SEMI SMT-ELS Standards Suite

- Surface Mount Technology – Equipment Link Standards -

As of Feb. 12, 2019

Flow Manufacturing Forum / Automation Technology Committee, SEMI

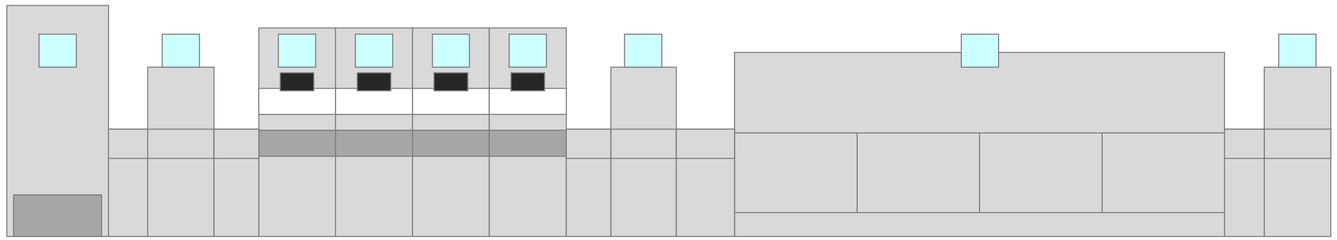
Homepage: http://www1.semi.org/jp/SEMI_SMT-ELS

Position of This Document

This document introduces the concept and functions of

SEMI SMT-ELS Standards suite

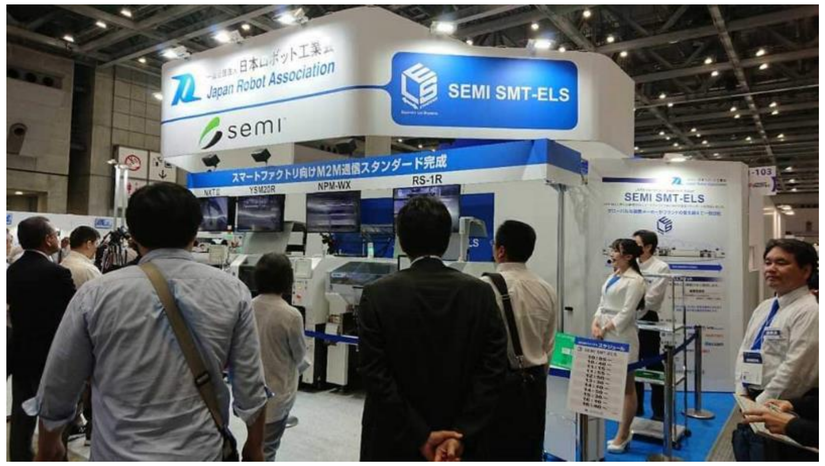
that makes SMT assembly line smarter



Please visit
http://www1.semi.org/jp/SEMI_SMT-ELS
for up-to-date information

Demonstrations

- Demonstrations Done
  - JISSO PROTEC — Tokyo — June — 2019
  - NEPCON ASIA — Shenzhen — August — 2019
  - Productronica — München — November — 2019
  - APEX — San Diego — February — 2020
- Watch the demo videos on: http://www1.semi.org/jp/SEMI_SMT-ELS



JISSO PROTEC / Tokyo
June 2019

NEPCON ASIA / Shenzhen
August 2019

Productronica / München
November 2019

Introduction of SEMI SMT-ELS

Motivation and Overview of SEMI SMT-ELS

What is SEMI SMT-ELS?

- SEMI SMT-ELS (Equipment Link Standards)
  - The Standards suite to make SMT assembly line smarter
  - Replacement of SMEMA
  - Addition of data communication capabilities
    - Host interface including tiered host capability
    - Equipment and equipment data communication

- SEMI Standards:
  - Global Standards that have been supporting semiconductor manufacturing lines and related factories

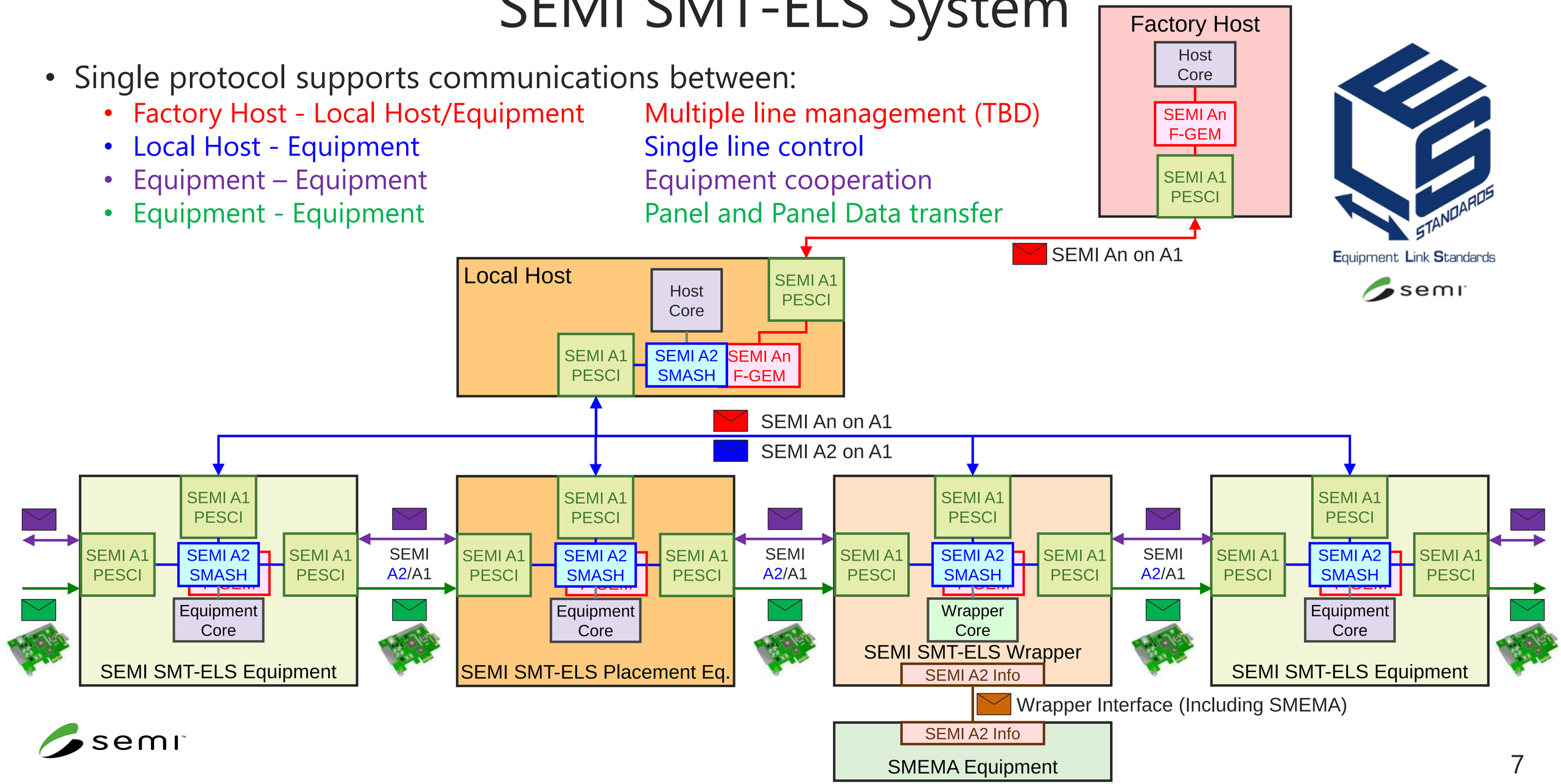
Purpose of SEMI SMT-ELS

- Provide the smart automation scheme of assembly line for IoT era
  - Combination of Vertical Management and Horizontal Control
  - Replacement of SMEMA and addition of data communication capability
  - Object Oriented Panel and Panel data handling/tracking
    - Panel ID, Product ID, Inspected Data, etc.
  - Functional extendibility over decades

- Provide highly interoperable equipment interface supported by global standard for:
  - Flexible mix-and-match of equipment from various suppliers
  - Quick ramp up of assembly line
  - Cost suppressions such as:
    - Use of SMEMA generation equipment with minimal modification
    - Conformance with low end PLCs
    - Use of the same protocol for both Vertical and Horizontal communications

SEMI SMT-ELS System

- Single protocol supports communications between:
  - Factory Host - Local Host/Equipment — Multiple line management (TBD)
  - Local Host - Equipment — Single line control
  - Equipment – Equipment — Equipment cooperation
  - Equipment - Equipment — Panel and Panel Data transfer



SEMI SMT-ELS Standards Suite and Freeze Version

- SEMI SMT-ELS Standards suite consists of the following SEMI Standards

Tier	Function
SMT Applications	Host / Equipment applications Host – Equipment communication control Equipment – Equipment communication control
SEMI A2 SMASH	Message and behavior for SMT assembly line
SEMI A1 PESCI	General-purpose equipment connection interface
SEMI A1.1 TCP/IP Interface for PESCI	TCP/IP Interface for SEMI A1 PESCI
TCP/IP	TCP/IP Interface

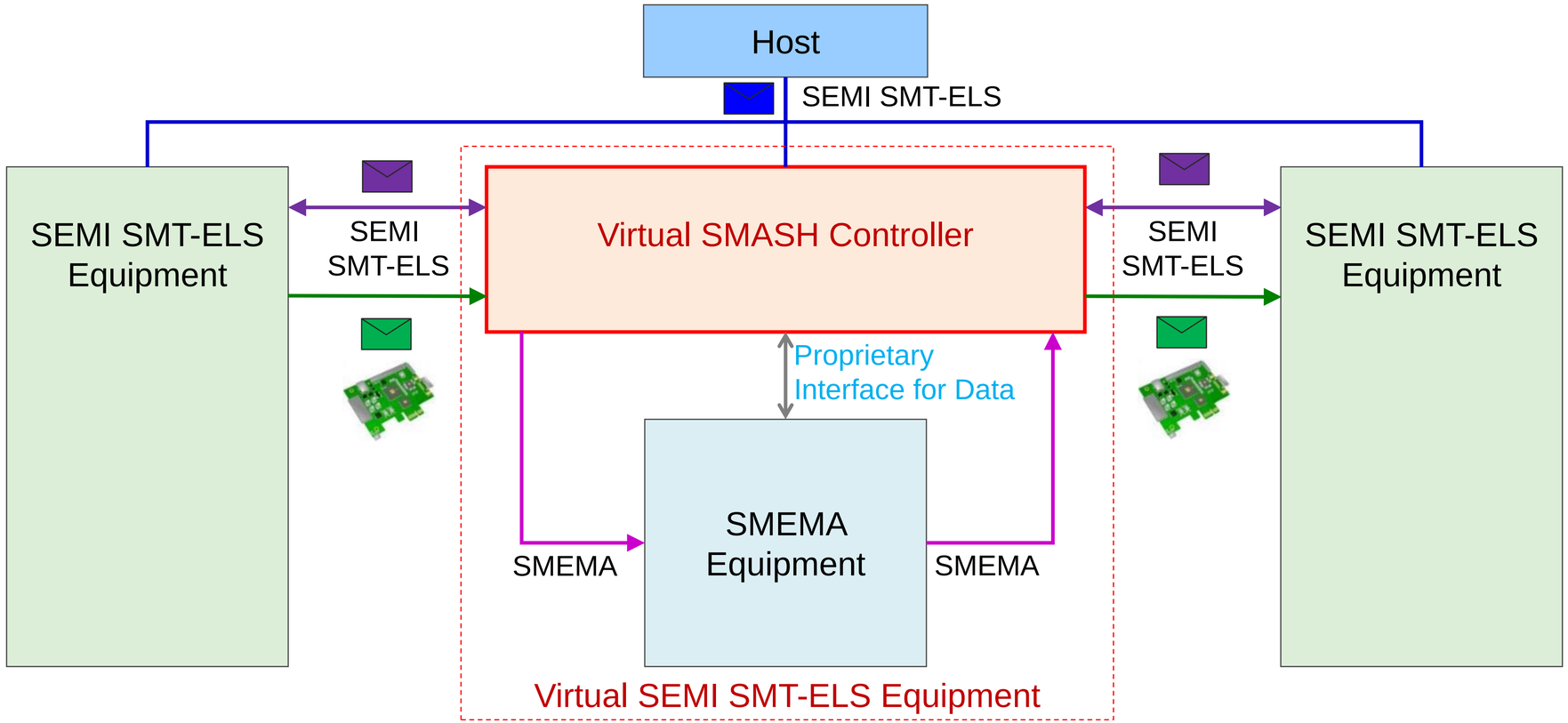
- Freeze Version Management
  - For interoperability, a guide that specifies the combination of the versions of above Standards is required
- SEMI SMT-ELS Freeze Version 0 is available now
  - SEMI A2-1019 Specification for Surface Mount Assembler Smart Hookup (SMASH)
  - SEMI A1-1019 Specification for Production Equipment Smart Connection Interface (PESCI)
  - SEMI A1.1-1019 Specification for TCP/IP Interface for Production Equipment Smart Connection Interface (PESCI)
- Please contact SEMI staff to purchase the above documents

