SEMI E87-0701
PROVISIONAL SPECIFICATION FOR CARRIER MANAGEMENT (CMS)

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1 Purpose

1.1 This document provides a standardized behavior for host view communication with production equipment during the coordination, execution, and completion of automated and manual carrier transfers to and from the equipment and, if it exists, its internal buffer space.

2 Scope

2.1 This is a provisional standard that covers host and equipment communication for SEMI E15.1 300 mm load ports. The provisional status is required because of the immaturity of implementations of integrated equipment with Automated Material Handling Systems (AMHS), and additional specifications may yet be defined to add further functionality. Also, further exception handling and error recovery scenarios need to be defined.

2.2 The scope of this document is to define standards that facilitate the host's knowledge and role in automated and manual carrier transfers, as well as internal buffer equipment carrier transfers. Specifically, this document provides state models and scenarios that define the host interaction with the equipment for the following:

- Carrier transfer between AMHS vehicles and production equipment load ports.
- Carrier transfers to/from production equipment internal buffer space.
- Equipment and load port access mode switching.
- Carrier to load port association.
- CarrierID verification and Carrier slot map verification.

2.3 In order for the provisional status to be removed, the following issues must be resolved:

- Linkage to substrate tracking, control job, and process job management standards.
- Carrier location information.
- Whether to use objects to represent carrier locations and load ports.
- The possible values for the carrier processing status attribute and whether or not a state model is needed for that attribute.

2.4 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 This standard applies to semiconductor equipment with SEMI E15.1 compliant load ports. It may also be applied to other manufacturing equipment that supports automated carrier transfers, and/or contains an internal buffer. This standard is intended to be used for production equipment. It may or may not be applied to other types of equipment. Also, stocker load ports are not addressed by this standard.

4 Referenced Standards

4.1 *SEMI Standards*

SEMI E15 — Specification for Tool Load port

SEMI E15.1 — Provisional Specification for 300 mm Tool Load port

SEMI E30 — Generic Model for Communications and Control of SEMI Equipment (GEM)

SEMI E39 — Object Services Standard: Concept, Behavior, and Services

SEMI E41 — Exception Management (EM) Standard

SEMI E53 — Event Reporting

SEMI E62 — Provisional Specification for 300 mm Front-Opening Interface Mechanical Standard (FIMS)

SEMI E90 — Specification for Substrate Tracking

SEMI E99 — Carrier ID Read/Write Functional Standard

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

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5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *AGT* — Automated Guided Transport

5.1.2 *AGV*— Automated Guided Vehicle

5.1.3 *AMHS* — Automated Material Handling System

5.1.4 *FIMS* — Front-Opening Interface Mechanical Standard

5.1.5 *FOUP* — Front Opening Unified Pod

5.1.6 *GEM* — Generic Equipment Model

5.1.7 *OHT* — Overhead Hoist Transport

5.1.8 *PGV* — Person Guided Vehicle

5.1.9 *PIO* — Parallel Input/Output Interface

5.1.10 *RGT* — Rail Guided Transport

5.1.11 *RGV* — Rail Guided Vehicle

5.2 *Definitions*

5.2.1 *Automated Material Handling System* — an automated system to store and transport materials within the factory.

5.2.2 *automation* — the degree to which activities of machines or production systems are self-acting. In this standard automation provides methods that will reduce the amount of operator intervention required.

5.2.3 *buffer* — a set of one or more locations for holding carriers at/inside the production equipment.

5.2.4 *carrier* — a container, such as a FOUP or open cassette, with one or more positions for holding substrates.

5.2.5 *CarrierID* — a readable and unique identifier for the carrier.

5.2.6 *CarrierID read* — the process of the equipment reading the CarrierID from the carrier.

5.2.7 *carrier ID tag (tag, ID tag)* — a physical device for storing Carrier ID and other information. There are two basic types of tags, read-only tags and read/write tags. [SEMI E99]

5.2.8 *Collection Event* — a collection event is an event (or grouping of related events) on the equipment that is considered to be significant to the host.

5.2.9 *docked position* — the position where the carrier is ready for wafer extraction or insertion.

5.2.10 *FIMS port* — the substrate access port where the FOUP is opened and closed.

5.2.11 *fixed buffer equipment* — production equipment that has only fixed load ports and no internal buffer for carrier storage. Substrates are loaded and unloaded directly from the carrier at the load port for processing.

5.2.12 *host* — the factory computer system or an intermediate system that represents the factory and the user to the equipment.

5.2.13 *internal buffer* — a set of locations within the equipment to store carriers. These locations exclude load ports.

5.2.14 *internal buffer equipment* — equipment that uses an internal buffer.

5.2.15 *load* — the operation of placing a carrier on a load port.

5.2.16 *load port* — the interface location on the equipment where carriers are loaded and unloaded.

5.2.17 *object instantiation* — the act of storing of information related to a physical or logical entity so that it can be recalled on demand based on its public identifier.

5.2.18 *on-line equipment* — equipment that is connected to, and able to communicate fully with, the host.

5.2.19 *process equipment* — equipment used to produce product, such as semiconductor devices. This excludes metrology and material handling equipment.

5.2.20 *production equipment* — equipment used to produce product, such as semiconductor devices, including substrate sorting, process, and metrology equipment and excluding material handling equipment.

5.2.21 *properties* — a set of name value pairs assigned to an object or used in a service message to include additional information about the object (i.e., carrier, port, etc.).

5.2.22 *re-initialization* — a process where production equipment is either powered off then on or when some kind of hardware or software reset is initiated to cause the equipment to reset and possibly reload its software. On production equipment that contains some kind of mass storage device this can also be called a “reboot”.

5.2.23 *read position* — any position on a load port or in an internal buffer from which the tag on a carrier can be read.

NOTE 2: This position may vary on any particular equipment depending on the read technology selected by the end user. Some technology/load ports may allow the carrier to be moved during reading. Equipment may have more than one read position.

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5.2.24 *single communication connection* — exactly one physical connection using exactly one logical session and a standard set of messages.

5.2.25 *slot map* — the information that relates which slots in a carrier hold substrates, both correctly and incorrectly.

5.2.26 *slot map read* — the process of the equipment reading the slot map for substrate position and placement within the carrier.

5.2.27 *standard message set* — messages conforming to standard message specifications.

5.2.28 *substrate* — material held within a carrier. This can be product, or durables such as reticles.

5.2.29 *substrate port* — the carrier location from which substrates are accessed by the equipment.

5.2.30 *transfer unit* — maximum number of carriers allowed in a specific transfer service:

- AA is the maximum number of carriers allowed for acquisition at the transfer source.
- BB is the maximum number of carriers allowed for deposit at the transfer destination.
- CC is the maximum number of carriers allowed for transfer in one transport vehicle.

The transfer unit is the minimum of AA, BB, and CC.

5.2.31 *undocked* — the status of a carrier on a load port or in an internal buffer that is not at the docked position.

5.2.32 *unload* — the operation of removing a carrier from a load port.

5.2.33 *write position* — any position on a load port or in an internal buffer from which the tag on a carrier can be written to. This position may vary on any particular equipment depending on the write technology selected by the end user. Some technology/load ports may allow the carrier to be moved during writing. The read position and the write position may or may not be the same position.

