AIAA G-133-1-2013

# Guide

# Space Plug-and-Play Architecture Standards Development Guidebook

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**Sponsored by**

American Institute of Aeronautics and Astronautics

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**Abstract**

This document provides a guideline for spacecraft platform, subsystem, and component (including payload) developers for integrating plug-and-play characteristics into spacecraft structures, avionics, and hardware and software components to promote their rapid integration. This guideline will be used as the foundation for Space Plug-and-play Architecture (SPA) standards. The SPA community anticipates adding protocols (e.g., Ethernet as SPA-E) as the PnP capabilities are normalized.

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## Contents



**Figures**

**Tables**

## Foreword

The desire to quickly and reliably assemble spacecraft has been a challenge since the 1960s. In the 1990s the international computer market noted a similar need to quickly and reliably assemble computers and computer accessories. The invention of Plug-and-Play (PnP) capabilities is now assumed for any modern terrestrial computer system. PnP capability is defined in various publicly available technical standards.

It is the purpose of the AIAA to capture, in this Space Plug-and-Play Architecture (SPA) Guidebook and associated technical standards, technical approaches to adapt the various computer PnP capabilities to small spacecraft and the space environment.

This Guidebook provides a general description of a data centric spacecraft model used to form the on-board PnP network. Various views are used to clearly indicate how this works. A common ontology is described to allow for a profile specific Common Data Dictionary (CDD) so that a stable set of terms may exist. Interfaces between devices are described to simplify the implementation of PnP at the device level. Finally, those PnP protocols identified to date are generally described, as are the adaptations needed for space application.

The detailed requirements for each of these topics are listed in the respective AIAA SPA standards listed below.

- SPA Networking Standard
- SPA Logical Interface Standard
- SPA Physical Interface Standard
- SPA 28V Power Service Standard
- SPA System Timing Standard
- SPA Ontology Standard
- SPA Test Bypass Standard
- SPA SpaceWire Subnet Adaptation Standard
- SPA System Capability Guide

At the time of approval, the members of the AIAA SPA Committee on Standards were:

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|---|---|
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| Jeanette Arrigo | Sierra Nevada Corporation |
| Scott Cannon | Utah State University |
| Ken Center | PnP Innovations |
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The above consensus body approved this document in November 2012.

The AIAA Standards Executive Council (VP-Standards, Laura McGill, Chairperson) accepted the document for publication in November 2012.

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*Alternate CoS Participant

## Introduction

This Guidebook provides the introduction to the SPA standard set. The SPA effort is a response to the need for reduced design, fabrication, integration, and test schedules (and therefore related engineering costs) for small spacecraft. The primary goal of SPA is to enable completion of all satellite development phases in days instead of months and years.

With the current technical and standards base, it is common to allocate months in a small satellite development schedule just for integration. This allocation is often repeated recursively at lower levels of decomposition of a large space platform.

Under SPA, computer-negotiated interfaces permit the elements of a complex system to transparently contribute information that accelerates the integration process by reducing or eliminating error-prone human interpretation. Electronic self-configuration/self-organization allows for rapid space vehicle construction. Additionally, the placement of sensors and actuators on the spacecraft is not restricted to specific, predetermined locations. In the terrestrial electronics industry, this capability is called "Plug-and-Play" (PnP). The approach fully supports an à la carte method of constructing arbitrarily complex arrangements of virtually any sensor or actuator type. Self-configuration/self-organization makes the network not only easy to expand and modify, but also robust to component failure from either natural causes or from deliberate attack.

The expected impact of Plug-and-Play goes beyond spacecraft manufacturing to increased manufacturing rates for satellite bus components. Through the production of scores or hundreds of units the economies of scale and the amortization of Non-Recurring-Engineering costs, including iterative design, testing and certification, can fundamentally alter the profitability of satellite fabrication and integration. The result will be faster turns of satellite orders at a lower delivered price and a better profit margin to the manufacturer.

As the SPA concept advances, the set of internalized transport protocols will grow. The initial content of this guidebook will focus on standardization of ontology, the use of xTEDS to establish component (hardware and software) communications interfaces, the logical flow of SPA messages, functions of the SPA network, and the employment of existing data transport standards to form plug-and-play information interfaces. SPA standards complete the architecture with inclusion of physical interfaces.

# 1 Scope

This Guidebook provides an overview for spacecraft platform (system), subsystem, and component (including payload) developers with spacecraft plug-and-play architectures to promote rapid design, fabrication, integration, and test. Included is an introduction to SPA, providing an informative reference for the uninitiated reader. It also includes a summary of the SPA standards. The standard user is directed to the SPA standards for detailed requirements. In cases where material in this document differs from a SPA standard, the standard will take precedence.

# 2 Tailoring

Tailoring is a process by which individual requirements or specifications, standards, and related documents are evaluated and made applicable to a specific program or project by selection, and in some exceptional cases, modification and addition of requirements in the standards. When viewed from the perspective of a specific program or project context, the requirements defined in the SPA standards may be tailored to match the actual requirements of the particular program or project. Tailoring of requirements shall be undertaken in consultation with affected stakeholders, including the procuring authority where applicable.

# 3 Applicable Documents

The following documents contain provisions which, through reference in this text, constitute provisions of the SPA standards. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

## 3.1 Normative References

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| W3C XML 1.0 | *Extensible Markup Language* |
| W3C XML Schema Part 1 | *XML Schema: Structures* |
| W3C XML Schema Part 2 | *XML Schema: Datatypes* |
| AIAA S-122-2007 | *Electrical Power Systems for Unmanned Spacecraft* |
| CCSDS 660.0-B-1 | *XML Telemetric and Command Exchange (XTCE)* |
| CCSDS 850.0-G-1 | *Spacecraft Onboard Interface Services – Informational Report* |
| ECSS-E-ST-50-12C | *SpaceWire – Links, Nodes, Routers and Networks*, July 2008 |
| IEEE 1451 Standards family | *Standard for a Smart Transducer Interface for Sensors and Actuators* |

# 4 Vocabulary

## 4.1 Acronyms and Abbreviated Terms

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| 6DoF | 6-degrees-of-freedom |
| AIAA | American Institute of Aeronautics and Astronautics |
| APT | advanced plug-and-play technology |
| ASIM | appliqué sensor interface module |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society of Testing and Materials |