SMEMA Equipment Conformance

Use of SMEMA Generation Equipment in SEMI SMT-ELS Line

Compatibility with SMEMA Equipment

- A SMEMA equipment can be used as a SEMI SMT-ELS equipment by adding Virtual SMASH Controller on the top
  - With minimal modification to perform equipment control such as conveyor width change via Proprietary Interface



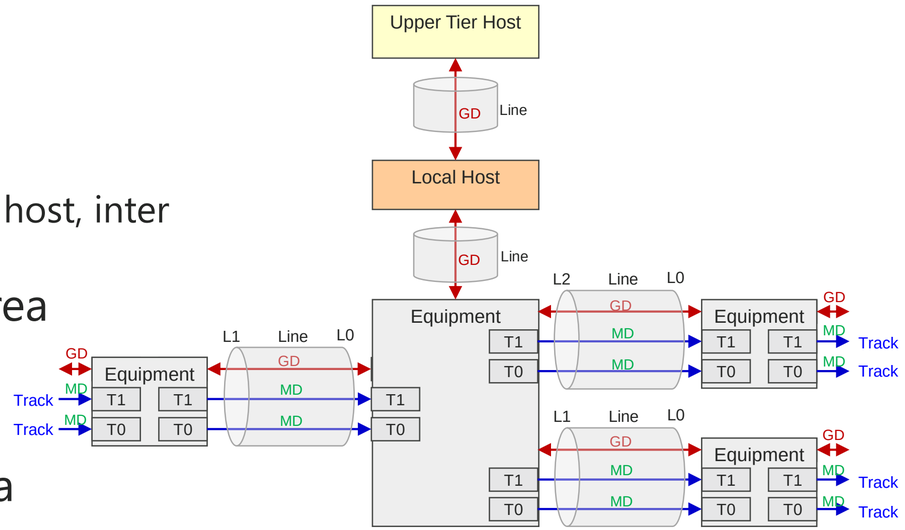
Concept of SEMI A1 PESCI

The General-Purpose Equipment Interface that SEMI SMT-ELS Uses

What is SEMI A1 PESCI?

- A general-purpose Production Equipment Smart Connection Interface

- General-purpose Data communication channel (GD)
  - Tiered Host connection
    - Equipment Group ➔ Local Host ➔ Upper Tier Host
  - Various addressing modes
    - Equipment to equipment, equipment to the local host, equipment to upper tier host, inter host
  - Message definitions are open to upper tier Standard per application area



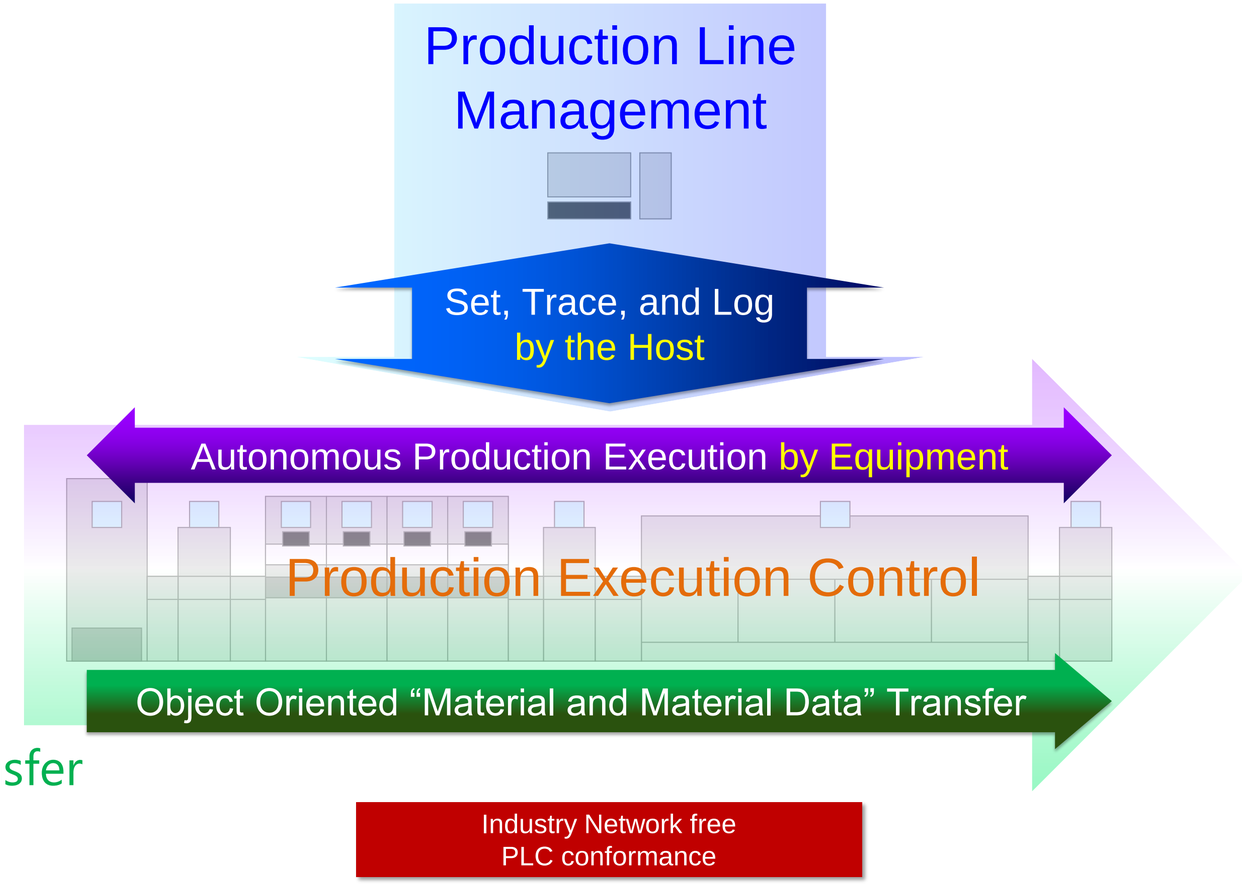
- Up to ten Material and Material Data transfer channels (Tracks)
  - Object Oriented simultaneous transfer of Material and its Material Data
    - Material Data definition is open to the upper tier Standard per application area
  - Compatible with various transfer means such as conveyors, AGVs, robots
  - Support Uni-direction, Alternate-direction, and Bi-direction transfer operation

- For the up-to-date information, visit:
  - http://www1.semi.org/jp/SEMI_A1_PESCI

Orthogonal “Line Management” and “Execution Control”

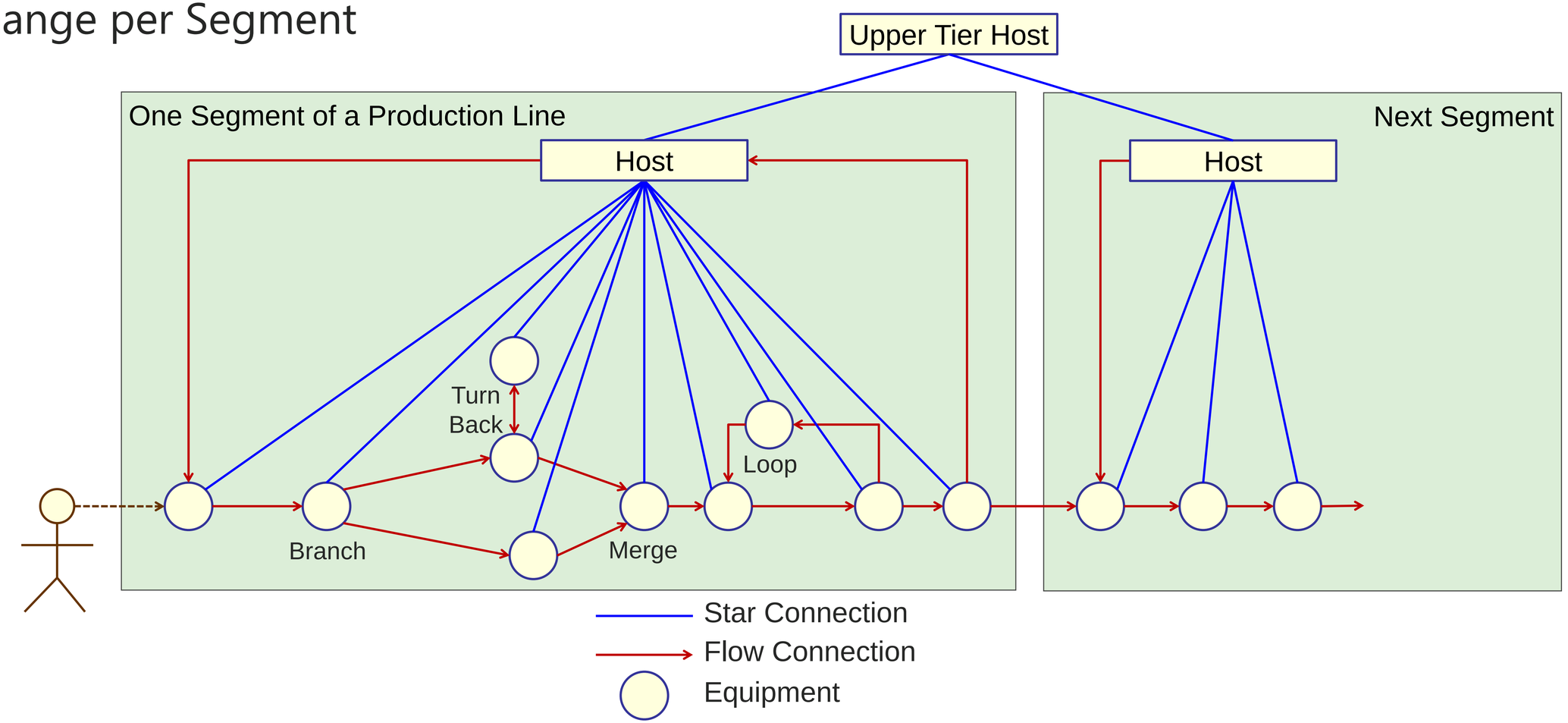
Production Line Management in Vertical and Production Execution Control in Horizontal

- Production Line Management:
  - Through Host-equipment communication (Point to Point)
  - Equipment settings and observations
  - Material tracking
- Production Execution Control:
  - By equipment-equipment communication (Daisy chain)
  - Autonomous Production Execution:
    - By equipment-equipment collaboration
    - Through General Data communication
  - Object Oriented Material and Material Data transfer
    - Simultaneous handoff of Material and Material Data
    - Direct reference of attached Material Data
    - Exception handlings of handoff (Pause – Recovery)



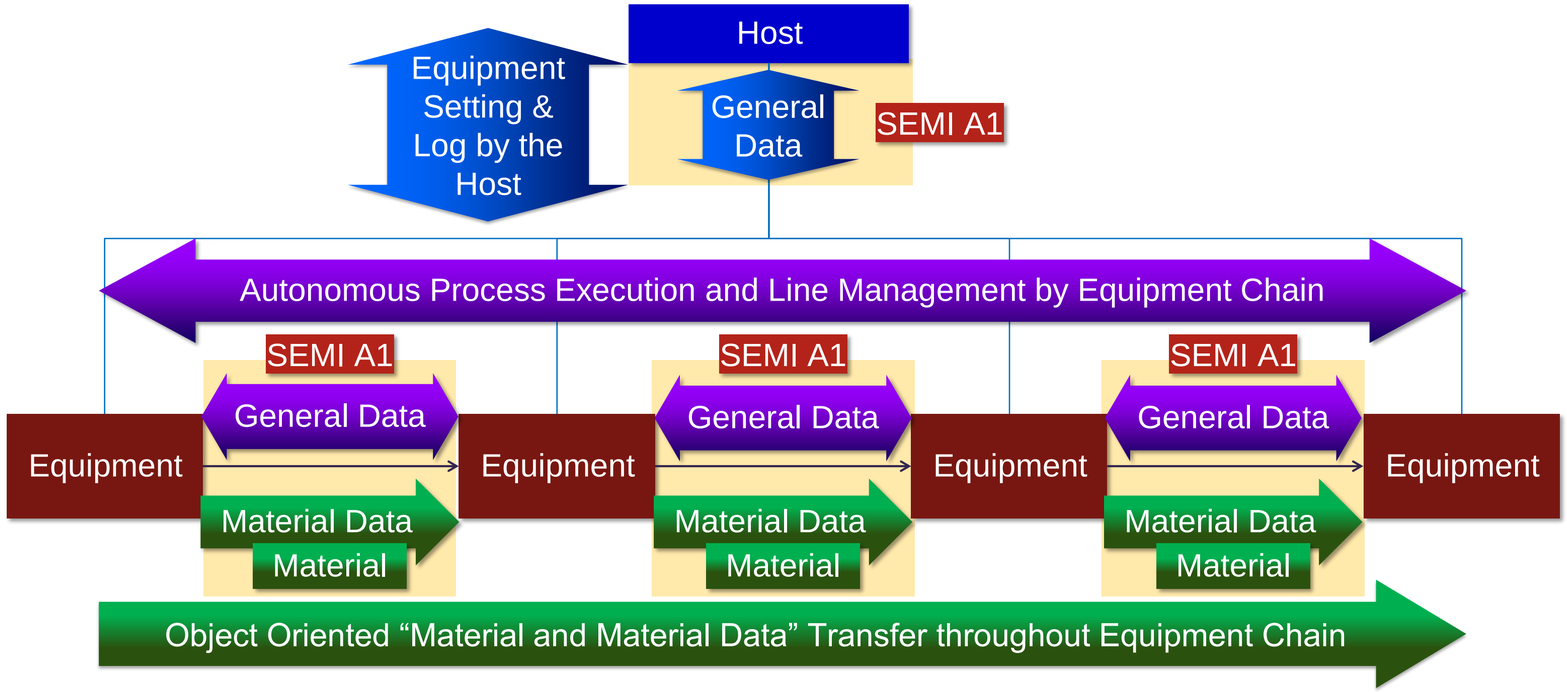
Segment and Tiered Host Operation Capability

