SEMI E82-0301
SPECIFICATION FOR INTERBAY/INTRABAY AMHS SEM (IBSEM)

This standard was technically approved by the Global Information & Control Committee and is the direct responsibility of the North American Information & Control Committee. Current edition approved by the Japanese Regional Standards Committee on December 1, 2000. Initially available at www.semi.org February 2001; to be published March 2001. Originally published September 1999.

This document replaces SEMI E30.4 in its entirety.

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1 Purpose

1.1 This standard establishes a Specific Equipment Model (SEM) for interbay and intrabay AMHS transport equipment (IBSEM). 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 IBSEM equipment into an automated (e.g., semiconductor fabrication and flat panel display) factory. This document accomplishes this by defining an operational model for IBSEM 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, data reports, and reporting levels). Several topics require additional activity that are within the scope of this standard: traffic management characteristics (queuing), parallel interface for carrier transfer (SEMI E23), transport system controller architecture, and delivery of the transfer unit.

2 Scope

2.1 The scope of this standard is limited to the usage and description of interbay and intrabay AMHS transport equipment (OHT, OHS, RGT, AGT, DWC) 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 transport system 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 IBSEM equipment. It expands the GEM standard requirements and capabilities in the areas of state models (TSC, transfer command, vehicle and carrier state models), collection events, alarm documentation, remote commands, data item variables, and material movement.

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

3 Limitations

3.1 *Evaluation of SEMI E32 (MMM)*

3.1.1 The concepts defined in SEMI E32 were analyzed and included where applicable to the IBSEM, but the GEM model was used as the basis for IBSEM requirements definition.

3.2 *Interbay and Intrabay AMHS Transport Equipment Types*

3.2.1 This standard is targeted at the different types of 300 mm and interbay and intrabay AMHS transport equipment. The term *IBSEM equipment* refers to all types of transport equipment. The equipment types have fundamental mechanical differences:

3.2.1.1 *Overhead Hoist Transport (OHT)* — An overhead rail guided transport system positioned for vertical access to SEMI E15.1 compliant ports.

3.2.1.2 *Over Head Shuttle (OHS)* — An overhead rail guided transport system (monorail) positioned for access to stocker automated interbay input and output ports. The OHS vehicle may or may not contain a transfer agent.

3.2.1.3 *Rail Guided Transport (RGT)* — A ground-based rail guided transport system positioned for access to SEMI E15.1 compliant ports.

3.2.1.4 *Automated Guided Transport (AGT)* — A ground-based transport system with automated guidance (i.e., no rail guidance). Automated guidance system allows vehicles to access SEMI E15.1 compliant ports.

3.2.1.5 *Direct WIP Conveyer (DWC)* — An overhead transport system, based on direct WIP roller conveyers. No vehicles are used for point to point delivery. The conveyers are positioned for vertical access to SEMI E15.1 ports.

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3.2.2 Transport vehicles may contain zero or more internal buffers for carrier transport. If mechanically feasible, the transport system may acquire or deposit carriers simultaneously. If transported in a safe manner, carrier transport may occur while occupying the acquire/deposit transfer port(s) of the transport vehicle (e.g., a single position hoist vehicle). In the context of this standard, a "vehicle" on a DWC is defined as a single carrier in the transport system.

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

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

SEMI E32 — Material Movement Management (MMM)

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

4.2 *Other References*

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

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *AGT* — Automated Guided Transport

5.1.2 *AMHS* — Automated Material Handling System

5.1.3 *DWC* — Direct WIP Conveyor

5.1.4 *FOUP* — Front Opening Unified Pod

5.1.5 *GEM* — Generic Equipment Model

5.1.6 *ITS* — Interbay or Intrabay Transport System

5.1.7 *OHS* — Over Head Shuttle

5.1.8 *OHT* — Overhead Hoist Transport

5.1.9 *PGV* — Person Guided Vehicle

5.1.10 *RGT* — Rail Guided Transport

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

5.1.12 *TSC* — Transport System Controller

5.2 *Definitions*

5.2.1 *active vehicle* — a vehicle in the transport system that contains a robot or other transfer agent for providing the acquiring (loading) and depositing (unloading) actions.

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

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

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

5.2.5 *host* — the factory computer system, or an intermediate system, that represents the factory and the user to the equipment. Refers to the system that controls or supervises the Transport System Controller (TSC) throughout this document.

5.2.6 *internal buffer* — locations within the equipment to store carriers. These locations exclude load ports.

5.2.7 *load port* — the interface location on the equipment where carriers are delivered.

5.2.8 *open cassette* — an open structure that holds one or more wafers.

5.2.9 *passive vehicle* — a vehicle in the transport system that does not contain a robot or other transfer agent for providing the acquiring (loading) and depositing (unloading) actions. The vehicle simply contains a position(s) to carry the transfer unit. The loading and unloading action must be accomplished at the load or unload port by a different system (e.g., stocker port robot).

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

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

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

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

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5.2.13 *transfer unit* — the element of movement (assemblage of carriers) of the ITS that consists of a maximum num-ber 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.
- The maximum size of the transfer unit is the minimum of AA, BB, and CC.

