Standard Transport Interface

This document is an early draft. The content will change and should not be used without consulting the author.

Revision history

Version	Date	Author	Description
0.1	04-03-2025	MIV	Initial version
	26-06-2025	PDA	Release

Review history

Version	Date	Reviewer	Notes / description
0.1	12-03-2025	AEF	Review
	26-06-2025	PDA	Release

Table of Contents

1 Introduction

This document is a specialization of the standard equipment interface [1], that describes the standard interface for transporting containers. This interface is used for communication between a high-level control (HLC) system and transport equipment of various types (Mobiler robot, conveyor, …).

The interface contains all the relevant telegrams for transporting containers, but not all the telegrams are relevant for all equipment. This means that for any equipment type there may be telegrams that are not relevant.

Detailed descriptions of the communication protocol, telegram format, and common telegrams used by this interface can be read in the standard equipment interface document [1]. Readers are advised to become familiar with that document before implementing the standard transport interface.

The document is currently a **draft** for the interface and is purely conceptual. *Major changes will be made to it* and a number of iterations are required before it is ready to be used for the design of a system using it. Notes and comments will be highlighted as red text or have an associated comment in google docs.

1.1 References

ID	Document	Description
[1]	**Title:** Standard Equipment Interface v2.1	The base interface description used for all equipment / robot cell open interfaces.
[2]	**Title:** Domain Model v1.3	Defines various terms and concepts used for the domain.
[3]	**Title:** Graph Theory	https://en.wikipedia.org/wiki/Graph_theory
[4]	**Title:** Standard Interface v1.0	https://docs.google.com/document/d/10arz_3_46BwXVqRED9VWcgoEzTSJKqlNwQr9WwJI0XU/edit?tab=t.0#heading=h.gjdgxs

1.2 Glossary

Abbreviation	Description
HLC	High-Level Control system - e.g. WCS/WMS, MES or MFS.
AMR	Autonomous Mobile Robot - An AMR is a mobile robot that navigates autonomously with its sensors in an environment. AMRs are highly flexible as these do not require the tracks used by AGVs.
Interfleet Manager (IFM)	The interfleet is a subsystem in the HLC which is responsible for ensuring interoperability between fleet managers. Some of the key responsibilities of the interfleet is to coordinate operations with mobile robots and ensure that connected fleet managers are in-sync. An interfleet manager can also be its own dedicated system.
Fleet Manager (FM)	A system which is responsible for managing the mobile robots (AGVs or AMRs) connected to it.

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1.4 Background / 5G-Robot

Parts of this document / release was made in the **5G-Robot** project also known under the long name **5G-ENABLED AUTONOMOUS MOBILE ROBOTIC SYSTEMS -** the largest innovation project that has been launched under the Innovation Fund Denmark's (IFD) Grand Solutions program.

The groundbreaking project united Denmark's leading robot, automation and factory digitalization companies as technology vendors, research partners and industry-leading end-user companies.

Illustration: Project partner logos.

The aim of the project was to revolutionize manufacturing - paving the way to smart production and smart factories and the application of a number of new technologies in production and manufacturing including 5G wireless communication, cloud and edge computing and digital twin.

Intelligent Systems played a leading role in the project, providing the glue that ties the robotic solutions of the partners together making the work as one - i.e. one connected integrated intelligent manufacturing system.

