Integrate AGVs efficiently in production plants

A whitepaper to illustrate the basics
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1 Abstract

More and more production plants plan to integrate robots for transportation. Robots made by Mobile industrial Robots (MiR) are cost effective, flexible, and hence open up completely new possibilities.

One can quickly setup a pilot project. However, once you start to practically integrate the robots into the production workflow; unexpected questions are going to come up. Often things will get complex and expensive.

With „AGV MULTIConnect“, Artschwager + Kohl (A+K) has created standard interface software to solve these complex problems.

AGV MULTIConnect is configurable interface software that allows you to quickly and efficiently integrate Mobile industrial Robots into automated production plants:

- Missions can be started from SAP or programmable logic controllers (PLCs), or both at the same time.
- Communication with SAP is done through IDOCs WMTOID01 (warehouse task), WMTCID01 (confirm warehouse task), WMCAID01 (cancel warehouse task). No SAP programming to create custom interfaces is required.
- Communication with PLCs is done through the OPC UA standard. This allows the PLC programmer to easily start and control missions.
- Once you have installed the software and the connections are configured, the software is ready to be used. No other programming is required.
- Use a web based user interface (available in English and German) for configuration and diagnostics. That way the SAP or PLC programmer can easily run diagnostics.

Use AGV MULTIConnect to connect SAP and PLCs to Mobile industrial Robots:

- Without programming
- Simple
- Reliable
- Fast
- Cost efficient

This whitepaper illustrates some of the intrinsic challenges that come from integrating MiR robots in automated production plants, and how A+K AGV MULTIConnect offers solutions for the most common of these challenges.
2 A detailed look at intrinsic challenges

Many questions will come up when you start planning to integrate several transport robots in automated production plans: Some of these questions are:

- Who is passing transport orders to the robots?
- Is it viable for SAP to give transport order to the robots?
- If yes, how can this be achieved?
- Is it better to send transport orders directly from PLCs?
- How can a PLC communicate with the robots?
- How does accounting work?
- How can a SAP system and PLCs start transport orders in such a way that SAP manages transport orders with goods while PLCs manage transport orders to make empty load carriers available where they are needed?
- What happens when a transport order cannot be executed or completed?
- How do you coordinate transport orders for robots, where some of the robots have distinct features?

Let’s have a look at the complete landscape to see what individual systems are involved. The following examples illustrate some of the typical setups found in production plants:

- some plants may only use an SAP system to issue transport orders to robots
- in other plants, one or more PLCs are used to issue transport orders
- yet another plant, both SAP and PLCs, as well as a manufacturing execution system (MES) all issue transport orders

This example shows a plant where an SAP system sends transport orders to robots.

The SAP interface communication works with IDOCs and is based on tRFC.

The MiR Fleet manager offers a HTTP/REST API interface.

Both interfaces are entirely incompatible with each other.

Usually, an individual software solution is developed and installed in such a scenario.

The second example shows what the interfaces look like when several PLCs are to send transport orders to robots.

None of these interfaces are compatible with the MiR Fleet manager REST API.

Again, an individual software solution must be developed and installed for each combination of interfaces involved.
The third example shows a plant where a combination of SAP, MES and one or more PLCs issue transport orders to robots for transportation.

The figure illustrates how for each combination, a whole series of individual solutions must be developed and installed.

The system as a whole becomes very complex, expensive to create, install and maintain.

The individual systems involved – from SAP, MES, PLCS, to MIR Fleet manager – in addition to having their own interfaces, also have their own specific features and their own internal process workflows. All of these factors must be considered when designing the program code for interface software.

Secondly, each interface requires ways to integrate diagnostics to view its internal analytical data. We know from experience that complex systems are exceedingly difficult to manage. Without diagnostic data, finding the cause of an issue and fixing it can take an immense amount of time.

Summary

In summary, it can be concluded that integrating autonomously guided vehicles (AGV) into an existing plant necessitates investing in a series of interfaces between individual systems.

To make integrating MiR robots into an automated production plant fast, cost effective and reliable, one must consolidate the complex requirements behind the individual interfaces into a standardized solution that SAP and PLC programmers can manage easily.

To achieve this goal, A+K has developed a standardized interface converter called AGV MULTIConnect.
3 Our solution: AGV MULTIConnect

AGV MULTIConnect is configurable communication software, also called middleware. It is a ready-to-use interface for quick and cost effective integration of Mobile industrial Robots into automated plants.

