IPC-HERMES-9852
The global standard for "M2M" in SMT assembly

IPC-HERMES-9852 Best Practices

The Global Standard for Machine-to-Machine Communication in SMT Assembly

Version 1.0

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1 Purpose of this Document

The Hermes Standard (IPC-HERMES-9852) provides a sound basis for transfer of PCBs from Machine to Machine together with its Digital Twin, i.e. the PCB related data. Hence, The Hermes Standard ensures consistency of PCB-related data with the physical PCB throughout the entire SMT Line. This data provides a sound basis to implement use cases for an automated, data driven SMT factory.

This document provides guidelines and recommendations

- to facilitate implementation and work with The Hermes Standard, and
- to implement data driven use cases using data provided by Hermes

The content of Hermes messages evolved over time from version to version. Some of the Hermes data is optional. Therefore, this document will describe for each workflow, which Hermes data is needed, and, thus, provide a guideline for an SMT manufacturer to specify for each machine in the SMT Line

- the necessary minimum Hermes version, and
- the required capabilities concerning handling of Hermes data.

2 Common Hermes Topics and Recommendations

2.1 Common Hermes Topics

2.1.1 Handling of Hermes Data

Machines shall handle data that they received in a Hermes message in one of the following ways:

- **Pass on**: Machine receives data and passes it on unmodified, no reaction on data
- **Update**: Machine receives data, updates it if applicable and then passes it on, no reaction on data
  Note: Machine will create data if it is first in the Hermes Line or if this data does not yet exist
- **React**: Machine receives data, reacts to it and then passes it on unmodified
- **React & Update**: Machine receives data, reacts to it, updates it if applicable and then passes it on

2.2 Recommendations

2.2.1 Error Handling and Recovery

2.2.1.1 Check alive

It is strongly recommended to implement Hermes version 1.1 or higher in which the “check alive” feature is mandatory. Without this feature an unconnected network cable will not be detected until a board transfer message is not responded to. For even more robust detection of connection loss the optional “Check alive response” feature is recommended.

2.2.1.2 Error before Service Descriptions exchanged

Machines cannot use the “Check alive” before service descriptions are exchanged and the supported version of The Hermes Standard is determined. In case a connection error happens, machine software can only show connection state and display a warning to the operator about missing response from upstream/downstream machine.

2.2.1.3 Lost Connection during Board Transfer

Errors during transport should be handled according to The Hermes Standard, see chapter “Transport Error Handling”. It is recommended that machine software handles connection loss towards the operator in a similar way for improved usability.
If no transfer is in progress, i.e. no “Start Transport” message has been sent: try restarting, if this fails raise an error.
If transfer was in progress, it is recommended to consider the board status unsafe and raise an error.

2.2.1.4 Missing Barcode Data

It is recommended that machines that failed reading a barcode mark the Board as failed using the *FailedBoard* attribute and move it out or raise an error to the operator. A machine that failed reading barcodes should not send *TopBarcode* / *BottomBarcode* attributes.

3 Hermes Use Cases

This section describes the basic Hermes use case, i.e. how HERMES replaces SMEMA, followed by additional use cases to support factory automation and traceability.

3.1 Hermes Basic Board Transfer

Description: A board is transferred from upstream to downstream machine. In addition to the handshake, as already given under SMEMA interface, the machines are enabled to transfer the board data set via The Hermes Standard interface.

Workflow: A machine in the SMT line indicates to send a board to its downstream neighbor and thereby also passes the available board data according to The Hermes Standard. The downstream machine initiates the start of transport via Hermes messages and as soon as both machines internally recognize the correct board departure respectively arrival the transport sequence is finished. The board with its data is now under the responsibility of the receiving downstream machine.

Limitations: none, requirements are valid for all machines in the SMT line

Hermes version: 1.0

Required setup:

- first machine in the SMT line has to setup a Hermes connection to its downstream neighbor
- all machines within the SMT line have to setup a Hermes connection to their upstream neighbor and a Hermes connection to their downstream neighbor
- the last machine in the SMT line has to setup a Hermes connection to its upstream neighbour

Required supported features: none

Data requirements:

- *BoardId*: First machine or creator of Hermes data **Update**, all other machines **Pass on**
- *BoardIdCreatedBy*: First machine or creator of Hermes data **Update**, all other **Pass On**
- *FailedBoard* in Hermes is handled similar to the “Failed Board Available” digital signal in SMEMA:
  - First machine or creator of Hermes data **Update**
  - All machines which actively set the optional “Failed Board Available” digital output on SMEMA N+1 interface, e.g. SPI or AOI **Update**
  - All machines which actively react on the optional “Failed Board Available” digital input on SMEMA N-1 interface, e.g. Rework or Classification Conveyors **React**
  - All other machines **Pass On**
- *FlippedBoard*:
  - First machine or creator of Hermes data: **Update**
  - Machines with board flipping capability: **Update**
  - All other: **Pass On**

Error Condition: If a board is not successfully transferred, so the board arrival and/or the board departure was not successful the transport sequence is completed with the *TransferState = 2 (Incomplete)* and alarms occur on the respective machine(s).

3.2 Hermes Data Driven Use Cases for Factory Automation Support

The following data driven use cases can be implemented using Hermes data:

- Automatic width adjustment
- Automatic program changeover (includes automatic conveyor width adjustment)
- Oven error loop

- Reverse Transportation
- Upstream reverse and flipping
- Downstream reverse and flipping
- Manual removal of boards
- Transfer subboard info
- Automatic stacker level height adjustment

3.2.1 Automatic Width Adjustment

Description: When performing a product change at an SMT line, usually the conveyor width of all machines in the SMT line needs to be adjusted. The Hermes Standard provides a *Width* attribute that is communicated M2M together with the board. Machines without program selection shall use this *Width* attribute to adjust their conveyor width accordingly, whereas machines with program selection will get the correct conveyor width from their program. Each machine shall communicate this width via Hermes to subsequent machine.
Machines with program selection may handle Hermes *Width* and width in their program in three different ways:
1) Use width from program to adjust conveyor width and send this width to downstream machine → **Update**
2) Use *Width* from Hermes to adjust conveyor width and send this width to downstream machine → **React**
3) Use width from program to adjust conveyor width and pass on *Width* from Hermes to downstream machine → **Pass on**

Workflow:

- Machine receives *Width* in *BoardAvailable* message:
  - Machine without program selection adjusts conveyor width prior to transferring the board in
  - Machine with program selection already has the correct conveyor width from previously activated program
- Machine sends the width with *BoardAvailable* message to downstream machine
  - Machine without program selection passes on the received *Width* unmodified
  - Machine with program selection sends width from previously activated program or passes on the received *Width* unmodified

Limitations: none
Hermes version: 1.0 or higher
Required setup: see 3.1 Hermes Basic Board Transfer
Required supported features: none
Data requirements:

- *Width*:
  - Machine without program selection **React**,
  - Machine with program selection **Update** or **React** or **Pass on**

Error Condition: In case of a mismatch between *Width* in Hermes and program selection the machine shall raise an error.

3.2.2 Automatic Program Changeover incl. Automatic Width Adjustment

Description: Automatic Program Changeover throughout the entire SMT line uses a product identification, which is provided to the first Hermes machine in the SMT line, and this product identification is communicated via Hermes from machine to machine all the way down the SMT line. Product Identification may be Top- or Bottom-Barcode, Product Type ID or Work Order ID or a combination of these. Prior to transferring a Board into a machine, this product identification will be received using Hermes and evaluated by the machine to look

up the program required to process this Board.
Note: Automatic Program Changeover usually includes Automatic Width Adjustment, see section 3.2.1.
Workflow:

- Upstream machine will send *BoardAvailable* with *Width*, *TopBarcode*, *BottomBarcode*, *ProductTypeId*
- Board Handling Machines will adjust their conveyor width based on received *Width*, see section 3.2.1 Automatic Width Adjustment
- Process Machines use *TopBarcode*, *BottomBarcode*, *ProductTypeId* or a combination of these attributes to identify the required program and load this program
  The loaded program includes conveyor width and machine may adjust its conveyor width accordingly. Instead, machine may use Hermes *Width* to adjust its conveyor width.
  Program may be selected, for example, by
  - Complete barcode (*TopBarcode* or *BottomBarcode*) is used to select the program, or
  - Barcode (*TopBarcode* or *BottomBarcode*) with a pattern applied to cut out the relevant part of the barcode to select the program, or
  - *ProductTypeId* to select the program, or
  - Barcode (*TopBarcode* or *BottomBarcode*) with a pattern applied to cut out the relevant part of the barcode and this relevant part of the barcode can be concatenated with ProductTypeId to select the program.
- In case of a program change, machines without stoppers at the end will send a *BoardForecast* with the new *Width* to allow a downstream conveyor to adjust its width accordingly
- In case of a required setup change, machine stops and notifies the Operator on its GUI