5.2.14 *Transport System* — a transport system dedicated to one or more bays in the factory and responsible for transferring carriers to production equipment, from production equipment, from production equipment to production equipment or from stocker to stocker. TS consists of the physical units of the system (e.g., vehicles, nodes, docking stations), the low-level unit controllers, and a system-level controller. TS 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 TS.

5.2.15 *Transport System Controller* — interbay or intrabay Transport System Controller that communicates with the Factory Host and represents the system as the equipment.

5.2.16 *Transport System Equipment* — an individual transport system viewed as a single piece of equipment, with distributed components and distributed control. The TS 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 transport system.

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

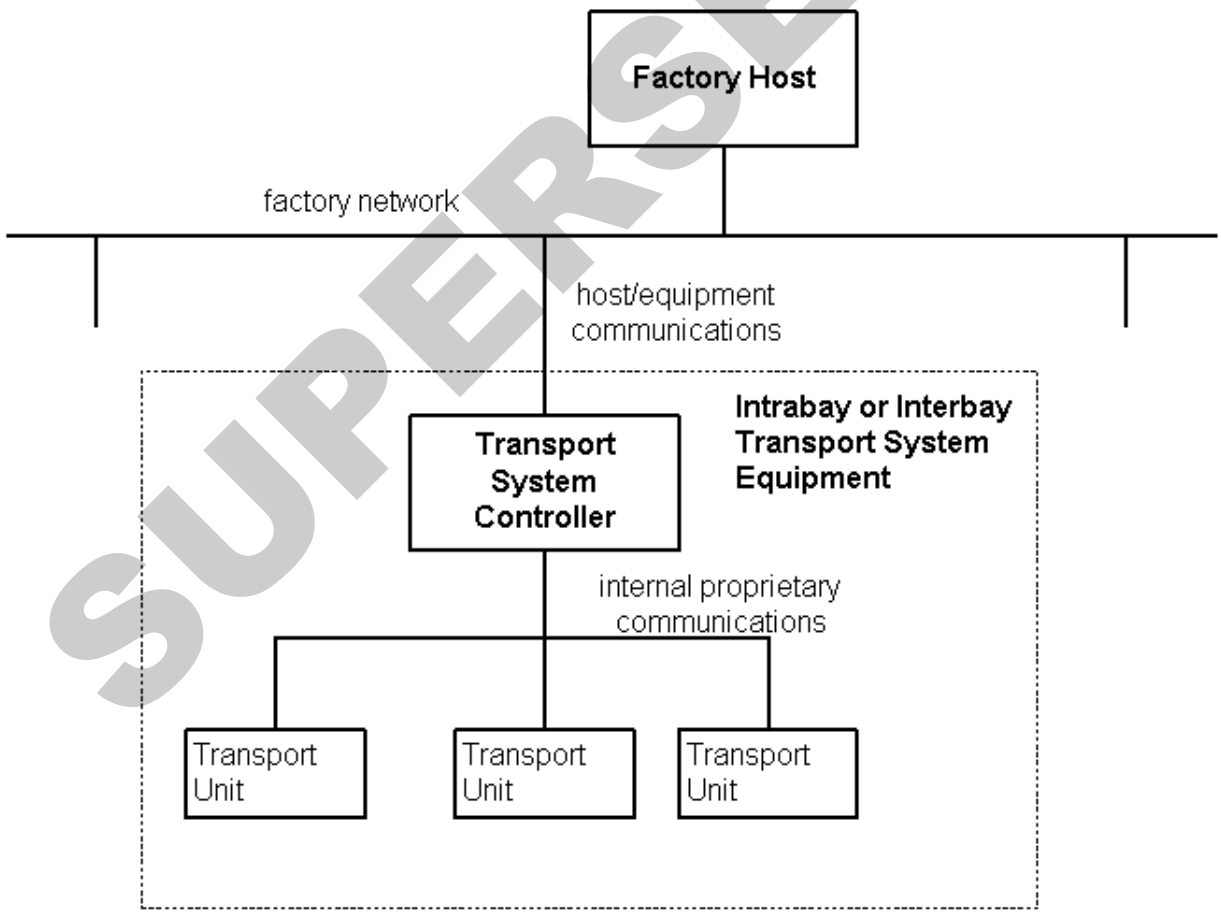

Figure 1
Example of Transport System Equipment

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6 Communication Requirements

6.1 It is required that any IBSEM compliant equipment follow the Communications State Model in SEMI E30. In addition, IBSEM compliant equipment shall support either the High-speed SECS Message Services Single-Session Mode (SEMI E37 and SEMI E37.1, HSMS and HSMS-SS) communication standard or SEMI Equipment Communications Standard 1 Message Transfer (SEMI E4, SECS-I) communication standard.

7 State Models

7.1 *State Model Requirements*

7.1.1 The state models included in this standard are a requirement for IBSEM 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.

