The Critical Role of Chassis Management for MOSA Systems Aligned to the SOSA® Standard

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Executive Summary

The Sensor Open Systems Architecture®, or SOSA® consists of nearly two dozen modules falling into two general categories: Core Mission or Processing Chain modules, and Sensor Management and Support System modules. The latter can be thought of as more-or-less generic functions that most or all SOSA based systems rely on. While sometimes thought of as mundane, these management and support modules can play very important, even critical roles in maintaining the correct and reliable operation of complex sensor systems. In this paper we will examine the structure of the in-band and out-of-band system management functions of the 1.1 System Management module, and the important tasks they perform in facilitating rapid system integration and maintaining a healthy sensor platform during mission operations.

The paper will highlight the critical role of a chassis manager within a SOSA Element as a key component of system management in providing the out-of-band interface to Plug-In Cards (PICs). It will also summarize the chassis management in-band system management interactions that must be provided by the chassis manager In-Band System Management (IBSM) agent and discuss the key role the chassis manager plays in SOSA system management.

Introduction

Modern military sensor, communications, and electronic warfare platforms are complex systems typically consisting of a mix of custom and commercial off-the-shelf electronic components working in-concert to execute their tasks. To help ensure reliable operation from power-on to shutdown, system integrators often rely on both out-of-band and in-band system management components and techniques.

In its 1.1 System Manager module, The Sensor Open System Architecture (SOSA®) Technical Standard [1] leverages VITA 46.11 [2] for out-of-band (OOB) chassis management functions, and defines an in-band (IB) interface for communications with both the chassis manager (which provides those OOB functions), as well as the individual plug-in cards that make up a SOSA based system.

While to some this may be seen as a relatively unimportant housekeeping function, in fact the 1.1 System Manager module provides a key role in the reliable and secure starting, operation, and shut-down of these complex systems. In this paper we will be examining this role as well as some of the important details of the OOB and IB system and chassis management functionality called for by the SOSA Technical Standard with respect to the management of the chassis and the plug-in cards (PICs) in the chassis. There are aspects of the 1.1 System Manager module that deal with interactions with other SOSA modules, but that is outside the scope of this paper.

What SOSA Defines in the 1.1 System Manager Module

The SOSA Technical Standard describes module 1.1 System Manager as [1]:

The System Manager Module is responsible for implementing functions necessary to manage the overall SOSA sensor system, its hardware and software infrastructure, and the security controls applied to it.

It goes further to describe the basic functions of this module as shown in Table 1:

Function	Description
Discovery	Identifying and obtaining information required to communicate with the SOSA sensor and its sensor components
Configuration	A detailed description of the sensor, its sensor components, and the security controls applied, reading and setting configuration parameters, and updating software packages
Control	Monitoring and setting control parameters for the sensor and its modules, such as mode and state, and performing control actions such as reset or BIT
Health Management	Publishing periodic health reports, notifying the occurrence of configuration, control, and health events, and logging health reports and events
Security Management	Monitoring the system to detect and counter cybersecurity anomalies and threats

Table 1: Functions of the 1.1 System Manager module as described in the SOSA Technical Standard.

As mentioned in the introduction, SOSA defines two basic mechanisms for these functions: Out-of-Band and In-Band. Architecturally this can be described by as follows:

