ID Error	*Error Description*	*Input Port Action*	*Intrabay Output Port Action**
Mismatch	The carrier ID read results in an ID that does not match any entries in the SC database. Example - Carrier 456 requested to ID reader but CarrierIDRead result is 123, but there is no SC database entry for a carrier with CarrierID 123.		1. CarrierWaitOut event for 456. 2. CarrierIDRead 123 event sent. 3. TransferComplete for 456 with mismatch error. 4. SC automatically deletes carrier 456 from SC database and send CarrierRemoveCompleted event. 5. SC automatically creates carrier 123 at the port and sends CarrierWaitOut event 6. Carrier continues to LP of this output port. (CarrierWaitOut for 123 at each position.) 7. IDReadError event sent when carrier arrives at the LP of this output port. Note: Optionally step 3 may come after step 4 or 5.

13.2.3.2 The following scenario represents a carrier ID *failure* at the stocker *input port* with *option 1* implemented.

STEP	COMMENTS	HOST	SC	COMMENTS
1.	The SC assigns an unknown CarrierID based on the failure. An example of such an unknown CarrierID would be "UNKNOWNSTK001" Note: IDReadStatus = 1 means that a Carrier ID Read failure occurred.		←S6,F11	Event Report Send (ERS) CarrierIDRead · CarrierID = "UNKNOWNSTK001" · PortID · IDReadStatus = 1
2.	Event Report Acknowledge (ERA)	S6,F12→		
3.			←S6,F11	Event Report Send (ERS) CarrierWaitIn · CarrierID = "UNKNOWNSTK001" · CarrierLoc = SOURCE · CarrierZoneName
4.	Event Report Acknowledge (ERA)	S6,F12→		
5.			←S6,F11	Event Report Send (ERS) ZoneCapacityChange
6.	Event Report Acknowledge (ERA)	S6,F12→		
7.	No TRANSFER command issued by Host since recovery is automatic.			
8.			←S6,F11	Event Report Send (ERS) CarrierTransferring · CarrierID = "UNKNOWNSTK001" · CarrierLoc · CarrierZoneName
9.	Event Report Acknowledge (ERA)	S6,F12→		
			←S6,F11	Event Report Send (ERS) ZoneCapacityChange
	Event Report Acknowledge (ERA)	S6,F12→		
10.			←S6,F11	Event Report Send (ERS) CraneActive
11.	Event Report Acknowledge (ERA)	S6,F12→		

STEP	COMMENTS	HOST	SC	COMMENTS
12.			←S6,F11	Event Report Send (ERS) CraneIdle
13.	Event Report Acknowledge (ERA)	S6,F12→		
14.			←S6,F11	Event Report Send (ERS) CarrierWaitOut · CarrierID = "UNKNOWNSTK001" · CarrierLoc = "LP1" · PortType = "LP" · CarrierZoneName
15.	Event Report Acknowledge (ERA)	S6,F12→		
			←S6,F11	Event Report Send (ERS) ZoneCapacityChange
	Event Report Acknowledge (ERA)	S6,F12→		
16.			←S6,F11	Event Report Send (ERS) IDReadError · CarrierID = "UNKNOWNSTK001" · CarrierLoc · IDReadStatus = 1
17.	Event Report Acknowledge (ERA)	S6,F12→		
18.	Carrier leaves the domain of the stocker as it is acquired by a person(PGV)		←S6,F11	Event Report Send (ERS) CarrierRemoved · CarrierID · HandoffType = MANUAL
19.	Event Report Acknowledge (ERA)	S6,F12→		
20.			←S6,F11	Event Report Send (ERS) ZoneCapacityChange
21.	Event Report Acknowledge (ERA)	S6,F12→		

13.2.4 *Host Initiated CANCEL of a TRANSFER Command*

13.2.4.1 The Host wishes to cancel a previously issued transfer command. The assumption is that the carrier is currently sitting on a stocker shelf and has not been picked up by the stocker crane.

STEP	COMMENTS	HOST	SC	COMMENTS
1.	Assumption is that a TRANSFER command(CommandID = 111111) is in the QUEUED state.			
2.	Host Command Send (HCS) CANCEL · CARRIERID = "111111"	S2,F41→		
3.			←S2,F42	Host Command Acknowledge (HCA)
4.			←S6,F11	Event Report Send (ERS) TransferCancelInitiated · CommandID = "111111" · CarrierID = "123456" · CarrierLoc = "STORAGE" · CarrierZoneName
5.	Event Report Acknowledge (ERA)	S6,F12→		
6.			←S6,F11	Event Report Send (ERS) TransferCancelCompleted · CommandID = "111111" · CarrierID = "123456" · CarrierLoc = "STORAGE" · CarrierZoneName
7.	Event Report Acknowledge (ERA)	S6,F12→		
8.	Event Report Acknowledge (ERA)	S6,F12→		

13.2.5 *Host Initiated ABORT of a TRANSFER Command*

13.2.5.1 The Host wishes to abort a previously issued transfer command. The assumption is that the carrier is currently in the ALTERNATE substate of STORED.

STEP	COMMENTS	HOST	SC	COMMENTS
1.	Assumption is that a TRANSFER command (CommandID = 111111) is in the ACTIVE state.			
2.	Host Command Send (HCS) ABORT · COMMANDID = "111111"	S2,F41→		
3.			←S2,F42	Host Command Acknowledge (HCA)
4.				The stocker must abort the transfer command if the carrier was in the ALTERNATE sub-state. Other INSTALL stocker carrier states may cause ABORT command rejection. The latter scenario is supplier specific.
5.			←S6,F11	Event Report Send (ERS) TransferAbortInitiated · CommandID = "111111" · CarrierID = "123456" · CarrierLoc = "STOCKER CRANE" · CarrierZoneName
6.	Event Report Acknowledge (ERA)	S6,F12→		
7.			←S6,F11	Event Report Send (ERS) TransferAbortCompleted · CommandID = "111111" · CarrierID = "123456" · CarrierLoc = "STOCKER CRANE" · CarrierZoneName
8.	Event Report Acknowledge (ERA)	S6,F12→		
9.	Event Report Acknowledge (ERA)	S6,F12→		
10.	Two options may be available for recovery: 1. Manual Recovery 2. Host Initiated Recovery The host would have to issue a TRANSFER command to dispose of the carrier on the stocker crane end-effector for the crane to be utilized for future transfers. This is a Supplier Option			

13.2.6 *Connection or Reconnection between SC and Host*

13.2.6.1 The Host System crashes (or loses communication with the SC for a time exceeding all time-outs and retries) and must re-synchronize with the SC with the possibility of several events completing while the communication link was lost.

STEP	COMMENTS	HOST	SC	COMMENTS
1.	Communication session between host and SC (re)established. Host establishes communication with the SC per the GEM standard scenario (e.g., S1F13, etc).			

STEP	COMMENTS	HOST	SC	COMMENTS
2.	Host Command Send (HCS) PAUSE	S2,F41→		
3.			←S2,F42	Host Command Acknowledge (HCA)
4.			←S6,F11	Event Report Send (ERS) SCPauseInitiated
5.	Event Report Acknowledge (ERA)	S6,F12→		
6.			←S6,F11	Event Report Send (ERS) SCPauseCompleted
7.		S6,F12→		
8.	Selected Equipment Status Request (SSR) ActiveCarriers ActiveZones ActiveTransfers	S1,F3→		HOST asks for carrier, zone and transfer command information
9.			←S1,F4	Selected Equipment Status Data (SSD) · ActiveCarriers . . (one CarrierInfo for each carrier) . · ActiveZones . . (one ZoneData for each zone) . · ActiveTransfers . . (one TransferCommand for each . Active TRANSFER command)
10.	The HOST updates its model of the system with the information from the status data.			
11.	Host Command Send (HCS) RESUME	S2,F41→		HOST enables the system to continue operations.
12.			←S2,F42	Host Command Acknowledge (HCA)
13.			←S6,F11	Event Report Send (ERS) SCAutoInitiated
14.	Event Report Acknowledge (ERA)	S6,F12→		
15.			←S6,F11	Event Report Send (ERS) SCAutoCompleted
16.	Event Report Acknowledge (ERA)	S6,F12→		
17.				System continues processing all commands that were in process or queued before/during the Host crash or communication loss/initialization. System will also now process new commands.

14 GEM Capabilities

14.1 The purpose of this section is to specify any SEMI E30 additional capabilities that are required to be supported by this class of equipment.

14.2 *Requirement*

14.2.1 This standard requires that the SEMI E30 fundamental requirements and additional capabilities have been implemented on the Stocker SEM equipment with the exception of Trace Data Collection, Process Program Management, Remote Control, Limits Monitoring and Spooling. If these capabilities are implemented, they will be implemented as required by the SEMI E30 document. The Stocker SEM Transfer Command State Model serves as the SEMI E30 Processing State Model. The SEMI E30 additional capabilities required by Stocker SEM are:

- Establish Communications,

- Dynamic Event Report Configuration,
- Variable Data Collection,
- Status Data Collection,
- Alarm Management,
- Equipment Constants,
- Equipment Terminal Services,
- Clock, and
- Control (host-initiated).

RELATED INFORMATION 1
STOCKER SEM UNIQUE CAPABILITIES

NOTICE: This related information is not an official part of SEMI E88, but was approved for publication by full letter ballot procedures.

R1-1 *Transfer Command Message Example (SML Format)*

R1-1.1 Variable data values specified in the following example TRANSFER command have been chosen arbitrarily for the purpose of demonstrating message structure/content.

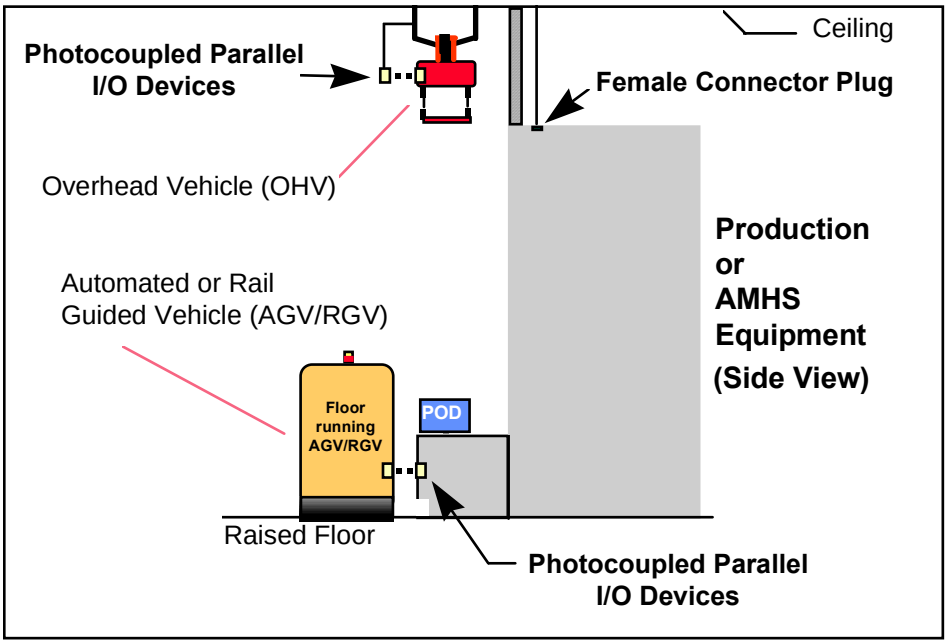
```
S2,F49
<L [4]
       <U2    0>                                          /* DATAID */
       <A[0]  "">                                         /* OBJSPEC */
       <A[8]  "TRANSFER">                                 /* RCMD */
       <L [2]
              <L [2]
                     <A[11] "COMMANDINFO">                /* CPNAME1 */
                     <L[2]
                            <L[2]
                                   <A[9]  "COMMANDID"> /* CPNAME */
                                   <A[6]  "111111">           /* CPVAL */
                            >
                            <L[2]
                                   <A[8]  "PRIORITY">         /* CPNAME */
                                   <U2    5>                  /* CPVAL */
                            >
                     >
              >
              <L [2]
                     <A[12] "TRANSFERINFO">               /* CPNAME2 */
                     <L[3]
                            <L[2]
                                   <A[9]  "CARRIERID">        /* CPNAME */
                                   <A[6]  "123456">           /* CPVAL */
                            >
                            <L[2]
                                   <A[6]  "SOURCE">           /* CPNAME */
                                   <A[0]  "">                 /* CPVAL */
                            >
                            <L[2]
                                   <A[4]  "DEST">             /* CPNAME */
                                   <A[5]  "SHELF">            /* CPVAL */
                            >
                     >
```

>

>

>

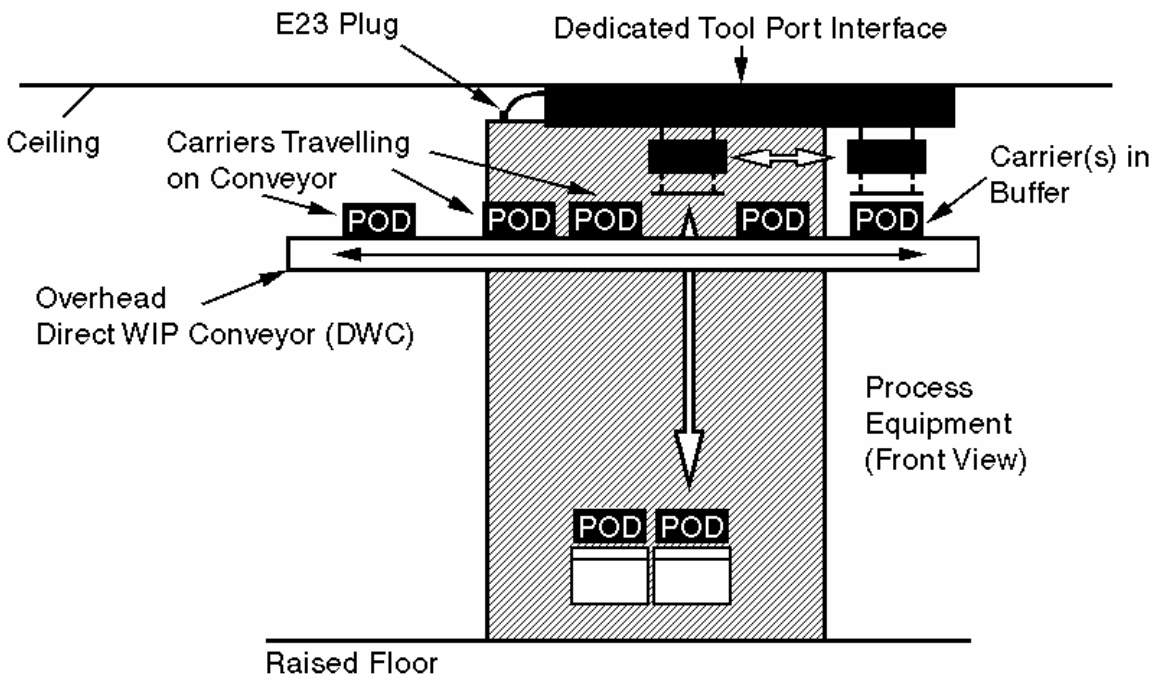
R1-2 *Parallel Interface for Carrier Handoff*



