRL-Pwr&Auth-2	power down OCU hardware	OCU Power & Authentication	C	HW		
CTRL-Pwr&Auth-3	start OCU HMI software	OCU Power & Authentication	C	NA		
CTRL-Pwr&Auth-4	shut down OCU HMI software	OCU Power & Authentication	C	SW1		
CTRL-Pwr&Auth-5	activate/deactivate power save	OCU Power & Authentication	C	SW1		
CTRL-Pwr&Auth-6	view indication that power save is active	OCU Power & Authentication	S	SW1	Icon	
CTRL-Pwr&Auth-7	log in to OCU HMI software	OCU Power & Authentication	C	NA		
CTRL-Pwr&Auth-8	log out of OCU HMI software	OCU Power & Authentication	C	SW1		
CTRL-Pwr&Auth-9	select software operating state/mode (Ex: training, safe, normal)	OCU Power & Authentication	C	SW1		
CTRL-Pwr&Auth-10	view indication of current OCU operating state/mode (Ex: training, safe, normal)	OCU Power & Authentication	S	SWP*, SW1	Icon (text)	

3.3 OCU Hardware Control

The OCU Hardware Control section lists the functions available to the operator to control high-level hardware such as the display and audio speaker.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-HW-1	turn display/backlight power on/off (quick access for visual signature control)	OCU HW	C	HW		
CTRL-HW-2	adjust display brightness	OCU HW	C	HW, SW2	Widget	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-HW-3	adjust display contrast	OCU HW	C	HW, SW3	Widget	
CTRL-HW-4	adjust OCU speaker volume (0 to 100%)	OCU HW	C	SW2	Widget	
CTRL-HW-5	mute/unmute OCU speaker (quick access for audio signature control)	OCU HW	C	HW		
CTRL-HW-6	view indication that OCU speaker is muted	OCU HW	S	SW1	Icon	
CTRL-HW-7	view indication that hand controller is disengaged (WCA implication)	OCU HW	S	SWP	Icon	

3.4 Unmanned Vehicle Control Rights

Different operators may compete for or share payload and/or mobility control of the same UGV asset, therefore, it is necessary to enforce a prioritization scheme to allow a single user to obtain access. The table below lists some high-level functions related to control rights.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Ctrl Rights-1	view assets that can be controlled by OCU	UV Control Rights	S	SW1		
CTRL-Ctrl Rights-2	"login" to unmanned system to establish communication (Option: login and password authentication when required)	UV Control Rights	C	SW1		
CTRL-Ctrl Rights-3	view indication that communication with asset has been established	UV Control Rights	S	SW1	Icon	
CTRL-Ctrl Rights-5	view current asset control modes for each asset, including self (Ex: mobility control, payload control, monitors)	UV Control Rights	S	SW1	Icon	
CTRL-Ctrl Rights-6	select/request unmanned vehicle control mode(s) (Ex: mobility control, payload control, monitor (default))	UV Control Rights	C	SW1		
CTRL-Ctrl Rights-7	logout (terminate comms) of asset	UV Control Rights	C	SW1		
CTRL-Ctrl Rights-8	view indication that communication with asset has been terminated (logout confirmation)	UV Control Rights	S	SW1	Icon	

3.5 Unmanned Vehicle Startup, Shutdown, Sleep

In order to extend the usable operational time of a UGV, remote operators can change the UGV operating mode to startup, shutdown, and sleep mode. Sleep mode functionality has been deferred to a future version of this document.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-UV Pwr-2	view indication that asset is powered up	UV Power	S	SW1		
CTRL-UV Pwr-4	view indication that asset is powered down*	UV Power	S	SW1	Icon or part of other widget	

3.6 Unmanned Vehicle E-stop

The following table lists basic functions related to UGV emergency stop (estop).

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Estop-1	send emergency stop (estop) message to asset	Estop	C	HW-covered		
CTRL-Estop-2	view indication that emergency stop is active (WCA implication)	Estop	S	SWP	Icon	
CTRL-Estop-3	cancel emergency stop	Estop	C	HW, SW1		

3.7 Basic Status

Basic status elements convey information about the OCU and UGV status, including physical parameters/variables, mode/state settings, sensor readings, detected system failures, etc. The following table lists the basic status functions and information that should be accessible by the operator through the OCU. Eventually, a fuller system health capability will be addressed providing system and subsystem status, prognostics, diagnostics, etc.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Basic Status-1	view local date and time in Date-Time-Group (DTG) format	Basic Status	S	SWP	Icon (text)	
CTRL-Basic Status-2	view Zulu date and time in Date-Time-Group (DTG) format	Basic Status	S	SWP	Icon (text)	
CTRL-Basic Status-3	switch between local and zulu time display	Basic Status	C	SW1		
CTRL-Basic Status-4	view unique identifier/call sign for each asset	Basic Status	S	SW1		
CTRL-Basic Status-5	select asset of interest if more than one system can be controlled	Basic Status	C	SW1		
CTRL-Basic Status-6	view indication of (selected) asset of interest on all relevant screens	Basic Status	S	SW1		
CTRL-Basic Status-7	view asset location/coordinates	Basic Status	S	SWP	Icon (text)	
CTRL-Basic Status-8	view OCU location/coordinates (longitude, latitude, altitude)	Basic Status	S	SW1	Icon (text)	
CTRL-Basic Status-9	switch between coordinate types (longitude, latitude, altitude, MGRS, UTM,…)	Basic Status	C	SW2		
CTRL-Basic Status-10	adjust number of coordinate digits displayed	Basic Status	C	SW1		
CTRL-Basic Status-11	view asset heading (compass tape, digital)	Basic Status	S	SW1	Widget	
CTRL-Basic Status-12	view next waypoint/task indicator (Range: distance and time, etc. Options: separate overlay, part of compass tape)	Basic Status	S	SW1	Widget	
CTRL-Basic Status-13	view current pitch/roll/attitude indicator (WCA implication)	Basic Status	S	SW1	Widget(s)	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Basic Status-14	view direction/distance to controller/self indicator (shows where controller/self is in relation to asset and how far away)	Basic Status	S	SW1	Widget	
CTRL-Basic Status-15	view OCU battery charge status (% charge, time remaining) (WCA implication)	Basic Status	S	SW1	widget	
CTRL-Basic Status-16	view indication of OCU battery issue (WCA implication)	Basic Status	S	SWP		
CTRL-Basic Status-17	view indication that OCU battery is being charged	Basic Status	S	SW1	widget (part of charge status widget)	
CTRL-Basic Status-18	view OCU GPS status/strength	Basic Status	S	SW1	Widget	
CTRL-Basic Status-19	view communications status/strength between OCU and asset (heartbeat) as well as OCU and C2 network	Basic Status	S	SW1	Widget	
CTRL-Basic Status-20	Comms ping	System Health	C	SW2		
CTRL-Basic Status-21	view asset GPS status/strength	System Health	S	SW1	Widget	
CTRL-Basic Status-22	view asset battery charge status (% charge, time remaining) (WCA implication)	System Health	S	SW1	Widget	
CTRL-Basic Status-23	view indication of asset battery issue (WCA implication)	System Health	S	SWP		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Basic Status-24	view indication that asset battery is being charged	System Health	S	SW1	widget (part of charge status widget)	
CTRL-Basic Status-25	view asset fuel status (% remaining, time remaining) (WCA implication)	System Health	S	SW1	Widget	
CTRL-Basic Status-26	view engine power status (on, off) (WCA implication)	System Health	S	SW1	Icons	
CTRL-Basic Status-27	view engine RPMs (WCA implication)	System Health	S	SW1	Widget	
CTRL-Basic Status-28	view engine temperature (WCA implication)	System Health	S	SW1		
CTRL-Basic Status-29	view oil pressure, quantity, temperature (WCA implication)	System Health	S	SW1		
CTRL-Basic Status-30	view sensor functional status (WCA implication)	System Health	S	SW2	Widget (system and subsystem health, prognostics, diagnostics)	
CTRL-Basic Status-31	view laser range finder functional status (WCA implication)	System Health	S	SW2	Widget (system and subsystem health, prognostics, diagnostics	
CTRL-Basic Status-32	view CBRN system(s) functional status (WCA implication)	System Health	S	SW2	Widget (system and subsystem health, prognostics, diagnostics	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Basic Status-33	view microphone functional status (WCA implication)	System Health	S	SW2	Widget (system and subsystem health, prognostics, diagnostics	
CTRL-Basic Status-34	view pan/tilt functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	
CTRL-Basic Status-35	view mast functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	
CTRL-Basic Status-36	view asset light(s) functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	
CTRL-Basic Status-37	view laser target designator functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	
CTRL-Basic Status-38	view arm functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	
CTRL-Basic Status-39	view end effector(s) functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	
CTRL-Basic Status-40	view gripper functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	
CTRL-Basic Status-41	view flipper functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
					health	
CTRL-Basic Status-42	view radio(s) functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	
CTRL-Basic Status-43	view spooler functional status (WCA implications)	System Health	S	SW2	Widget (system and subsystem health	

3.8 Mission Planning

Mission planning in the context of this section relates to the functions of UGV path planning. This capability is intended to provide a simple navigation mechanism. The waypoint is intended to represent a geo-location and may define some simple level of tolerance with respect to signifying the capture of the waypoint itself and desired speed between path segments. Actions at waypoints, waypoint time constraints (e.g., arrival and departure), plan volatility, plan validation, multi-plan definition/selection, and waypoint corridors are deferred to subsequent versions.