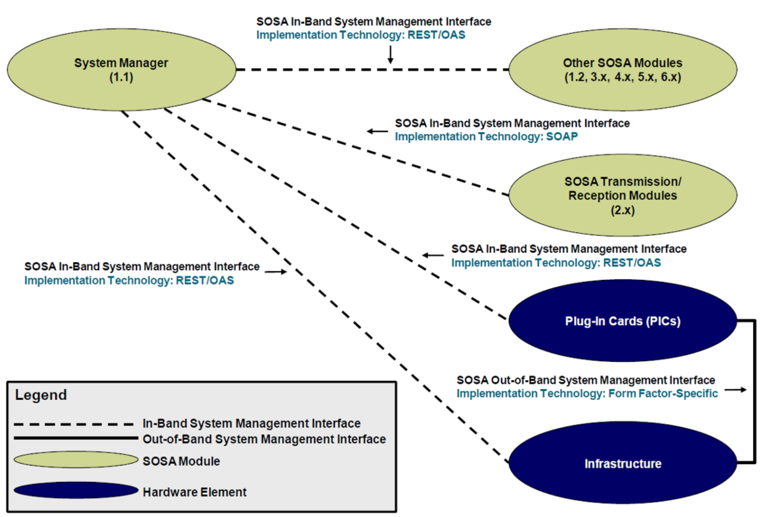

Figure 1:General SOSA System Manager Architecture, with specific in-band and out-of-band interfaces identified. From Technical Standard for SOSA® Reference Architecture, Edition 2.0 Snapshot 3.

Figure 2 focuses on the parts of the architecture having to do with chassis and PIC management:

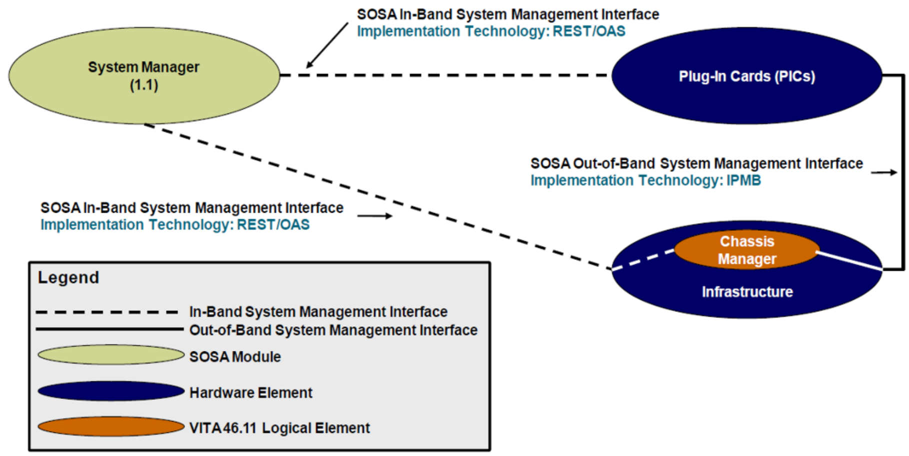

Figure 2: View of the hardware components and their interfaces. From Technical Standard for SOSA® Reference Architecture, Edition 2.0 Snapshot 3

The OOB element is defined by the Technical Standard as leveraging VITA 46.11: System Management on VPX standard, with specific language what functionality must be supported by both the PICs and the Chassis Manager hardware (beyond what VITA 46.11 calls out as mandatory). It also calls out physical implementation details such as the use of power rails (3.3V_AUX for VPX, VAUX for VNX+), support for dual Intelligent Platform Management Busses (IPMB) on Chassis Manager, PIM, and backplane hardware, and specific implementation and behavior details of features such as the SYSRESET* and NVMRO signals.

An example of a system using SOSA hardware components and their connectivity to SOSA defined system and chassis management elements is shown in Error! Reference source not found.. Note that the critical system management elements include:

• **Hardware Management Controller (HMC)**: This is a hardware element that contains a VITA 46.11 Chassis Management Controller, as well as an Ethernet interface for connection to the sensor Control Plane. The HMC also connects to various chassis sensors chassis Field Replaceable Unit (FRU) information, as well as the dual IPMBs which connect the Chassis Manager (ChMC) to the various PICs to form the OOB interface.

• **Intelligent Platform Management Controller (IPMC)**: Each PIC must contain an IPMC. The IPMC interfaces to the Chassis Manager via the IPMB, and performs PIC hardware management functionality, including (but not limited to):

— Supporting PIC FRU discovery commands from the Chassis Manager

— Support access to PIC sensors

— Responds to and logs events

— Performs (on command from the Chassis Manager) PIC activation, deactivation, reset, and other control functions

— Supports message bridging and firewall functions

• **System Manager**: The System Manager is the entity responsible for overall operation of the system. It interacts with the HMC through the Chassis Manager In-Band System Management interface, which is a set of commands chassis and security management for which the HMC is responsible for.

The system manager can reside on a PIC within the chassis or compute entity outside of the chassis provided it has connectivity to the HMC and PICs via the in-band system management interface.

