SEMI E87-0524
SPECIFICATION FOR CARRIER MANAGEMENT (CMS)

This Standard was technically approved by the Information & Control Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on February 2, 2024 and April 26, 2024. Available at www.semiviews.org and www.semi.org in May 2024; originally published in 1999; previously published March 2024.

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1 Purpose

1.1 This Specification 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 Specification covers host and equipment communication for SEMI E15.1, 300 mm load ports.

2.2 This Specification defines 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 Specification provides state models and scenarios that define the host interaction with the equipment for the following:

- Carrier transfer between automated material handling system (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.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other 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 and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E15.1 — Specification for 300 mm Tool Load Port

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

SEMI E39 — Specification for SECS-II Protocol for Object Services (OSS)

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Full document details: SEMI E87-0524

SEMI E40 — Specification for Processing Management

SEMI E84 — Specification for Enhanced Carrier Handoff Parallel I/O Interface

SEMI E90 — Specification for Substrate Tracking

SEMI E94 — Specification for Control Job Management

SEMI E172 — Specification for SECS Equipment Data Dictionary (SEDD)

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *AMHS* — automated material handling system

5.1.2 *FIMS* — front-opening interface mechanical standard

5.1.3 *FOUP* — front opening unified pod

5.1.4 *GEM* — generic equipment model

5.1.5 *PIO* — parallel input/output interface

5.2 *Definitions*

5.2.1 *automated material handling system (AMHS)* — 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.

5.2.2.1 *Discussion* — 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 *Carrier Complete Prediction (CCP)* — the process that detects and reports the equipment's prediction on when the carrier will be complete.

5.2.9 *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.

5.2.10 *docked position* — the position where the carrier is ready for substrate extraction or insertion.

5.2.11 *front-opening interface mechanical standard (FIMS) port* — the substrate access port where the FOUP is opened and closed.

5.2.12 *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.

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

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

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

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

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

5.2.18 *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.

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

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

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

5.2.22 *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.).

5.2.23 *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.'

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

NOTE 1: 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.

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

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

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

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

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

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

5.2.31 *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.

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

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

5.2.34 *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 (GEM) Standard SEMI E30*

- Event Notification

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Full document details: SEMI E87-0524

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

6.3 *Object-Based Standards*

- Object Services Standard (SEMI E39)

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. 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 for the Carrier object. Using SEMI E39, 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 cannot be changed using SetAttr service as defined in OSS.
- 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 column is defined as Read Only (RO) or Read/Write (RW). The Reqd column is used to specify whether the attribute is required for implementation. A ‘Y’ in the Requirement (Reqd) column indicates if this attribute is supported in order to meet fundamental compliance for the service. ‘N’ in the Requirement (Reqd) column indicates when this attribute is supported in order to meet Optional Requirements. 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 or N	Text = ‘Carrier’

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7.2 *State Model Methodology*

7.2.1 A state model has three elements: definitions of each state and substate, 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 Related Information 1 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. More explicitly, there must be a unique collection event for each state transition.

7.2.2.2 Equipment must maintain state models for each of the required state models as defined in this Standard. Equipment shall maintain individual and unique state models for each logical entity instantiated or physical entity in the equipment that has state models associated with it. The event identifier reported during a particular state transition change for each of these state models shall be shared for all associated state models but unique for each transition. For example, if the equipment has two load ports and the load port state model defines ten transitions, there must be exactly ten event identifiers for each load port transfer state model but not ten for each physical load port. The information identifying the physical entity or logical entity undergoing the transition will be contained within the associated event report.

7.2.2.3 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.

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

7.2.2.5 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, and
- Actions taken which are most closely associated with the transition.

7.2.2.6 When a state model is defined with multiple AND substates, the equipment may report all state entry events with only one collection event. When conditional paths are defined in the state model, it is not necessary to report any state transition(s) until a terminal state is reached at which time each transition used to reach that state is reported.

Table 2 State Transition Table

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*

[1] Elsevier Science, P. O. Box 945, New York, NY 10159-0945, USA; 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*

#1 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*

#1 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 Specification 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 front opening unified pods (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.

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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 substate 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 contains two substates, 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 substate 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 substate. 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 substate of TRANSFER READY. When transitioning to the TRANSFER READY state, if a carrier is present on the specified load port, this is the active substate. In this state, the load port is available for unloading of a carrier from the load port 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.

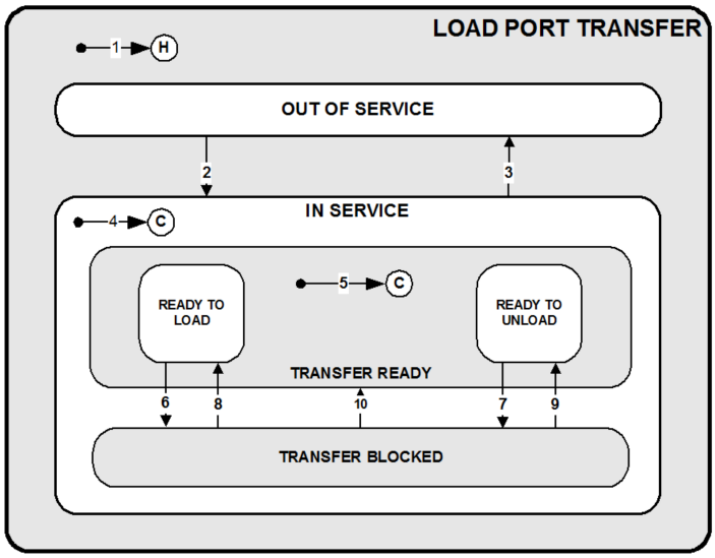

Figure 1
Load Port Transfer State Model Diagram

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9.5.4 *Load Port Transfer State Transition Table*

Table 5 Load Port Transfer State Transition Definition

#	*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 PortTransferState
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 PortTransferState
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 PortTransferState
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 PortTransferState
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 substate is READY TO UNLOAD, else the substate 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 PortTransferState

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#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
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 (refer to SEMI E84). *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 PortTransferState
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 (refer to SEMI E84). *Internal Buffer:* A CarrierIn service has started for this load port. *By CarrierReCreate Service:* A CarrierReCreate service command has been issued by host or operator.	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 PortTransferState
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 the PIO 'COMPT' signal (refer to SEMI E84). *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 PortTransferState

Documents
Document Sharing Hub
Full document details: SEMI E87-0524

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
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/ CancelCarrierAtPort 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 PortTransferState
10	TRANSFER BLOCKED	The transfer was unsuccessful, and the carrier was not loaded or unloaded.	TRANSFER READY		The substate of TRANSFER READY which is decided by transition #5. Data required to be available for this event report: PortID PortTransferState

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. 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.