- Tiered Host operation
- Localization of equipment dependent detail control in a Segment
- Easy to change per Segment



Application of SEMI A1 PESCI

- Host and Equipment connection (point to point) for:
  - Equipment management
  - WIP tracing
- Equipment and Equipment connection (daisy chain) for:
  - Generic communication between equipment via the adjacent equipment
  - Simultaneous handoff of Material and its Material Data



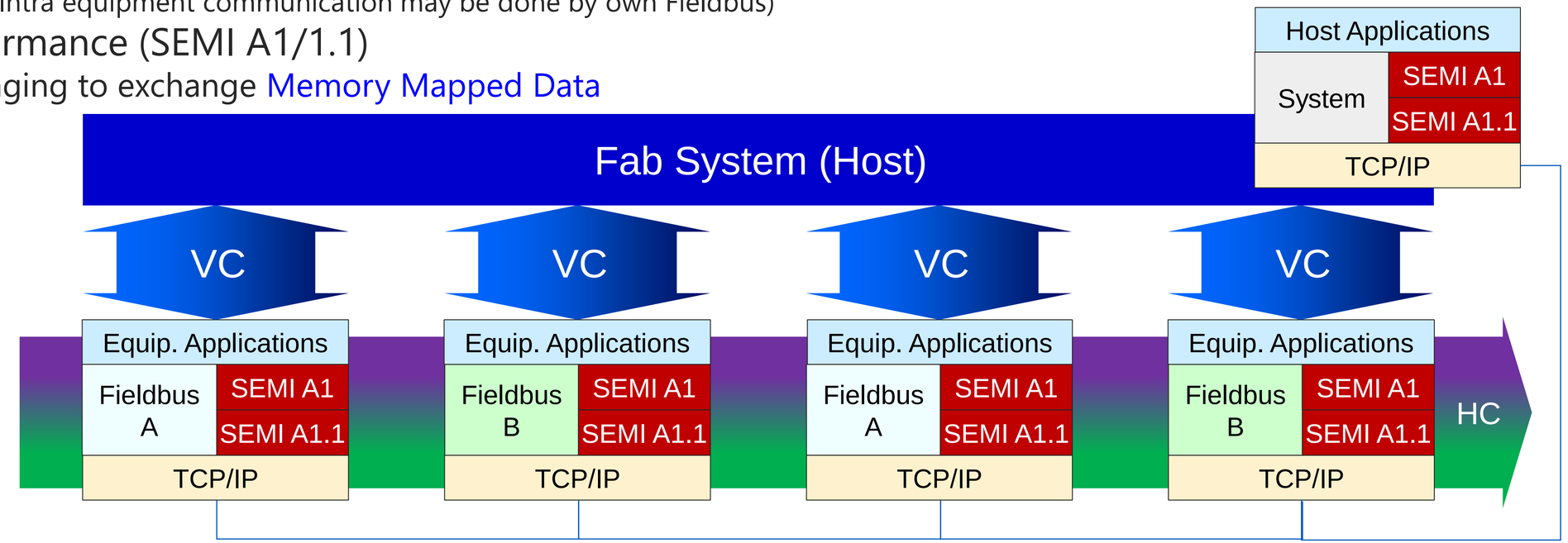
Definition Overview of SEMI A1/1.1

- SEMI A1 defines communication channels for equipment
  - Material and Material Data (MD) (Material Handshake)
    - Performs simultaneous handoff of Material and its Data
  - General Data (GD) (Data Handshake)
    - Performs generic data communication
    - Both for host-equipment and equipment-equipment communications
  - Simple “Memory Image Exchange” type of messaging
    - Better conformance even with low-end PLC

- SEMI A1.1 defines TCP/IP interface for SEMI A1
  - TCP/IP interface for both MD and GD Handshakes
  - “Memory Image Exchange” messaging scheme
    - for better conformance with low cost control components such as PLC
  - Direct mapping on TCP/IP
    - for higher compatibility among various control components

Connectivity and Interoperability

- Connections for production line (SEMI A1)
  - General Data between the host and equipment — Data Handshake
  - General Data between adjacent equipment — Data Handshake
  - Material and Material Data handoff between equipment — Material Handshake
- Communication Protocol for SEMI A1 (SEMI A1.1)
  - Direct mapping on TCP/IP
    - Connectivity between PLCs based on different Fieldbus
      (Intra equipment communication may be done by own Fieldbus)
- PLC conformance (SEMI A1/1.1)
  - Messaging to exchange Memory Mapped Data

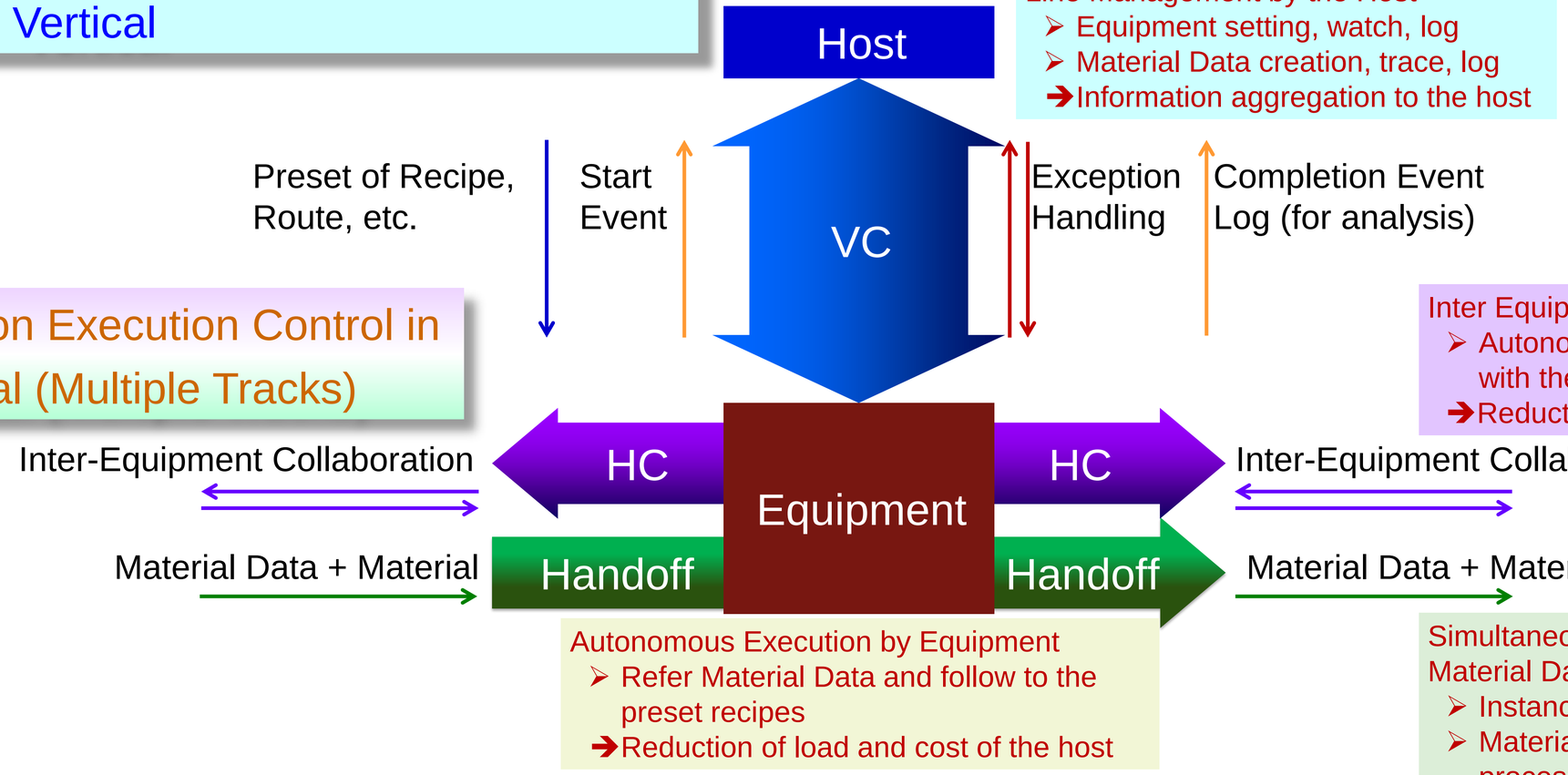


VC: Vertical Communication
HC: Horizontal Communication

Equipment Model of SEMI A1 PESCI

- Production Line Management in Vertical

- Production Execution Control in Horizontal (Multiple Tracks)



Line Management by the Host
- Equipment setting, watch, log
- Material Data creation, trace, log

➔Information aggregation to the host

Inter Equipment Communication
- Autonomous coordination along with the line

➔Reduction of Host load/cost

Autonomous Execution by Equipment
- Refer Material Data and follow to the preset recipes

➔Reduction of load and cost of the host

Simultaneous handoff of Material and Material Data
- Instance ID, Product ID, Log
- Material require equipment to process according to the Material Data

➔Object Oriented

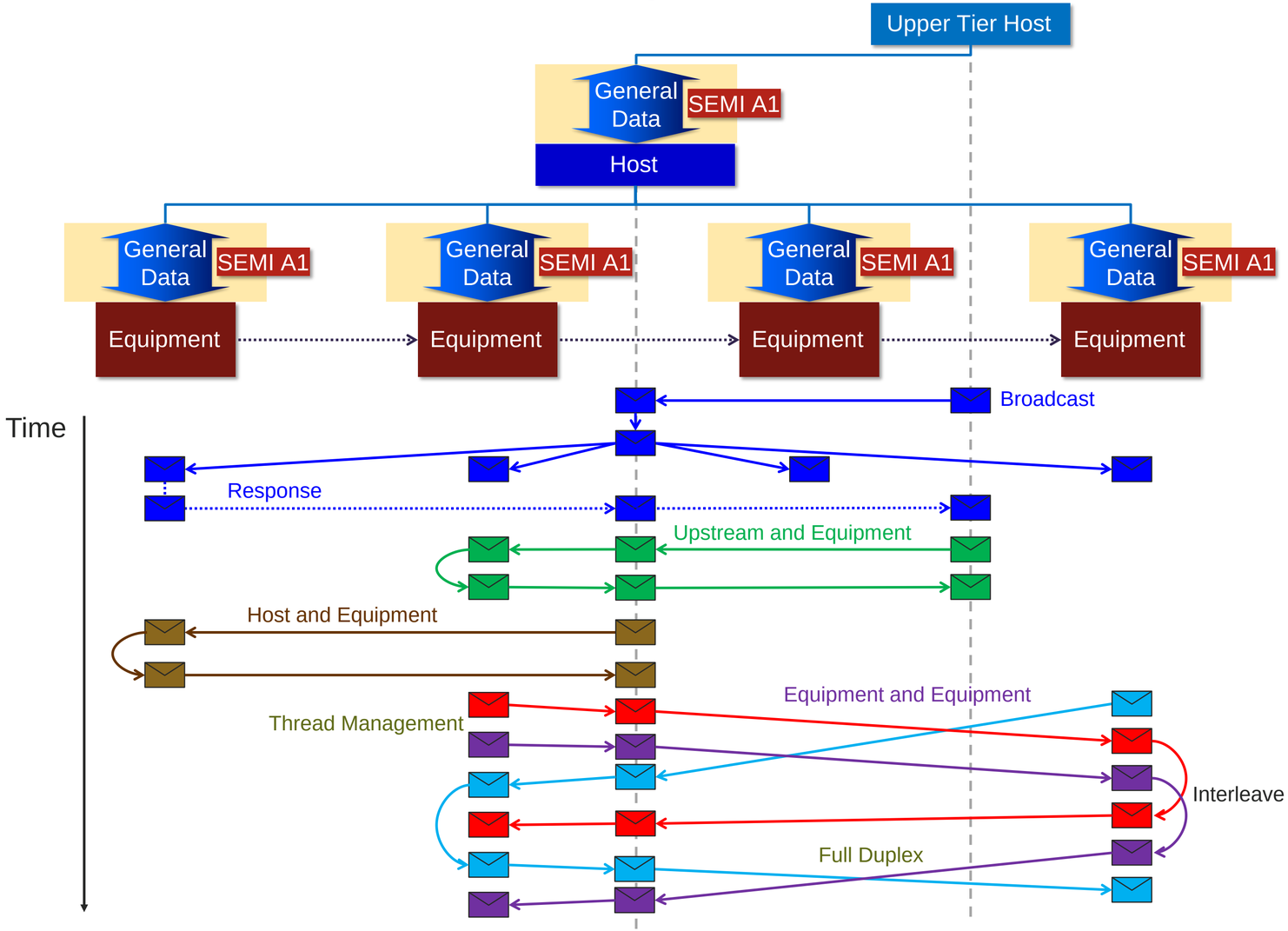
Standardized communication specification
- Direct use of TCP/IP
- Memory Block transfer for PLC conformance