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

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

7.2 *TSC State Model*

7.2.1 *TSC State Model Requirements*

7.2.1.1 The purpose of the Transport System state model is to provide information to the host regarding the overall status of the Transport System. The TSC state model is valid when the SEMI E30 (GEM) state is ON-LINE. The TSC state model is **not** valid when the SEMI E30 (GEM) state is OFF-LINE. Since a transport system may consist of many components (e.g., vehicle, robot arm, ID reader, etc.), it may be possible to continue ON-LINE operation when the operation mode of some transport components (as viewed by the TSC) is a manual state. The details of what happens when individual components of the transport system enter a manual state are specific to the IBSEM equipment supplier. When the SEMI E30 Control state changes from OFF-LINE to ON-LINE, the TSC State Model is started from the TSC INIT state.

7.2.2 *TSC State Model*

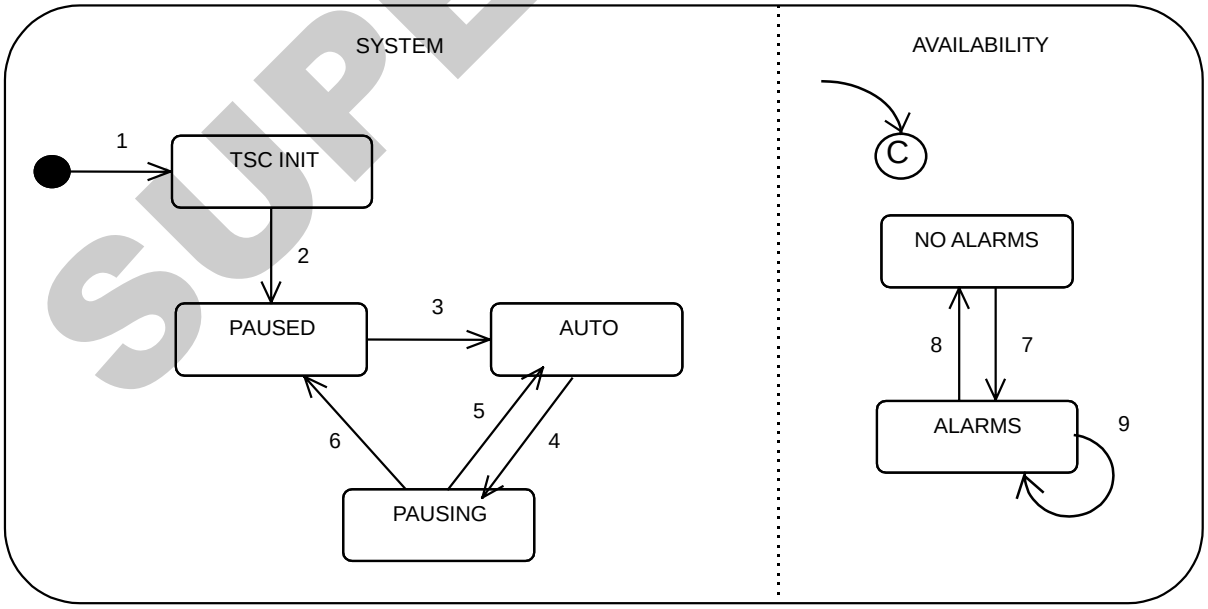

Figure 2
Generic IBSEM TSC State Model Diagram

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7.2.3 *TSC State Definitions*

7.2.3.1 *TSC INIT* — TSC initialization of TS components is occurring. This is a non-operational state. No commands from the host will be processed or queued. The system will not move out of this state if there are vehicles actively loading or unloading carriers at ports. These vehicles must be manually or automatically recovered before moving on to the next state.

7.2.3.2 *PAUSING* — A system PAUSE command has been received and is being processed. All vehicles that are currently loading or unloading will continue until the load/unload is complete. Vehicles that are currently moving may continue to move but they must not begin a load or unload. TRANSFER commands are accepted and queued. All status requests will be processed. The RESUME command will also be processed.

7.2.3.3 *PAUSED* — No vehicles are in the process of loading or unloading a carrier at a port, but vehicles may still be moving. TRANSFER commands are accepted and queued. All status requests will be processed. The RESUME command will also be processed.

7.2.3.4 *AUTO* — System is in the normal operational state. Commands are actively processed.

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

7.2.3.6 *ALARMS* — There are one or more alarms present in the system, but the TSC is still capable of normal processing since several components may remain unaffected by the alarm situation.

7.2.4 *TSC State Transition Table*

Table 1 TSC State Transition Table

Transition #	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	None	TSC Initiation	TSC INIT	S6F11 TSCAutoInitiated	System runs through its startup sequence.
2	TSC INIT	System started up successfully. All loads and unloads are complete.	PAUSED	S6F11 TSCPaused	System ready
3	PAUSED	TSC is resumed.	AUTO	S6F11 TSCAutoCompleted	System will now perform all commands.
4	AUTO	TSC is requested to pause.	PAUSING	S6F11 TSCPauseInitiated	Vehicles that are stopped stay stopped. Vehicles that are moving stop at the next logical point without proceeding.
5	PAUSING	TSC is resumed.	AUTO	S6F11 TSCAutoCompleted	System will now perform all commands.
6	PAUSING	All carrier loads and unloads are completed. No new acquires or deposits will occur. Outstanding acquires and deposits will complete.	PAUSED	S6F11 TSCPauseCompleted	System will accept and queue new commands but will not execute them.
7	NO ALARMS	Alarm Set	ALARMS	S6F11 AlarmSet	System can process normally for transport components that are unaffected by the alarm.
8	ALARMS	Last remaining alarm cleared.	NO ALARMS	S6F11 AlarmCleared	
9	ALARMS	Alarm Set	ALARMS	S6F11 AlarmSet	Alarm occurs when there is already an outstanding alarm.