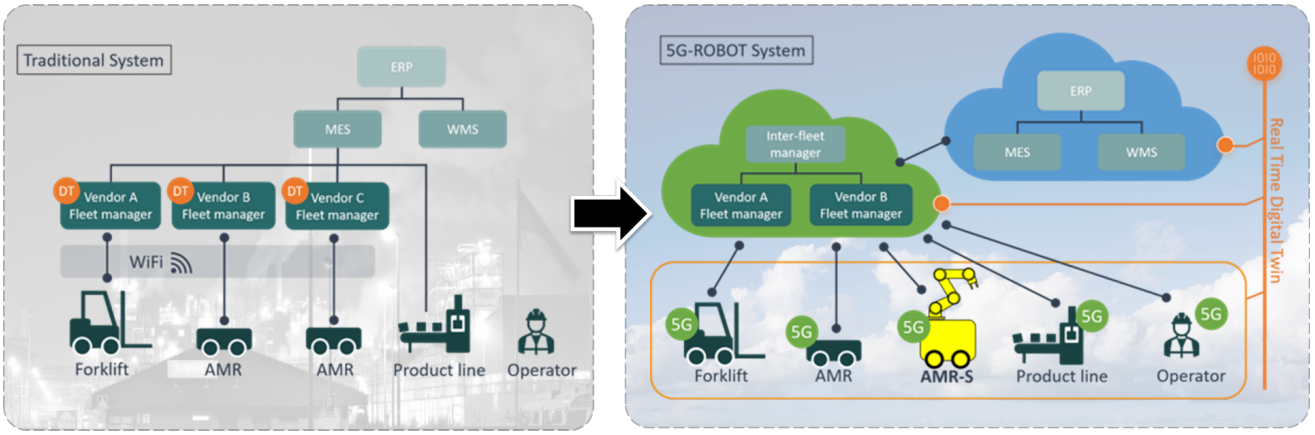


Illustration: The aim is to revolutionize manufacturing paving the way to smart production and smart factories.

Read more about the 5G-Robot project here: https://www.5gsmartproduction.aau.dk/5g-robot

2 Domain Model

Refer to the following concepts in the domain model [2]:

- Topology Concept

2.1 Glossary

Term	Description
Graph Concept	
Node	Name used for a location in a transportation network
Edge	Name used for link between 2 nodes or locations in a transportation network
Container Concept	
Item	Describes a distinct physical object (or a number of indistinguishable items).
Container	Generally designates entities which can contain other items or containers, primarily for the purposes of transport and packaging. A container can be a box, pallet, carton or other similar items.
Pallet	A generalization of a container that can be palletized with items and/or containers.
Location	A place where an object exists. This can either correlate with a physical location or can be used for logical grouping. Typically used for specifying where containers or items are located.
Equipment Concept	
Equipment	A piece of or a group of physical hardware, such as collaborative robot manipulators, actuators, and barcode scanners.

2.2 Container Movement Concept

When transporting containers they are basically just moved from location A to location D, but doing this may require movements through locations B and C. Making interim stops along is handled in different ways depending on the equipment used, so the HLC's task is to make sure that the container is guided to its destination.

During the transport, containers may have to change from one equipment to another. This is assumed to be facilitated by the HLC. If a container is to move from one equipment type to another (i.e. from conveyor system to AMR) then the HLC will facilitate this by sending the relevant commands. Basically it is the HLC that controls what happens and when so that control over both equipment is maintained.

If on the other hand 2 conveyor systems are connected so the container is handed over automatically from one equipment to the next, then the HLC will not be required to take any specific action.

How handover happens will be specified in a given project.

2.3 Transportation network

The transportation network consists of locations and links between them. The topology of these are following what is known as Graph Theory [5].

The basic naming chosen here is that locations may be called nodes and links between them are called edges. Which term to use depends on the context.

To transport a container to its destination the HLC will send directions to the equipment. Once started the HLC is only to act when a container is at a node with multiple edges to choose from, where the HLC will request the equipment to choose a specific edge.

2.4 Not covered by this interface

Regarding AMR then this interface only covers transfer of containers to and from AMR. Actual guidance of AMR is handled by Interfleet Manager in cooperation with a Fleet Manager.

3 Error Types

The following list of error codes are the ones referenced in this interface.

Error ID	Error Message	Reason
FROM_LOCATION_NOT_FOUND	From Location Not Found	The *from_location_id* was not recognized.
ITEM_NOT_FOUND	Item Not Found	The *item_id* was not recognized.
TO_LOCATION_NOT_FOUND	To Location Not Found	The *to_location_id* was not recognized.
UNKNOWN_REQUEST	Unknown Request	The *request_id* was not recognized.

4 Telegrams

4.1 Item/Container Transport

4.1.1 Item/Container Transport Request (HLC -> Equip)

Telegram Type ID: transport.request

Telegram transmitted by the HLC. These telegrams are used when an item/container needs to be moved to or from locations on the equipment.