10.2.1.1 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.

10.2.1.2 A carrier object is instantiated by CarrierID read only if there are no currently existing objects with the CarrierID just read.

10.2.1.3 A carrier object can also be instantiated by either the ProceedWithCarrier or CancelCarrier Services on an NOT ASSOCIATED port. (This implies a failed CarrierID read event.)

10.2.1.4 When the carrier is instantiated by CarrierID read, the ContentMap attribute shall be an empty list (a list of zero) or a structured list of empty lot and substrate identifiers. Implementers shall apply the chosen approach consistently for all carriers instantiated by CarrierID read. The recommended approach is an empty list.

10.2.1.5 When the carrier is instantiated by CarrierID read, the AdditionalInfo attribute shall be an empty list (a list of zero) or a structured list of empty name and value identifiers. Implementers shall apply the chosen approach consistently for all carriers instantiated by CarrierID read. The recommended approach is an empty list.

10.2.1.6 When the carrier is instantiated by CarrierID read, the AdditionalSubstrateInfoMap attribute shall be an empty list (a list of zero) or a structured list of list objects. Implementers shall apply the chosen approach consistently for all carriers instantiated by CarrierID read. The recommended approach is an empty list.

10.2.1.7 The SlotMap attribute should be a list consisting of all slots enumerated as ‘UNDEFINED’ when the carrier object is instantiated by CarrierID read.

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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, its 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 or CarrierReCreate (with PropertiesList) service;
2. CarrierID read with no currently existing carrier objects having the carrierID just read; and
3. ProceedWithCarrier or CancelCarrier Service on an NOT ASSOCIATED 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 CarrierID is the Carrier Object Identifier. The equipment is responsible for ensuring uniqueness of the CarrierID 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 its 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;
3. An equipment based CarrierID verification fails after a carrier object was previously instantiated with a 'Bind' service (Equipment initiated CancelBind); and
4. The host or operator has issued a CarrierReCreate service.

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 marked 'Y' in the 'Reqd' column in the Carrier Attribute Definition (Table 6) are required to be associated with the carrier object and are always maintained and updated by the equipment.

10.3.2.2 Attributes marked 'N' in the 'Reqd' column in the Carrier Attribute Definition (Table 6) can be omitted if it is not used. Those attributes are used only in the case the capability is implemented.

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.

10.3.4 *Carrier Attribute Definition Table*

Table 6 Carrier Attribute Definition

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
AdditionalInfo	Specifies additional information for the carrier through name-value pairs. Refer to § 10.3.5.	RO	N	List of structures consisting of two fields {name, value}

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Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
AdditionalSubstrate InfoMap	Specifies additional information for the substrates in the carrier's slots. Represented by name-value pairs for each substrate. Refer to § 10.3.6.	RO	N	Ordered list of n structures, where n is equal to the carrier's Capacity attribute, and each structure is a list of name-value pairs that correspond to the substrate object's AdditionalInfo attribute. List of Structure {$Name_1$, $Value_1$} {$Name_2$, $Value_2$} …. {$Name_m$, $Value_m$} where m=number of elements in the substrate's AdditionalInfo attribute. When a slot has no substrate, the structure is an empty list.
Capacity	Maximum number of substrates a carrier can hold.	RO	Y	Positive integer.
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.
CCPImminent LeadTimeInterval	Carrier Complete Prediction Lead Time Interval. This attribute is required only when Carrier Complete Prediction is implemented. This attribute specifies the lead time (in seconds) before the predicted carrier complete time (Tpred) when the carrier goes into the CARRIER COMPLETE IMMINENT state. If this attribute is set to 0 (zero), the Carrier Complete Prediction is disabled (i.e., the carrier goes into PREDICTION DISABLED state).	RO	N	Non-negative integer. Default value = 0. Valid values: 0–3600.
CCPredictedTime	Carrier Complete Predicted Time This attribute is required only when Carrier Complete Prediction is implemented. This attribute is populated with the predicted carrier complete time (Tpred) when the carrier will be finished.	RO	N	The format of the timestamp is defined by the protocol for implementation.

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Full document details: SEMI E87-0524

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
CCPStatus	State of the Carrier Complete Prediction of the carrier. This attribute is required only when Carrier Complete Prediction is implemented.	RO	N	Enumerated: PREDICTION DISABLED, NOT PREDICTED, PREDICTING, PREDICTED, CARRIER COMPLETE IMMINENT, PREDICTION COMPLETED, PREDICTION FAILED.
CCPTimeoutInterval	Carrier Complete Prediction Timeout Interval. This attribute is required only when Carrier Complete Prediction is implemented. This attribute specifies the maximum time interval (in seconds) the equipment waits for the carrier to be complete after the predicted carrier completion time (Tpred). If this time interval elapses without the carrier finishing, the carrier object shall transition into 'PREDICTION FAILED' state to indicate the prediction is no longer effective. If this attribute is set to 0 (zero), the timeout failure condition is not checked.	RO	N	Non-negative integer. Default value = 0. Valid values: 0–28800.
ContentMap	Ordered list of lot and substrate identifiers corresponding to slot 1,2,3,…n. The ordered list could be empty (list of zero) when the carrier is instantiated by a CarrierID read.	RO	Y	When ContentMap is not an empty list, it is an 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, 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 1–80 characters.
ObjType	Object type.	RO	Y	Text 1–40 characters equal to 'Carrier'.
ObjID	Object identifier.	RO	Y	Text 1–80 characters equal to the CarrierID.
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', each value in the list is from the following enumeration: UNDEFINED, EMPTY, NOT EMPTY, CORRECTLY OCCUPIED, DOUBLESLOTTED, CROSS SLOTTED. (NOT EMPTY provided for equipment that cannot detect incorrectly slotted substrates).

Documents
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Full document details: SEMI E87-0524

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
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.
SubstrateCount	The number of substrates currently in the carrier.	RO	Y	Non-negative integer less than or equal to the Capacity.
Usage	The type of material contained in the carrier (i.e., TEST, DUMMY, PRODUCT, FILLER, etc.).	RO	Y	Text as defined by the equipment.

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

10.3.5 *AdditionalInfo Attribute* — This attribute provides a generic mechanism to provide additional information about the carrier through name-value pairs, rather than creating custom attributes on the SEMI E87 carrier object.