6 Requirements

6.1 Carrier Management Standard (CMS) compliant equipment is required to provide certain capabilities defined by other standards: accessibility to status information, event reporting, alarm management, and equipment control. These requirements shall be satisfied through compliance to the following sets of standards:

6.2 Generic Equipment Model Standard (GEM) SEMI E30

- Event Notification
- Status Data Collection
- Equipment Constants
- Alarm Management
- Equipment Control

6.3 Object-Based Standards

- Object Services Standard (SEMI E39)
- Event Reporting (SEMI E53)
- Exception Management (SEMI E41)

7 Conventions

7.1 *Objects*

7.1.1 Whenever the equipment is required to know about specific kinds of entities, and required to manage information concerning these entities, it is useful to treat these entities as objects that comply with the basic requirements of SEMI E39 Object Services Standard (OSS). This is especially true whenever there are a large number of objects of a given type or when the entities are transient rather than permanent. In both cases, it is difficult to describe a general way for the host and equipment to specify which particular entity is referenced and to get information related only to a specific one out of many.

7.1.2 By defining these entities as objects that comply with OSS, it is only necessary for the host to specify the type of object and its specific identifier in order to inquire about one or more properties of the specific entity of interest.

7.1.3 *Object Properties*

7.1.3.1 A property (attribute) is information about an individual object that is presented as a name/value pair. The name is a formally reserved text string that represents the property, and the value is the current setting for that property.

7.1.3.2 Properties shall be accessible to the host via the service GetAttr and SetAttr for the Carrier and Carrier Location objects. Using SEMI E39 Object Services Standard, for example, it is possible to:

- get the list of IDs for the current carriers at the equipment, and
- get the specified properties for one or more individual carriers.

7.1.4 *Rules for Object Properties*

- Attributes with RO access can not be changed using SetAttr service as defined in OSS.

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- Attributes with RW access can be changed using SetAttr service as defined in OSS.
- Additional attributes may be specified by the user or the equipment supplier by using an attribute name starting with "UD" (User Defined). Care should be taken to ensure the name of the attribute is unique.

7.1.5 *Object Attribute Table*

7.1.5.1 The object attribute table is used to list all the attributes related to the defined object as shown below the access is defined as Read only (RO) or Read/Write (RW). The REQD column is used to specify whether the attribute is required for implementation. Finally, the Form column is used to specify the format of that particular attribute.

Table 1 Object Attribute Table

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
ObjType	Object type	RO	Y	Text = "Carrier"

7.2 *State Model Methodology*

7.2.1 A state model has three elements: definitions of each state and sub-state, a diagram of the states and the transitions between states, and a state transition table. The diagram of the state model uses the Harel State Chart notation. An overview of this notation is presented in an Appendix of SEMI E30. The definition of this notation is presented in Science of Computer Programming 8, "Statecharts: A Visual Formalism for Complex Systems", by D. Harel, 1987.[1]

7.2.2 *State Model Requirements*

7.2.2.1 The state models included in this standard are a requirement for CMS compliance. A state model consists of a state model diagram, state definitions, and a state transition table. All state transitions in this standard, unless otherwise specified, shall correspond to collection events.

7.2.2.2 A state model represents the host's view of the equipment, and does not necessarily describe the internal equipment operation. All CMS state model transitions shall be mapped sequentially into the appropriate internal equipment collection events that satisfy the requirements of those transitions. In certain implementations, the equipment may enter a state and have already satisfied all of the conditions required by the CMS state model for transition to another state. In this case, the equipment makes the required transition without any additional actions in this situation.

7.2.2.3 Some equipment may need to include additional sub-states other than those in this standard. Additional sub-states may be added, but shall not change the CMS defined state transitions. All expected transitions between CMS states shall occur.

7.2.2.4 Transition tables are provided in conjunction with the state diagrams to explicitly describe the nature of each state transition. A transition table contains columns for Transition number, Previous State, Trigger, New State, Actions, and Comments. The "trigger" (column 3) for the transition occurs while in the "previous" state. The "actions" (column 5) includes a combination of:

- Actions taken upon exit of the previous state.
- Actions taken upon entry of the new state.
- Actions taken which are most closely associated with the transition.

Table 2 State Transition Table

Num	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*

1 Elsevier Science, P. O. Box 945, New York, NY 10159-0945, http://www.elsevier.nl/homepage/browse.htt

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7.3 *Services*

7.3.1 Services are functions or methods that may be provided by either the equipment or the host. A service message may be either a request message, which always requires a response, or a notification message that does not require a response.

7.3.2 *Service Message Description*

7.3.2.1 A service message description table defines the parameters used in a service, as shown in the following table:

Table 3 Service Message Description Table

Service Name	*Type*	*Description*

Type can be either "N" = Notification or "R" = Request & Response.

7.3.2.2 Notification type messages are initiated by the service provider (e.g., the equipment) and the provider does not expect to get a response from the service user. Request messages are initiated by a service user (e.g., the host). Request messages ask for data or an activity from the provider. Request messages expect a specific response message (no presumption on the message content).

7.3.3 *Service Message Parameter Definition*

7.3.3.1 A service parameter dictionary table defines the description, range, and type for parameters used by services, as shown in the following table:

Table 4 Service Message Parameter Definition Table

Parameter Name	*Form*	*Description*

A row is provided in the table for each parameter used on a service.

7.3.4 *Service Message Definition*

7.3.4.1 A service message description table defines the parameters used in a service message. It also describes each message and its cause/effect to the equipment. The columns labeled Req/Ind and Rsp/Conf link the parameters to the direction of the message.

Service Parameter	*Req/Ind*	*Resp/Conf*	*Description*

7.3.4.2 The columns labeled Req/Ind and Rsp/Conf link the parameters to the direction of the message. The message sent by the initiator is called the "Request". The receiver terms this message the "Indication". The receiver may then send a "Response", which the original sender terms the "Confirmation".

7.3.4.3 The following codes appear in the Req/Ind and Rsp/Conf columns and are used in the definition of the parameters (e.g., how each parameter is used in each direction):

"M"	Mandatory Parameter – must be given a valid value.
"C"	Conditional Parameter – may be defined in some circumstances and undefined in others. Whether a value is given may be completely optional or may depend on the values of other parameters.
"U"	User-Defined Parameter.
"-"	The parameter is not used.
"="	(for response only) Indicates that the value of this parameter in the response must match that in the primary (if defined).

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7.4 *Alarm Requirements Definition*

7.4.1 An alarm requirements definition table defines the specific set of alarms required by CMS. The table is divided up by equipment configuration, and then by alarm. The danger and affected columns are marked with "X" characters to show each alarm and its possible impact to operators, equipment, and material. The table format is shown in the following example:

Equipment		*Danger*		*Affected*		
Configuration	*Alarm Text*	*Potential*	*Imminent*	*Operator*	*Equipment*	*Material*
Configuration 1	Alarm 1	X		X	X	X
	Alarm 2		X			X
Configuration 2	Alarm 3	X		X	X	
	Alarm 4	X			X	X

8 Overview

8.1 CMS defines the behavior, data, and services required for equipment supporting automated carrier transfer. This document provides a standard interface for host/equipment communications regarding the transfer of carriers. The standardized carrier transfer host interface includes not only transfers to and from the external load ports, but also transfers to and from the internal buffer positions on internal buffer type equipment.

8.2 *Single Connection Requirement*

8.2.1 The expectation of the production equipment supplier is that this standard be implemented in conjunction with the GEM interface to their production equipment and without the use of a separate communication connection.