The vehicle is assumed to have access to terrain data from various sources such as historic terrain maps and/or real-time terrain scanning. The operator can view the terrain data and plot waypoints for the UGV to traverse. Waypoints can also be assigned using a leader-follower scheme. This section has been divided into terrain map data, waypoint navigation planning, leader/follower, formation planning, mission plan archive and after action review subsections.

3.8.1 Terrain Map Data

Planning navigation for UGV requires a detailed map characterizing traversable terrain. The operator should be able to ascertain which areas of the map are traversable by a particular UGV platform and at what parameter bounds (e.g. speeds, etc.). The following table lists terrain and waypoint information available to the OCU operator.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Msn Plan-1	access map-based mission data entry, allowing entry of waypoints in context with terrain features	Msn Plan - Map	S	SW1	Graphic (UGV map icon)	MIL STD 2525B
CTRL-Msn Plan-2	access waypoint (table) based mission data entry, allowing creation and review of waypoints in context with their attributes (parameters, actions, etc.)	Msn Plan - Map	S	SW2		
CTRL-Msn Plan-3	access terrain information data	Msn Plan - Map	S	SW1		

3.8.2 Waypoint navigation planning

The OCU operator can create/edit navigational waypoints manually, load preconfigured waypoints, and save waypoint configurations. The following table lists waypoint navigation planning functions available to the OCU operator.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Msn Plan-4	create a new mission plan file (plan = waypoints, TBD parameters, actions for vehicle autonomy)	Msn Plan - Create	C	SW1	TBD Mission Plan Map Graphics	MIL STD 2525B
CTRL-Msn Plan-5	name a new mission plan file	Msn Plan - Create	C	SW2		
CTRL-Msn Plan-6	save a mission plan file	Msn Plan - Create	C	SW2		
CTRL-Msn Plan-7	add waypoints to a mission plan	Msn Plan - Create	C	SW2		
CTRL-Msn Plan-8	receive indication if unsafe route paths are plotted (map overlay)	Msn Plan - Create	S	SW1		
CTRL-Msn Plan-9	adjust default TBD parameters within a mission plan (start time, in place time, end time, platform max speed, corridor width, contingency plans, etc)	Msn Plan - Create	C	SW2		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Msn Plan-10	insert TBD actions at waypoints (ex: stop/wait for user input, send message at arrival, sensor actions, etc.)	Msn Plan - Create	C	SW2	TBD Mission Plan Map Graphics	
CTRL-Msn Plan-11	edit a mission plan (name, waypoints, parameters, actions, etc.)	Msn Plan - Create	C	SW2		

3.8.3 Leader/follower planning

The following table lists leader/follower planning functions available to the OCU operator.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Msn Plan-12	specify the asset leader/follower mode within a leader/follower configuration	Msn Plan-LdrFllwr	C	SW2		

3.8.3.1 Formation planning

Vehicles in a leader/follower mode of operation can operate within different formations. These are often implemented as offset position vectors relative to the lead vehicle position. Typically, the operator is allowed to select from a set of pre-configured formations. There are many disturbances than can affect formations (e.g. variation in terrain, obstacles, loss of communication, etc.). These disturbances must be reported to the OCU operator so that potential breaks information can be appropriately handled. The table below lists a set of available functions available to the operator for formation planning.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Msn Plan-13	select min/max following distance (follower attribute)	Msn Plan - Formation	C	SW2	TBD ldr/fllwr graphics	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Msn Plan-14	select position with respect to lead vehicle (follower attribute)	Msn Plan - Formation	C	SW2	TBD ldr/fllwr graphics	
CTRL-Msn Plan-15	select distance from (offset) with respect to lead vehicle (follower attribute)	Msn Plan - Formation	C	SW2	TBD ldr/fllwr graphics	
CTRL-Msn Plan-16	designate lead vehicle (follower attribute)	Msn Plan - Formation	C	SW2		
CTRL-Msn Plan-17	select TBD timeout behaviors (follower attribute)	Msn Plan - Formation	C	SW2		
CTRL-Msn Plan-18	broadcast/multicast group (leader attribute)	Msn Plan - Formation	C	SW2		
CTRL-Msn Plan-19	adjust position update frequency (leader attribute)	Msn Plan - Formation	C	SW2		
CTRL-Msn Plan-20	select TBD timeout behaviors (leader attribute)	Msn Plan - Formation	C	SW2		

3.8.4 Mission Plan Archive & After Action Review (AAR)

Historical data plays a key role in the development of mission plans. Certain planned paths might have high mobility risk (e.g. rollover, stuck, etc.) associated with them. This information would be valuable to the OCU operator when planning missions. Additionally, after a UGV mission, it is important to record the mission effectiveness to a historical database to aid future mission planning.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Msn Plan-21	open/load an existing mission plan file	Msn Plan-Archive	C	SW2		
CTRL-Msn Plan-22	delete existing mission plan file	Msn Plan-Archive	C	SW2		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Msn Plan-23	send existing mission plan file	Msn Plan-Archive	C	SW2		
CTRL-Msn Plan-24	access map-based mission data review	Msn Plan - AAR	S	SW1		
CTRL-Msn Plan-25	view mission performance calculations using mission plan attributes	Msn Plan - AAR	S	SW2	Widgets	
CTRL-Msn Plan-26	access database of previous missions and outcomes	Msn Plan - AAR	S	SW2		
CTRL-Msn Plan-27	save mission information	Msn Plan - AAR	C	SW2		
CTRL-Msn Plan-28	retrieve of mission information	Msn Plan - AAR	C	SW2		

3.9 Mobility

Mobility is affected not only by terrain but by other factors such as UGV configuration and dynamics, UGV controllable degrees-of-freedom, speeds, teleoperation communications channels, the ability to sense terrain and obstacles surrounding the UGV, etc. If mobility parameters are not properly conveyed to the OCU operator, mission failure risk increases. Thus, it is important to relay important mobility related information to the operator continuously. This section is divided into basic mobility functions, teleoperation, mobility/teleoperation aids, and autonomous navigation systems subsections.

3.9.1 Basic Mobility Functions

Basic mobility information and controls available to the OCU operator are listed in the table below.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Mobility-1	issue mobility stop command (ex: rolling stop, etc.) (Not E-stop)	Mobility-Basic	C	SW1		
CTRL-Mobility-2	view indication of mobility stop command received	Mobility-Basic	S	SW1	Icon	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Mobility-3	view current vehicle speed (Options: speedometer, digital, setting value)	Mobility-Basic	S	SW1	Widgets	
CTRL-Mobility-4	view current rotation rate	Mobility-Basic	S	SW2		
CTRL-Mobility-5	switch between vehicle speed units (mph, km/h)	Mobility-Basic	C	SW2		
CTRL-Mobility-6	engage/disengage parking brake	Mobility-Basic	C	SW1		
CTRL-Mobility-7	view indication that parking brake is enabled	Mobility-Basic	S	SW1	Icon	
CTRL-Mobility-8	view trip meter/distance traveled	Mobility-Basic	S	SW2	Widget	
CTRL-Mobility-9	reset trip meter	Mobility-Basic	C	SW2		
CTRL-Mobility-10	view indication that transition between mobility states/modes is not permitted (payload adjustment necessary, etc) (WCA implication)	Mobility-Basic	S	SWP, SW1		

3.9.2 Teleoperation

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Mobility-13	activate/deactivate teleoperation mode	Mobility-Teleop	C	SW1		
CTRL-Mobility-14	view current teleoperation mode (Ex: activated, deactivated)	Mobility-Teleop	S	SW1	Icon	
CTRL-Mobility-15	select asset gear (Ex: forward, reverse, park, etc.)	Mobility-Teleop	C	SW1		
CTRL-Mobility-16	view current asset gear (Ex: forward, reverse, park, etc.)	Mobility-Teleop	S	SW1	Icon	
CTRL-Mobility-17	steer asset, including pivot steer	Mobility-Teleop	C	HW, SW1		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Mobility-18	control vehicle speed (Options: acceleration rate/brake, speed setting (slow, fast, creep, etc))	Mobility-Teleop	C	HW, SW1		
CTRL-Mobility-19	adjust vehicle speed options (Ex: slow, fast, creep, etc.)	Mobility-Teleop	C	HW, SW1		
CTRL-Mobility-20	view curent vehicle speed option (Ex: slow, fast, creep, etc.)	Mobility-Teleop	S	SW1		
CTRL-Mobility-21	view speed/acceleration limits (ex: ANS or platform safety limits)	Mobility-Teleop	S	SW1	Widget (part of current speed widgets)	
CTRL-Mobility-22	activate/deactivate cruise control	Mobility-Teleop	C	SW1		
CTRL-Mobility-23	view indication that cruise control is active	Mobility-Teleop	S	SW1	Icon	
CTRL-Mobility-24	set cruise control speed	Mobility-Teleop	C	SW2		
CTRL-Mobility-25	adjust cruise control speed	Mobility-Teleop	C	SW2		
CTRL-Mobility-26	view current cruise control speed setting	Mobility-Teleop	S	SW1	Widget (part of current speed widgets)	

3.9.3 Mobility/Teleoperation Aids

Mobility aids provide the OCU operator useful indicators to help guide UGV assets. These aids can come in many forms such as audible, visual, and tactile. The following table lists the teleoperation aid functions available to the OCU operator.

