SEMI E88-0704
SPECIFICATION FOR AMHS STORAGE SEM (STOCKER SEM)

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1 Purpose

1.1 This standard establishes a Specific Equipment Model (SEM) for AMHS storage equipment (Stocker SEM). The model consists of equipment characteristics and behaviors that are to be implemented in addition to the SEMI E30 fundamental requirements and selected additional capabilities. The intent of this standard is to facilitate the integration of Stocker SEM equipment into an automated (e.g., semiconductor fabrication and flat panel display) factory. This document accomplishes this by defining an operational model for Stocker SEM equipment as viewed by a factory automation controller (Host). This definition provides a standard host interface and equipment operational behavior (e.g., control, state models, and data reports). Several topics require additional activity that are within the scope of this standard: queuing, parallel interface for carrier transfer (SEMI E23), stocker controller architecture, and scheduling and transport of the transfer unit.

2 Scope

2.1 The scope of this standard is limited to the usage and description of AMHS storage equipment (Stockers) as perceived by a SEMI Equipment Communications Standard 2 (SECS-II) host that complies with the GEM model (as specified in Section 13). It defines the view of the equipment through the SECS communication link. It does not define the internal operation of the equipment. It includes a specific transfer command state model and stocker controller state model as the basis for all equipment of this class.

2.2 This document assumes that the GEM fundamental requirements and selected additional capabilities (as specified in Section 13) have been implemented on the Stocker SEM equipment. It expands the GEM standard requirements and capabilities in the areas of state models (stocker controller, transfer command, carrier and stocker crane state models), collection events, alarm documentation, remote commands, data item variables, and material movement.

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

3 Limitations

3.1 *SEMI Standards Alignment*

3.1.1 The GEM (SEMI E30) model was used as the basis for Stocker SEM requirements definition in alignment with existing AMHS SEM Specifications.

3.2 *AMHS Storage Equipment Description*

3.2.1 This standard is targeted at the different types/configurations of 300 mm AMHS storage equipment. The term Stocker SEM equipment refers to all the types of AMHS storage equipment. The equipment types may have fundamental mechanical differences.

3.2.2 *Stocker (configuration)*

3.2.2.1 A Stocker is generally an AMHS automated storage and retrieval device used to provide temporary storage of carriers. The device is not required to provide temporary storage of carriers (for example, when used as a device to connect multiple IBSEM devices or as a floor to floor lifter). Additionally, any number of physical interfaces may exist to connect the stocker with external devices such as: Interbay and/or Intrabay Transport Systems, Process Equipment, other StockerSEM devices, Operator ports, etc.

4 Referenced Standards

4.1 *SEMI Standards*

SEMI E4 — SEMI Equipment Communications Standard 1 Message Transfer (SECS-I)

SEMI E5 — SEMI Equipment Communications Standard 2 Message Content (SECS-II)

SEMI E23 — Specification for Cassette Transfer Parallel I/O Interface

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

SEMI E37 — High-Speed SECS Message Services (HSMS) Generic Services

SEMI E37.1 — High-Speed SECS Message Services Single Selected-Session Mode (HSMS-SS)

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

4.2 *Other References*

Harel, D., "Statecharts: A Visual Formalism for Complex Systems," Science of Computer Programming 8 (1987) 231-274.[1]

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 *BP* — Buffer Port

5.1.3 *FOUP* — Front Opening Unified Pod

5.1.4 *GEM* — Generic Equipment Model

5.1.5 *IBSEM* — InterBay/IntraBay Specific Equipment Model

5.1.6 *ITS* — Interbay or Intrabay Transport System

5.1.7 *LP* — Loading Port

5.1.8 *OP* — Output Port

5.1.9 *PGV* — Person Guided Vehicle

5.1.10 *SC* — Stocker Controller

5.1.11 *TCP/IP* — Transmission Control Protocol/Internet Protocol

5.1.12 *TSC* — Transport System Controller

5.2 *Definitions*

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

5.2.2 *automation* — the capability of managing material and data within the factory.

5.2.3 *bidirectional load port* — a load port used for loading and unloading carriers.

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

5.2.5 *buffer port* — special buffer port location on a stocker output shuttle. Contains carrier presence sensors so that the host can be notified when a carrier is situated at this position.

5.2.6 *carrier* — a container with one or more fixed positions for holding substrates. Examples of carriers include FOUPs and open cassettes.

5.2.7 *carrier ID* — a readable and unique identifier for the carrier.

5.2.8 *FOUP*—a closed carrier for holding wafers.

5.2.9 *host* — the factory computer system, or an intermediate system, that represents the factory and the user to the equipment. Refers system that controls or supervises the Stocker Controller (SC) throughout this document.

5.2.10 *independent port* — a load port on the stocker that is dedicated to input or output. It is considered that the carriers can only be transferred in one direction.

5.2.11 *interbay transport system* — a transport system used to move work-in-process between stockers in different parts of the factory.

5.2.12 *Intrabay Transport System* — a transport system dedicated to one or more bays in the factory and responsible for transferring carriers to and from production equipment. ITS consists of the physical units of the system (e.g., vehicles, nodes, docking stations), the low-level unit controllers, and a system-level controller. ITS excludes factory floor storage systems (stockers), but includes any short-term storage integral to the system, such as storage locations within an overhead track system that are accessible only to units of the particular ITS.

5.2.13 *load port* — the interface location on the equipment where carriers are transferred.

5.2.14 *loading port* — user or vehicle accessible port location on a stocker output shuttle. Contains carrier presence sensors so that the host can be notified when a carrier is situated at this position.

5.2.15 *output port* —port location on a stocker output shuttle, typically accessible by the stocker crane. Contains carrier presence sensors so that the host can be notified when a carrier is situated at this position.

5.2.16 *process equipment* — equipment used to make semiconductor devices. This excludes metrology and material handling equipment.

5.2.17 *production equipment* — equipment used to produce semiconductor devices, including wafer sorting, process, and metrology equipment and excluding material handling equipment.

5.2.18 *Stocker Controller* — stocker Equipment Controller that communicates with the host and represents the system as the equipment.

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

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5.2.19 *stocker crane* — stocker transfer agent specialized for the movement of carriers between shelves and input and output port locations.

5.2.20 *stocker equipment* — an individual stocker viewed as a single piece of equipment, with distributed components and distributed control, as illustrated in Figure 1. The stocker controller communicates with the host using HSMS and GEM and represents the system as an equipment. The factory may require more than one type of stocker.