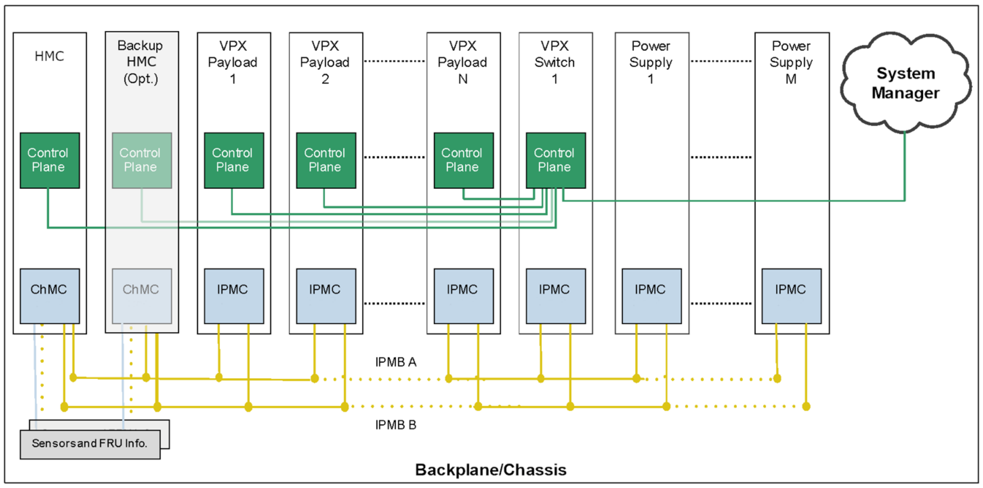

Figure 3: Example SOSA System Management Backplane/Chassis Implementation. From Technical Standard for SOSA® Reference Architecture, Edition 2.0 Snapshot 3, slightly edited for clarity.

VITA 46.11 Overview

VITA 46.11 forms the core of the SOSA OOB Management Functionality. VITA 46.11, in turn, leverages the earlier Intelligent Platform Management Interface (IPMI) specification [3] developed by Intel and others in the late 1990s and early 2000s, and later work done in development of the PICMG Advanced TCA (ATCA) specification. However, VITA 46.11 adds significant capabilities and functionality beyond these two specifications and ignores some functionality (especially from ATCA) which is of no value to OpenVPX or VNX+ systems (like hot-swapping).

Most of the uniqueness of VITA 46.11 is in the command set. The VITA 46.11 command set is organized into three Tiers, with Tier 1 providing the simplest functionality, and Tiers 2 and 3 adding progressively more complex functionality. Each Tier is further composed of mandatory and optional commands. This tiered architecture allows the implementer to select the appropriate functionality for their particular system.

However, SOSA defines a relatively complete implementation of VITA 46.11 for HMCs and PICs, requiring Tier 3 command support (which includes Tier 1 and 2 mandatory and optional functionality), along with a number of Tier 3 optional commands such as the Firmware and Bridged Firewall functionality, and the Payload Mode Sensor commands.

The minimum capabilities of a Tier-1 IPMC and ChMC (from V46.11 ref):

- To be responsible for System IPMB start-up and fault handling.
- To support the discovery of the FRU it controls.
- To support access to the management information for the FRU it controls.

Tier-2 capabilities include all Tier-1 mandatory capabilities (as well as some optional), but add to that:

- To participate in event generation and reception.
- To support a Dynamic Sensor Population.
- To optionally support Subsidiary FRUs.

Likewise, Tier-3 capabilities include all Tier-2 mandatory capabilities (as well as some optional), but add to that:

- To support redundant System IPMB interfaces.
- To support operating the System IPMB in FAST-MODE (400 kHz).
- To provide local event logging for locally generated events.
- To support FRU activation, resets, and control bits.
- To support IPMI message bridging for Intelligent Subsidiary FRUs.
- To provide IPMI message firewall capability.

