SELECTING THE RIGHT STANDARDS FOR YOUR FACTORY USE CASE AND TECHNOLOGY NEEDS

SEMI® EQUIPMENT COMMUNICATION AND AUTOMATION STANDARDS SUITES

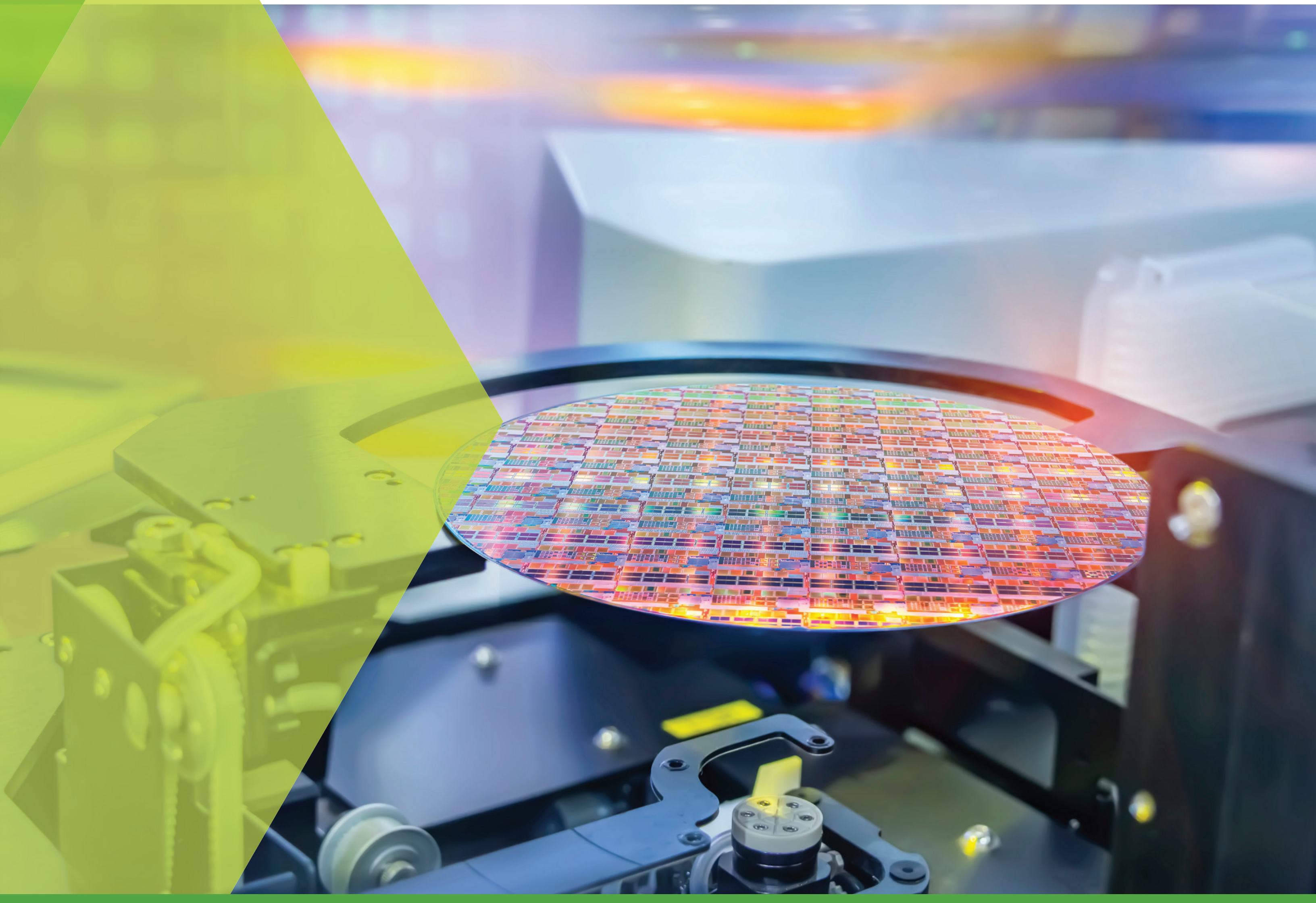

TABLE OF CONTENTS

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Abstract

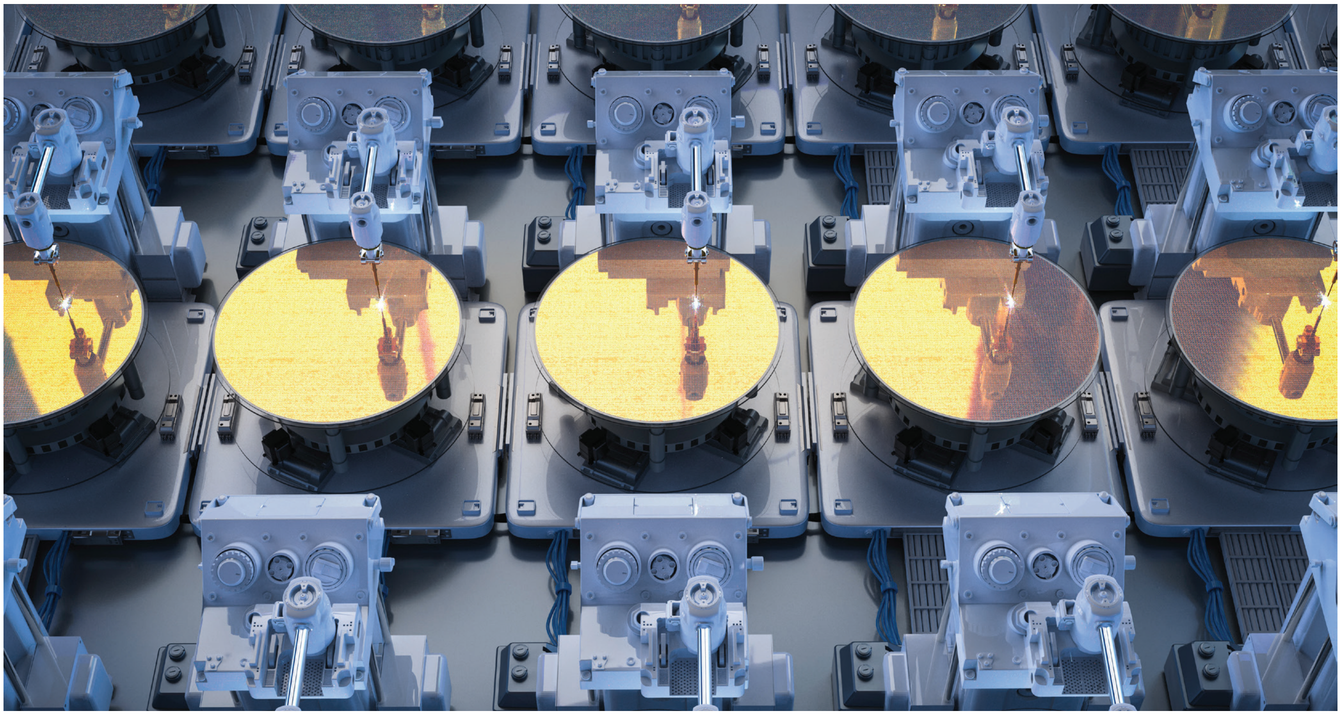
To enable equipment automation, control, and data collection in modern semiconductor manufacturing fabs, it is essential that factory host systems communicate with manufacturing equipment, test, and assembly components. Due to the sheer volume of different suppliers, communication protocols, and how software applications interact with one another, developing custom solutions for each integration is not only complex, but costly. These challenges can be reduced through the adoption of standards-based integration approaches.