3.9.4 Autonomous Navigation Systems

After the OCU operator provides the sequence of waypoints to follow, it is the task of an autonomous navigation system to plan continuous paths between these waypoints for the UGV asset to traverse. The mission may require adjustment due to detected

obstacles, updated enemy locations, environmental changes, etc. The table below lists functions related to interacting with the autonomous navigation system.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Mobility-27	select/assign a mission plan to an asset (plan = waypoints and parameters/actions for vehicle autonomy)	Mobility-ANS	C	SW1		
CTRL-Mobility-28	load/send mission plan onto asset computer	Mobility-ANS	C	SW1		
CTRL-Mobility-29	execute/activate autonomy	Mobility-ANS	C	SW1		
CTRL-Mobility-30	view indication that execute/activate autonomy command is received	Mobility-ANS	S	SW1		
CTRL-Mobility-31	pause autonomy	Mobility-ANS	C	SW1		
CTRL-Mobility-32	view indication that pause autonomy command is received	Mobility-ANS	S	SW1		
CTRL-Mobility-33	resume autonomy (Options: to next plan waypoint, user-selected waypoint, closest waypoint, etc.)	Mobility-ANS	C	SW1		
CTRL-Mobility-34	view indication that resume autonomy command is received	Mobility-ANS	S	SW1		
CTRL-Mobility-35	re-route asset to arbitrary waypoint during mission	Mobility-ANS	C	SW1		
CTRL-Mobility-36	view current vehicle plan (identifier/name) being executed	Mobility-ANS	S	SW1		
CTRL-Mobility-37	view current plan/segment execution state (Ex: stopped, executing, paused, failed, etc)	Mobility-ANS	S	SW1	Icons	
CTRL-Mobility-38	view current plan/segment execution status	Mobility-ANS	S	SW1	Icons	
CTRL-Mobility-39	activate leader/follower formation mode	Mobility-ANS	C	SW1		
CTRL-Mobility-40	view indication that activate formation command is received	Mobility-ANS	S	SW1		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Mobility-41	view indication that asset is in leader/follower formation mode	Mobility-ANS	S	SW1	Icon	
CTRL-Mobility-42	pause leader/follower formation mode	Mobility-ANS	C	SW1		
CTRL-Mobility-43	view indication that pause formation command is received	Mobility-ANS	S	SW1		
CTRL-Mobility-44	resume leader/follower formation mode	Mobility-ANS	C	SW1		
CTRL-Mobility-45	view indication that resume formation command is received	Mobility-ANS	S	SW1		
CTRL-Mobility-46	view current leader/follower formation execution status	Mobility-ANS	S	SW1	Icons	
CTRL-Mobility-47	report current leader/follower formation execution status	Mobility-ANS	C	SW2		

3.10 Payload Control

Flexible UGV assets can often be configured in many ways including what types of payloads are attached. Robotic arms, sensors, software, weapons are a few examples of common payloads. It is important for each UGV asset to have the capability to identify these payloads, understand their capabilities, and provide the additional functionality and status information to the OCU operator automatically. This section is divided into Basic Payload Control Functions and Information, Sensors, Emitters, and Actuators.

3.10.1 Basic Payload Control Functions and Information

The following sections provide basic payload control functions and information.

3.10.2 Sensors

There are many types of payload sensors that can be used on-board a UGV asset. These include but are not limited to Video, Chemical, Biological, Radiological, & Nuclear (CBRN); Chemical Explosive; Microphone; and Laser Range Finder. This section examines the data and controls available for each sensor.

3.10.2.1 Video-Based Sensor

Video based sensors come in various forms. Some video data are colored and others present information in monochrome. Others convey different meanings with hue, saturation, and value (e.g. infrared vs. LADAR) of each pixel. Some cameras can only turn when the vehicle is commanded to turn while others can be controlled independently from the UGV chassis. Even with these differences, there are common HMI elements that can be extracted.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-1	view video feeds from one or multiple sensors (Ex: single view, dual view, quad view, etc.)	Payload-VideoSnsr	S	SW1	Widget (video viewer)	
CTRL-Snsrs-2	select sensor of interest if more than one video-based sensor is available for control	Payload-VideoSnsr	C	HW, SW1		
CTRL-Snsrs-3	view indication of (selected) sensor of interest on all relevant screens	Payload-VideoSnsr	S	SW1		
CTRL-Snsrs-4	activate/deactivate control of video-based sensor	Payload-VideoSnsr	C	SW1		
CTRL-Snsrs-5	view current sensor control mode (Ex: activated, deactivated)	Payload-VideoSnsr	S	SW1		
CTRL-Snsrs-6	turn video feed on/off (Ex: as a bandwidth control measure)	Payload-VideoSnsr	C	SW1		
CTRL-Snsrs-7	view frames per second indicator	Payload-VideoSnsr	S	SW1	Widget (video viewer)	
CTRL-Snsrs-8	reset sensor	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-9	select sensor vision (color, polarity, etc.)	Payload-VideoSnsr	C	HW, SW1		
CTRL-Snsrs-10	control sensor azimuth	Payload-VideoSnsr	C	HW, SW1		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-11	control sensor elevation	Payload-VideoSnsr	C	HW, SW1		
CTRL-Snsrs-12	view current sensor heading (compass tape, digital; world-relative and vehicle-relative indication)	Payload-VideoSnsr	S	SW1	Widget(s), Graphic (map overlay)	
CTRL-Snsrs-13	view sensor elevation	Payload-VideoSnsr	S	SW1	Widgets	
CTRL-Snsrs-14	activate/deactivate stare	Payload-VideoSnsr	C	SW1		
CTRL-Snsrs-15	view indication that stare is active	Payload-VideoSnsr	S	SW1	Icon	
CTRL-Snsrs-16	activate/deactivate track	Payload-VideoSnsr	C	HW, SW1		
CTRL-Snsrs-17	view indication that track is active	Payload-VideoSnsr	S	SW1	Icon	
CTRL-Snsrs-18	activate/deactivate image freeze	Payload-VideoSnsr	C	SW1		
CTRL-Snsrs-19	view indication that image freeze is active	Payload-VideoSnsr	S	SW1	Icon	
CTRL-Snsrs-20	activate/deactivate image stabilization	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-21	view indication that image destabilization is active	Payload-VideoSnsr	S	SW1	Icon	
CTRL-Snsrs-22	open/close iris	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-23	view indication that focus/iris control is manual	Payload-VideoSnsr	S	SW1	Icon	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-24	return to automatic focus/iris control	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-25	control sensor magnification/zoom	Payload-VideoSnsr	C	HW, SW1		
CTRL-Snsrs-26	view current zoom level (%, value (1X, 2X…), etc.)	Payload-VideoSnsr	S	SW1	Widget, Icon (digital)	
CTRL-Snsrs-27	control camera focus (+, -)	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-28	turn auto-focus on/off	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-29	adjust IR illumination	Payload-VideoSnsr	C	SW1	Widget	
CTRL-Snsrs-30	adjust IR brightness/gain	Payload-VideoSnsr	C	SW1	Widget	
CTRL-Snsrs-31	turn IR filter on/off	Payload-VideoSnsr	C	SW1		
CTRL-Snsrs-32	invert video	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-33	view indication that video is inverted	Payload-VideoSnsr	S	SW1	Icon	
CTRL-Snsrs-34	set automated scan pattern	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-35	activate/deactivate automated scan pattern	Payload-VideoSnsr	C	SW2		
CTRL-Snsrs-36	toggle video overlays on/off	Payload-VideoSnsr	C	SW2		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-37	turn on/off rear-view mirror overlay	Payload-VideoSnsr	C	SW2	Widget	
CTRL-Snsrs-38	take a snapshot/screen capture	Payload-VideoSnsr	C	SW1		
CTRL-Snsrs-39	view indication that snapshot/ screen capture was taken	Payload-VideoSnsr	S	SW1	Icon	
CTRL-Snsrs-40	view indication if snapshot/screen capture is not possible (WCA implication)	Payload-VideoSnsr	S	SW1		
CTRL-Snsrs-41	activate/deactivate digital video recorder (DVR)	Payload-VideoSnsr	C	SW1		
CTRL-Snsrs-42	view indication that DVR is active	Payload-VideoSnsr	S	SW1	Icon	

3.10.2.2 CBRN

Chemical, Biological, Radiological, & Nuclear sensors are integrated at the platform. There are a variety of sensors and operational modes vary for each sensor. This HMI definition is generic and targeted for the platform to control the sensor accordingly to meet the HMI requirements.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-43	turn CBRN systems/sensors on/off	Payload-CBRN	C	SW1		
CTRL-Snsrs-44	view CBRN system(s) status	Payload-CBRN	S	SW1		
CTRL-Snsrs-45	set/view CBRN system sensitivity levels, alert and alarm thresholds (WCA implications)	Payload-CBRN	C	SWP, SW1		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-46	set/view CBRN false alarm control	Payload-CBRN	C	SW2		
CTRL-Snsrs-47	view indication of chemical detection(s) (type, LEL, and units) (WCA implication)	Payload-CBRN	S	SWP, SW1		
CTRL-Snsrs-48	view indication of biological target detection(s) (WCA implication)	Payload-CBRN	S	SWP, SW1		
CTRL-Snsrs-49	view indication of radiological detection(s) (units) (WCA implications)	Payload-CBRN	S	SWP, SW1		
CTRL-Snsrs-50	view indication of nuclear detections (rate, total dose, units) (WCA implications)	Payload-CBRN	S	SWP, SW1		
CTRL-Snsrs-51	turn auto-save streaming CBRN sensor data on/off (includes date, time, location stamp)	Payload-CBRN	C	SW2		
CTRL-Snsrs-52	view saved sensor data (option: 2D map showing route and indications of sensor data changes)	Payload-CBRN	S	SW2	Widget	