5.2.20.1 Communications with transport system equipment may require a low-level handshake with a transport unit directly involved in the transfer of material (such as a vehicle or a docking station on an overhead track).

5.2.20.2 Communications between the various stocker units and controllers are proprietary to the supplier.

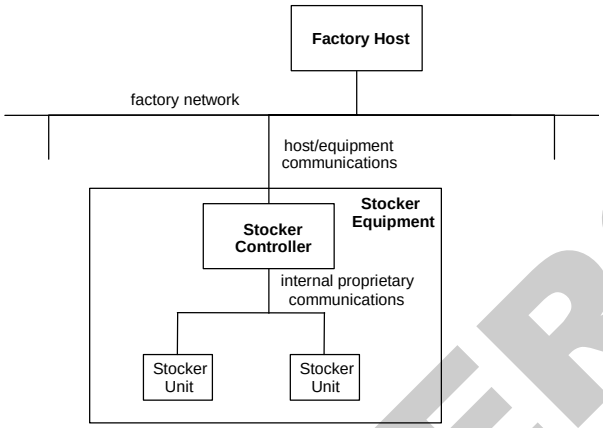

Figure 1
Example of Stocker Equipment

5.2.21 *stocker shelf* — locations within the stocker equipment to store carriers. These locations exclude load ports.

5.2.22 *stocker unit* — a physical component of the stocker system, such as a stocker crane, ID reader, wafer sensor, shuttle port, etc.

5.2.23 *swapping port* — a load port on the stocker capable of handling single load and unload of carriers or simultaneous replace of carriers.

5.2.24 *transfer agent* — a component of equipment specialized to the movement of transfer objects from place to place within a factory. May be of different types with widely-differing characteristics. Examples are fixed-arm robots, robot arms on fixed tracks, overhead gantries or even systems containing a heterogeneous collection of other transfer agents. Humans may also act as transfer agents.

5.2.25 *transfer completed port* — the destination port specified in a transfer command.

5.2.26 *transfer port* — point on the transport system at which a change of equipment ownership of the carrier occurs.

5.2.27 *transfer unit* — the element of movement (assemblage of carriers) of the ITS that consists of a maximum number of carriers allowed in a specific transfer command:

- AA is the maximum number of carriers allowed for acquire 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.

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

5.2.27.2 For purposes of the Stocker SEM, the transfer unit is limited to one carrier.

5.2.28 *transport system* — the component of AMHS that moves material from one part of the factory to another.

5.2.29 *transport unit* — a physical component of a transport system, such as a vehicle, node, or docking unit.

5.2.30 *zone* — a logical assignment referencing a set of one or more locations. A stocker can have several logical zone assignments. For example, a specific stocker may have 2 zones defined as LEFT_ZONE and RIGHT_ZONE. The assignment of zones is specific to the Stocker SEM equipment supplier and it may be desirable for the supplier to remain flexible in the assignment of zones so that it could be configured to meet the specific requirements of different users. A specific zone may only contain shelf locations or ports, but not both. A location may be in at most one zone.

6 Overview and Assumptions

NOTE 1: This section has been included as background information to help clarify requirements.

6.1 *Destination Control (to Shelf or to Output Port)*

6.1.1 The destination is controlled by Host when the carrier is input to the stocker (i.e., the carrier enters the stocker domain). The destination of the transfer command is required. It would be invalid for the Host to issue a transfer command to the SC without including a valid destination.

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6.1.2 *Output to the Interbay Output Port*

6.1.2.1 The destination for a transfer command to move a carrier to an interbay output port must be a loading port. It is the responsibility of the Host to ensure that sufficient capacity exists in the destination stocker when delivering from a source stocker to a destination stocker (i.e., an interbay move). For example, it would be the responsibility of the Host to check the remaining capacity of the destination stocker prior to issuing the transfer command to send the carrier to the interbay output port of the source stocker.

6.1.3 *Output to the Intrabay Output Port*

6.1.3.1 The destination for a transfer command to move a carrier to an intrabay output port must be a loading port.

6.1.4 *Store to the Stocker Shelf*

6.1.4.1 The specific stocker shelf location is to be controlled by the Stocker Controller (SC). The Host does not specify a shelf ID in a transfer command. The Host sends the name of a zone as the destination in the transfer command

6.1.4.2 The carrier is stored to a stocker shelf temporarily when the Host requested output port destination is occupied. This is the responsibility of the Stocker Controller. The carrier count of the stocker is incremented due to this temporary storage (i.e., the current capacity decreases).

6.1.4.3 For multi-crane stockers, the carrier is temporarily stored to a stocker shelf when the source and destination is not accessible by the same stocker crane. This is the responsibility of the Stocker Controller. The carrier count of the zone containing the location where the carrier is temporarily stored is incremented due to this temporary storage (i.e. the current capacity decreases).

6.2 *Quantity Control in the Stocker (Capacity Planning)*

6.2.1 The number of carriers in the stocker is controlled by the Host. A list of carrier database entries in the specified stocker's SC database will be available to the Host upon request via a remote command.

6.3 *Number of Stocker Cranes*

6.3.1 No Limitation. May be zero for systems that do not include a crane. Host does not control the stocker crane directly.

6.4 *Port Type*

6.4.1 The independent input port and the independent output port are required for the Stocker SEM. The swapping type is considered as an independent port.

6.5 *Plural Sets of Input/Output Ports*

6.5.1 Plural sets of Input/Output ports connected to the interbay or intrabay transport system must be considered. (This would be considered a Multi-loop type interface connection to the stocker.) Examples of plural sets of interfaces are as follows:

- Main Loop/Sub Loop,
- Right-handed rotation/Left-handed rotation, and
- Double Track (i.e., Stacked Track).

6.6 *Carrier ID Reader*

- Manual Input Port: Carrier ID Reader is mandatory.
- Automated Input Port: Carrier ID Reader is a customer option.
- Carrier ID Reader at any output port: Carrier ID Reader is a customer option.

6.6.1 The intrabay automated input port is sometimes used as the manual Input Port. If one port is used for both an automated and a manual, the Carrier ID Reader is mandatory for this port. If there is a Carrier ID Reader, the scenario for a stocker transfer without a Carrier ID Reader is not applicable.