A-1.1.1.2 Figure R1-1

A-1.1.1.3 Carrier Handoff Example Diagram for OHV/AGV/RGV

A-1.1.1.4



A-1.1.1.5

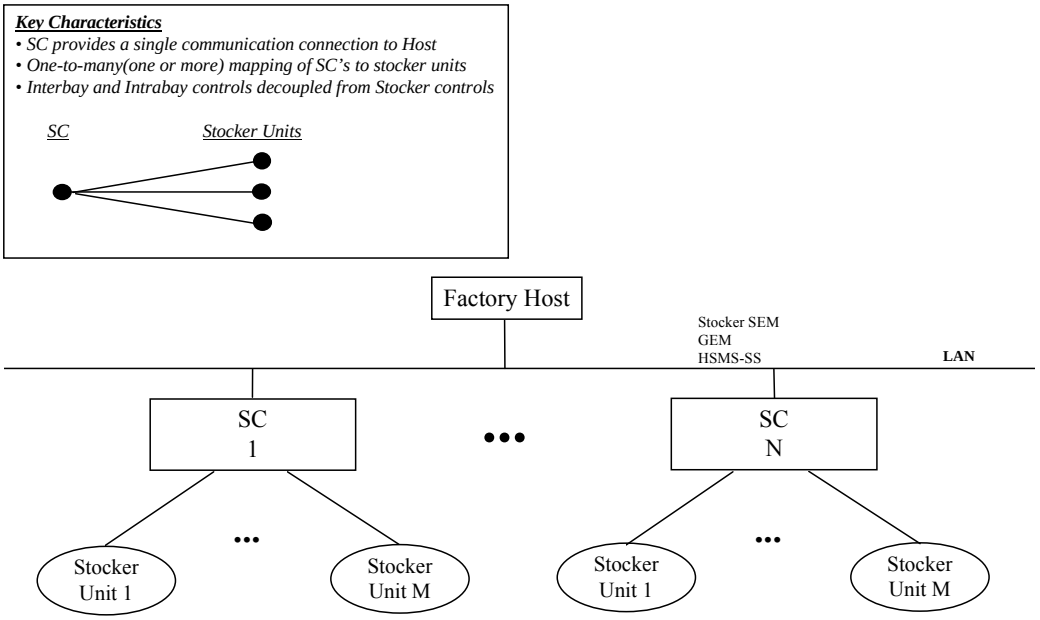
A-1.1.1.6 Figure R1-2

A-1.1.1.7 Carrier Handoff Example Diagram for DWC

A-1.1.1.8

A-1.1.1.9

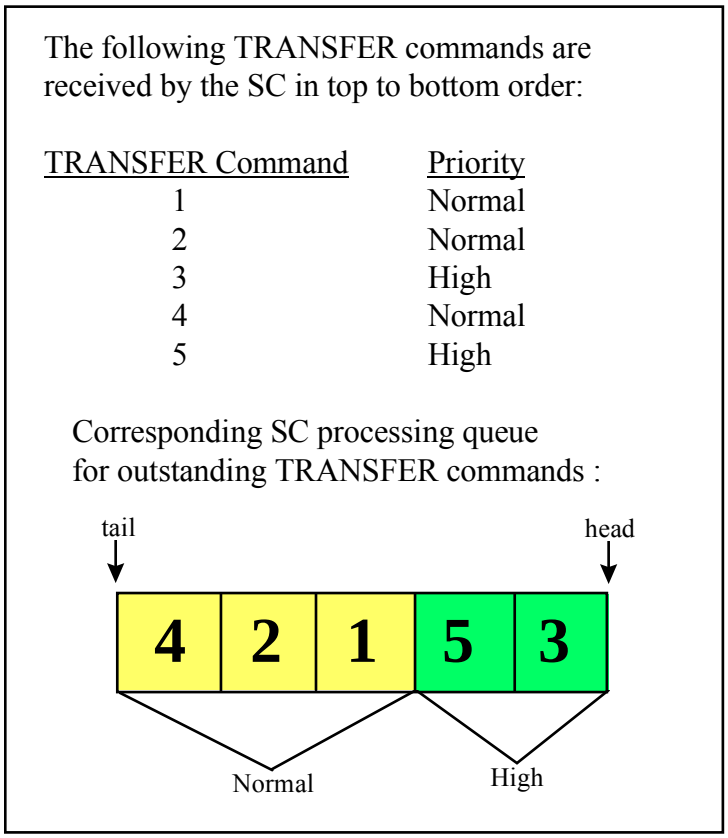
R1-3 *Hardware Architecture*



A-1.1.1.10 Figure R1-3
A-1.1.1.11 SC Architecture (Logical View)
A-1.1.1.12

R1-4 *Stocker Command Scheduling Characteristics*

R1-4.1 At a minimum, the SC must offer Priority-based First-In-First-Out (FIFO) queuing of TRANSFER commands. In other words, all TRANSFER commands which have yet to be processed by the SC must be serviced in the order in which they are received by the SC based on the priority given in the host command. The minimum priority levels required to be available on Stocker SEM equipment are "Normal" and "High" (refer to Figure R1-4 for an example). "Normal" and "High" priorities will be denoted by U2 compatible numbers as per the definition of the priority in the Variable Data and Remote Command sections of this document. Other options may be implemented, but to be a Stocker SEM equipment it must at a minimum have the ability to be configured to perform Priority-based FIFO queuing of TRANSFER commands. Additionally, the command priorities are to be utilized during execution of the commands to the following level: any "High" priority command will cause all other commands that are not "High" priority to be usurped. That is to say that all other commands will modify the execution steps to allow the "High" priority commands to be completed in the minimal elapsed time possible. Multiple "High" priority commands will act upon each other according to the same rules as "Normal" commands act on each other.



A-1.1.1.13 Figure R1-4
A-1.1.1.14 SC Priority-Based FIFO TRANSFER Command Processing Example
A-1.1.1.15

R1-4.2 The SC must manage the resources so that TRANSFER requests are queued for later service if all resources are currently utilized.

RELATED INFORMATION 2
REQUIREMENTS FOR COMPLIANCE

NOTICE: This related information is not an official part of SEMI E88, but was approved for publication by full letter ballot procedures.

Table R2-1 provides a checklist for Stocker SEM compliance.

R2-1 *Stocker SEM Compliance Statement*

Table R2-1 Stocker SEM Compliance Statement

Fundamental Stocker SEM Requirements	*Implemented*	*Stocker SEM Compliant*
SC State Model	□ Yes □ No	□ Yes □ No
Transfer Command State Model	□ Yes □ No	□ Yes □ No
Stocker Crane State Model *(optional, see section 8.5)*	□ Yes □ No	□ Yes □ No
Stocker Carrier State Model	□ Yes □ No	□ Yes □ No
Collection Event List	□ Yes □ No	□ Yes □ No
Collection Event Data Availability	□ Yes □ No	□ Yes □ No
Variable Data Items	□ Yes □ No	□ Yes □ No
Variable Data Availability	□ Yes □ No	□ Yes □ No
Alarm List	□ Yes □ No	□ Yes □ No
Remote Command List	□ Yes □ No	□ Yes □ No
Remote Command Parameters	□ Yes □ No	□ Yes □ No
Remote Command Mapping	□ Yes □ No	□ Yes □ No
Transfer Command Format	□ Yes □ No	□ Yes □ No
System Architecture	□ Yes □ No	□ Yes □ No
Stocker Command Scheduling Characteristics	□ Yes □ No	□ Yes □ No

SEMI E90-0705
SPECIFICATION FOR SUBSTRATE TRACKING

This specification was technically approved by the global Information & Control Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on April 7, 2005. It was available at www.semi.org in June 2005 and on CD-ROM in July 2005. Originally published September 1999; previously published March 2004.

1 Purpose

1.1 The purpose of this standard is to provide the standard services of equipment to track substrates (manufactured product) in manufacturing equipment. This standard defines the concepts and behaviors for the information management of substrates, as well as the messages/services.

2 Scope

2.1 Essentially, information about substrates must be managed by the factory system, while the equipment is required to provide the services for the substrate information management. This standard addresses the requirement for the equipment services to manage information of substrates that reside in the equipment.

2.2 The scope of this standard is to define the information services of equipment that can be requested by the user. To clarify required services, the concepts and behaviors of the substrate, the substrate location, the batch and the batch location are defined.

2.3 This standard is applicable to any manufacturing equipment that handles substrates. To implement these services, the equipment and factory system must be integrated by means of a communication link.

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 This standard assumes that the substrate(s) to be managed has been resident in the equipment and has been given a substrate identifier.

3.2 The service for a substrate is valid while the substrate is registered in the equipment. That is, the service is available from the moment that the substrate is registered into the equipment and, to the moment that the substrate is removed from the equipment.

3.3 This standard is only for information services. It does not address any mechanism to read or write information from/to the substrate.

4 Referenced Standards and Documents

4.1 *SEMI Standards*

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

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

SEMI E53 — Event Reporting

SEMI E87 — Specification for Carrier Management (CMS)

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

5 Terminology

5.1 *Definitions*

5.1.1 *batch* — a group of substrates to be processed in a process resource simultaneously.

5.1.2 *batch location* — locations in the equipment where substrates visit as a group of substrates for storage or processing.

5.1.3 *batch container* — a supporting structure that is used to hold substrates for processing, and it may visit multiple locations in equipment with substrates in it. Whether a batch container is used or not depends on the type of equipment. Typical example for a batch container is a "boat" used in furnace equipment.

5.1.4 *carrier ID* — the name to identify a specific substrate carrier.

5.1.5 *carrier slot* — physical location capable of holding a substrate within cassette type carrier.

5.1.6 *carrier slot map* — the registry of substrates to the substrate carrier slots.

5.1.7 *carrier substrate location* — a substrate location within a substrate carrier capable of holding a substrate.

5.1.8 *default substrate ID (default ID)* — the substrate ID assigned to the substrate when no substrate ID information is given by the user but the carrier ID for the source carrier is known. The default ID is the combined text of the source carrier ID and the slot number.

5.1.9 *equipment substrate location* — a substrate location on a equipment resource.

5.1.10 *location ID* — the name of a material location.

5.1.11 *lot* — a group of one or more substrates of the same type. A lot must be organized by the user. The group may be referred to for tracking of substrates in the factory.

5.1.12 *material location* — an identifiable place within the equipment or carrier where material can be held.

5.1.13 *register* — an operation that adds the substrate object to the equipment's database. This operation is performed automatically when the equipment receives both a carrier and information from the host about the contents of the carrier. The operation is also performed automatically when the equipment detects the substrate ID.

5.1.14 *remove* — the operation that removes a substrate from the equipment.

5.1.15 *service* — represents a function offered to a user by a provider. A service consists of a sequence of service primitives, each described by a list of parameters.

5.1.16 *substrate* — the basic unit of material on which work is performed to create a product. Examples include wafers, die, plates used for masks, flat panels, circuit boards, and leadframes.

5.1.17 *substrate carrier* — a carrier to hold substrates to be transferred to/from the equipment. A substrate carrier has one or more position to hold substrates (carrier substrate location).

5.1.18 *substrate history* — ordered set of information about the locations visited by the substrate.

5.1.19 *substrate ID* — identifier of a substrate.

5.1.20 *substrate location* — a material location which is capable of holding a substrate. For example, but not limited to, process modules, transfer subsystems, wafer chucks, robot end effecter, and carrier slots.

5.1.21 *substrate type* — represents the type of the substrate, such as wafers, CDs, flat panels, or masks.

5.2 *Data Type*

5.2.1 *Boolean* — may take on one of two possible values, equating to TRUE or FALSE.

5.2.2 *enumerated* — may take on one of a limited set of possible values. These values may be given logical names, but they may be represented by any single-item data type except floating point.

5.2.3 *floating point* — may take on any single numeric value, positive or negative. Messaging protocol may impose a limit on the range of possible values.

5.2.4 *form* — type of data: positive integer, unsigned integer, integer, floating point, enumerative, Boolean, text, formatted text, structure, list, and ordered list.

5.2.5 *formatted text* — text with an imposed format. This could be by position, by use of special characters, or both.

5.2.6 *integer* — may take on the value of any negative or unsigned integer. Messaging protocol may impose a limit on the range of possible values.

5.2.7 *list* — a set of one or more items that are all of the same form (one of the above forms).

5.2.8 *ordered list* — a list for which the order in which items appear is significant.

5.2.9 *positive integer* — may take the value of any positive whole number. Messaging protocol may impose a limit on the range of possible values.

5.2.10 *structure* — a complex set of information consisting of specific sets of items of possibly mixed data types, in a specified arrangement.

5.2.11 *text* — a text string. The message protocol restricts its length or ASCII representation. Messaging protocol may impose restrictions, such as length or ASCII representation.

5.2.12 *unsigned integer* — may take the value of any positive integer or zero. Messaging protocol may impose a limit on the range of possible values.

6 Convention

6.1 *Harel State Model*

6.1.1 This document uses the Harel state chart convention for describing dynamic operation of defined objects. The outline of this convention is described in an attachment of SEMI E30. The official definition of this convention is described in "Statecharts: A Visual Formalism for Complex Systems" written by D. Harel in Science of Computer Programming 8, 1987.[1]

6.1.2 A transition table is used with the state chart for clearly describing the character of each state transition. The table contains the folllowing: a transition number, current state, trigger, new state, and operation in transition.

6.1.3 The state models included in this standard are a requirement for Substrate Tracking compliance. A state model consists of a state model diagram, state definitions, and a state transition table. When using collection events, all state transitions in this standard, unless otherwise specified, shall correspond to collection events.