➔Connectivity, quick launch

VC: Vertical Communication
HC: Horizontal Communication

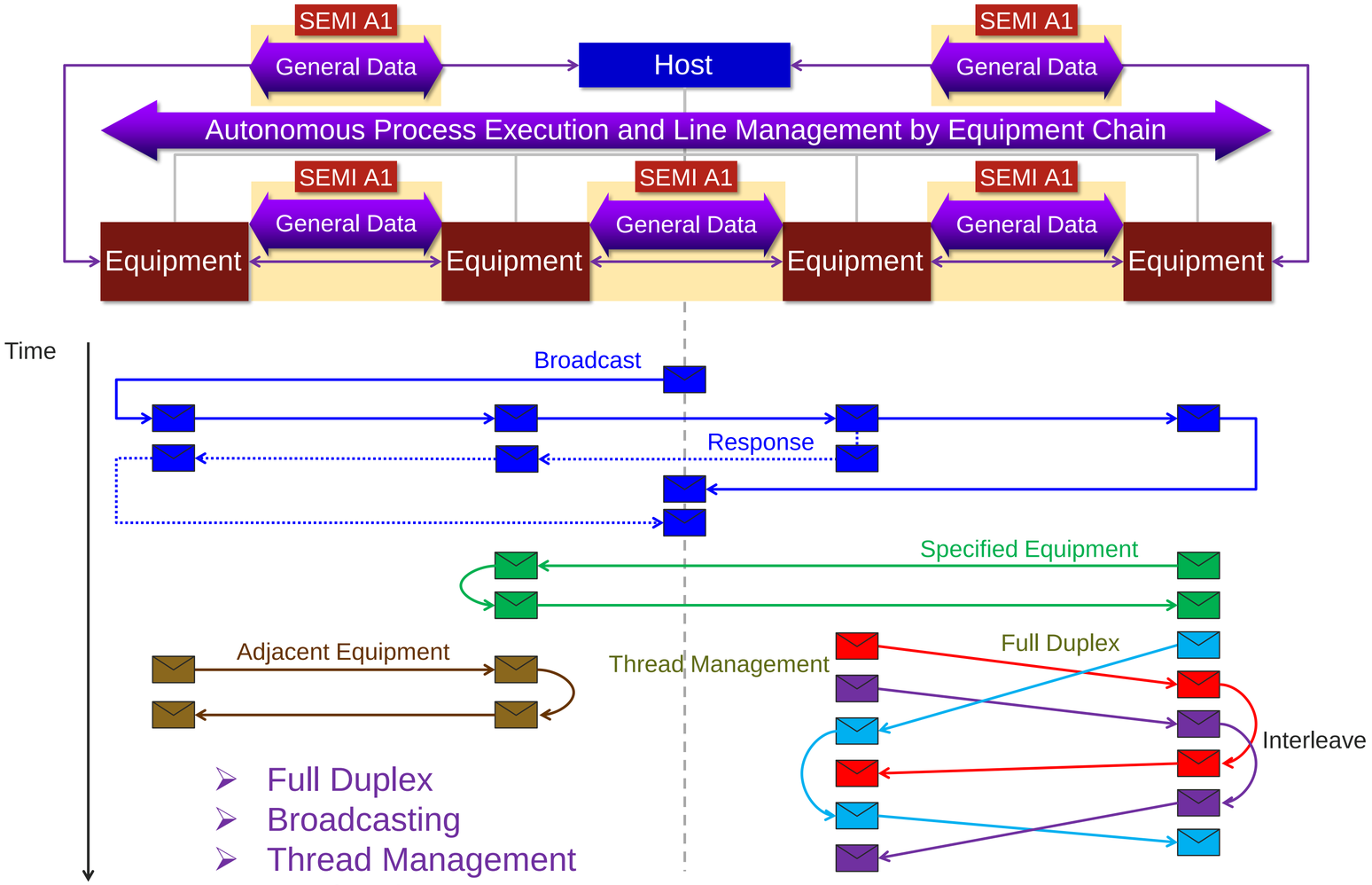
General Data Communication (Vertical)

SEMI A1 supports various Addressing Modes for Vertical Communication



General Data Communication (Horizontal)

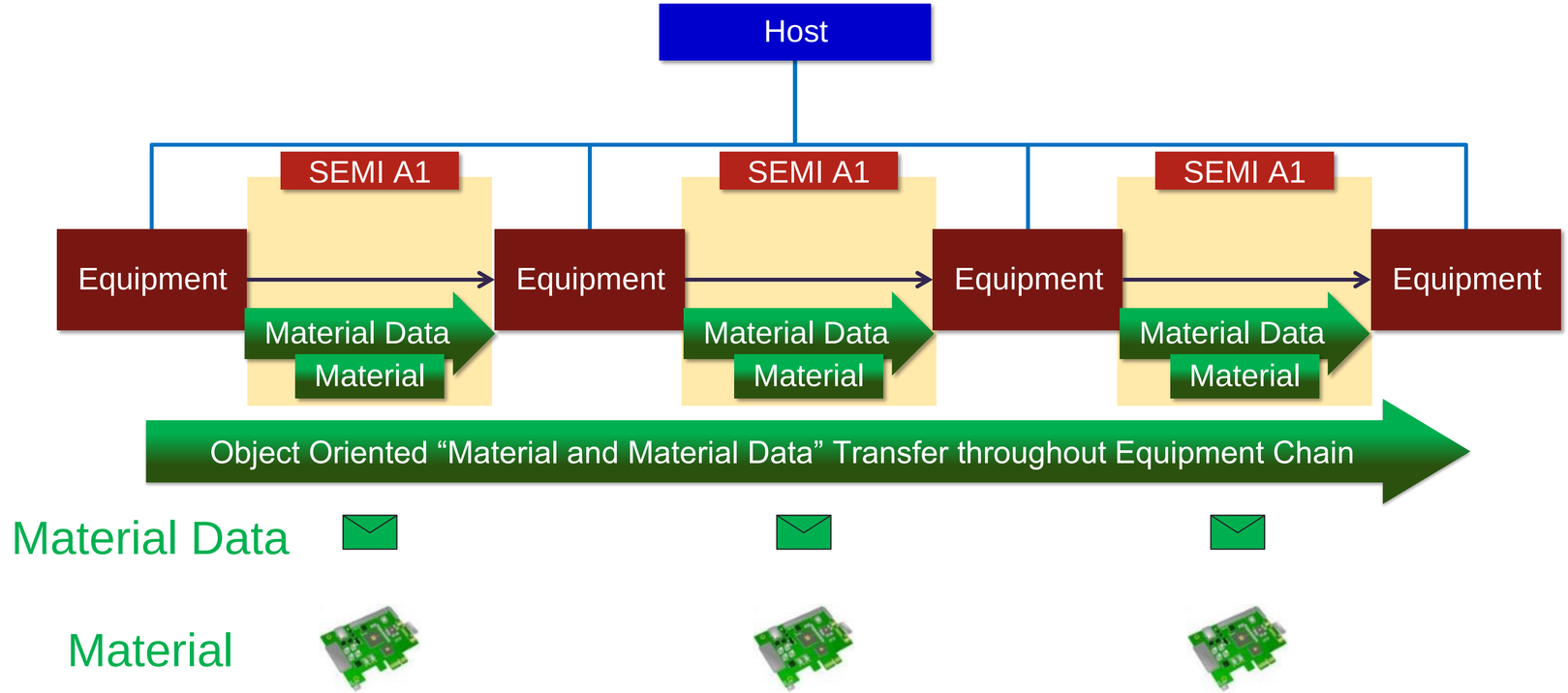
SEMI A1 supports various Addressing Modes for Horizontal Communication



- Full Duplex
- Broadcasting
- Thread Management
- Interleaving Management

Material and Material Data Transfer

SEMI A1 supports simultaneous handoff of Material and Material Data
Multiple Tracks are controlled independently



- Object Oriented way
- Material carries its characteristics as Material Data
- Equipment refers Material Data and executes prespecified operation

Typical Example of Material Data (MD)

- Material Data is an identification tag of the WIP

- Consists of the following three sections
  - Instance ID Identifier of the individual material
  - Class ID Identifier of the product class, the material belongs to
  - Log Result record at each equipment
    - Applied parameters or measured results (value or classification)
    - To be used as process log
    - May also be used for notifications for process/route changes to the equipment after

Field	Mnemonic	Definition	Usage
Instance ID	Material ID	Identifier of this individual material	To be used to identify this individual material
Class ID	Product ID	Identifier of Product this material to be	To be used to select recipe or route
	Version ID	Identifier of Version of the product	May be used for modification of recipe or route
Log	Result E0	Result record at equipment 0	Control of process or branch in the equipment after
	Result E1	Result record at equipment 1	
	Result E2	Result record at equipment 2	
	…….	…….	
	Result En	Result record at equipment n	

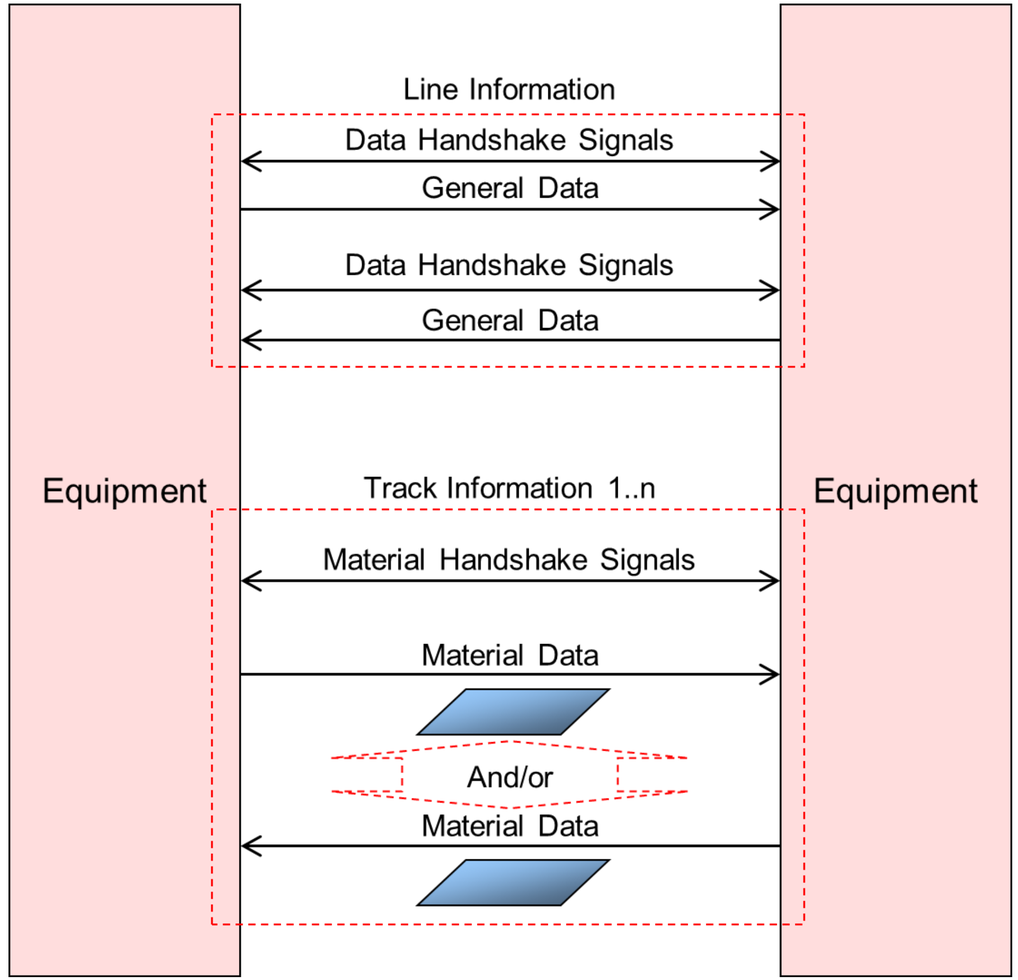
“Line” a Connection between Equipment

One “Line” Consists of

- One Line Information channel
- Up to ten Track Information channels

- Line Information
  - Full duplex data channel
  - For “General Data”
  - By “Data Handshake”