6.7 *Tag*

6.7.1 Same assumptions as Carrier ID Reader.

6.8 *Carrier Exchanger/Gas Purger*

6.8.1 Out of scope of Stocker SEM.

6.9 *Robot Arm in the Passive Type Stocker*

6.9.1 No assumption is made regarding the passive type stocker.

6.10 *Empty or Not Empty Carriers*

6.10.1 No assumption is made regarding empty and not empty carriers.

6.11 *Monitor/Dummy*

6.11.1 No assumption.

6.12 *Operation Mode*

6.12.1 No assumption.

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6.13 *Transfer Completed Port*

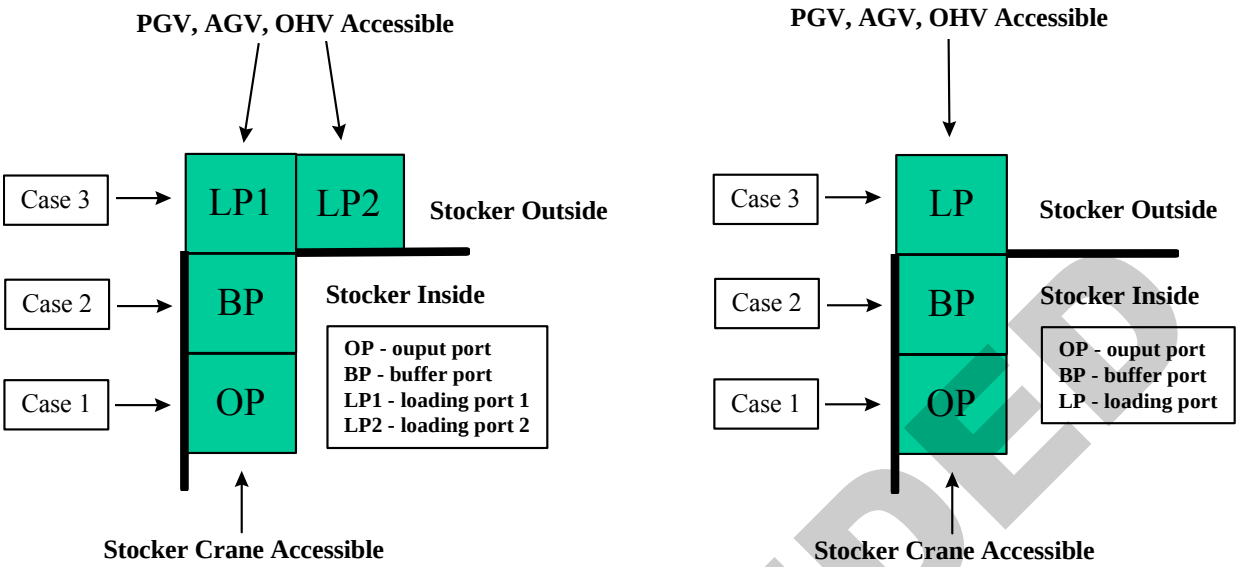

Figure 2
Output Shuttle Examples: L-Shaped Shuttle on Left, I-Shaped Shuttle on Right

6.13.1 The Transfer Completed Port is always the LoadingPort (LP) specified in the transfer command. If the end user desires that the Host issue a transfer to the TSC prior to the carrier arriving at the LP, the states defined in the Stocker Carrier State Model may be utilized.

7 Communication Requirements

7.1 It is required that any Stocker SEM compliant equipment follow the Communications State Model in SEMI E30. In addition, Stocker SEM compliant equipment shall support either SEMI E37 and SEMI E37.1 or SEMI E4.

8 State Models

8.1 *State Model Requirements*

8.1.1 The state models included in this standard are a requirement for Stocker SEM equipment. This standard requires implementation of all SEMI E30 state models (such as control, communication, on-line/off-line, etc. according to the GEM capabilities required per Section 13). 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.

8.1.2 A state model is the host's view of the equipment, and does not necessarily describe the internal equipment operation. All Stocker SEM state model transitions shall be mapped into the appropriate internal equipment 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 Stocker SEM state model for transition to another state. The equipment makes the required transition without any additional actions in this situation.

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

8.2 *SC State Model*

8.2.1 *SC State Model Requirements*

8.2.1.1 The purpose of the SC state model is to provide information to the host regarding the overall status of the stocker system. The SC state model is valid when the SEMI E30 (GEM) state is ON-LINE. The SC state model is **not** valid when the SEMI E30 (GEM) state is OFF-LINE. Since a stocker may consist of many components (e.g.,

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stocker crane, conveyor, ID reader, etc.), it may be possible to continue ON-LINE operation when the operation mode of some stocker components (as viewed by the SC) is a manual state. The details of what happens when individual components of the stocker enter a manual state are specific to the Stocker SEM equipment supplier. When the SEMI E30 Control state changes from OFF-LINE to ON-LINE, the SC State Model is started from the SC INIT state.

8.2.2 *SC State Model*

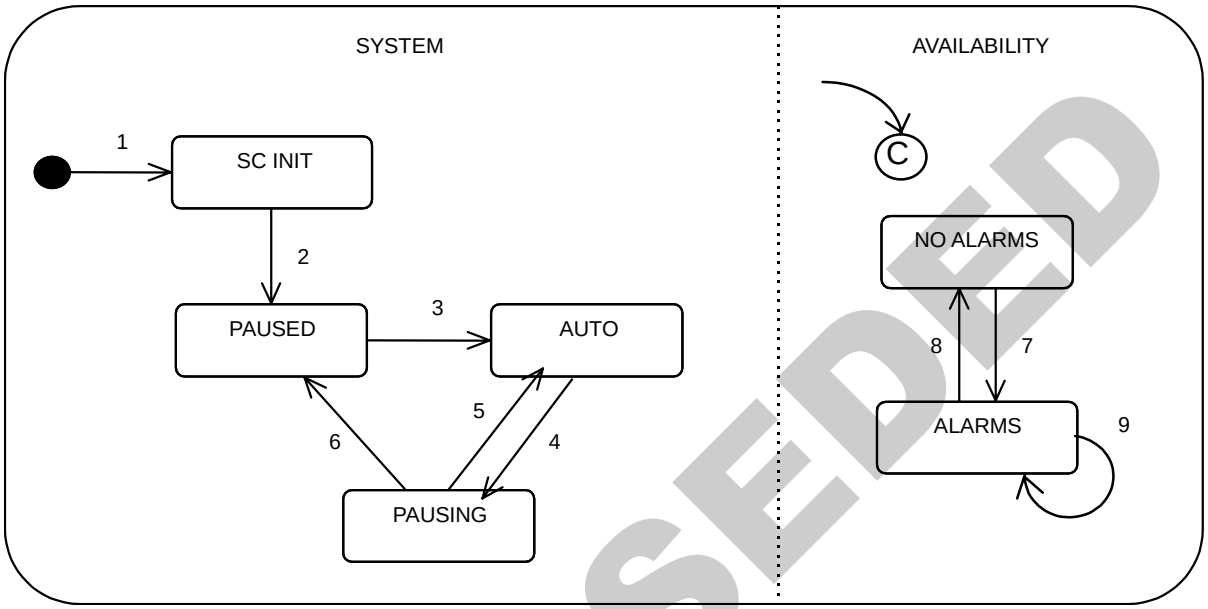

Figure 3
Generic Stocker SEM SC State Model Diagram

8.2.3 *SC State Definitions*

8.2.3.1 *SC INIT* — SC initialization of stocker components is occurring. This is a non-operational state. No commands from the host will be acknowledged, queued or processed. The system will not move out of this state if there are carriers moving on any of the stocker units controlled by the SC. Such devices must be manually or automatically recovered before transitioning to the next state.