When the telegram is sent, it is expected that the items/container at the from-location is available for pickup and the transport can start immediately.

As an example, this telegram can be used when new materials are ready to be transported to the input buffer of a production cell. The HLC sends the telegram, after which the production cell can start the transport.

When processing this request, the equipment must respond using the telegram Item/container Transport Reply. If the transport is accepted, the equipment must send an Item/Container Transport Completed telegram upon completion, as well as any other relevant "Item/Container at location" messages.

Properties

Property	Type	Description
request_id	UUID	ID of the request.
from_location_id	LocationID	ID of the location where the item is initially.
from_sub_location_id	LocationID or null	**Optional.** If a location has multiple serviceable sub-locations, this property is used to specify this. If not applicable, i.e. if there is no ambiguity for the location, this value is null or omitted.
to_location_id	LocationID	ID of the location where the item should be transported to.
to_sub_location_id	LocationID or null	**Optional.** If a location has multiple serviceable sub-locations, this property is used to specify this. If not applicable, i.e. if there is no ambiguity for the location, this value is null or omitted.
item_id	ItemID or null	ID of the item or container to be transported.

Errors

The following error types can be returned by the cell for this request:

- FROM_LOCATION_NOT_FOUND
- ITEM_NOT_FOUND
- TO_LOCATION_NOT_FOUND

Example


```
{
 "header":  {...},
 "request_id": "62d7a39a-97e2-11ed-a8fc-0242ac120002",
 "from_location_id": "7",
 "from_sub_location_id": "1",
 "to_location_id": "8",
 "to_sub_location_id": null,
 "item_id": "5741000119020"
}
```


4.1.2 Item/Container Transport Reply (Equip -> HLC)

Telegram Type ID: transport.reply

Telegram transmitted by the cell. Used as a response for an Item/container transport.

If accepted, the cell should start transporting the container immediately after sending the response.

When the transport is completed, an Item/container transport completed telegram be sent by the cell, as well as any other relevant "Item/Container at location" messages.

Properties

Property	Type	Description
request_id	UUID	ID of the transport request.
response	Boolean	True if confirmed, false if rejected.

Errors

The following error types can be returned by the cell for this request:

- UNKNOWN_REQUEST

Example


```
{
 "header":  {...},
 "request_id": "62d7a39a-97e2-11ed-a8fc-0242ac120002",
 "response": true
}
```

4.1.3 Item/Container Transport Completed (Equip -> HLC)

Telegram Type ID: transport.completed

Telegram transmitted by the cell. Used to signal that a container transport has been completed (see Item/container transport request and Item/container transport reply). Should be sent in combination with any other relevant "Item/Container at location" telegrams.

Properties

Property	Type	Description
request_id	UUID	ID of the transport request.

Errors

The following error types can be returned by the cell for this request:

- UNKNOWN_REQUEST

Example

```
{
  "header":  {...},
  "request_id": "62d7a39a-97e2-11ed-a8fc-0242ac120002"
}
```