10.3.5.1 This attribute can be used to provide custom information about the carrier to the equipment, and/or provide equipment-generated information about the carrier. For example, it could be used to specify if the carrier requires a nitrogen purge, or a list of gases used to purge the carrier.

10.3.5.2 Supported AdditionalInfo element names are specified by the equipment.

NOTE 2: The equipment and host negotiate how data in AddtionalInfo attribute is to be used. Such negotiations are outside the scope of this Specification.

10.3.5.3 Information already defined as SEMI E87 carrier attributes are not accessed through the AdditionalInfo attribute. For example, CarrierAccessingStatus and Usage information are already defined as carrier attributes and are not specified as elements in the carrier's AdditionalInfo attribute.

10.3.5.4 The Equipment could add or delete elements in the AdditionalInfo attribute, or it could change the value for an existing name-value pair.

10.3.5.5 The host cannot change the AdditionalInfo attribute other than through a Bind, CarrierNotification, ProceedWithCarrier or CarrierReCreate service.

10.3.5.5.1 If the equipment does not support the AdditionalInfo attribute and the SEMI E87 service specifies the AdditionalInfo attribute as anything other than an empty list, the SEMI E87 service shall fail.

10.3.5.5.2 Only valid element names supported by the equipment for the carrier's AdditionalInfo attribute elements can be specified in the AdditionalInfo attribute. If the SEMI E87 service specifies the AdditionalInfo attribute with an invalid element name, the SEMI E87 service shall fail.

NOTE 3: The carrier's AdditionalInfo attribute is read-only because if the Host changes the value, there is an expectation of some corresponding behavior change on the equipment. Since the name-value pair is implementation specific, the Specification can't dictate what the behavior change will be.

10.3.6 *AdditionalSubstrateInfoMap Attribute* — This attribute specifies additional information for each substrate in the carrier's slots.

10.3.6.1 Each element in the attribute maps to a slot in the carrier. That element shall be an empty list structure if the carrier slot is empty. Otherwise that element shall be the AdditionalInfo attribute for the substrate in that slot.

10.3.6.2 If the equipment does not support the AddtionalInfo attribute on the SEMI E90 substrate, and a SEMI E87 service (e.g., Bind or ProceedWithCarrier) specifies an AdditionalSubstrateInfoMap element that is not an empty list for the substrates in the carrier slot, the SEMI E87 service shall fail.

10.3.6.3 Only valid element names supported by the equipment for the substrate.AdditionalInfo attribute can be specified in the AdditionalSubstrateInfoMap attribute. If a SEMI E87 service (e.g., Bind or ProceedWithCarrier) specifies an AdditionalSubstrateInfoMap element with an invalid substrate AdditionalInfo name, the SEMI E87 service shall fail.

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Full document details: SEMI E87-0524

10.3.6.4 The host cannot change the AdditionalSubstrateInfoMap attribute other than through a Bind, CarrierNotification, ProceedWithCarrier or CarrierReCreate service.

10.3.6.4.1 When the equipment creates SEMI E90 objects corresponding to substrates in the carrier (i.e. after the SlotMap goes to SLOT MAP VERIFICATION OK state), the corresponding elements of the AdditionalSubstrateInfoMap are passed to the SEMI E90 substrate object as part of the substrate object creation.

NOTE 4: The carrier's AdditionalSubstrateInfoMap attribute is read-only because if the Host changes the value, there is an expectation of some corresponding behavior change on the equipment. Since the name-value pair is implementation specific, the Specification can't dictate what the behavior change will be.

10.3.7 *Rules for Carrier Attributes*

- The equipment shall change object attributes, AdditionalInfo, AdditionalSubstrateInfoMap, 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, AdditionalInfo, AdditionalSubstrateInfoMap, 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. If the equipment supports AdditionalInfo or AdditionalSubstrateInfoMap properties, they shall be actively updated by the equipment.

10.3.8 *Carrier Location*

10.3.8.1 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.

10.3.9 *Carrier Location Examples*

10.3.9.1 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.

10.3.10 *Rules for Carrier Complete Prediction Attributes*

10.3.10.1 Rules in this section apply to the optional attributes, additionally to the rules in § 10.3.5, when the Carrier Complete Prediction is implemented.

- The equipment shall maintain and update the object attribute CCPStatus.
- When the equipment puts the carrier into the PREDICTED state, the object attribute CCPredictedTime shall be updated with the predicted carrier complete time (Tpred). The equipment shall not change the CCPredictedTime attribute once it has been set.
- Carrier attributes CCPImminentLeadTimeInterval and CCPTimeoutInterval may be provided before the carrier arrives as part of Bind or CarrierNotification service. Those attributes should be retained until either CancelBind or CancelCarrierNotification service is received or the carrier is removed.
- Carrier attributes CCPImminentLeadTimeInterval and CCPTimeoutInterval may also be provided by the ProceedWithCarrier or CarrierReCreate service.

Documents
Document Sharing Hub
Full document details: SEMI E87-0524

- If the CCPImminentLeadTimeInterval or CCPTimeoutInterval is not specified, the default value applies to the attribute.

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 CarrierLocation-Matrix. 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 ¶ 9.1). The LocationID form for the front-opening interface mechanical standard (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.

10.6.3 *SubstrateCount*

10.6.3.1 The SubstrateCount 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 its own actions of adding and removing a substrate to and from a carrier. If the equipment does not know the value of SubstrateCount prior to instantiation, the equipment shall instantiate the carrier object with the value of null for SubstrateCount.

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.

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.

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Full document details: SEMI E87-0524