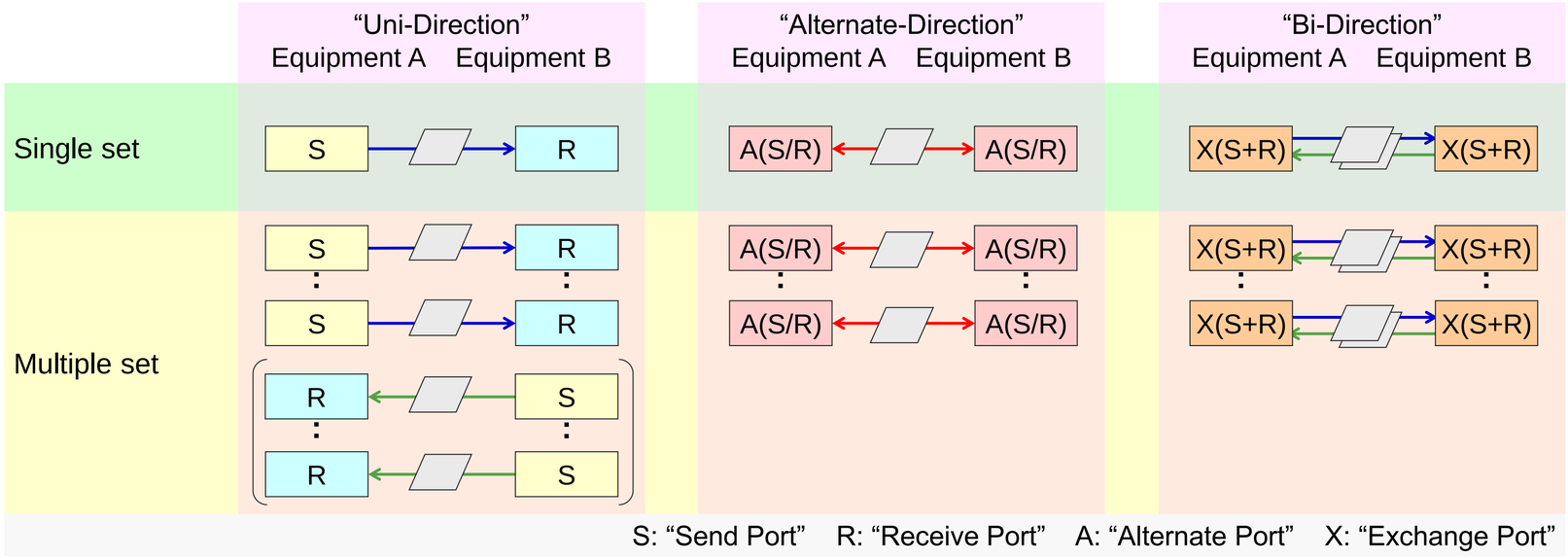
- Track Information 1 .. n
  - n tracks of half duplex transportation channels
  - For “Material and Material Data”
  - By “Material Handshake”



Track Types

- Three Track Types
  - Uni-Direction — Material flows to one direction
  - Alternate-Direction — Material flows both directions alternatively
  - Bi-Direction — Materials are swapped in one cycle

- Multiple Tracks per one Line



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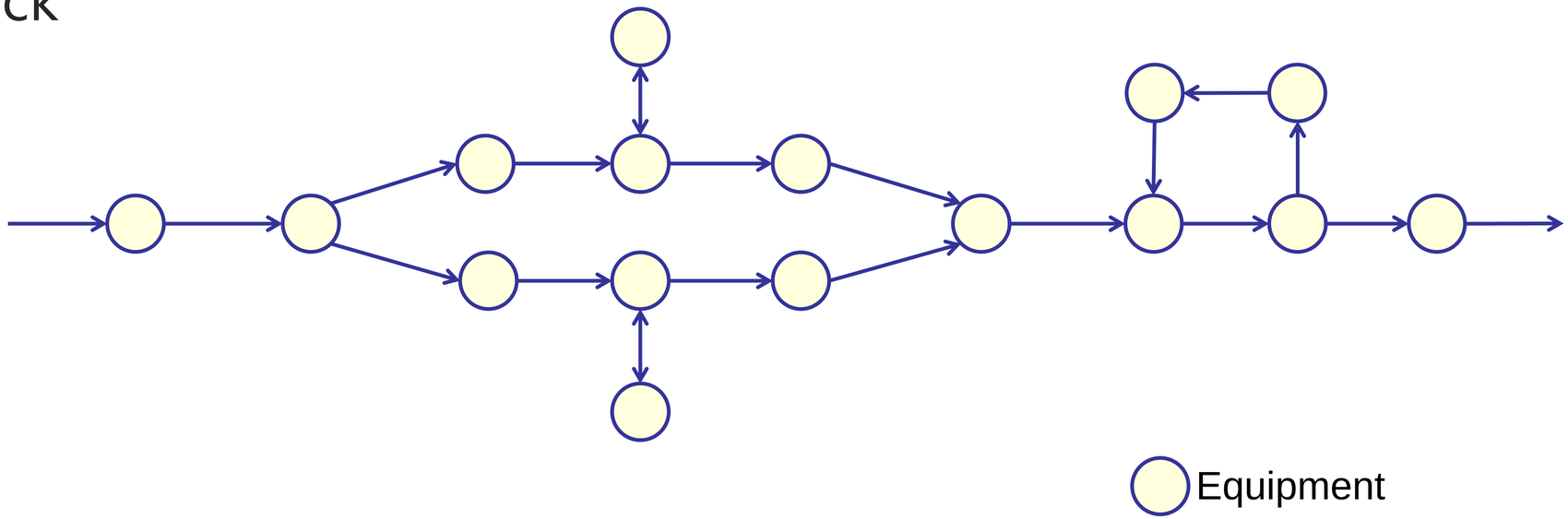
Line Topology

- Supports line topology that includes:
  - Branch
  - Merge
  - Loop
  - Turn back



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Handoff Function

- Handoff Step function
  - Compatible with handoff mechanisms that require multiple handoff steps
  - Conveyor, Robot, Isolation doors, etc.

- Operator assistance and recovery
  - Pause – Recovery functions
    - Operator or equipment initiated upon handoff exception
    - Restart, Resume, Forward, Abort can be selected for recovery

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Pizza Factory Analogy of SEMI A1 Application

Manufacturing Management:
- I am the host.
- I preset all work orders to my workers.
- I start material and take all working log.

Host

General Data:
Work Order Setting and Log by the Host

SEMI A1 / GD Handshake

Work Order:
- If Type A comes, I make it t=5mm
- If Type B comes, I make it t=4mm

E1

General Data:
Hey, getting thick!🡐
🡒Ok, I adjust!

GD Handshake / SEMI A1 / MD Handshake

Material Data:
- My name is #132
- I am going to be Pizza Type A
- 13:20.15 Started

GD Handshake / SEMI A1 / MD Handshake

Material Data:
- My name is #132
- I am going to be Pizza Type A
- 13:20.15 Started
- 13:20.45 12in. t=5mm @E1

SEMI A1 / GD Handshake

Work Order:
- If Type A comes, I put cheese and tomatoes
- If Type B comes, I put four different cheeses

E2

General Data:
I'm getting sick🡐
🡒Ok, I halt.

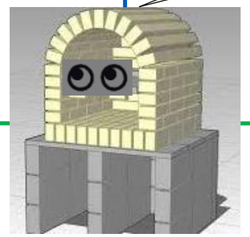
GD Handshake / SEMI A1 / MD Handshake

Material Data:
- My name is #132
- I am going to be Pizza Type A
- 13:20.15 Started
- 13:20.45 12in. t=5mm @E1
- 13:21.30 Cheese and tomatoes are put @E2

SEMI A1 / GD Handshake

Work Order:
- If Type A comes, I bake it for 3 minutes
- If Type B comes, I bake it for 2 minutes

E3



GD Handshake / SEMI A1 / MD Handshake

Material Data:
- My name is #132
- I am going to be Pizza Type A
- 13:20.15 Started
- 13:20.45 12in. t=5mm @E1
- 13:21.30 Cheese and tomatoes are put @E2
- 13:24.55 3 minutes @E3

General Data: Autonomous Process Execution and Line Management by Equipment Chain

Material Data: Object Oriented "Material and Material Data" Transfer throughout Equipment Chain

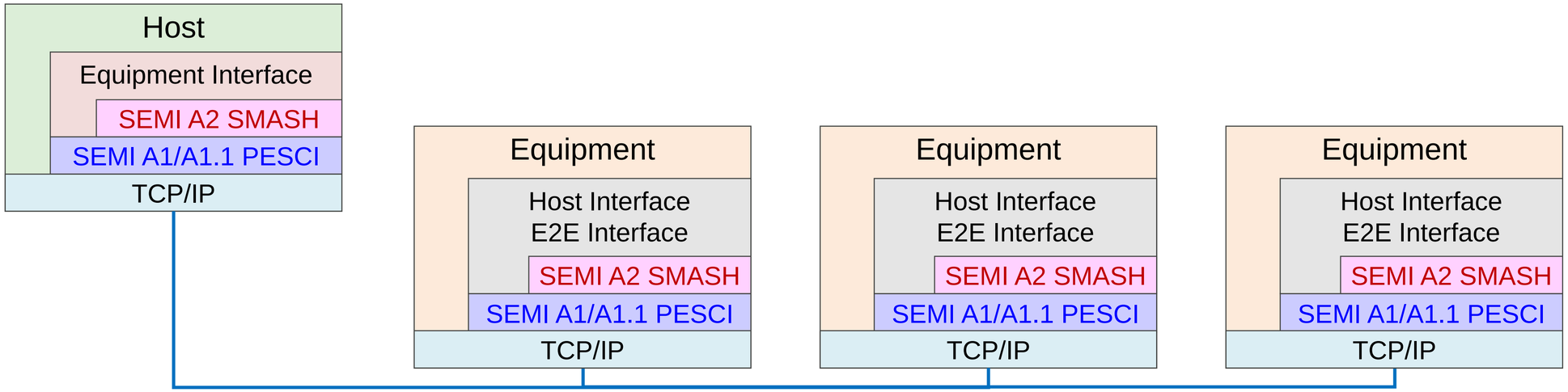
Functions of SEMI SMT-ELS

Currently Available Functions of SEMI SMT-ELS

Position of SEMI SMT-ELS Standards Suite

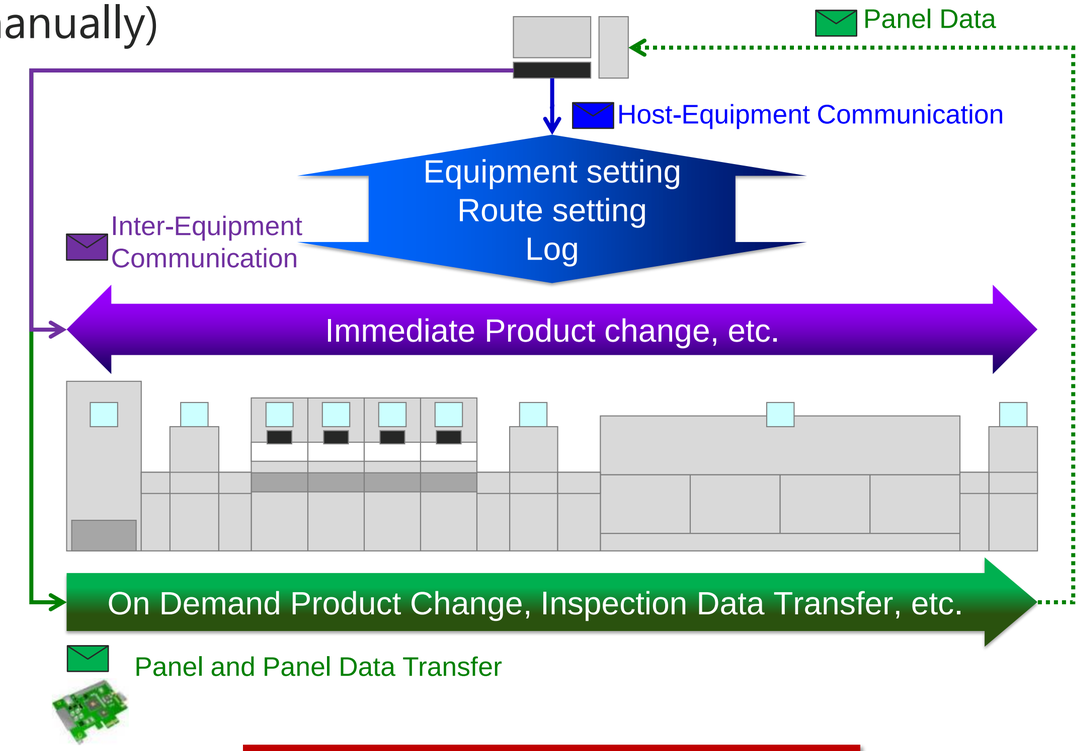
- SEMI SMT-ELS Standard Suite supports both:
  - Host – equipment (Vertical) communication — Point to point
  - Equipment – equipment (Horizontal) communication — Daisy chain