5 Scenarios and Example Flows

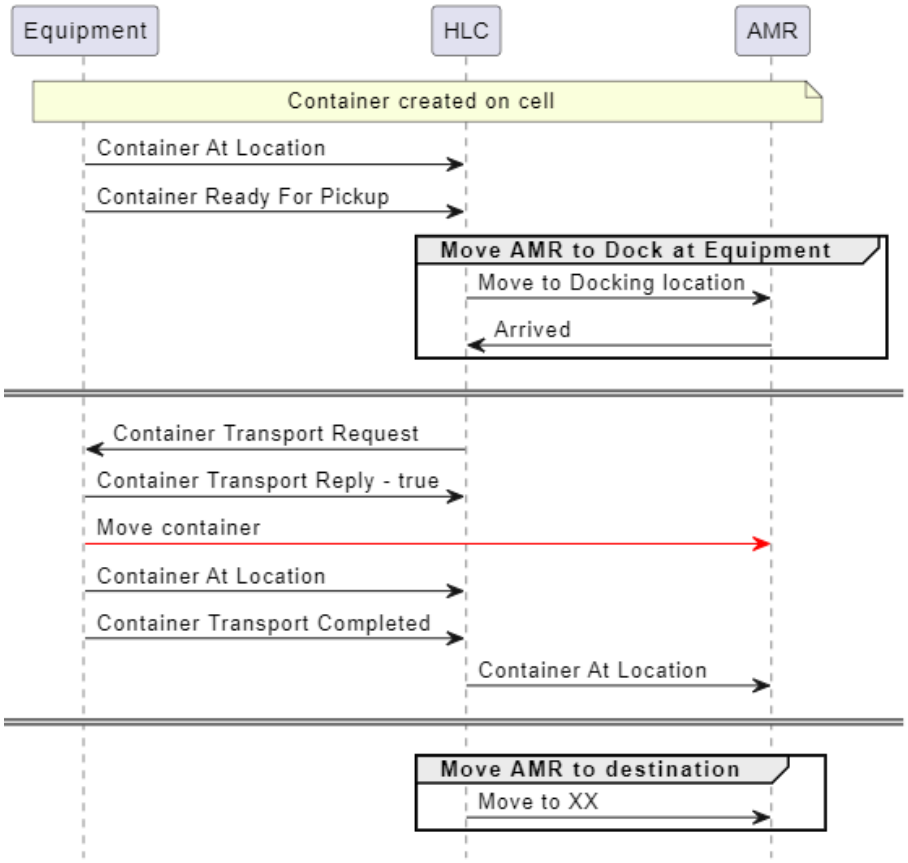
5.1 Transfer Flow

How to transfer containers depends on who controls the manipulator to move the container.

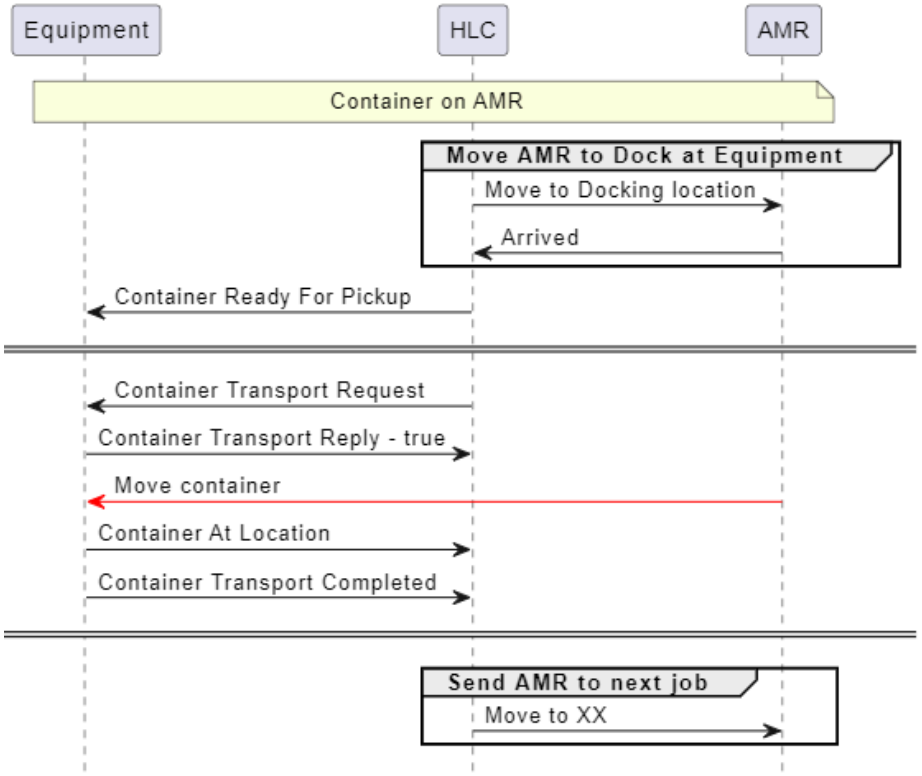
5.1.1 Manipulator on Equipment

In this example, there is some equipment with its own manipulator and is therefore able to move the container. Pickup is done with an AMR.

Here, a container is located on the equipment and requests the transport.



