High-bay rack warehouse Abalioglu, Izmir, Turkey

Functional specification for integration of Material Flow Control System and Warehouse Management System

Version 0.5

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1 Introduction

The purpose of this document is to detail the communication concept of the automated warehouse. The document

- covers the warehouse layout and designation of storage locations,
- details hierarchy of the system,
- allots functions to Material Flow Control System (MFCS) provided by Ücge and Iskra impuls, and to Warehouse Management System (WMS) provided by Logo,
- details communication interface between MFCS and WMS.

2 High-bay warehouse layout

High-bay warehouse comprises of three aisles. On each side of an aisle are double deep racks with 60 horizontal locations and 8 vertical locations. Racks in the warehouse have 5752 (3 x 2 x 60 x 8 x 2 - 8) slots for storing transport units. On the output of the warehouse there is a gravitational rack system capable of storing 192 (24 x 8) transport units.

Automated machines are taking care of storing and retrieving of the goods. In each aisle there is a crane (automatic storage retrieval machine, ASRS) with one deck. For conveying the transport unit to and from the warehouse, there are also some supporting conveyor tables and two shuttle cars.

2.1 Designation of warehouse locations

There are three types of locations in the system:

1. rack locations,
2. conveyor locations (conveyor tables), and
3. crane and shuttle locations (decks).

Rack locations in high-bay warehouse are denoted as

R*rrxxyz* ,

where

- *rr* is a rack index: 11, 12, 21, 22, 31, 32, (52)
- *xx* is horizontal index: 01 … 60, (01 … 24)
- *y* is vertical index: 1 … 8, (1)
- *z* is depth index: 1 … 2, (1 … 6).

Values in parenthesis are given for gravitational rack system.

Conveyor locations (tables) are denoted as

T*fsn* ,

where

- *f* is a functional group: 0 … 3,
- *s* is a subgroup: 0 … 2,
- *n* is a conveyor number: 0 … 4.

Deck locations on vehicles (cranes and shuttles) are denoted as

C*v0n* ,

where

- v is the vehicle number: 1 … 4, (5),
- *n* is deck number: 1, (1 … 2).

Values in parenthesis are given for shuttle 5, which has two decks.

Some examples of warehouse location designations are given in Figure 1 and Figure 2 . For crane 1 the designated rack locations are at level 1, for crane 2 at level 3 and for crane 3 at level 5.