10.7.2 *Carrier State Model Diagram*

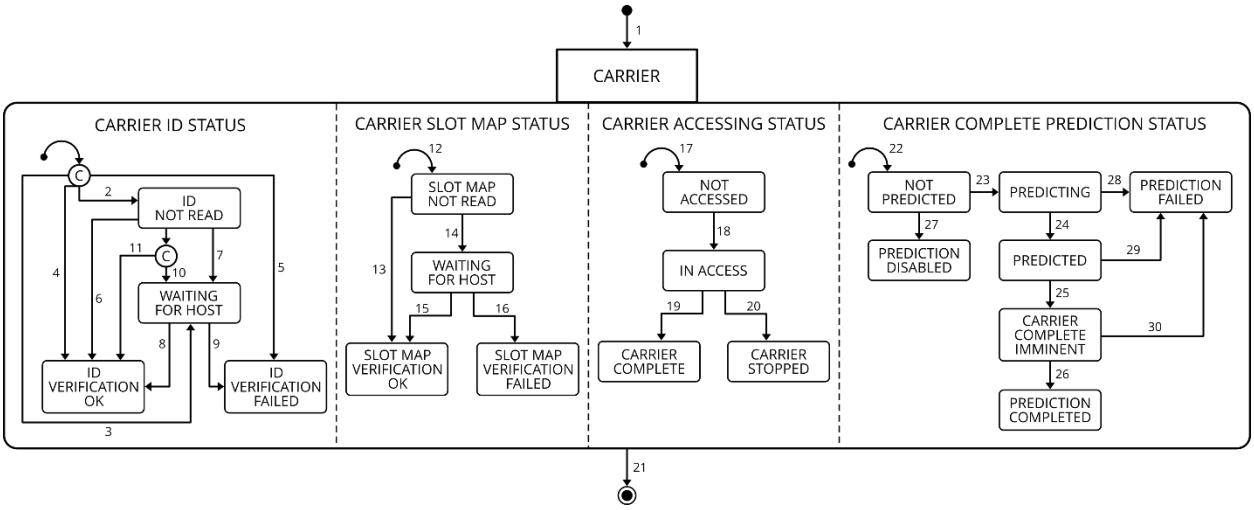

Figure 2
Carrier State Model Diagram

10.7.3 *Carrier State Definitions*

10.7.3.1 *CARRIER* — The CARRIER state has three fundamental states of CARRIER ID STATUS, CARRIER SLOT MAP STATUS and CARRIER ACCESSING STATUS, and an additional state CARRIER COMPLETE PREDICTION STATUS. The Additional state is required only when the Carrier Complete Prediction is implemented.

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 reader, 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 failed verification by the host following the CancelCarrier service. This is a final state.

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Full document details: SEMI E87-0524

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 by the host.

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 substate 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.

10.7.3.4.2 *SLOT MAP VERIFICATION FAILED* — This is a substate of CARRIER SLOT MAP STATUS and is active when the Slot Map failed verification by the host (e.g., carrier was waiting for slot map information from the host or verification by the host and the carrier was canceled). 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. The slot map is verified by either successful equipment verification or host verification of the slot map that was scanned by the equipment or provided by the host when BypassScanSlotMap is TRUE. 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.

10.7.3.5 *CARRIER COMPLETE PREDICTION STATUS* — This is a substate of CARRIER, to indicate current status of the carrier with respect to its prediction for READY TO UNLOAD. It has seven substates, NOT PREDICTED, PREDICTING, PREDICTED, CARRIER COMPLETE IMMINENT, PREDICTION COMPLETED, PREDICTION FAILED, PREDICTION DISABLED.

10.7.3.5.1 *NOT PREDICTED* — This is a substate of CARRIER COMPLETE PREDICTION STATUS and is active when the carrier object is created.

10.7.3.5.2 *PREDICTING* — This is a substate of CARRIER COMPLETE PREDICTION STATUS . The equipment is either waiting for conditions to be satisfied so it can make the calculation to predict when the carrier is complete or is actively calculating the prediction. The calculation details are implementation specific. (Refer to § 10.7.8.1.2.) There is no expectation the equipment starts calculating as soon as the carrier transitions to the PREDICTING state or how long it will take. For carriers in this state, the equipment also checks for possible carrier complete prediction failure conditions (refer to § 10.7.8.8).

10.7.3.5.3 *PREDICTED* — This is a substate of CARRIER COMPLETE PREDICTION STATUS and is active when the equipment has calculated the predicted carrier complete time (Tpred), and the carrier does not satisfy the transition to CARRIER COMPLETE IMMINENT. The equipment also checks for possible carrier complete prediction failure conditions.

10.7.3.5.4 *CARRIER COMPLETE IMMINENT* — This is a substate of CARRIER PREDICTION STATUS and is active when the condition (refer to ¶ 10.7.8.7) is already satisfied. The equipment also checks for possible carrier complete prediction failure conditions.

10.7.3.5.5 *PREDICTION COMPLETED* — This is a substate of CARRIER COMPLETE PREDICTION STATUS and is active when the equipment's access to the carrier is finished and the prediction did not fail. This is a final state.

10.7.3.5.6 *PREDICTION FAILED* — This is a substate of CARRIER COMPLETE PREDICTION STATUS and is active when a carrier complete prediction fail condition is satisfied (refer to § 10.7.8.8). For carriers in this state, the equipment no longer predicts carrier complete time (Tpred) and any previous predictions are invalid. This is a final state.

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10.7.3.5.7 *PREDICTION DISABLED* — This is a substate of CARRIER COMPLETE PREDICTION STATUS and is active when the carrier's prediction capability is disabled. For carriers in this state, the equipment does not make any prediction when the carrier will be complete. This is a final state.

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.

Table 7 Carrier State Transition Definition

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
1	(no state)	A carrier is instantiated.	CARRIER	None.	No event is required for this transition
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 CarrierIDStatus
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 CarrierIDStatus 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 or UnknownCarrierID Events*: 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 CarrierIDStatus This transition can happen only if a bind service has not been received.
5	(no state)	*ID Read fail or UnknownCarrierID Events:* 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 CarrierIDStatus This transition can happen only if a bind service has not been received.

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Full document details: SEMI E87-0524

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
6	ID NOT READ	*Normal*: CarrierID is read successfully and the equipment has verified the carrierID successfully. *Abnormal:* The carrier was instantiated via a CarrierNotification service and upon carrier placement the equipment has sent a CarrierID Read Fail Event or UnknownCarrierID Event. Subsequently the host has issued a ProceedWithCarrier service. The ProceedWithCarrier service must provide the PortID parameter as well as the CarrierID parameter in order to unambiguously identify the physical carrier.	ID VERIFICATION OK	None.	Data required to be available for this event report: PortID CarrierID CarrierIDStatus
7	ID NOT READ	*Abnormal #1*: CarrierID is read unsuccessfully, or *Abnormal #2*: A Bind service is previously received, but the carrier arrives at a different load port.	WAITING FOR HOST	None.	Data required to be available for this event report: PortID CarrierID CarrierIDStatus
8	WAITING FOR HOST	A ProceedWithCarrier service is received.	ID VERIFICATION OK	None.	Data required to be available for this event report: PortID CarrierID CarrierIDStatus
9	WAITING FOR HOST	A CancelCarrier/ CancelCarrierAtPort service is received.	ID VERIFICATION FAIL	None.	Data required to be available for this event report: PortID CarrierID CarrierIDStatus
10	ID NOT READ	BypassReadID 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 CarrierIDStatus
11	ID NOT READ	BypassReadID 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 CarrierIDStatus
12	(no state)	A carrier is instantiated.	SLOT MAP NOT READ	None.	No event is required for this transition.

