

Factory Productivity

**Manufacturing Operation & Exception
Scenarios:
for reliable high volume manufacturing**

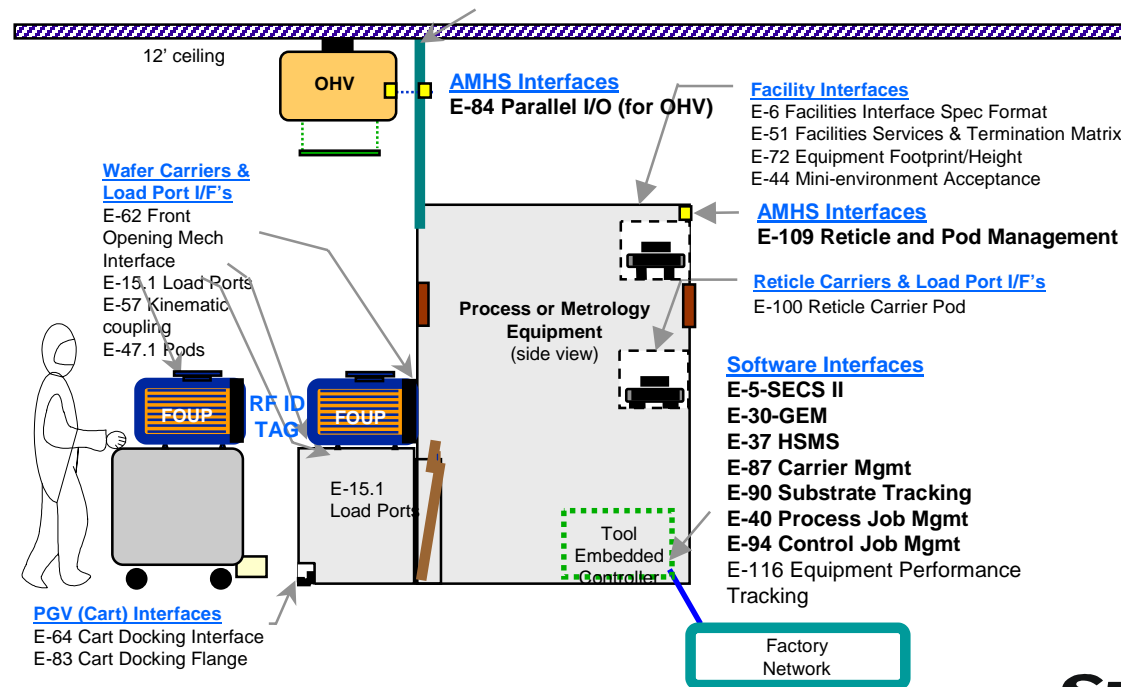
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INTERNATIONAL
SEMATECH

Background

- **Software Test project focused on functional implementation in a static environment (single FOUP/Batch, sequential processing)**
- **Significant progress has been made in getting all relevant standards implemented, with all basic functions and services**
- **Fully integrated high volume fabs remain a challenge!**



High Volume Manufacturing

New High Volume Fabs require new levels of integration and overall management

- **Maximum use and efficiency of equipment output based on cascade processing (i.e., the first wafer of a new lot must follow the last wafer of a finishing lot without interruption)**
- **Material delivery must be prioritized and optimized by the factory scheduler, and verification and execution by the equipment must act as component elements within that plan**
- **Job execution must be performed flawlessly within a cascaded environment the Control Job, Process Job and recipe executed on the right wafers at the right time**
- **Exception Handling in the highly integrated fab must be robust**

Material Delivery & Verification

E84 P I/O and E87 Carrier Management define the capabilities to get the right material to the equipment in the right order

- **Enable consistent, reliable hand-off of carriers**
- **Should support delivery and queuing to allow cascade processing**
- **Should meet the factory scheduler priorities, whether fixed buffer or internal buffer**
- **Provide ID and verification of the material**
- **Allows the factory to track the material location**
- **Enable linkage of the carrier and material to the correct processing instructions**

Job Execution

E40 Process Job and E94 Control Job, combined with recipe management, provide the essential controls within a tool to allow the material to be processed correctly

- **Maximize the productive output of equipment**
- **Must support concurrent processing of control and process jobs**
- **Are designed to ensure that the right processing is achieved on each wafer**
- **Links the correct recipe with each wafer(s)**
- **Allow recipe parameter tuning for APC, FDC, and other advanced control mechanisms**