9 Load Port

9.1 A load port (port) is used by the factory to load and unload carriers to and from production equipment. A load port may be used as an input load port, an output load port, or as an input/output load port, depending upon equipment type, configuration and/or factory practices. This classification may be fixed or it may be programmable by the user. A load port is generally designed to handle one specific carrier type, such as substrate cassettes, leadframe magazines, SMIF pods, or FOUPs.

9.2 *Load Port Numbering*

9.2.1 The load port number shall be assigned incrementally from the bottom left to bottom right, then top left to top right when facing the front of the equipment. The load port numbering requirement is to provide a common reference base to external entities, such as humans.

9.3 *Carrier Slot Numbering*

9.3.1 The slot numbers for a carrier shall be assigned incrementally from the bottom, starting with "1."

9.4 *Load Port Resource Sharing*

9.4.1 A model of a load port must account for any mechanical assemblies that are either active during carrier transfer or are capable of interacting with the transfer. The load port is responsible for such mechanisms when the load port is in the TRANSFER READY state. If these mechanisms are shared with other load ports, then the sharing must be coordinated.

9.5 *Load Port Transfer State Model*

9.5.1 The purpose of the Load Port Transfer State Model is to define the host view of a carrier transfer, which includes the host interactions with the equipment necessary to transfer carriers to and from equipment load ports. Each load port on the equipment shall maintain an independent instance of this state model.

9.5.2 *Load Port Transfer State Model Diagram*

9.5.2.1 Figure 1 is the diagram for the Load Port Transfer State Model.

9.5.3 *Load Port Transfer State Definitions*

9.5.3.1 LOAD PORT TRANSFER — The super state for the IN SERVICE and OUT OF SERVICE states.

9.5.3.2 OUT OF SERVICE — Transfer to/from this load port is disabled. A transition to IN SERVICE is required to continue using this load port for transfers.

9.5.3.3 IN SERVICE — Transfer to/from this load port is enabled. A transition to OUT OF SERVICE disables the load port for transfer use.

9.5.3.4 TRANSFER READY — A sub-state of IN SERVICE. The load port is available for carrier transfer. The transfer can either be manual or automated, and can be a load or an unload. This state

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contains two sub-states, which are used depending on whether or not a carrier is present on the load port (READY TO LOAD and READY TO UNLOAD).

9.5.3.5 READY TO LOAD — A sub-state of TRANSFER READY. When transitioning to the TRANSFER READY state, if a carrier is not present on the specified load port, this is the active sub-state. In this state, the load port is available to be loaded with an external carrier, or with a carrier that is currently located inside the equipment (i.e. internal buffer).

9.5.3.6 READY TO UNLOAD — A sub-state of TRANSFER READY. When transitioning to the TRANSFER READY state, if a carrier is present on the specified load port, this is the active sub-state. In this state, the load port is available for unloading of a carrier from the loadport to material handling equipment. When the load port is being used by the equipment, the state shall transition to TRANSFER BLOCKED.

9.5.3.7 TRANSFER BLOCKED — The carrier transfer state is neither READY TO LOAD nor READY TO UNLOAD. Because of load port related activity being performed, transfer is not available to/from this load port at this time.

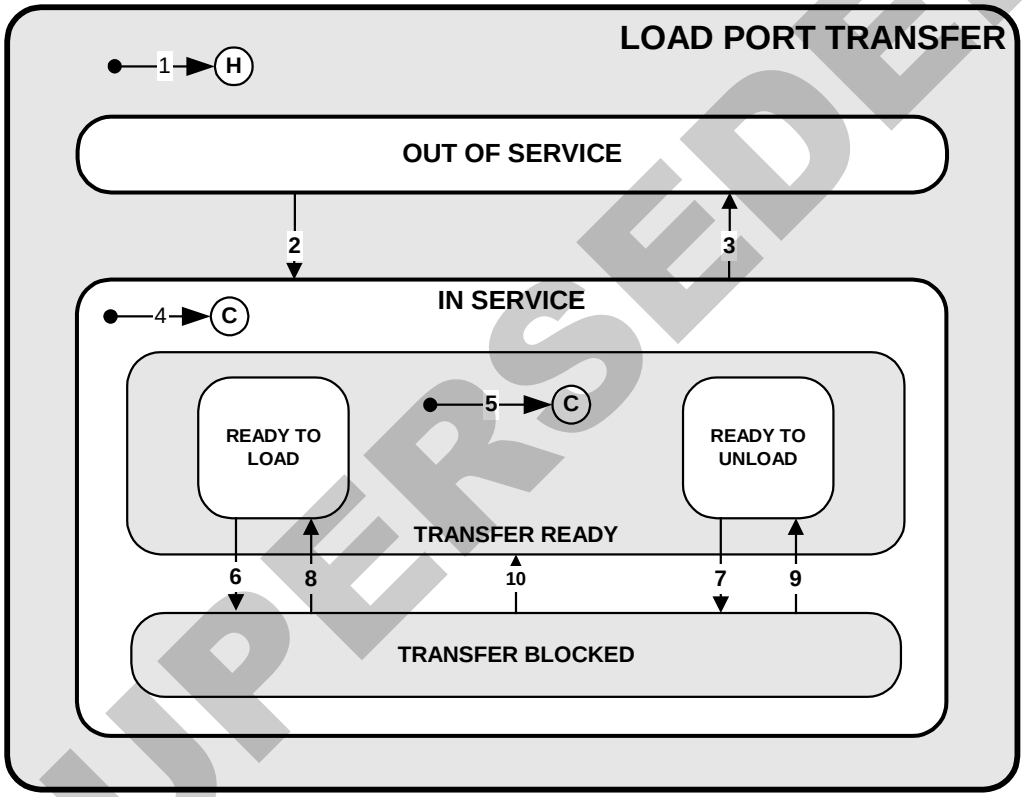

Figure 1
Load Port Transfer State Model Diagram

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9.5.4 *Load Port Transfer State Transition Table*

Table 5 Load Port Transfer State Transition Definition

Num	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	(no state)	System reset.	OUT OF SERVICE or IN SERVICE (History)		This transition is based on what the current transfer status was prior to system reset. Data required to be available for this event report: PortID
2	OUT OF SERVICE	The host or an operator has invoked the ChangeServiceStatus service for this load port with a value of IN SERVICE.	IN SERVICE		Load port is now usable for transfer. Data required to be available for this event report: PortID
3	IN SERVICE	The host or an operator has invoked the ChangeServiceStatus service for this load port with a value of OUT OF SERVICE.	OUT OF SERVICE		Load port is now rendered unusable for transfer. Attempted usage of the load port for carrier transfer after the state transition results in an alarm. Data required to be available for this event report: PortID
4	IN SERVICE	*Service:* The host or an operator has invoked the ChangeServiceStatus service for this load port with a value of IN SERVICE. *System Reset:* This transition can be activated by an equipment re-initialization.	TRANSFER READY or TRANSFER BLOCKED		This is the default entry into IN SERVICE. The state is TRANSFER BLOCKED if the carrier, or load port, is not available for carrier transfer. Otherwise, the state is TRANSFER READY. Data required to be available for this event report: PortID
5	TRANSFER READY	*Service:* The host or an operator has invoked the ChangeServiceStatus service for this load port with a value of IN SERVICE. *System Reset:* This transition can be activated by an equipment re-initialization. *Failed Transfer:* If a transfer fails, this transition is activated by transition #10.	READY TO LOAD or READY TO UNLOAD		When entering the TRANSFER READY state, if a carrier is present, the sub-state is READY TO UNLOAD, else the sub-state is READY TO LOAD. If the state is READY TO LOAD, data required to be available for this event report: PortID If the state is READY TO UNLOAD, data required to be available for this event report: PortID CarrierID
6	READY TO LOAD	*Manual*: The equipment recognizes the logical indication of the start of a manual load transfer. This trigger is configurable by the user, examples are included in table 8. *Automated*: The PIO load transfer is beginning and the PIO ready signal is activated. *Internal Buffer:* A CarrierOut service has started for this load port.	TRANSFER BLOCKED		When a CarrierOut service is queued and the equipment load port is currently in the TRANSFER BLOCKED state, the equipment shall keep the load port in the TRANSFER BLOCKED state. Data required to be available for this event report: PortID

