



AEROSPACE RECOMMENDED PRACTICE

ARP6128™**REV. A**

Issued 2013-03
Reaffirmed 2019-04
Stabilized 2025-06

Superseding ARP6128

Unmanned Systems Terminology
Based on the ALFUS Framework

RATIONALE

This document is now stabilized. The material is still relevant from a historical perspective, but the terminology may not align with the latest NIST publications.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) describes terminology specific to unmanned systems (UMSs) and definitions for those terms. It focuses only on terms used exclusively for the development, testing, and other activities regarding UMSs. It further focuses on the autonomy and performance measures aspects of UMSs and is based on the participants' earlier work, the Autonomy Levels for Unmanned Systems (ALFUS) Framework, published as NIST Special Publication 1011-I-2.0 and NIST Special Publication 1011-II-1.0. This Practice also reflects the collaboration results with AIR5665. Terms that are used in the community but can be understood with common dictionary definitions are not included in this document. Further efforts to expand the scope of the terminology are being planned.

1.1 Purpose

The purpose of this Aerospace Recommended Practice is to communicate to the unmanned systems community a common set of terminology and definitions that can be used as guidance for designing, developing, testing, or otherwise describing an unmanned system or any of its subsystems.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AIR5665 Architecture Framework for Unmanned Systems

2.1.2 NIST Publications

Available from National Institute of Standards and Technology, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

NIST Special Publication 1011-I-2.0 Autonomy Levels for Unmanned Systems (ALFUS) Framework Volume I: Terminology, Version 2.0

NIST Special Publication 1011-II-1.0 Autonomy Levels for Unmanned Systems (ALFUS) Framework Volume II: Framework Models, Version 1.0

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

2.2.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E2521 Standard Terminology for Urban Search and Rescue Robotic Operations

ASTM F2541 Standard Guide for Unmanned Undersea Vehicles (UUV) Autonomy and Control

ASTM F2395 Standard Terminology for Unmanned Air Vehicle Systems

2.3 Terminology/Definitions

See Appendix A for references.

2.3.1 ACTUATOR

A motor or mechanism capable of controlled prismatic (linear) or revolute (angular) motion.

2.3.2 AGENT

An entity that can act on behalf of another entity.

2.3.3 AUTONOMOUS

Operations of an unmanned system (UMS) wherein the UMS receives its mission from the human or agent and accomplishes that mission with or without further human-robot interaction (HRI). The level of HRI, along with other factors such as mission complexity, and environmental difficulty, determine the level of autonomy for the UMS [2]. Finer-grained autonomy level designations can also be applied to the tasks, lower in scope than mission.

2.3.3.1 Associated Terms

Fully Autonomous - See under MODE OF UNMANNED SYSTEM OPERATIONS.

Semi-Autonomous - See under MODE OF UNMANNED SYSTEM OPERATIONS.

Autonomous Collaboration - The ability of a UMS to collaborate with one or more manned vehicles or UMS without the need for an external controlling element.

2.3.4 AUTONOMOUS COLLABORATION

See under Autonomous.

2.3.5 AUTONOMY

- a. The condition or quality of being self-governing [1].
- b. A UMS's own ability of sensing, perceiving, analyzing, communicating, planning, decision-making, and acting, to achieve its goals as assigned by its human operator(s) through designed human robot interface. Autonomy is characterized into levels by factors including mission complexity, environmental difficulty, and level of HRI to accomplish the missions.

2.3.5.1 Associated Terms

Autonomy Level or Level of Autonomy - Set(s) of progressive indices, typically given in numbers, identifying a UMS's capability for performing autonomous missions. Two types of metrics are used, Detailed Model for Autonomy Levels and Summary Model for Autonomy Levels.

Detailed Model for Autonomy Levels - A comprehensive set of metrics that represent multiple aspects of concerns, including mission complexity, environmental difficulty, and level of HRI that, in combination, indicate a UMS's level of autonomy. This model corresponds to the Summary Model for Autonomy Levels.

Summary Model for Autonomy Levels - A set of linear scales, 0 through 10 or 1 through 10, indicating the level of autonomy of a UMS. This model is derived from the UMS's Detailed Model for Autonomy Levels.

2.3.6 AUTONOMY LEVEL OR LEVEL OF AUTONOMY

See under Autonomy.

2.3.7 AUTONOMY LEVELS FOR UNMANNED SYSTEMS (ALFUS)

A framework within which UMS autonomy can be characterized, identified, or evaluated with respect to the context. ALFUS is metrics based and provides a common vernacular to facilitate autonomous capability articulation.

2.3.8 BYSTANDER

See under HUMAN ROBOT INTERACTION.

2.3.9 COLLABORATION or COOPERATION

Multiple agents working together to achieve a common goal.

2.3.10 CONTEXTUAL AUTONOMY OR CONTEXTUAL AUTONOMOUS CAPABILITY (CAC) MODEL FOR UNMANNED SYSTEMS (UMS)

A UMS's Contextual Autonomy or CAC is characterized by the missions that the system is capable of performing, the environments within which the missions are performed, and human independence that can be allowed in the performance of the missions.

Each of the aspects, or axes, namely, mission complexity (MC), environmental complexity (EC), and human independence (HI) is further attributed with a set of metrics, or capabilities in the complementary perspective, to facilitate the specification, analysis, evaluation, and measurement of the CAC of particular UMSs.

This CAC model facilitates the characterization of UMSs from the perspectives of requirements, capability, and levels of difficulty, complexity, or sophistication. The model also provides ways to characterize UMS's autonomous operating modes. The three axes can also be applied independently to assess the levels of MC, EC, and autonomy for a UMS.

2.3.11 CONTROL

The ability to compensate for differences between actual and intended or desired states.

2.3.12 CONTROLLING ELEMENT

The part of a UMS that provides a method for a human or agent to control it remotely.

2.3.13 COOPERATION

See COLLABORATION.