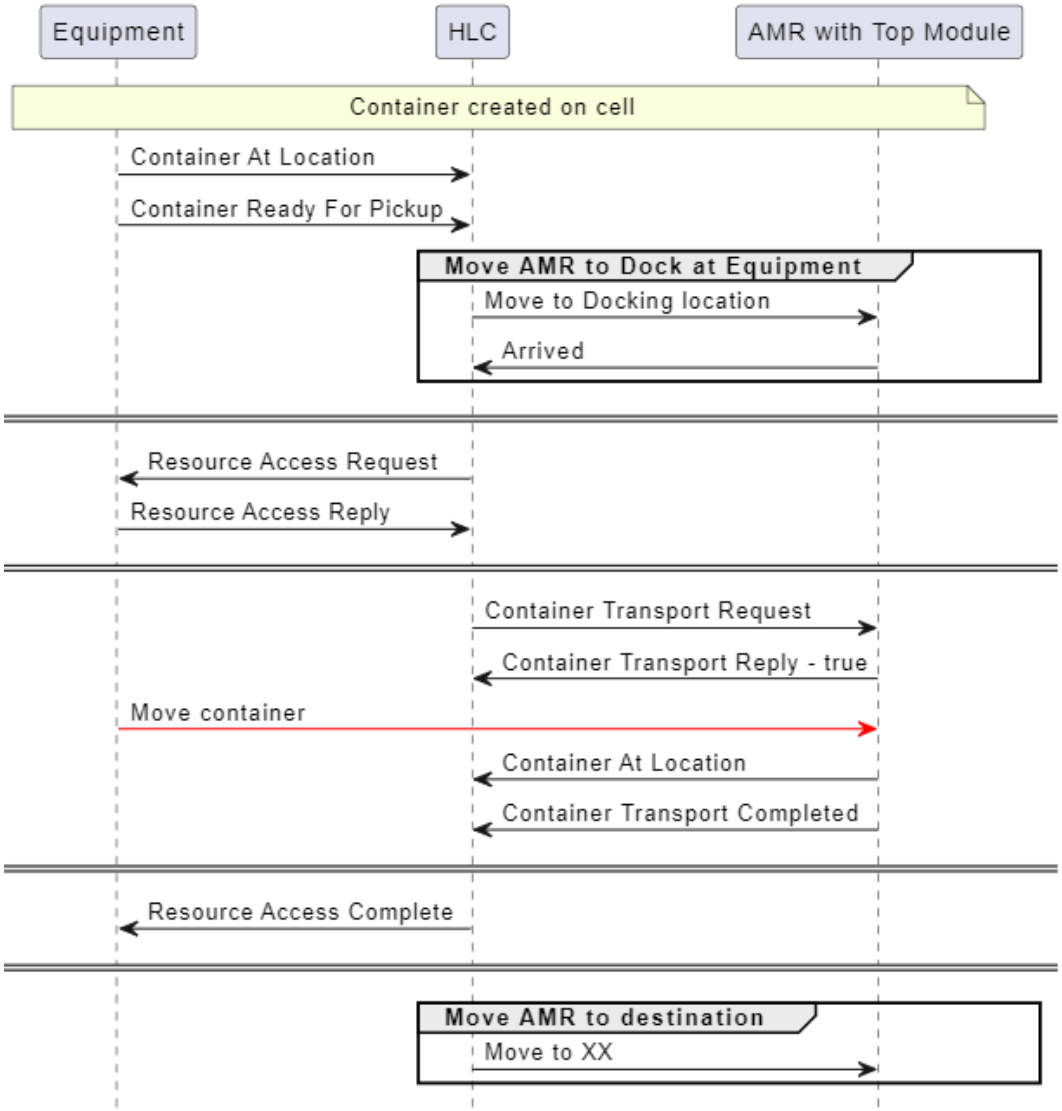
In the next example a container is being delivered by AMR to the equipment.


