Background Statement for SEMI Draft Document 6835

LINE ITEM REVISION TO SEMI E87-0921 SPECIFICATION FOR CARRIER MANAGEMENT (CMS) and SEMI E87.1-0921 SPECIFICATION FOR SECS-II PROTOCOL FOR CARRIER MANAGEMENT (CMS)

NOTICE: This Background Statement is not part of the balloted item. It is provided solely to assist the recipient in reaching an informed decision based on the rationale of the activity that preceded the creation of this ballot.

NOTICE: For each Reject Vote, the Voter shall provide text or other supportive material indicating the reason(s) for disapproval (i.e., Negative[s]), referenced to the applicable section(s) and/or paragraph(s), to accompany the vote.

NOTICE: Recipients of this ballot are invited to submit, with their Comments, notification of any relevant patented technology, copyrighted items, or trademarks of which they are aware and to provide supporting documentation. In this context, 'patented technology' is defined as technology for which a patent has been issued or has been applied for. In the latter case, only publicly available information on the contents of the patent application is to be provided.

NOTICE: Additions are indicated by underline and deletions are indicated by ~~strikethrough~~.

Background

SEMI E87-0619 added the Carrier Ready to Unload Prediction (CaRTUP) functionality, which defines a state model on the carrier object to indicate it's prediction for when it will enter the Ready to Unload state.

Implementers have identified some issues where it is not clear what the expected behavior in fully automated scenarios interacting with the Factory Automation (FA) Host (using Equipment Based Verification and Host Based Verification).

Proposed changes do not modify the current Carrier State Model defined in SEMI E87-0921.

What is the problem being solved?

This Line Item Revision aims to address issues found with SEMI E87's Carrier Ready to Unload functionality and clarify things to help the reader. It also addresses missing information in the Compliance Table to help its usefulness.

Scope

This ballot proposal contains the following line items:

- Line Item #1: Improve Carrier Ready to Unload Prediction (CaRTUP) functionality.
- Line Item #2: Update CMS Compliance Statement to include missing information.

SEMI E87 is the primary standard. It will be updated as part of this Line Item Revision ballot.

SEMI E87.1 is the only subordinate standard. It will be updated as part of this ballot and will be compatible with the revised primary Standard.

What is the history of this issue and ballot?

➔ This is the first time the ballot has been issued.

Who will this affect? How? Why?

➔ This ballot will affect anyone using the Carrier Ready to Unload (CaRTUP) functionality of SEMI E87.

Is this a change to an existing solution, or, is it a new activity?

➔ These are changes to existing Specifications.

Revision Control

This revision control records activity within the task force as well as formal submit and resubmit dates and results per SEMI. Entries have been made by the task force.

Date	*Version*	*Name*	*Edits*
January 16, 2023	1.0	Albert Fuchigami	Initial Draft of the ballot
January 27, 2023	1.1	Brian Rubow	Added content to include missing Access Mode State Model to the Compliance Table.
February 1, 2023	1.2	Albert Fuchigami	Moved Access Mode State Model change to new Line Item #2, and added missing Section 15 and 17 items. Added new CaRTU Calculated event and updated CaRTUPredictedTime attribute to be updated when this event is raised at Tc Integrated TF Member feedback and corrected issues.
March 1, 2023	1.3	Michelle Sun	Converted draft to Informational Ballot format

Review Information

Please submit your feedback to:

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If you wish to submit feedback on this ballot, please do so by **March 29, 2023**.

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INFORMATIONAL BALLOT

SEMI Draft Document 6835

LINE ITEM REVISION TO SEMI E87-0921 SPECIFICATION FOR CARRIER MANAGEMENT (CMS) and SEMI E87.1-0921 SPECIFICATION FOR SECS-II PROTOCOL FOR CARRIER MANAGEMENT (CMS)

1 Line Item #1: Improve Carrier Ready to Unload Prediction (CaRTUP) functionality.

1.1 Proposal – Update sections related to Carrier Ready to Unload Prediction to make things clearer to implementers. Changes include:

- Define new Carrier Attribute CaRTUPredictedTime to report the predicted time the carrier will be ready to unload (Tp), and corresponding variables.
- Defined new CaRTU Calculated event to indicate when predicted CaRTU time (Tp) has been calculated.
- Clarify how various prediction times are calculated and what triggers various Carrier Ready To Unload Prediction Status state model transitions.
- Add new Related Information Section R3-4 to Related Information 3 CARRIER READY TO UNLOAD PREDICTION to describe scenarios how various Tc, Tp, Te and carrier attributes work together to update the Carrier Ready to Unload Prediction Status state model.
- Clarified behavior with carrier prediction when the carrier is cancelled.
- Change Carrier Ready to Unload acronym CRTU to CaRTU to be consistent with attribute names.

1.2 Changes to SEMI E87.

For brevity, not all section contents are listed – just enough to provide context and clarifications where the changes should occur

- Update Terminology with new acronym, clarify collection event and add new CaRTU Calculated Event.

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *AMHS* — automated material handling system

5.1.2 ~~*CRTU*~~ *CaRTU*— carrier ready to unload

5.1.3 *CaRTUP* – carrier ready to unload prediction

5.1.4 *FIMS* — front-opening interface mechanical standard

5.2.8 *carrier ready to unload (~~CRTU~~ CaRTU)* — the state in which a carrier is ready to be unloaded from the equipment.