Limitations: none
Hermes version: 1.1 or higher
Required setup: see 3.1 Hermes Basic Board Transfer
Required supported features:

- *FeatureBoardForecast* for machines without stopper at the end and machines downstream of it

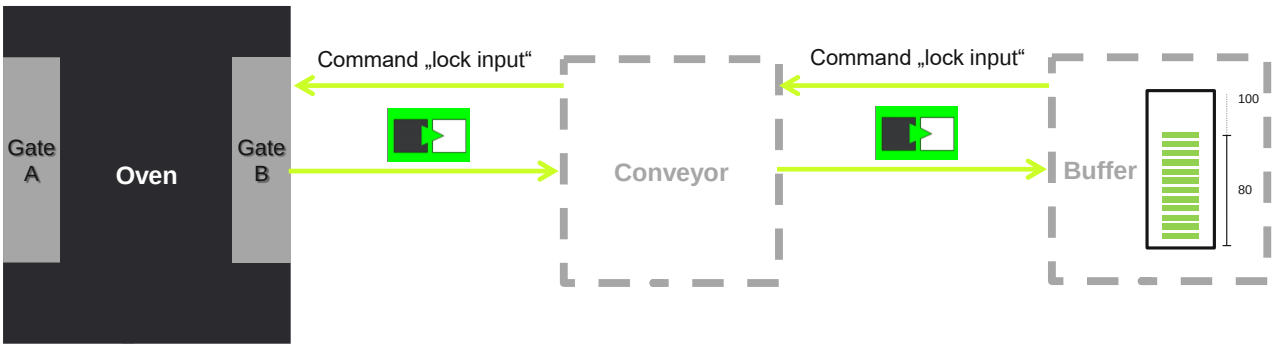
Data requirements:

- *TopBarcode, BottomBarcode, ProductTypeId*: Board Handling Machines **Pass on**, Process Machines **React**

Error Condition: In case of no matching program to download or failure while downloading the machine shall raise an error.

3.2.3 Oven Error Loop

Description: In the case of an oven, in which the transport and process cannot be stopped, it is necessary to block the inlet if the downstream machines are not able to accept any additional boards.



Workflow:

- A machine behind an oven is not able to accept boards, irrespective of the machine being ready or the buffer becoming critical or full.
- A machine shall communicate this situation to the upstream machines using the Hermes *Command* message.
- If a machine receives such a Hermes *Command* and is configured not to react to it, it shall forward this *Command* upstream.
- As soon as the oven receives this *Command*, it blocks its inlet for new boards.
- If the downstream machine is ready again or the buffer space is big enough, the downstream machine communicates this situation again to the upstream machine.
- The oven receives this information and unblocks its inlet.

Limitations: The setting of the prewarning Buffer level needs to be configured according to oven capacity
Hermes version: 1.4 or higher
Required setup: see 3.1 Hermes Basic Board Transfer
Required supported features:

- *FeatureCommand*

Data requirements:

- *Command*:
  - Oven **React** to “Lock input conveyor” and “Unlock input conveyor”
  - Machines between Oven and Buffer **Pass on**
  - Buffer **Update**

Error Condition: none

3.2.4 Reverse Transportation

Description: A board is loaded to a machine and unloaded on the same interface in the opposite direction.
Workflow:

- Board is loaded e.g. from a magazine station to a process machine
- Board gets processed
- Reverse transportation on the same conveyor back to the machine where the board came from.