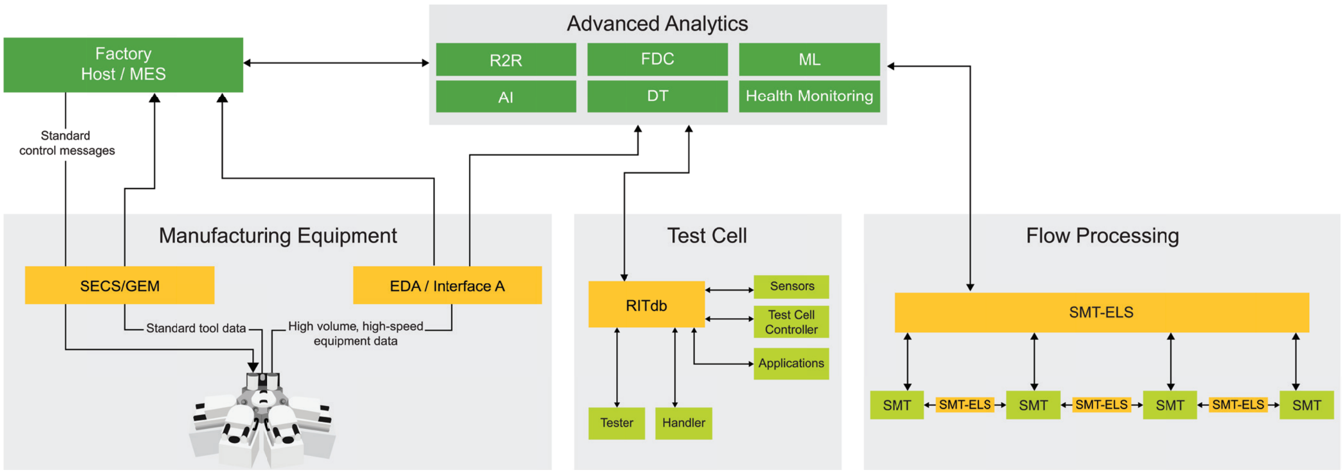
This whitepaper describes four SEMI Standards Suites that can be used to support equipment communications and automation. Each suite supports different use cases and features. By narrowing the wide field of possibilities to a smaller group of established standards, integration can scale much faster and more efficiently for both the factories and suppliers.

Overview

Within a semiconductor manufacturing facility, there can be thousands of individual units of equipment provided by scores of suppliers. Each can have their own ways of communicating with the factory automation components, such as Factory Host and Manufacturing Execution Systems (MES), and equipment engineering components performing advanced analytics, including Fault Detection and Classification (FDC), Machine Learning (ML), Artificial Intelligence (AI), Digital Twin (DT), and Run-to-Run (R2R) Control. Although many of the protocols used may be open source or are industry standards (e.g., OPC®, Hadoop®, or Apache Kafka®), often there are no standards or guidelines that describe how to use these protocols, such as how messages are structured, what data is sent, and what behavior is expected when a certain message is received. This results in both the equipment supplier and equipment user having to customize their systems each time they integrate a new piece of equipment.

SEMI provides a number of SEMI Standards Suites to address this issue. Establishing clear expectations about the equipment data and behavior significantly reduces the integration time and effort.





SEMI offers the following Standards Suites for equipment communication and automation:

- **SECS/GEM** – Point-to-point command and control channel with a centralized factory host that also supports data collection capabilities.
- **Equipment Data Acquisition (EDA) / Interface A Standards** – Framework used to define equipment metadata, administer access rights, and manage data collection plans. Ideal for collecting high frequency and high-volume data through a dedicated channel.
- **Rich Interactive Test Database (RITdb)** – Defines a data and event sharing and streaming methodology that enables real-time messaging designed for the Test Environment.
- **SMT-ELS** – Basic framework well suited for flow-oriented processing components, such as Surface Mount Technology (SMT) and Printed Circuit Board Assembly (PCBA) assembly line scenarios.

More technical details and a list of resources for various SEMI Standards Suites can be found in the Appendices section of this whitepaper.