5.2.9 *CaRTU Calculated Event* — the collection event raised when the equipment has calculated the predicted CaRTU time (Tp).

5.2.10 ~~*CRTU*~~ *CaRTU Prediction (CaRTUP)*— the process that detects and reports the CRTU Calculated and Prediction Event to the host.

5.2.11 ~~*CRTU*~~ *CaRTU Prediction Event (Prediction Event)* — the collection event raised that a carrier has been ~~estimated~~ predicted to come ~~*CRTU*~~ *CaRTU* within specified time later.

- Update Table 6 with new acronym and define new carrier attribute CaRTUPredictedTime.

Table 6 Carrier Attribute Definition

Attribute Name	*Definition*	*Access*	*Reqd*	*Form*
CaRTUPStatus	State of the ~~CRTU~~ CaRTU Prediction of the carrier. This attribute is required only when ~~CRTU~~ CaRTU Prediction is implemented.	RO	N	Enumerated: PREDICTION DISABLED, WAITING FOR CARRIER, WAITING FOR PREDICTION, PREDICTED, PREDICTION ABORTED, PREDICTION COMPLETED.
CaRTUPredictedTime	CaRTU Predicted Time This attribute is required only when CaRTU Prediction is implemented. This attribute is populated with the predicted CaRTU time (Tp) when the carrier will be ready to unload.	RO	N	The format of the timestamp is defined by the protocol for implementation. If the predicted time is not available, the attribute is an empty string.
CaRTUPSettingTime	~~CRTU~~ CaRTU Prediction Setting Time. This attribute is required only when ~~CRTU~~ CaRTU Prediction is implemented. This attribute specifies the lead time (in seconds) for ~~detecting~~ sending the ~~CRTU~~ CaRTU Prediction Event. The ~~CRTU~~ CaRTU Prediction Event is ~~detected~~ sent when the current time reaches within the lead time to ~~CRTU~~ CaRTU time of the carrier ~~estimated~~ predicted by equipment. If this attribute is set to 0 (zero), the ~~CRTU~~ CaRTU Prediction is disabled (i.e., goes into PREDICTION DISABLED state).	RO	N	Non-negative integer. Default value = 0.
CaRTUPTimeOut	~~CRTU~~ CaRTU Prediction Time Out. This attribute is required only when ~~CRTU~~ CaRTU Prediction is implemented. This attribute specifies the maximum time allowed to wait for the ~~CRTU~~ CaRTU after the predicted ~~CRTU~~ CaRTU time Tp. If this time elapses after the predicted ~~CRTU~~ CaRTU time Tp and the carrier is still not ready to be unloaded, the carrier object shall be into 'PREDICTION ABORTED' state to inform the prediction is no longer effective. If this attribute is set to 0 (zero), the abort condition is not checked, and the carrier stays in PREDICTED state until unloaded.	RO	N	Non-negative integer. Default value = 0.

- Update Rules for Carrier Ready to Unload Prediction to include new carrier attribute CaRTUPredictedTime

10.3.8 *Rules for Carrier Ready To Unload Prediction Attributes*

10.3.8.1 Rules in this section apply to the optional attributes, additionally to the rules in § 10.3.5, when the ~~CRTU~~ CaRTU Prediction is implemented.

- The equipment shall maintain and update the object attribute CaRTUPStatus.
- When the equipment calculates the predicted CaRTU time (Tp), the object attribute CaRTUPredictedTime shall be updated with the predicted time. The equipment shall not change the CaRTUPredictedTime attribute once it has been set.

- Update Section 10.7.3 with new acronyms

10.7.3. *Carrier State Definitions*

10.7.3.1 *CARRIER* — The CARRIER state has three fundamental states of CARRIER ID STATUS, CARRIER SLOT MAP STATUS and CARRIER ACCESSING STATUS, and an additional state CARRIER READY TO UNLOAD PREDICTION STATUS. The Additional state is required only when the ~~CRTU~~ CaRTU Prediction is implemented.

- Update Table 7 with new acronyms and updates to support behavior when cancelling the carrier.