3.10.2.3 Chemical Explosive Detection

Chemical detectors identify the presence of specific chemicals in the surrounding area of the UGV asset. These sensors report detections back to the OCU operator so that disposal/avoidance decisions can be made. The following table presents the basic Chemical Explosive Detection sensor functions and status information available to the OCU operator.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-53	turn chemical explosive detection system(s) on/off	Payload-ChemExp	C	SW1		
CTRL-Snsrs-54	adjust chemical explosive detection system sensitivity levels	Payload-ChemExp	C	SW2		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-55	view indication of chemical detection(s) (type of chemical) (WCA implications)	Payload-ChemExp	S	SW2		
CTRL-Snsrs-56	set/view chemical explosive detection system false alarm control	Payload-ChemExp	C	SW2		

3.10.2.4 Microphone

It is often necessary to listen remotely using a UGV microphone payload for surveillance and/or to communicate with remote individuals. The following table provides functions and status available to the OCU operator related to the unmanned system microphone.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-57	start microphone recording	Payload-MicPhone	C	SW1		
CTRL-Snsrs-58	view indication that audio is being recorded	Payload-MicPhone	S	SW1	Icon	
CTRL-Snsrs-59	stop microphone recording	Payload-MicPhone	C	SW1		
CTRL-Snsrs-60	adjust micropone audio format	Payload-MicPhone	C	SW2		

3.10.2.5 Laser Range Finder (LRF)

Successful UGV navigation requires detailed knowledge of the surrounding area. Static and dynamic obstacles and other terrain features can impede UGV mobility if not detected. Laser range finder sensors can help in this regard by providing distance information. These distance vectors can also aid in aiming weapons. The following table presents HMI laser range finder related functions and status available to the OCU operator.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Snsrs-61	select laser range finder (LRF) type	Payload-LRF	C	SW1		
CTRL-Snsrs-62	turn LRF on	Payload-LRF	C	SW1		
CTRL-Snsrs-63	turn LRF off	Payload-LRF	C	SW1		
CTRL-Snsrs-64	use/activate LRF (capture range data)	Payload-LRF	C	HW, SW1	Icon	
CTRL-Snsrs-65	view LRF data return (heading, range, elevation to target)	Payload-LRF	S	SW1	Widget	
CTRL-Snsrs-66	adjust LRF data update rate (first or last return)	Payload-LRF	C	SW2		

3.10.2.6 Sensor Archive

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-SnsrArchive-1	system will use default file naming convention for files	SnsrArchive-Basic	S	SW2	Icon (text)	
CTRL-SnsrArchive-2	view memory storage remaining (file size, amount of record time remaining)	SnsrArchive-Basic	S	SW2	Widget	
CTRL-SnsrArchive-3	browse saved files (imagery, video, audio, etc)	SnsrArchive-Basic	S	SW2	Widget	
CTRL-SnsrArchive-4	view number of picture files stored	SnsrArchive-Basic	S	SW2	Widget	
CTRL-SnsrArchive-5	view number of video files stored	SnsrArchive-Basic	S	SW2	Widget	
CTRL-SnsrArchive-6	view number of audio files stored	SnsrArchive-Basic	S	SW2	Widget	
CTRL-SnsrArchive-7	review date, time, location (asset), size of file	SnsrArchive-Basic	S	SW2	Widget	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-SnsrArchive-8	sort files by type, date, time, location, size, etc.	SnsrArchive-Basic	C	SW2	Widget	
CTRL-SnsrArchive-9	open/view picture file	SnsrArchive-Snapshot	C	SW2	Widget (picture viewer)	
CTRL-SnsrArchive-10	delete picture file	SnsrArchive-Snapshot	C	SW2		
CTRL-SnsrArchive-11	rename picture file	SnsrArchive-Snapshot	C	SW2		
CTRL-SnsrArchive-12	download/save picture file to external source	SnsrArchive-Snapshot	C	SW2		
CTRL-SnsrArchive-13	send picture file	SnsrArchive-Snapshot	C	SW2		
CTRL-SnsrArchive-14	play video file	SnsrArchive-Video	C	SW2	Widget (video viewer) Icon	
CTRL-SnsrArchive-15	pause video	SnsrArchive-Video	C	SW2	Icon	
CTRL-SnsrArchive-16	fast forward/rewind video file	SnsrArchive-Video	C	SW2	Icons	
CTRL-SnsrArchive-17	rename recorded video file	SnsrArchive-Video	C	SW2		
CTRL-SnsrArchive-18	delete video file	SnsrArchive-Video	C	SW2		
CTRL-SnsrArchive-19	download/save video file to external source	SnsrArchive-Video	C	SW2		
CTRL-SnsrArchive-20	play audio	SnsrArchive-Audio	C	SW2	Widget (audio player) Icon	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-SnsrArchive-21	adjust audio playback volume	SnsrArchive-Audio	C	SW2	widget	
CTRL-SnsrArchive-22	fast forward/rewind audio	SnsrArchive-Audio	C	SW2	Icon	
CTRL-SnsrArchive-23	delete audio file	SnsrArchive-Audio	C	SW2		
CTRL-SnsrArchive-24	send audio file	SnsrArchive-Audio	C	SW2		
CTRL-SnsrArchive-25	rename audio file	SnsrArchive-Audio	C	SW2		

3.10.3 Emitters

UGVs also have payloads which can affect its surrounding environment at a distance. These include Lights, Speakers, Laser Target Designators, and Weapons. The following subsections describe HMI related functions associated with each of these emitters.

3.10.3.1 Lights

UGVs operate in nighttime as well as daytime operations. During nighttime operations, a light may be needed for visual control through an OCU. Thus, the operator must be able to control the state of the light. The basic controls and status through the HMI are listed in the table below.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Emittors-1	select light/mode of interest if more than one light or light mode is available (Ex: mobility headlights, sensor "flashlight," IR light, etc.)	Payload-Lights	C	SW2		
CTRL-Emittors-2	view indication of selected light/mode of interest	Payload-Lights	S	SW1		
CTRL-Emittors-3	turn light on	Payload-Lights	C	HW, SW2		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Emittors-4	view indication that light is powered on	Payload-Lights	S	SW1	Icon	
CTRL-Emittors-5	turn light off	Payload-Lights	C	HW, SW2		
CTRL-Emittors-6	control light intensity (0 to 100%)	Payload-Lights	C	HW, SW2		
CTRL-Emittors-7	view current light intensity setting	Payload-Lights	S	SW2		
CTRL-Emittors-8	control light elevation	Payload-Lights	C	SW2		
CTRL-Emittors-9	control light azimuth	Payload-Lights	C	SW2		

3.10.3.2 Unmanned System Speaker

On occasion, it is necessary for an operator to communicate remotely through a UGV asset. A speaker system payload provides the ability to perform this action. Volume and positioning of the speaker (if not omnidirectional) is required. The table below provides information related to control and status of a speaker payload through the OCU operator interface.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Emittors-10	key push to talk (PTT) to activate asset speaker	Payload-Speaker	C	SW2		
CTRL-Emittors-11	control asset speaker volume	Payload-Speaker	C	SW2		
CTRL-Emittors-12	view current asset speaker volume setting	Payload-Speaker	S	SW2		
CTRL-Emittors-13	mute/unmute asset speaker	Payload-Speaker	C	SW2		
CTRL-Emittors-14	view indication that asset speaker is muted	Payload-Speaker	S	SW2		
CTRL-Emittors-15	select what is to be played over speaker	Payload-Speaker	C	SW2		

3.10.3.3 Laser Target Designator

A UGV can point a laser at a target remotely if a laser target designator payload is attached. The OCU operator must be able to visually identify the target and then point the laser at the target. The following table lists the functions available to the OCU operator for a Laser Target Designator (LTD).