6.1.4 A state model represents the host's view of the equipment and does not necessarily describe the internal equipment operation. When using collection events, all Substrate Tracking 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 Substrate Tracking state models for transition to another state. In this case, the equipment makes the required transition without any additional actions.

6.2 *OMT Object Information Model*

6.2.1 The object models are represented using the Object Modeling Technique (OMT) developed by Rumbaugh, James, et al, in Object Oriented Modeling Design, Prentice Hall, Englewood Cliffs, NJ, 1991.[2]

6.2.2 An overview of this notation is provided in the Appendix 1 of SEMI E39.

6.3 *Object Attributes Representation*

6.3.1 The object information model for standardized objects will be supported by an attribute definition table with the following column headings:

Attribute Name	*Definition*	*Access*	*Reqmt*	*Format*
The formal text name of the attributes.	Description of information contained.	RO or RW	Y or N	Refer to the description below.

6.3.1.1 The Access column uses RO (read only) or RW (read/write) to indicate the access that a service user has to the attribute.

6.3.1.2 A "Y" or "N" in the Requirement (Reqmt) column indicates if this attribute must be supported in order to meet the fundamental requirement for the service.

6.3.1.3 The Format column is used for showing the data type of the attribute. (See ¶5.2.)

---

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

2 Prentice Hall, Inc., Upper Saddle River, NJ 07458, http://www.prenhall.com/divisions/ecs/cscat.html

6.4 *Service Message Representation*

6.4.1 *Service Resource Definition* — A service resource definition table defines the specific sets of messages for a service group, as shown in the following table:

Message Service Name	*Type*	*Description*
Message name	N or R	Purpose of the service.

6.4.1.1 Type can be either N = Notification or R = Request. Notification type messages are initiated by a service provider and the provider does not expect to get the response from the service user or requester.

6.4.1.2 Request messages are initiated by a service user or requester. The Request message asks for data or an activity from the provider. Request messages expect a specific response message (no presumption on the message context).

6.4.2 *Service Parameter Dictionary* — A service parameter dictionary table defines the parameters for one or more services, as shown in the following table:

Parameter	*Form*	*Description*
Parameter X	Data type	The parameter called X is B in A.

6.4.2.1 A row is provided in the table for each parameter of the service. The first column contains the name of the parameter. This is followed by columns describing form and contents of the corresponding primitive.

6.4.2.2 The Form column is used to indicate the type of data contained in a parameter. (See ¶5.2 for definitions.)

6.4.2.3 The Description column in the Service Parameter Dictionary table describes the meaning of the parameter, the values it can assume, and any interrelationships with other parameters.

6.4.2.4 To prevent the definition of numerous parameters named “XxxList”, this document adopts the convention of referring to the list as “(List of) Xxxx”. In this case, the definition of the variable Xxx will be given, not of the list. The term “list” indicates a collection (or set) of zero or more items of the same data type. Where a list is used in both the request and the response, the list order in the request is retained in the response. A list must contain at least one element unless zero elements are specifically allowed.

6.4.3 *Service Message Definition* — A service message definition table defines the parameter used in a service, as shown in the following table:

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
Parameter X	see below	see below	A description of the service.

6.4.3.1 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”.

6.4.3.2 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 shall match the value in the primary (if defined).

7 Overview

7.1 *Purpose of Substrate Tracking*

7.1.1 Substrate tracking consists of the following capabilities, as described below:

7.1.2 *Substrate Location Tracking* — Substrate Location Tracking provides the capability to determine the current location of substrates in the equipment. The indication of the substrate location will help the user to understand the environment to which the substrate is exposed in the equipment.

7.1.3 *Batch Location Tracking* — Batch Location Tracking provides the capability to determine the current location of a group of substrates in the equipment. Typical example of a substrates group is a batch in batch process equipment.

7.1.4 *Substrate History Record* — Substrate History Record provides the capability to read the history of substrates in the equipment. The user can inquire about the history of a particular substrate, substrate location, or batch location with substrate position in a batch. A history includes the series of locations that the substrate has visited in the equipment.

7.1.5 *Substrate Process Tracking* — Substrate Process Tracking provides the capability of tracking current substrate processing state. For example, the user may determine whether a substrate is processed or not by requesting its state when the process has been completed abnormally. The user may use the state transitions to trigger wafer level data collection.

7.2 *View of Substrate Tracking*

7.2.1 Figure 1 shows the view of Substrate Tracking using the OMT representation. It is assumed that substrates are available before usage of the services. Substrate carriers may or may not be used to load the substrates to the equipment. Substrates are loaded into the equipment and travel through substrate locations and batch locations. The equipment must maintain all information necessary to track substrates in the equipment.

7.3 *Substrate Location and Batch Location*

7.3.1 A substrate location is a discrete position that can hold a substrate in the equipment. This document will not define where the substrate location exists. Substrate locations shall be determined by the design of equipment and the applications. For example, to track the order of process chambers that is applied to a substrate process in a multi-chamber single wafer process equipment, it is appropriate to designate process chambers for substrate locations. On the other hand, in batch process equipment, process chambers are designated for batch locations and substrate locations are not used to track the order of process chambers that is applied to the substrates of a batch. All substrate locations shall be documented by the equipment supplier.

7.3.2 Batch Location indicates the physical location of a group of substrates (e.g., batch) on the equipment. Generally in batch process equipment, Batch Location is assigned to a process chamber and changed when a batch is transferred from one chamber to another. Individual substrate positions in a batch (e.g., slot positions of a batch container or a process carrier) might be informed with Batch Location. Batch Locations and notation of the substrate positions in a batch are defined and documented by the equipment supplier.

7.3.3 Figure 2 shows the concept of the substrate location using OMT representation. This figure is provided to clarify the definition of locations.

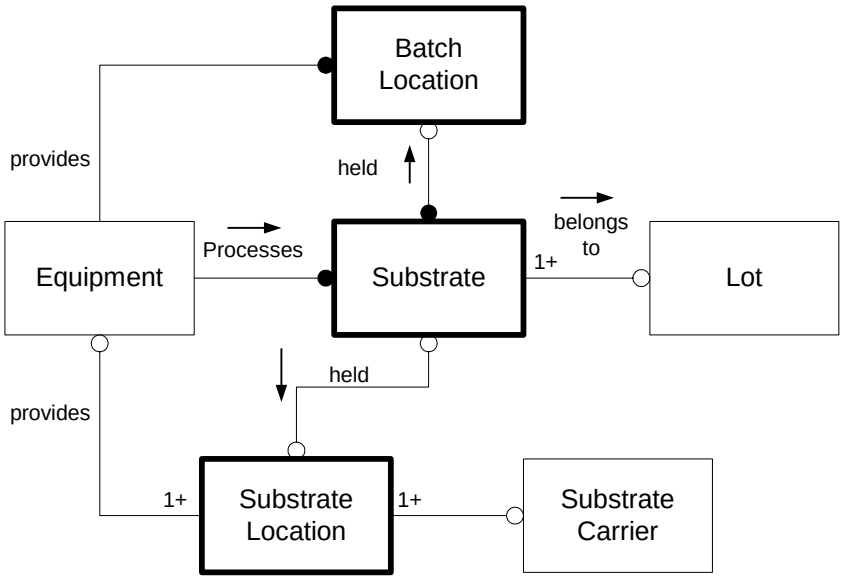


Figure 1
Overview of Substrate Tracking

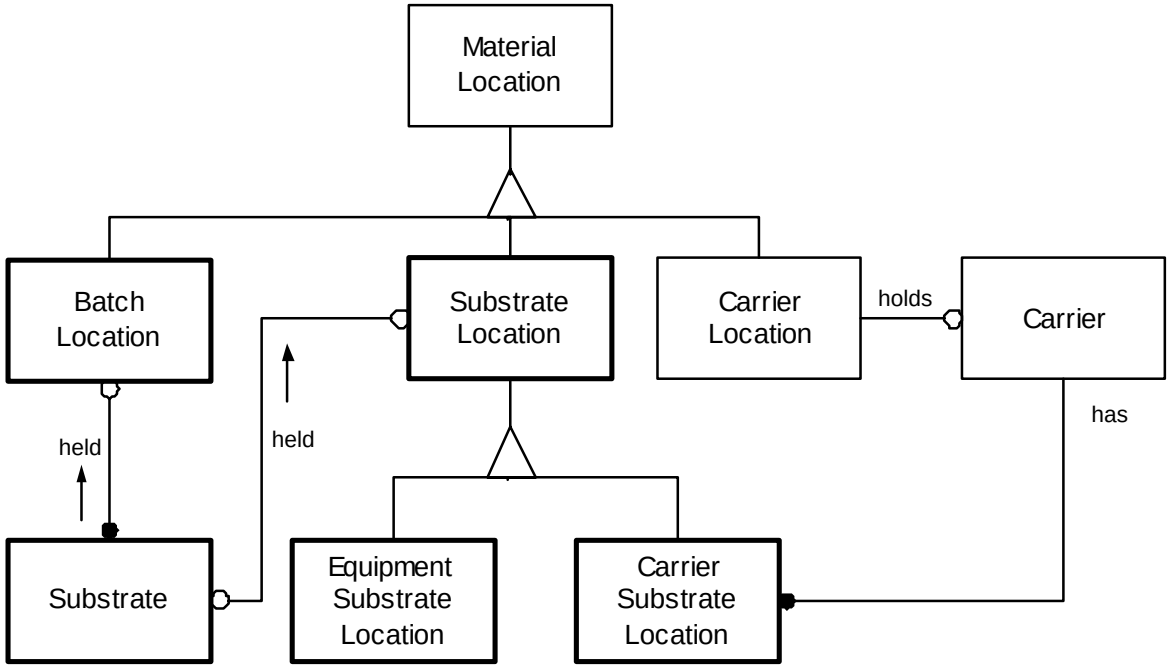


Figure 2
Concept of Substrate Location

7.3.4 Material Location is classified into Substrate Location, Batch Location, and Carrier Location. A Carrier Location may hold a carrier, a Substrate Location may hold a substrate, and a Batch Location may hold a group of substrates. Typical example of a substrates group is a batch in batch process equipment.

7.3.5 Substrate Location is classified into Equipment Substrate Location and Carrier Substrate Location. Carrier has Carrier Substrate Locations. A Carrier Substrate Location is the location which can hold a substrate in a carrier. An Equipment Substrate Location is the location which can hold a substrate on the equipment resource.

7.3.6 Substrate travels on substrate locations and/or batch locations.

7.4 *Identification of Substrate*

7.4.1 Substrate shall be identified by substrate ID. There are options for assigning substrate ID to a substrate.

- When a carrier is used for loading substrates and the carrier is given its carrier ID, substrate IDs can be obtained by utilizing the carrier ID and carrier substrate location. This standard will define the requirement for the substrate ID assignment to the substrates in a carrier.
- Substrate ID may be read from the substrate directly by a substrate ID reader. The substrate ID read from the substrate can be used for the identification.
- Substrate ID may be assigned by the user (i.e., host or operator). The substrate ID can be used for the identification. This standard will define the service for registering substrates.

7.4.2 The recommendation of a particular option for assigning substrate IDs is not within the scope of this standard. It must be selected based on the equipment design and applications.

8 Substrate Tracking Requirement

8.1 Compliance to Substrate Tracking Service (STS) requires that an implementation also provide certain capabilities that are defined in other standards.

- STS requires compliance to SEMI E39 (OSS) for Substrate objects. The attributes of these objects may be accessed through use of the GetAttr and SetAttr services.
- STS requires an event reporting capability. This capability may be satisfied by the Event Reporting capability in SEMI E30 (GEM) or by SEMI E53 (ERS).

8.2 STS compliant equipment must implement capabilities defined in the following sections of this document:

- §9, Substrate Object Definition,
- §10, Substrate Location Object Definition,
- §12, Substrate Tracking Services,
- §13, Variable Data, if SEMI E53 is not implemented, and
- §11, Batch Location Object Definition, is an optional requirement.

8.3 When the equipment provides a substrate reader, the equipment shall implement an equipment constant to allow the host to choose between using or not using this capability. The equipment constant: “SubstrateReaderEnabled” is used to choose whether or not the equipment performs the reading of the substrate and use the Substrate Reading Status state model. The equipment is responsible for creating the substrate objects. The substrate ID assigned to the substrate object is the same as the one provided by the host in the ContentMap attribute or created by the equipment using the following rule when the SubstID in the content map is not provided. The default substrate ID shall be represented in text as the carrierID, a period and the substrate slot location. For example, if CarrierID = “xyz” and substrate slot location = “5”, then the substrate ID would be = “xyz.05”.

8.4 All state transitions defined for the three state models specified in this document must be reportable via discrete collection events as defined in ¶6.1, Harel State Model. The three state models are the Substrate Object State Model (Figure 3), the Substrate Location State Model (Figure 4) and the Batch Location State Model (Figure 5).

8.4.1 The data in Table 15 (Variables Required for Substrate Object State Model Transitions**)** is required to be available for the Substrate Object State Model transition collection events. Fixed buffer equipment must support discrete state transitions for Substrate. Internal buffer equipment must support related state transitions that occur for a group of Substrate objects. An equipment may support both discrete and related state transitions for Substrate.

8.4.2 The data in Table 16 (Variables Required for Substrate Location Object State Model Transitions) is required to be available for the Substrate Location Object State Model transition collection events.

8.4.3 The data in Table 17 (Variables Required for Batch Location Object State Model Transitions) is required to be available for the Batch Location Object State Model transition collection events.

8.5 Each Substrate Object instantiated on the equipment must maintain an independent instance of the Substrate Object State Model. When discrete and unrelated state transitions occur for Substrate Object models, each shall trigger a separate collection event. However, when related state transitions occur for a group of Substrate Object models (such as with internal buffer equipment material transfers), each model does not trigger a separate collection event. Instead, a single collection event shall be triggered (for all related Substrate Objects in the group). The data items defined in Table 15 are required to be valid for collection events triggered by state model transitions in the following way:

8.5.1 These variables from Table 15 must be valid for collection events triggered by discrete state transitions:

- AcquiredID (equipment with substrate ID readers only)
- SubstID
- SubstIDStatus (equipment with substrate ID readers only)
- SubstBatchLocID (batch process equipment only)
- SubstDestination
- SubstHistory
- SubstSubstLocID
- SubstLotID
- SubstMtrlStatus
- SubstPosInBatch (batch process equipment only)
- SubstProcState
- SubstSource
- SubstState
- SubstType
- SubstUsage

8.5.2 These variables from Table 15 must be valid for collection events triggered by a group of related state transitions:

- AcquiredIDList (equipment with substrate ID readers only)
- SubstIDList
- SubstIDStatusList (equipment with substrate ID readers only)
- SubstBatchLocIDList (batch process equipment only)
- SubstDestinationList
- SubstHistoryList
- SubstLocIDList
- SubstLotIDList
- SubstMtrlStatusList
- SubstPosInBatchList (batch process equipment only)
- SubstProcStateList
- SubstSourceList
- SubstStateList

- SubstTypeList
- SubstUsageList

8.5.3 As an example of how the variables are constructed for related state transitions, the value of SubstIDList shall be the list of SubstID data items that identify the Substrate Objects related by the collection event.