SEMI Standards Suite	Description	Typical Use Cases	Why Consider This Approach
SECS/GEM Standards	• Defines messages, state models, and scenarios to enable factory GEM host software to control, configure, monitor, and collect data from equipment. • Utilizes bidirectional binary communication protocols based on TCP/IP or serial communication. • The GEM Standard is widely adopted across multiple industries. GEM 300 adoption is nearly 100% in Semiconductor front-end. GEM and GEM 300 adoption is increasing in Semiconductor Back End. • SEMI E192 provides adoption guidelines for the 60+ SEMI Standards that can be implemented in a GEM interface. These define additional messages, state models, scenarios, notifications, data, alarms, and other features. • The GEM 300 Standards extend a GEM interface with job, load port, carrier, and substrate management for full automation.	• Factory host software controls, monitors, and collects data from equipment. This includes managing the equipment recipes, collecting process data, tracking equipment utilization, and coordinating instructions from other factory systems. (e.g., MES, recipe server, analysis components, fault detection, etc.) • GEM is also used for point-to-point communications with hardware components (e.g. RFID tag readers) and within equipment to communicate with third party modules. SEMI Standards such as SEMI E91, E99 and E130 describe how the equipment acts as a GEM host to communicate with those components.	• GEM provides a complete set of features to enable full factory automation. A GEM interface is a broker that allows the factory host to decide which alarm and collection event notifications to receive, what data to receive with collection event and trace report notifications and the trace report frequency. • The GEM Standard is mature yet continues to be enhanced without breaking backward compatibility.

EDA / Interface A Standards	• High-speed data collection .(trace reports, event reports, exception reports).
	
	• Utilizes industry communication protocols over TCP/IP:
	
	  • HTTP/1.1 with SOAP/XML technology. (Uni-directional ASCII protocol)
	  • HTTP/2 with gRPC/Protocol Buffers technology. (bidirectional binary protocol)
	
	• Initially slow start to industry adoption, but has gained significant momentum.
	
	• Focused on real time data collection. No support to retrieve historical data or control the equipment.
		• Self-contained data collection framework. (out of the box, EDA provides access control, data collection plan management and metadata organization).
		
		• Data collection performance is actively monitored and managed.
		
		• Many equipment suppliers implement both SECS/GEM and EDA so that EDA data collection is kept separate from the SECS/GEM control channel.
			• Equipment data can be sent to multiple EDA Consumers, each with its own set of Data Collection Plans (DCPs).
			
			• EDA Clients can configure their own DCPs to meet their needs using a sophisticated set of data collection triggers to collect different sets of data, rather than a fixed set of data that is difficult to change once approved.
			
			• Only authenticated and authorized users can collect data through the EDA interface.
			
			• The communication channel can be secured with encryption.

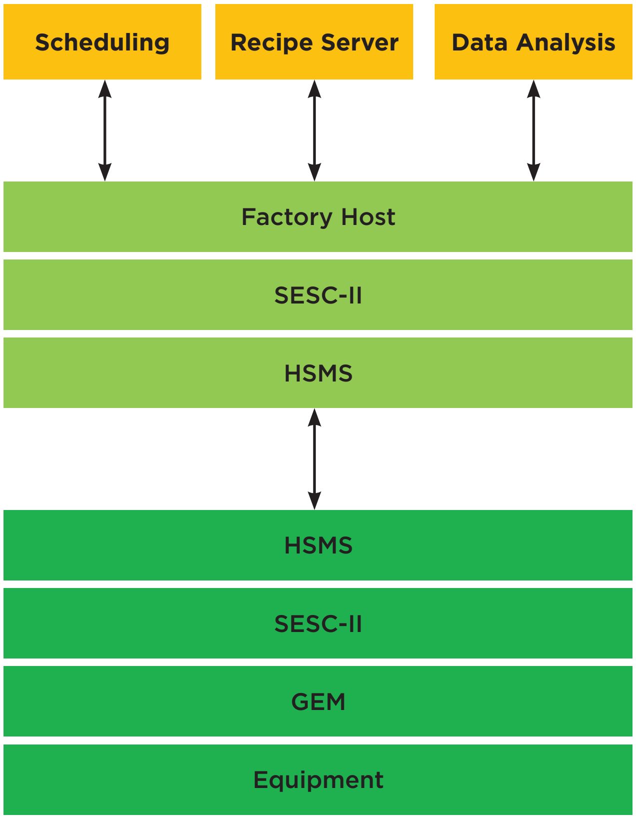
SEMI Standards Suite	Description	Typical Use Cases	Why Consider This Approach
RITdb Standards	• Address Test Environment challenges using a publish/ subscribe (pub/sub) architecture. This allows for different topologies to support different querying and latency requirements (e.g., within the Test Cell, within the Test Floor, and across business units). • Utilizes open-source, bidirectional binary communication protocols over TCP/IP. • Industry is starting to adopt. • Data collection is about the product/die and not as much about monitoring equipment performance. • RITdb encompasses more than a file format structure like STDF. • RITdb can accommodate applications with different data availability latency requirements. • Within the Test Cell, milliseconds latency is required. • Within the Test Floor, seconds latency is necessary. • Across business units, much longer latency is acceptable.	• Data Collection from Test Cell components. (e.g., testers, handlers, robots, test controller, etc.). • Controlling and updating test program execution in the Test Cell. • Storing test data for future retrieval and analysis.	• Data collection and control is based around the product/die. • Test Programs are adapted on the fly at the die level without impacting the test program, often at millisecond resolution. This requires much quicker decisions and communications than what can be done at a job level. Decision making could be distributed among different entities rather than through a centralized source. • Consumers subscribe to a topic to collect data rather than using predefined reporting – often the equipment doesn't know what data can be collected until it starts executing the test program. • RITdb messages contain an extractable storage structure, minimizing potential data precision loss than if data were translated and stored in an intermediate format. Applications can 'play back' archived RITdb messages against newly developed analysis rules. • The communication channel and message payload can be secured with encryption.
SMT-ELS Standards	• Communication for flow-oriented components. • Utilizes a bidirectional, ASCII communication protocol over TCP/IP. • Starting to gain adoption and is supported by major SMT equipment suppliers. • There are more operator interactions with the equipment than other parts of the manufacturing process. • Supports transferring information and metadata about the material being handed off to the adjacent equipment (e.g., board dimensions and some flow control).	• Control and processing of SMT lines with equipment from different SMT vendors/suppliers. • Good for some peer-to-peer communications between adjacent equipment. • Minimal factory involvement in controlling the equipment.	• Line-based processing tools are more basic; material predominantly flows one-way through the processing line along well-established, fixed material paths. • Often SMT equipment is controlled by non-PC computing devices (e.g., Programmable Logic Controllers [PLCs]) that require more basic communication and control behavior. Using a lightweight protocol makes it easier to integrate into non-PC computing devices.