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Emittors-16	use Laser target designator	Payload-LTD	C	HW, SW1		

3.10.4 Actuators

Actuator payloads provide mechanical means of manipulation. These are often driven by electric motors which have individual controllers. The operator specifies set points to these controllers such as desired position, speed, etc. Status information about the successful control of these actuators is fed back to the remote OCU operator. The sections below provide functions for actuator payloads: Pan/tilt, Mast, Arm, and End Effectors

3.10.4.1 Pan/Tilt

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Actuators-1	control pan/tilt azimuth	Payload-Pan/Tilt	C	HW, SW1		
CTRL-Actuators-2	control pan/tilit elevation	Payload-Pan/Tilt	C	HW, SW1		
CTRL-Actuators-3	view pan/tilt functional status (WCA implications)	Payload-Pan/Tilt	S	SW2		

3.10.4.2 Mast

A mast provides the ability to raise and lower payloads. These payloads could be antenna, radar, flags, and various sensors. The operator can typically set the mast height and speed of ascent. Feedback positions/speeds and forces/torques are common status information provided back to the operator. The table below lists related functions for masts.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Actuators-4	raise mast (TBD increments)	Payload-Mast	C	SW1		
CTRL-Actuators-5	lower mast (TBD increments)	Payload-Mast	C	SW1		
CTRL-Actuators-6	move mast to preset position	Payload-Mast	C	SW1		
CTRL-Actuators-7	view current mast height (show position relative to min. and max. height possible)	Payload-Mast	S	SW1	Widget	
CTRL-Actuators-8	adjust mast speed movement rate (0 to 100%)	Payload-Mast	C	SW2		
CTRL-Actuators-9	stow mast	Payload-Mast	C	SW1		
CTRL-Actuators-10	view indication that mast is stowed	Payload-Mast	S	SW1	Icon (part of mast height widget)	
CTRL-Actuators-11	lock/unlock mast	Payload-Mast	C	SW1		
CTRL-Actuators-12	view indication that mast is locked	Payload-Mast	S	SW1	Icon (part of mast height widget)	
CTRL-Actuators-13	view indication of mast obstacle (implies sensor system) (WCA implication)	Payload-Mast	S	SW1	Icon or widget	
CTRL-Actuators-14	view indication that platform tilt is excessive for mast movement/extension (WCA implication)	Payload-Mast	S	SW1	Widget (part of pitch/roll indicator)	
CTRL-Actuators-15	view indication that mast is too high for platform movement (WCA implication)	Payload-Mast	S	SW1	Icon (part of mast height widget)	

3.10.4.3 Arm

Robotic Arm payloads provide a means to manipulate objects. Types include lower arms which extend underneath the UGV platform and upper arms that rest on top of a UGV chassis. The arm is often positioned via a commanded desired position of the end

effectors (e.g. grasper) using inverse kinematics. For most UGVs however, robotic arm links/joints are often controlled independently by the operator. Also, torques/forces provided by the motors are limited and the robotic arm may not be able to lift certain heavy objects and if attempted may cause the UGV to rollover. Therefore, feedback to the operator is often essential. The following table provides status and control functions regarding robotic arm payloads.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Actuators-16	select arm of interest if more than one arm is available	Payload-Arm	C	SW2		
CTRL-Actuators-17	view indication of (selected) arm(s) of interest on all relevant screens	Payload-Arm	S	SW1		
CTRL-Actuators-18	activate/deactivate arm control	Payload-Arm	C	SW1		
CTRL-Actuators-19	view current arm control mode (Ex: activated, deactivated)	Payload-Arm	S	SW1		
CTRL-Actuators-20	raise arm (might include max height command)	Payload-Arm	C	HW, SW1		
CTRL-Actuators-21	lower arm	Payload-Arm	C	HW, SW1		
CTRL-Actuators-22	extend arm forward (option: full extend command)	Payload-Arm	C	HW, SW1		
CTRL-Actuators-23	move arm back	Payload-Arm	C	HW, SW1		
CTRL-Actuators-24	adjust rate of arm speed/movement	Payload-Arm	C	SW1		
CTRL-Actuators-25	lock arm	Payload-Arm	C	SW1		
CTRL-Actuators-26	view indication that arm is locked	Payload-Arm	S	SW1		
CTRL-Actuators-27	stow arm	Payload-Arm	C	SW2		
CTRL-Actuators-28	view indication that arm is stowed	Payload-Arm	S	SW1		
CTRL-Actuators-29	adjust arm angle	Payload-Arm	C	HW, SW1		
CTRL-Actuators-30	view current arm orientation (see isometric positional model section for more options)	Payload-Arm	S	SW1	Widget	

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Actuators-31	indicate when arm is at joint limit (WCA implication)	Payload-Arm	S	SW1		
CTRL-Actuators-32	adjust individual joint motor (+/- 100%)	Payload-Arm	C	SW1		
CTRL-Actuators-33	view current individual joint motor setting	Payload-Arm	S	SW1		
CTRL-Actuators-34	control individual joint position	Payload-Arm	C	SW1		
CTRL-Actuators-35	view current individual joint position	Payload-Arm	S	SW1		
CTRL-Actuators-36	engage joint motor brake	Payload-Arm	C	SW1		
CTRL-Actuators-37	view indication that joint motor brake is engaged	Payload-Arm	S	SW1		
CTRL-Actuators-38	release joint motor brake	Payload-Arm	C	SW1		
CTRL-Actuators-39	enter calibration mode	Payload-Arm	C	SW2		
CTRL-Actuators-40	enter global control mode	Payload-Arm	C	SW1		
CTRL-Actuators-41	enter Cartesian control mode	Payload-Arm	C	SW1		
CTRL-Actuators-42	adjust individual joint torque	Payload-Arm	C	HW, SW1		

3.10.4.4 End Effectors

End effectors are typically positioned at the end of a robotic arm, and perform manipulation of objects such as grabbing, turning, cutting, ripping, etc. The OCU operator often operates end effectors using joysticks. Force feedback is often useful in controlling these devices remotely to convey physical resistance to the operator.

3.10.4.4.1 Basic End Effector Functions

The table below presents a list of basic end effectors functions.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Actuators-43	adjust end effector velocity (X, Y, Z axis +/- 100%)	Payload-EndEffectors	C	SW1		
CTRL-Actuators-44	view current end effector velocity settings	Payload-EndEffectors	S	SW1		
CTRL-Actuators-45	adjust end effector torque (X, Y, Z axis +/- 100%)	Payload-EndEffectors	C	SW1		
CTRL-Actuators-46	view current end effector torque applied	Payload-EndEffectors	S	SW1		
CTRL-Actuators-47	adjust end effector orientation (θRoll, θPitch, θYaw 0 to 360 degrees)	Payload-EndEffectors	C	HW, SW1		
CTRL-Actuators-48	view current end effector orientation	Payload-EndEffectors	S	SW1		
CTRL-Actuators-49	view change to end effector N	Payload-EndEffectors	S	SW1		
CTRL-Actuators-50	view end effector ID	Payload-EndEffectors	S	SW2		
CTRL-Actuators-51	turn end effector on/off	Payload-EndEffectors	C	SW2		
CTRL-Actuators-52	start/stop end effector	Payload-EndEffectors	C	SW2		

3.10.4.4.2 Gripper

Grippers allow grasping of objects. The table below lists gripper functions available to the OCU operator.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Actuators-53	adjust gripper max torque (0 to 100%)	Payload-Gripper	C	SW2		
CTRL-Actuators-54	view current gripper torque setting	Payload-Gripper	S	SW2		
CTRL-Actuators-55	adjust gripper velocity (0 to 100%)	Payload-Gripper	C	SW2		
CTRL-Actuators-56	view current gripper velocity setting	Payload-Gripper	S	SW2		
CTRL-Actuators-57	open gripper	Payload-Gripper	C	HW, SW1		
CTRL-Actuators-58	close gripper	Payload-Gripper	C	HW, SW1		
CTRL-Actuators-59	move gripper up/down	Payload-Gripper	C	HW, SW1		
CTRL-Actuators-60	move gripper right/left	Payload-Gripper	C	HW, SW1		
CTRL-Actuators-61	view gripper orientation/absolute position (see isometric positional model section for more options)	Payload-Gripper	S	SW1	Widget	

3.10.4.4.3 Flipper

Flipper actuators can be used to enhance the mobility of the UGV chassis. They can allow a tracked vehicle to climb stairs, traverse ditches/ruts, etc. The operator should be able to control the position of the flippers via the OCU and also view the geometric relationship of multiple flippers in relationship to the chassis. The table below provides a list of flipper status and control functions available to the OCU operator.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Actuators-62	move flipper up/down	Payload-Flipper	C	HW, SW1		
CTRL-Actuators-63	move flipper forward	Payload-Flipper	C	HW, SW1		
CTRL-Actuators-64	move flipper back	Payload-Flipper	C	HW, SW1		

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Actuators-65	view flipper orientation (see isometric positional model section for more options)	Payload-Flipper	S	SW1	Widget	

3.11 Poses

Poses are preconfigured arrangements of robotic actuators. OCU operators should be able to select poses and view when the pose has been met by the UGV asset. The following table provides functions for control and status of the UGV asset.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Pose-1	activate a pre-defined pose (Ex: drive, drive high, drive low, deploy, stow, ascend/stairs, descend/stairs, peek over, peek under, self-inspect, load CMD, place CMD, box, fiber, front)	Poses	C	SW2	Widget	
CTRL-Pose-2	view current pose selection	Poses	S	SW1		
CTRL-Pose-3	deactivate pose	Poses	C	SW2		
CTRL-Pose-4	set/define a custom pose	Poses	C	SW2	Widget	

3.12 Isometric Positional Model

Isometric positional model provides means to view and control the UGV asset platform through a 2D projection of the UGV asset. The user may select from a set of different pre-configured projections. This aids the user in controlling the positioning of the UGV asset by simplifying the display. A table will be developed in future versions of this IOP that will list the functions available to the OCU operator for the Isometric Positional Model.