- Missions can be started by SAP or programmable logic controllers (PLCs), or by both at the same time
- Communication with SAP is done by way of sending standard IDOCs WMTOID01 (warehouse task), WMTCID01 (confirm warehouse task) and WMCAID01 (cancel warehouse task)
- Communication with PLCs is done through the OPC UA standard
- Once the software is installed and configured, no other programming is required
- Configuration and diagnostics are done via a web based user interface, available in both English and German

This section details the individual connectors, their features, and how you can use them in your production plant.

3.1 Introducing AGV MULTIConnect

AGV MULTIConnect is a modular middleware.

AGV MULTIConnect provides a centralized data warehouse to persist incoming transport orders and manages their execution (Job Management).

AGV MULTIConnect also provides a series of connectors to accept incoming transport orders from SAP and PLCs (OPC UA).

Another connector is responsible for communicating with the MiRFleet Manager.

Optionally, additional connectors can be integrated for the award of orders by systems other than SAP and OPC. In addition, connectors for communication with other AGVs can also be integrated.

3.2 Requirements for operating AGV MULTIConnect

AGV MULTIConnect is ready-to-use software. It only needs to be installed, configured and is then ready for operation. No programming whatsoever is required.

AGV MULTIConnect must be installed on a Windows Server to be able to communicate with SAP. Communicating with PLCs based on OPC UA only requires a standard Windows 10 installation. We also recommend installing the software on a virtual machine.

Follow the visual step-by-step-instructions in the accompanying user manual to make the installation process quick and easy. During setup, a free edition of Microsoft SQL Server is installed, along with the built-in web server that comes with Windows, the AGV MULTIConnect database, and its required connectors.
Next, the website will help guide you through the configuration and diagnostics.

The integrated user management allows a flexible model of user and user role permissions for configuration and diagnostics. Roles Administrator and Worker are there by default. While the Administrator has all permissions, the Worker can only view diagnostics.

### 3.3 The MiRFleet Connector

Using the website, an administrator must enter the URL and connection properties for MiRFleet. AGV MULTIConnect also requires a username and password so that it can connect to MiRFleet.

Once connected, the AGV MULTIConnect automatically caches all positions and missions stored in MiRFleet in its own database.

An administrator can deactivate positions and missions that are not to be used for executing transport orders.

### 3.4 The OPC UA Connector

#### 3.4.1 Configuration

Using the web based user interface an administrator configures an URL to access an OPC server for a PLC, and selects an arbitrary name, e.g. DieCutter5.

Once the server is set up, the administrator creates an OPC channel, which allows a mission to be started and managed. All required variables for this channel must be set.

Each channel contains the following items:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPC Server</td>
<td>The administrator configures the OPC server, e.g. DieCutter5</td>
</tr>
<tr>
<td>Mission</td>
<td>The administrator configures the String item to be used. The PLC code can easily set the name of the mission. Optionally, the mission name can be entered in quotation marks, indicating a constant value. In that case, the PLC does not require an item for the mission name.</td>
</tr>
<tr>
<td>Source</td>
<td>The administrator configures the String item to be used. The PLC code can easily set the name of the source position. Optionally, the position name can be entered in quotation marks, indicating a constant value. In that case, the PLC does not require an item for the source position. If the mission does not require a source position, leave this field blank.</td>
</tr>
<tr>
<td>Destination</td>
<td>The administrator configures the String item to be used. The PLC code can easily set the name of the destination position. Optionally, the position name can be entered in quotation marks, indicating a constant value. In that case, the PLC does not require an item for the destination position. If the mission does not require a destination position, leave this field blank.</td>
</tr>
<tr>
<td>Priority</td>
<td>The administrator configures the I32 item to be used. The PLC code can easily set the priority. Optionally, the priority can be entered in quotation marks, indicating a constant value. In that case, the PLC does not require an item for priority.</td>
</tr>
</tbody>
</table>
| Start      | The administrator configures the I32 item to be used. To start a mission, the PLC code writes a value not equal to zero. We recommend using incrementing numbers, as this simplifies diagnostics on
3.4.2 Starting missions

To start a mission, the PLC program code needs to only write the desired values to the OPC items and then write a non-zero value to the Start item.

The OPC connector recognizes the change in value in the Start item, and subsequently reads in all configured item values from the PLC. It then creates a new transport order.

Once AGV MULTIConnect has successfully verified mission, source, and destination, the transport order is added to its internal queue. The OPC connector writes value 1 to the Status item. If the mission, source or destination do not exist or are deactivated, the OPC connector writes value 4 to the Status item, and a corresponding error code and error message to the items ErrorCode and ErrorText, respectively.