SECS/GEM Standards Suite

Refer to SEMI E192 for guidance on selecting applicable GEM-related Standards.

Features in the GEM Standard

Below are key details about the GEM Standard itself.



Communication and Control Models

- **Communication State Model:** Establishes rules and message scenarios for initiating and maintaining communication between the equipment and host.
- **Control State Model:** Defines how control is shared or transferred between the host and equipment operator.
- **Processing State Model:** Each equipment implements a unique model to report its operational status.
- **Protocol:** GEM interfaces primarily use HSMS (SEMI E37) over Ethernet, with SECS-I (SEMI E4) available for serial communication.
- **Message Layer:** All GEM communications follow the SECS-II (SEMI E5) message structure for standardized data exchange.

Data Collection and Reporting

- **Collection Event Notifications:** Allow equipment to notify the host when specific activities occur. Equipment may publish hundreds or thousands of events, but the host selects which ones to monitor.
- **Dynamic Collection Event Reports:** Enable the host to specify which data variables and status variables to include in event messages.
- **Trace Data Collection:** Lets the host define a set of status variables and a reporting frequency for continuous data publishing.
- **Status Data Collection:** Allows the host to query status variables at any time. While GEM defines a core set of standard variables (e.g., equipment ID), equipment can define additional custom variables.
- **Alarm Notifications:** Inform the host when conditions arise that may pose risks to equipment, materials, or personnel. The host selects which alarms to monitor from the equipment's published list.

Configuration and Control

- **Equipment Constants:** Provide configurable parameters that control equipment behavior. Equipment can publish any number of constants.
- **Recipe Management:** Supports uploading, downloading, deleting, and executing recipes. Operator actions related to recipes are reported via collection events.
- **Remote Commands:** Allow the host to send commands with optional arguments to control equipment operations. GEM defines standard commands, but equipment can support additional custom commands.

Operator Interaction and Message Handling

- **Terminal Services:** Facilitate two-way text communication between the host and equipment operator.
- **Spooling:** Ensures message integrity by storing messages during communication outages and allowing retrieval once connectivity is restored.

Self-Discovery and Documentation

- **Implementation Features:** The factory host can query the equipment to retrieve lists of available status variables, collection events, data variables, alarms, and equipment constants.
- **Documentation:** To support integration and usability, the GEM Standard requires equipment to provide documentation of its SECS/GEM interface. This documentation can also be downloaded directly through the GEM interface.

GEM 300 Standards

The GEM 300 Standards, a set of standards that extend GEM for higher levels of factory automation, are widely adopted in all 300mm front-end and increasing adoption in major back-end semiconductor facilities.
Key standards include:

- **SEMI E40/E94** – Define job management, specifying which substrates to process, which recipes to use, and where to place completed substrates.
- **SEMI E87** – Manages carrier arrival, departure, and verification to ensure correct material handling.
- **SEMI E90** – Tracks substrate movement and processing status throughout the equipment.

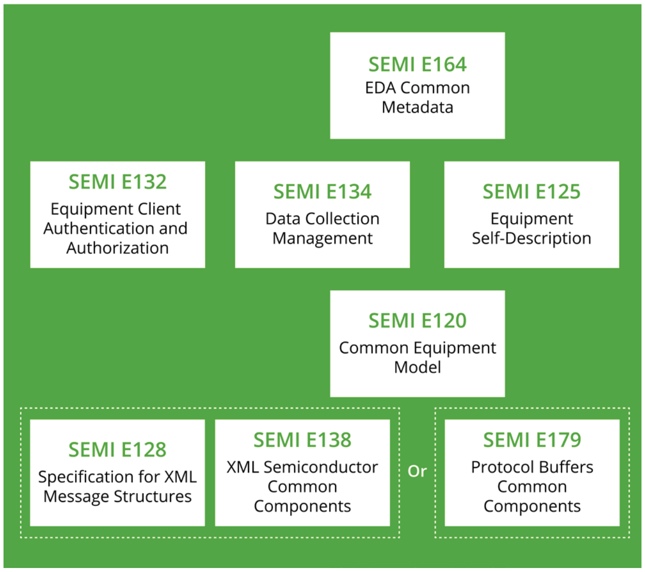
EDA / Interface A Standards Suite

The EDA Standards are a collection of SEMI Standards that enable high-speed data publication from any equipment to any data consumer through web services. Only authenticated and authorized users can collect real-time data. EDA cannot be used to control the equipment or access historical data.

Each consumer has their own set of Data Collection Plans (DCPs) tailored for their needs. DCPs support a sophisticated set of data collection triggers and techniques, and data is sent to each consumer through direct, dedicated channels.

Common scenarios use EDA to collect data for advanced analytics and then use those analysis results to adjust settings through the control channel, such as SECS/GEM.

EDA Standards Suite



The EDA Standards Suite includes:

- SEMI E132 – Mechanism to authenticate Clients before further communications, and a flexible authorization scheme for access control.
- SEMI E134 – Defines a way to request operational data to be sent automatically or based on ad hoc requests.
- SEMI E125 – Defines infrastructure to describe variables, events, exceptions, and physical equipment configuration available from the equipment.
- SEMI E120 – Provides an object model of semiconductor equipment and related elements.
- SEMI E164 – Defines common representation and conventions of SEMI E125 equipment metadata, including content defined in other SEMI Standards.