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Num	Previous State	Trigger	New State	Actions	Comments
7	READY TO UNLOAD	*Manual*: The equipment recognizes the logical indication of the start of a manual unload transfer. This trigger is configurable by the user, examples are included in table 8. *Automated*: The PIO unload transfer is beginning and the PIO ready signal is activated. *Internal Buffer:* A CarrierIn service has started for this load port.	TRANSFER BLOCKED		When a CarrierOut service is queued and the equipment load port is currently in the TRANSFER BLOCKED state, the equipment shall keep the load port in the TRANSFER BLOCKED state. Data required to be available for this event report: PortID
8	TRANSFER BLOCKED	*Manual:* The carrier unload transfer has completed, and the load port is now empty and ready for load transfer. This is indicated when two conditions are met, the presence signal indicates that no carrier is present and the operator has logically indicated that the transfer is complete. *Automated:* The PIO unload transfer ends with a PIO complete signal. *Internal Buffer:* The carrier has finished its move from the load port into the internal buffer, and no CarrierOut services are queued for this load port.	READY TO LOAD		A carrier can now be loaded onto the load port from either an external entity, or by the equipment's internal material handling resource. Data required to be available for this event report: PortID
9	TRANSFER BLOCKED	*Manual:* Processing for substrates contained within the carrier has completed, or a CancelCarrier/ CancelCarrierAtPort service has been issued, and the carrier has returned to the load/unload position on the load port. *Automated:* Processing for the substrates belonging to the carrier has completed, or a CancelCarrier/CancelCarrier-AtPort service has been received, and the carrier has returned to the load/unload position. *Internal Buffer:* A carrier has completed its move from the internal buffer to the load port.	READY TO UNLOAD		The carrier on the load port can now be unloaded from the load port to an external entity. Data required to be available for this event report: PortID CarrierID
10	TRANSFER BLOCKED	The transfer was unsuccessful, and the carrier was not loaded or unloaded.	TRANSFER READY		The sub-state of TRANSFER READY which is decided by transition #5. Data required to be available for this event report: PortID

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10 Carrier Object

10.1 Information about a carrier is encapsulated as an object. This allows the host to exchange information with the equipment about one or more specific carriers using services defined in SEMI E39, Object Services Standard. A carrier has properties (attributes) that are defined in Table 6, Carrier Attribute Definition.

10.2 *Object Instantiation*

10.2.1 The carrier object is a software representation of the carrier in the equipment. Under normal circumstances this object is instantiated by the equipment when the host uses the Bind or Carrier Notification service or when the equipment successfully reads the carrierID from the carrier. A carrier object is instantiated by carrierID read only if there are no currently existing objects with the carrierID just read. A carrier object can also be instantiated by either the ProceedWithCarrier or CancelCarrier Services on an UNASSOCIATED port. (This implies a failed carrierID read event.) The ContentMap attribute will be an empty list (a list of zero) when the instantiation is done by CarrierID read. The SlotMap attribute should be a list consisting of all slots enumerated as "UNDEFINED" when the carrier object is instantiated by CarrierID read.

10.2.2 From the host point of view, an object is instantiated if the host is able to query the equipment about that object, it's current state, and other attributes. Once instantiated, the object is considered destroyed (no longer instantiated) if the response to such queries is "unknown object".

10.2.3 Summary of carrier object instantiation:

1. Bind or Carrier Notification Service;
2. CarrierID read with no currently existing carrier objects having the carrierID just read; and
3. ProceedWithCarrier or CancelCarrier Service on an UNASSOCIATED port with a carrier.

10.2.4 *Carrier Object Identifier (ObjID)*

10.2.4.1 The purpose of an Object Identifier is to allow references to an object within the system. The object identifier is created when an object is instantiated and should be unchanged or persistent until the end of the object lifecycle. The Object Identifier shall be unique at the equipment during lifecycle of the object. The Carrier ID is the Carrier Object Identifier. The equipment is responsible for ensuring uniqueness of the Carrier ID prior to instantiation by the bind service.

10.2.5 *Carrier Object Destruction*

10.2.5.1 Normally, the Carrier Object reaches the end of its lifecycle when the carrier is unloaded from the equipment. Abnormally, the Carrier Object reaches the end of it's lifecycle when a CancelBind or CancelCarrierNotification service is executed prior to the carrier being loaded, or when an equipment based carrier verification fails following carrier instantiation by the bind service.

10.2.5.2 Summary of carrier object destruction:

1. A carrier is unloaded from the equipment;
2. A CancelBind or CancelCarrierNotification service is received; and
3. An equipment based verification fails (after the object has been instantiated via the bind services).

10.3 *Carrier Attribute Definitions*

10.3.1 The following table contains the attributes that are of importance to the host and/or the equipment in order to manage the history and the reports about the carrier object.

10.3.2 *REQD Column*

10.3.2.1 All attributes in the following table are required to be associated with the carrier object. However only the attributes marked with a "Y" in the REQD column are always required to be maintained and updated by the equipment. The attributes marked with an "N" in the REQD column are only required to be maintained if they are provided by the host by either the Bind or ProceedWithCarrier Services or if the equipment has means of determining the attribute values. (for example, if the equipment has a waferID reader, the equipment can determine the ContentMap).

10.3.3 *ACCESS Column*

10.3.3.1 Even though a value may be marked as RO (read only), the initial value for the attribute may be provided by the host when attached to either the Bind or ProceedWithCarrier services. The only other time the Usage and CarrierCapacityStatus attributes are updated is at the first ProceedWithCarrier service.

