

# ISMI RaP Prototype

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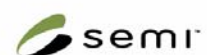
ISMI

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## Prototype Motivations

- **Improve the RaP specification**
  - **Clarity and organization of the document**
  - **Completeness and consistency of the information**
- **Verify that RaP is implementable**
  - **Identify design and implementation issues related to the RaP specification content**
  - **Modify the specification to make implementation easier, where practical**
  - **Demonstrate RaP usage scenarios**



# Challenges to Prototyping

- **When To Do It**

- Too early – specification isn't firm enough
- Too late – specification is too rigid
- Accidentally chose a good solution
  - Just after the concepts specification is approved and during development of implementation standards

- **Flexibility Is Critical**

- Some parts of the document continue to change during the prototyping process
  - To some degree, because of the prototype effort
- Must accept that the prototype will not represent the final SEMI specification 100%
- But must react to changes that have substantial effects on the result

# Prototype Approach

- **Simulate the process a supplier will use to add RaP support to equipment**
  - Generate detailed software requirements for adding RaP support
  - Design and build a prototype implementation
- **Deliver a lessons-learned report at the end of each SW development phase**
  - Provide feedback to the RaP Task Force as soon as possible

# Prototype Phases

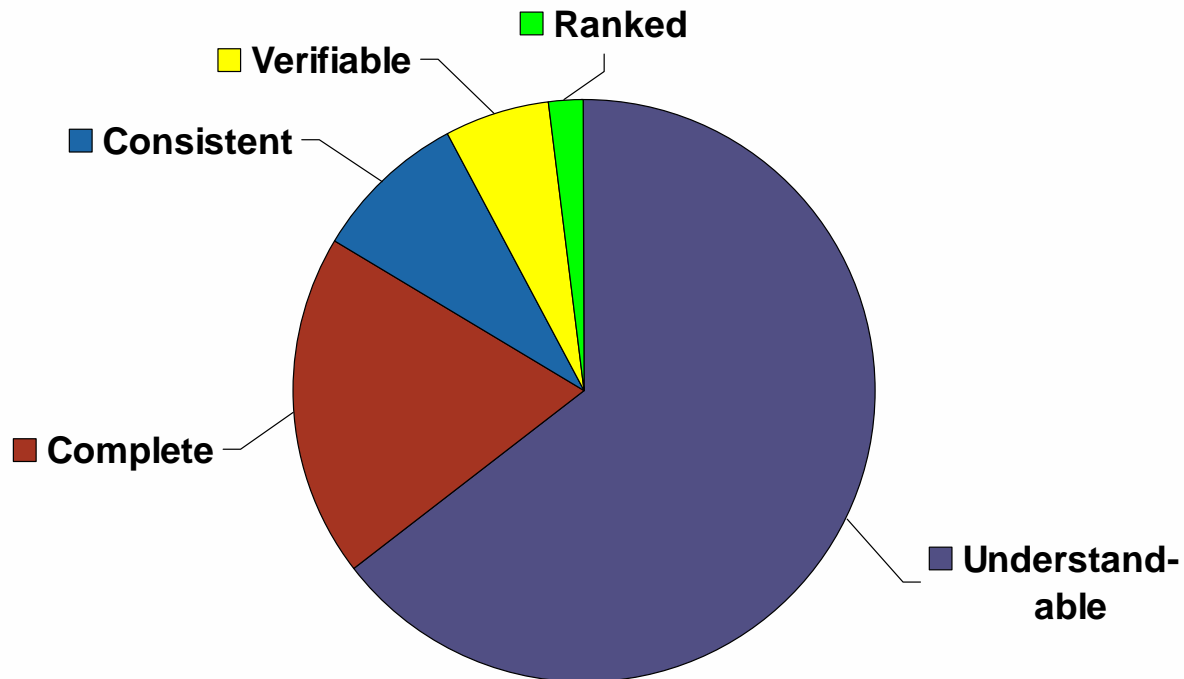
- **Protocol Mapping**
  - Created a “stand-in” SECS-II mapping
- **Requirements Analysis**
  - RaP support for the TrackSys TS-400 tool
- **System Analysis**
  - Impact on tool HW & SW
  - Relationship to other SEMI standards
- **Design**
- **Implementation**
- **Demonstration**

} of a RaP  
Prototype

# RaP Requirements Assessment

- **Assess the RaP specification as a set of software requirements**
  - **Assessment criteria used were a subset of the criteria in the IEEE Software Requirements Recommendation (IEEE Std 830-1998)**
    - **Unambiguous (Understandable)**
    - **Complete**
    - **Consistent**
    - **Ranked**
    - **Verifiable**
- **Assessment is contained in “TrackSys TS-400 Software Requirements” deliverable**