8.2.3.2 *PAUSING* — A system PAUSE command has been received and is being processed. All carriers that are currently moving will continue until their physical movement stops (their transfer command may still be active). Carriers that are currently moving may continue to move but they must not begin another movement. TRANSFER commands are accepted and queued. All status requests will be processed. The RESUME, INSTALL, REMOVE, and LOCATE commands will also be processed.

8.2.3.3 *PAUSED* — No carriers are in the process of moving on any of the stocker units controlled by the SC. Carriers may be at any port position including the OP, BP, and LP positions. TRANSFER commands are accepted and queued. All status requests will be processed. The RESUME, INSTALL, REMOVE, and LOCATE commands will also be processed.

8.2.3.4 *AUTO* — Stocker is in the normal operational state. Commands are actively processed.

8.2.3.5 *NO ALARMS* — There are no alarms present in the system.

8.2.3.6 *ALARMS* — There are one or more alarms present in the system.

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8.2.4 *SC State Transition Table*

Table 1 SC State Transition Table

Transition #	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	none	SC Initiation.	SC INIT	S6F11 SCAutoInitiated	System runs through its startup sequence.
2	SC INIT	System started up successfully. All carrier movement stopped.	PAUSED	S6F11 SCPaused	System ready.
3	PAUSED	RESUME command.	AUTO	S6F11 SCAutoCompleted	System can now execute remote commands based upon other internal conditions (Alarm, GEM ONLINE, etc).
4	AUTO	PAUSE command.	PAUSING	S6F11 SCPauseInitiated	Carriers that are not moving remain there. Carriers that are moving must stop at the next logical stopping point.
5	PAUSING	RESUME command.	AUTO	S6F11 SCAutoCompleted	System can now execute remote commands based upon other internal conditions (Alarm, GEM ONLINE, etc).
6	PAUSING	All carrier movement has completed.	PAUSED	S6F11 SCPauseCompleted	System will accept and queue new commands but will not execute them. No new movement will occur. Outstanding Transfer Commands will remain NOT ACTIVE.
7	NO ALARMS	Alarm Set.	ALARMS	S6F11 AlarmSet	
8	ALARMS	All Alarms cleared.	NO ALARMS	S6F11 AlarmCleared	
9	ALARMS	Alarm Set.	ALARMS	S6F11 AlarmSet	Alarm occurs when there is already an outstanding alarm.

8.3 *TRANSFER Command State Model*

8.3.1 *TRANSFER Command State Model Requirements*

8.3.1.1 The TRANSFER command state model serves as the SEMI E30 Processing State Model. The purpose of the TRANSFER command state model is to provide information to the host regarding the control of the TRANSFER command. The TRANSFER command allows the host to manage carrier movement and scheduling. The control of each TRANSFER command must independently support the TRANSFER command state model.

8.3.2 *TRANSFER Command State Model Diagram*

8.3.2.1 The TRANSFER command state model is detailed for Stocker SEM equipment in Figure 4.

8.3.3 *TRANSFER Command State Definitions*

8.3.3.1 *QUEUED* — SC has acknowledged and queued the TRANSFER command. TRANSFER command has not been initiated.

8.3.3.2 *ACTIVE* — The carrier is involved in the physical aspect of the TRANSFER command. It is denoted by the time spanned by command initiation to command completion.

8.3.3.3 *TRANSFERRING (ACTIVE sub-state)* — The transfer command is actively being executed by the stocker.

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8.3.3.4 *PAUSED (ACTIVE sub-state)* — The Transfer command is not actively being executed by the stocker. This may be due to an internal equipment error that does not immediately terminate the Transfer command unsuccessfully. This would allow the Host or Operator the opportunity to retry the transfer.

8.3.3.5 *CANCELING* — The TRANSFER command cancel procedure is being performed to terminate a transfer command which never entered the ACTIVE state (currently QUEUED). This state is entered via a CANCEL remote command.

8.3.3.6 *ABORTING* — The TRANSFER command abort procedure is being performed to terminate a transfer command which has entered the ACTIVE state. This state can only be entered via an ABORT remote command. An unsuccessful transfer command completion will ultimately result from this state.

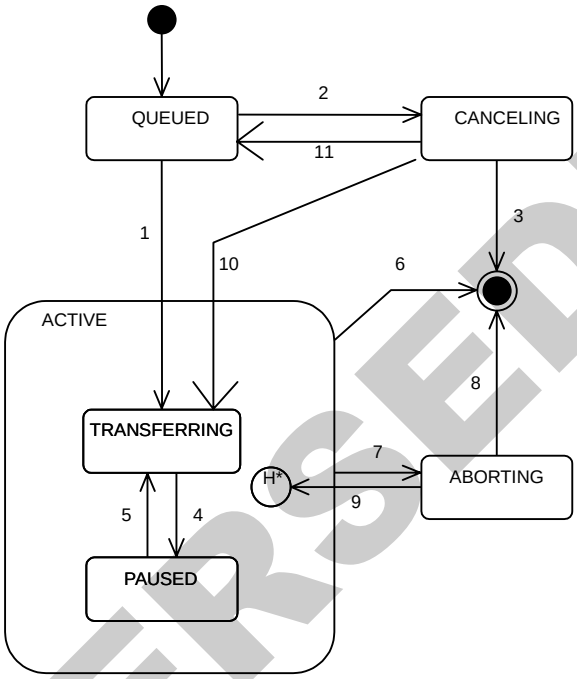

Figure 4
Generic Stocker SEM TRANSFER Command State Model Diagram

8.3.4 *TRANSFER Command State Transition Table*

Table 2 Transfer Command State Transition Table

Transition #	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	QUEUED	The TRANSFER command has been initiated by the SC.	TRANSFER-RING	S6F11 TransferInitiated	
2	QUEUED	Host sends CANCEL command for a specified TRANSFER command to SC.	CANCELING	S6F11 TransferCancel-Initiated	TRANSFER command is to be removed from the TRANSFER command queue.
3	CANCELING	The cancel procedure for the TRANSFER command has completed by the stocker and the SC.	None	S6F11 TransferCancel-Completed	The carrier will still be situated at the transfer source location. The carrier may now be included in a future transfer.