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7.3 *TRANSFER Command State Model*

7.3.1 *TRANSFER Command State Model Requirements*

7.3.1.1 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 interbay or intrabay delivery and scheduling. The control of each TRANSFER command must independently support the TRANSFER command state model.

7.3.2 *TRANSFER Command State Model Diagram*

7.3.2.1 The TRANSFER command state model is detailed for IBSEM equipment in Figure 3.

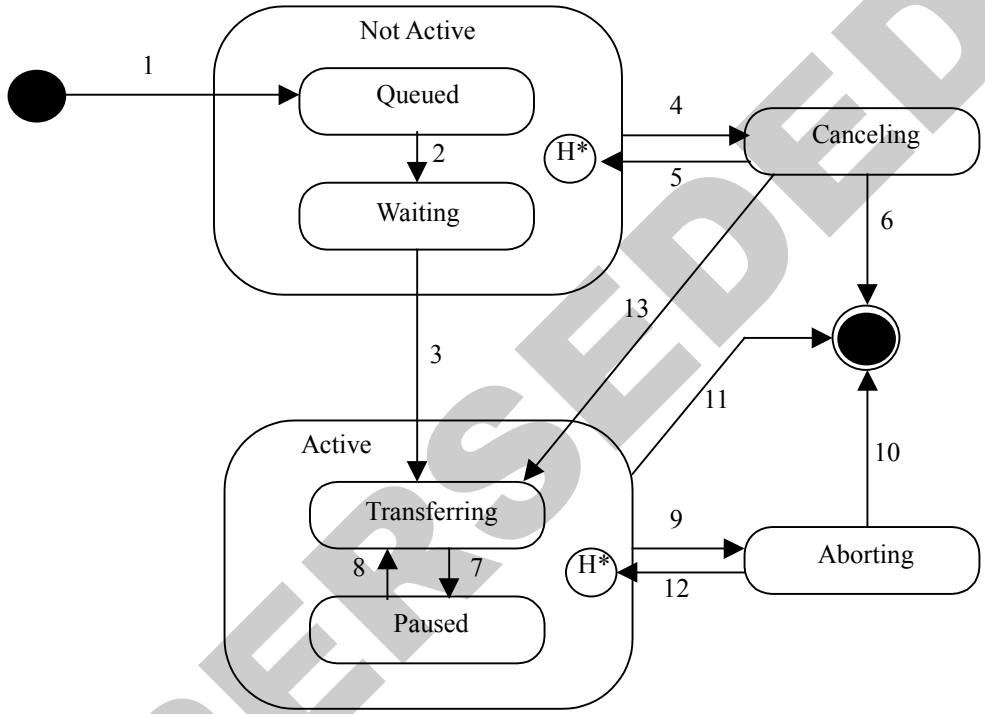

Figure 3
Generic IBSEM TRANSFER Command State Model Diagram

7.3.3 *TRANSFER Command State Definitions*

7.3.3.1 *NOT ACTIVE* — The transfer unit is not involved in the physical aspect of the TRANSFER command. It is denoted by the time spanned by the queuing of the TRANSFER command to the moment just prior to the acquire of the first carrier in the transfer unit.

7.3.3.2 *QUEUED (NOT ACTIVE sub-state)* — TSC has acknowledged and queued the TRANSFER command. TRANSFER command has not been initiated.

7.3.3.3 *WAITING (NOT ACTIVE sub-state)* — TRANSFER command has been initiated. A vehicle is on its way to the source location to acquire the transfer unit.

7.3.3.4 *ACTIVE* — The transfer unit is involved in the physical aspect of the TRANSFER command. It is denoted by the time spanned by the acquire of the first carrier in the transfer unit to the deposit of the last carrier in the transfer unit.

7.3.3.5 *TRANSFERRING (ACTIVE sub-state)* — The transfer command is actively being executed by the transport equipment.

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7.3.3.6 *PAUSED (ACTIVE sub-state)* — The transfer command is not actively being executed by the transport equipment.

7.3.3.7 *CANCELING* — The TRANSFER command cancel procedure is being performed to terminate a transfer command which never entered the ACTIVE state (either QUEUED or WAITING). This state is entered via a CANCEL remote command. An unsuccessful transfer command completion will ultimately result.

7.3.3.8 *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.

