

# **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 MULTICConnect“, Artschwager + Kohl (A+K) has created standard interface software to solve these complex problems.

AGV MULTICConnect 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 MULTICConnect 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 MULTICConnect offers solutions for the most common of these challenges.

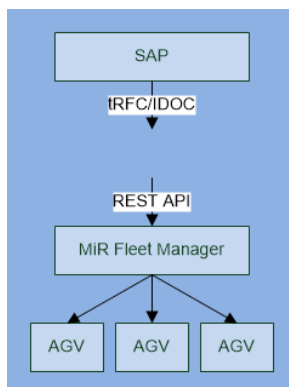
## 2 A detailed look at intrinsic challenges

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



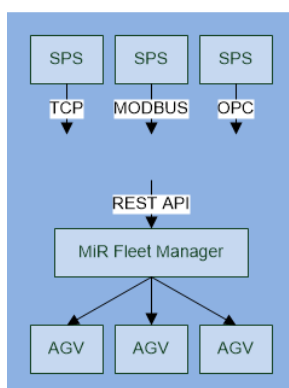
This example shows a plant where an SAP system sends transport orders to robots.

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.

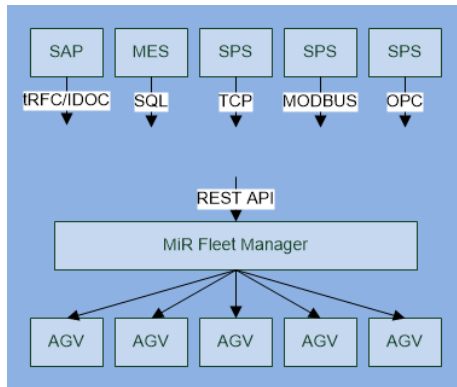
Usually, an individual software solution is developed and installed in such a scenario.



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 MULTICConnect.

### 3 Our solution: AGV MULTICConnect

AGV MULTICConnect 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 WMT0ID01 (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 MULTICConnect

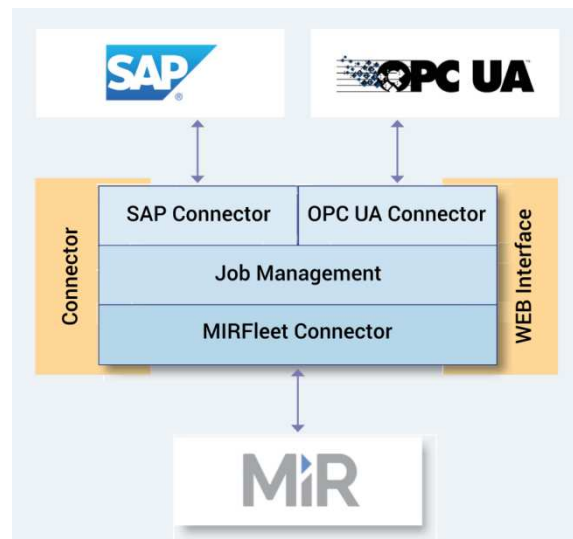
AGV MULTICConnect is a modular middleware.

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

AGV MULTICConnect 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 MULTICConnect

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

AGV MULTICConnect 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 MULTICConnect 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 MULTICConnect also requires a username and password so that it can connect to MiRFleet.

Once connected, the AGV MULTICConnect 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:

Function	Description
OPC Server	The administrator configures the OPC server, e.g. DieCutter5
Mission	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.
Source	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.
Destination	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.
Priority	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.
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

	the website.
Status	The administrator configures the I32 item to be used. When the order is started, the OPC connector writes the order's current status to the item. The status can be one of the following values: 0 - No order has been started for this channel 1 - Executing 2 - Completed without errors 4 - Completed with errors 8 - Unknown
Error Code	The administrator configures the I32 item to be used. If the order status has a value of 4, the OPC connector writes an error code to this item.
Error Text	The administrator configures the String item to be used. If the order status has a value of 4, the OPC connector writes an error message to this item.

### 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 MULTICoconnect 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:

Function	Description
ASHOST	the SAP system's IP address
SYSNR	the SAP system number, e.g. 70
CLIENT	the SAP system's internal client number
USER	SAP system account
PASSWD	SAP system password
GWHOST	the Gateway hosts' IP address
GWSERV	the Gateway's port number, e.g. 3370
PROGRAM_ID	e.g. AgvMultiConnect
SAPMODE	1 = SAP custom interface 2 = SAP standard interface (Default)

#### 3.5.2 SAP sends a warehouse task

When SAP triggers a warehouse task, it sends an IDOC WMT0ID01 to the AGV MULTICConnect, 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

Field	Description
TANUM	Transport order number
VLENR	Source position
NLENR	Destination position
PRIORITY	Priority

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

Field	Description	Purpose
TANUM	Transport order number	
VLTYT	Source storage type	These three fields are combined with a dash

VLBER	Source storage area	“-“ to form the source position: <type>-<area>-<location>, e.g. 0050-0001-222. If one of the fields is empty, it will be ignored.
VLPLA	Source storage location	
NLTYP	Destination storage type	These three fields are combined with a dash “-“ to form the source position: <type>-<area>-<location>, e.g. 0042-0001-333. If one of the fields is empty, it will be ignored.
NLBER	Destination storage area	
NLPLA	Destination storage location	
PRIORITY	Priority	

SAP does not attach the name of a mission to a transport order. To be able to resolve a specific mission, AGV MULTICConnect 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:

Mission	Source parameter	Destination parameter	Source pattern	Destination pattern	Order
Move	Source	Destination	*222	*	1

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 MULTICConnect, which in turn saves the IDOC to its internal database.