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#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
13	SLOT MAP NOT READ	BypassScanSlotMap variable is set to FALSE: *Equipment based verification* Slot Map is read and verified successfully by the equipment. BypassScanSlotMap variable is set to TRUE: SlotMap has been provided in a previous ProceedWithCarrier, Bind or CarrierNotification service and the carrier is in ID VERIFICATION OK state.	SLOT MAP VERIFICATION OK	None.	Data required to be available for this event report: PortID (if valid) CarrierID LocationID CarrierAccessingStatus SlotMapStatus
14	SLOT MAP NOT READ	BypassScanSlotMap variable is set to FALSE: *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 substrate position within the carrier:* The Slot Map read has indicated an abnormal substrate position. BypassScanSlotMap variable is set to TRUE: SlotMap has not been provided in previous ProceedWithCarrier, Bind or CarrierNotification services and the carrier is in ID VERIFICATION OK state.	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 SlotMapStatus
15	WAITING FOR HOST	BypassScanSlotMap variable is set to FALSE: A ProceedWithCarrier service is received. BypassScanSlotMap variable is set to TRUE: A ProceedWithCarrier service with SlotMap is received and the carrier is in ID VERIFICATION OK state.	SLOT MAP VERIFICATION OK	Proceed with the carrier as instructed.	Data required to be available for this event report: PortID (if valid) CarrierID LocationID SlotMapStatus

Documents
Document Sharing Hub
Full document details: SEMI E87-0524

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
16	WAITING FOR HOST	A CancelCarrier/ CancelCarrierAtPort service is received.	SLOT MAP VERIFICATION FAILED	Prepare the carrier for Unload.	Data required to be available for this event report: PortID (if valid) CarrierID LocationID CarrierAccessingStatus SlotMapStatus
17	(no state)	A carrier object is instantiated.	NOT ACCESSED	None.	No event is required for this transition
18	NOT ACCESSED	The equipment starts accessing the carrier.	IN ACCESS	None.	Data required to be available for this event report: CarrierID CarrierAccessingStatus
19	IN ACCESS	The equipment finishes accessing the carrier normally.	CARRIER COMPLETE	None.	Data required to be available for this event report: CarrierID CarrierAccessingStatus
20	IN ACCESS	The equipment finishes accessing the carrier abnormally.	CARRIER STOPPED	None.	Data required to be available for this event report: CarrierID CarrierAccessingStatus
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
22	(no state)	A carrier object is instantiated.	NOT PREDICTED	None.	No event is required for this transition.
23	NOT PREDICTED	The following three conditions are satisfied: • Carrier attribute CCPImminent LeadTimeInterval is not set to 0 (zero) and • Carrier's CARRIER SLOT MAP STATUS is SLOT MAP VERIFICATION OK and • Carrier's CARRIER ACCESSING STATUS is IN ACCESS	PREDICTING	At some point the equipment calculates when the carrier will be complete.	Data required to be available for this event report: CarrierID CCPStatus
24	PREDICTING	Predicted carrier complete time (Tpred) has been calculated.	PREDICTED	Save predicted carrier complete time (Tpred) in CCPredictedTime attribute.	Data required to be available for this event report: CarrierID CCPStatus CCPredictedTime

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#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
25	PREDICTED	The lead notification time (Tlead) is before or equal to the current time (Tcurr).	CARRIER COMPLETE IMMINENT	None.	Data required to be available for this event report: CarrierID CCPStatus CCPPredictedTime
26	CARRIER COMPLETE IMMINENT	Carrier's CARRIER ACCESSING STATUS is CARRIER COMPLETE or CARRIER STOPPED.	PREDICTION COMPLETED	None.	Data required to be available for this event report: CarrierID CCPStatus CCPActualTime CCPActualTimeDifference
27	NOT PREDICTED	1) The following three conditions are satisfied: • Carrier attribute CCPImminent LeadTimeInterval is set to 0 (zero) and • Carrier's CARRIER SLOT MAP STATUS is SLOT MAP VERIFICATION OK and • Carrier's CARRIER ACCESSING STATUS is IN ACCESS. or 2) The carrier is cancelled.	PREDICTION DISABLED	None.	Data required to be available for this event report: CarrierID CCPStatus
28	PREDICTING	1) The equipment cannot predict when carrier will be complete. or 2) The carrier is cancelled. or 3) The carrier's CARRIER ACCESSING STATUS is CARRIER COMPLETE or CARRIER STOPPED.	PREDICTION FAILED	None.	Data required to be available for this event report: CarrierID CCPStatus CCPFailedReason
29	PREDICTED	1) The equipment determines the predicted carrier complete time (Tpred) is no longer valid. or 2) The carrier is cancelled. or 3) The carrier's CARRIER ACCESSING STATUS is CARRIER COMPLETE or CARRIER STOPPED. or 4) The predicted carrier complete time (Tpred) is before or equal to the current time (Tcurr).	PREDICTION FAILED	None.	Data required to be available for this event report: CarrierID CCPStatus CCPFailedReason

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Full document details: SEMI E87-0524

#	Previous State	Trigger	New State	Actions	Comment
30	CARRIER COMPLETE IMMINENT	1) The current time (Tcurr) is after the predicted carrier complete time (Tpred) plus the non-zero CCPTimeoutInterval. or 2) The equipment determines the predicted carrier complete time (Tpred) is no longer valid. or 3) The carrier is cancelled.	PREDICTION FAILED	None.	Data required to be available for this event report: CarrierID CCPStatus CCPFailedReason

#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, the CARRIER SLOT MAP STATUS substate, and the CARRIER COMPLETE PREDICTION STATUS substate).

10.7.5 *Slot Map Read Details*

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

10.7.5.2 *Bypass Scan Slot Map* — A carrier slot map scanner may be unavailable: either out of service, not installed, or otherwise malfunctioning and unable to execute a scan operation. This represents a steady condition that often is known in advance.

10.7.5.2.1 The equipment shall provide a user-configurable variable BypassScanSlotMap used to bypass verification of the Slot Map when the slot map scanner is unavailable or not installed and the load port is ASSOCIATED.