3.13 Radio

A radio provides a communication interface with remote devices such as the OCU. A radio can provide the operator with access to various communication protocols, power levels, frequency bands, data rates, etc. This is often desirable when environmental conditions impede communications in particular frequency bands. The operator should be able to set the current communication mode between the OCU and UGV. Also he/she should also be able to assess the health condition of the communications channel. The table below provides status and control for radio systems.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Radio-1	select radio of interest	Radio	C	SW1		
CTRL-Radio-2	view indication of (selected) radio of interest	Radio	S	SW1		
CTRL-Radio-3	select radio frequency/channel	Radio	C	SW1		
CTRL-Radio-4	view current frequency/channel setting	Radio	S	SW1		
CTRL-Radio-5	view radio battery status	Radio	S	SW1	Widget	
CTRL-Radio-6	view current communications mode	Radio	S	SW1		
CTRL-Radio-7	key radio (push-to-talk)	Radio	C	HW, SW1		
CTRL-Radio-8	SNR	Radio	S			
CTRL-Radio-9	Center Frequency	Radio	C			
CTRL-Radio-10	Channel Frequency Response	Radio	S			
CTRL-Radio-11	Latency	Radio	S			
CTRL-Radio-12	Point of Modulation Bandwidth	Radio	S			
CTRL-Radio-13	Packet Error Rate (%),	Radio	S			
CTRL-Radio-14	Data Rate (Mbps),	Radio	S			
CTRL-Radio-15	Modulation Scheme	Radio	S			
CTRL-Radio-16	RF Transmit Power (dBm),	Radio	S			
CTRL-Radio-17	Received Signal Power (dBm),	Radio	S			
CTRL-Radio-18	Error Vector Magnitude (EVM),	Radio	S			

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-Radio-19	Mode of Operation (Point-to-Point or Multipoint)	Radio	S			

3.14 OCU Maintenance

OCUs are devices that must be maintained. Use in harsh environments can result in broken joysticks, damaged screens and sensors, etc. An embedded self-diagnostic system would enable operators and maintainers to determine when a device needs repair. The table below lists functions related to OCU maintenance. A means for software updates must also be provided.

ID	Function/Task	Category	Control (C) or Status (S)	Access Level	Common Widget or Icon/ Graphic	Reference
CTRL-OCUMaint-1	view current software version	OCU Maintenance	S	SW2		
CTRL-OCUMaint-2	view plug in version	OCU Maintenance	S	SW2		
CTRL-OCUMaint-3	view current system load	OCU Maintenance	S	SW2		
CTRL-OCUMaint-4	update/load software	OCU Maintenance	C	SW2		
CTRL-OCUMaint-5	view current asset version	OCU Maintenance	S	SW2	Widget (common ID)	
CTRL-OCUMaint-6	view hard drive status	OCU Maintenance	S	SW2		
CTRL-OCUMaint-7	view OCU usage statistics (hours of operation) (do not allow user to reset the OCU usage status)	OCU Maintenance	S	SW2	Widget	

3.15 Alerts – Warnings, Cautions, Advisories (WCAs)

Alerts are basic elements of any system indicating that there is a potential or existing problem related to the UGV asset. Alerts can be conveyed to the user using audio, visual, tactile, or other information.

3.15.1 Active Alert Counter

An active alert counter should:

- always displayed in a dedicated location on the controller HMI
- display active WCAs only
- include a widget to enable users to access an Alert List

3.15.2 Alert Message/Pop-Up

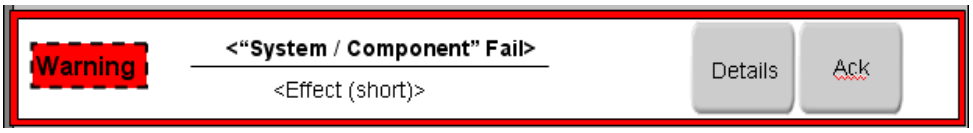
The pop-up is classified based on the alert type. Alert types are Warning (red), Caution (yellow) or Advisory (blue).

- Warning (Red) - denotes a fatal system fault that has a negative mission impact and should be given immediate action
- Caution (Yellow) - denotes non-fatal system faults that could have a negative mission impact and should be given action soon
- Advisory (Blue) - denotes a minor system fault or instruction that does require immediate action and may be temporarily ignored

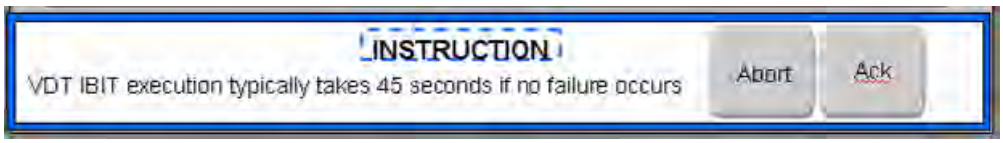
Warning alerts will have an audio tone associated with them. The tone will come from a headset and an OCU speaker if not muted.

Example:

Text specific to the issue are provided to describe a warning or caution. The top line of the pop-up is the test fail title which will identify what system or component has failed. The bottom line is the effect (a brief short message) on the vehicle system . Each event has a short and long description. Alert type indication is located on the left side of the pop-up.



Advisory pop-ups indicate the type of advisory as well as a description of the event. Advisory type is located in the top center of the pop-up. The description is presented below it.



Depending on alert type, two or three soft keys will appear on the right side of the pop-up. The soft keys enable the user to acknowledge a fault, display details of a fault, hide the pop-up, or complete some action specific to the pop-up event.

1. Acknowledge (Ack) - acknowledges the fault and returns to previous screen displayed. A fault indication will appear in the corresponding fault indicator box on the status header.
2. Details – displays the Full Details screen. A fault indication will appear in the corresponding fault indicator box on the status header.
3. Hide - hides a caution event pop-up, but does not acknowledge the fault indication. The HMI will return to normal operation. A fault indication will appear in the corresponding fault indicator box on the status header. Warning pop-ups do not have a Hide Key option. The operator must acknowledge the pop-up by pressing either the Acknowledge key or the Details key.
4. Advisory <Action> – Example: Abort button to stop a commanded IBIT

More than one event requiring a pop-up may occur at one time. The HMI will present a pop-up for each event in order of criticality. Each event pop-up must be acknowledged separately.

3.15.3 Alert List

An Alert list shall be available when the interface is in any state/mode. The list contains all active or historical events (faults) for all subsystems. The operator may delete fault notifications, acknowledge alerts, view basic alert information, and view detailed alert information.

- Category (CAT) field - criticality category (type) of the fault (Red-Warning, Yellow-Caution, Blue-Advisories). Pressing this field will sort faults in order of criticality (Red-Warning, Yellow-Caution, Blue-Advisories).

- Subsystem field - name, category or the system that fault occurred in. Pressing this field will sort faults in alphabetical order.
- Title field - LRU (component) failure name. Pressing this field will sort faults in alphabetical order.
- Potential Source field - source of fault. Pressing this field will sort faults in alphabetical order.
- ACK (Acknowledged) field - indicates acknowledgement of a fault. If fault has been acknowledged it will contain a Y to represent Yes or N for No. Pressing this field will sort faults in acknowledged order of yes to no (Y to N).
- Status field - whether the fault is active, intermittent or inactive. Pressing this field will sort faults in order of Active, Intermittent and Inactive.
- Date and time
- Code field - fault event code associated with the component fault. Pressing this field will sort fault codes in ascending numerical order.

3.15.4 List of Recommended WCAs

	Alert	Alert Category	Notes
1	OCU battery low		could be caution and warning threshold values
2	OCU battery issue (fault, etc.)		
3	asset battery low		could be caution and warning threshold values
4	asset battery issue (fault, etc.)		
5	asset fuel low		could be caution and warning threshold values
6	asset engine issue (high RPMs, temp, etc.)		could be caution and warning threshold values
7	asset oil issues (temperature, qty, etc.)		could be caution and warning threshold values
8	no communications	warning	
9	estop		
10	hand controller disengaged	warning	
11	mobility mode failure	warning	
12	asset pitch/roll/attitude issue for safe mobility		pitch/roll indicator color coding
13	asset pitch/ tilt excessive for mast movement/extension		could be caution and warning threshold values

	Alert	Alert Category	Notes
14	pose is not possible due to current asset attitude	advisory	
15	indication that transition between mobility states/modes is not permitted (payload adjustment necessary, etc)	advisory	
16	asset unable to proceed (autonomously)		
17	Software Control Disabled		
18	Mobility Stop		
19	Navigation System Health Failed		
20	Navigation Sensors Health Failed		
21	VC Health Failed		
22	Navigation system Heartbeat Timeout		
23	Navigation system Guidance Timeout		
24	Mast Failed		
25	Plan Loaded		
26	Execute Failed		
27	Resume Failed		
28	Load Plan Failed		
29	Validate Failed		
30	Execute Timeout		
31	Execute Failed		
32	Resume Timeout		
33	Stop Timeout		
34	Late To Next Waypoint		
35	Plan Executing		
36	Plan Execute Failure		
37	Corridor Exceeded		
38	Operator Intervention Required		
39	Plan Paused		
40	Plan Stopped		
41	End of Plan		
42	indication if snapshot/screen capture is not possible	advisory	
43	chemical detection(s)	warning	

	Alert	Alert Category	Notes
44	biological target detection	warning	
45	radiological detection(s)	warning	
46	nuclear detections	warning	
47	mast obstacle		implies sensor system
48	mast too high for asset movement	advisory	
49	arm is at joint limit	advisory	part of orientation icons, isomodel
50	fiber cable remaining		could be caution and advisory threshold values
51	system/subsystem functional status issues		needs to be broken out
52	system fault		
53	joint fault		

3.16 OCU Hardware Control Mappings

Please see the attached set of spreadsheets for recommend Hardware Control mappings. These will be refined in future versions of this IOP.