AGV MULTICConnect 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 MULTICConnect 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 MULTICConnect sends IDOC WMCAID01 to SAP.

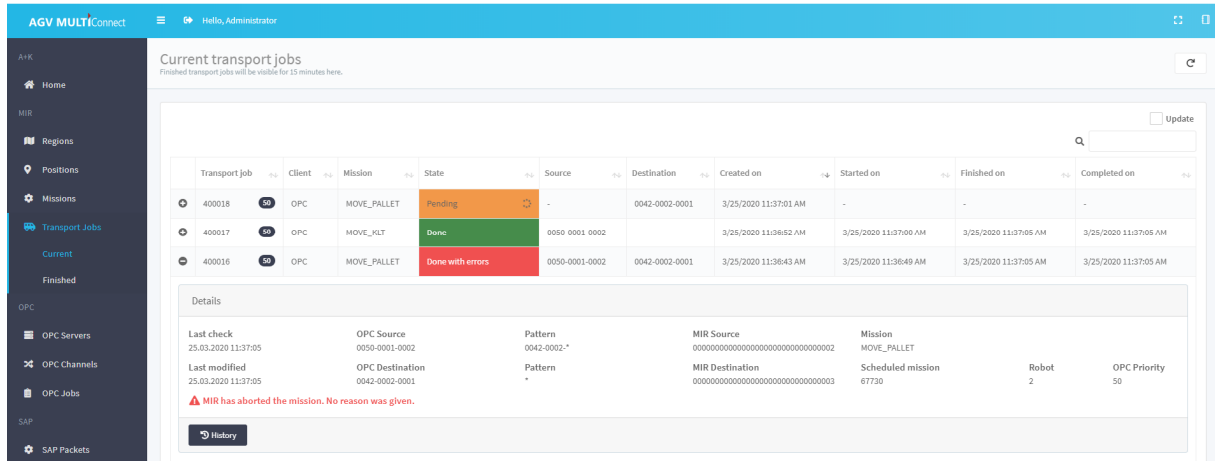
## **3.6 Monitoring in real time**

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



The screenshot shows the AGV MULTIConnect interface. The main area displays a table of 'Current transport jobs'. The table has columns for Transport job, Client, Mission, State, Source, Destination, Created on, Started on, Finished on, and Completed on. Three jobs are listed: 400018 (Pending), 400017 (Done), and 400016 (Done with errors). Below the table, the details for job 400016 are shown, including last check and modified times, OPC Source and Destination, Pattern, MIR Source and Destination, Mission, Scheduled mission, Robot (2), and OPC Priority (50). A red warning message states: 'MIR has aborted the mission. No reason was given.'