10.7.5.2.2 When a slot map scanner is not installed, the value of BypassScanSlotMap shall be TRUE and cannot be changed to FALSE. When a slot map scanner is installed, the value of BypassScanSlotMap shall be FALSE (default value). The value of BypassScanSlotMap can be set to TRUE when there is a slot map scanner installed but not used (e.g., slot map scanner becomes unavailable due to hardware issues).

10.7.5.3 The carrier object is instantiated in the SLOT MAP NOT READ state, and after the carrier is received and the ID is verified, the Slot Map state transitions to SLOT MAP WAITING FOR HOST or SLOT MAP VERIFICATION OK, depending upon the BypassScanSlotMap value.

10.7.5.3.1 When BypassScanSlotMap value is TRUE, the equipment should use the Slot Map provided by the Bind, CarrierNotification or ProceedWithCarrier service.

10.7.5.3.1.1 If Slot Map information has not been provided in a Bind, CarrierNotification or ProceedWithCarrier service, the carrier Slot Map state transitions to WAITING FOR HOST and waits for the host to send a ProceedWithCarrier which contains the Slot Map to be used for this carrier or CancelCarrier/CancelCarrierAtPort for this carrier.

10.7.5.3.1.2 If the Slot Map information has been provided in a Bind, CarrierNotification or ProceedWithCarrier service, the carrier Slot Map state transitions to SLOT MAP VERIFICATION OK.

10.7.5.3.1.3 If the Slot Map information provided in a Bind, CarrierNotification or ProceedWithCarrier service does not match with physical Slot Map, the error handling implementation will be equipment dependent.

10.7.5.3.2 When BypassScanSlotMap value is FALSE, the equipment should scan the Slot Map, perform the Slot Map verification, and report the result with proper transition.

10.7.5.3.2.1 If the Slot Map information has not been provided in a Bind, CarrierNotification or ProceedWithCarrier service, the carrier Slot Map state transitions to WAITING FOR HOST and waits for the host to send a ProceedWithCarrier or CancelCarrier/CancelCarrierAtPort for this carrier. ProceedWithCarrier service shall contain Slot Map if WAITING FOR HOST is triggered by carrier slot map read failure.

10.7.5.3.2.2 If the Slot Map information has been provided in a Bind, CarrierNotification or ProceedWithCarrier service, and the Slot Map matches the physical Slot Map read by the equipment, the carrier Slot Map state transitions to SLOT MAP VERIFICATION OK.

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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.

10.7.7.1 The equipment shall provide a user-configurable variable BypassReadID used to bypass verification of the carrier ID when the carrier ID reader is unavailable or not installed and the load port is ASSOCIATED.

10.7.7.2 BypassReadID is not used to bypass the carrier ID reader. 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.

10.7.7.2.1 When BypassReadID value is TRUE, then the Carrier ID received in the Bind is used automatically.

10.7.7.2.2 When BypassReadID value is FALSE, 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.

10.7.8 *Carrier Complete Prediction Details*

10.7.8.1 The purpose of the Carrier Complete Prediction functionality is to provide a factory host with sufficient pre-notification before a carrier can be unloaded. This makes it possible for the factory system to schedule an AMHS vehicle for early carrier pick-up. This will allow the factory to reduce carrier exchange time and therefore potentially improve equipment productivity.

10.7.8.1.1 The equipment can predict when it will be complete with the carrier regardless if the equipment is a fixed buffer tool or an internal buffer tool. This prediction can help the host schedule material transfers accordingly.

NOTE 5: With internal buffer tools especially, there are factors that make predicting when the carrier will be ready to unload from the equipment difficult. (For example, external factors that are beyond the control of the equipment involved such as external transfer times by the AMHS or operator). Refer to Related Information 3, § R3-4 for more details.

10.7.8.1.2 How and when the equipment calculates when the carrier will be complete is an implementation detail.

10.7.8.1.2.1 This Specification does not define any requirements on the prediction algorithm, the prediction quality or when the calculation is made when the carrier is in the PREDICTING state. (For example, there is no requirement that the prediction has to be made within 30 seconds of the carrier entering the PREDICTING state.)

10.7.8.2 The equipment uses these conventions as part of its prediction calculations when access to a certain carrier is finished.

10.7.8.2.1 *Tcurr* — The current time.

10.7.8.2.2 *Tcalc* — The time of the condition calculation, where the equipment predicts when the carrier will be finished.

10.7.8.2.2.1 The equipment transitions the carrier to the PREDICTED state and populates the carrier's CCPredictedTime attribute.

10.7.8.2.3 *Tpred* — The predicted carrier complete time, calculated at Tcalc.

10.7.8.2.3.1 How the equipment calculates Tpred is an implementation detail.

10.7.8.2.3.2 The Tpred value does not change once it has been calculated as it will be used to determine when the carrier transitions to the CARRIER COMPLETE IMMINENT, PREDICTION COMPLETED and PREDICTION FAILED states.

10.7.8.2.3.3 The equipment cannot specify the predicted carrier complete time (Tpred) to occur in the past. (That is, before or equal to the current time [Tcurr].) If it does, the prediction fails.

10.7.8.2.4 *Tlead* — The lead notification time ahead of the predicted carrier complete time (Tpred). (That is, Tlead = Tpred – CCPImminentLeadTimeInterval.)

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10.7.8.3 Figure 3 shows the relationship between the Carrier Complete Prediction Status substates where the prediction is successful.

10.7.8.3.1 For simplicity, the figure does not show the additional conditions required to transition into the PREDICTING state. (That is, carrier attribute CCPImminentLeadTimeInterval not set to 0 (zero) and carrier is SLOT MAP VERIFICATION OK.)

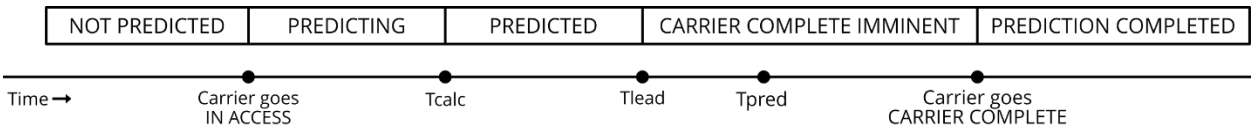

Figure 3
Carrier Complete Prediction Status Substate Relationship When Prediction Is Accurate

10.7.8.4 Figure 4 shows the relationship between the Carrier Complete Prediction Status substates for a prediction failure situation. (In this example, prediction fails because the carrier does not complete within the expected timeout interval.)