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10.3.4 *Carrier Attribute Definition Table*

Table 6 Carrier Attribute Definition

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
ObjType	Object type.	RO	Y	Text 1 to 40 characters equal to “Carrier”.
ObjID	Object identifier.	RO	Y	Text 1 to 80 characters equal to the CarrierID.
Capacity	Maximum number of substrates in carrier.	RO	Y	Positive integer.
SubstrateCount	The number of substrates currently in the carrier.	RO	Y	Non negative integer less than or equal to the Capacity.
CarrierIDStatus	Current state of the carrier ID verification.	RO	Y	Enumerated: ID NOT READ, [ID] WAITING FOR HOST, ID VERIFICATION OK, ID VERIFICATION FAILED.
CarrierAccessingStatus	The current accessing state of the carrier by the equipment. The current substate of the CarrierAccessingStatus state model.	RO	Y	Enumerated: NOT ACCESSED, IN ACCESS, CARRIER COMPLETE, CARRIER STOPPED
ContentMap	Ordered list of lot and substrate identifiers corresponding to slot 1,2,3,…n	RO	Y	Ordered list of n structures, where n is equal to the value of “Capacity” above, and each structure consists of a LotID and SubstrateID. List of Structure LotID SubstrateID When no Lot ID is provided by the host, the LotID value should be null. When a slot has no substrate or the host does not know substrate identifier, the LotID and SubstrateID value should be null.
LocationID	Identifier of current location.	RO	Y	Text 1 to 80 characters.
SlotMap	Ordered list of slot status as provided by the host and corresponding to slot 1,2,3…n until a successful slot map read, then as read by the equipment.	RO	Y	Ordered list of n, where n is equal to the value of “Capacity” above, each value in the list is enumerated Enumerated Enumerated: UNDEFINED, EMPTY, NOT EMPTY, CORRECTLY OCCUPIED, CROSS SLOTTED, DOUBLESLOTTED. (NOT EMPTY provided for equipment that cannot detect incorrectly slotted substrates)
SlotMapStatus	Current state of slot map verification.	RO	Y	Enumerated: SLOT MAP NOT READ, [SLOT] WAITING FOR HOST, SLOT MAP VERIFICATION OK, SLOT MAP VERIFICATION FAILED.
Usage	The type of material contained in the carrier (i.e., TEST, DUMMY, PRODUCT, FILLER, etc.).	RO	Y	Text as defined by the Equipment.

NOTE 1: NOT EMPTY is included to indicate presence for equipment that is only able to detect wafer presence but not correct positioning of the wafer slot. For equipment that can detect incorrect positioning such as cross-slotted or double slotted, NOT EMPTY may not be applicable.

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10.3.5 *Rules for Carrier Attributes*

- The equipment shall change object attributes, Capacity, ContentMap, SlotMap, Substrate count and Usage, provided by the host. All other attributes, such as LocationID, shall be set and maintained by the equipment.
- The attributes, Capacity, ContentMap,, Substrate count and Usage, shall be provided with Bind, CarrierNotification, or ProceedWithCarrier service before or when SlotMap is provided.
- The SlotMap shall be provided with Bind, CarrierNotification, or ProceedWithCarrier to verify CarrierID, when the SlotMap verification is equipment based. And it shall not be provided when the SlotMap verification is host based.
- Carrier properties may be provided before the carrier arrives as part of the Bind service and should be retained until either a CancelBind service is received or the carrier is removed.
- Carrier properties may also be provided by the ProceedWithCarrier service. The carrier properties that are provided by the ProceedWithCarrier service may differ based whether or not the object is instantiated by the service.
- Carrier properties that are required shall be actively updated by the equipment.

10.3.6 *Carrier Location*

10.3.6.1 A carrier location, signified by LocationID, is used for tracking carriers as they move through the equipment. A carrier location is any physical area that is capable of holding a carrier. It is not intended to represent entire mechanisms, which may have a variety of other properties of interest, but only that portion where a Carrier may rest.

10.3.7 *Carrier Location Examples*

10.3.7.1 Carrier Locations include load port locations, substrate port locations, internal buffer locations, as well as grippers, conveyors, and elevators that are used internally for moving the carrier from one fixed location to another.

10.4 *Carrier Location Naming*

10.4.1 Carrier locations shall be assigned a unique name. Information about the carrier location can be obtained by querying the CarrierObject for the LocationID or by asking the equipment for the CarrierLocationMatrix. The text form of the LocationID shall be descriptive of the location. For example, LocationID form for load port load/unload location might be “LPn”, where “n” equal is equal to the load port number (the load port number is determined through the numbering rule in Section 9.1). The LocationID form for the FIMS port location might be “FIMSn”. The LocationID form for a buffer location might be “BUFn”.

10.5 *Load Port Carrier Locations*

10.5.1 For fixed buffer equipment configured to handle FOUPs, a Load Port has two different Carrier Locations. One represents the place where a Carrier is delivered and picked up, while the other represents the place where the Carrier is docked and can be opened.

10.6 *Carriers Between Locations*

10.6.1 When the carrier is traveling from one location to another, the location attribute remains equal to the source location until the carrier movement is complete and the carrier is resting at the new carrier location (the destination location).

10.6.2 *Usage*

10.6.2.1 The Usage parameter indicates the type of substrate the carrier contains. All Usage values are equipment specific values. Some internal buffer equipment manages carriers by establishing logical partitions. This type of equipment shall use the Usage parameter to determine which logical partition where the carrier is held. The Usage parameter can also be used in conjunction with CarrierProcessingStatus.

10.6.3 *Carrier Capacity Status*

10.6.3.1 The Carrier Capacity Status parameter can be sent to the equipment by the host in either the Bind service or the ProceedWithCarrier service. However the equipment shall update this parameter based on the results of the read slot map operation. Furthermore, the equipment shall update the parameter based on it’s own actions of adding and removing a substrate to and from a carrier. If the equipment does not know the value of CarrierCapacity prior to instantiation, the equipment shall instantiate the carrier object with the value of UNDEFINED for CarrierCapacity.

10.6.4 *Lot information for ContentMap*

10.6.4.1 Lot is defined in SEMI E90 as a group of one or more substrates of the same type. It is organized external to the equipment. The Lot ID is the identifier of this group. If the equipment is informed of the Lot ID to which a substrate belongs, the equipment must maintain this information.

10.6.5 *Carrier Accessing Status*

10.6.5.1 The CarrierAccessingStatus is used by the host to know whether or not the carrier owned by the equipment can be moved out. If the carrier is within the internal buffer equipment, this status may be used by the host to issue CarrierOut service.

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10.6.5.2 Enumerated values of CarrierAccessingStatus correspond to the substates of CarrierAccessingStatus (see Figure 2). Detailed definitions of these substates depend on the type of carrier usage. Some examples of possible definitions of CARRIER COMPLETE are shown below.

10.6.5.2.1 *PRODUCT* — When substrates of the carrier have been finished processing by the equipment.

10.6.5.2.2 *DUMMY* — When substrates of the carrier have been finished using by the equipment, and the substrates will be not reusable.

10.6.5.2.3 *TEST* — When substrates of the carrier have been finished processing by the equipment, and the carrier will be empty.

10.6.5.2.4 *REJECT* — When the carrier have been finished accessing by the equipment, and the carrier will be full.

10.6.5.3 Suppliers shall document the interpretation in the equipment specification document.

10.7 *Carrier State Model*

10.7.1 The purpose of the Carrier State Model is to define the host's view of a carrier. The equipment shall maintain a separate and independent state model for each carrier in/at the equipment.