3.4.3 Controlling missions

Once the started mission has been executed without errors, or aborted with errors, the OPC connector writes to the Status item a value of 2, or 4, respectively, and also sets items ErrorCode and ErrorText if appropriate.

If a PLC has started a mission, but does not need or want to wait for the mission’s completion, it can write a value of 0 to the Start item right away. The OPC connector then writes a value 8 to the Status item variable.

This allows for scenarios where a new transport order is started without waiting for the previous order to complete, e.g. clearing an assembly line.
3.5 The SAP Connector

The SAP connector is based on tRFC, and functions as both tRFC server and tRFC client. The server accepts warehouse tasks and cancellations from SAP. The client is responsible for confirming warehouse tasks and cancels them as well.

3.5.1 Configuration

Using the web based user interface, an administrator configures the credentials needed to access an SAP system. This includes:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHOST</td>
<td>the SAP system’s IP address</td>
</tr>
<tr>
<td>SYSNR</td>
<td>the SAP system number, e.g. 70</td>
</tr>
<tr>
<td>CLIENT</td>
<td>the SAP system’s internal client number</td>
</tr>
<tr>
<td>USER</td>
<td>SAP system account</td>
</tr>
<tr>
<td>PASSWD</td>
<td>SAP system password</td>
</tr>
<tr>
<td>GWHOST</td>
<td>the Gateway hosts’ IP address</td>
</tr>
<tr>
<td>GWSERV</td>
<td>the Gateway’s port number, e.g. 3370</td>
</tr>
<tr>
<td>PROGRAM_ID</td>
<td>e.g. AgvMultiConnect</td>
</tr>
<tr>
<td>SAPMODE</td>
<td>1 = SAP custom interface</td>
</tr>
<tr>
<td></td>
<td>2 = SAP standard interface (Default)</td>
</tr>
</tbody>
</table>

3.5.2 SAP sends a warehouse task

When SAP triggers a warehouse task, it sends an IDOC WMTOID01 to the AGV MULTIConnect, which in turn saves the IDOC to its internal database.

The IDOC contains a series of fields. Depending on the configuration of SAPMODE, source and destination are grabbed from different fields inside the IDOC.

**SAPMODE 1 = SAP custom interface**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TANUM</td>
<td>Transport order number</td>
</tr>
<tr>
<td>VLENR</td>
<td>Source position</td>
</tr>
<tr>
<td>NLENR</td>
<td>Destination position</td>
</tr>
<tr>
<td>PRIORITY</td>
<td>Priority</td>
</tr>
</tbody>
</table>

**SAPMODE 2 = SAP standard interface (default)**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>TANUM</td>
<td>Transport order number</td>
<td></td>
</tr>
<tr>
<td>VLTYMP</td>
<td>Source storage type</td>
<td>These three fields are combined with a dash</td>
</tr>
</tbody>
</table>
SAP does not attach the name of a mission to a transport order. To be able to resolve a specific mission, AGV MULTIConnect does the following:

Once the missions are read in from MiRFleet and cached, an administrator must configure “mappings” for use with SAP. For each mapping, a search pattern is entered for source and destination positions. These patterns can include wild cards “?” (any one character) and “***” (any number of character).

Mapping example:

<table>
<thead>
<tr>
<th>Mission</th>
<th>Source parameter</th>
<th>Destination parameter</th>
<th>Source pattern</th>
<th>Destination pattern</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move</td>
<td>Source</td>
<td>Destination</td>
<td>*222</td>
<td>*</td>
<td>1</td>
</tr>
</tbody>
</table>

In this example, the mission “Move” is started when the source position name received from the SAP system ends with the string “222”. The destination position received from SAP is irrelevant as the “***” pattern indicates “any” destination position is possible.

If more than one mission is found from the configured search patterns, the mission with the lowest order number is selected and executed. To avoid confusion, we recommend you configure the patterns in such a way that exactly one mission is found at all times.

Depending on the setup in the plant, it can be practical to use only a single mission, or one mission for each distinct type of transport.

Missions and mission parameters inside MiRFleet can be designed to accept both a source and destination, a source only, a destination only, or no position at all.
3.5.3 SAP cancels a warehouse task

When SAP cancels a warehouse task, it sends an IDOC WMCAID01 to AGV MULTIConnect, which in turn saves the IDOC to its internal database.

AGV MULTIConnect verifies that the original warehouse task has not yet been transferred to the MiRFleet. If the warehouse task has not yet been transferred, it is cancelled immediately, and an IDOC WMCAID01 is sent to SAP.