Exception Handling

Even in the best implementations, unexpected events occur. Capabilities for recovery must be planned, supported, and automated

- **Consensus recovery methods for commonly occurring error conditions required**
- **Operator and Atomic level commands must be supported**
- **Commands must be available remotely and at the equipment user interface**

HVM Challenges

- **The standards and guidance were constructed to facilitate concurrent and parallel processing, in cascade mode (no pause between the last wafer of one lot/carrier/batch and the first wafer of the next)**
- **As fabs were ramping and the equipment became fully loaded, undesired behavior was identified, causing significant adverse impact**
- **In some cases, the stress of full loading exposed previously unknown or unobserved deficiencies and incompatibilities in the software, such as layering and weaknesses in architecture**
- **Interpretation of the standards have resulted in conflicts, inconsistencies, and variability in implementations across suppliers and equipment**

What does this mean?

- **Most of the requirements and behavior needed for High Volume Manufacturing are common among the IC makers**
- **Clear communication of expectations can reduce misinterpretation, improve implementation, and accelerate availability**
- **We can identify and prioritize those common needs areas**

Material Delivery & Verification

- **E84/E87 Interaction and Behavior**

- **What are the driving factors to provide guidance in this area**

- Wide variation in behavior between tool type and suppliers
 - E84 Parallel I/O drop out result in the loss of integration between AMHS and tool
 - This is the key interaction to keep the equipment fully loaded with material to process, enabling cascade processing
 - Premature E84 signals/actions cause conflict between AMHS and actual lot status
 - Misalignment/wrong states between E84 and E87 allow conflicting actions to be undertaken when the load port or AMHS is in an incorrect or illegal state

- **What are the typical impact of non-performance in this area**

- Cycle time
 - AMHS performance is degraded, vehicles waiting for tool action cause blockages
 - Equipment sits idle waiting for material, loss of productivity
 - “Cancels” which degrade overall factory system performance

- **Consensus common needs and guidance area**

- Parallel scenario E84/E87
 - E84 relation to E87
 - CarrierRecreate scenario

Material Delivery & Verification

- **ID Reader**
 - **What are the driving factors to provide guidance in this area**
 - Insure the right material is at the right equipment
 - Insure the wafers in the carrier are correct and in the right slots
 - **What are the typical impact of non-performance in this area**
 - Cycle time
 - Misprocess
 - Rework
 - **Consensus common needs and guidance area**
 - Wafer ID reader usage commands
 - RFID from different manufacturers (pending)

Job Execution

- **E94/E40 Interaction and Behavior**
 - **What are the driving factors to provide guidance in this area**
 - The way that concurrent processing is supported
 - Randomly pause one CJ and start another
 - Linkage between CJ-PJ-recipe (PJ becomes associated with different CJ)
 - If an exception occurs (such as an abort) it can cause inconsistencies in other staged, queued, or in process jobs
 - Some equipment just do not support the concurrent processing requirement
 - These relationships are key to desired implementation behavior
 - **What are the typical impact of non-performance in this area**
 - Cycle time
 - Misprocess
 - Scrap
 - Yield
 - **Consensus common needs and guidance area**
 - Parallel scenarios
 - Multiple sequential PJ with same wafers
 - PRMtrlist type Substrate scenario

Job Execution

- **Recipes**

- **What are the driving factors to provide guidance in this area**

- Increased need for APC and FDC
 - Recipe management systems integration
 - Recipe setup and behavior in concurrent execution mode

- **What are the typical impact of non-performance in this area**

- Scrap
 - Yield
 - Cycle time

- **Consensus common needs and guidance area**

- Recipe tuning behavior
 - Download of recipes (preventing recipe download from affecting current running recipes)

Exception Handling capabilities

- **Commands and Capabilities**

- **What are the driving factors to provide guidance in this area**

- Need GUI access to equipment operation – must be able to do locally what the host can do remotely
 - Need the atomic commands for error handling and recovery
 - Maintenance and engineering operations

- **What are the typical impact of non-performance in this area**

- Loss of productivity, idle equipment (inefficient offline capability) Limited ability to run in offline mode
 - Not able to do some error handling and recovery
 - Automation of error recovery cannot be accomplished without access to atomic commands