2 Ctrl IOP - OCU HW Control Mappings_05

A master list or potential functions for hardware implementation is provided as well as a set of one-hand and two-hand control mappings. The purpose is to provide recommendations for hand control functionality. This may be used to design a custom device including all applicable recommendations or as a guideline to create the most standardized device possible with off-the-shelf hardware.

Functions are candidates for hand control placement based on the following criteria:

- Mission Critical - immediate access is critical to mission success and/or crew safety
- Frequency of Use - function is frequently used, must always be accessible to maintain reasonable crew performance
- Sequence of Use - function is a required action/step in a mission critical or frequent task

It is understood that not all functions will be available with every robotic system. The table format allows a designer to quickly find the functions pertaining to their system.

The following information is also provided for one hand and two hand controls with and without displacement.

- Function: Function name, characterized as a mobility or payload function
- Ranking: Functions are ranked to aid a designer who is working with an off-the-shelf device with a pre-determined set of switches and/or on a device with limited space.
- Label: Recommended switch label (if applicable)
- Switch Type: Basic switch description
- Switch Characteristics: Switch size, shape, movement/displacement characteristics, etc
- Right Side / Left Side: Recommended grip/side for function placement on a two-handed device. Based on function sequence, simultaneous accessibility, and device space available
- Displacement Function: Function allocation for devices with displacement (Ex: joystick fore/aft, left right; yoke grip rotation for/aft, yoke rotation left/right)
- Secondary Action Required: Details any secondary actions required to activate function. Ex: Hold palm grips/deadman in while pressing "Lase" button to activate laser range finder
- Description: Function description, including relevant hardware and software behaviors

4 Operator Control Unit (OCU)

4.1 Use of This Section

This section is to be utilized as recommended guidance in the development and implementation of Operator Control Units for unmanned ground vehicle systems, providing a framework allowing system developers to effectively locate controls that are common across most unmanned vehicle platforms. Use of this guidance will also serve to drive consistency across unmanned platform programs through common OCU hardware and sizes. The OCU in this document will be broken down in size categories for each of the sections.

The function tables included in this document are associated with a Microsoft Excel file with the same content. This file can be particularly efficient for the intended audience as it enables sorting and search capabilities.

OCU-WG-Function Table.xlsx

4.1.1 Intended audience

This document is intended for systems engineers and designers engaged in the development of unmanned ground vehicle systems. This would apply to custom design solutions as well as off the shelf integrations.

4.2 Micro (ex. Handheld, Cell Phone Size)

A micro OCU is handheld device (approximately cell phone size) including external connections and accessories. It should possess the following attributes at a minimum.

Attributes		
Man Portable	Yes	
Stationary Or Dynamic Environment	Dynamic	
Display Size Range	3 inches minimum	
USB Port(s)	1 mini USB (minimum)	
Sunlight Readable	Yes	
Backlit	Yes	
External Connections	Charging port, headphones, 3.5 mm jack, Head Mounted Display(possible),	
Video/Picture Storage	Yes	

GPS	Yes	
Hard Buttons	3 minimum (with one hard power button)	
Joystick Capability		
Touch Screen	Yes	
RS 232 Serial Interface	No	
Volume Control	Yes	
Contrast Adjustment	Yes	
Brightness Adjustment	Yes	

4.3 Small (ex. Laptop/Backpack)

A Small OCU is approximately laptop size, including external connections and accessories. It should be man portable by one person. It should possess the following attributes at a minimum

Attributes		
Man Portable	Yes	
Stationary Or Dynamic Environment	Dynamic	
Display Size Range	6 inches minimum	
USB Port(s)	2 USB 2.0 minimum	
Sunlight Readable	Yes	
Backlit	Yes	
External Connections	Headphones, USB, 3.5 mm jack, VGA, DVI, charging port, Ethernet connection, coax cable	
Video/Picture Storage	Yes	
GPS	Yes	
Hard Buttons	6 minimum	
Joystick Capability	Yes	
Touch Screen	No	
RS 232 Serial Interface	Yes	
Volume Control	Yes	
Contrast Adjustment	Yes	
Brightness Adjustment	Yes	

4.4 Medium (ex. briefcase/table top)

A Medium OCU is approximately computer desktop size, including external connections and accessories. It should be man portable by no more than 4 people. It should possess the following attributes at a minimum

Attributes	

Man Portable	Yes
Stationary Or Dynamic Environment	Dynamic
Display Size Range	6 inches minimum
USB Port(s)	2 USB 2.0 minimum
Sunlight Readable	No
Backlit	No
External Connections	Coax cable
Video/Picture Storage	Yes
GPS	No
Hard Buttons	6 minimum
Joystick Capability	
Touch screen	No
RS 232 Serial Interface	Yes
Volume control	Yes
Contrast Adjustment	Yes
Brightness Adjustment	Yes

4.5 Vehicle Platform Embedded OCU

A Vehicle Platform Embedded OCU is a vehicle mounted crew station not expected to be removed from a manned vehicle platform, including external connections and accessories. It should possess the following attributes at a minimum

Attributes	
Man Portable	No
Stationary Or Dynamic Environment	Dynamic
Display Size Range	8 inches minimum
USB Port(s)	2 USB 2.0 minimum
Sunlight Readable	No
Backlit	No
External Connections	Coax cable
Video/Picture Storage	Yes
GPS	No
Hard buttons	6 minimum
Joystick Capability	
Touch Screen	No
RS 232 Serial Interface	Yes
Volume Control	Yes

4.6 Stationary (ex. Command and Control Center)

A Stationary OCU is a stationary command and control center, which is not located within a vehicle platform, but is located in its own facility space, either outside in the environment or inside a building. It would be a coordinated multiple person effort to

move this type of command and control center. It should possess the following attributes at a minimum

Attributes	
Man Portable	No
Stationary Or Dynamic Environment	Stationary
Display Size Range	8 inches minimum
USB Port(s)	2 USB 2.0 minimum
Sunlight Readable	No
Backlit	No
External Connections	Coax cable
Video/Picture Storage	Yes
GPS	No
Hard Buttons	6 minimum
Joystick capability	
Touch Screen	No
RS 232 Serial Interface	Yes
Volume Control	Yes

5 Control Standards

5.1 OCU Standards and Guidelines

This section includes recommended standards and guidelines related to OCUs. This section is divided into standards and guidelines. Items listed under the Standards sections have an associated standard (MIL, NEMA, NIST, ISA, SAE, etc.) referenced. Items listed under the Guidelines sections provide best practice information (articles, papers, website, etc.)

5.1.1 OCU Physical Attributes

5.1.1.1 Standards

Number	Document Title	Description	Reference
MIL-DTL-38999 L	DETAIL SPECIFICATION: CONNECTORS, ELECTRICAL, CIRCULAR, MINIATURE, HIGH DEN-SITY, QUICK DISCONNECT (BAYONET, THREADED, AND BREECH COUPLING), ENVIRON-MENT RESISTANT, REMOVABLE CRIMP AND HERMETIC SOLDER CONTACTS, GENERAL SPECIFICATION FOR	General Specification for Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant.	MIL-DTL-38999L
CEA-861E	A DTV PROFILE FOR UNCOMPRESSED HIGH SPEED DIGITAL INTERFACES	Digital Television Profile	
Universal Serial Bus Specification 2.0	UNIVERSAL SERIAL BUS	See document title	
EIA/TIA-232-F	INTERFACE BETWEEN DATA TERMINAL EQUIPMENT AND DATA CIRCUIT-TERMINATING EQUIPMENT EMPLOYING SERIAL BINARY DATA INTERCHANGE	See document title	

Interfaces (Ethernet)			www.IEEE802.org
IEEE 802.3u	100BASE-TX, 100BASE-T4, 100BASE-FX Fast Ethernet at 100 Mbit/s (12.5 MB/s) w/autonegotiation	Gigabit Ethernet specification	
802.3af	Power over Ethernet (12.95 W)	See document title	
802.3at	Power over Ethernet enhancements (25.5 W)	See document title	
IEEE_802.3ab	BALANCED COPPER CABLING, TYPE 1000BASE-T	See document title	
Interfaces (USB)			www.USB.org, *Universal Serial Bus Specification Revision 2.0, Universal Serial Bus Specification Revision 3, USB Class Codes*
USB 2.0	Specification @ USB.org	See document title	
USB OTG	Specification @ USB.org	See document title	
TYPE A	Specification @ USB.org	See document title	
TYPE B	Specification @ USB.org	See document title	
Mini A	Specification @ USB.org	See document title	
Mini B	Specification @ USB.org	See document title	
Micro A	Specification @ USB.org	See document title	
Micro B	Specification @ USB.org	See document title	
USB 3.0	Specification @ USB.org	See document title	
Power Interface			
MIL-STD-1275D	DEPARTMENT OF DEFENSE INTERFACE STANDARD: CHARACTERISTICS OF 28 VOLT DC ELECTRICAL SYSTEMS IN MILITARY VEHICLES (29 AUG 2006)	See document title	

Video Physical Interface			
VGA	Video Graphics Array specification	See document title	
HDMI	High Definition Multimedia Interface (HDMI) specification	See document title	
Component	Component video analog interface specification	See document title	
Composite	Composite video interface specification	See document title	
Video Interface Transmission			
ISO/IEC 13818-2:2000	H.262/MPEG-2 video format specification	See document title	
Advanced Video Coding	H.264/MPEG-4 video format specification	See document title	