Limitations: Requirements apply to the affected machines and transport machines in between
Hermes version: 1.1 or higher
Required setup: For reverse transportation all involved machines need to setup one upstream and one downstream connection per gate with reverse transportation.
Required supported features: none
Data requirements: *ServiceDescription*: *InterfaceId* must be set
Error Condition: none

3.2.5 Upstream Reverse and Flipping

Description: A board shall be processed both sides and therefore turned over between process steps. The flipping unit is located upstream to the process machine regarding to the direction of the production line. The flipping unit processes only when instructed by the process machine by using Hermes data.
Workflow:

- Flipping unit loads a board from upstream

- It passes the board through to the process machine unturned
- Process machine sends *BoardForecast* message to the flipping unit to indicate that a board will be reverse transferred soon and space for the board has to be reserved; no new board loading from upstream.
- Protocol and board handling to process machine
- Process machine processes top side of the board
- Protocol and board handling back to flipping unit and indication that the board shall be turned over
- Flipping unit turns over the board as requested
- To the process machine it sends: *BoardAvailable*, *FlippedBoard*=2 (Bottom side is up)
- Protocol and board handling to process machine
- Process machine processes bottom side of the board; flipping unit now can load a new board from upstream if available
- Process machine unloads the board to the downstream Output

Limitations: Requirements apply to the affected machines and transport units in between.
Hermes version: 1.4 or higher
Required setup: For reverse transportation all involved machines need to setup one upstream and one downstream connection per gate with reverse transportation
Required supported features:

- *FeatureBoardForecast*

Data requirements:

- *FlippedBoard*: Process Machines **React**, Flipping Unit **Update,** Board Handling Machines **Pass on**
- *Route:* Process Machines **Update**, Flipping Unit **React,** Board Handling Machine **Pass on**
- *Action:* Process Machines **Update**, Flipping Unit **React,** Board Handling Machine **Pass on**

Error Condition: none

3.2.6 Downstream Reverse and Flipping

Description: A board shall be processed both sides and therefore turned over between process steps. The flipping unit is located downstream to the process machine regarding to the direction of the production line. The flipping unit processes only when instructed by the process machine by using Hermes data.
Workflow:

- Process machine processes top side of a board
- Indication to the flipping unit that the next coming board shall be turned over and returned
- Flipping unit sends BoardForecast message to the process machine to confirm the upcoming reversal transport
- Protocol and board handling to flipping unit
- Process machine must ensure that board can be returned
- Flipping unit turns over the board as requested
- Protocol and board handling back to the process machine
- Process machine processes bottom side of the board
- Protocol and board handling to flipping unit and indication that the board now can be passes through unturned
- Board passes through the flipping unit unturned

Limitations: Requirements apply to the affected machines and transport units in between.
Hermes version: 1.4 or higher

Required setup: For reverse transportation all involved machines need to setup one upstream and one downstream connection per gate with reverse transportation

Required supported features:

- *FeatureBoardForecast*

Data requirements:

- *FlippedBoard*: Process Machines **React**, Flipping Unit **Update,** Board Handling Machines **Pass on**
- *Route:* Process Machines **Update**, Flipping Unit **React,** Board Handling Machines **Pass on**
- *Action:* Process Machines **Update**, Flipping Unit **React,** Board Handling Machines **Pass on**

Error Condition: none

3.2.7 Manual Removal of Boards

3.2.7.1 Monitored Removal

Description: A manual removal of boards might happen on purpose. In order to provide documentation about the event of removal the machine shall inform the Supervisory System. For this purpose, the Hermes message *BoardDeparture* can be used.

Workflow:

- The machine control recognizes the sudden absence of the board (planned or unplanned).
- Optionally it requests the user for a manual confirmation.
- Hermes message *BoardDeparture* is send to vertical channel including all board attributes.

Limitations: none

Hermes version: 1.2 or higher

Required setup: Hermes vertical channel setup to connect to Supervisory System.

Required supported features:

- *FeatureBoardTracking*

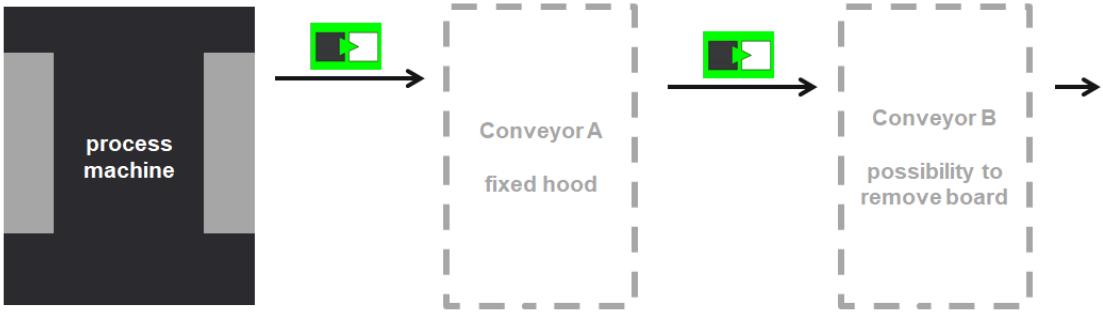
Data requirements:

- *BoardDeparture*/*BoardTransfer*: All machines **Update**
- All other data as specified in *BoardDeparture* message must **Pass on**.