The SOSA Technical Standard Version 2 Snapshot 3 specifically states that a SOSA aligned ChMC and IPMCs:

- Must support all mandatory Tier-3 functionality
- Must implement the optional firmware firewall commands
- If a PIC implements a VITA 46.11 Payload Mode Sensor (while Payload Mode Sensor is a mandatory Tier-3 command, not all PICs are required to utilize it as it does not make sense for some PICs)
    - It must populate the “Discrete Reading Mask” in the sensor data record with 0x007F, making sensor states readable.
    - It must indicate its operational state (Starting, Stopping, Operational, Faulted, Cleaning, Off) in bits 0-6
    - Must support the “Get Payload Mode Capabilities” request with 0x001E in the “supported modes” field
- ChMCs that support radial IPMBs must support the VITA 46.11 Bridged Firewall functionality, to filter traffic between links

Along with a number of other rules, recommendations, and suggestions regarding the behavior of SOSA HMCs and IPMCs.

Note, too, that a number of the functions defined by VITA 46.11 and interactions defined in the SOSA Technical Standard require system/chassis specific values. Among these are sensor value and alert thresholds. These thresholds tell the ChMC when sensors are reporting non-normative values, indicating warning or fault conditions. These values, unique to the hardware that makes up the system, are critical for prognostics and system health monitoring.

Through these commands/capabilities, a SOSA/VITA 46.11 ChMC can perform important system-level functions outside of the normal operation of the sensor platform interfaces, including:

- Hardware inventory (discovery)
- Turning on or off individual PICs (an important function for both isolating troublesome hardware, as well as managing inrush currents during system start)
- Monitoring (and control in some cases) of board sensors
- Monitoring (and control in some cases) of chassis sensors
- Monitoring (and control in some cases) of power supplies
- Event handling
- Payload state monitoring and control
- Perform maintenance operations like firmware updates, zeroization/sanitation, etc.
- Monitor and control certain system parameters like NVMRO

One important feature of VITA 46.11 that is not found in IPMI or ATCA is support for radial IPMBs. While traditional bussed IPMBs are supported and leveraged by the majority of fielded systems, there are some systems that require (for application-specific reasons) discrete, unique IPMB connections between the ChMC and the IPMCs of the individual PICs. This relatively new feature of VITA 46.11 is not widely used yet, but is expected to over the coming years.

SOSA In-Band Interface

With respect to hardware, the SOSA In-Band System Manager interface can be essentially classed as two sub-interfaces: one for the ChMC (performed through the SOSA Chassis Manager In-Band Interface) and one for the PICs themselves (the SOSA PIC In-Band System Management Interface). The functionality of these elements are defined in Section 6.6 of the SOSA standard. The In-Band System Management Interface interacts directly with agents running on the PIC and ChMC.

Both the PIC and chassis manager interfaces share a set of common functions defined as the Common Element In-Band and System Management Interactions. The functionality of these is depicted in Figure 4. Functions new in snapshot 3 are shown in red.

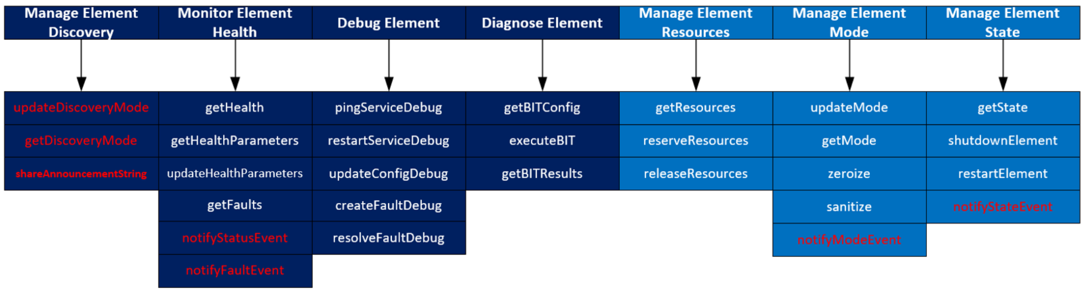

Figure 4: Common Element In-Band System Management Definitions (SOSA Technical Standard Table 6.2.2.1-1 through -7

The PIC specific In-band interface rules add the interactions shown in Figure 5.