# Requirements Issues Breakdown



104 issues identified during Requirements Phase

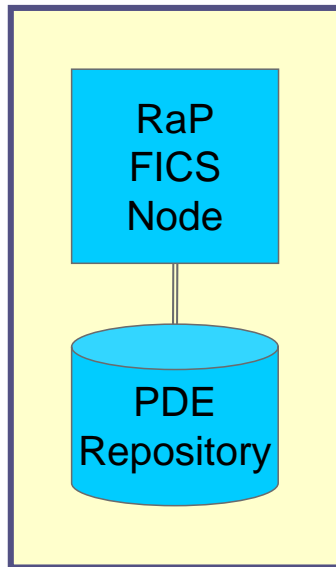
# Sample Requirements Issues

- **Understandability**
  - 8.4.3 The text says “This PDEeditor shall be capable of initiating transfer of PDEs to and from the equipment.” What if the equipment and editor share recipe storage area?
- **Completeness**
  - 8.3.5 The description of the TransferContainer manifest does not describe the content of the manifest when PDEheaders are being transferred.
- **Consistency**
  - 8.3.3, Table 16: The entry for tcid says its form is UUID; the entry for uid says its form is String, and there is no entry for gid. These should all (tcid, uid, gid) have consistent data types.

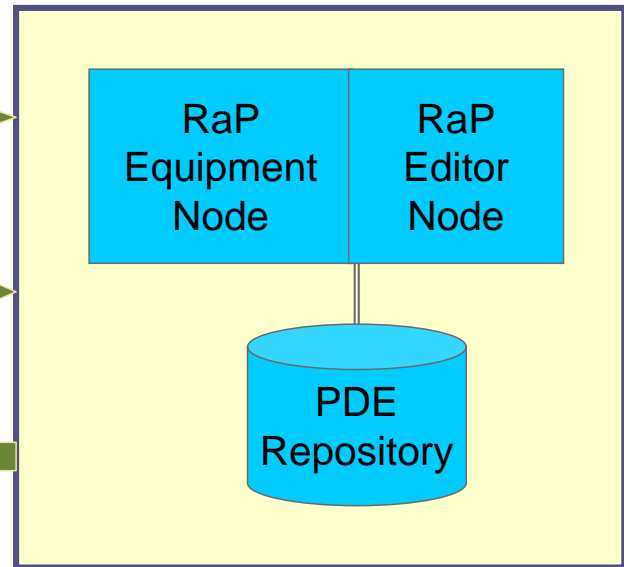
**Note: PDE -> Process Definition Element = Recipe Component**

# RaP Prototype Components

## Factory System Simulator



## Equipment Simulator



RaP Services

PJM Messages

GEM Events

- The prototype consists of two applications:
  - Factory System Simulator
  - Equipment Simulator

# RaP Prototype Implementation

- Technologies Used
  - Microsoft .NET and C#
  - Cimatrix CIMConnect for SECS-II and HSMS communications
  - SQLite (a lightweight RDB) for persistent storage of recipe metadata
    - o Windows file system for recipe body storage
  - SharpZipLib for recipe compression and multi-file archive support

**Note: None of these technology choices were dictated by the RaP specification**

# Equipment Simulator

The screenshot shows the 'Equipment Simulator' interface. The 'Equipment SECS Communications' window displays configuration (Equipment ID: 0, Connection ID: 1), current status (Comm: Enabled / Communicating, Link: Connect), RaP Variables (ResolvePDEReferences (EC 4031), PDEchanged (SV 4032)), and a Message Traffic table. The 'Message Details' window shows a 'getPDE Request' message with its content: L {A 7b7d9000-33f9-11d9-9669-0800200c9a66} {A c4102cb0-3368-11d9-9669-0800200c9a66} {A cc049cd0-3368-11d9-9669-0800200c9a66} {A a20da220-336b-11d9-9669-0800200c9a66} {A 9094da70-3368-11d9-9669-0800200c9a66}

Time	Direction	Protocol	Summary
12:37:47.256	H -> E	RaP	getPDE Reply
12:37:43.872	E -> H	RaP	getPDE Request
12:37:38.253	H -> E	RaP	getPDEdirectory Reply
12:37:38.193	E -> H	RaP	getPDEdirectory Request

Maximum entries: 50. Clear Messages

Message Details: Timestamp: 12:37:43.872, Msg Type: S19F7, Direction: E -> H, TID: 10, Protocol: RaP, Reply Expected: True, Summary: getPDE Request

Message Content:  
L {A 7b7d9000-33f9-11d9-9669-0800200c9a66}  
{A c4102cb0-3368-11d9-9669-0800200c9a66}  
{A cc049cd0-3368-11d9-9669-0800200c9a66}  
{A a20da220-336b-11d9-9669-0800200c9a66}  
{A 9094da70-3368-11d9-9669-0800200c9a66}

RaP communications monitoring



# Equipment Simulator

The screenshot shows the 'Equipment Recipe Store' interface with two overlapping windows. The top window shows the 'Recipe View' with a table of recipes. The bottom window shows the 'PDE View' with a table of PDEs.