Table 7 Carrier State Transition Definition

INFORMATIONAL BALLOT

#	*Previous State*	*Trigger*	*New State*	*Actions*	*Comment*
23	WAITING FOR CARRIER	(1) Carrier attribute CaRTUPSettingTime is not set to 0 (zero) and the ~~The~~ CARRIER ACCESSING STATUS is "IN ACCESS" ~~and the Carrier attribute CaRTUPSettingTime is not set to 0 (zero).~~, or (2) Carrier attribute CaRTUPSettingTime is not set to 0 (zero) and the carrier is cancelled	WAITING FOR PREDICTION	Start ~~estimation of~~ calculating the ~~CRTU~~ predicted CaRTU time (Tp) ~~to detect the Prediction Event~~	Data required to be available for this event report: PortID (if valid), CarrierID
24	WAITING FOR PREDICTION	The ~~estimated CRTU~~ calculated predicted CaRTU time (Tp) is within the specified lead time (CaRTUPSettingTime) from the current time.	PREDICTED	~~Stop updating Tp to preserve the value, and start estimation of CRTU~~ Continue recalculating estimated CaRTU time (Te) to detect the abort condition	Refer to § 10.7.8.4 for the detail condition for the Prediction. Data required to be available for this event report: PortID, CarrierID, CaRTUPredictedTime
25	PREDICTED	The carrier is ready to be unloaded.	PREDICTION COMPLETED	Stop ~~the estimation of CRTU~~ recalculated the estimated CaRTU time (Te).	Data required to be available for this event report: PortID, CarrierID, CaRTUPActualTime
26	WAITING FOR CARRIER	(1) Carrier attribute CaRTUPSettingTime is set to 0 (zero) and the ~~The~~ CARRIER ACCESSING STATUS is 'IN ACCESS' ~~and the Carrier attribute CaRTUPSettingTime is set to 0 (zero).~~, or (2) Carrier attribute CaRTUPSettingTime is set to 0 (zero) and the Carrier is cancelled	PREDICTION DISABLED	None.	Data required to be available for this event report: PortID (if valid), CarrierID
27	WAITING FOR PREDICTION	(1) ~~CRTU~~ CaRTU Prediction is not available for any reason with the equipment or, (2) For internal buffer equipment, the load port for the unload is changed.	PREDICTION ABORTED	None.	Refer to § 10.7.8.5 for the detail condition of the PREDICTION ABORTED. Data required to be available for this event report: PortID (if valid), CarrierID, CaRTUPAbortedReason

28	PREDICTED	(1) The estimated ~~CRTU~~ CaRTU time (Te) in this state exceeded CaRTUPTimeOut after the predicted ~~CRTU~~ CaRTU time (Tp), or (2) For internal buffer equipment, the load port associated to the carrier is changed.	PREDICTION ABORTED	None.	Refer to § 10.7.8.5 for the detail condition of the PREDICTION ABORTED. Data required to be available for this event report: PortID, CarrierID, CaRTUPAbortedReason
29	PREDICTION ABORTED	The carrier is ready to be unloaded.	PREDICTION COMPLETED	None.	Data required to be available for this event report: PortID, CarrierID

- Update Section 10.7.8 with new acronyms and clarify time and prediction functionality.

10.7.8 *Carrier Ready To Unload (~~CRTU~~ CaRTU) Prediction Details*

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

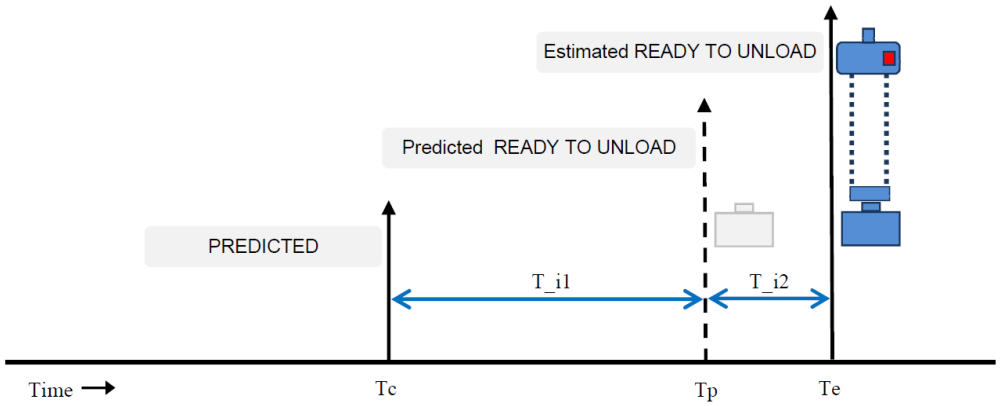

Figure 1
Carrier Ready To Unload Prediction Behavior

10.7.8.2 Figure 3 shows how the equipment predicts the time when a certain carrier can be unloaded.

~~In the figure, the Tc represents the time at which the equipment is predicting the event that a carrier will be 'READY TO UNLOAD' on a load port. At the Tc, the equipment calculates the predicted time Tp at which the carrier will be ready for pickup to determine the Prediction Event. After this time Tc, the equipment calculates continually the estimated time Te at which the carrier can be picked up after the Tp. T_i1 represents the time difference between the current time Tc and the predicted time Tp for the detection of the Prediction Event. T_i2 represents the time difference between predicted time Tp and the time Te estimated after the Tp.~~

10.7.8.2.1 Tc: The time of the condition calculation, where the equipment predicts when the carrier will be ready to unload at the loadport and shares this information with the host.

8.7.8.2.1.1 The equipment raises the CaRTU Calculated Event and populates the carrier's CaRTUPredictedTime attribute.

8.7.8.2.1.2 The CaRTUPredictedTime data is required to be available for the CaRTU Calculated Event.

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10.7.8.2.2 Tp: The predicted CaRTU time when the carrier's load port ~~-~~will be READY TO UNLOAD, calculated at Tc.

10.7.8.2.2.1 How the equipment calculates Tp is an implementation detail.

10.7.8.2.2.2 The Tp value does not change once it has been calculated at Tc as it will be used to determine when the carrier enters the PREDICTED, PREDICTION COMPLETED and PREDICTION ABORTED states.

10.7.8.2.2.3 To be effective, Tp should never be calculated to occur in the past (i.e. before the current time). Otherwise, the equipment will transition to PREDICTED, PREDICTION COMPLETED and PREDICTION ABORTED states right away, reducing the usefulness of the CaRTUP functionality.