- SEMI SMT-ELS Standard Suite has the following tier structure
  - SEMI A2 SMASH — Messages and behaviors for SMT assembly line
  - SEMI A1 PESCI — General-purpose equipment connection interface
  - SEMI A1.1 TCP/IP Interface for PESCI — TCP/IP Interface for SEMI A1 PESCI



Functions Currently SEMI SMT-ELS Provides

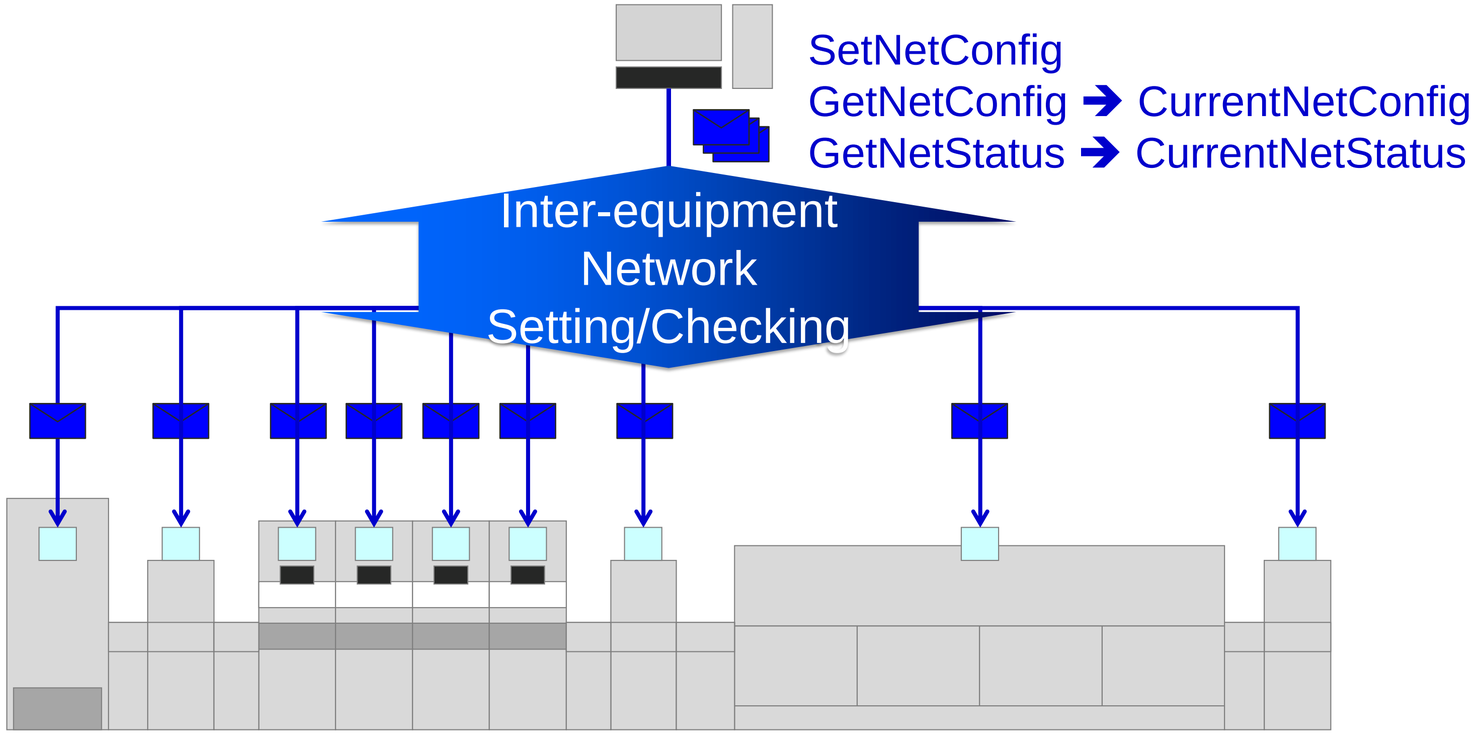
- Equipment management by the host
  - Inter-equipment network setting (can also be done manually)
  - Route setting of Panel (can also be done manually)
- Equipment to equipment communication/cooperation
  - Panel Data reference mode setting
  - Immediate product change
- Simultaneous transfer of Panel and Panel Data
  - On-demand product change by Panel attached Panel Data
  - Traceability of a Panel
  - Handoff functions by using conveyor
    - Handoff Step function which executes multiple step handoff
    - Pause – Recovery function for exception handling
- Preconditions
  - SMEMA equipment conformance with Virtual SMASH Controller
  - PLC conformance (not only for PC level controller)



Industry Network Independent Protocol
Use of SMEMA Generation Equipment
with SEMI SMT-ELS Controller
PLC Conformance

Inter-equipment Network Setting/Checking

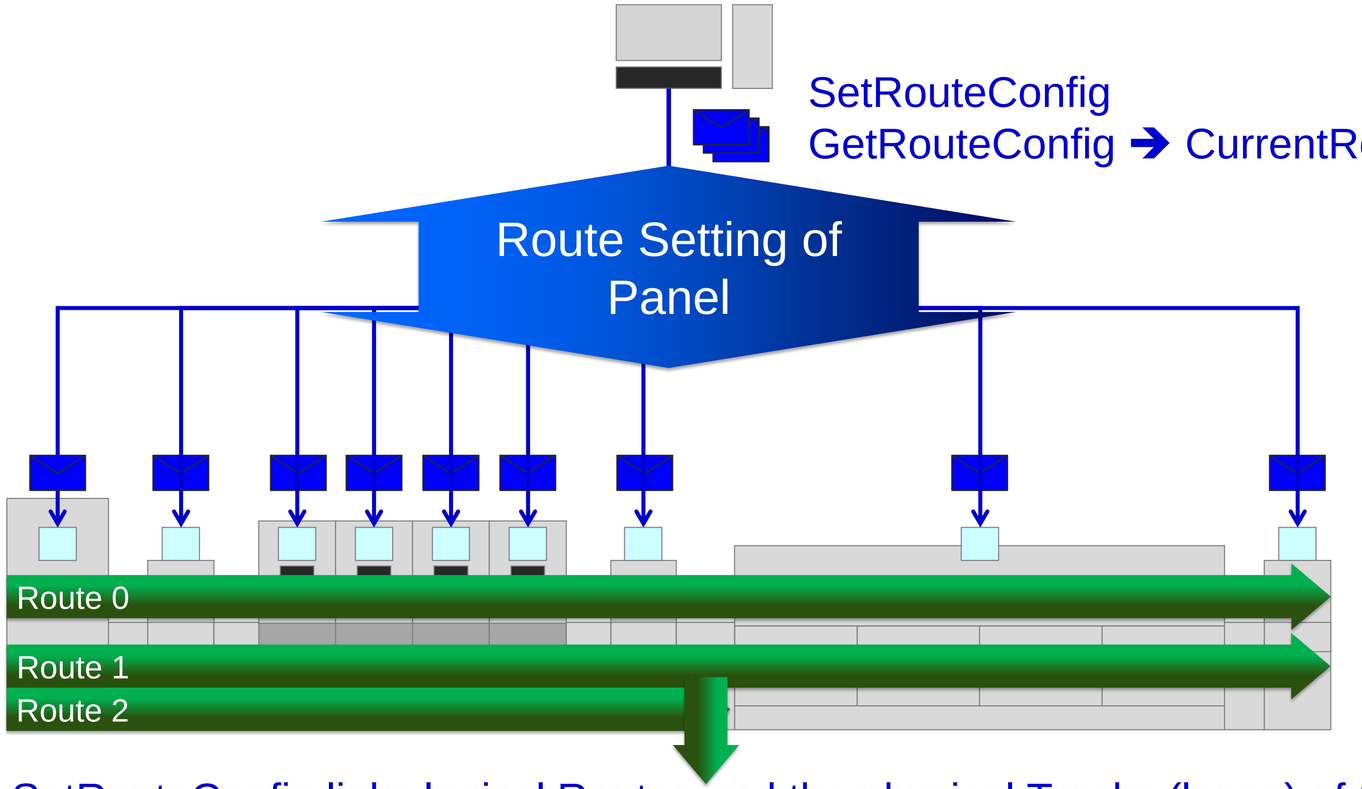
SetNetConfig message from the host sets IP Address and Port Number
to be used for equipment-equipment communication (Can also be set manually)



Inter-equipment communication is opened by this action

Route Setting of Panel

SetRouteConfig message sets required number of Routes to each equipment
(can also be set manually)
Route is selected and used per Product or Inspection Result

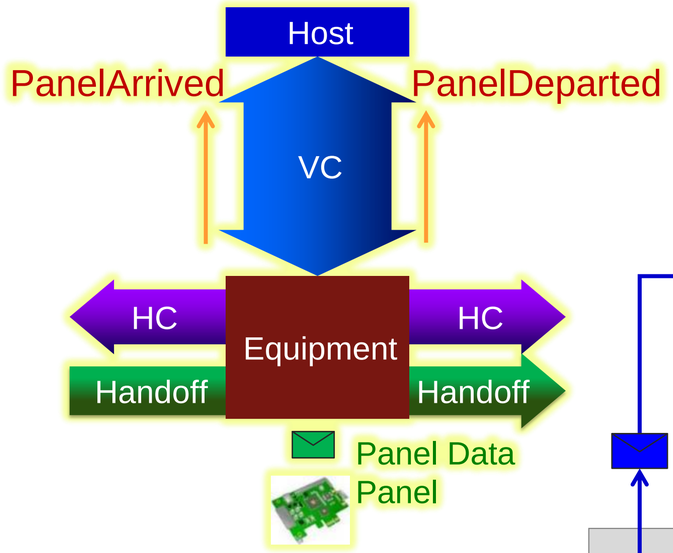


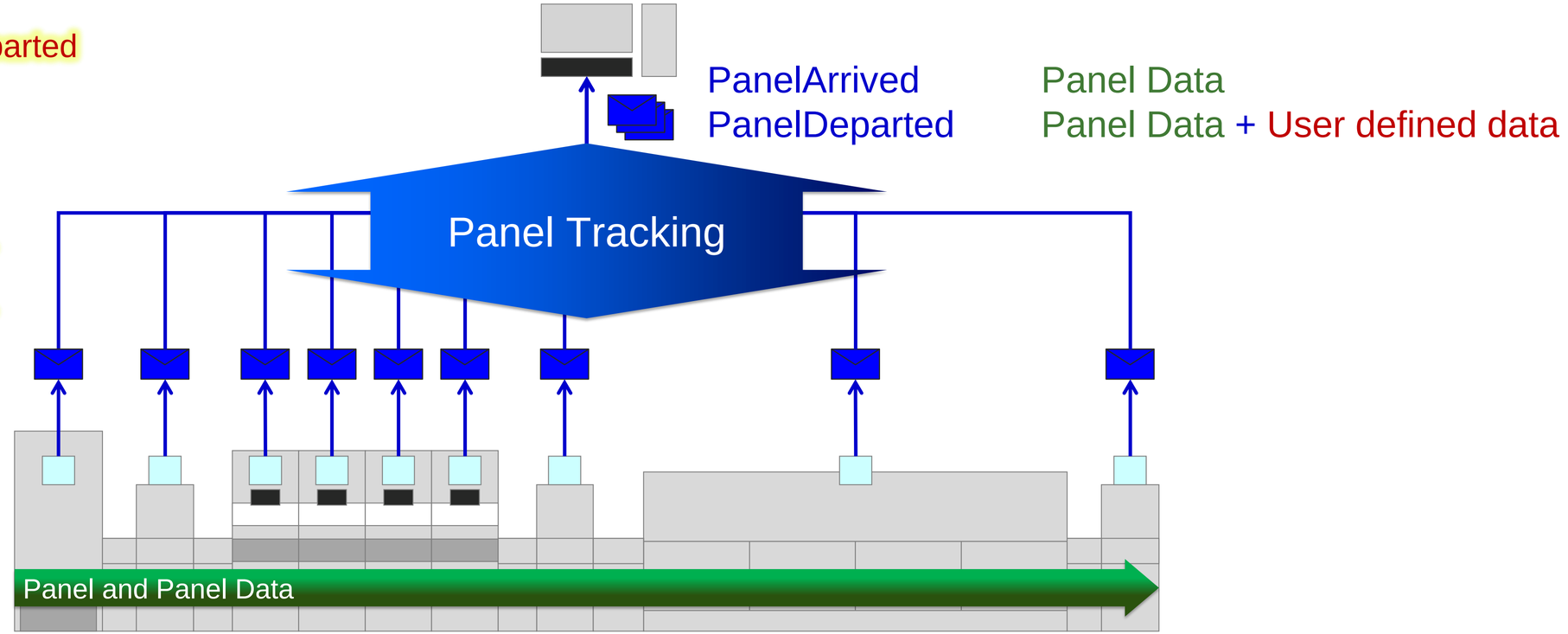
SetRouteConfig links logical Routes and the physical Tracks (lanes) of the equipment
Branch condition can also be set

Panel Data
Panel

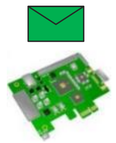
Panel Arrival/Departure Events

PanelArrived and PanelDeparted messages from equipment provides Panel tracking.