8.6 Each Substrate Location Object instantiated on the equipment must maintain an independent instance of the appropriate Substrate Location Object State Model. Each Substrate Location Object shall trigger a separate collection event for each state transition. The data items defined in Table 16 are required to be valid for collection events triggered by each state model transition.

8.7 Each Batch Location Object instantiated on the equipment must maintain an independent instance of the Batch Location Object State Model. Each Batch Location Object shall trigger a separate collection event for each state transition. The data items defined in Table 17 are required to be valid for collection events triggered by each state model transition.

9 Substrate Object Definition

9.1 A substrate is a base upon which a product unit is built in the manufacturing equipment. Wafers and flat panel displays are examples of substrates. A substrate may be associated with a lot, which the factory uses for tracking purposes.

9.1.1 The substrate object shall be created when the substrate is registered by the equipment. There are two possible ways of registering the substrate.

(1) The substrate is registered by the equipment when the information for the carrier containing the substrate is registered. The information required to create a substrate object must be provided with the carrier. However, the specification of carrier management services is outside the scope of this standard. Substrate Tracking implementations shall be consistent with the Carrier Management standard. For instance, if the Carrier Management standard specifies the method of identifying the substrates in a carrier, then Substrate Tracking shall recognize those identifiers.

(2) The substrate is registered when the substrate is transferred directly (not in a carrier) to the equipment by the Create service defined in SEMI E39 to inform the equipment of this event.

9.2 *Substrate Object State Model*

9.2.1 A substrate has both a state indicating where it is located and a state indicating the progress of processing. These states are represented by the SUBSTRATE TRANSPORT and the SUBSTRATE PROCESSING states, which are concurrent substates of the SUBSTRATE State Model shown in Figure 3.

9.2.2 If the equipment provides a mechanism for reading substrates, then, the equipment shall include a state model in parallel with the Substrate Transport and Substrate Processing States called “Substrate Reading Status” See Figure 3 and Table 1 for additional requirements.

9.3 *Substrate Object State Definitions*

9.3.1 ABORTED — The process has been aborted during the processing. The substrate will require special treatment.

9.3.2 AT DESTINATION — The substrate has been placed at its designated destination substrate location. The substrate may have been placed at a carrier substrate location when the carrier is used to unload the substrate from the equipment, or at an equipment substrate location when the substrate is to be removed by itself from the equipment.

9.3.3 AT SOURCE — The state which the substrate is originally received. The substrate is held at carrier substrate location when a carrier is used to supply the substrate.

9.3.4 AT WORK — The substrate has been taken from the original substrate location or destination substrate location, and is traveling on intermediate equipment substrate locations. The substrate has been taken out of the carrier and placed into the equipment when a carrier is used to supply the substrate.

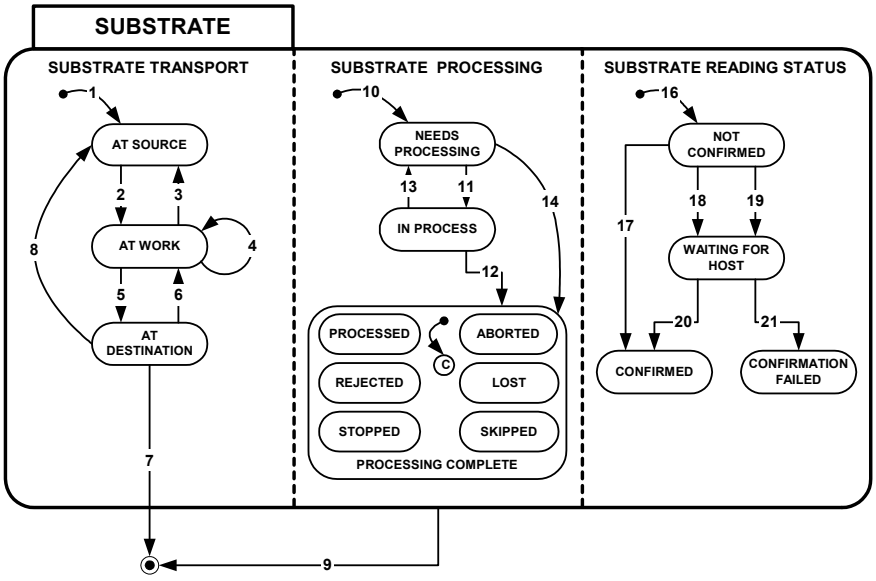


Figure 3
Substrate Object State Model
A-1.1.1.1

9.3.5 IN PROCESS — Substrate is being processed. One or more substrate properties are being changed by the processing instructions or measurement of the substrate in the equipment. The nature of the process depends upon the equipment processing capabilities.

9.3.6 LOST — The terminal state when the substrate has been broken and/or removed from the equipment by an external entity and it no longer exists at the equipment.

9.3.7 NEEDS PROCESSING — Processing requirements exist that have not yet been fulfilled. This is the default entry state when the substrate is originally received. In some cases, the substrate may return to this state while it waits for additional processing to be performed.

9.3.8 PROCESSED — All substrate processing has successfully completed. No further processing will be performed by the equipment.

9.3.9 PROCESSING COMPLETE — The state in which the substrate has completed all processing associated with a recipe specification. The substrate processing completed because the process requirement was aborted, stopped or successfully completed. The substrate is no longer changed by the recipe's processing instructions or its measurment/inspection requirements completed. This state is a super-state of the terminal states of the substrate; PROCESSED, ABORTED, REJECTED, LOST, STOPPED, or SKIPPED.

9.3.10 REJECTED — The state which the substrate has been processed completely; however, the result of the processing may have a problem. The substrate will require special treatment. This substate is not required for equipment that is unable to identify rejected substrates.

9.3.11 SKIPPED — As directed by an operator or a host, the substrate was not processed.

9.3.12 STOPPED — The process has been stopped during the processing. The substrate will require special treatment.

9.3.13 SUBSTRATE — The superstate of the SUBSTRATE TRANSPORT and SUBSTRATE PROCESSING. SUBSTRATE TRANSPORT and SUBSTRATE PROCESSING are concurrent substates. The state is created when the substrate is initially registered to the equipment, and deleted when the substrate is removed from the equipment.

9.3.14 SUBSTRATE PROCESSING — The superstate of NEEDS PROCESSING, IN PROCESS, PROCESSING COMPLETE which represents the processing state of the substrate.

9.3.15 SUBSTRATE TRANSPORT — The superstate of the AT SOURCE, AT WORK, AT DESTINATION which represents the transport state of the substrate within the equipment.

9.3.16 SUBSTRATE READING STATUS — The superstate of NOT CONFIRMED, WAITING FOR HOST, CONFIRMED and CONFIRMATION FAILED that represents the status of the substrate ID confirmation by the equipment.

9.3.17 NOT CONFIRMED — This is the entry state for the substrate object at the time of its creation when a substrate reader is available and enabled in the equipment.

9.3.18 WAITING FOR HOST — The status of the substrate when the substrate ID could not be identified by the reader, was discovered to be at a wrong source location or there was no matching ID in the source set.

9.3.19 CONFIRMED — The state of the substrate when it's substrate ID has been confirmed by the equipment or the host after it was read.

9.3.20 CONFIRMATION FAILED — The state of the substrate when the host decides to cancel the substrate.

9.4 *Substrate State Transition*

Table 1 Substrate State Model Transition Table

No.	*Current State*	*Trigger*	*New State*	*Action*	*Comment*
1	no state	The substrate is registered.	AT SOURCE		
2	AT SOURCE	The substrate is taken from the source substrate location and placed into the equipment.	AT WORK	Update substrate location history.	Substrate tracking through the equipment substrate locations begin.
3	AT WORK	The substrate has moved to the source substrate location.	AT SOURCE	Update substrate location history.	This transition is not required for compliance to this standard.
4	AT WORK	The substrate has moved out from current equipment substrate location towards a new equipment substrate location.	AT WORK	Update substrate location history.	The substrate has moved between equipment substrate locations. This transition is not required for compliance to this standard. This transition is not required if the equipment only provides a single Equipment Substrate Location.
5	AT WORK	The substrate is moved to the destination substrate location.	AT DESTINATION	Update substrate location history.	
6	AT DESTINATION	The substrate is taken from the destination substrate location and placed into the equipment.	AT WORK	Update substrate location history.	This transition is not required for compliance to this standard.
7	AT DESTINATION	The substrate is removed from the equipment by a normal transfer sequence.	(Extinction)	The substrate object is deleted in the equipment.	
8	AT DESTINATION	The user informs or the equipment detects that the substrate is AT SOURCE.	AT SOURCE	Update substrate location history.	This transition is not required for compliance to this standard.
9	Any SUBSTRATE substate	The equipment detects or is informed by the user that a substrate has been removed.	(Extinction)	The substrate object is deleted in the equipment.	The removal may be detected by the equipment or informed by the user. This transition would not occur during normal wafer movement. So if transition 7 occurs, there is no need to report a transition 9.
10	no state	The substrate object is created.	NEEDS PROCESSING		
11	NEEDS PROCESSING	Substrate starts actual processing. One or more substrate properties begin to be affected by the equipment recipe instructions or measurement of the substrate.	IN PROCESS		The document for each equipment implementation shall describe the trigger for this transition.

No.	*Current State*	*Trigger*	*New State*	*Action*	*Comment*
12	IN PROCESS	The processing completes because the processing activities were aborted, stopped or completed. One or more substrate properties are no longer affected by the processing instructions or measurement of the substrate.	PROCESSING COMPLETE	One of the substates PROCESSED, ABORTED, STOPPED, REJECTED, LOST, SKIPPED is determined.	This is a terminal state. The substrate either returns to the specified destination or it is no longer at the equipment.
13	IN PROCESS	The process associated with the processing instructions completed and the substrate is to be processed again.	NEEDS PROCESSING		The documentation for each equipment implementation shall describe the trigger for this transition. This transition is not required for compliance to this standard.
14	NEED PROCESSING	The substrate has been removed from the equipment by an external agent or it is physically missing (LOST) or the substrate has been not processed (SKIPPED).	PROCESSING COMPLETE	One of the substrates LOST, SKIPPED, is determined.	
15					Not used.
16	no state	The substrate object is created	NOT CONFIRMED	none	This transition is not reported.
17	NOT CONFIRMED	Substrate was successfully read and SubstID provided in the ContentMap matched the AcquiredID read by the equipment.	CONFIRMED	Issue an event for transition 17.	Data required to be available for this event report: SubstID AcquiredID
18	NOT CONFIRMED	Substrate ID reading has failed after several retries	WAITING FOR HOST	Issue an event for transition 18. Wait for the host to issue either “ProceedWithSubstrate” or “CancelSubstrate” services.	Data required to be available for this event report: SubstID
19	NOT CONFIRMED	Substrate ID was successfully read but the acquired ID is different from the one the equipment used to instantiate the substrate object.	WAITING FOR HOST	Issue an event for transition 19. Wait for the host to issue either “ProceedWithSubstrate” or “CancelSubstrate” services.	Data required to be available for this event report: SubstID AcquiredID
20	WAITING FOR HOST	Equipment has received a “ProceedWithSubstrate” service.	CONFIRMED	Issue an event for transition 20.	Data required to be available for this event report: SubstID AcquiredID (if valid)

No.	Current State	Trigger	New State	Action	Comment
21	WAITING FOR HOST	Equipment has received a “CancelSubstrate” service.	CONFIRMATION FAILED	Issue an event for transition 21 and update the substrate processing status to SKIPPED taking the appropriate transition. The substrate is returned or placed into its destination location.	

9.5 *Substrate Object Attribute Definition*

9.5.1 Table 2 defines attributes for substrate objects. These attributes can be accessed by using GetAttr and SetAttr messages as defined in SEMI E39 (OSS).

Table 2 Substrate Object Attribute Table

Attribute Name	Definition	Access	Reqmt	Format
AcquiredID	Contains the ID read from the substrate. Empty string before the substrate is read. The attribute shall be updated as soon the Substrate ID has been successfully read. [Equipment with substrate ID reader only]	RO	N	Text
BatchLocID	Identifier for current batch location.	RO	N	Text (batch process equipment only)
LotID	Identifier of the lot associated with the substrate by the user.	RW	N	Text
MaterialStatus	Current status of the substrate that represents criteria of the processing quality. The criteria is equipment design dependent.	RO	N	Enumerated: equipment dependent
ObjID	Object Identifier.	RO	Y	Text equal to the Substrate ID
ObjType	Object type.	RO	Y	Text = “Substrate”
SubstDestination	Identifier of the substrate location on which the substrate shall be finally restored. When a carrier is used for restoring the substrate, the value shall be the concatenation of carrier identifier (carrier ID) string and a numeric string representing the substrate position in the carrier to represent the carrier and position of the substrate restored.	RO	Y	Text If empty string, then same as source substrate location
SubstHistory	History of locations visited.	RO	Y	List of structures consisting of SubstLocID or BatchLocID+“.”+SubstPosInBatch (batch process equipment only), TimeIn, TimeOut
SubstIDStatus	Status of the substrate ID. This attribute is mandatory only when the equipment provided a substrate reader.	RO	N	Enumerated NOT CONFIRMED WAITING FOR HOST CONFIRMED CONFIRMATION FAILED

Attribute Name	*Definition*	*Access*	*Reqmt*	*Format*
SubstLocID	Identifier for current equipment substrate location.	RO	Y	Text (If batch process equipment, this data is empty while the substrate belongs to a batch)
SubstPosInBatch	Current substrate position in a batch.	RO	N	Text (batch process equipment only, and empty if substrate position in a batch is not informed)
SubstProcState	Processing state of the substrate. "NEEDS PROCESSING": initial value to indicate that processing in the equpment is required and has not started. "IN PROCESS": processing has started. "PROCESSED": processing has completed normally. "ABORTED": processing has terminated abnormally. "STOPPED": processing has terminated at completion of certain processing step. "REJECTED": the substrate has been identified as needing special treatment. "LOST": the substrate has been removed from the equipment by an external agent or it is physically missing. "SKIPPED": the substrate was not processed.	RO	Y	Enumerated: NEEDS PROCESSING IN PROCESS PROCESSED ABORTED STOPPED REJECTED LOST SKIPPED
SubstSource	Identifier of the substrate location on which the substrate has been initially registered. When a carrier is used for registering the substrate, the value shall be the concatenation of carrier identifier (carrier ID) string and a numeric string representing the substrate position in the carrier to represent the carrier and position of the substrate registered.	RO	Y	Text
SubstState	Transport state of the substrate.	RO	Y	Enumerated: AT SOURCE AT WORK AT DESTINATION
SubstType	The type of the substrate. It includes wafers, flat panels, CD's or masks.	RW	N	Enumerated: WAFER FLAT PANEL CD MASK
SubstUsage	How the substrate is used, such as "product", "test", and "filler".	RW	N	Enumerated: PRODUCT TEST FILLER Additional types defined and added by the equipment.