10.7.8.4.1 For simplicity, the figure does not show the additional conditions required to transition into the PREDICTING state. (That is, carrier attribute CCPImminentLeadTimeInterval not set to 0 (zero) and carrier is SLOT MAP VERIFICATION OK.)

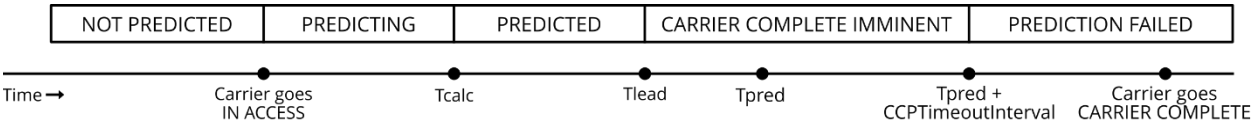

Figure 4
Carrier Complete Prediction Status Substate Relationship When Prediction Fails

10.7.8.5 Refer to Related Information 3, § R3-5 for details on various Carrier Complete Prediction scenarios.

10.7.8.6 *Carrier Attributes for Carrier Complete Prediction* — Different factories have different AMHS installations, therefore the required pre-notification time depends on the equipment user. It is therefore important that the factory host can configure the pre-notification time. It is also important to be able to configure a maximum delay time between predicted time and actual time the carrier is complete, after which the equipment will no longer consider its prediction valid. The factory host can configure the conditions to optimize the carrier transfer time by using the following carrier attributes.

10.7.8.6.1 *CCPImminentLeadTimeInterval* — Carrier Complete Prediction Setting Time Interval. This attribute describes the time interval (in seconds) between host notification (through transition to the CARRIER COMPLETE IMMINENT state) and the anticipated carrier complete.

10.7.8.6.2 *CCPTimeoutInterval* — Carrier Complete Prediction Timeout Interval. This attribute specifies the maximum time interval (in seconds) after the predicted carrier complete time (Tpred) and the current time (Tcurr) before the prediction is considered a failure. If the value is zero (0), there is no maximum time interval.

10.7.8.6.2.1 If this interval elapses and the carrier is still not complete, the carrier object shall transition from the CARRIER COMPLETE IMMINENT to the PREDICTION FAILED state.

10.7.8.6.2.2 If this interval is set to 0 (zero), the equipment does not check the time interval between the predicted carrier complete time (Tpred) and the current time (Tcurr) as a condition of the failing the prediction.

10.7.8.7 *Condition for the CARRIER COMPLETE IMMINENT* — This state shall be assumed when the difference between the predicted carrier complete time (Tpred) and current time (Tcurr) is less than or equal to the CCPImminentLeadTimeInterval.

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10.7.8.8 *Condition for the PREDICTION FAILED* — this state shall be assumed when at least one of the following conditions is fulfilled to indicate the prediction cannot be calculated or is not valid:

- The carrier is in the CARRIER COMPLETE IMMINENT state and the carrier did not finish within the non-zero CCPTimeoutInterval after the predicted carrier complete time (Tpred) (That is, the difference between the current time (Tcurr) after the predicted carrier complete time (Tpred) is greater than or equal to CCPTimeoutInterval).
- The equipment has made a prediction (carrier is in the PREDICTED state) and the predicted carrier complete time (Tpred) is in the past (i.e., before the current time [Tcurr]).
- The equipment has made a prediction (carrier is in the PREDICTED or CARRIER COMPLETE IMMINENT states) and the equipment determines the predicted carrier complete time (Tpred) is no longer valid. For example, there is a problem on the equipment, additional processing has been scheduled using that carrier, or associated jobs using that carrier have been stopped or aborted.
- The equipment has started the carrier complete prediction process, and the carrier is cancelled. (Refer to § 10.7.8.9.)
- The equipment has started the carrier complete prediction process and the carrier finishes before the carrier is in the CARRIER COMPLETE IMMINENT state. (That is, the carrier is in the PREDICTING or PREDICTED state and its CARRIER ACCESSING STATUS transitions to the CARRIER COMPLETE or CARRIER STOPPED state.)
- The carrier is in the PREDICTING state and cannot make a prediction. (For example, the implementation doesn't have enough information for their prediction logic, or the prediction analysis engine isn't working.)

10.7.8.8.1 As part of determining if the prediction it has made is no longer valid, the equipment may perform other calculations. This is an implementation detail.

10.7.8.8.1.1 For example, the equipment could choose to periodically calculate a new estimate when the carrier will be complete to reflect what is happening on the equipment. This value is internal to the equipment and is not shared with the host. The equipment compares it against the predicted carrier complete time (Tpred) it calculated at Tcalc. If the new estimate is significantly different from Tpred, the equipment considers the prediction no longer valid. (Refer to Related Information 3, § R3-5.1.9 for an example use case scenario.)

10.7.8.9 *Cancelling a Carrier* — When a carrier is cancelled (though the CancelCarrier or CancelCarrierAtPort service), the equipment transitions to a final CARRIER COMPLETE PREDICTION STATUS substate.

10.7.8.9.1 If the carrier is in the NOT PREDICTED state when the carrier is cancelled, the carrier goes to the PREDICTION DISABLED state.

10.7.8.9.2 Otherwise, if the carrier is in the PREDICTING, PREDICTED or CARRIER COMPLETE IMMINENT states when the carrier is cancelled, the carrier goes to PREDICTION FAILED state.

NOTE 6: If the equipment starts the carrier complete prediction process (i.e., has transitioned into the PREDICTING state), cancelling the carrier means the prediction is no longer calculated and the PREDICTION FAILED state is the correct state to transition to.

10.7.8.10 *Carrier Movement Interval* — Some equipment users would like to know how long the equipment takes to move a carrier so it can be unloaded. This information is used to better schedule carrier transfers because the factory host can account for that time and know when the carrier can be ready to unload after a carrier is complete and the factory host has arranged for it to be unloaded.

10.7.8.10.1 The equipment shall provide a status variable (CarrierMovementInterval) that reports a non-zero value that represents a typical interval (in seconds) for the equipment to move a carrier to a state where it can be unloaded at a load port.

10.7.8.10.1.1 For fixed buffer tools, this can be the average time to get to a state where the load port is ready for an unload handoff (e.g., load port door is closed, and the carrier is undocked and unclamped).

10.7.8.10.1.2 For internal buffer tools, this can be the average time to move the carrier from an internal buffer location to an external load port where it is ready for an unload handoff (e.g., load port door is closed, and the carrier is undocked and unclamped).