The EDA Standards Suite also includes several helper Standards that define protocol-specific common elements that span multiple Standards: SEMI E128, E138 and E179.

EDA Freeze Versions identify a specific set of SEMI Standards and versions that equipment users and equipment suppliers use as a unified set to implement the interface. This is very important in preventing disruption of manufacturing processes with EDA implementations that are not working with the same versions of interfaces and behaviors

The EDA Freeze Versions are:

- EDA Freeze 1 (1105) Released November 2005
- EDA Freeze 2 (0710) Released July 2010

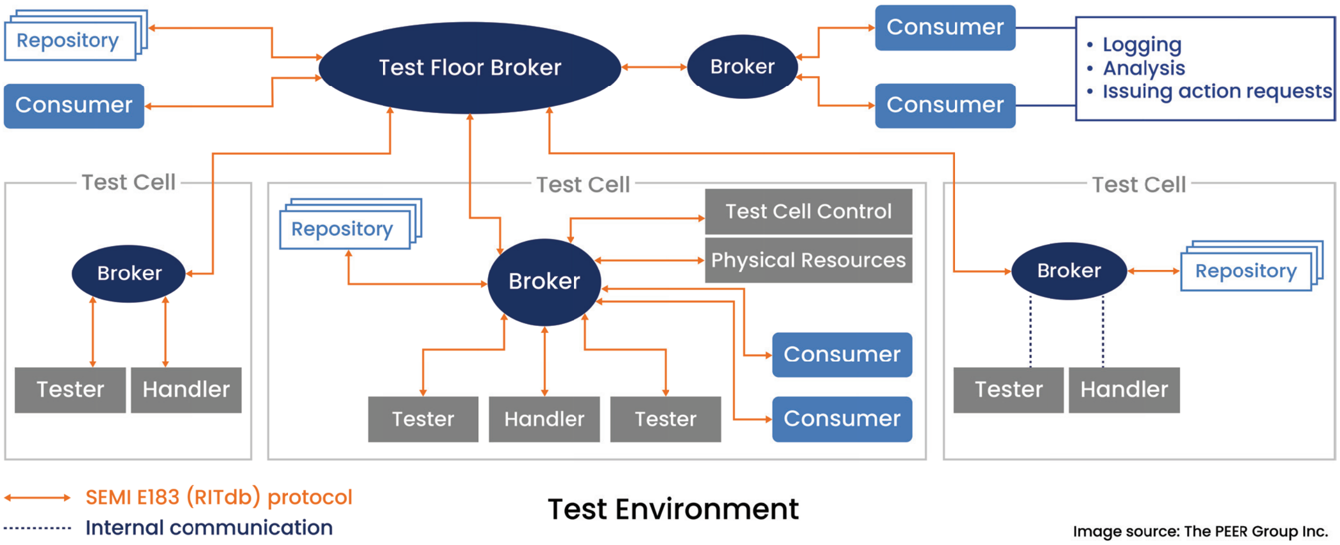
Note - Although SEMI E164 is not part of the EDA Freeze 2 definition, some equipment users request it. SEMI E164 allows for faster integration because everyone has the same expectations on about how the equipment metadata will be configured.

EDA Freeze 3
The semiconductor manufacturing industry is demanding more data, faster. This in turn is driving the SEMI Standards Program to develop EDA Freeze 3. Freeze 3 will integrate HTTP/2 with gRPC and Protocol Buffers technology to deliver higher performance and more efficient data transfers. It will also streamline functionality to better reflect actual customer use cases, including clarifying deployment scenarios and caching data support.

RITdb Standards Suite

The RITdb Standards Suite is designed for the Test Environment. Unlike front-end manufacturing standards that focus on the equipment, RITdb Standards focus on the product/die. They support a collaborative decision-making model that enables different rule engines to contribute to a decision rather than relying on a single point of expertise, such as the Host/MES.

RITdb enables high-speed communication on a machine-to-machine basis using the MQTT protocol (a pub/sub model). The test equipment can support RITdb natively, or for legacy equipment, support an add-on component that collects and processes information in parallel. In this case, RITdb features may be limited due to equipment capability.



Some key features of this Standard Suite include:

- Supports messaging to control the equipment/Test Cell.
- Does not require predefined data collection plans to receive published real-time data and events.
- Supports historical data collection and the ability to ‘play back’ historical data against new rule engines.
- Defines data containers for equipment information, events, logging, and product data.

SEMI E183 defines a data and event sharing and stream methodology for semiconductor test and related operations. The SEMI Standards Program is developing new specifications for event messaging and control messaging as well as RITdb implementation guidance documents.

SMT-ELS Standards Suite

The SMT-ELS Standards Suite applies to communication for flow-oriented components. Flow manufacturing is different from front-end manufacturing and is more common in SMT and PCBA production lines. Flow manufacturing addresses a different set of challenges:

- Unlike front-end manufacturing where material could go to different tools or potentially return to the same tools for additional processing, flow manufacturing tends to be linear with few choices in the routing path.
- The tools are simpler resulting in more operator involvement. The equipment executes simpler recipes based on the material that arrives at the equipment.