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Transition #	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
4	TRANSFER-RING	The SC pauses execution of the TRANSFER command due to an anomaly condition.	PAUSED	S6F11 TransferPaused for a specific CommandID	It is an important distinction to make that the TRANSFER command is paused and not just the transfer agent. The Stocker Controller state will be ALARM.
5	PAUSED	The SC resumes execution of the TRANSFER command since the anomaly condition has been cleared.	TRANSFER-RING	S6F11 TransferResumed for a specific CommandID	If this was the only remaining stocker alarm, the Stocker Controller state will transition to NO ALARMS.
6	ACTIVE	The TRANSFER command has completed by the stocker and SC (either successfully or unsuccessfully).	None	S6F11 TransferCompleted sent to Host with appropriate ResultCode ResultCode = 0 if successful ResultCode is nonzero if unsuccessful	Carrier(s) could be located at any location or port located along the path of the transfer, if the TRANSFER command completed unsuccessfully. **Supplier Option** — The location of the carrier(s) associated with an unsuccessful transfer command must be a legal SourcePort for a new TRANSFER command.
7	ACTIVE	Host sends ABORT command for a specified TRANSFER command to SC.	ABORTING	S6F11 TransferAbort-Initiated	
8	ABORTING	The abort procedure for the TRANSFER command has completed by the stocker and SC.	None	S6F11 TransferAbort-Completed	Carrier could be located at any location or port located along the path of the ACTIVE transfer. **Supplier Option** — The location of the carrier associated with the aborted transfer command must be a legal SourcePort for issuing a new TRANSFER command.
9	ABORTING	TRANSFER command cannot be aborted.	ACTIVE	S6F11 TransferAbort-Failed	TRANSFER command could not be aborted due to the physical state of the equipment. Such conditions must be documented by the Stocker SEM equipment Supplier.
10	CANCELING	Transport system is unable to cancel the TRANSFER command because the transfer is now ACTIVE.	TRANSFER-RING	S6F11 TransferInitiated	
11	CANCELING	Transport system is unable to cancel the TRANSFER command and it is still queued.	QUEUED	S6F11 TransferCancel-Failed	

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8.4 *Stocker Carrier State Model*

8.4.1 *Stocker Carrier State Model Requirements*

8.4.1.1 The purpose of the stocker carrier state model is to provide information to the host regarding carrier tracking (the Host will not control carriers) while the carrier is in the domain of the stocker. The carrier is in the domain of the stocker when it is in storage or transport internal to the stocker or on a stocker interface port (manual, interbay, or intrabay). The equipment shall track each carrier in compliance with the Stocker Carrier State Model.

8.4.2 *Stocker Carrier State Model*

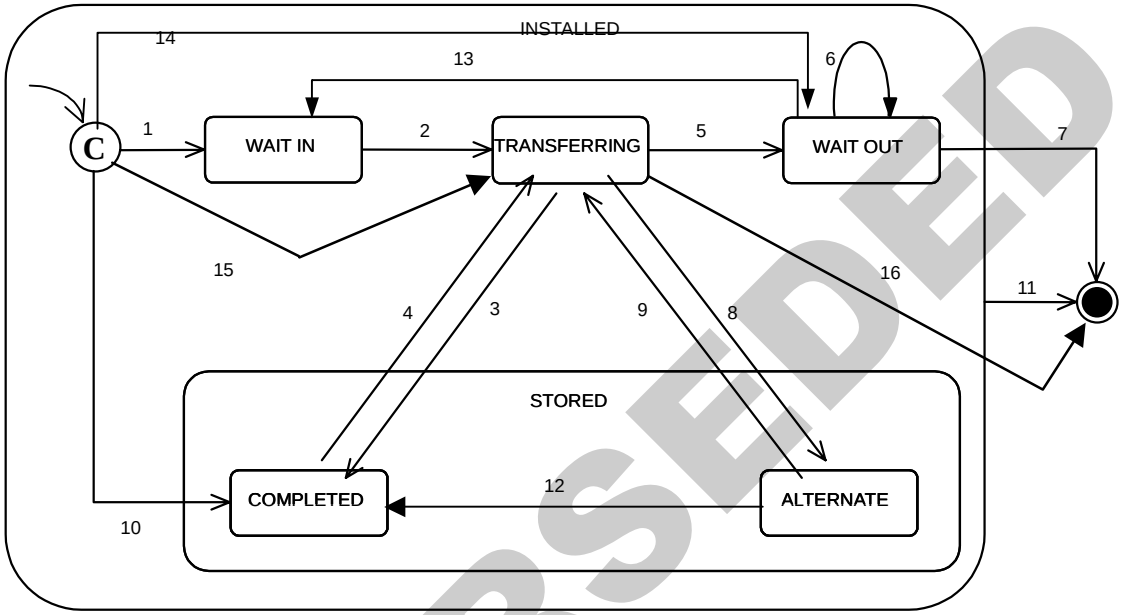

Figure 5
Generic Stocker SEM Carrier State Model Diagram

8.4.3 *Stocker Carrier State Definitions*

8.4.3.1 *INSTALLED* — Carrier in stocker database.

8.4.3.2 *WAIT IN (INSTALLED sub-state)* — Carrier at final internal port location of the stocker. Carrier is ready to be transferred to storage or output location and no further movement or action should be taken on this carrier prior to transfer.

8.4.3.3 *WAIT OUT (INSTALLED sub-state)* — Carrier is at an Output, Buffer, or Loading Port.

8.4.3.4 *TRANSFERRING (INSTALLED sub-state)* — Carrier moving between locations in the stocker.

8.4.3.5 *STORED (INSTALLED sub-state)* — Carrier is sitting at a storage location.

8.4.3.6 *COMPLETED (STORED sub-state)* — The carrier is stored at a shelf location as a result of completing a transfer for which this shelf represents the destination of the transfer command.

8.4.3.7 *ALTERNATE (STORED sub-state)* — The carrier is temporarily stored at a shelf location. The transfer command completion is pending until the destination and the crane become available.