10.7.8.2.3 Te: The estimated time when the carrier's load port ~~-~~will be READY TO UNLOAD, after Tp was calculated at ~~after~~ Tc.

10.7.8.2.3.1 The equipment may choose to recalculate the estimated CaRTU time (Te), reflecting what is happening on the equipment since the original prediction was calculated. This value is used to determine if the prediction made at Tc is no longer valid and the host should be notified.

10.7.8.2.3.2 This value is internal to the equipment and is not shared with the host.

10.7.8.2.3.3 If the equipment is not explicitly recalculating the estimated time, the estimated time becomes the current time after the predicted CaRTU time (Tp) has passed.

NOTE 2: The choice to recalculate Te is an implementation detail. If the equipment is continuously recalculating Te, it has to balance the performance cost of recalculating the estimate and the accuracy of the updated estimate.

10.7.8.2.4 T_i1: The time interval in seconds between ~~Tc~~ the current time and the predicted time the carrier will be ready to unload ~~Tp~~ (T_i1 = Tp – ~~Tc~~ current time)

10.7.8.2.5 T_i2: The time interval in seconds between ~~Tp and Te~~ the predicted time the carrier will be ready to unload and currently estimated time the carrier will be ready to unload (after the prediction time has passed) (T_i2 = Te – Tp).

10.7.8.2.6 Figure 4 shows the relationship between the CaRTU Calculated Event, CaRTU Prediction Event and the Carrier Ready to Unload Prediction Status states.

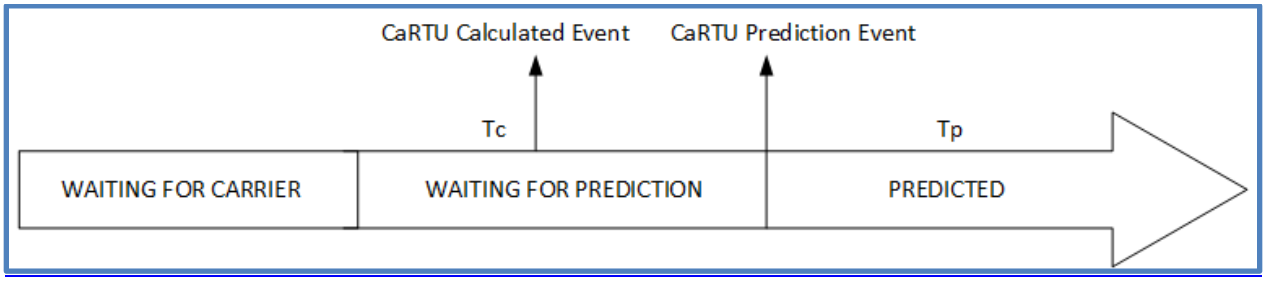

Figure 4
Carrier Ready To Unload Prediction Related Events

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

10.7.8.3.1 *CaRTUPSettingTime — Carrier Ready To Unload Prediction Setting Time*. This attribute describes the time difference (in seconds) between host notification (through transition to the PREDICTED state) and the anticipated readiness for carrier unload.

10.7.8.3.2 *CaRTUPTimeOut — Carrier Ready To Unload Prediction Time Out.* This attribute specifies the maximum time difference between originally anticipated time for the carrier's ready to unload and the current time. If this time elapses and the carrier is still not ready for unloading, the carrier object shall transition from the PREDICTED to the PREDICTION ABORTED state. If this time is set to 0 (zero), the equipment does not check T_i2 for the condition of the PREDICTION ABORTED state.

10.7.8.4 *Condition for the PREDICTED* — This state shall be assumed, when ALL of the following conditions have been fulfilled:

- T_i1 ≤ CaRTUPSettingTime, that is, the CARRIER READY TO UNLOAD PREDICTION state model shall transition to the PREDICTED state whenever the equipment determines that the currently predicted time at which the carrier is ready to unload is smaller than or equal to the CaRTUPSettingTime later than the current time.
- The equipment has determined the load port at which the carrier will be ready for unload.

10.7.8.4.1 For internal buffer equipment, the equipment is required to predict one carrier per load port at one time. Each of the carriers queued to a load port shall remain in the WAITING FOR PREDICTION state until the carrier currently in the load port is removed.

10.7.8.5 *Condition for the PREDICTION ABORTED* — this state shall be assumed, when at least one of the following conditions is fulfilled:

- If the CARRIER READY TO UNLOAD PREDICTION status is WAITING FOR PREDICTION and the equipment can't ~~estimate~~ calculate the time for READY TO UNLOAD (caused by a problem on the equipment.)
- T_i2 ≥ CaRTUPTimeOut, i.e. ~~In the PREDICTED state~~, the estimated time of the carrier getting ready for unloading is greater than or equal to the time specified in CaRTUPTimeOut past the predicted time.
- For internal buffer equipment, the equipment has changed the load port at which the carrier will be ready for unload.

10.7.8.6 *Cancelling a Carrier* - When a carrier is cancelled (though the CancelCarrier or CancelCarrierAtPort service), the equipment will transition from the WAITING FOR CARRIER state to a final CARRIER READY TO UNLOAD PREDICTION state.