10.7.2 *Carrier State Model Diagram*

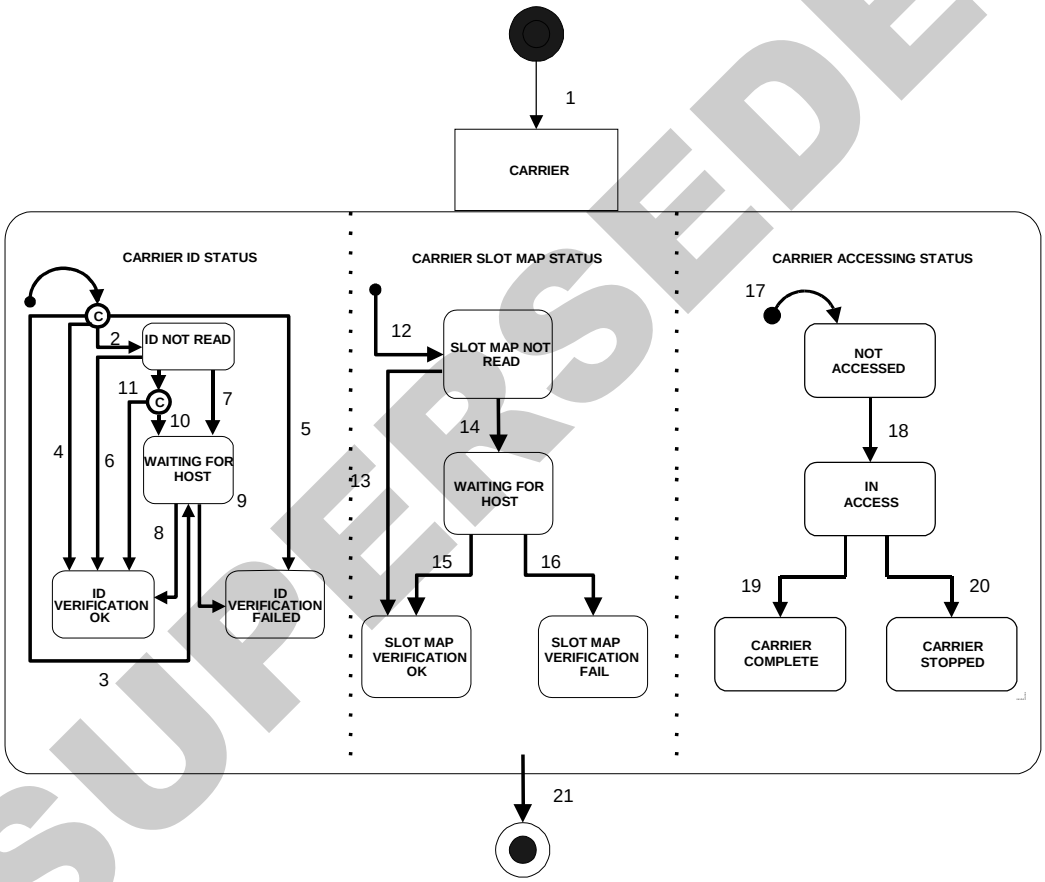

Figure 2
Carrier State Model Diagram

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10.7.3 *Carrier State Definitions*

10.7.3.1 *CARRIER* — The CARRIER state has two ANDed (orthogonal) substates: CARRIER ID READ and CARRIER SLOT MAP READ.

10.7.3.2 *CARRIER ACCESSING STATUS* — This is a substate of CARRIER and indicates the current accessing status of the carrier. It has four substates, NOT ACCESSED, IN ACCESS, CARRIER COMPLETE, and CARRIER STOPPED. The initial default entry substate is NOT ACCESSED.

10.7.3.2.1 *NOT ACCESSED* — This is a substate of CARRIER ACCESSING STATUS and is active when access by the equipment to the carrier has not been started. The carrier can be moved out.

10.7.3.2.2 *IN ACCESS* — This is a substate of CARRIER ACCESSING STATUS and is active when access by the equipment to the carrier has been started but has not been finished, and the carrier should not be moved out.

10.7.3.2.3 *CARRIER COMPLETE* — This is a substate of CARRIER ACCESSING STATUS and is active when the access by the equipment to the carrier has been finished, and the carrier should be moved out. This is a final state.

10.7.3.2.4 *CARRIER STOPPED* — This is a substate of CARRIER ACCESSING STATUS and is active when the access by the equipment to the carrier has been stopped abnormally, and the carrier should be moved out. This is a final state.

10.7.3.3 *CARRIER ID STATUS* — This is a substate of CARRIER and indicates the current status of the carrier with respect to its identifier. It has four substates, ID NOT READ, WAITING FOR HOST, ID VERIFICATION FAILED, ID VERIFICATION OK. The initial substate is conditional based on information the equipment has about the carrier. When the carrierID is provided by the Bind or the Carrier Notification service, the carrier object shall be instantiated in the ID NOT READ substate. When the carrierID is provided by the carrier ID read, the carrier shall be instantiated in the WAITING FOR HOST substate. When the Carrier is instantiated by the ProceedWithCarrier service, the carrier shall be instantiated in the ID VERIFICATION OK substate. Finally when the carrier is instantiated by the CancelCarrier service, the carrier will be instantiated in the ID VERIFICATION FAILED substate.

10.7.3.3.1 *ID NOT READ* — This is a substate of CARRIER ID STATUS. This state is active whenever the CarrierID has not been read by the equipment.

10.7.3.3.2 *ID VERIFICATION FAILED* — This is a substate of CARRIER ID STATUS and is active when the carrierID has verification by the host with the CancelCarrier service. This is a final state.

10.7.3.3.3 *ID VERIFICATION OK* — This is a substate of CARRIER ID STATUS and is active as soon as the CarrierID has been accepted. The ID is determined to be accepted by either successful verification by the equipment or the host, or by bypassing ID read because a carrier ID reader is not available and the BypassReadID variable is set to true. This is a final state.

10.7.3.3.4 *WAITING FOR HOST* — This is a substate of CARRIER ID STATUS and is active during the period of time when the carrierID has been read by the equipment successfully or unsuccessfully and has not yet been verified.

10.7.3.4 *CARRIER SLOT MAP STATUS* — This is a substate of CARRIER and indicates the current status of the carrier with respect to its slot map. It has four substates, SLOT MAP NOT READ, WAITING FOR HOST, SLOT MAP VERIFICATION FAILED, SLOT MAP VERIFICATION OK. The initial default entry sub-state is SLOT MAP NOT READ.

10.7.3.4.1 *SLOT MAP NOT READ* — This is a substate of CARRIER SLOT MAP STATUS and is the default entry state. It is active when the Carrier is first loaded at the equipment until the Slot Map has been read successfully by the equipment at the Substrate Port.

10.7.3.4.2 *SLOT MAP VERIFICATION FAIL* — This is a substate of CARRIER SLOT MAP STATUS and is active when the Slot Map has been read by the equipment and has failed verification by the host. This is a final state.

10.7.3.4.3 *SLOT MAP VERIFICATION OK* — This is a substate of CARRIER SLOT MAP STATUS and is active as soon as the slot map has been verified. This is a final state.

10.7.3.4.4 *WAITING FOR HOST* — This is a substate of CARRIER SLOT MAP STATUS and is active when the equipment is waiting for input from the host.