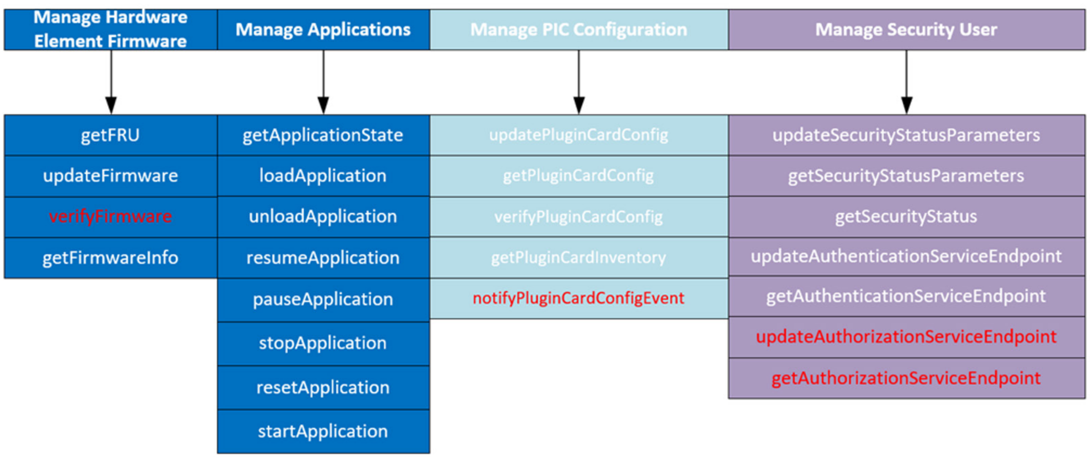

Figure 5 SOSA PIC In-Band System Management Interactions SOSA Technical Standard Rules 6.6.1.3-3

Its functionality can be generally described as higher-level sensor and general operation functions, including:

- Managing sensor configuration
- Accessing logs
- Performing diagnostics and accessing BIT results
- Issuing zeroization and sanitation commands
- Providing other sensor operational state, mode and health functions

To a certain extent these functions somewhat blur the line between the PIC hardware itself and the sensor "application" that is in operation on the PIC. This is intentional, as the target PIC may be a processor-based single-board computer running application code, or something more hardware-based like an FPGA or ASIC-based PIC performing a fixed SOSA Module function. In either case the System Manager needs to perform these functions on PIC-by-PIC basis.

The In-Band Chassis Management Interface, on the other hand, provides an interface for the System Manager to interact with the OOB elements of the system – specifically the ChMC. The SOSA Technical Standard defines this set of interactions between the System Manager and the ChMC, which in-turn utilizes the functionality defined in VITA 46.11 to effect chassis management.

The Chassis Manager specific in-band interface rules add the interactions shown in Figure 6.

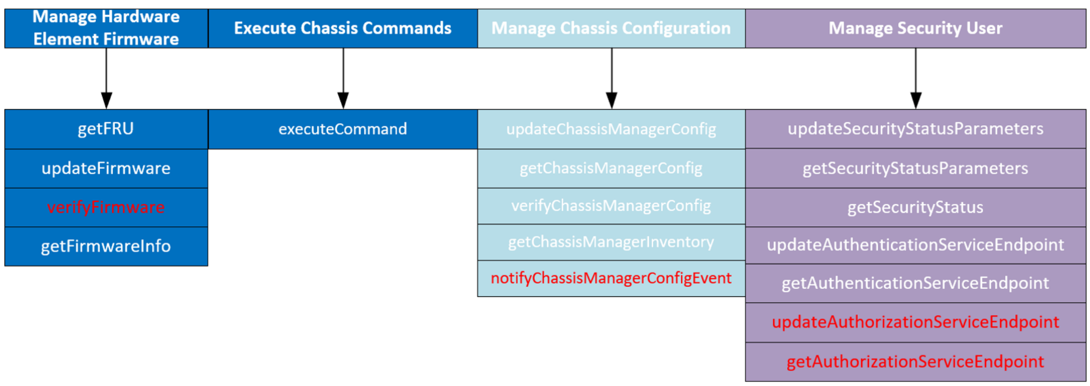

Figure 6: SOSA Chassis Manager In-Band System Management Interactions SOSA Technical Standard Rules 6.6.1.3-3