9.5.2 SubstHistory attribute is a composite data type. The constitute data is defined in Table 3.

Table 3 Attribute Data Definition

Data Identifier	*Description*	*Form*
BatchLocID+"."+SubstPosInBatch	Batch location, on which the group of substrates (e.g., batch) has visited, with substrate position information in a batch (recorded while the substrate belongs to a batch). For example, if BatchLocID = "Chamber-A" and SubstPosInBatch = "30", then what is recorded is "Chamber-A.30".	Text (batch process equipment only, and if substrate position in a batch is not informed "."+SubstPosInBatch portion is not recorded).

Data Identifier	*Description*	*Form*
SubstLocID	Equipment substrate location on which the substrate has visited. Must be copied from SubstLocID of which the substrate has visited. (If batch process equipment, this data is not recorded while the substrate belongs to a batch.)	Text
TimeIn	Actual arrival time of the substrate on the substrate location.	The format of the timestamp defined by the protocol for implementation.
TimeOut	Actual departure time of the substrate from the substrate location.	The format of the timestamp defined by the protocol for implementation.

10 Substrate Location Object Definition

10.1 A Substrate Location Object (SLO) provides a model for identifying substrate locations. Each SLO on an equipment is assigned a substrate location ID to uniquely identify it. The assignment shall be documented by the equipment supplier. There are two types of substrate locations: carrier substrate location, which is the location or position (e.g., slot) in the carrier, and equipment substrate location, which is on the equipment resource. The equipment substrate location is a persistent object, while the carrier substrate locations are dynamic objects that shall be created or deleted by the placement or removal of carriers on the equipment.

10.1.1 Source substrate locations and Destination substrate locations are the points at which substrates transfer to/from the equipment's internal substrate locations (often locations at which processing occurs). A carrier substrate location is the Source or Destination substrate location when a carrier is used to transfer the substrate. An equipment substrate location can be the Source or Destination substrate location when the substrate is transferred directly (without a carrier).

10.2 *Substrate Location State Model*

Figure 4 shows the dynamic behavior of the substrate location using the Harel state chart representation.

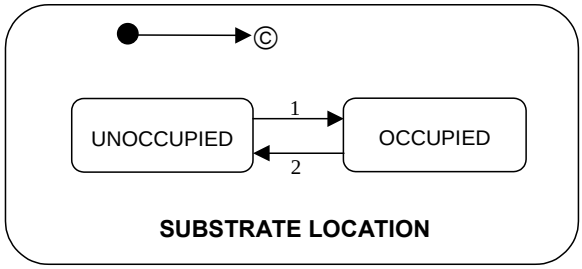


Figure 4
Dynamic Behavior Model of Substrate Location
A-1.1.1.2

10.3 *Substrate Location State Definitions*

10.3.1 SUBSTRATE LOCATION — the superstate of UNOCCUPIED and OCCUPIED.

10.3.2 UNOCCUPIED — the state in which the substrate location does not hold or have a substrate.

10.3.3 OCCUPIED — the state in which the substrate location holds a substrate.

10.4 *Substrate Location State Transition*

Table 4 Substrate Location State Model Transition Table

No.	*Current State*	*Trigger*	*New State*	*Action*	*Comment*
1	UNOCCUPIED	Substrate moves onto the substrate location.	OCCUPIED	None.	
2	OCCUPIED	Substrate moves off the location.	UNOCCUPIED	Update substrate tracking history.	

10.5 *Substrate Location Object Attributes*

10.5.1 Table 5 defines attributes for substrate location objects. These attributes can be accessed by using GetAttr and SetAttr messages as defined in SEMI E39 (OSS).

Table 5 Substrate Location Object Attribute Table

Attribute Name	*Definition*	*Access*	*Reqmt*	*Format*
DisableEvents	When set to TRUE, the transitions for this substrate location do not generate events to the host.	RW	Y	Boolean TRUE = Disable FALSE = Enable
ObjID	Object Identifier.	RO	Y	Text equal to the Substrate Location ID
ObjType	Object type.	RO	Y	Text = “SubstLoc”
SubstID	Substrate Identifier relevant to the location.	RO	Y	Text
SubstLocState	Substrate Location state.	RO	Y	Enumerated: UNOCCUPIED, OCCUPIED

11 Batch Location Object

11.1 A Batch Location Object (BLO) provides a model for identifying a group of substrates (e.g., batch) locations. Each BLO on an equipment is assigned a batch location ID to uniquely identify it. The assignment shall be documented by the equipment supplier. The batch location is a persistent object.

11.2 *Batch Location State Model*

11.2.1 Figure 5 shows the dynamic behavior of the batch location using the Harel state chart representation.

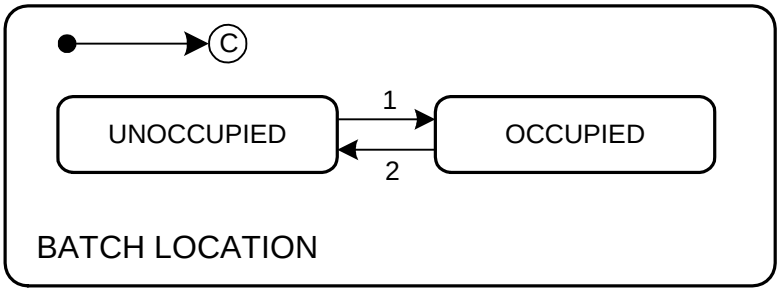


Figure 5
Dynamic Behavior Model of Batch Location

11.3 *Batch Location State Definitions*

11.3.1 BATCH LOCATION — the superstate of UNOCCUPIED and OCCUPIED.

11.3.2 UNOCCUPIED — the state in which the batch location does not hold or have any substrate of batch.

11.3.3 OCCUPIED — the state in which the batch location holds one or more substrates of batch.

11.4 *Batch Location State Transition*

Table 6 Batch Location State Model Transition Table

No.	*Current State*	*Trigger*	*New State*	*Action*	*Comment*
1	UNOCCUPIED	A group of substrates (e.g., batch), even if they are a part of group, moves onto the batch location.	OCCUPIED	None.	
2	OCCUPIED	All substrates of the group (e.g., batch) moves off the location.	UNOCCUPIED	Update substrate tracking history.	

11.5 *Batch Location Object Attributes*

11.5.1 Table 7 defines attributes for batch location objects. These attributes can be accessed by using GetAttr and SetAttr messages as defined in SEMI E39 (OSS).

Table 7 Batch Location Object Attribute Table

Attribute Name	*Definition*	*Access*	*Reqmt*	*Format*
ObjID	Object Identifier.	RO	N	Text equal to the Batch Location ID
ObjType	Object type.	RO	N	Text = "BatchLoc"
BatchLocState	Batch Location state.	RO	N	Enumerated: UNOCCUPIED, OCCUPIED
BatchSubstIDMap	Ordered list of substrate identifiers corresponding to the positions in a batch (e.g., slot positions of a batch container or a process carrier).	RO	N	Ordered list of SubstID (Ordered list indicates position in the batch and SubstID can be actual substrate identifier, blank "" when location is empty or "filler" when such substrate is used.) This attribute is updated each time a substrate is moved into or out of the batch or as soon as the equipment has the information.
DisableEvents	When set to TRUE, the transitions for this substrate location do not generate events to the host.	RW	Y	Boolean TRUE = Disable FALSE = Enable

12 Substrate Tracking Services

12.1 *Creating and Deleting Substrate Objects*

12.1.1 Equipment may create substrate objects as appropriate during equipment operation. On some equipment (at the option of the equipment designer), substrate objects may also be registered (created) at the equipment through the host-initiated Create service defined in SEMI E39. Equipment is not required to provide host-initiated Register (Create) Substrate or Remove Substrate services for fundamental compliance to STS. Table 8 defines the attribute settings that may be initialized through this service.

12.1.2 In general, it depends on the application whether or not attributes are initialized by the user of the create service. In some situation, it may be necessary to match the new substrate with a location, for example, while in other situations it would be unnecessary. Each application must specify its own requirements.

12.1.3 ObjType is a required argument of the Create service and should not be reset by including it as an attribute setting. In the table, M indicates Mandatory, O indicates Optional, and R specifies Restricted (shall be ignored if used).

Table 8 Substrate Attributes Settable through Create

Substrate Attribute Name	*Use as AttrSetting in Create Service*
LotID	O
MaterialStatus	O
ObjID	M
ObjType	R
SubstDestination	O
SubstHistory	O
SubstLocID	O
SubstProcState	O
SubstSource	O
SubstState	O

Substrate Attribute Name	*Use as AttrSetting in Create Service*
SubstType	O
SubstUsage	O

12.1.4 Use of attribute settings for the Delete service are optional and specific to the application.

12.2 Table 9 defines services required for substrate tracking. These services must be supported with substrate object.

Table 9 Substrate Tracking Service Message Definition Table

Message Service Name	*Type*	*Description*
CancelSubstrate	R	Request to the equipment to skip the substrate and move into its source location or destination location. Equipment instantiated substrate ID is required by this service. This service is only required when the equipment provides capabilities for reading substrate identifiers.
Change substrate state	R	Request to change substrate state. This message can be used to inform the equipment that external intervention has occurred and the state of the substrate (SubstState) must be corrected. For example, changing from AT DESTINATION state to AT SOURCE state.
ProceedWithSubstrate	R	Request to the equipment to accept the substrate. Equipment instantiated substrate ID is required by this service. This service is only required when the equipment provides capabilities for reading substrate identifiers.
UpdateSubstrateObject	R	Request to create a substrate object or to continue updating existent substrate object attributes for the specified substrate identifier with the substrate information provided with the service. If the substrate object was previously instantiated, the attribute(s) of the substrate are updated as specified with this service. If transfer is not completed or substrate is not at the equipment the service request fails. This service is used when substrates are moved directly between linked equipment without the use of a carrier. This is an optional service.

12.3 *Substrate Tracking Service Parameter Dictionary*

Table 10 Substrate Tracking Service Parameter

Dictionary Parameter	*Form*	*Description*
ErrorCode	Enumerated	Contains the code for the specific error found.
ErrorText	Text	Text in support of the error code.
STAcknowledge	Enumerated	Acknowledge of request.
Status	A list of ErrorCode/ErrorText pairs	Report any errors found.
STStatus	A structure consisting of STAcknowledge and Status	Return information for a service.
SubstID	Text	Identifier of a substrate.
SubstLocID	Text	Identifier of substrate location.
SubProcState	Enumerated	Processing State of a substrate.
SubstState	Enumerated	Transport State of a substrate.

Dictionary Parameter	*Form*	*Description*
(List of) SubstrateObjectAttributes	List of structure: Attribute name Attribute Value	List of substrate attributes. Each substrate attributes is an attribute name/value pair. The UpdateSubstrateObject service requires some substrate object attributes to be specified. For example, SubstrateID, SubstType, and at least one of the following must be included: SubstState, SubstProcState. All other substrate object properties are optional as is in the case of LotID, SubstSource, SubstUsage, SubstHistory, etc. Supplier may define attributes to be included in the service that are equipment dependent as in the case of linked litho tools.
ObjSpec	See SEMI E39.	Specifier of the object owner.
ObjectActionStatus	Structure ServiceAcknowledge Status	
(List of) ObjectActionParameterResult	List of structure: Attribute name Attribute Value	List of return parameters regarding the result of the request as name/value pairs.
ObjectAction	Text	"UpdateSubstrateObject"
OperationID	Unsigned Integer	Identifies a specific request. See SEMI E39.
ObjectLinkID	Unsigned Integer	Set to non-zero if and only if additional completion reports will be sent.
ServiceAcknowledge	Enumerated	0 - Acknowledge performed successful 1 - Service does not exist 2 - Cannot perform now 3 - At least one parameter is invalid 4 - Service will be performed later with notification 5 - Service is not completed or prohibited 6 - Not used 7-63 - Reserved
Status	List of structure Errorcode Errortext	

Table 11 Change Substrate State Message Pararmeter Table

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
(list of) SubstID	M	=	
(list of) SubstState	C (See NOTE 1.)	—	The order of SubstStates corresponds to the order of SubstID list.
(list of) SubstProcState	C (See NOTE 1.)	—	The order of SubstStates corresponds to the order of SubstID list.
Status	—	M	Information about the results.

Table 12 UpdateSubstrateObject Service Parameter

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
ObjectAction	M	—	"UpdateSubstrateObject"
ObjSpec	C	—	The object specifier of the object owner. See SEMI E39.

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
SubstrateObjectAttributes	M	=	SubstrateID, SubstType, and at least one of the following must be included: SubstState, SubstProcState. See UpdateSubstrateObject service message definition for additional requirements.
OperationID	C	—	Used if multiple requests will be linked to events. Set to zero otherwise.
ObjectLinkID	—	C	Set to non-zero if additional completion reports will be sent.
ObjectActionStatus	—	M	Acknowledge of the service acceptance and a list of error code and error text pairs if any.
ObjectActionParameterResult	—	C	List of return parameters regarding the result of the request as name/value pairs. Service returns the substrate object attributes updated that the request specified.