Error Condition: none

3.2.7.2 Removal at next possible withdrawal Point

Description: A process machine instructs the next possible downstream conveyor to stop the board for its manual removal. In this example only conveyor B provides the possibility that the board can be manually removed.



Workflow:

- Process machine sends *BoardAvailable* with *Route* = 999 to conveyor A to indicate removal of the next coming board
- Protocol and board handling to conveyor A
- Conveyor A does not offer the option of removing the board manually
- Board passes through to conveyor B
- Conveyor B requests the user to remove the board
- Removal is monitored (see 3.2.7.1 Monitored Removal),
- Hermes data is discarded for further downstream transportation.

Limitations: Requirements apply to the affected machines and transport units in between.
Hermes version: 1.4 or higher
Required setup: see 3.1 Hermes Basic Board Transfer
Required supported features: none
Data requirements:

- *Route*: Machines, in which the call for removal is decided **Update**, machines without the possibility for manual removal **Pass on**, machines with the possibility for manual removal **React**

Error Condition: none

3.2.8 Transfer Subboard Info

Description: Subboard information may be required in case a Board is used with multiple subboards or a carrier which contains multiple subboards. The subboard information can be used to transfer the barcode, position and the state of each subboard within this panel/carrier. Equipment can then use this subboard information and react on it or just pass it on.
For example an Inspection System may use the subboard status to decide whether to inspect or skip a certain subboard. Based on the inspection result it may update the subboard status, so that downstream machines know which subboards to process and which to skip.
Workflow:

- First capable machine, e.g. Printer, Inspection or Placer or a supervisory system needs to update the property *Subboards* in *BoardAvailable*
- All downstream machines until the last capable machine at least need to pass on *Subboards*, all capable machines at least need to react, if applicable, react & update

Limitations:

- Functionality is available only downstream
- Number of subboards and barcode size must not exceed the machines message size capabilities

Hermes version: 1.4 or higher
Required setup: see 3.1 Hermes Basic Board Transfer
Required supported features: none
Data requirements:

- *Subboards*: **Pass on** or **React** or **React & Update**

Error Condition: none

3.2.9 Automatic Stacker Level Height Adjustment

Description: The Stacker can calculate its necessary level pitch by using the Hermes *TopClearance* and *BottomClearance* attributes when receiving a board and adjust automatically its level pitch accordingly.

Workflow:

- Stacker receives *TopClearance* and *BottomClearance* in *BoardAvailable* or *BoardForecast* message
- Based on received *TopClearance* and *BottomClearance* Stacker calculates necessary level pitch

Limitations: none
Hermes version: 1.0 (1.1 if using *BoardForecast*) or higher
Required setup: see 3.1 Hermes Basic Board Transfer
Required supported features: *FeatureBoardForecast* if used
Data requirements:

- *TopClearance* and *BottomClearance*: Pick & Place / Mounter **Update**, Stacker **React**, all other machines **Pass on**

Error Condition: max. clearance height of Stacker exceeded

4 Appendix

4.1 Glossary / Abbreviations

AOI	Automatical Optical Inspection
ID	Identifier
M2M	Machine-to-Machine
SMT	Surface-Mount Technology
SPI	Solder Paste Inspection

4.2 References

[IPC_HERMES_9852] IPC-HERMES-9852 The global standard for machine-to-machine communication in SMT assembly, V1.4, www.the-hermes-standard.info

4.3 History

Version	Date	Author	Change
0.1	05-Oct-2021	Workgroup Hermes Use Cases	Initial Version
0.2	20-Oct-2021	Workgroup Hermes Use Cases	Updated after Review of Width Adjustment
0.3	26-Oct-2021	Workgroup Hermes Use Cases	Major rework
0.4	27-Oct-2021	Workgroup Hermes Use Cases	Updated after Review
0.5	04-Nov-2021	Workgroup Hermes Use Cases	Updated after Review, pending approval
1.0	14-Mar-2022	Tom Marktscheffel, Peter Sundström	Approved