7.3.4 *TRANSFER Command State Transition Table*

Table 2 Transfer Command State Transition Table

Tran-sition #	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	None	The Host generated TRANSFER command is successfully acknowledged by the TSC.	QUEUED		
2	QUEUED	The TRANSFER command has been initiated by the TSC.	WAITING	S6F11 Transfer-Initiated	Transport vehicle is dispatched to acquire the transfer unit.
3	WAITING	The acquire of the first carrier of the transfer unit begins.	TRANSFERRING	S6F11 Transferring	
4	NOT ACTIVE	Host issued cancel for the TRANSFER command is accepted by the TSC.	CANCELING	S6F11 TransferCancel-Initiated	A CANCEL remote command was issued to terminate a TRANSFER command that has not entered the physical aspect of the command.
5	CANCELING	Transport system is unable to cancel the TRANSFER command.	Previous NOT ACTIVE sub-state	S6F11 TransferCancel-Failed	The ability of the equipment to successfully complete a cancel of the TRANSFER command is specific to the IBSEM equipment supplier.
6	CANCELING	The cancel procedure for the TRANSFER command has completed by the transport system and TSC.	None	S6F11 TransferCancel-Completed	The transfer unit will still be situated at the transfer source location. The carriers in the transfer unit may now be included in a future transfer (either AMHS or PGV based).
7	TRANSFERRING	The TSC pauses execution of the TRANSFER command due to an anomaly condition.	PAUSED	S6F11 TransferPaused	It is an important distinction to make that the TRANSFER command is paused even though the vehicle may not be.
8	PAUSED	The TSC resumes execution of the TRANSFER command since the anomaly condition has been cleared.	TRANSFERRING	S6F11 Transfer-Resumed	
9	ACTIVE	Host initiates an abort	ABORTING	S6F11	An ABORT remote

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Tran-sition #	Previous State	Trigger	New State	Actions	Comments
		of a TRANSFER command.		TransferAbort-Initiated	command was issued to terminate a TRANSFER command.
10	ABORTING	The abort procedure for the TRANSFER command has completed by the transport system and TSC.	None	S6F11 TransferAbort-Completed	Transfer unit could be located at any location or port located along the path of the ACTIVE transfer. The location of the carrier(s) associated with the aborted transfer command must be legal SourcePort(s) for issuing a new TRANSFER command.
11	ACTIVE	The TRANSFER command has completed by the transport system and TSC (either successfully or unsuccessfully).	None	S6F11 TransferCompleted sent to Host with appropriate ResultCode ResultCode = 0 if successful ResultCode Not = 0 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. The location of the carrier(s) associated with an unsuccessful transfer command must be legal SourcePort(s) for a new TRANSFER command.
12	ABORTING	Transport system is physically unable to abort the TRANSFER command.	Previous ACTIVE sub-state	S6F11 TransferAbort-Failed	The ability of the equipment to successfully complete an ABORT of the TRANSFER command is specific to the IBSEM equipment supplier.
13	CANCELING	Transport system is unable to cancel the TRANSFER command because the transfer is now ACTIVE.	TRANSFERRING	S6F11 Transferring	The ability of the equipment to successfully complete a cancel of the TRANSFER command is specific to the IBSEM equipment supplier.

7.4 *Vehicle State Model*

7.4.1 *Vehicle State Model Requirements*

7.4.1.1 The purpose of the vehicle state model is to provide information to the host for use of transport vehicle information and metric tracking (i.e., the Host will not control vehicles). Each vehicle must individually comply with the vehicle state model. Implementation of this state model is not a requirement for Transport Systems which do not have vehicles. An example of such a Transport System is a DWC. The Host should not be dependent on any events from the vehicle state model.