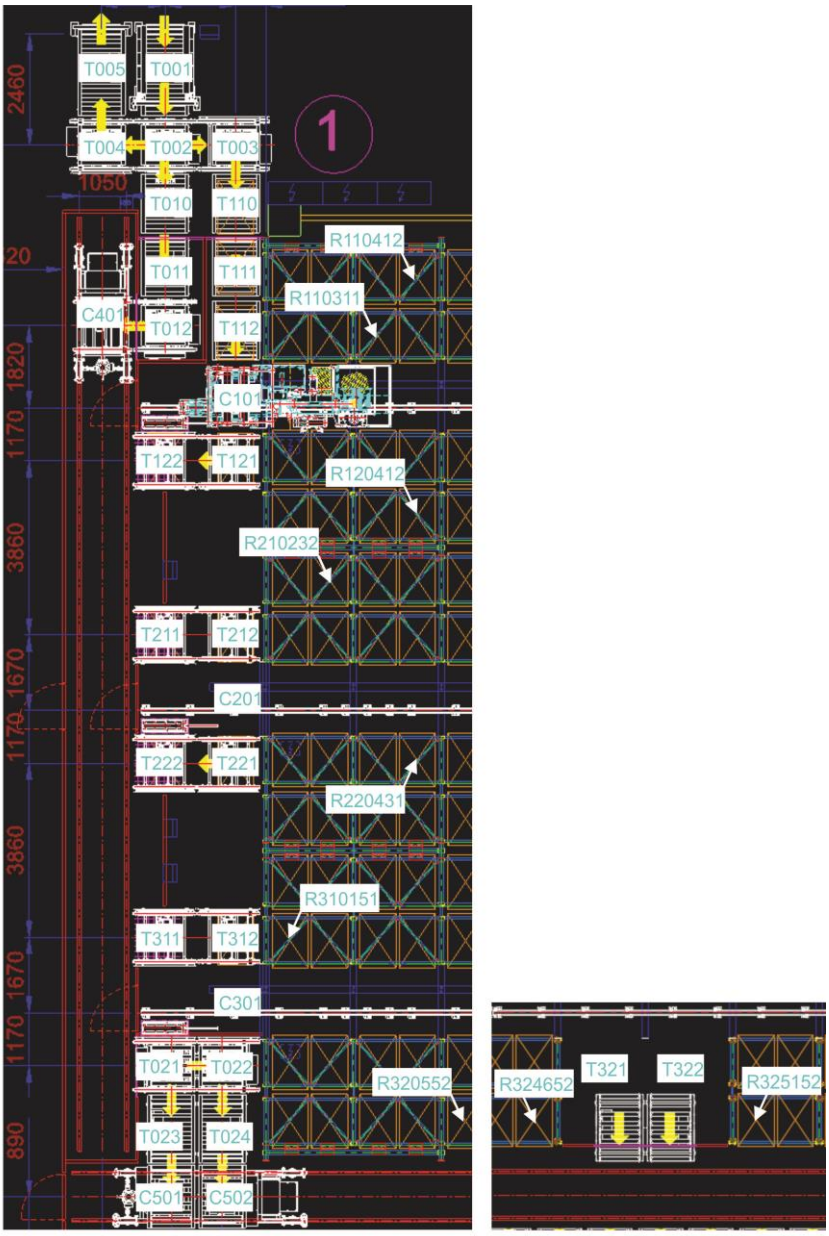

FIGURE 1 HIGH-BAY WAREHOUSE: TOP VIEW WITH DESIGNATED LOCATIONS OF RACKS, TRANSPORT PATHS, AND VEHICLES

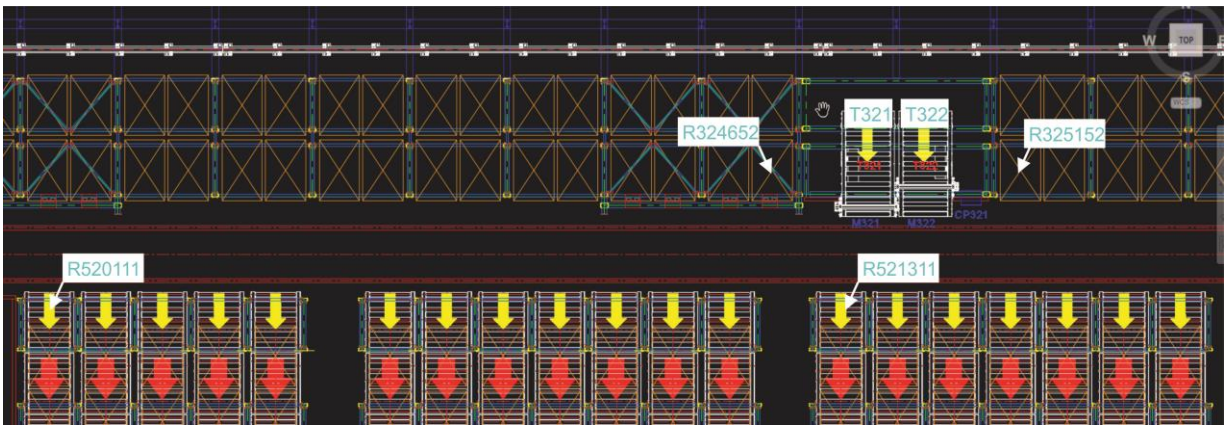

FIGURE 2 HIGH-BAY WAREHOUSE: TOP VIEW WITH DESIGNATED LOCATIONS OF GRAVITATIONAL RACK SYSTEM

2.2 Permanently blocked rack locations

Conveyor lines are physically occupying some rack locations (see Figure 1 and Figure 2). Therefore, some rack locations do not exist and cannot be used for storage. Table 2 lists non-existing rack locations, which should be permanently blocked.