10.7.8.6.1 If the CaRTUPSettingTime is 0 (zero), the Carrier goes to the PREDICTION DISABLED state.

10.7.8.6.2 If the CaRTUPSettingTime is not set to 0 (zero), Tp is set to the current time. This results in the equipment goes to the WAITING FOR PREDICTION state, then to the PREDICTED state and then the PREDICTION COMPLETED state.

- Update Table 37 with new acronyms and variables corresponding to the new carrier attribute CaRTUPredictedTime.

Table 37 Variable Data Definitions

Variable Name	*Description*	*Type*	*Access*	*Comment*
CaRTUPStatus	State of the ~~CRTU~~ CaRTU Prediction of a carrier.	Enumerated: PREDICTION DISABLED, WAITING FOR CARRIER, WAITING FOR PREDICTION, PREDICTED, PREDICTION ABORTED, PREDICTION COMPLETED	RO	This variable is required only when ~~CRTU~~ CaRTU Prediction is implemented.

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Variable Name	*Description*	*Type*	*Access*	*Comment*
CaRTUPStatusi	State of the ~~CRTU~~ CaRTU Prediction of the carrier associated with the ith load port.	Enumerated: PREDICTION DISABLED, WAITING FOR CARRIER, WAITING FOR PREDICTION, PREDICTED, PREDICTION ABORTED, PREDICTION COMPLETED	RO	This variable is required only when ~~CRTU~~ CaRTU Prediction is implemented. A load port that is not associated with a carrier has a PREDICTION DISABLED value.
CaRTUPredictedTime	Predicted time the carrier will be ready to unload.	The format of the timestamp is defined by the protocol for implementation.	RO	This variable is required only when CaRTU Prediction is implemented. The variable has a non-empty value once the equipment has calculated the predicted CaRTU time (Tp). Otherwise the variable is an empty string.
CaRTUPredicted Timei	Predicted time the carrier associated with the ith load port will be ready to unload.	The format of the timestamp is defined by the protocol for implementation.	RO	This variable is required only when CaRTU Prediction is implemented. A load port that is not associated with a carrier has an empty value. The variable has a non-empty value once the equipment has calculated the predicted CaRTU time (Tp) for the carrier. Otherwise the variable is an empty string.
CaRTUPSettingTime	~~CRTU~~ CaRTU Prediction Setting Time (in seconds) specified for a carrier.	Non-negative integer	RO	This variable is required only when ~~CRTU~~ CaRTU Prediction is implemented. Value of 0 (zero) indicates no ~~CRTU~~ CaRTU Prediction is applied
CaRTUPTimeOut	~~CRTU~~ CaRTU Prediction Expiration Lead Time (in second) specified for a carrier.	Non-negative integer	RO	This variable is required only when ~~CRTU~~ CaRTU Prediction is implemented. A value of 0 (zero) indicates no ~~CRTU~~ CaRTU Prediction Expiration is applied.
CaRTUPActualTime	Difference of time (in seconds) from the ~~Prediction Event~~ predicted time carrier will be ready to unload (Tp) to the ~~real~~ ~~CRTU~~ actual time the carrier was ready to unload.	Non-negative integer	RO	This variable is required only when ~~CRTU~~ CaRTU Prediction is implemented.

Variable Name	*Description*	*Type*	*Access*	*Comment*
CaRTUPAborted Reason	The reason for the transition to the PREDICTION ABORTED state.	Text	RO	This variable is required only when ~~CRTU~~ CaRTU Prediction is implemented. Information to aid host in deciding appropriate action. The reason is defined by the equipment supplier.

- Update Table 39 with new acronyms.

Table 39 CMS Compliance Statement

Fundamental CMS Requirements	*CMS Section*	*Implemented*	*CMS Compliant*
Carrier Object Implementation (Except additional option capabilities, see the Additional CMS Capabilities (Carrier Ready To Unload ~~[CRTU~~ *(CaRTU*] Prediction) below in this table for the exception.)	10	☐ Yes ☐ No	☐ Yes ☐ No

Fundamental CMS Requirements	*CMS Section*	*Implemented*	*CMS Compliant*
Reservation Visible Signal	12.2	☐ Yes ☐ No	☐ Yes ☐ No
Carrier Ready To Unload (~~CRTU~~ *CaRTU*) Prediction (including following requirements)			
• Attributes for ~~CRTU~~ CaRTU Prediction in Table 6	10.3.4		
• CARRIER READY TO UNLOAD PREDICTION STATUS in Table 2	10.7.2		
• CARRIER READY TO UNLOAD PREDICTION STATUS in Carrier State Definition	10.7.3	☐ Yes ☐ No	☐ Yes ☐ No
• Rules for Carrier Ready To Unload Attributes	10.3.6		
• Carrier Ready To Unload Prediction Detail	10.7.8		
• Variables for ~~CRTU~~ CaRTU Prediction in Table 37	19.2		

- Add new Related Information Section R3-4 to Related Information 3 CARRIER READY TO UNLOAD PREDICTION to describe how various Tc, Tp, Te and carrier attributes work to update the Carrier Ready to Unload Prediction Status state model.

R3-4 Carrier Ready to Unload Prediction Examples

R3-4.1 The following scenarios describe how the Carrier Ready to Unload Prediction work.