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7.4.2 *Vehicle State Model*

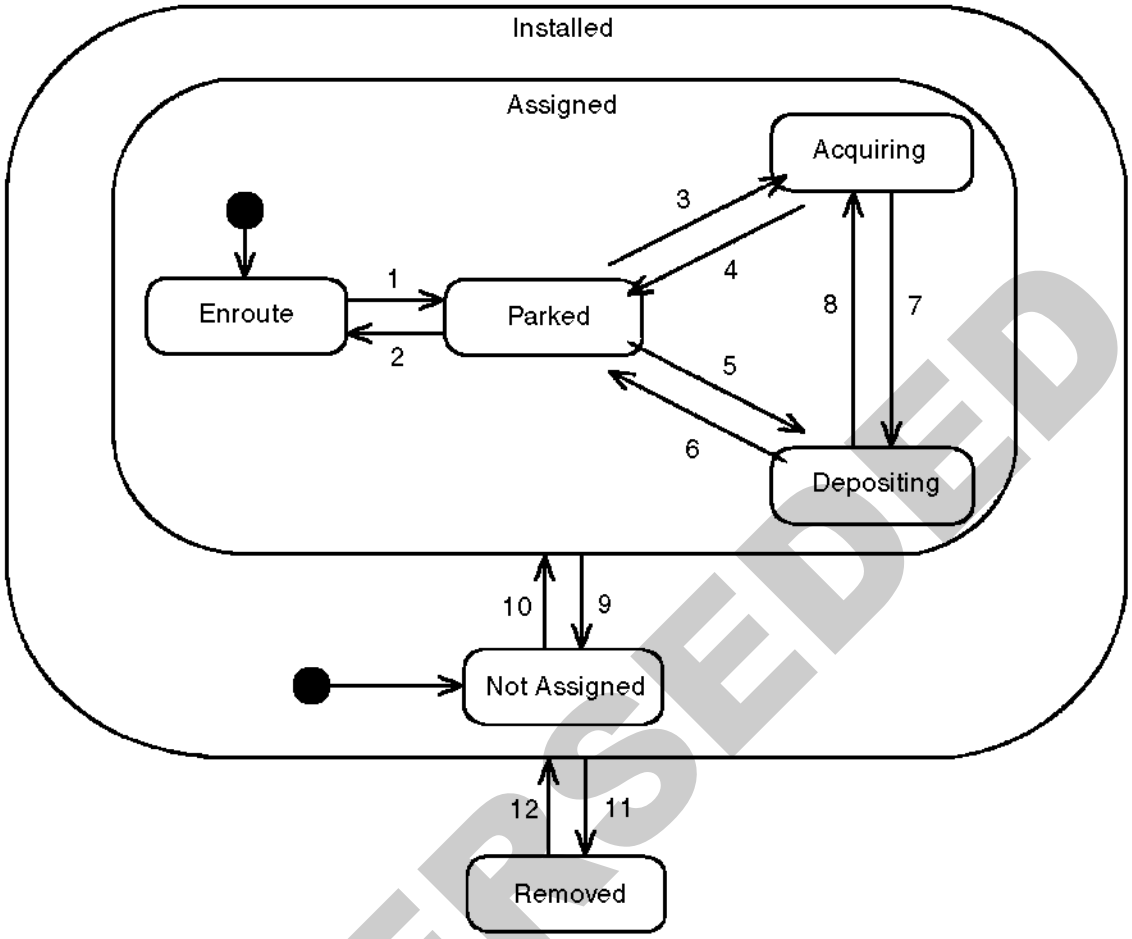

Figure 4
Generic IBSEM Vehicle State Model Diagram

7.4.3 *Vehicle State Definitions*

7.4.3.1 *INSTALLED* — The vehicle is available or being used for TRANSFER commands. All enabled collection events and alarms will be sent to the Host for vehicles in this state.

7.4.3.2 *REMOVED* — The vehicle is not available for Host initiated TRANSFER commands. No collection events or alarms will be sent to the Host for vehicles in this state.

7.4.3.3 *ASSIGNED (INSTALLED sub-state)* — Vehicle is allocated to a TRANSFER command.

7.4.3.4 *NOT ASSIGNED (INSTALLED sub-state)* — Vehicle is not allocated to a TRANSFER command.

7.4.3.5 *ENROUTE (ASSIGNED sub-state)* — The vehicle is on its way to a transfer port. This is the default entry into the ASSIGNED state since it must be entered for the host to track vehicle metrics completely and adequately.

7.4.3.6 *PARKED (ASSIGNED sub-state)* — This state occurs when the vehicle is in the following conditions:

- After the arrival of the vehicle is completed and before the action of the transfer agent is started.
- After the action of the transfer agent has completed and before the departure of the vehicle.
- After continuous actions of the transfer agent (e.g., acquire/acquire and deposit/deposit) are completed.

7.4.3.7 *ACQUIRING (ASSIGNED sub-state)* — The vehicle is currently involved in carrier acquire (one or more carriers possible depending on vehicle limitations).

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7.4.3.8 *DEPOSITING (ASSIGNED sub-state)* — The vehicle is currently involved in carrier deposit (one or more carriers possible depending on vehicle limitations).

7.4.4 *Vehicle State Transition Table*

Table 3 Vehicle State Transition Table

Transition #	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
1	ENROUTE	Vehicle arrives at a transfer port associated with an ACTIVE transfer command.	PARKED	S6F11 VehicleArrived	
2	PARKED	Vehicle departs a transfer port associated with an ACTIVE transfer command.	ENROUTE	S6F11 VehicleDeparted	
3	PARKED	The carrier handoff parallel I/O starts for the vehicle to acquire (load) the transfer unit.	ACQUIRING	S6F11 VehicleAcquire-Started	If the vehicle is a passive type then the acquire occurs by the robot on the other equipment loading the transfer unit to the vehicle.
4	ACQUIRING	The carrier handoff parallel I/O completes for the vehicle to acquire (unload) the transfer unit.	PARKED	S6F11 VehicleAcquire-Completed	
5	PARKED	The carrier handoff parallel I/O starts for the vehicle to deposit (unload) the transfer unit.	DEPOSITING	S6F11 VehicleDeposit-Started	If the vehicle is a passive type then the deposit occurs by the robot on the other equipment unloading the transfer unit from the vehicle.
6	DEPOSITING	The carrier handoff parallel I/O completes for the vehicle to deposit (unload) the transfer unit.	PARKED	S6F11 VehicleDeposit-Completed	
7	ACQUIRING	The carrier handoff parallel I/O completes for the vehicle to acquire (load) the transfer unit and starts for the vehicle to deposit (unload) the carrier.	DEPOSITING	S6F11 VehicleDeposit-Started	Carrier Replace See scenario for an example.
8	DEPOSITING	The carrier handoff parallel I/O completes for the vehicle to deposit (unload) the transfer unit and starts for the vehicle to acquire (load) the carrier.	ACQUIRING	S6F11 VehicleAcquire-Started	Carrier Replace See scenario for an example.
9	ASSIGNED	Vehicle has completed the TRANSFER command.	NOT ASSIGNED	S6F11 Vehicle-Unassigned	
10	NOT ASSIGNED	Vehicle is allocated to a TRANSFER command.	ASSIGNED	S6F11 VehicleAssigned	
11	INSTALLED	Vehicle is removed from use of transfer commands.	REMOVED	S6F11 VehicleRemoved	
12	REMOVED	Vehicle is installed for use of transfer commands.	INSTALLED	S6F11 VehicleInstalled	

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7.5 *IBSEM Carrier State Model*

7.5.1 *IBSEM Carrier State Model Requirements*

7.5.1.1 The purpose of the carrier state model is to provide information to the host regarding carrier tracking (the Host will not control carriers). Each carrier must comply with the carrier state model.