Recipe Name	Creation Date	Description	# PDEs
CoatAndBake1	11/11/2004 9:51:03 AM	Parameterized version of basic coat and bake, TS-400 format	4 / 1
CoatAndBake2	11/10/2004 5:03:47 PM	Parameterized version of basic coat and bake, uses existing TS-310 recipe	3 / 1

Name	Creation Date	Type	Master?	Group Name
CoatAndBake1	11/11/2004 9:51:03 AM	ts400PD	True	CoatAndBake1
CoatAndBake1-Coat	11/11/2004 10:14:43 AM	ts400PI	False	CoatAndBake1-Coat
CoatAndBake1-Bake	11/11/2004 10:23:13 AM	ts400PI	False	CoatAndBake1-Bake
CoatAndBake2	11/10/2004 5:03:47 PM	ts310PD	True	CoatAndBake2
TS310-CoatAndBake	11/10/2004 5:03:47 PM	ts310	False	TS310-CoatAndBake

Multiple views of local recipe store contents



# Equipment Simulator

Name	Creation Date	Type	Master?	Group Name
CoatAndBake1	11/11/2004 9:51:03 AM	ts400PD	true	CoatAndBake1
CoatAndBake1-Coat	11/11/2004 10:14:43 AM	ts400PI	false	CoatAndBake1-Coat
CoatAndBake1-Bake	11/11/2004 10:23:13 AM	ts400PI	false	CoatAndBake1-Bake
CoatAndBake2	11/10/2004 5:03:47 PM	ts310PD	true	CoatAndBake2
TS310-CoatAndBake	11/10/2004 5:03:47 PM	ts310	false	TS310-CoatAndBake

Refresh

**View of remote recipe store contents. Needed to support getPDE (download) service.**

## Design And Implementation Issues

- **Calculating checksums over XML documents**
  - XML supports multiple (byte-level) representations for the same document content, so:
    - XML must be fully canonicalized before checksum calculations
    - The “original” XML must be accurately reproduced from recipe storage in order to verify checksum
- **Recipe storage must be carefully designed to avoid having to open/read every stored recipe component (PDE) when:**
  - Servicing a getPDEdirectory request
  - Traversing PDE dependencies within a recipe
  - Determining PDE group membership

## Very Large Recipes (> 4 GB)

- **Difficulties due to large recipes**
  - **HSMS limits total message size to 4GB; SECS-II limits single data item size to 16MB\***
    - **RaP SECS mapping must work around these constraints**
      - **Probably using multi-message transfer of recipe**
    - **Implementation of this mapping will be more complex than for a single request-response message pair**
  - **RaP implementer must be careful not to instantiate entire recipe in memory**
    - **RaP Prototype makes heavy use of Streams to pass recipe data from one sub-system to another**
      - **Streams are read or written as infrequently as possible**
    - **Must be sure that helper utilities avoid in-memory instantiation as well**

\* These constraints don't apply to the RaP WebService (SOAP/XML) mapping.

## Very Large Recipes (> 4 GB)

- **Large recipes lead to long processing times**
  - **Recipe transmission time**
  - **Local and remote recipe processing time**
    - **XML parsing, XML canonicalization**
    - **Checksum calculation and recipe content validation**
    - **Data compression/decompression**
    - **File I/O**
  - **As a result, any of these operations can take a long time:**
    - **Local generation of a RaP request and/or processing of the RaP response**
    - **Remote request processing; remote response generation**
    - **Message transmission to and from remote node**

## Very Large Recipes (> 4 GB)

- **Large recipes lead to long processing times**
  - **It may not be feasible to block other host or equipment operations**
    - **First and foremost, wafer processing must not be affected**
    - **Process or metrology data still needs to be collected**
    - **User interfaces need to stay responsive**
  - **The solution is asynchronous (multi-threaded) programming**
    - **Multi-threaded programming can be complex and error-prone**
    - **It's hard to think in parallel**

## Prototype Deliverables Summary

- **Reports from each phase of the activity**
  - **Identifying issues with the RaP document and content**
  - **Identifying design and implementation issues**
- **RaP support requirements**
  - **For a sample process tool: TrackSys TS-400**
  - **Lots of detail, 57 pages**
- **A prototype RaP implementation**
  - **Factory System Simulator**
  - **Tool Simulator**

# Prototype Activity Assessment

- This effort was effective in identifying a large number of potential RaP improvements
  - Many of these have already been incorporated into the specification
- The Requirements Phase was most effective in identifying document and content issues
  - Use of SW requirements assessment criteria could be adopted by other standards teams
- The Design and Implementation Phases were necessary to identify implementation difficulties
  - Fewer issues, difficult to uncover before implementation

# Conclusions

- Prototyping is particularly effective when
  - The main (concepts) document is near approval
  - The implementation standards are in early draft
- Stable commercial implementations possible up to two years earlier
  - Changes detected by early prototyping would ordinarily be
    - Found during commercial implementation ~6-12 months later
    - ...and corrected ~6-12 months after that (12-24 months total)
- The industry would benefit from a process that encourages/requires early prototyping
  - A model is needed for how to fund and execute such prototyping activity
  - ISMI may do this for select priority issues, but the industry needs it done consistently for all cases