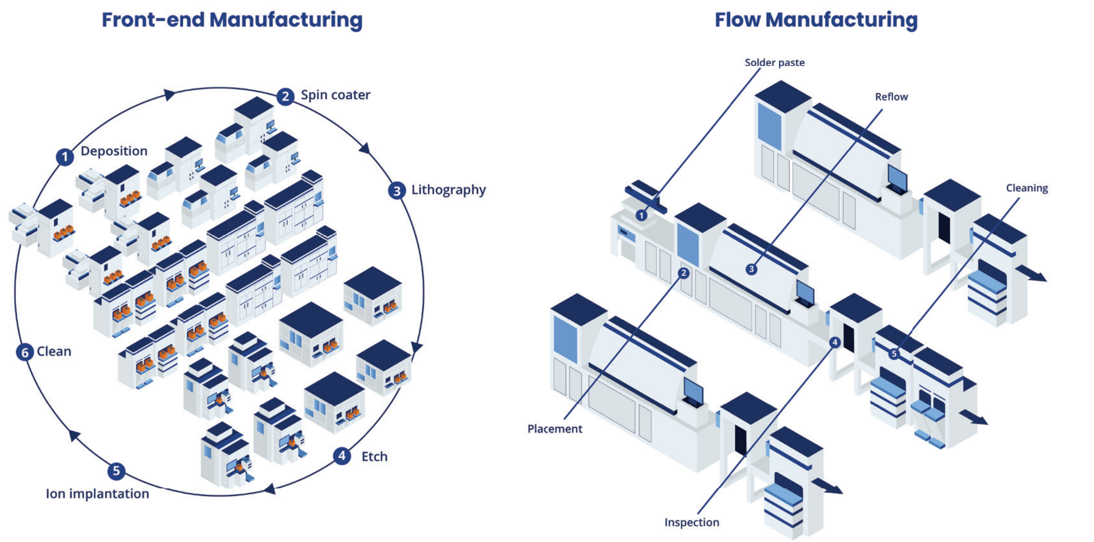
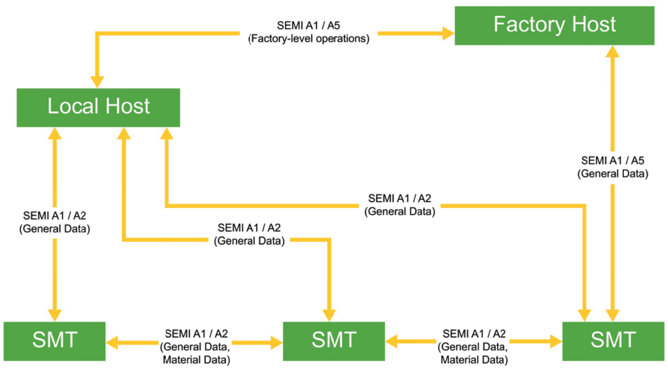


Image source: The PEER Group Inc.

The SMT-ELS Standards are based on a lightweight protocol so that less complex computing devices such as PLCs can implement them. They address Horizontal Communication (HC) between different equipment on the line, and Vertical Communication (VC) between equipment and higher-tier hosts, for example, a line controller/ equipment host or a factory automation host.



The SMT-ELS Standards Suite includes:

- SEMI A1 – Defines a communication interface for equipment control in a flow shop type manufacturing line.
- SEMI A2 – Defines an interface for equipment control in an assembly line for printed circuit board (PCB) that uses surface mount technology (SMT)
- SEMI A5 – Extends SEMI A2 for factory-level operations

Data Sharing Considerations

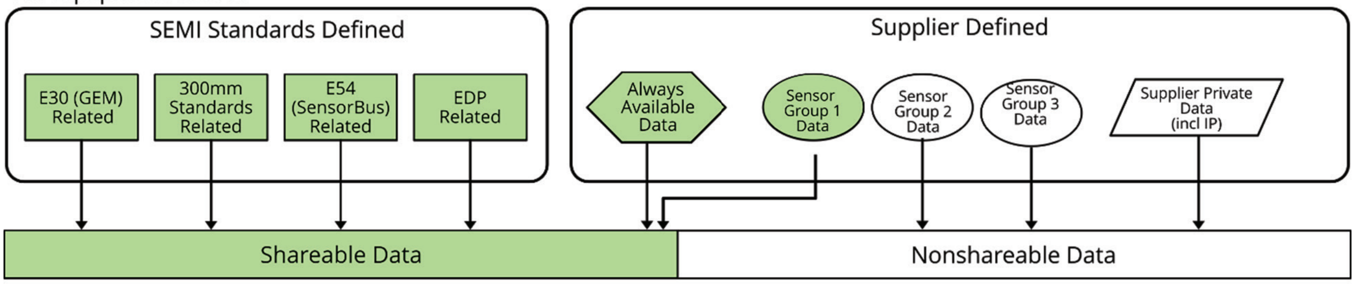
A common debate between equipment suppliers and equipment users is over what equipment data is accessible. SEMI E190 (Specification for Equipment Data Publication [EDP]) defines shareable and nonshareable data, providing a framework that various parties can use for their discussions about who has access to different equipment data.

- **Shareable Data** – Accessible from the manufacturing equipment through software interfaces (streaming interfaces and local data sources).
- **Nonshareable Data** – Equipment data that is not shareable; equipment supplier does not make this data accessible to the equipment user. This data can include the supplier's private information, intellectual property (IP), and information that is only accessible through graphical user interfaces (GUIs) and hardware instrument panels.

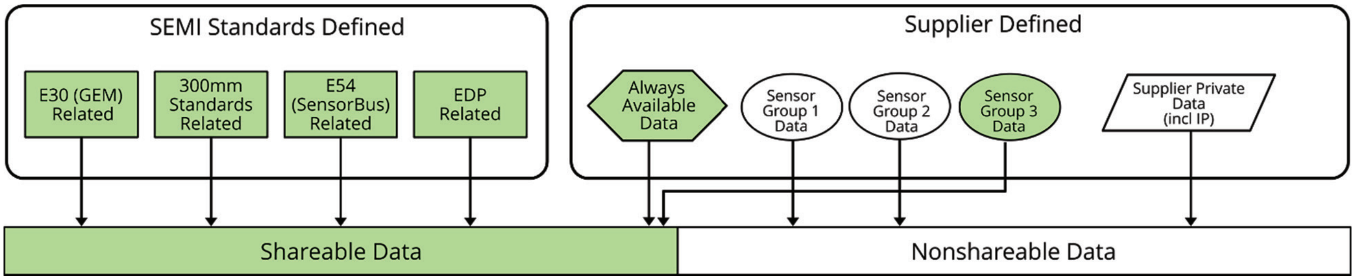
Equipment suppliers and each equipment user negotiate what equipment data is considered shareable and nonshareable through agreements between these two entities.