7.5.2 *IBSEM Carrier State Model*

Figure 5
Generic IBSEM Carrier State Model Diagram

7.5.3 *Carrier State Definitions*

7.5.3.1 *INSTALLED* — A TSC database entry exists for the carrier.

7.5.4 *Carrier State Transition Table*

Table 4 Carrier State Transition Table

Transition #	*Previous State*	*Trigger*	*New State*	*Actions*	*Comments*
1	None	A TSC database entry is created for the carrier.	INSTALLED	S6F11 CarrierInstalled	
2	INSTALLED	A TSC database entry is removed for the carrier.	None	S6F11 CarrierRemoved	

8 Collection Event List

8.1 This section identifies data collection events and defines (Stream 6) suggested associated variable data items. The host can use the report definition scenario defined in SEMI E30 to define reports at IBSEM defined levels. The intent of this section is to demonstrate that certain suggested data is available at specific events.

8.2 *Requirements*

8.2.1 This standard requires all collection events listed in the SEMI E30 standard (according to the GEM capabilities required per Section 13).

8.3 *Collection Event Table*

Table 5 Collection Event Table (State Transition Based)

Collection Event Name	*From State*	*To State*	*Suggested DVVAL's or Reports*
TSC STATE TRANSITION EVENTS			
AlarmCleared	ALARMS	NO ALARMS	CommandID VehicleInfo
AlarmSet	NO ALARMS ALARMS	ALARMS ALARMS	CommandID VehicleInfo
TSCAutoCompleted	PAUSED PAUSING	AUTO AUTO	N/A
TSCAutoInitiated	None	TSC INIT	N/A
TSCPauseCompleted	PAUSING	PAUSED	N/A
TSCPaused	TSC INIT	PAUSED	N/A
TSCPauseInitiated	AUTO	PAUSING	N/A

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Collection Event Name	*From State*	*To State*	*Suggested DVVAL's or Reports*
TRANSFER COMMAND STATE TRANSITION EVENTS			
TransferAbortCompleted	ABORTING	None	CommandID L,n 1.<L,2> 1. <TransferInfo$_1$> 2. <CarrierLoc$_1$ (*1)> . . n, <L,2> 1. <TransferInfo$_n$> 2. <CarrierLoc$_n$ (*1)>
TransferAbortFailed	ABORTING	ACTIVE (History)	CommandID
TransferAbortInitiated	ACTIVE	ABORTING	CommandID
TransferCancelCompleted	CANCELING	None	CommandID
TransferCancelFailed	CANCELING	NOT ACTIVE (History)	CommandID
TransferCancelInitiated	NOT ACTIVE	CANCELING	CommandID
TransferCompleted	ACTIVE	None	CommandInfo ResultCode L,n 1.<L,2> 1. <TransferInfo$_1$> 2. <CarrierLoc$_1$ (*1)> . . n, <L,2> 1. <TransferInfo$_n$> 2. <CarrierLoc$_n$ (*1)>
TransferInitiated	QUEUED	WAITING	CommandID
TransferPaused	TRANSFERRING	PAUSED	CommandID
TransferResumed	PAUSED	TRANSFERRING	CommandID
Transferring	WAITING CANCELING	TRANSFERRING TRANSFERRING	CommandID
VEHICLE STATE TRANSITION EVENTS			
VehicleArrived	ENROUTE	PARKED	VehicleID TransferPortList
VehicleAcquireStarted	PARKED DEPOSITING	ACQUIRED ACQUIRED	VehicleID TransferPort CarrierID
VehicleAcquireCompleted	ACQUIRING	PARKED	VehicleID TransferPort CarrierID
VehicleAssigned	NOT ASSIGNED	ASSIGNED	VehicleID CommandID
VehicleDeparted	PARKED	ENROUTE	VehicleID TransferPortList
VehicleDepositStarted	PARKED ACQUIRING	DEPOSITING DEPOSITING	VehicleID TransferPort CarrierID

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Collection Event Name	*From State*	*To State*	*Suggested DVVAL's or Reports*
VehicleDepositCompleted	DEPOSITING	PARKED	VehicleID TransferPort CarrierID
VehicleInstalled	REMOVED	INSTALLED	VehicleID
VehicleRemoved	INSTALLED	REMOVED	VehicleID
VehicleUnassigned	ASSIGNED	NOT ASSIGNED	VehicleID CommandID
CARRIER STATE TRANSITION EVENTS			
CarrierInstalled	None	INSTALLED	VehicleID CarrierID CarrierLoc CommandID
CarrierRemoved	INSTALLED	None	VehicleID CarrierID CarrierLoc CommandID