R3-4.1.1*Carrier Is Ready To Unload Before Predicted Time Scenario*

R3-4.1.1.1Preconditions: CaRTUPSettingTime is 60 seconds, CaRTUPTimeOut is 120 seconds. Carrier is IN ACCESS and WAITING FOR PREDICTION states.

Table R3-1 Carrier is ready to unload before predicted time

#	*Timestamp*	*Trigger*	*Result*
1	9:00:00	Time = Tc	Equipment calculates Tp = 9:05:00. CaRTU Calculation Event is sent to the host..
2	9:04:00	Ti_1 <= CaRTUPSettingTime (T_i1 = Tp-T)	Carrier goes into PREDICTED state because the current time <= Tp – CARTUPSetting Time. Prediction Event is sent to the host.
3	9:04:30	Carrier goes into READYTOUNLOAD State	Carrier goes into PREDICTION COMPLETED state CaRTUPActualTime = Difference between Actual READY TO UNLOAD time and Tp = Difference between 9:04:30 and 9:05:00 = 30sec

R3-4.1.2 *Carrier Is Ready To Unload After Predicted Time But Before Timeout Scenario*

R3-4.1.2.1 Preconditions: CaRTUPSettingTime is 60 seconds, CaRTUPTimeOut is 120 seconds. Carrier is IN ACCESS and WAITING FOR PREDICTION states. Equipment is not continuously recalculating Te. (so after Tp has passed, Te is the current time value)

Table 3-2 Carrier is ready to unload after predicted time but before timeout

#	*Timestamp*	*Trigger*	*Result*
1	9:00:00	Time = Tc	Equipment calculates Tp = 9:05:00. CaRTU Calculation Event is sent to the host.
2	9:04:00	Ti_1 <= CaRTUPSettingTime	Carrier goes into PREDICTED state because the current time <= Tp – CARTUPSetting Time. Prediction Event is sent to the host.
3	9:04:45	Carrier goes into ReadyToUnload State	Carrier goes into PREDICTION COMPLETED state CaRTUPActualTime = Difference between Actual READY TO UNLOAD time and Tp = Difference between 9:05:45 and 9:05:00 = 45sec

R3-4.1.3 *Carrier Is Not Ready To Unload After Timeout Period Scenario*

R-34.1.3.1 Preconditions: CaRTUPSettingTime is 60 seconds, CaRTUPTimeOut is 120 seconds. Carrier is IN ACCESS and WAITING FOR PREDICTION states. Equipment is not continuously recalculating Te. (so after Tp has passed, Te is the current time value)

Table R3-3 Carrier is not ready to unload after timeout period

#	*Timestamp*	*Trigger*	*Result*
1	9:00:00	Time = Tc	Equipment calculates Tp = 9:05:00. CaRTU Calculation Event is sent to the host.
2	9:04:00	Ti_1 <= CaRTUPSettingTime	Carrier goes into PREDICTED state because the current time <= Tp – CARTUPSetting Time. Prediction Event is sent to the host.
3	9:05:00	Time = Tp Carrier is not Ready to Unload	<None>
4	9:07:00	Ti_2 >= CaRTUPTimeOut	Carrier goes into PREDICTION ABORTED state because the time difference between the current time and predicted time (Tp) exceeds the CaRTUPTimeout value. i.e. Te (9:07:00) – Tp (9:05:00) >= CaRTUPTimeout (120sec)

R3-4.1.4 *New Estimated Carrier Ready To Unload Time Exceeds Timeout Period Before Prediction Time Scenario*

R3-4.1.4.1 Preconditions: CaRTUPSettingTime is 60 seconds, CaRTUPTimeOut is 120 seconds. Carrier is IN ACCESS and WAITING FOR PREDICTION states. Equipment is continuously recalculating Te.

Table R3-4 New Estimated Carrier Ready To Unload Time exceeds Timeout Period Before Prediction Time

#	*Timestamp*	*Trigger*	*Result*
1	9:00:00	Time = Tc	Equipment calculates Tp = 9:05:00. CaRTU Calculation Event is sent to the host.
2	9:01:00	New estimate calculated	Equipment recalculates Te = 9:10:00. Carrier goes into PREDICTION ABORTED state because the time difference between the estimated time (Te) and predicted time (Tp) exceeds the CaRTUPTimeout value. i.e. Te (9:10:00) – Tp (9:05:00) is 300sec and that exceeds CaRTUPTimeout (120sec)

NOTE 5: If the equipment does not want the carrier to go into the PREDICTION ABORTED state in Step #2, it should not use Te=9:10:00 as its recalculated estimate. Transitioning from WAITING FOR PREDICTION state to PREDICATED ABORTED state gives the host notice that the predicted CaRTU time (Tp) is unlikely to be achieved.

R3-4.1.5 *New Estimated Carrier Ready To Unload Time Exceeds Timeout Period After Prediction Time Scenario*

R3-4.1.5.1 Preconditions: CaRTUPSettingTime is 60 seconds, CaRTUPTimeOut is 120 seconds. Carrier is IN ACCESS and WAITING FOR PREDICTION states. Equipment is continuously recalculating Te.