8.4.4 *Stocker Carrier State Transition Table*

Table 3 Stocker Carrier State Transition Table

Transition #	*Previous State*	*Trigger*	*New State*	*Action*	*Comments*
1	none	Carrier is registered into stocker.	WAIT IN	S6F11 CarrierWaitIn	

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Transition #	*Previous State*	*Trigger*	*New State*	*Action*	*Comments*
2	WAIT IN	Stocker is executing a TRANSFER command for the carrier.	TRANSFERRING	S6F11 Carrier-Transferring	
3	TRANSFERRING	Completion of a TRANSFER command with a DEST of internal stocker storage.	COMPLETED	S6F11 CarrierStored	Carrier is at an internal storage destination.
4	COMPLETED	Stocker is executing a TRANSFER command for the carrier.	TRANSFERRING	S6F11 Carrier-Transferring	
5	TRANSFERRING	Carrier has arrived at the output port.	WAIT OUT	S6F11 CarrierWaitOut	
6	WAIT OUT	Carrier has advanced (automatically) on a port beyond the output port.	WAIT OUT	S6F11 CarrierWaitOut	
7	WAIT OUT	Carrier is removed from the stocker domain (removed from the output LP).	None	S6F11 CarrierRemoved	
8	TRANSFERRING	The destination of the move command is occupied.	ALTERNATE	S6F11 CarrierStoredAlt	SC is waiting for the Destination to become available.
9	ALTERNATE	The port becomes available and transfer command is first in queue.	TRANSFERRING	S6F11 CarrierResumed	Carrier continues with move to the Destination.
10	None	Carrier entry is created or modified in the SC database.	COMPLETED	S6F11 CarrierInstall-Completed	Could be due to an INSTALL remote command or initiated by the Stocker Controller.
11	INSTALLED	Carrier entry is removed from the SC database.	None	S6F11 CarrierRemove-Completed	Could be due to a REMOVE remote command.
12	ALTERNATE	Transfer command is Aborted.	COMPLETED	S6F11 CarrierStored	
13	WAIT OUT	Carrier on a bi-directional port is ready to be moved to a storage or output location.	WAIT IN	S6F11 CarrierWaitIn	Examples of a trigger could be the operator pressing a button or the host issuing a transfer command for the carrier.
14	None	The result of ID read at an output port that did not match the expected ID.	WAITOUT	S6F11 CarrierWaitOut	

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Transition #	*Previous State*	*Trigger*	*New State*	*Action*	*Comments*
15	None	1. Carrier created directly on the crane (as the result of duplicate ID recovery). 2. Transfer Command received from host with the source being a port with no SC controlled sensors (e.g.directly connected process equipment).	TRANSFERRING	S6F11 Carrier-Transferring	It is also permissible to use state transitions #1 and #2 for the scenario in trigger #2 especially when the transfer command is queued. This transition may not be required in all configurations.
16	TRANSFERRING	Carrier has arrived at an Output port and is removed from the stocker domain.	None	S6F11 CarrierRemoved	This generally occurs when delivering directly to process equipment at a port with no sensors controlled by the SC.

8.5 *Stocker Crane State Model*

8.5.1 *Stocker Crane State Model Requirements*

8.5.1.1 The purpose of the stocker crane state model is to provide information to the host for use of stocker crane information and metric tracking (i.e., the Host will not control the stocker crane). If it is possible for the stocker to continue operation while the stocker crane is not operational then the Stocker Crane State Model will retain its current state and the SC State Model will be ALARM. When the stocker crane becomes operational again, the state of the Stocker Crane State Model will transition to the new state. Whether it is possible to continue operation while the stocker crane is not operational is specific to the stocker SEM equipment supplier. If a single stocker contains multiple stocker cranes, each stocker crane must comply with the stocker crane state model. Compliance with the stocker crane state model is only required for devices that contain a crane. The Host should not be dependent on any events from the stocker crane state model.

8.5.2 *Stocker Crane State Model*

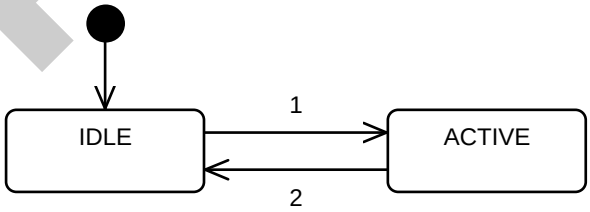

Figure 6
Generic Stocker SEM Stocker Crane State Model Diagram

8.5.3 *Stocker Crane State Definitions*

8.5.3.1 *IDLE* — The stocker crane is not performing Host or SC initiated work.

8.5.3.2 *ACTIVE* — The stocker crane is busy performing Host or SC initiated work.

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8.5.4 *Stocker Crane State Transition Table*

Table 4 Stocker Crane State Transition Table

Transition #	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	IDLE	Crane is requested to perform host or SC initiated work.	ACTIVE	S6F11 CraneActive	
2	ACTIVE	Crane completes host or SC initiated work.	IDLE	S6F11 CraneIdle	

8.6 *Port Transfer State Model*

8.6.1 *Port Transfer State Model Requirements*

8.6.1.1 The purpose of the port state model is to provided information to the host for the use in accessing ports. This may permit the host and stocker to utilize ports that are in service while avoiding the use of ports that are not in service.