Equipment
HLC
AMR
Container on AMR
Move AMR to Dock at Equipment
Move to Docking location
Arrived
Container Ready For Pickup
Container Transport Request
Container Transport Reply - true
Move container
Container At Location
Container Transport Completed
Send AMR to next job
Move to XX

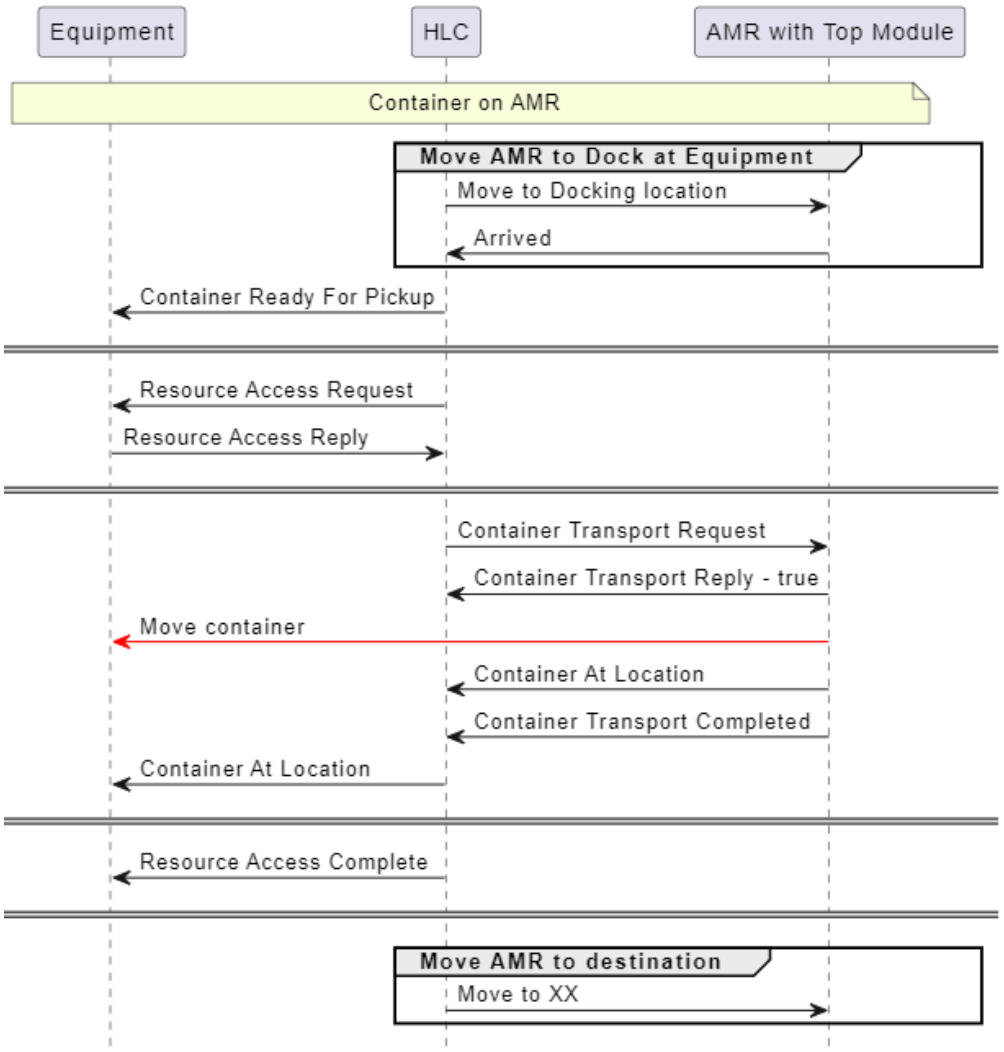
5.1.2 Manipulator on Other Equipment

In this example there is some equipment without a manipulator. An AMR with a manipulator is used for transport.

Here a container is located on the equipment and requests the transport.



In the next example a container is being delivered by AMR to the equipment.


Equipment
HLC
AMR with Top Module
Container on AMR
Move AMR to Dock at Equipment
Move to Docking location
Arrived
Container Ready For Pickup
Resource Access Request
Resource Access Reply
Container Transport Request
Container Transport Reply - true
Move container
Container At Location
Container Transport Completed
Container At Location
Resource Access Complete
Move AMR to destination
Move to XX