5.1.1.2 Guidelines

Number	Document Title	Description	Reference
N/A	N/A	With procurement reform the US military connector specifications are moving from standard Mil-38999 to COTS connectors.	Interfaces (Ethernet)
N/A	N/A	Utilize STD Ethernet interfaces for to support 10/100/1000 Mb date rates	Interfaces (Ethernet)
N/A	N/A	Utilize STD 802-3af Power of Ethernet (POE) to power devices, even OCU's were power requirements are less than 12.5 watts.	Interfaces (Ethernet)
N/A	N/A	Utilize 802.3at for POE applications up to 25 watts.	Interfaces (Ethernet)
N/A	N/A	Use standard Device Classes for audio, HID, Mass Storage verses proprietary solutions.	Interfaces (USB)
N/A	N/A	Use standard connectors when possible	Interfaces (USB)
N/A	N/A	For vehicle powered devices, conform to MIL-STD-1275 requirements.	Power Interface
N/A	N/A	Utilize highest compression rates allowable for application to minimize network impact.	Video Interface Transmission

5.2 HMI Standards and Guidelines

This section provides recommended standards and guidelines related to Human Machine Interfaces (HMI). This section is divided into standards and guidelines. Items listed under the Standards section have an associated standard (MIL, NEMA, NIST, ISA, SAE, etc.) referenced. Items listed under Guidelines section provide best practice information (articles, papers, website, etc.). In future versions of this document, additional tables will be developed, containing standards and guidelines for State and Mode Selection, Mobility Control (including e-Stop), Basic Status, Mission Planning, Radio Setup, Image/Video Archive and Browsing, and Alerts (WCAs).

5.2.1 General Purpose HMI Standards

5.2.1.1 Standards

Number	Document Title	Description	Reference
MIL-STD-1472F	HUMAN ENGINEERING	This standard establishes general human engineering design criteria for military systems, subsystems, equipment and facilities.	
ASTM F1166-07	Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities	The focus of these design criteria is on the design and evaluation of human-machine interfaces, including the interfaces between humans on the one side and controls and displays, physical environments, structures, consoles, panels and workstations, layout and arrangement of ship spaces, maintenance workplaces, labels and signage, alarms, computer screens, material handling, valves, and other specific equipments on the other.	http://www.astm.org/Standards/F1166.htm

5.2.1.2 Guidelines

Number	Document Title	Description	Reference
IST-1-507674-IP	Information Society Technologies (IST) Adaptive Integrated Driver-Vehicle Interface, Recommendations for HMI Guidelines	This report presents a collection of recommendations to experts active in the field of standards and guidelines relevant to HMI development of IVICS and ADAS. The recommendations are based	http://www.aide-eu.org/pdf/sp4_deliv_new/aide_d4_3_2.pdf

	and Standards (2004)	on findings and results that have been achieved in the subprojects of the AIDE IP. The report considers different data sources which describe activities to present these results to institutions involved in standardization, to discuss recommendations on standards and guidelines and how to use them for future work of international standardization bodies, i.e. a joint workshop conducted together with ISO WG8, activities within the eSafety WG on HMI, exchange of information and discussions within the AIDE forums. The report is intended to be a recommendation and helpful input but does not put any obligation to the recipient.	
MIL-HDBK-759C	Department of Defense Handbook for Human Engineering Design Guidelines	This document provides basic guidelines and data on human engineering design for military systems, equipment, and facilities.	
MIL-HDBK-761A	Department of Defense Handbook for human engineering guidelines for management information systems	The purpose of this document is to provide human factors engineering design guidance for the analysis, design, and evaluation of computer based Management Information Systems. Guidance is presented in the form of 1) analysis and design techniques which should be applied to the development and evaluation of User-Computer Interface (UCI) design concepts, and 2), design guidelines which should be used during UCI requirements analysis, design, development, test and integration.	

MIL-HDBK-1908B	Department of Defense Handbook for Definitions of Human Factor's Terms	The goals of this handbook are to eliminate definition overlap, duplication, and conflict and to minimize the length of human factors (HFAC) standardization documents; therefore, as HFAC documents have been revised, their definitions were dropped in favor of citing this handbook.	
MIL-HDBK-857A	Department of Defense Handbook for Geospatial Symbols for Digital Displays	This document serves a three-fold purpose. Section 4 contains information that is historical in nature about the development of the GeoSym product. This information is provided for the reader as an explanation of the objectives of GeoSym. Section 5 contains information about the user environment within which GeoSym is designed to be utilized. Section 6 contains technical information critical to the design of application software that utilizes the GeoSym product.	

5.2.2 Robotic Asset Selection, Login and Controls

5.2.2.1 Standards

Number	Document Title	Description	Reference
None at this time	N/A	N/A	N/A

5.2.2.2 Guidelines

Number	Document Title	Description	Reference
N/A	Security of Cryptographic Systems: Requirements of	Describes general characteristics of a military cryptographic system for security.	http://www.umich.edu/~umich/fm-34-40-2/ch2.pdf

	Military Systems		

5.2.3 Payload Control

5.2.3.1 Standards

Number	Document Title	Description	Reference
None at this time	N/A	N/A	N/A

5.2.3.2 Guidelines

Number	Document Title	Description	Reference
N/A	Toward a Common Architecture for the Advanced Explosive Ordnance Disposal Robotic Systems (AEODRS) Family of Unmanned Ground Vehicles	Includes figures with common signals for various payloads near end of document.	http://www.contineo-robotics.com/caffeine/uploads/files/GVSETS_Paper_number_213.pdf

5.2.4 Common Icons and Graphics

5.2.4.1 Standards

Number	Document Title	Description	Reference
MIL-STD-1472	Human Engineering	Excellent reference document for defining user interface.	
ISA-5.5-1985	Graphic Symbols for Process Displays	A standard for industrial process control displays, but has useful information about problems understanding color/symbol meanings.	http://www.isa.org/Content/Microsites165/SP18,_Instrument_Signals_and_Alarms/Home163/ISA_Standards_for_Committee_Use/S_55.pdf
MIL-STD-2525C	Department of Defense Interface Standard Common Warfighting Symbology	MIL-STD-2525 is designed to equip the DOD with a standard solution that provides sets of command and control (C2) symbols, a coding scheme for symbol automation and information transfer, and technical details to support systems. The standard provides support through interoperability and users' input, which are essential to ensure that the standard continues to meet the warfighter's requirements. MIL-STD-2525 is the primary directive that DOD uses to standardize warfighting symbology	

5.2.4.2 Guidelines

Number	Document Title	Description	Reference
None at this time	N/A	N/A	N/A

5.2.5 Input Device Mapping

5.2.5.1 Standards

Number	Document Title	Description	Reference
SAE AS6040	Joint Architecture for Unmanned Systems (JAUS) HMI Service Set	This document defines a set of standard application layer interfaces called JAUS HMI Services. JAUS Services provide the means for software entities in an unmanned system or system of unmanned systems to communicate and coordinate their activities. The HMI Services represent the platform-independent Human Machine Interface (HMI) capabilities commonly found across all domains and types of unmanned systems. Five services are defined in this document:• Drawing• Pointing Device• Keyboard• Digital Control• Analog Control Each service is described by a JAUS Service Definition (JSD) which specifies the message set and protocol required for compliance	http://standards.sae.org/as6040/

5.2.5.2 Guidelines

Number	Document Title	Description	Reference
None at this time	N/A	N/A	N/A

6 Platform Discovery

Platform Discovery will be implemented as specified in the UGV Interoperability Profile (IOP) – *JAUS Profiling Rules* document.

7 Appendix A – Acronyms and Abbreviations

ABCS	Army Battle Command System (ABCS)
API	Application Programmer Interface
A/V	Audio/Visual
BCTM	Brigade Combat Team Modernization
BFT	Blue Force Tracking
C2	Command and Control
CADRG	Compressed Arc Digitized Raster Graphics
CCL	Common Communication Link
COP	Common Operational Picture
COTS	Commercial Off the Shelf
DDS	Data Distribution Services
DISA	Defense Information Systems Agency
DTED	Digitized terrain Elevation Data
E-IBCT	Early Infantry Brigade Combat Team
FBCB2	Force XXI Battle Command Brigade and Below
GEOTIFF	Geospatial Tagged Image File Format
HCI	Human Computer Interaction
HCI	Human Computer Interface
HMD	Helmet Mounted Display
ICD	Interface Control Document
IEC	International Electrotechnical Commission
IMS	Intelligent Munitions Systems
IOP	Interoperability Profile
IPC	Inter-Process Communication
ISO	International Organization for Standardization
JAUS	Joint Architecture for Unmanned Systems
JBC-P	Joint Battle Command - Platform
JVMF	Joint Variable Message Format
MILS	Multiple Independent Levels of Security
MISB	Motion Imagery Standards Board
MPEG	Motion Pictures Expert Group
NIK	Network Integration Kit
OCU	Operator Control Unit
OS	Operating System

OS-RVT	One System Remote Video Terminal
PDA	Personal Digital Assistant
POSIX	Portable Operating System Interface
QA	Quality Assurance
S&T	Science and Technology
SA	Situational Awareness
UAS	Unmanned Aerial System
UBC	Unified Battle Command
UGS	Unattended Ground Sensors
UGV	Unattended Ground Vehicle
UMS	Unmanned System(s)
VPF	Vector Product Format
WCA	Warnings, Cautions, and Advisories
WCAN	Warnings, Cautions, Advisories, and Notifications
WMI	Warfighter Machine Interface
WSMS	Weapon Systems Mapping Services