8.6.2 *Port Transfer State Model*

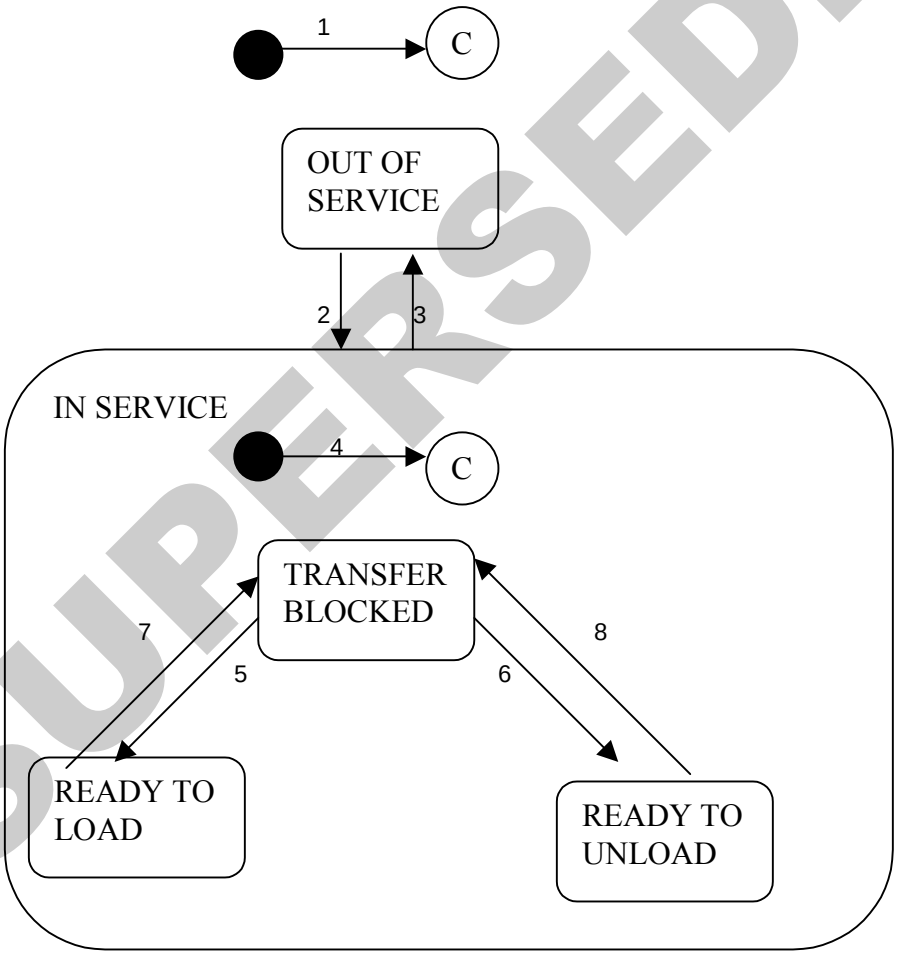

Figure 7
Port State Model Diagram

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8.6.3 *Port Transfer State Definitions*

8.6.3.1 OUT OF SERVICE — Transfer to/from this port is disabled and the port should not be used in any Transfer command issued by the host. If the SC State is "Alarm" and the port cannot be accessed normally, the port transfer state shall be "Out Of Service". This includes situations where the "Alarm" may not be directly related to the port. For example, the alarm may be associated with the crane and since the crane cannot function, the port cannot be serviced normally. If any port on a multi-position conveyor with a single LP position is "Out Of Service", then all ports on the conveyor shall be "Out Of Service". If a command is issued by the host which uses this port, it will not be rejected simply because the port is in this state.

8.6.3.2 IN SERVICE — Transfer to/from this port is enabled.

8.6.3.3 The following are **optional** sub-states of the IN SERVICE state to provide information to the host for the use in accessing ports. The information is generally obtained by the SC via a low-level interface with the connected equipment (generally inline process tools). The connected equipment should generally, though not required, follow the Load Port Transfer State Model defined in SEMI E87. If these states are implemented, they are **not required** for every port.

8.6.3.3.1 *TRANSFER BLOCKED* — The state is neither READY TO LOAD nor READY TO UNLOAD.

8.6.3.3.2 *READY TO LOAD* — The port is able to accept (be loaded with) a carrier from the Stocker SEM equipment.

8.6.3.3.3 *READY TO UNLOAD* — The port is able to have a carrier removed (unloaded) by the Stocker SEM equipment.

8.6.3.4 *Port Transfer State Transition Table*

Table 5 Port Transfer State Transition Table

Transition #	*Previous State*	*Trigger*	*New State*	*Action*	*Comments*
1	None	System reset.	OUT OF SERVICE Or IN SERVICE	S6F11 PortOutOfService Or S6F11 PortInService	The new state is based on the current status of the port or the state prior to system reset.
2	OUT OF SERVICE	The equipment has determined that the port can be utilized for transfers.	IN SERVICE	S6F11 PortInService	
3	IN SERVICE	The equipment has determined that the port should not be used for transfers.	OUT OF SERVICE	S6F11 PortOutOfService	This could be the result of an alarm condition that affects only the port, the entire device, or a portion of the device which includes the port.
4	None	System Reset.	TRANSFER BLOCKED READY TO LOAD READY TO UNLOAD	S6F11 PortTransferBlocked S6F11 PortReadyToLoad S6F11 PortReadyToUnload	The new state is based on the current status of the port.
5	TRANSFER BLOCKED	Port ready for carrier delivery.	READY TO LOAD	S6F11 PortReadyToLoad	
6	TRANSFER BLOCKED	Port ready for carrier removal.	READY TO UNLOAD	S6F11 PortReadyToUnload	
7	READY TO LOAD	No carrier transfer allowed.	TRANSFER BLOCKED	S6F11 PortTransferBlocked	
8	READY TO UNLOAD	No carrier transfer allowed.	TRANSFER BLOCKED	S6F11 PortTransferBlocked	

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9 Collection Event List

9.1 This section identifies data collection events and defines (Stream 6) reporting levels for variable data items. The host can use the report definition scenario defined in SEMI E30 to define reports at Stocker SEM defined levels. The intent of this section is to demonstrate that certain suggested data is available at specific events. The collection events are grouped according to whether or not they are associated with a state change (according to the state models defined within this document).

9.2 *Requirements*

9.2.1 This standard requires all collection events listed in the SEMI E30 standard (according to the GEM capabilities required per Section 14). There are cases where specific collection event names are designated for GEM defined collection events. Such collection event names are denoted by "Y" in the GEM column.

9.3 *State Transition Collection Event Table*

Table 6 State Transition Collection Event Table

Collection Event Name	*From State*	*To State*	*Required DVVALs*	*GEM*
SC STATE TRANSITION EVENTS				
AlarmCleared	ALARMS	NO ALARMS	CommandID ErrorID StockerUnitInfo ErrorNumber	Y
AlarmSet	NO ALARMS ALARMS	ALARMS ALARMS	CommandID ErrorID StockerUnitInfo RecoveryOptions ErrorNumber	Y
SCAutoCompleted	PAUSED PAUSING	AUTO AUTO	N/A	N
SCAutoInitiated	None	SC INIT	N/A	N
SCPauseCompleted	PAUSING	PAUSED	N/A	N
SCPaused	SC INIT	PAUSED	N/A	N
SCPauseInitiated	AUTO	PAUSING	N/A	N
TransferAbortCompleted	ABORTING	None	CommandID CarrierID CarrierLoc CarrierZoneName	N
TRANSFER COMMAND STATE TRANSITION EVENTS				
TransferAbortFailed	ABORTING	ACTIVE	CommandID CarrierID CarrierLoc CarrierZoneName	N
TransferAbortInitiated	ACTIVE	ABORTING	CommandID CarrierID CarrierLoc CarrierZoneName	N
TransferCancelCompleted	CANCELING	None	CommandID CarrierID CarrierLoc CarrierZoneName	N