For example, an equipment supplier has an agreement with Equipment User A to share data from Sensor Group 1. That data, along with all other shareable data, is included in the shareable data bucket, along with data defined by various SEMI Standards that the equipment supports (e.g., SEMI E30 (GEM), 300mm Standards, and EDP related Standards). However, the equipment supplier does not have a similar agreement with Equipment User B, so Sensor Group 1 Data is not included in the shareable data for Equipment User B.

For Equipment User A



For Equipment User B



Supplier Defined Equipment Data	Agreed Shareable		
	Equipment User A	Equipment User B	Equipment User C
Sensor Group 1 Data	Yes	No	No
Sensor Group 2 Data	No	No	Yes
Sensor Group 3 Data	No	Yes	No

Conclusion

The SEMI Standards Suites described in this white paper are the result of countless hours of dedicated requirements analysis and system engineering effort over many years by industry domain experts around the world. They constitute the very foundation that supports our industry's ever-evolving automation technologies and systems which in turn enable the continuous productivity gains we take for granted.

Each SEMI Standards Suite addresses different factory use case scenarios through different technologies and philosophical approaches. By understanding the different origins and advantages of each Standards Suite, semiconductor manufacturing equipment suppliers and customers can simplify their evaluation and decision-making processes, reducing the time and complexity it takes to meet their business and technical objectives.

SEMI Standards Program

The SEMI Standards Program is a global initiative that facilitates the development of technical standards for the semiconductor and microelectronics industries. The program brings together industry experts through Technical Committees and Task Forces to collaboratively create and refine standards that improve manufacturing efficiency, safety, interoperability, and innovation.

SEMI Standards development activities take place throughout the year in all major manufacturing regions. For more information and to participate, please visit the **SEMI Standards website** and **events page**. There are no fees to join the SEMI International Standards Program. Task Force members help develop SEMI Standards and often have access to other resources.

If there are any questions regarding SEMI Standards activities, please contact your **local SEMI Standards** staff.

Appendix - SECS/GEM Standards Suite Datasheet

Deployment Architecture (Client/Server, Peer-to-Peer)	Client/Server
Network Protocol	TCP/IP
Protocol Type (Binary, ASCII)	Binary Protocol • TCP/IP protocol is SEMI E37 (HSMS) • Serial protocol is SEMI E4 (SECS-I)
Encryption Support	None
Capabilities – Data Collection	Yes • Dynamic collection event report and trace report setup. • Host entity can enable and disable any collection events and alarms for reporting.
Capabilities – Control	Yes • Host can send standard or custom commands. Commands can include name/value pair arguments. • Host can change equipment settings using equipment constants • Host can manage recipes.
Capabilities – Metadata Organization	Yes • GEM host can query the list of available variables, collection events, and alarms. • GEM host can query the GEM Documentation and SEMI E172 SEDD file. The SEDD file lists supported messages, remote commands, a map to standard features and other information about the GEM interface.
Decision-Making Control	Centralized Source
Authentication/Authorization	None
Message Definition (Defined, Custom)	Yes • SEMI E5 defines a dictionary of standard messages. • SEMI E30 and other GEM related Standards use a subset of these messages and define use cases for them. • Implementers can define custom messages.
Extensibility	Yes • Every GEM implementation extends the set of variables, collection events, alarms, remote commands, and recipes which are available for use within the standard messages. • There are over 60 SEMI Standards that extend the GEM Standard with additional functionality, as summarized in SEMI E192.
Limitations	• Traditionally an equipment's GEM interface only supports a single host connection, although many solutions exist that support multiple host connections. • No support for historical data, but does support message preservation when communication is lost. • Without authentication, any GEM host software with the connection information can connect to an unused GEM interface.
Version Compatibility	Any GEM host can connect and utilize any equipment's GEM interface regardless of the GEM version. • The GEM Standard is regularly updated and improved without breaking compatibility.

Resources

SEMI Standards

- SEMI E4 - Specification for SEMI Equipment Communications Standard 1 Message Transfer (SECS-I)
- SEMI E5 - Specification for SEMI Equipment Communications Standard 2 Message Content (SECS-II)
- SEMI E30 - Specification for the Generic Model for Communications and Control of Manufacturing Equipment (GEM)
- SEMI E37 - Specification for High-Speed SECS Message Services (HSMS) Generic Services
- SEMI E40 - Specification for Processing Management
- SEMI E87 - Specification for Carrier Management (CMS)
- SEMI E90 - Specification for Substrate Tracking
- SEMI E94 - Specification for Control Job Management
- SEMI E192 - Guide for Equipment Adoption Criteria for GEM and GEM-related Standards

Appendix – EDA / Interface A Standards Suite Datasheet

Deployment Architecture (Client/Server, Peer to Peer)	Client/Server
Network Protocol	TCP/IP
Protocol Type (Binary, ASCII)	Both • ASCII Protocol - HTTP/1.1 with SOAP/XML • Binary Protocol - HTTP/2 with gRPC/Protocol Buffers
Encryption Support	Yes • Using SSL/TLS (Easier to secure the communication channel with Freeze 3.)
Capabilities – Data Collection	Yes • Dynamic collection plan setup and enabling/disabling.
Capabilities – Equipment Control	None
Capabilities – Metadata Organization	Yes • Parameters (variables), Events, Exceptions (alarms) and equipment structure definitions. • Messages to retrieve metadata.
Decision Making Control	N/A
Authentication/Authorization	Yes • Role and access rights-based authentication and authorization defined in SEMI E132.
Message Definition (Defined, Custom)	Yes • SEMI Standards define message structure. No support for custom messages.
Extensibility	Partial • Self-contained framework – cannot change the messaging or software interface • 'Freeze' version ensures equipment suppliers and equipment users are working against the same set of standards/revisions. • Can extend the data (e.g., changing the equipment metadata model by adding new parameters, events and exceptions or changing the equipment structure.)
Limitations	• No support to control the equipment or access historical data.
Version Compatibility	• Implementations can only connect to systems supporting the same EDA Freeze version.