Table 13 ProceedWithSubstrate Service Parameter

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
ObjectAction	M	-	"ProceedWithSubstrate".
ObjSpec	M	-	The object specifier of the object owner. See SEMI E39.
SubstrateObjectAttributes	M	=	SubstID, and SubstLocID are required.
OperationID	M	-	Used if multiple requests will be linked events. Set to zero otherwise.
ObjectLinkID	-	M	Set to non-zero if additional completion reports will be sent.
ObjectActionStatus	-	M	Acknowledge of the service acceptance and a list of error code and error text pairs if any.
ObjectActionParameterResult	-	M	SubstID, and SubstLocID are required.

Table 14 CancelSubstrate Service Parameter

Parameter	*Req/Ind*	*Rsp/Conf*	*Description*
ObjectAction	M	-	"CancelSubstrate".
ObjSpec	M	-	The object specifier of the object owner. See SEMI E39.
SubstrateObjectAttributes	M	=	SubstID, and SubstLocID are required.
OperationID	M	-	Used if multiple requests will be linked events. Set to zero otherwise.
ObjectLinkID	-	M	Set to non-zero if additional completion reports will be sent.
ObjectActionStatus	-	M	Acknowledge of the service acceptance and a list of error code and error text pairs if any.
ObjectActionParameterResult	-	M	SubstID, and SubstLocID are required.

13 Variable Data

13.1 The host may inquire about any data related to specific Substrates, Substrate Locations and Batch Locations at any time by using the OSS service GetAttr.

13.2 Implementations of Specification for Substrate Tracking that use the Event Reporting capability specified by SEMI E30 (GEM) have the following requirement: For the objects defined by Specification for Substrate Tracking, the identifier of that object and all of the attributes of that object shall be available for inclusion in event reports associated with that object. The tables listed below specify the object attribute variables that must be available for state model transitions:

- Table 15 Variables Required for Substrate Object State Model Transitions
- Table 16 Variables Required for Substrate Location Object State Model Transitions
- Table 17 Variables Required for Batch Location Object State Model Transitions

13.3 Table 18 provides the definition of Status Variable Data that equipment shall support for the persistent objects defined by this standard, namely Substrate Location and Batch Location.

13.4 Variables in each table are presented in alphabetical order.

Table 15 Variables Required for Substrate Object State Model Transitions

Variable Name	*Description*	*Access*	*Form*	*Comment*
AcquiredID	Contains the ID read from the substrate. Empty string before the substrate ID is read.	RO	Text.	Empty string if read failed.
AcquiredIDList	A list of AcquiredIDs related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of AcquiredID.	This variable is mandatory only when the equipment provides a substrate reader. When a group of substrates have a related state model transition, only one collection event is triggered. The list length will be equal to the number of substrates involved in the related state model transition.
SubstBatchLocID	Current BatchLocID for the substrate associated with the last event.	RO	Text.	Batch process equipment only. Empty if substrate is not part of a batch.
SubstBatchLocIDList	A list of SubstBatchLocIDs related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstBatchLocID.	Batch process equipment only. When a group of substrates have a related state model transition, only one collection event is triggered.
SubstDestination	Destination Substrate Location for the substrate associated with the last event.	RO	Text.	If empty string, then same as source Substrate Location.
SubstDestinationList	A list of SubstDestinations related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstDestination.	When a group of substrates have a related state model transition, only one collection event is triggered.

Variable Name	*Description*	*Access*	*Form*	*Comment*
SubstHistory	List of history of locations visited for the substrate associated with the last event.	RO	List of structures consisting of Location ID, Time In, and Time Out.	
SubstHistoryList	A list of SubstHistorys related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstHistory.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstID	Identifier of substrate associated with last event.	RO	Text.	
SubstIDList	A list of substrate identifiers related by the same Substrate Object State Model or Substrate Location Object State Model state transition that triggered a collection event with which this variable was associated.	RO	Ordered list of SubstID.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstIDStatus	Status of the substrate ID.	RO	Enumerated: NOT CONFIRMED WAITING FOR HOST CONFIRMED CONFIRMATION FAILED	This variable is mandatory only when the equipment provides a substrate reader.
SubstIDStatusList	A list of SubstIDStatuses related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstIDStatus.	This variable is mandatory only when the equipment provides a substrate reader. When a group of substrates have a related state model transition, only one collection event is triggered. The list length will be equal to the number of substrates involved in the related state model transition.
SubstSubstLocID	Current substrate location for the substrate associated with the last event.	RO	Text.	If batch process equipment, this data is empty while the substrate belongs to a batch.

Variable Name	*Description*	*Access*	*Form*	*Comment*
SubstLocIDList	A list of substrate location identifiers related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstSubstLocID.	When a group of substrates have a related state model transition, only one collection event is triggered. The list length will be equal to the number of substrates involved in the related state model transition. If batch process equipment, this will be a list of empty strings while the substrate belongs to a batch.
SubstLotID	The LotID of the Substrate Object associated with last event.	RO	Text.	
SubstLotIDList	A list of substrate LotIDs related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstLotID.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstMtrlStatus	Processing quality criteria associated with the last event.	RO	Enumerated (equipment specific).	
SubstMtrlStatusList	A list of MtrlStatus related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstMtrlStatus.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstPosInBatch	Current substrate position in a batch for the substrate associated with the last event.	RO	Text.	Batch process equipment only. Empty if substrate position in a batch is not informed or the substrate is not part of a batch.
SubstPosInBatchList	A list of SubstPosInBatchs related by same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstPosInBatch.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstProcState	Processing state of the substrate associated with the last event.	RO	Enumerated: NEEDS PROCESSING IN PROCESS PROCESSED ABORTED STOPPED REJECTED	May not be implemented when the equipment does not have capability of process.

Variable Name	*Description*	*Access*	*Form*	*Comment*
SubstProcStateList	A list of substrate process states related by the same Substrate Object State Model state transition that triggered a collection event with which this variable was associated.	RO	Ordered list of SubstProcState.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstSource	Source Substrate Location for the substrate associated with the last event.	RO	Text.	
SubstSourceList	A list of SubstSources related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstSource.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstState	The current state of the substrate associated with the last event.	RO	Enumerated: AT SOURCE AT WORK AT DESTINATION	
SubstStateList	A list of substrate states related by the same Substrate Object State Model state transition that triggered a collection event with which this variable was associated.	RO	Ordered list of SubstState.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstType	Substrate SubstType for the substrate associated with the last event.	RO	Enumerated: wafer, disc, flat panel, reticle	SEMI E5, ¶9.2 contains a dictionary of units.
SubstTypeList	A list of SubstTypes related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstType.	When a group of substrates have a related state model transition, only one collection event is triggered.
SubstUsage	Description of the substrate associated with the last event.	RO	Enumerated: PRODUCT TEST FILLER	Indicates how the substrate is used. Additional types defined and added by the eqiupment.
SubstUsageList	A list of SubstUsages related by the same Substrate Object State Model state transition that triggered a collection event.	RO	Ordered list of SubstUsage.	When a group of substrates have a related state model transition, only one collection event is triggered.

Table 16 Variables Required for Substrate Location Object State Model Transitions

Variable Name	*Description*	*Access*	*Form*	*Comment*
SubstLocID	Identifier for substrate location associated with the last event.	RO	Text.	
SubstLocState	State of substrate location associated with the last event.	RO	Enumerated: OCCUPIED UNOCCUPIED	
SubstLocSubstID	Substrate Identifier relevant to the location associated with last event.	RO	Text.	Blank "" when location is UNOCCUPIED.

Table 17 Variables Required for Batch Location Object State Model Transitions

Variable Name	*Description*	*Access*	*Form*	*Comment*
BatchLocID	Identifier for batch location associated with the last event.	RO	Text.	
BatchLocState	State of batch location associated with the last event.	RO	Enumerated: OCCUPIED UNOCCUPIED	
BatchSubstIDMap	Ordered list of substrate identifiers corresponding to the positions in a batch (e.g., slot positions of a batch container or a process carrier) associated with the last event.	RO	Ordered list of SubstID.	Ordered list indicates position in the batch and SubstID can be actual substrate identifier, blank “” when location is empty or “filler” when such substrate is used.

Table 18 Status Variables Representing Object Attributes for Persistent Objects

Variable Name	*Description*	*Access*	*Form*	*Comment*
$BatchLocID_i$	Identifier of the ith batch location.	RO	Text.	
$BatchLocState_i$	State of ith batch location.	RO	Enumerated: OCCUPIED UNOCCUPIED	
$BatchSubstIDMap_i$	Ordered list of substrate identifiers corresponding to the positions in the batch held at the ith batch location.	RO	Ordered list of SubstID.	Ordered list indicates position in the batch and SubstID can be actual substrate identifier, blank "" when position is empty or "filler" when such substrate is used.
$SubstLocID_i$	Identifier of the ith equipment substrate location.	RO	Text.	
$SubstLocState_i$	State of ith equipment substrate location.	RO	Enumerated: OCCUPIED UNOCCUPIED	
$SubstrLocSubstrID_i$	Substrate ID of the substrate at the ith equipment substrate location, when occupied.	RO	Text.	Blank “” when location is UNOCCUPIED.

14 Additional Events (Equipment with substrate ID reader only)

14.1 *SubstrateIDReaderAvailable Event*

14.1.1 An event shall be generated whenever a substrate ID reader becomes available.

14.2 *SubstrateIDReaderUnavailable Event*

14.2.1 An event shall be generated whenever a substrate ID reader becomes unavailable.

15 Requirements for Compliance

15.1 Table 19 provides a checklist for Substrate Tracking (STS) compliance.

Table 19 STS Compliance Statement

Fundamental STS Requirements	*STS Section*	*Implemented*	*STS Compliant*
Substrate Tracking	8 (except 8.4)	☐ Yes ☐ No	☐ Yes ☐ No
Substrate Object and State Model	9	☐ Yes ☐ No	☐ Yes ☐ No
Substrate Location Object and State Model	10	☐ Yes ☐ No	☐ Yes ☐ No
Service Message Implementation (except host-initiated Register (Create) Substrate and Remove Substrate)	12	☐ Yes ☐ No	☐ Yes ☐ No
Variable Data	13	☐ Yes ☐ No	☐ Yes ☐ No
Events	8.4	☐ Yes ☐ No	☐ Yes ☐ No
Additional STS Capabilities	*STS Section*	*Implemented*	*STS Compliant*
Host-Initiated Register (Create Substrate)	12.1.1	☐ Yes ☐ No	☐ Yes ☐ No
Host-Initiated Remove Substrate		☐ Yes ☐ No	☐ Yes ☐ No
Batch Location Object and State Model	11	☐ Yes ☐ No	☐ Yes ☐ No
UpdateSubstrateObject service	12	☐ Yes ☐ No	☐ Yes ☐ No
Substrate Reading Status	9.3	☐ Yes ☐ No	☐ Yes ☐ No
"SubstIDStatus" substrate object attribute	9.5	☐ Yes ☐ No	☐ Yes ☐ No
ProceedWithSubstrate service	12.2	☐ Yes ☐ No	☐ Yes ☐ No
CancelSubstrate service	12.2	☐ Yes ☐ No	☐ Yes ☐ No
Additional Events	14	☐ Yes ☐ No	☐ Yes ☐ No

RELATED INFORMATION 1

NOTICE: This related information is not an official part of SEMI E90. This related information was approved for publication by full letter ballot procedures on January 14, 2000.

R1-1 Substrate State Model Implementation

R1-1.1 The Substrate Object State Model defined in ¶9.1 is a generic representation of the substrate object state model that includes standard transitions for various equipment types.

R1-1.2 Some equipment may not be able to implement all of the transitions defined in this model. For example, the transition from AT WORK to AT SOURCE (Transition Number 3) represents the case where the substrate returns to the original (source) location, typically for further processing. If the equipment is unable to implement this return, then the transition would never occur, and it should be omitted from the implemented state model.

R1-1.3 The state model shall be implemented based on the definition of the state model; however, substates and transitions that cannot occur for a particular equipment design may be omitted where the model allows.

R1-2 Example of Substrate Object State Model for Simple Equipment

R1-2.1 This section shows an example of Substrate Object State Model for simple equipment. (See Figure R1-1.)

R1-2.2 The equipment transports the substrate only in a forward direction, so that the Substrate Transport Substate takes straight forward transitions from AT SOURCE to AT WORK and then to AT DESTINATION. For example, the wirebonder removes leadframes from a magazine and carries them on a transport mechanism but is unable to return them to the magazine.

R1-2.3 Also, the equipment processes the substrate only in forward steps so that the Substrate Processing Substate takes straight forward transitions from NEED PROCESSING to IN PROCESS and then to PROCESSING COMPLETE. The REJECTED state is not applied to this equipment.

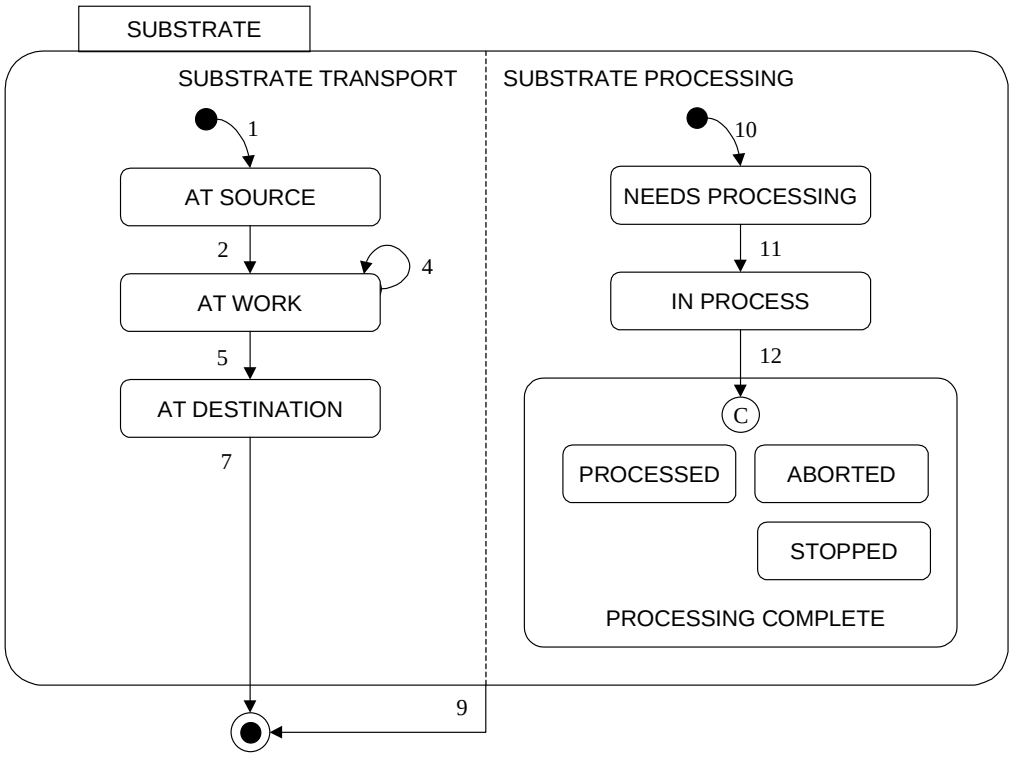


Figure R1-1
Substrate State Model for Simple Equipment

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SEMI E90.1-0705
PROVISIONAL SPECIFICATION FOR SECS-II PROTOCOL SUBSTRATE TRACKING

This specification was technically approved by the global Information & Control Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on April 7, 2005. It was available at www.semi.org in June 2005 and on CD-ROM in July 2005. Originally published March 2001; previously published July 2003.