If the warehouse task has already been submitted to MiRFleet, it can no longer be cancelled.

3.5.4 MiRFleet executed the warehouse task successfully

When MiRFleet reports that the warehouse task has been completed without errors, AGV MULTIConnect sends IDOC WMTCID01 to SAP.

3.5.5 MiRFleet aborted the warehouse task

When MiRFleet reports that the warehouse task has been aborted or completed with errors, AGV MULTIConnect sends IDOC WMCAID01 to SAP.

3.6 Monitoring in real time

The web based user interface reports diagnostic data in real-time. The list of active missions records all incoming transport orders along with their status information, and is updated automatically.

For each transport order, contextual status information is persisted and visualized. In case of a technical issue, it is easy to retrace logged information in a timeline.
4 Configuration examples

4.1 View current transport orders with detailed information

4.2 View detailed diagnostics for an aborted transport order

A timeline shows what happened during the lifetime of the transport order.

Legend:

New: Transport order received
Transmitting: MiRFleet is ready to receive, order is being transmitted
Pending: MiRFleet is waiting for a robot to become available
Executing: MiRFleet has selected robot 2 to execute the mission
Aborted: The mission has been aborted with errors
Aborted: The transport request was reported back to the SAP or OPC UA-PLC as "completed with error"
4.3 Configure an OPC channel

![Image of OPC channel configuration](image1)

#### Configure an OPC channel

- **OPC Server**: DieCutter5
- **OPC Namespace**: SP502a
- **Start**: s=SP502a.DB1112.StartMission
- **Status**: s=SP502a.DB1112.Status
- **Error Code**: s=SP502a.DB1112.ErrorCode

4.4 Assigning source / destination positions to MiR missions

![Image of MiR mission assignments](image2)

#### Assigning source / destination positions to MiR missions

- **Region**: A1
- **Missions**:
  - MiRFleet1: MOVIE_K27
  - MiRFleet1: MOVIE_PALLET
5 Summary

AGV MULTIClone makes it very easy to start and control missions from SAP or PLCs.

Our configurable middleware connects individual systems easily, quickly, reliably and cost-efficiently.

AGV MULTIClone standardizes the required interfaces as well as the processes involved and hence reduces inherent complexity to a minimum.

You can avoid recruiting high-priced software specialists to develop individual interfaces, and hence prevent unnecessary financial investments.

Installation and configuration is designed to be very easy. Using the step-by-step user manual, PLC technicians or administrators can install, configure and run the software themselves.

The web based real-time diagnostic tools make investigating technical issues transparent and also reduce complexity. PLC programmers and SAP programmers alike can retrace and verify the individual data received from and submitted to the client systems at the telegram level.

During operation, real-time diagnostics support the on-duty personnel by visualizing information about waiting, executing, completed and aborted transport orders, and offers insights to recorded logs, e.g. disruptions in process availability.
6 How to get in touch

We look forward to your call. We speak German and English.
You can also reach us by E-mail, by phone or on LinkedIn.
We are always there to listen to your questions. We are happy to help.

Get in touch using:

Phone +49 9132 83666 0
E-Mail sales@artschwagere-kohl.de
LinkedIn Jürgen Kohl, Artschwager + Kohl Software

Please do not hesitate to submit your questions and suggestions.
We also offer a fully functional 180-days demo version of AGV MULTICConnect.

6.1 About Artschwager + Kohl Software GmbH

For more than 20 years, Artschwager + Kohl Software GmbH (A+K) has been specializing in
developing and integrating software solutions for production automation in plants.

We develop

- warehouse management software (WMS) for manual and automated processes, modernizes
  and integrates warehouses with SAP EWM and other ERP systems
- manufacturing execution systems (MES) for manual and automated production plants,
  automated plants, and updates manual production plants to the digital age
- transport management systems (TMS) for autonomously guided vehicles (AGV), for fork lift
  guidance systems, and for automated conveying systems.

We integrate TMS with SAP and other ERP systems, deliver guidance systems for fork lifts and tugger
trains, and integrate those with existing processes in production plants.

Our customers are production plants as well as all sizes of manufacturing engineering and plant
engineering companies – from market leaders to mid-size businesses. We offer 24/7 support and tailor
services to our customers’ needs.
7 Appendix

Manufacturer
Artschwager + Kohl Software GmbH
Gustav-Hertz-Str. 9
D–91074 Herzogenaurach
Phone: +49 (0) 9132 83 666 0
Fax: +49 (0) 9132 83 666 50
E-Mail: sales@artschwager-kohl.de
Web: www.artschwager-kohl.de

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