- **Consensus common needs and guidance area**

- Operator local/remote operations
 - Atomic commands

Exception Handling capabilities

- **Exception Handling**

- What are the driving factors to provide guidance in this area
 - Need consistent behavior between tools
 - Provide information to streamline the error recovery methods available
 - Eliminate the need to do extra material handling and disposition to recover from an exception
 - Standardize the interaction the operator needs to do
- What are the typical impact of non-performance in this area
 - Cycle time
 - Reduced AMHS throughput
 - Depending on operators and elaborate manual recovery methods
 - Higher cost (support), lower productivity
- Consensus common needs and guidance area
 - **Unexpected Events E84/E87**
 - Mismatch between SlotMap or ContentMap with MtrlList
 - Access mode violation error
 - OHT request pickup before carrier complete
 - Out of Service load port operations
 - Tool reboot FOUP on port, wrong environmental conditions/states
 - **Unexpected Events E40/E94**
 - Control job exception handling ack codes
 - Abort/Stop/Pause initiated on CJ with all variations
 - **Unexpected Events Recipe**
 - Out of range recipe parameter

**We want to leverage successful methods
and learning to accelerate implementation
and improvement**

**The Software Test project demonstrated
that working closely together is the most
productive method**

A New Project

Project MFGM021 “Manufacturing Operation and Exception Scenarios - for reliable high volume manufacturing” was created

- **Purpose:**

Improve equipment performance in dynamic high volume manufacturing operations

- **Objectives:**

Provide guidance on expected/required operational behavior and functionality

Provide general approach to exception handling and recovery for some commonly occurring situations

Provide training and education to a wide cross section of the supplier base

Investigate and develop testing tools and methods for the space

Pilot improvement project with a supplier to demonstrate effective correction

Leverage the learning, experience, and the success of the Software Test Project

Project Approach

Provide Guidance

- Identify requirements that are common among IC makers
- Establish consensus interpretation, priority, and desired behavior
- Publish the guidance to the industry

Communication & Education

- Regional Workshops
- Supplier visits (as possible)
- Establish an open participation discussion thread forum

Involve the Supplier community

- Solicit and accept input
- Establish open dialog
- Work with suppliers to develop and execute the content
- Seek to work together to improve performance in critical areas

Seek to develop testing methods and tools

Schedules and deliverables

Project planning is still underway, however the following preliminary deliverables and schedule have been established

- **Update the International SEMATECH 300mm Operational Flowcharts and Scenarios (Production Equipment) to current SEMI standard revisions – in progress**
- **Version 1.0 of the Guidance document published in August '03**
- **Version 2.0 of the Guidance document published in January '04**
- **An open participation discussion thread forum launched mid-August '03 on the ISMT 'Resources for the Industry' web page (<http://www.sematech.org/public/resources/stds/index.htm>)**
- **Workshop(s) to be scheduled**

An introduction to the Guidance document format:

Guidance Text

- **Some sections of the document will provide guidance in text format for specific areas:**
 - Describing the issue
 - Defining the desired behavior

Guidance for E84/E87 Inter-relations and exception handling recommendations

Background: This section outlines expectations IC makers have for tool behavior when material handling errors occur. It specifically clarifies some of the E84 and E87 inter-relations.

Equipment FOUP unload Operations- Abnormal

E87 configuration: Load port-auto access mode, AMHS triggered unclamp is 'OFF', Fixed buffer equipment

Anomaly behavior: Request is made to unload FOUP prior to completion of processing.

Scenario: While the equipment is in the process of accessing a FOUP, the E84 'Handoff Available' should NOT be asserted. Under no conditions should the tool accept a 'Unload request' from the OHT while the FOUP is docked to the tool and not in a E87 'Ready to Unload' state.