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10.7.8.10.2 The factory host can use this information with the predicted carrier complete time (Tpred) to make better decisions on when material transfers should be scheduled for that carrier.

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: MANUAL and AUTO. These are defined in ¶ 11.3.3.

11.1.2 The access mode for a load port may be switched at any time 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.

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 signal 'READY' is active for load (refer to SEMI E84).	PIO signals a transfer complete signal 'COMPT' (refer to SEMI E84).
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 signal 'READY' is active for unload (refer to SEMI E84).	PIO signals a transfer complete signal 'COMPT' (refer to SEMI E84).

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.

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11.3.2 *Access Mode State Model Diagram*

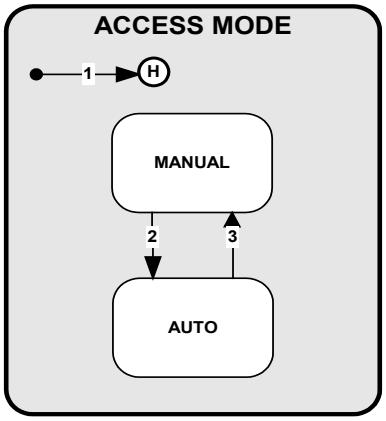

Figure 5
Access Mode State Model Diagram

11.3.3 *Access Mode State Definitions*

11.3.3.1 *ACCESS MODE* — The parent state for the MANUAL and AUTO substates.

11.3.3.2 *MANUAL* — A substate of ACCESS MODE. When the production equipment or specified load ports are in this mode, only manual (non-AMHS) carrier transfers are allowed. The production equipment may generate an alarm if an automated (AMHS) transfer is attempted, but this capability is not required. If a ChangeAccess service with the value of MANUAL is received in this state, the equipment shall accept the service and no event is sent for this action.

11.3.3.3 *AUTO* — A substate of ACCESS MODE. When the production equipment or specified load ports are in this mode, only automated (AMHS) carrier transfers are allowed in normal operation. The production equipment shall have the capability of generating an AccessModeViolation alarm if a manual transfer is attempted. If a ChangeAccess service with the value of AUTO is received in this state, the equipment shall accept the service and no event is sent for this action.

11.3.3.3.1 The passive equipment shall behave as follows if a manual transfer occurs in AUTO mode:

11.3.3.3.1.1 If an operator removes a carrier from a load port in access mode AUTO and transfer state READY TO UNLOAD, the equipment shall raise an AccessModeViolation alarm. After the load port transfer state finally transitioned to the READY TO LOAD state the AccessModeViolation alarm shall be cleared automatically. The load port access mode shall remain in AUTO.

11.3.3.3.1.2 If an operator places a carrier on a load port in access mode AUTO and transfer state READY TO LOAD the equipment shall raise an AccessModeViolation alarm. The equipment shall treat the transfer as incomplete but provide means for the operator to continue or cancel the manual carrier delivery (refer to ¶ 11.3.3.3.1.2.2 for restrictions on continuing).

11.3.3.3.1.2.1 Removing the carrier shall be treated as the cancellation of the manual carrier delivery. The load port shall transition to READY TO LOAD and the AccessModeViolation alarm shall be cleared automatically. The load port access mode shall remain in AUTO.

11.3.3.3.1.2.2 If the operator selects the continue option, the equipment shall treat the transfer as normally completed. The AccessModeViolation alarm shall be cleared automatically. Some IC makers have a policy against accepting a carrier manually placed onto a load port in access mode AUTO. Therefore, in order to prevent the operator who placed the carrier from continuing the manual carrier delivery, the equipment shall provide a configuration to disable the continue option.

11.3.4 *Access Mode State Transition Table*

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

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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 AccessMode
2	MANUAL	The host or operator has executed a ChangeAccess service with the value of AUTO. This trigger can happen at any time, except during a carrier transfer or if the load port is RESERVED.	AUTO		The operator may also trigger this transaction from the production equipment console. Data required to be available for this event report: PortID AccessMode
3	AUTO	The host or operator has executed a ChangeAccess service with the value of MANUAL. This trigger can happen at any time, except during carrier transfer or if the load port is RESERVED.	MANUAL		The operator may also trigger this transaction from the production equipment console or a manual switch at the load port. Data required to be available for this event report: PortID AccessMode

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 In the Reservation State Model, the ReserveAtPort and CancelReservationAtPort services 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 § 13, ¶¶ 15.4.2 and 16.4.11.)
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.
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 buffer equipment, the Reservation State Model, the ReserveAtPort service, the CancelReservationAtPort service, and all other associated functionality are necessary for fundamental compliance to this Standard.

12.1.3 For fixed buffer equipment, the Reservation State Model, the ReserveAtPort service, the CancelReservationAtPort 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.

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Full document details: SEMI E87-0524

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*

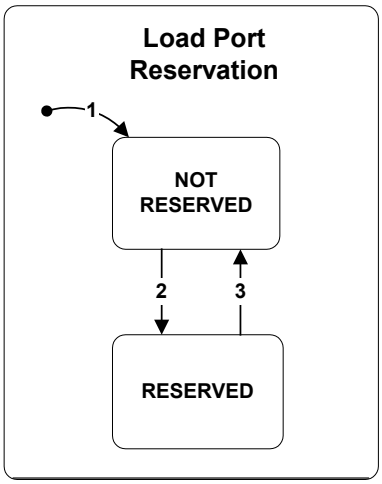

Figure 6
Reservation State Model Diagram

12.4 *Load Port Reservation State Definitions*

12.4.1 *LOAD PORT RESERVATION* — The super state of the substates NOT RESERVED and RESERVED.

12.4.2 *NOT RESERVED* — A substate of LOAD PORT RESERVATION, this state is active when there is no reservation existing at the load port.

12.4.3 *RESERVED* — A substate of LOADPORT RESERVATION, this state is active when there is a reservation for future activity at the load port. When in this state, the access mode for a load port may not be changed.

12.5 *Load Port Reservation State Transition Table*

Table 10 Load Port Reservation State Transition Table

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	(no state)	System reset.	NOT RESERVED		No event report is required for this transition.
2	NOT RESERVED	*Service:* If reserved by service, the host or operator sends a ReserveAtPort or a Bind service to the production equipment. *CarrierOut:* This happens when the equipment physically initiates a CarrierOut operation.	RESERVED	If the user has configured the equipment to use the reservation visible signal indicator, it is activated for this load port.	Data required to be available for this event report: PortID LoadPortReservationState CarrierID may be included when a carrier out or a bind service triggers this transition.

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