Table R3-5 New Estimated Carrier Ready To Unload Time Exceeds Timeout Period After Prediction Time

#	*Timestamp*	*Trigger*	*Result*
1	9:00:00	Time = Tc	Equipment calculates Tp = 9:05:00. CaRTU Calculation Event is sent to the host.
2	9:04:00	Ti_1 <= CaRTUPSettingTime	Carrier goes into PREDICTED state because the current time <= Tp – CARTUPSetting Time. Prediction Event is sent to the host.
3	9:05:00	Time = Tp Carrier is not Ready to Unload	<None>
4	9:05:15	New estimate calculated	Equipment recalculates Te = 9:10:00. Carrier goes into PREDICTION ABORTED state because the time difference between the estimated time (Te) and predicted time (Tp) exceeds the CaRTUPTimeout value. i.e. Te (9:10:00) – Tp (9:05:00) is 300sec and that exceeds CaRTUPTimeout (120sec)

R3-4.1.6 *Carrier Ready To Unload In The Past Scenario 1* – The prediction time is calculated to be in the past and has not exceeded the CaRTUPTimeout value for the Carrier.

R3-4.1.6.1 Preconditions: CaRTUPSettingTime is 60 seconds, CaRTUPTimeOut is 120 seconds. Carrier is IN ACCESS and WAITING FOR PREDICTION states. Equipment is continuously recalculating Te.

R3-4.1.6.2 This scenario should not occur. Tp should always be in the future.

Table R3-6 Carrier Ready To Unload In The Past – Scenario 1

#	*Timestamp*	*Trigger*	*Result*
1	9:00:00	Time = Tc	Equipment calculates Tp = 8:59:00. CaRTU Calculation Event is sent to the host.
2	9:00:00	Ti_1 <= CaRTUPSettingTime	Immediately afterwards, Carrier goes into PREDICTED state because the current time <= Tp – CARTUPSetting Time. Prediction Event is sent to the host.

R3-4.1.7 *Carrier Ready To Unload In The Past Scenario 2* – The prediction time is calculated in the past and exceeds the CaRTUPTimeout value for the carrier.

R3-4.1.7.1 Preconditions: CaRTUPSettingTime is 60 seconds, CaRTUPTimeOut is 120 seconds. Carrier is IN ACCESS and WAITING FOR PREDICTION states. Equipment is continuously recalculating Te.

R3-4.1.7.2 This scenario should not occur. Tp should always be in the future

Table R3-7 Carrier Ready To Unload In The Past – Scenario 2

#	*Timestamp*	*Trigger*	*Result*
1	9:00:00	Time = Tc	Equipment calculates Tp = 8:57:30. CaRTU Calculation Event is sent to the host.
2	9:00:00	Ti_2 >= CaRTUPTimeOut	Immediately, Carrier goes into PREDICTION ABORTED state because the time difference between the current time and predicted time (Tp) exceeds the CaRTUPTimeout value. i.e. Te (8:57:30) – Tp (8:57:30) >= CaRTUPTimeout (120sec)

1.2 Changes to SEMI E87.1

For brevity, not all section contents are listed – just enough to provide context and clarifications where the changes should occur

- Add mapping for new CaRTUPredictedTime and CaRTUPredictedTimei variables.

Table 4 Variable Data Item Mapping Table

Variable Name	*Class*	*Format*
CaRTUPStatus	DVVAL	Format Code 51 Enumerated as: 0 = PREDICTION DISABLED 1 = WAITING FOR CARRIER 2 = WAITING FOR PREDICTION 3 = PREDICTED 4 = PREDICTION ABORTED 5 = PREDICTION COMPLETED
CaRTUPStatus$_i$	SV	Format Code 51 Enumerated as: 0 = PREDICTION DISABLED 1 = WAITING FOR CARRIER 2 = WAITING FOR PREDICTION 3 = PREDICTED 4 = PREDICTION ABORTED 5 = PREDICTION COMPLETED
CaRTUPredictedTime	DV	Format Code 20 Formatted per TIMESTAMP SECS-II data item
CaRTUPredictedTimei	SV	Format Code 20 When predicted time is calculated, it is formatted per TIMESTAMP SECS-II data item. Otherwise it is an empty string.
CaRTUPSettingTime	DVVAL	Format Code 54
CaRTUPTimeOut	DVVAL	Format Code 54
CaRTUPActualTime	DVVAL	Format Code 54

- Add mapping for new carrier attribute CaRTUPredictedTime

INFORMATIONAL BALLOT

Table 5 Carrier Object Attribute Definitions

Attribute Name	*Attribute Data Form: SECS-II Structure*
CaRTUPStatus	Format Code 51 CaRTUPStatus CaRTUPStatus enumerated per variable CaRTUPStatus
CaRTUPredictedTime	FormatCode 20 CaRTUPredictedTime When predicted time is calculated, it is formatted per TIMESTAMP SECS-II data item. Otherwise it is an empty string.
CaRTUPSettingTime	Format Code 54 CaRTUPSettingTime
CaRTUPTimeOut	Format Code 54 CaRTUPTimeOut

6 Line Item #2: Update CMS Compliance Statement to include missing information.

6.1 Proposal – Update CMS Compliance Statement Table to include sections defined in the SEMI E87 Specification but not included in the table.

6.2 Changes to SEMI E87.

For brevity, not all section contents are listed – just enough to provide context and clarifications where the changes should occur

- Update Table 39 with the following changes:
  - Access Mode State Model from section 11 as Fundamental CMS Requirements
  - Carrier Release Control from section 15 as Additional CMS Capabilities
  - Carrier Tag Read/Write from section 17 as Additional CMS Capabilities.