1 Purpose

1.1 This document maps the services and data of SEMI E90 to SECS-II streams and functions, and data definitions.

2 Scope

2.1 This is a specification covering equipment supporting automated substrate tracking.

2.2 This document applies to all implementations of SEMI E90 that use the SECS-II message protocol (SEMI E5). Compliance to this standard requires compliance to both SEMI E90 and SEMI E5.

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.

2.4 This standard is provisional. To have the provisional status removed, the following must be completed:

- Table 1, Services Message Mapping Table
- Table 3, Services Parameters to SECS-II Data Items Mapping

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 Referenced Standards and Documents

3.1 *SEMI Standards*

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

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

SEMI E39.1 — SECS-II Protocol for Object Services Standard (OSS)

SEMI E53 — Event Reporting

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

4 Mapping

4.1 This section shows the specific SECS-II streams and functions that shall be used for SECS-II implementation of the services defined in SEMI E90, as well as the parameter mapping for data attached to services.

4.2 *Message Mapping*

4.2.1 *Services Message Mapping* — Table 1 defines the relationships between SEMI E90 services and SECS-II messages.

4.2.2 *Event Message Mapping* — Table 2 defines the relationships between SEMI E90 collection events and SECS-II messages.

Table 1 Services Message Mapping Table

Service Name	*Stream, Function*	*SECS-II Message Name*
change substrate state	(not yet defined)	(not yet defined)
register substrate	S14,F9/10	Create Object Request/Acknowledge (SEMI E39.1)
remove substrate	S14,F11/12	Delete Object Request/Acknowledge (SEMI E39.1)
UpdateSubstrateObject	S14F19/F20	Generic Service Request/Acknowledge
ProceedWithSubstrate	S14F19/F20	Generic Service Request/Acknowledge
CancelSubstrate	S14F19/F20	Generic Service Request/Acknowledge

Table 2 Event Message Mapping Table

Event Name	*Stream, Function*	*SECS-II Message Name*
All state model transitions	If SEMI E30 style events: S6F11/12 If SEMI E53 style events: S6F11/12 S6F13/14	If SEMI E30 style events: Event Report Send/Acknowledge If SEMI E53 style events: Event Report Send/Acknowledge Annotated Event Report Send/Ack

4.3 *Parameter Mapping* — Table 3 defines the relationships between SEMI E90 service parameters and SECS-II data definitions.

Table 3 Service Parameters to SECS-II Data Items Mapping

Parameter Name	*Range*	*SECS-II Data Item*
ErrorCode	Enumerated.	ERRCODE
ErrorText	1 to 80 characters.	ERRTEXT
ObjectAction	“UpdateSubstrateObject”.	SVCNAME
ObjectActionStatus	List of service acknowledge and status.	L,2 1. SVCACK 2. Status
ObjectAction-ParameterResult	(List of) name value pairs providing information about the attributes successfully set.	L,n 1. L,2 1. $SPNAME_1$ 2. $SPVAL_1$: n. L,2 1. $SPNAME_n$ 2. $SPVAL_n$
ObjectLinkID	51.	LINKID
OperationID	51.	OPID
STAcknowledge	0 if success; 1 if error (Conforms to ObjAck in SEMI E39.1)	OBJACK
Status	List of error information.	L,n n = number of errors 1. L,2 1. <$ErrorCode_1$> 2. <$ErrorText_1$> . . n. L,2 1. <$ErrorCode_n$> 2. <$ErrorText_n$>

Parameter Name	*Range*	*SECS-II Data Item*
STStatus	STAcknowledge and Status.	L,2 1. <STAcknowledge> 2. <Status>
SubstID	1–80 characters (Conforms to ObjID in SEMI E39.1)	OBJID
SubstIDList (ordered list of)	List of Substrate IDs.	L,n n = number of substrate identifiers 1. <$SubstID_1$> . . n. <$SubstID_n$>
SubstLocID	1–80 characters (Conforms to ObjID in SEMI E39.1)	OBJID
SubstLocIDList (ordered list of)	List of Substrate Location ID's corresponding to the SubstIDList (ordered list of).	L,n n = number of substrate identifiers in SubstIDList (ordered list of) 1. <$SubstLocID_1$> . . n. <$SubstLocID_n$>
SubstProcState	Enumerated per Variable SubstProcState.	U1
SubstProcStateList (ordered list of)	List of Substrate Processing States corresponding to the SubstIDList (ordered list of).	L,n n = number of substrate identifiers in SubstIDList (ordered list of) 1. <$SubstProcState_1$> . . n. <$SubstProcState_n$>
SubstrateObject-Attributes	(List of) substrate object attribute names and values.	L,n 1. L,2 1. $SPNAME_1$ 2. $SPVAL_1$: n. L,2 1. $SPNAME_n$ 2. $SPVAL_n$
SubstState	Enumerated per Variable SubstState.	U1
SubstStateList (ordered list of)	List of Substrate Transport States corresponding to the SubstIDList (ordered list of).	L,n n = number of substrate identifers in SubstIDList (ordered list of) 1. <$SubstState_1$> . . n. <$SubstState_n$>

4.4 *SECS-II Data Items without Corresponding SEMI E90 Parameters* — Table 4 contains the SECS-II data items that do not correspond to SEMI E90's service parameter.

Table 4 Additional Data Item Requirements Table

Function	*SECS-II Data Item*
"TimeIn" from SubstHistory variable data definition	TIMESTAMP
"TimeOut" from SubstHistory variable data definition	TIMESTAMP

5 Variable Data Item Mapping

5.1 Table 5 shows the specific SECS-II data classes, and formats needed for SECS-II implementations of SEMI E90 variable data items.

Table 5 Variable Data Item Mapping

Variable Name	*Class*	*Format*
BatchLocID	DVVAL	A[1..80] (Conforms to ObjID in SEMI E39.1.)
$BatchLocID_i$	SV	A[1..80] (Conforms to ObjID in SEMI E39.1.)
BatchLocState	DVVAL	51(U1) Enumerated as: 0-UNOCCUPIED 1-OCCUPIED
$BatchLocState_i$	SV	51(U1) Enumerated as: 0-UNOCCUPIED 1-OCCUPIED
BatchSubstIDMap	DVVAL	L,n n = number of positions in a batch 1. <$SubstID_1$> . . n. <$SubstID_n$>
$BatchSubstIDMap_i$	SV	L,n n = number of positions in a batch 1. <$SubstID_1$> . . n. <$SubstID_n$>
SubstBatchLocID	DVVAL	A[1..80] (Conforms to ObjID in SEMI E39.1.)
SubstDestination	DVVAL	A[1..80] (Conforms to ObjID in SEMI E39.1.)
SubstHistory	DVVAL	L,n n = number of substrate locations visited by the substrate 1. L,3 1. <$SubstLocID_1$> 2. <$TimeIn_1$> 3. <$TimeOut_1$> . . n. L,3 1. <$SubstLocID_n$> 2. <$TimeIn_n$> 3. <$TimeOut_n$>
SubstID	DVVAL	A[1..80] (Conforms to ObjID in SEMI E39.1.)
SubstLocID	DVVAL	A[1..80] (Conforms to ObjID in SEMI E39.1.)
$SubstLocID_i$	SV	A[1..80] (Conforms to ObjID in SEMI E39.1.)
SubstLocState	DVVAL	51 (U1) Enumerated as: 0 – UNOCCUPIED 1 – OCCUPIED
$SubstLocState_i$	SV	51 (U1) Enumerated as: 0 – UNOCCUPIED 1 – OCCUPIED
SubstLocSubstID	DVVAL	A[1..80] (Conforms to ObjID in SEMI E39.1.)
$SubstLocSubstrID_i$	SV	A[1..80] (Conforms to ObjID in SEMI E39.1.)
SubstLotID	DVVAL	A[1..80]
SubstMtrlStatus	DVVAL	U1 (equipment dependent enumeration)

Variable Name	*Class*	*Format*
SubstPosInBatch	DVVAL	A (range is equipment dependent)
SubstProcState	DVVAL	51 (U1) Enumerated as: 0 – NEEDS PROCESSING 1 – IN PROCESS 2 – PROCESSED 3 – ABORTED 4 – STOPPED 5 – REJECTED 6 – LOST 7 – SKIPPED
SubstrateReaderEnabled	EC	Binary 0 = Disabled 1 = Enabled
SubstSource	DVVAL	A[1..80] (Conforms to ObjID in SEMI E39.1.)
SubstState	DVVAL	51 (U1) Enumerated as: 0 – AT SOURCE 1 – AT WORK 2 – AT DESTINATION
SubstSubstLocID	DVVAL	A[1..80] (Conforms to ObjID in SEMI E39.1.)
SubstType	DVVAL	51 (U1) Enumerated as: 0 – WAFER 1 – FLAT PANEL 2 – CD 3 – MASK
SubstUsage	DVVAL	51 (U1) Enumerated as: 0 – PRODUCT 1 – TEST 2 – FILLER

6 SECS-II Attribute Definitions

6.1 *Substrate Object SECS-II Attributes Definitions* — The following are the SECS-II structure definitions for the SEMI E90 Substrate Object.

Table 6 Substrate Object SECS-II Attribute Definitions

Attribute Name	*Attribute Date Form: SECS-II Structure*
“BatchLocID”	<OBJID> BatchLocID
“ObjType”	“Substrate”
“ObjID”	<OBJID> SubstID (Conforms to the restrictions of ObjID as specified in SEMI E39.1, §6.)
“LotID”	20 (A) LotID
“MaterialStatus”	51 (U1) MaterialStatus MaterialStatus is an equipment specific enumerated value
“SubstDestination”	<OBJID> SubstLocID

Attribute Name	*Attribute Date Form: SECS-II Structure*
"SubstHistory"	L,n n = number of substrate locations visited by the substrate 1. L,3 1. <OBJID$_1$> SubstLocID$_1$ 2. <TIMESTAMP$_1$> TimeIn$_1$ 3. <TIMESTAMP$_1$> TimeOut$_1$ . . n. L,3 1. <OBJID$_n$> SubstLocID$_n$ 2. <TIMESTAMP$_n$> TimeIn$_n$ 3. <TIMESTAMP$_n$> TimeOut$_n$
"SubstLocID"	<OBJID> SubstLocID
"SubstPosInBatch"	20(A) SubstPosInBatch
"SubstProcState"	51 (U1) SubstProcState SubstProcState enumerated per Variable SubstProcState.
"SubstSource"	<OBJID> SubstLocID
"SubstState"	51 (U1) SubstState SubstState enumerated per Variable SubstState.
"SubstType"	51 (U1) SubstType SubstType enumerated per Variable SubstType.
"SubstUsage"	51 (U1) SubstUsage SubstUsage enumerated per Variable SubstUsage.
"SubstIDStatus"	51 (U1) Enumerated 0 = NOT CONFIRMED 1 = WAITING FOR HOST 2 = CONFIRMED 3 = CONFIRMATION FAILED
"AcquiredID"	A[0,80]

6.2 *Substrate Location Object SECS-II Attributes Definitions* — The following are the SECS-II structure definitions for the E90 Substrate Location Object.

Table 7 Substrate Location Object Attribute Definitions

Attribute Name	*Attribute Data Form: SECS-II Structure*
"DisableEvents"	11 (Boolean)
"ObjType"	"SubstLoc"
"ObjID"	<OBJID> SubstLocID (Conforms to the restrictions of ObjID as specified in SEMI E39.1, §6.)
"SubstID"	<OBJID> SubstID
"SubstLocState"	51 (U1) SubstLocState SubstLocState enumerated per Variable SubstLocState.

6.3 *Batch Location Object SECS-II Attributes Definitions* — The following are the SECS-II structure definitions for the SEMI E90 Batch Location Object.

Table 8 Batch Location Object Attribute Definitions

Attribute Name	*Attribute Data Form: SECS-II Structure*
"ObjID"	<OBJID> BatchLocID (Conforms to the restrictions of ObjID as specified in SEMI E39.1, §6.)
"ObjType"	"BatchLoc"

Attribute Name	*Attribute Data Form: SECS-II Structure*
"BatchLocState"	51(U1) BatchLocState BatchLocState enumerated per Variable BatchLocState.
"BatchSubstIDMap"	L,n n = number of positions in a batch 1. <$OBJID_1$> $SubstID_1$ . . n. <$OBJID_n$> $SubstID_n$
"DisableEvents"	11 (Boolean)

SEMI E91-0600
SPECIFICATION FOR PROBER SPECIFIC EQUIPMENT MODEL (PSEM)

This specification was technically approved by the Global Information & Control Committee and is the direct responsibility of the Japanese Communications Committee. Current edition approved by the Japanese Regional Standards Committee on January 14, 2000. Initially available at www.semi.org March 2000; to be published June 2000. Originally published September 1999.

1 Purpose

1.1 This document establishes a Specific Equipment Model for prober equipment (PSEM). The PSEM consists of equipment characteristics and behaviors that apply to this class of equipment and are required to be implemented in addition to the fundamental requirements and additional capabilities specified in SEMI E30 (GEM). The intent of this document is to facilitate the integration of prober equipment into an automated semiconductor factory. This document accomplishes this by defining an operational model for prober equipment as viewed by a factory automation controller. This definition provides a standard host interface and equipment operational behavior.