10.7.4 *Carrier State Transition Table*

10.7.4.1 Table 7 indicates the triggers and the expected behavior of the instantiated carrier object.

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Table 7 Carrier State Transition Definition

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
1	(no state)	A carrier is instantiated.	CARRIER	None.	Data required to be available for this event report: CarrierID
2	(no state)	*Normal:* A Bind or Carrier Notification service is received.	ID NOT READ	None.	Data required to be available for this event report: CarrierID
3	(no state)	*Normal:* A carrierID not currently existing at the equipment is successfully read. *Abnormal:* A carrierID is read successfully but an equipment based verification failed.	WAITING FOR HOST	None.	Data required to be available for this event report: CarrierID PortID Normally, this transition will happen after a successful ID read if a bind service has not been issued (host based verification) or abnormally if a bind service is followed by a successful ID read and an unsuccessful equipment based verification.
4	(no state)	*ID Read fail*: A ProceedWithCarrier service is received.	ID VERIFICATION OK	A carrier is instantiated having the carrierID provided by the Proceed WithCarrier service.	Data required to be available for this event report: CarrierID This transition can happen only if a bind service has not been received.
5	(no state)	*ID Read fail:* A CancelCarrier service is received.	ID VERIFICATION FAIL	A carrier is instantiated having the carrierID provided by the Cancel Carrier service.	Data required to be available for this event report: CarrierID This transition can happen only if a bind service has not been received.
6	ID NOT READ	Carrier ID is read successfully and the equipment has verified the carrierID successfully.	ID VERIFICATION OK	None.	Data required to be available for this event report: PortID CarrierID
7	ID NOT READ	Carrier ID is read unsuccessfully.	WAITING FOR HOST	None.	Data required to be available for this event report: PortID CarrierID
8	WAITING FOR HOST	A ProceedWithCarrier service is received.	ID VERIFICATION OK	None.	Data required to be available for this event report: PortID CarrierID
9	WAITING FOR HOST	A Cancel Carrier Service is received.	ID VERIFICATION FAIL	None.	Data required to be available for this event report: PortID CarrierID
10	ID NOT READ	$BypassReadID_i$ variable is set to FALSE, and a carrier is received when the id reader is not in service or not installed.	WAITING FOR HOST	Wait for ProceedWith-Carrier.	Data required to be available for this event report: PortID CarrierID

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#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
11	ID NOT READ	$BypassReadID_i$ variable is set to TRUE, and a carrier is received when the id reader is not in service or not installed.	ID VERIFICATION OK	None.	Data required to be available for this event report: PortID CarrierID
12	(no state)	A carrier is instantiated.	SLOT MAP NOT READ	None.	No event is required for this transition.
13	SLOT MAP NOT READ	Slot Map is read and verified successfully by the equipment.	SLOT MAP VERIFICATION OK	None.	Data required to be available for this event report: PortID (if valid) CarrierID LocationID
14	SLOT MAP NOT READ	*Normal host based verification:* Slot Map is read successfully and the equipment is waiting for host verification. *Equipment based verification fail:* Slot Map is read successfully but equipment based verification has failed. *Slot map read fail:* Slot Map cannot be read. *Abnormal wafer position within the carrier:* The Slot Map read has indicated an abnormal wafer position.	WAITING FOR HOST	Save new slot map in the SlotMap attribute.	Data required to be available for this event report: PortID (if valid) CarrierID LocationID SlotMap (if valid) Reason
15	WAITING FOR HOST	A ProceedWithCarrier service is received.	SLOT MAP VERIFICATION OK	Proceed with the Carrier as instructed.	Data required to be available for this event report: PortID (if valid) CarrierID LocationID
16	WAITING FOR HOST	A CancelCarrier service is received.	SLOT MAP VERIFICATION FAIL	Prepare the Carrier for Unload.	Data required to be available for this event report: PortID (if valid) CarrierID LocationID
17	(no state)	A carrier object is instantiated.	NOT ACCESSED	None.	Data required to be available for this event report: CarrierID
18	NOT ACCESSED	The equipment starts accessing the carrier.	IN ACCESS	None.	Data required to be available for this event report: CarrierID
19	IN ACCESS	The equipment finishes accessing the carrier normally.	CARRIER COMPLETE	None.	Data required to be available for this event report: CarrierID
20	IN ACCESS	The equipment finishes accessing the carrier abnormally.	CARRIER STOPPED	None.	Data required to be available for this event report: CarrierID

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#	Previous State	Trigger	New State	Actions	Comment
21	CARRIER	*Normal:* The carrier is unloaded from the equipment. *Abnormal by service:* CancelBind or CancelCarrierNotification service is received prior to the carrier load. *Abnormal by equipment:* An equipment based verification fails and the equipment performs a self-initiated CancelBind service.	(no state)	The equipment destroys the instance of this carrier object.	Data required to be available for this event report: CarrierID

NOTE 1: Only one collection event report is required when entering the Carrier State Model (instantiating a carrier object). This event report shall include the entry state of the all the substates of Carrier State Model, (including CARRIER ID STATUS substate and the CARRIER SLOT MAP STATUS substate).

10.7.5 *Slot Map Read Details*

10.7.5.1 The Slot Map shall be read on all production equipment prior to removal of substrates from the carrier.

10.7.6 *Carrier Read Failure* — A carrier read failure occurs when the carrier ID reader is present, in service, and reports that it is unable to read the ID of a carrier. This represents a transient random failure rather than a steady condition.

10.7.7 *Bypass Read ID* — A carrier ID reader may be unavailable: either out of service, not installed, or otherwise malfunctioning and unable to execute a read operation. This represents a steady condition that often is known in advance. The equipment shall provide a user-configurable variable BypassReadID that the user is able to set to specify the action to take when a carrier is received to an ASSOCIATED loadport. In this case, the carrier object is instantiated in the ID NOT READ state, and when the carrier is received, the state model transitions to either WAITING FOR HOST or ID VERIFICATION OK, depending upon whether BypassReadID is FALSE (the default value) or TRUE. When TRUE, then the Carrier ID received in the Bind is used automatically. Otherwise, the carrier transitions to WAITING FOR HOST and waits for the host to send a ProceedWithCarrier. The ID used will be the ID included with the ProceedWithCarrier.

11 Access Mode

11.1 *Access Mode State Model*

11.1.1 The Access Mode State Model defines the host view of equipment access mode, as well as the host interactions with the equipment necessary to switch the access mode. Each Load Port has its own Access Mode State Model. There are two access mode states. These are defined in Section 11.3.3.

11.1.2 The access mode for a load port may be switched at anytime by the host or the operator, except when the Load Port Reservation State Model for that Load Port is in the RESERVED state or during carrier transfer. Carrier transfer boundaries, for determining when access mode may be changed, are designated by Table 8, Carrier Transfer Boundaries.

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Table 8 Carrier Transfer Boundaries

Transfer Type	*Transfer Method*	*Starting Boundary*	*Ending Boundary*
LOAD	MANUAL	This starting boundary is specified by the user. Known examples of the starting boundary include but are not limited to; the presence sensor detecting a carrier, a load port door opening, input to the equipment by the operator through a switch at the load port or the equipment console.	This ending boundary is specified by the user. Known examples of the ending boundary include but are not limited to; a preset configurable time following presence and placement sensor detecting a carrier, a load port door closing, or input to the equipment by the operator through a switch at the load port or the equipment console or a service message.
	AUTO	The PIO Ready signal is active for load.	The PIO signals a transfer complete.
UNLOAD	MANUAL	This starting boundary is specified by the user. Examples of the starting boundary include but are not limited to presence and placement sensor no longer detecting a carrier, a load port door opening, or input to the equipment by the operator through a switch at the load port or the equipment console or a service message.	This ending boundary is specified by the user. Examples of the ending boundary include but are not limited to a preset configurable time following presence and placement sensor no longer detecting a carrier, a load port door closing, or input to the equipment by the operator through a switch at the load port or the equipment console, or a service message.
	AUTO	The PIO Ready signal is active for unload.	The PIO signals a transfer complete.