Table 39 CMS Compliance Statement

Fundamental CMS Requirements	*CMS Section*	*Implemented*	*CMS Compliant*
Carrier Object Implementation (Except additional option capabilities, see the Additional CMS Capabilities (Carrier Ready To Unload [*CRTU*] Prediction) below in this table for the exception.)	10	☐ Yes ☐ No	☐ Yes ☐ No
Access Mode State Model	11	☐ Yes ☐ No	☐ Yes ☐ No
Load Port Reservation State Model (internal buffer equipment)	12	☐ Yes ☐ No	☐ Yes ☐ No

Additional CMS Capabilities	CMS Section	Implemented	CMS Compliant
Load Port Reservation State Model (fixed buffer equipment)	12	☐ Yes ☐ No	☐ Yes ☐ No
Reservation Visible Signal	12.2	☐ Yes ☐ No	☐ Yes ☐ No
Carrier Ready To Unload (*CRTU*) Prediction (including following requirements) • Attributes for CRTU Prediction in Table 6 • CARRIER READY TO UNLOAD PREDICTION STATUS in Table 2 • CARRIER READY TO UNLOAD PREDICTION STATUS in Carrier State Definition	 10.3.4 10.7.2 10.7.3	 ☐ Yes ☐ No	 ☐ Yes ☐ No

• Rules for Carrier Ready To Unload Attributes • Carrier Ready To Unload Prediction Detail • Variables for CRTU Prediction in Table 37	10.3.6 10.7.8 19.2		
Carrier Release Control	15	☐ Yes ☐ No	☐ Yes ☐ No
Carrier Tag Read/Write	17	☐ Yes ☐ No	☐ Yes ☐ No

INFORMATIONAL BALLOT

The rest of this document is material that is called out in the procedure guide as part of the ballot, but is not part of the balloted change.

NOTICE: Per section 3.4.3.3.1 of the SEMI Standards Procedure Guide, the purpose, scope, limitations and terminology sections are included.

SEMI E87-0921
SPECIFICATION FOR CARRIER MANAGEMENT (CMS)

This Standard was technically approved by the Information & Control Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on April 30, 2021. Available at www.semiviews.org and www.semi.org in September 2021; originally published in 1999; previously published February 2020.

NOTICE: Paragraphs entitled 'NOTE:' are not an official part of this Standard or Safety Guideline and are not intended to modify or supersede the official Standard or Safety Guideline. These have been supplied by the global technical committee to enhance the usage of the Standard or Safety Guideline.

NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (¶) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and ¶¶) the symbols are used to reference more than one section or paragraph, respectively.

1 Purpose

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

2 Scope

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

2.2 This Specification defines standards that facilitate the host's knowledge and role in automated and manual carrier transfers, as well as internal buffer equipment carrier transfers. Specifically, this Specification provides state models and scenarios that define the host interaction with the equipment for the following:

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

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

3 Limitations

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

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

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

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

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

SEMI E40 — Specification for Processing Management

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

SEMI E90 — Specification for Substrate Tracking

SEMI E94 — Specification for Control Job Management

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *AMHS* — automated material handling system

5.1.2 *CRTU*— carrier ready to unload

5.1.3 *FIMS* — front-opening interface mechanical standard

5.1.4 *FOUP* — front opening unified pod

5.1.5 *GEM* — generic equipment model

5.1.6 *PIO* — parallel input/output interface

5.2 *Definitions*

5.2.1 *automated material handling system (AMHS)* — an automated system to store and transport materials within the factory.

5.2.2 *automation* — the degree to which activities of machines or production systems are self-acting.

5.2.2.1 *Discussion* — In this Standard, automation provides methods that will reduce the amount of operator intervention required.

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

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

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

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

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

5.2.8 *carrier ready to unload (CRTU)* — the state in which a carrier is ready to be unloaded from the equipment.

5.2.9 *CRTU Prediction*— the process that detects and reports the CRTU Prediction Event to the host.

5.2.10 *CRTU Prediction Event (Prediction Event)* — the event that a carrier has been estimated to come *CRTU*-within specified time later.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

NOTE 1: This position may vary on any particular equipment depending on the read technology selected by the end user. Some technology/load ports may allow the carrier to be moved during reading. Equipment may have more than one read position.

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

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

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

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

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

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

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

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

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

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

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

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

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INFORMATIONAL BALLOT

SEMI E87.1-0921
SPECIFICATION FOR SECS-II PROTOCOL FOR CARRIER MANAGEMENT (CMS)

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1 Purpose

1.1 This Specification maps the services and data of SEMI E87 to SECS-II streams and functions, and data definitions.

2 Scope

2.1 This Specification covers equipment supporting automated access to load ports from the host point-of-view.

2.2 This Specification applies to all implementations of SEMI E87 that use the SECS-II message protocol (SEMI E5). Compliance to this Standard requires compliance to both SEMI E87 and SEMI E5.

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

3 Limitations

3.1 This Specification applies to semiconductor equipment with SEMI E15.1 compliant load ports. It may also be applied to other manufacturing equipment that supports automated carrier transfer and or contains an internal buffer.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

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

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

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

SEMI E87 — Specification for Carrier Management (CMS)

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