### 4.2 View detailed diagnostics for an aborted transport order

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

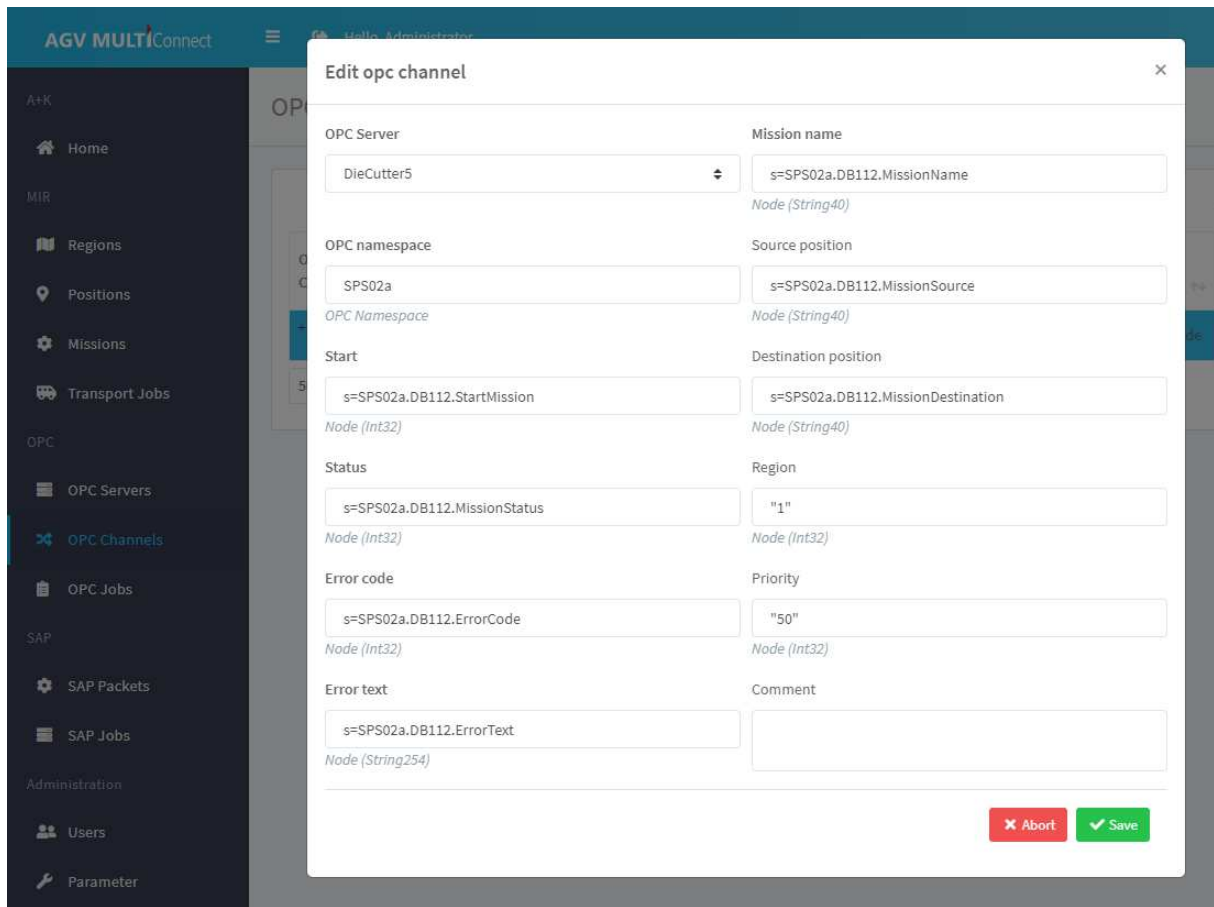
Job: '400016' (ID 54155)

State	Scheduler ID	Robot	Created on	Ordered on	Started on	Finished on	Completed on	Error code	Requests	Action
New	-	-	3/25/2020 11:36:43 AM	-	-	-	-		-	Insert
Transmitting	-	-	3/25/2020 11:36:43 AM	-	-	-	-		1	Update
Pending	67730	-	3/25/2020 11:36:43 AM	3/25/2020 11:36:44 AM	-	-	-		2	Update
Executing	67730	2	3/25/2020 11:36:43 AM	3/25/2020 11:36:44 AM	3/25/2020 11:36:49 AM	-	-		3	Update
Done with errors	67730	2	3/25/2020 11:36:43 AM	3/25/2020 11:36:44 AM	3/25/2020 11:36:49 AM	3/25/2020 11:37:05 AM	-	Aborted_by_MIR	4	Update
Done with errors	67730	2	3/25/2020 11:36:43 AM	3/25/2020 11:36:44 AM	3/25/2020 11:36:49 AM	3/25/2020 11:37:05 AM	3/25/2020 11:37:05 AM	Aborted_by_MIR	4	Update

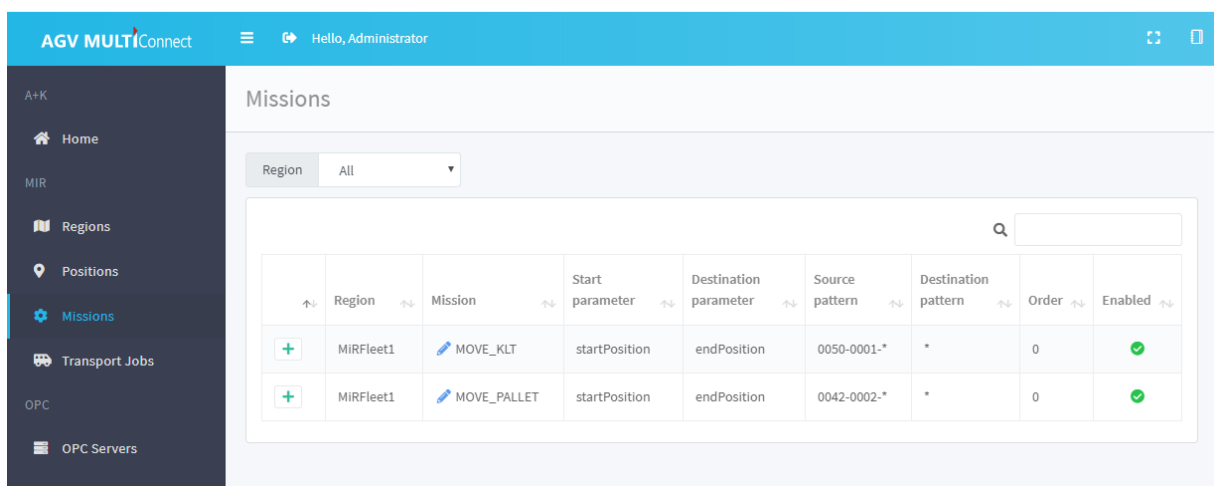
Legend:

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



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



## 5 Summary

AGV MULTICConnect 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 MULTICConnect 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:

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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

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