11.2 *Manual Carrier Transfer Confirmation Trigger*

11.2.1 For a manual transfer completion confirmation, the production equipment supplier must implement a software or hardware mechanism for an operator to inform the equipment that the carrier transfer is complete.

11.3 *Access Mode Initial Value*

11.3.1 Also, when equipment re-initialization occurs, the access mode(s) must be remembered, and used as the initial value when initializing. Since the access mode is remembered through re-initializations, the initial value that is used the very first time the software is ever loaded is not important. The equipment supplier is free to set this default value.

11.3.2 *Access Mode State Model Diagram*

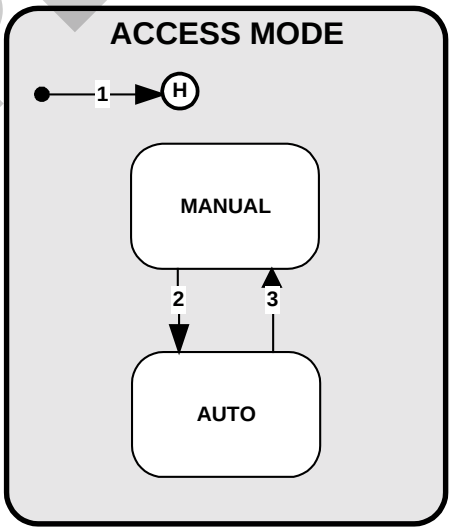

Figure 3
Access Mode State Model Diagram

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11.3.3 *Access Mode State Definitions*

11.3.3.1 ACCESS MODE — The parent state for the MANUAL and AUTO sub-states.

11.3.3.2 MANUAL — A sub-state of ACCESS MODE. When the production equipment or specified load port is in this mode, only manual (non-AMHS) carrier transfers are allowed. The production equipment shall have the capability of generating an alarm if an automated (AMHS) delivery is attempted.

11.3.3.3 AUTO — A sub-state of ACCESS MODE. When the production equipment or specified load ports are in this mode, only automated (AMHS) carrier transfers are allowed. The production equipment shall have the capability of generating an alarm if a manual delivery is attempted.

11.3.4 *Access Mode State Transition Table*

11.3.4.1 Table 9 defines the transitions for the Access Mode State Model.

Table 9 Access Mode State Transition Definitions

#	*Previous State*	*Trigger*	*New state*	*Actions*	*Comments*
1	(no state)	System restart.	MANUAL or AUTO (History)	The access mode returns to the mode it was previous to the system reset.	Data required to be available for this event report: PortID
2	MANUAL	The host or operator has executed a ChangeAccess service with the value of AUTO. This trigger can happen at anytime, except during a carrier transfer.	AUTO		Manual deliveries are not allowed after this state transition. The operator may also trigger this transaction from the production equipment console. Data required to be available for this event report: PortID
3	AUTO	The host or operator has executed a ChangeAccess service with the value of MANUAL. This trigger can happen at anytime, except during carrier transfer.	MANUAL		The operator may also trigger this transaction from the production equipment console or a manual switch at the load port. Automated transfers are not allowed after this state transition. Data required to be available for this event report: PortID

12 Reservation State Model

12.1 The purpose of the Reservation State Model is to define the host view of future activity at a specific load port.

12.1.1 The Reservation State Model, the ReserveAtPort service and CancelReserveAtPort enable the following items:

1. They enable the host to inform the equipment of a future carrier delivery without specifying the carrier ID and at the same time allow host based verification. (Equipment based verification is enabled via the Load Port/Carrier Association State Model, the Bind service, and the Carrier Notification service detailed in Sections 13, 15.4.2 and 15.4.11 of SEMI E87.)

2. They enable the equipment to send a state change event to the host if the operator (either local or remote) informs the equipment of a future carrier delivery to a port without specifying the carrier ID. Thus the host knows that the operator expects to use that port for something the host did not request for AMHS based delivery.

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3. They enable internal buffer equipment to inform the host that it is physically initiating a carrier out operation (this carrier has a known or specified ID) and that no AMHS delivery should be scheduled.

4. The Bind and CancelBind services also trigger changes in the Load Port Reservation State Model. If the Load Port Reservation state model is in the NOT RESERVED state, the Bind service triggers a transition to the RESERVED state. If the Load Port Reservation is in the RESERVED State, the CancelBind service triggers a transition to NOT RESERVED.

12.1.2 For internal buffers equipment, the Reservation State Model, the ReserveAtPort service, the CancelReserveAtPort service, and all other associated functionality is necessary for fundamental compliance to this standard.

12.1.3 For fixed buffer equipment, the Reservation State Model, the ReserveAtPort service, the CancelReserveAtPort service, and all other associated functionality is a user option and not necessary for fundamental compliance.

12.1.4 For equipment implementing the reservation state model, the equipment shall provide a load port reservation state model for each load port.

12.2 *Reservation Visible Signal*

12.2.1 When a port reservation has taken place, the equipment shall display a visible signal indicating that the designated load port is in the Reserved State. Examples of visible signals for the associated load port are: Blinking LEDs, flags, color indicators, or other methods that allow easy recognition that the load port is reserved; proximity to or location on the load port is recommended. The visible signal shall remain present as long as the load port state remains RESERVED. When the state changes to NOT RESERVED the visible indicator shall cease. This capability is not required for fundamental compliance to CMS.

12.3 *Reservation State Model Diagram*

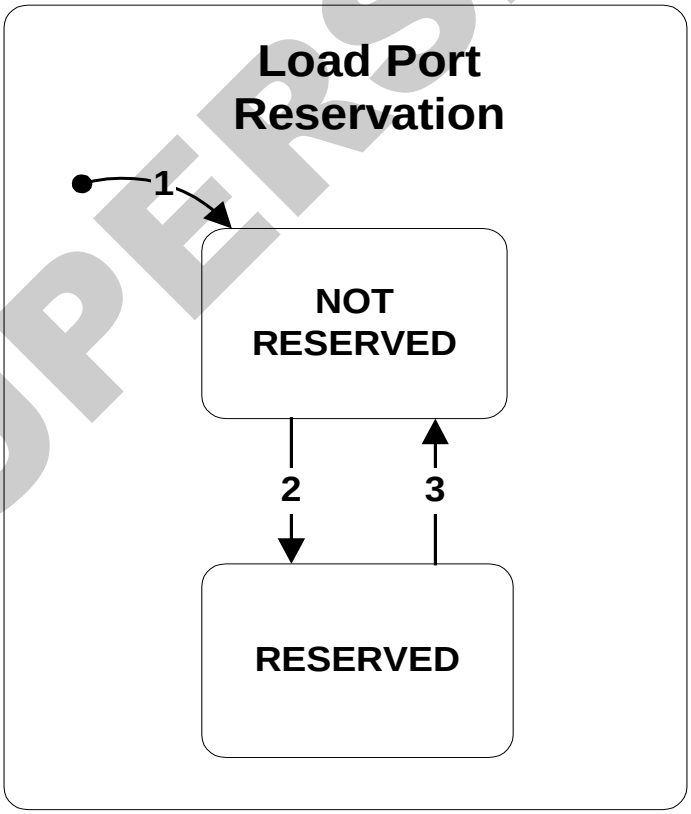

Figure 4
Reservation State Model Diagram

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