Like the In-Band System Management Interface, the In-Band Chassis Management Interface interactions are relatively high-level, requiring the ChMC to not only perform multiple tasks on perhaps multiple PICs and sensors, but also to sometimes make decisions based on the results the ChMC collected. For instance, one defined interaction is getHealth. The function of this interaction is defined as "Supply data that describes the current and/or projected condition and well-being of a Sensor Component." While in this case the target of the command is a single PIC, the ChMC is expected to make an evaluation of the health of the PIC based on the sensor data collected from the PIC. The data it returns is a) a count of faults recorded by the PIC, and b) an evaluation of the health of the PIC ("Healthy", "Degraded", or "Critical"). Both of these parameters require an evaluation of the raw data collected from the PIC by the ChMC.

However, the In-Band Chassis Management Interface executeCommand interaction is one exception to this. It provides access directly to low-level ChMC functions. This interaction allows the System Manager to execute VITA 46.11 ChMC commands and reading the results directly. In this way the entire set of VITA 46.11 commands supported by a specific HMC can be accessed.

How the System Benefits from the Chassis Management Functionality of the 1.1 System Manager Module

The ultimate objective of the Chassis Management functionality of the 1.1 System Manager Module is to help ensure the reliable and secure operation of the sensor processing hardware, while avoiding interruption of the core operation of that hardware. It accomplishes this by leveraging the powerful OOB functionality provided by VITA 46.11 and combining it with a carefully crafted hardware and system management interaction architecture.

Table 1 outlines the basic functionality provided by the 1.1 System Manager Module. However, the value of that functionality extends well beyond those basic definitions. Predictive maintenance through the collection of operational data such as total on time, on time at temperature, sensor log data, and the like can be used to anticipate faults so that maintenance can be scheduled and unplanned down-time is avoided. Equipment manifest data can be used to detect unexpected changes in hardware, firmware and software configuration, providing an important security capability. And the ability to manage the power state of individual PICs can enable multiple system operational/power modes, and can reduce system wear-and-tear by reducing overall system-generated heat and undesirable inrush power spikes.

An effective implementation of a system manager can greatly increase the sensor system's ability to support the mission. By actively monitoring health and taking action, it can minimize the impact of hardware faults or software crashes, by redeploying application tasks to healthy PICs or instigating application restarts or PIC resets. This can have a significant impact on the effectiveness and mission availability of a SOSA sensor system.

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Referenced Documents

(Please note that the links below are good at the time of writing but cannot be guaranteed for the future.)

[1] Technical Standard for SOSA® Reference Architecture, Edition 2.0 (Snapshot 3), published by The Open Group, May 2025; refer to: publications.opengroup.org/standards/sosa/s251

[2] ANSI/VITA 46.11-2022: System Management on VPX, published by VITA (VMEbus International Trade Association), April 2022; refer to: www.vita.com

[3] IPMI: Intelligent Platform Management Interface Specification Second Generation, V2.0 E7 Markup, published by Intel Corporation, Hewlett-Packard Company, NEC Corporation, Dell Inc., April 2015; refer to: www.intel.com/content/dam/www/public/us/en/documents/specification-updates/ipmi-intelligent-platform-mgt-interface-spec-2nd-gen-v2-0-spec-update.pdf

About the Authors

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About Elma Electronic

For more than 50 years, Elma Electronic has been a trusted leader in mission-critical embedded computing solutions for demanding defense programs. We engineer and manufacture ruggedized systems that excel in harsh field deployments. Our long track record spans land, air, and sea platforms, with deep understanding of C5ISR, EW, SIGINT, EO/IR systems and sensor integration requirements.

We specialize in MOSA-compliant open standards-based systems using SOSA®, CMOSS, OpenVPX & VNX+ architectures, MIL-STD qualified enclosures, high-speed backplanes, and integrated subsystem solutions.

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The Open Group SOSA® Consortium enables government and industry to collaboratively develop open standards and best practices to enable, enhance, and accelerate the deployment of affordable, capable, interoperable sensor systems. The SOSA Consortium is creating open system reference architectures applicable to military and commercial sensor systems and a business model that balances stakeholder interests. The architectures employ modular design and use widely supported, consensus-based, nonproprietary standards for key interfaces.

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