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Collection Event Name	*From State*	*To State*	*Required DVVALs*	*GEM*
TransferCancelFailed	CANCELING	QUEUED	CommandID CarrierID CarrierLoc CarrierZoneName	N
TransferCancelInitiated	QUEUED	CANCELING	CommandID CarrierID CarrierLoc CarrierZoneName	N
TransferCompleted	ACTIVE	None This event will occur when the carrier arrives at the transfer completed port. The TRANSFER command DEST is an LP if transferring to an output of the stocker.	CommandID CarrierID CarrierLoc ResultCode CarrierZoneName	N
TransferInitiated	QUEUED CANCELING	TRANSFERRING TRANSFERRING	CommandID CarrierID CarrierLoc CarrierZoneName Dest	N
TransferPaused	TRANSFERRING	PAUSED	CommandID CarrierID CarrierLoc CarrierZoneName	N
TransferResumed	PAUSED	TRANSFERRING	CommandID CarrierID CarrierLoc CarrierZoneName	N
STOCKER CARRIER STATE TRANSITION EVENTS				
CarrierInstallCompleted	None	COMPLETED	CarrierID CarrierLoc CarrierZoneName	N
CarrierRemoveCompleted	INSTALLED	None	CarrierID CarrierLoc CarrierZoneName	N
CarrierRemoved	WAIT OUT TRANSFERRING	None None	CarrierID HandoffType	N
CarrierResumed	ALTERNATE	TRANSFERRING	CommandID CarrierID CarrierLoc CarrierZoneName Dest StockerCraneID	N
CarrierStored	TRANSFERRING	COMPLETED	CarrierID CarrierLoc CarrierZoneName	N

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Collection Event Name	*From State*	*To State*	*Required DVVALs*	*GEM*
CarrierStoredAlt	TRANSFERRING	ALTERNATE	CommandID CarrierID CarrierLoc CarrierZoneName Dest	N
CarrierTransferring	WAIT IN COMPLETED None	TRANSFERRING TRANSFERRING TRANSFERRING	CarrierID CarrierLoc CarrierZoneName StockerCraneID	N
CarrierWaitIn	None	WAIT IN	CarrierID CarrierLoc CarrierZoneName	N
CarrierWaitOut	TRANSFERRING WAIT OUT None	WAIT OUT WAIT OUT WAIT OUT	CarrierID CarrierLoc CarrierZoneName PortType	N
ZoneCapacityChange	Any State or None	Any State or None	ZoneData	N
STOCKER CRANE STATE TRANSITION EVENTS				
CraneActive	IDLE	ACTIVE	CommandID StockerCraneID	N
CraneIdle	ACTIVE	IDLE	CommandID StockerCraneID	N
PORT TRANSFER STATE TRANSITION EVENTS				
PortInService	None OUT OF SERVICE	IN SERVICE	PortID	
PortOutOfService	None IN SERVICE	OUT OF SERVICE	PortID	
PortTransferBlocked	Any	TRANSFER BLOCKED	PortID	
PortReadyToLoad	Any	READY TO LOAD	PortID	
PortReadyToUnload	Any	READY TO UNLOAD	PortID	

9.4 *Non-Transition Collection Event Table*

Table 7 Non-Transition Collection Event Table

Collection Event Name	*Event Description*	*Required DVVALs or Reports*
CarrierIDRead	A carrier identification has been performed by the stocker system. For reads that occur at an Input port, the event shall come prior to the CarrierWaitIn event. For reads that occur at CarrierWaitOut port locations, the CarrierIDRead event and the CarrierWaitOut events for that port shall be sent to the host in a consistent sequence (i.e. CarrierIDRead shall always precede the CarrierWaitOut, or alternatively, the CarrierWaitOut event shall always precede the CarrierIDRead event). There are not dependencies with this event at any other location.	CarrierID CarrierLoc IDReadStatus
CarrierInstallFailed	An INSTALL command has failed.	CarrierID FailureCode
CarrierLocateCompleted	A LOCATE remote command has completed.	CarrierLocations CommandID
CarrierRemoveFailed	A REMOVE command has failed.	CarrierID FailureCode

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Collection Event Name	*Event Description*	*Required DVVALs or Reports*
IDReadError	All carriers related to an ID error situation have been dispositioned. This event occurs automatically when the stocker places the carrier that experienced the ID error to the pickup port (See Section 13.3.3).	CarrierID CarrierLoc IDReadStatus
OperatorInitiatedAction	The operator initiated an action from the Stocker Controller.	CommandID CommandType CarrierID Source Dest Priority

10 Variable Data Items

10.1 The purpose of this section is to define the list of variable data item requirements for Stocker SEM equipment. Values of these variables will be available to the host via collection event reports and host status queries.

10.2 *Requirements*

- All variable data items and data item restrictions defined in SEMI E30 are required on Stocker SEM equipment (according to the GEM capabilities required per Section 13).
- All variable data items in the Stocker SEM Variable Data Item Dictionary for specific equipment classifications are required for Stocker SEM equipment. The data item restrictions are also required.
- Some SVs in the Variable Data Item Dictionary are referenced by an "i" subscript (e.g., $CarrierID_i$). The "i" subscript denotes a specific instance of the SV. This is necessary since there is usually more than one instance of such an SV active in the system at the same time (e.g., if there are 20 carriers active at the same time then "i" could range from 1 to 20 for $CarrierID_i$). Variable Data Items containing the "i" subscript should not have Variable IDs assigned to them.
- All variable data items with a format of ASCII (A) shall be limited to printable characters in the decimal range of 32 to 126, with the exception of the following non-permitted characters: "*" (decimal 42), "\"(decimal 92).

10.2.1 Variable data items are documented in the Stocker SEM Variable Data Item Dictionary using the following format:

Variable Name	*Type*	*Description*	*Class*	*Format*	*Comments*

Where:

Variable Name: A unique name for the variable data item.

Type: CV – meaning common variables, variables that are general to all vehicles.

CSV – meaning configuration specific variables.

Description: If class is DVVAL, then the description shall contain a statement of when data is valid in terms of Stocker SEM events.

Class: The data type of the item.

Format: <SECS Message Language (SML) mnemonic>acceptable formats are SEMI E5 lists, ASCII, floating point, unsigned integer or signed integer. A description of "ANY", indicates that only the above formats are acceptable and is left to the supplier to decide.

Comments: Any additional information pertinent to the variable name.

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