8.4 *Non-Transition Collection Event Table*

Table 5a Non-Transition Collection Event Table

Collection Event Name	*Event Description*	*Required DVVALs*
OperatorInitiatedAction	The operator initiated an action from the Stocker Controller. The related State Transition Events defined in Table 5 shall be required after this "OperatorInitiatedAction" event.	CommandID CommandType CarrierID SourcePort DestPort Priority

9 Variable Data Items

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

9.2 *Requirements*

- All variable data items defined in GEM and data item restrictions defined in SEMI E30 are required on IBSEM equipment (according to the GEM capabilities required per Section 13).
- All variable data items in the IBSEM Variable Data Item Dictionary for specific equipment classifications are required for IBSEM equipment. The data item restrictions are also required.
- Some SV's 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 ID's assigned to them.

9.2.1 Variable data items are documented in the IBSEM Variable Data Item Dictionary using the following format:

Variable Name	*Type*	*Description*	*Class*	*Format*	*Comment*

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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 IBSEM 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.

9.3 *Variable Data Item Types*

9.3.1 *Equipment Constants (ECV)* — The value can be changed by the host using S2F15. The operator may have the ability to change some or all of the values. The value of an equipment constant may be queried at any time by the host using the S2F13/14 transaction or Stream 6 reports.

9.3.2 *Status Variables (SV)* — The values are valid at all times. A SV may not be changed by the host or operator, but may be changed by the equipment. A host or operator command may change an equipment status thus changing a SV. The value of status variables may be queried by the host at any time using the S1F3/4 or Stream 6 reports.

9.3.3 *Data Variables (DVVAL)* — These are variables which are valid upon the occurrence of a specific collection event, and may or may not be valid at other times depending upon the equipment. An attempt to read a variable data item when it's invalid will not result in an error, but the data reported may not have relevant meaning.

9.3.4 *Variable Data (V)* — This is a class of variable data which includes all the previously defined types of variables.

9.4 *Variable Data Item Dictionary*

Table 6 Variable Data Item Dictionary

Variable Name	*Type*	*Description*	*Class*	*Format*	*Comment*
ActiveCarriers	CV	List current status of all carrier information in the TSC database.	SV	L,n 1. <CarrierInfo$_1$> . . n. <CarrierInfo$_n$>	
ActiveTransfers	CV	List current status of all ACTIVE TRANSFER commands.	SV	L,n 1. <TransferCommand$_1$> . . n. <TransferCommand$_n$>	
ActiveVehicles	CV	List current status of all vehicles available or being used for TRANSFER commands.	SV	L,n 1. <VehicleInfo$_1$> . . n. <VehicleInfo$_n$>	
CarrierID	CV	ID of the carrier being moved.	DVVAL	A[1–64]	
CarrierID$_i$	CV	ID of the ith carrier.	SV	A[1–64]	

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Variable Name	*Type*	*Description*	*Class*	*Format*	*Comment*
CarrierInfo	CV	All database information associated with a particular carrier generating an event.	DVVAL	L,3 1. <CarrierID> 2. <VehicleID> 3. <CarrierLoc>	
$CarrierInfo_i$	CV	All database information associated with the ith carrier.	SV	L,3 1. $<CarrierID_i>$ 2. $<VehicleID_i>$ 3. $<CarrierLoc_i>$	
CarrierLoc	CSV	Unique location of the carrier within ITS as reported by the TSC.	DVVAL	A[1–64]	
$CarrierLoc_i$	CSV	Unique Location of the ith carrier within ITS as reported by the TSC.	SV	A[1–64]	
CommandName	CV	Host command issued to controller.	DVVAL	A[1–20]	
CommandID	CV	Remote Command ID Command ID generated by TSC.	DVVAL	A[1–64]	Used to subsequently refer to a specified remote command (e.g., to cancel a remote command). If a command is generated by the Transport System Controller using Non-Transition Collection Event "OperatorInitiatedAction", the commandId must begin with the string 'MANUAL' followed by any arbitrary sequence identifier.
$CommandID_i$	CV	The ith Remote Command ID. The ith Command ID generated by TSC.	SV	A[1–64]	Used to subsequently refer to a specified remote command (e.g., to cancel a remote command).
CommandInfo	CV	Command information associated with a particular transfer command.	DVVAL	L,3 1. <CommandID> 2. <Priority> 3. <Replace>	
$CommandInfo_i$	CV	Command information associated with the ith transfer command.	SV	L,3 1. $<CommandID_i>$ 2. $<Priority_i>$ 3. $<Replace_i>$	
CommandType	CV	The type of Command being initiated	DVVAL	A[1-20]	Valid Values are 'TRANSFER' 'CANCEL' 'ABORT'
DestPort	CV	Destination port unique identifier	DVVAL	A[1–64]	Must be the name of the port not the corresponding transport system node name or number.
$DestPort_i$	CV	The ith Destination port unique identifier	SV	A[1–64]	Must be the name of the port not the corresponding transport system node name or number.

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