Panel Data and user defined production data are reported to the host.



Panel Data

- The following Panel Data is defined
- Items can optionally be added per the requirements of each production line

Field	Mnemonic	Definition	MD Mode			Usage
			M0	M1	M2	
Instance ID	Panel IX	Panel Index used by SMASH	C	C	C	
	Panel ID	Panel Identifier	C	C	R	To be used for Panel identification
	Top Bottom	Specify the surface, top or bottom	C	C	R	
Class ID	Product IX	Product Index used by SMASH	C	C	C	
	Product ID	Product ID of the Panel	C	R	R	To be used for recipe or route selection
	Panel Width	Width of the Panel	C	R	R	To be used for conveyor width setting
	Panel Length	Length of the Panel	C	C	C	
	Panel Thickness	Thickness of the Panel	C	C	C	
Log	Inspection Result	Result from inspection equipment	C	C	C	Downstream equipment may use
User defined			O	O	O	

R: Required, C: Conditional, O: Optional

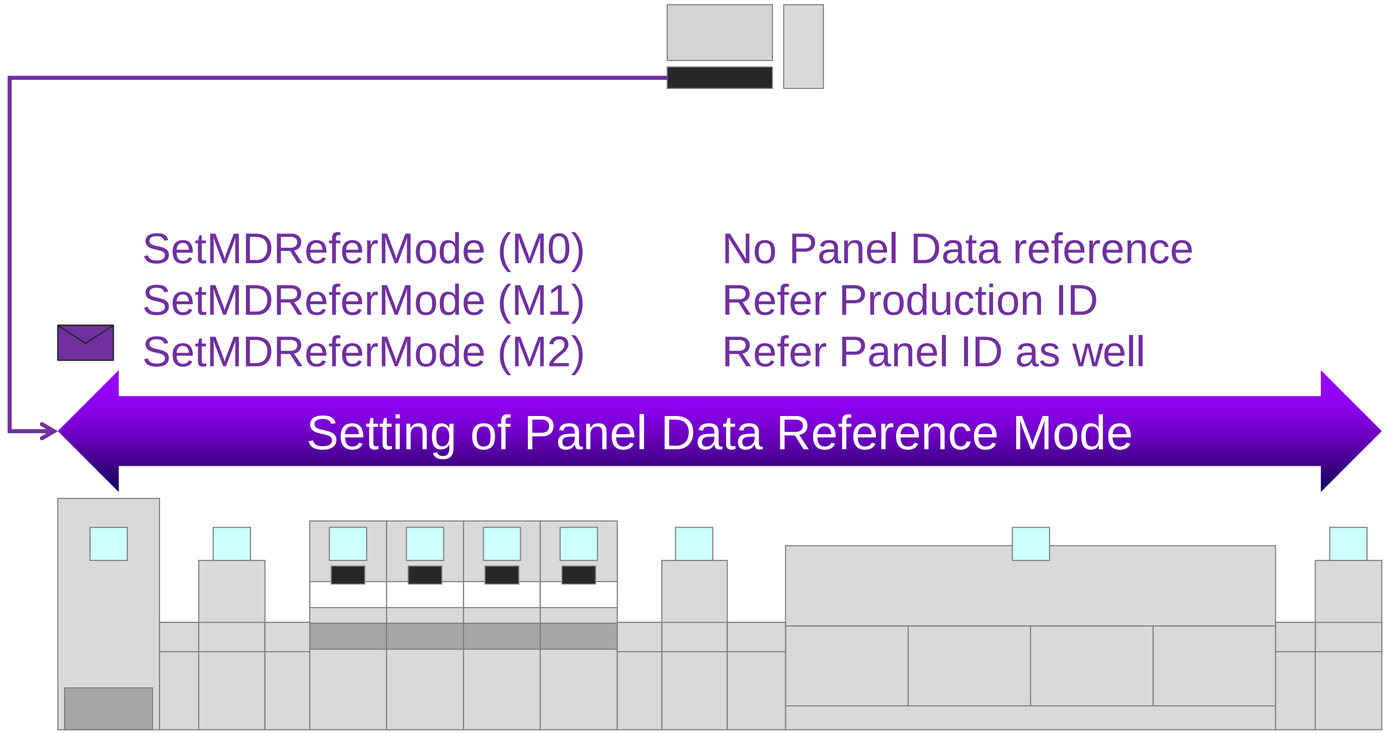
Panel Data Reference Mode

- Panel and Panel Data are transferred simultaneously
- Assembly line can select M0 to M2 per Panel Data availability

Reference Mode	M0	M1	M2	Note
Use	For transition use Panel Data is not valid yet	Product Management	Product and Panel Managements	
Panel Data to be used	Not used	Top Bottom Product ID Panel Width	Panel ID Top Bottom Product ID Panel Width	
Trace of a Panel	No	No	Yes	Panel ID Panel ID reader is required
Top / Bottom	No	Yes	Yes	
On demand Product change	No	Yes	Yes	Product ID Panel Width
Immediate Product Change	Yes	Yes	Yes	By horizontal communication
Panel Handoff	Yes	Yes	Yes	

Setting of Panel Data Reference Mode

SetMDReferMode sets Panel Data Reference Mode by using Horizontal Communication

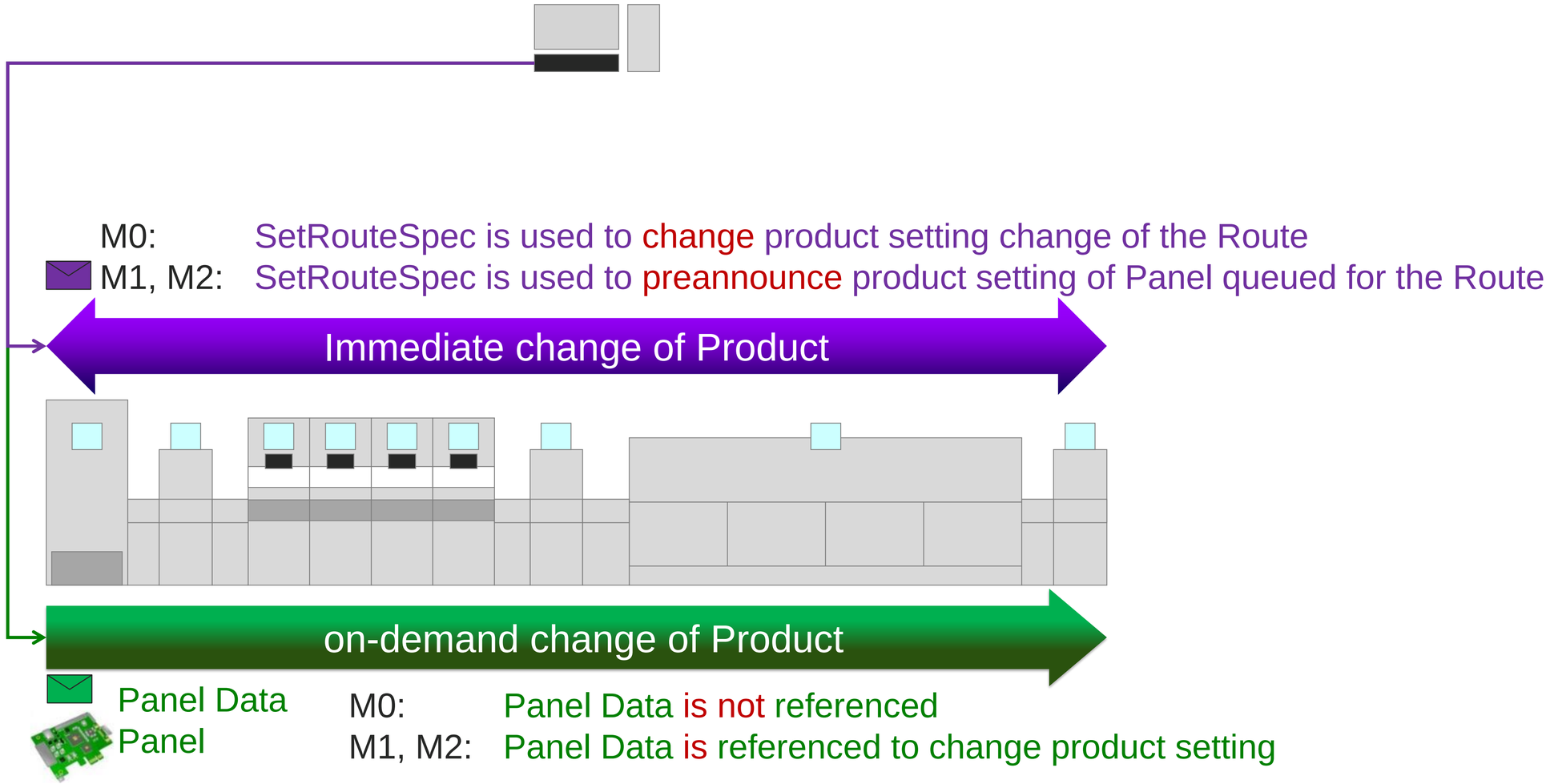


Setting shall be done when no Panel is in the line

Product Change per Panel Data Reference Mode

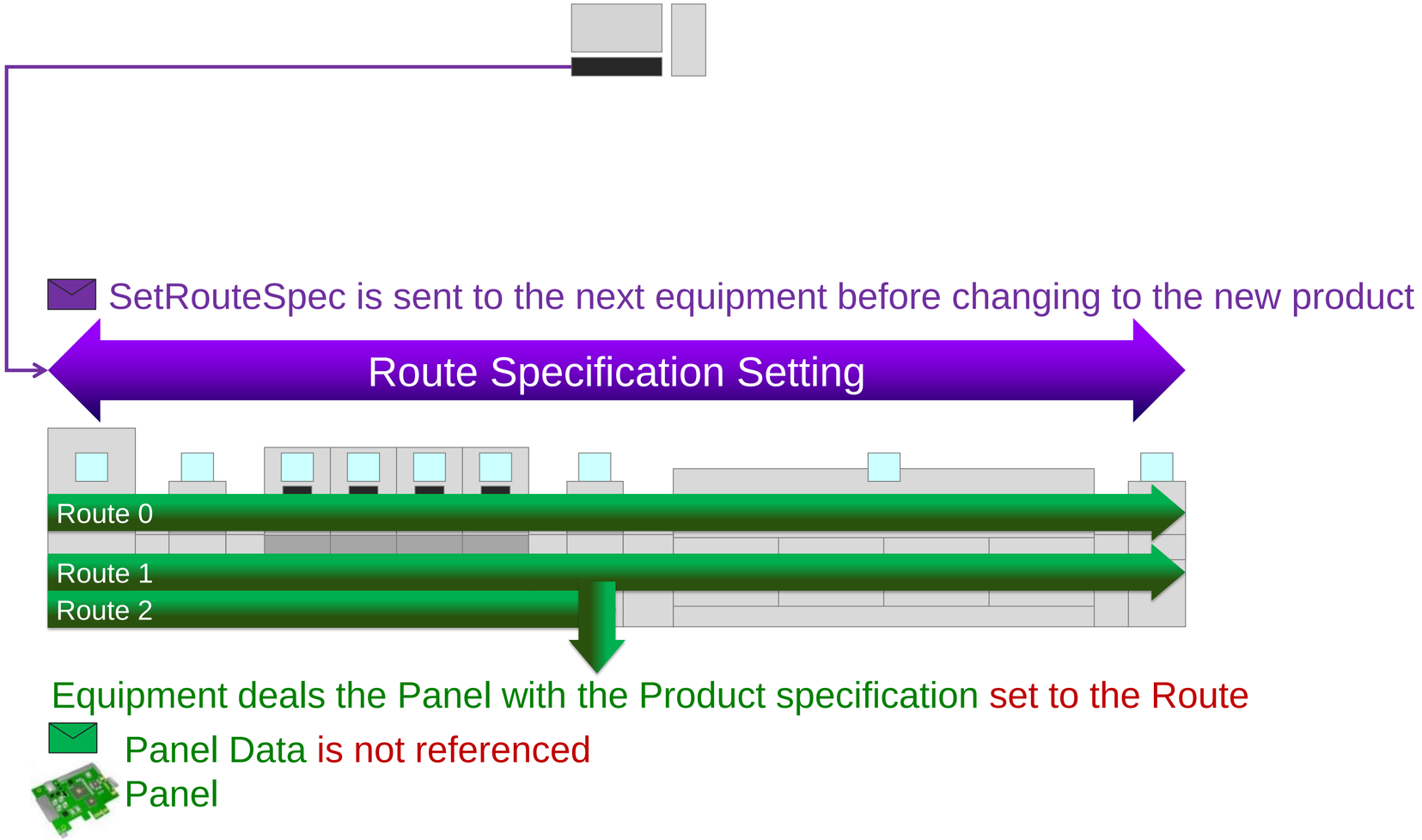
M0 Advance change of product setting to the Route by SetRouteSpec message