Guidance Scenarios

- Graphical scenarios, that provide detailed examples of the desired behavior

Example Sequential Action

SECS/GEM Message

Action	SECSMsg	SECSDesc	PJ1 Process job State Model	PJ2 Process job State Model	CJ1 Control Job State Model	Substrate '3' State	Notes
Previous actions of AWHs material delivery assumed to have been successful							All material currently exists on the equipment
Host issues PJ Multi Create Command (E40) S16F16 PRJobMultiCreate for 2 process jobs. Slot position 3 common across jobs.	S16F16	PRJobMultiCreate	No State	No State			Job1 Attributes: PRJobID= "PJ1", CARRIERID="03459398", SlotIDList="<U2 1> <U2 3> <U2 5> RCPSPEC="ThisRecipe" Job2 Attributes: PRJobID="PJ2", CARRIERID="03459398", SlotIDList="<U2 3> <U2 7> <U2 9>", RCPSPEC="ThatRecipe"
Equip. acknowledges PJ Multi Create command S16F16 PRJobMultiCreate Ack	S16F16		QUEUED/POOLED (Enumeration =0)	QUEUED/POOLED (Enumeration =0)		NEEDS PROCESSING (Enumeration =)	
Host issues CJ Create Command (E94) S14F9 Create Obj. Request, specifying both P.J's. PJ is first in list order.	S14F9	CJCreate	QUEUED/POOLED (Enumeration =0)	QUEUED/POOLED (Enumeration =0)	No State		CJ1 Attributes: ObjID="CJ1", ProcessingCtrlSpec="<A PJ2> <A PJ1>"
Equip. acknowledges CJ Create command S14F10 Create Obj. Ack	S14F10		QUEUED/POOLED (Enumeration =0)	QUEUED/POOLED (Enumeration =0)	QUEUED (Enumeration =0)		
Equip. notifies host that CJ created. <no state> to QUEUED CEID (E94)	S6F11	CJQueued	QUEUED/POOLED (Enumeration =0)	QUEUED/POOLED (Enumeration =0)	QUEUED (Enumeration =0)		Refers to E94 Control Job State Model Transition #1
Host acknowledges CJ Created to QUEUED event	S6F12		QUEUED/POOLED (Enumeration =0)	QUEUED/POOLED (Enumeration =0)	QUEUED (Enumeration =0)		
Equip. sends CJ QUEUED to SELECTED CEID (E94)	S6F11	CJSelected	QUEUED/POOLED (Enumeration =0)	QUEUED/POOLED (Enumeration =0)	SELECTED (Enumeration =1)		Refers to E94 Control Job State Model Transition #3
Host acknowledges PJ Setup to PROCESSING event	S6F12		QUEUED/POOLED (Enumeration =0)	PROCESSING (Enumeration =3)	EXECUTING (Enumeration =3)		Refers to E87 Carrier state model
Carrier Accessing Status transitions from Not Accessed to IN ACCESS CEID (E87)	S6F11	Carrier In Access	QUEUED/POOLED (Enumeration =0)	PROCESSING (Enumeration =3)	EXECUTING (Enumeration =3)		Refers to transition #18. This event should be sent when first wafer is pulled out of carrier
Host Acknowledges Carrier IN ACCESS Event (E87)	S6F12		QUEUED/POOLED (Enumeration =0)	PROCESSING (Enumeration =3)	EXECUTING (Enumeration =3)		
*Equip. sends Substr. AT SOURCE to AT WORK CEID (E90)	S6F11	Substrate At Work	Wafer TrackIn gEvent	H<-E			Refers to transition #2 of Substrate State Model
*Host acknowledges Substrate AT SOURCE to AT WORK event	S6F12		Wafer TrackIn gEvent	H->E			
*Equip. sends Substrate NEEDS PROCESSING to IN PROCESS CEID (E90)	S6F11	Substrate In Process	Wafer TrackIn gEvent	H<-E			Refers to transition #11 of Substrate State Model. Tool should send when processing/measurement has begun on wafer
*Host acknowledges Substrate IN PROCESS event (E90)	S6F12		Wafer TrackIn gEvent	H->E			

Comment, direction and guidance

The object, action and state to act upon

Guidance Tables

- Some guidance will be provided in tables and figures:

Subject

Desired Behavior

Boundaries

Host & Remote Command Table

Remote Command	Description	Requires Privilege	Operator Command	Host Command	200mm or 300mm or 200mm	Mode	Related Standard
START	START process	No	Yes	Yes	200mm	Normal	E30
STOP	STOP equipment processing activity	No	Yes	Yes	200mm	Normal	E30
PAUSE	PAUSE equipment processing activity	No	Yes	Yes	200mm	Normal	E30
RESUME	RESUME equipment processing activity after a PAUSE	No	Yes	Yes	200mm	Normal	E30
GO_LOCAL	Enter LOCAL control mode	No	Yes	Yes	Both	Normal	E30
GO_REMOTE	Enter REMOTE control mode	No	Yes	No	Both	Normal	E30
CJ-CREATE	Create a Control Job	Yes	Yes	Yes	Both	Normal	E94
CJ-START	START specified Control Job	Yes	Yes	Yes	Both	Normal	E94

We want to build on the success of the ISMT Software Testing project. We've made a great start getting the basic capabilities in equipment. Now we need to fine tune those capabilities and add the advance functionality needed to meet the demands of High Volume manufacturing.