Resources

SEMI Standards

- SEMI E120 - Specification for the Common Equipment Model (CEM)
- SEMI E125 - Specification for Equipment Self Description (EqSD)
- SEMI E128 - Specification for XML Message Structures
- SEMI E132 - Specification for Equipment Client Authentication and Authorization
- SEMI E134 - Specification for Data Collection Management
- SEMI E138 - Specification for XML Semiconductor Common Components
- SEMI E164 - Specification for EDA Common Metadata
- SEMI E178 - Guide for EDA Freeze Version
- SEMI E179 - Specification for Protocol Buffers Common Components

EDA Freeze Versions

Freeze 1 (1105) Released November 2005		Freeze 2 (0710) Released July 2010	
E120-1104	E120.1-1104	E120-0310	E120.1-0310
E125-1105	E125.1-1105	E125-0710	E125.1-0710
E132-1105	E132.1-1105	E128-0310	(none)
E134-1105	E134.1-1105	E132-0310	E132.1-0310
		E134-0710	E134.1-0710
		E138-0709	(none)

EDA Freeze 3 Resources

- Articles in SEMI Standards Watch Newsletter
- Addressing Big Data Needs with EDA / Interface A – SEMICON Japan 2024 Presentation

Appendix – RITdb Standards Suite Datasheet

Deployment Architecture (Client/Server, Peer-to-Peer)	Peer-to-Peer
Network Protocol	TCP/IP
Protocol Type (Binary, ASCII)	Binary Protocol • MQTT with CBOR encoding
Encryption Support	Yes • Using SSL/TLS
Capabilities – Data Collection	Yes • Entities subscribe to the data they want. (No formal data collection plan management).
Capabilities – Equipment Control	Pending • Entities subscribe to the control messages they are interested in (future update to SEMI E183)
Capabilities – Metadata Organization	Yes • Messages to query what metadata was sent in the past. • SQLite database can be accessed to get metadata details
Decision Making Control	Distributed
Authentication/Authorization	Yes • Role and access rights-based authentication and authorization is native to MQTT.
Message Definition (Defined, Custom)	Yes • SEMI Standard provides required message structure. • Implementers can provide custom • Future SEMI Standards to define standardized event and control messages.
Extensibility	Yes Future standards to build upon it, specifying expected behavior, information, and results.
Limitations	• If there is no broker in the topology, some functionality is limited.
Version Compatibility	Any RITdb client can connect and subscribe to a RITdb publisher regardless of the RITdb version. • The RITdb Standard can be updated without breaking compatibility.

Resources

SEMI Standards

- **SEMI E183 - Specification for Rich Interactive Test Database (RITdb)**

Online Forum

- **RITdb LinkedIn Group**

Blogs/Articles

- **Modernized IC Test Using SEMI RITdb Standards**
- **RITdb: The Interplanetary Database for Manufacturing**
- **New Standards on Test Cell Data and Events**

SEMI U Training

- **Implementing the SEMI E183 Standard (Rich Interactive Test Database) Bundle**

RITdb Utilities

- There are helper utilities (including a STDF Translator and RITdb Demo) available to RITdb Task Force members

Appendix – SMT-ELS Standards Suite Datasheet

Deployment Architecture (Client/Server, Peer-to-Peer)	• Client/Server for Vertical Communications (between a higher-tier host and equipment) • Peer-to-Peer for Horizontal Communications (between different equipment on the line)
Network protocol	TCP/IP
Protocol Type (Binary, ASCII)	Binary
Encryption Support	None
Capabilities – Data Collection	Yes • Fixed event reports determined by the implementer. No dynamic data collection plan support.
Capabilities – Equipment Control	Yes • Horizontal Communications – Supported • Vertical Communications – Future enhancement (not required)
Capabilities – Metadata Organization	Partial • SEMI A2 defines what content to report and structure. No way to query what metadata is supported by the implementation. (no additional content defined by the supplier)
Decision making control	• Horizontal Communications - Adjacent Equipment • Vertical Communications – future enhancement for centralized Higher-tier host (not required)
Authentication/Authorization	None
Message Definition (Defined, Custom)	Yes • SEMI Standard provides required message structure. • Future SEMI Standards to define standardized event and control messages.
Extensibility	Partial • Possible to define custom SEMI A1 messages and send different data. • Incorporating 'freeze' concept in SMT-ELS Standards Suite to ensure everyone is working against the same set of standards/revisions
Limitations	• The Standard does not effectively deal with complex material routing or dynamic data collection scenarios.
Version Compatibility	• Implementations can only connect to systems supporting the same SMT-ELS Freeze version (future functionality).

Resources

SEMI Standards

- SEMI A1 - Specification For Production Equipment Smart Connection Interface (PESCI)
- SEMI A2 - Specification For Surface Mount Assembler Smart Hookup (SMASH)
- SEMI A5 – Specification for Factory Operation Extension for SEMI A2 SMASH (SMASH-FOX)

Blogs/Articles and Online Resources

- SMT-ELS Landing Page: **https://www.semi.org/zh/SEMI_SMT-ELS**
- SEMI Blog Article
- Japanese - **https://www.semi.org/jp/blogs/semi-news/semi-smt-els-standards-suite**
- English - **https://www.semi.org/en/blogs/semi-news/semi-smt-els-standards-suite**

SEMI A2 (SMT-ELS) introduction Video:

- Japanese- **https://www.youtube.com/watch?v=EiyCxQ-oqGQ**
- English - **https://www.youtube.com/watch?v=jIU39MDJpCo**
- Chinese- **https://www.youtube.com/watch?v=ux_fbzKK0Ac**

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https://www.semi.org/en/products-services/standards