M1, M2 On-demand change of product setting of the Panel by Panel Data



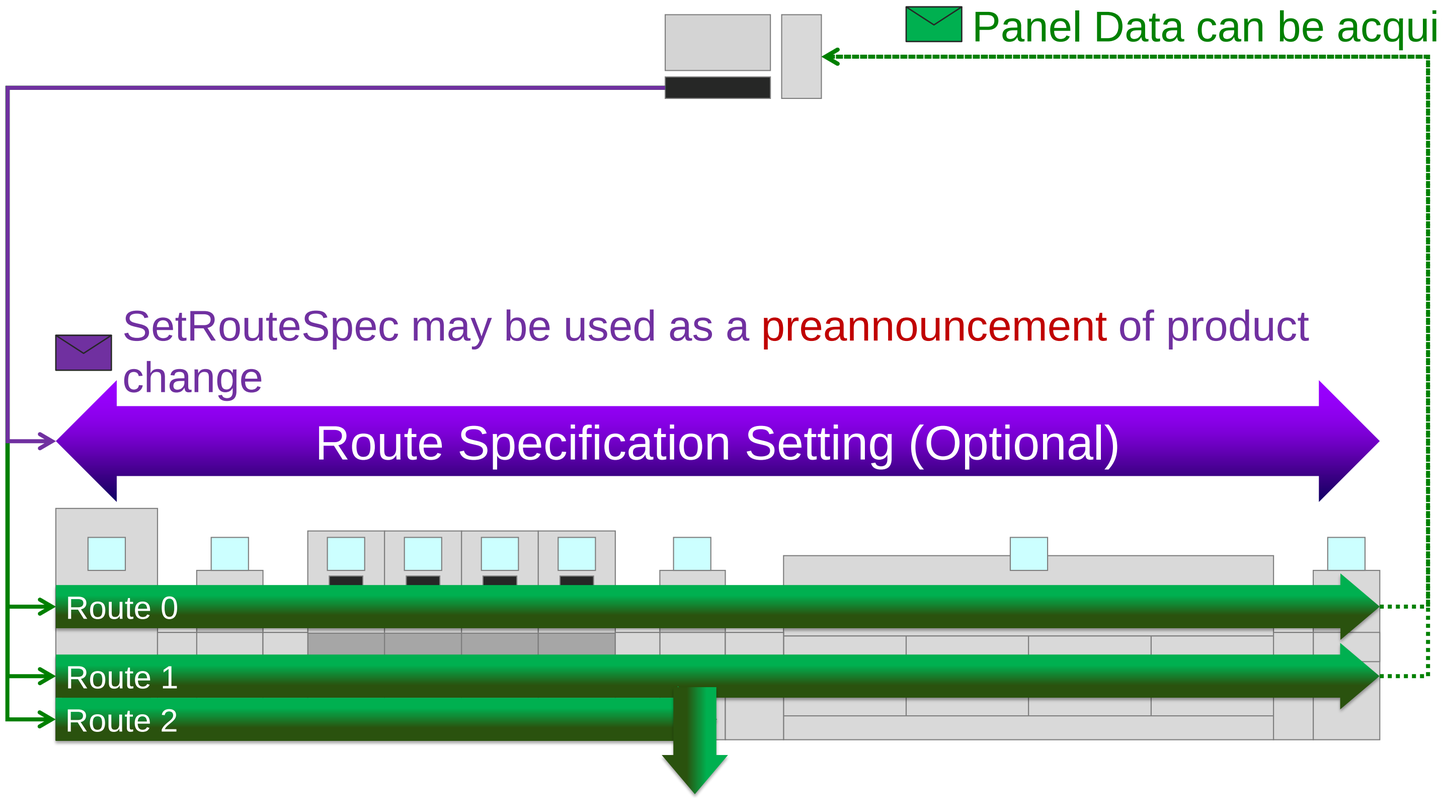
M0: No Panel Data Reference

Panel Data is transferred with the Panel but not referenced
(Transition use, equivalent function with SMEMA)



M1, M2: Panel Data Reference

Panel Data is transferred with the Panel and referenced



Equipment deals the Panel with the Product specification brought by the Panel Data

Panel Data is referenced

Panel

Functions to be Added Shortly

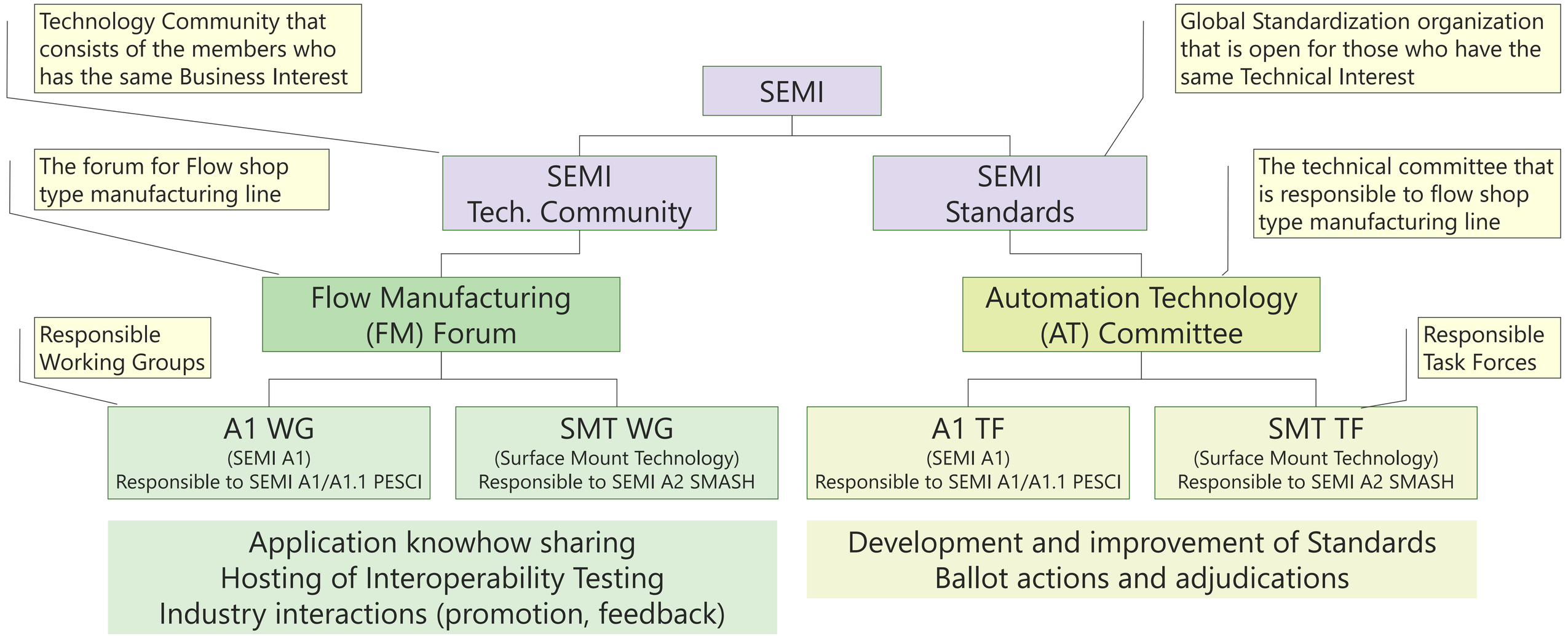
- Vertical Communication
  - Production Program management (Recipe Management)
  - Equipment production events

- Horizontal Communication
  - Inter-Segment connection (such as carrier handling AGV interface)

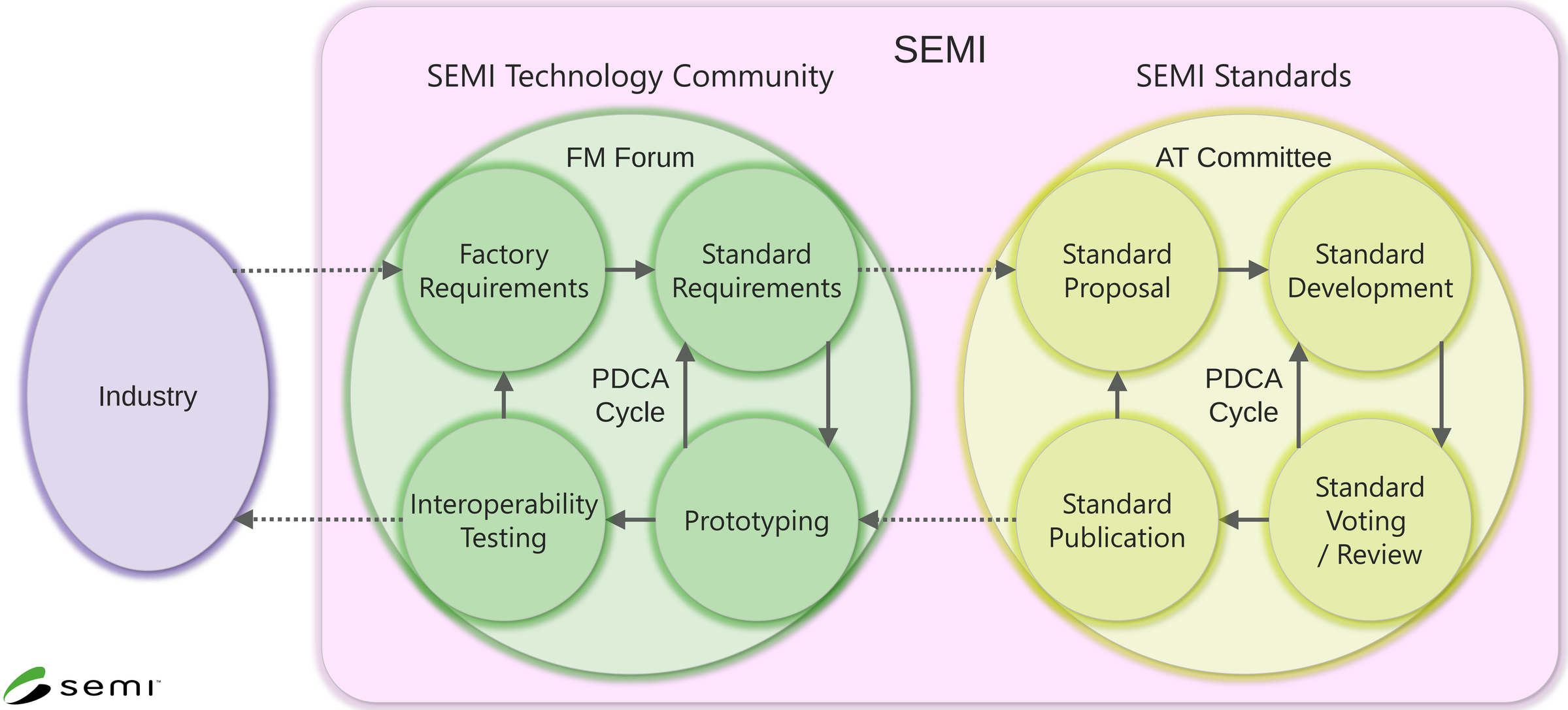
SEMI SMT-ELS Activities

Organization, Activities and Document Control

SEMI SMT-ELS Organization



Relationship between FM Forum and AT Committee



Interoperability Testing Support

- Flow Manufacturing Forum hosts interoperability testing
  - Interoperability should be managed by the forum members since SEMI should be neutral and is not in the position to test or certificate
- Two testing categories
  - Equipment Level Testing
  - Package Level Testing
- Participants who appropriately performed the testing with multiple proven members are posted to SEMI SMT-ELS homepage
- Please visit SEMI SMT-ELS homepage for up-to-date information

For More Information

- SEMI SMT-ELS homepage
  - http://www1.semi.org/jp/SEMI_SMT-ELS
- SEMI A1 PESCI homepage
  - http://www1.semi.org/jp/SEMI_A1_PESCI
- Association Contact
  - Junko Collins, Director, Standards & EHS /SEMI Japan
  - Email: jcollins@semi.org

Thank you!

SEMI SMT-ELS