2 Scope

2.1 The scope of this document is limited to the definition of prober equipment behavior as perceived by a Semiconductor Equipment Communications Standard (SECS-II) (SEMI E5) host that complies with GEM. The document defines the view of the equipment through the SECS communications link, but does not define the internal operation of the equipment. It includes a specific processing state model as the basis for the behavior of all equipment of this class.

2.2 This document requires that the GEM fundamental requirements and applicable additional capabilities have been implemented on the prober equipment. This document expands GEM Standard requirements and capabilities in the areas of the processing state model, collection events, remote commands, data item variables and process program management, and adds Prober Job state model to GEM Standard requirements and capabilities. This document does not include the definition of the treatment of Multiple Stage.

2.3 This document applies to the class of prober equipment in which the wafer is unloaded from the same slot in the same carrier which loaded the wafer after processing.

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

3 Referenced Standards

3.1 *SEMI Standards*

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

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

SEMI M20 — Specification for Establishing a Wafer Coordinate System

SEMI M21 — Specification for Assigning Addresses to Rectangular Elements in a Cartesian Array

3.2 *Other Documents*

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

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

4 Terminology

4.1 *alignment* — a procedure in which a coordinate system is established on a substrate.

4.2 *bin* — categorized data of die as a result of measurement.

4.3 *cassette* — a physical object containing one or more substrate locations (see slot). For example, a SEMI standard cassette is a carrier with 25 substrate slot locations.

4.4 *die* — 1. A field sub-unit. 2. An area of substrate that contains the device being manufactured.

4.5 *execution area* — the area from which a current copy of the process program instructions are executed.

4.6 *inker* — a resource of the prober. The electromechanical units to put ink mark on die.

4.7 *instruction data* — the Result Data to refer on the inspection process.

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

4.8 *job* — a lot, processed with a single process program on PSEM equipment.

4.9 *load* — move material to the probing or marking location from the cassette.

4.10 *lot* — a group of one or more substrates of the same type (e.g., wafers, masks, CDs).

4.11 *map* — a list of coordinate positions of die on a substrate. MAP is defined in accordance with SEMI M21 in this document.

4.12 *map data* — the categorized data of die as a result of measurement associated with coordinates. Map data also have an information that identifies origin die.

4.13 *marking* — the process of the prober that making an ink mark on a die using the inker.

4.14 *material* — 1. The basic unit of process, physically a cassette or some cassettes. 2. A lot.

4.15 *measurement* — making a test, contacting the probe card and the die. The tester sends to the prober a categorized data as a result of test.

4.16 *probe card* — the electromechanical interface necessary to enable temporary electrical contact between the substrate to be tested and the tester resource. May consist of multiple components.

4.17 *re-inspection* — a process where the same substrate is tested again by using the inspected map data.

4.18 *slot* — a physical location within a cassette capable of containing a substrate. (Also referred to as a carrier location).

4.19 *state* — 1. A static set of conditions. If the conditions are met, the state is current (SEMI E30). 2. A state reacts predictably to specific stimuli.

4.20 *substrate* — 1. The basic unit of material, processed by PSEM equipment such as wafers.

4.21 *testing equipment* — an equipment class generally consisting of integrated mechanisms and controls for performing electrical tests of packaged devices and or wafer die during the manufacturing process.

4.22 *unload* — remove materials to the cassette slots from the probing or marking location.

4.23 *wafer end* — the end of measuring process of a wafer.

5 State Model

5.1 The purpose is to define the equipment-specific processing state model and Prober Job state models necessary to portray the expected operational states of the equipment to enable host tracking and control in place of a local operator.

5.1.1 The processing state models in this document are required for implementing an PSEM-compliant prober, in addition to the required state models in SEMI E30. A state model consists of a state model diagram, state definitions, and a state transitions' table. A state model represents the host's view of the prober, but not necessarily the actual prober operations. All PSEM state model transitions shall be mapped sequentially into the actual equipment events that satisfy the requirements of those transitions. In certain implementations, the prober may enter a state and has already satisfied all of the conditions required by the PSEM state model for transition to another state. In this situation, the prober makes the required transition without any additional actions.

5.1.1.1 Various symbols used in a state diagram are described in Figure 1.

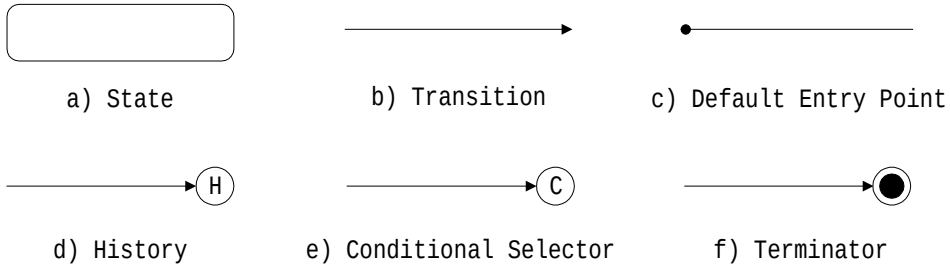

Figure 1
Various Symbols Used in a State Diagram

5.1.2 Some equipment may need to include additional states. However, any additional states must not change the PSEM-defined state transitions. All expected transitions between PSEM states must occur.

5.2 *PSEM Processing State Model*

5.2.1 *Purpose*

5.2.1.1 The purpose of the PSEM Processing State Model is to make an accurate model for the behavior of the PSEM prober from Processing State Model defined in SEMI E30.

5.2.2 *PSEM Processing State Model Diagram*

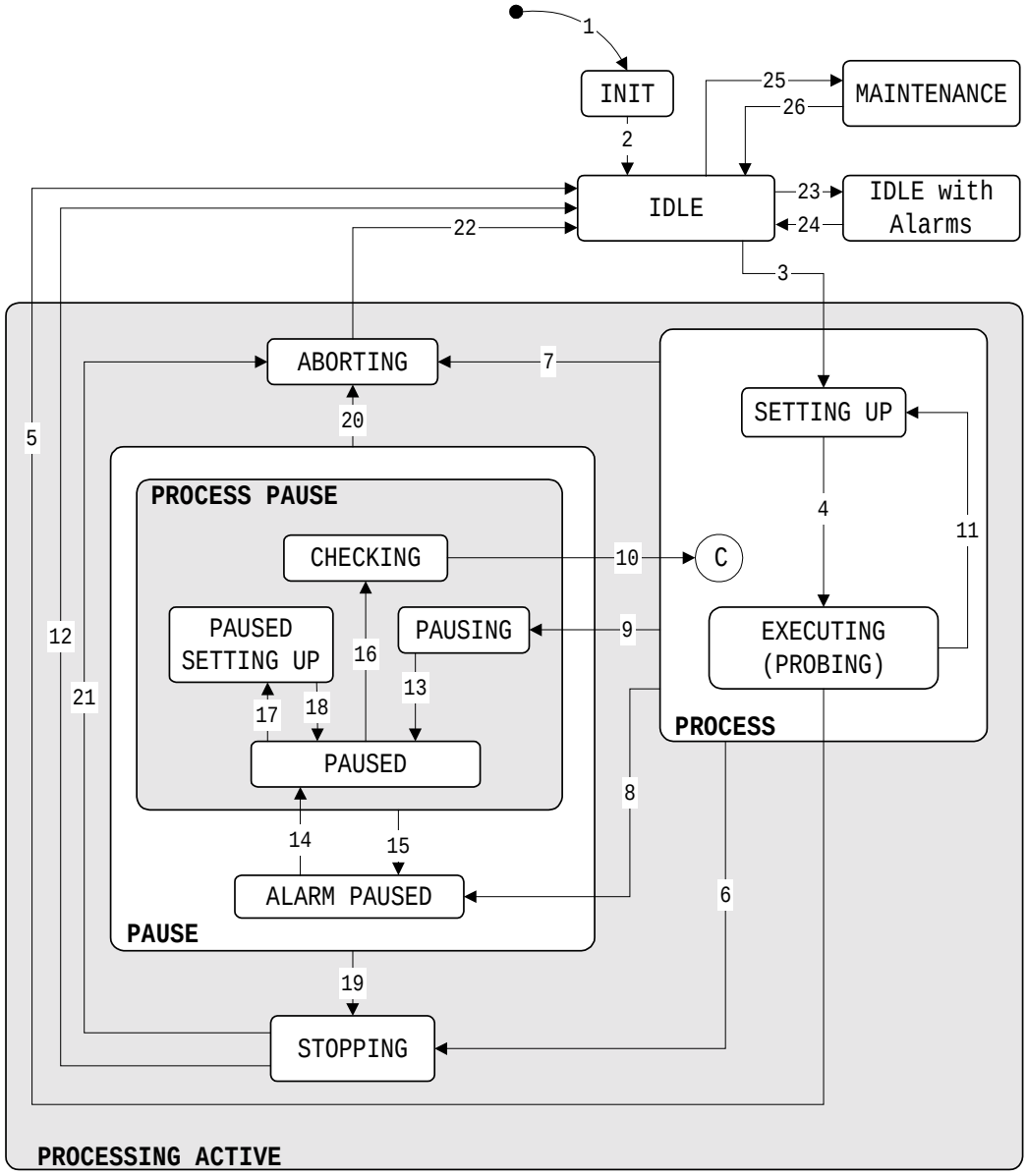

Figure 2
PSEM Processing State Model Diagram

5.2.3 *Description of Prober Processing States*

5.2.3.1 *ABORTING (PROCESSING ACTIVE Sub-state)* — The prober has received ABORT command. All activities are suspended. The prober is taking an appropriate action to ensure possible safe state for the prober itself and materials. Wafer data or lot data may be unavailable.

5.2.3.2 *ALARM PAUSED (PAUSE Sub-state)* — An alarm has occurred in PROCESS or PROCESS PAUSE state. The prober is waiting for the alarm to be cleared.

5.2.3.3 *CHECKING (PROCESS PAUSE Sub-state)* — The prober verifies that a process program update performed is valid. This is a procedure same with that taken in SETTING UP state before the prober is ready to transit to READY state. Upon completion of verification, an event will be created if the verification is successfully ended. A transition is made to the process state, based on the process model condition table.

5.2.3.4 *EXECUTING (PROCESS Sub-state)* — The prober is processing material automatically and can continue to do so without external intervention. This state may include interaction with the host or operator.

5.2.3.5 *IDLE* — The prober is waiting for an instruction. IDLE is free of ALARMS and error conditions.

5.2.3.6 *IDLE with ALARMS* — An alarm has occurred in the IDLE state and the prober is waiting for all alarms to be cleared.

5.2.3.7 *INIT* — Prober is in the course of initialization.

5.2.3.8 *MAINTENANCE*

5.2.3.8.1 The operator's instruction has disabled production by the prober.

5.2.3.8.2 Maintenance and inspection of the prober are executed in this state.

5.2.3.9 *PAUSE (PROCESSING ACTIVE Sub-state)* — PROCESS state is interrupted when the processing can be paused. An action to ensure safety of the prober is taken. The prober waits for a command (RESUME, STOP or ABORT) or the alarm to be cleared.

5.2.3.10 *PAUSED (PROCESS PAUSE Sub-state)* — In this state an operator can correct an error as far as the current process program selection is not affected. PROCESS state is suspended and the prober waits for a command (RESUME, STOP or ABORT). In this state, the operator is allowed to correct an error conditions that does not affect the current process program selected. One of such corrective actions that can be taken by the operator is manual alignment of the wafer in process.

5.2.3.11 *PAUSED SETTING UP (PROCESS PAUSE Sub-state)* — When PROCESS state is suspended, the prober is made to perform simple set-up operations. Probe card replacing work and inker replacing work are included in those operations.

5.2.3.12 *PAUSING (PROCESS PAUSE Sub-state)* — PROCESS state is interrupted when the processing can be paused. The prober cannot transit to PAUSED state until safe state is ensured.

5.2.3.13 *PROCESS (PROCESSING ACTIVE Sub-state)* — This state is the parent of those sub-states that refer to the preparation and execution of a process program.

5.2.3.14 *PROCESS PAUSE (PAUSE Sub-state)* — The prober is free of alarm conditions in the PAUSE state.

5.2.3.15 *PROCESSING ACTIVE* — The state in which the prober is processing materials.

5.2.3.16 *SETTING UP (PROCESS Sub-state)* — The prober is trying to satisfy requirements to be able to start processing. This is the state under which the prober has already received a process program and materials to be processed, then has received START command from the host or the operator and is making preparation for the processing according to the process program.

5.2.3.17 *STOPPING (PROCESSING ACTIVE Sub-state)* — The prober has received STOP command and sets up for the stop. All necessary cleanup is completed within this state with regard to material, data, control system, etc. Data is preserved. Any error condition is cleared before exiting from this state.

5.2.4 *PSEM Processing State Transition Table*

Table 1 Processing State Transition Table

No.	*Current State*	*Trigger*	*New State*	*Action*	*Comment*
1	Undefined	After turning the power on, the operator has commanded the prober to perform initialization.	INIT	The prober executes initialization.	None
2	INIT	Initialization of all probers completes without an alarm or error.	IDLE	The prober is waiting for a command by the host or the operator.	None
3	IDLE	Prober Job has been created, and the prober has already received a process program and materials, then has received START command from the host or the operator.	SETTING UP	The prober is set up according to the process program.	None
4	SETTING UP	All set-up performance has completed.	EXECUTING	The prober executes wafer transfer and measuring.	None
5	EXECUTING	Material processing completes.	IDLE	None	None
6	PROCESS	The prober received STOP command.	STOPPING	The prober completes the current wafer or the current die under EXECUTING state and unloads it in accordance with the setting of ECV “StopUnit”.	The prober starts clearing data. Whether or not unloading is executed after the completion of the current wafer or the current die depends on the specification.
7	PROCESS	The prober received ABORT command from operator, host or self generated.	ABORTING	The prober is placed in a safe state.	Wafer data or lot data may be invalid or not available.
8	PROCESS	An alarm occurs.	ALARM PAUSED	PROCESS activity is suspended, the prober is waiting for all alarms to be cleared, STOP or ABORT command.	ALARM PAUSED is PAUSE sub-state.
9	PROCESS	The prober received PAUSE command from the host or the operator.	PAUSING	PROCESS state is suspended when the processing can be stopped. All operations required to put the prober in safe condition are performed.	PAUSING is PROCESS PAUSE sub-state.
10	CHECKING	Parameter checking ends normally.	Previous PROCESS state.	Processing re-starts from the previously suspended state.	None