TABLE 1 PERMANENTLY BLOCKED RACK LOCATIONS

Permanently blocked rack locations	Reason
R324711 – R324712	Space is occupied by conveyors 321 and 322
R324811 – R324812	Space is occupied by conveyors 321 and 322
R324911 – R324912	Space is occupied by conveyors 321 and 322
R325011 – R325012	Space is occupied by conveyors 321 and 322

2.3 Locations not used on MFCS

Although there are 6 depths on gravitational conveyors, only depth $z = 1$ can be used for commands, as vehicle 5 always deposits transport units to depth 1. As MFCS has no information on how transport units are removed from gravitational lines, it does not handle the material picture on gravitational conveyor lines. Therefore, it is also not able to report positons of a transport unit when it moves from depth 1 to any other position.

2.4 Other limitations

Conveyor T023 cannot be reached with deck C502 of shuttle 5.

Slot R526011 in the gravitational rack cannot be reached with deck C501 of shuttle 5.

2.5 Transport units

A transport unit is a standard euro pallet of size 800 mm x 1200 mm. Goods to be stored in the warehouse must be placed on a pallet in such a way that

- there is no overhang,
- pallet with goods is up to 1800 mm high, and
- weight of goods, including a pallet, does not exceed 800 kg.

Format of barcodes, used to uniquely identify transport units is not yet defined.

3 Hierarchy of the system

The automated warehouse consists of eight sub-systems (Figure 3):

- 3 x programmable logic controller (PLC) for cranes,
- 2 x programmable logic controller (PLC) for shuttles
- 1 x programmable logic controller (PLC) for the conveyor system,
- material flow and control system (MFCS) with supervisory control and data acquisition (SCADA) functionality, and
- warehouse management system (WMS).

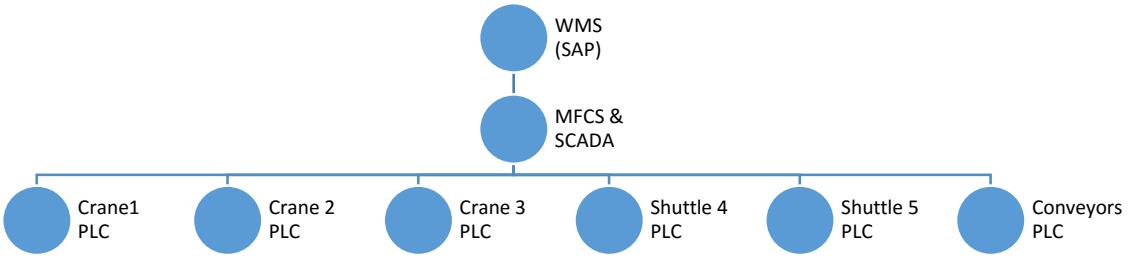

FIGURE 3 ARCHITECTURE OF COMPUTER SYSTEMS IN WAREHOUSE.

The vehicles and the conveyor system are fully automated and computer guided. The automation is carried out on several levels. Sensors, frequency converters, etc. represent the low automation level. These are controlled by the PLC located either in the electrical cabinet of a vehicle or in the electrical cabinet of the conveyor system. PLCs processes the input data and command the vehicles and conveyors in order to perform simple commands.

Supervisory control and data acquisition (SCADA) system takes values from PLCs in order to show to an operator the current status of the system. In also performs logging of some interesting quantities.

Movements of the vehicles and conveyors are performed according to the commands received from MFCS. The main task of MFCS is to brake the complex commands, received from WMS, to the simple commands, which can be executed by PLCs. MFCS has to execute the commands received from WMS in such a way to finish the commands as soon as possible (rearrangement of commands, parallel commands …).

WMS takes care of warehouse organization and business logic. It initiates automatic movements in the warehouse. The picture of the warehouse (which locations are occupied; which transport unit is stored there) should be handled by WMS. The optimal placement of goods in the warehouse is very important for efficient movements of transport units and goods. WMS should also strive to achieve high availability of the system by distributing the similar product to different aisles. The placement of the goods is done solely by WMS.

The communication between PLCs is implemented by Profinet protocol, while PLCs and MFCS communicate by TCP/IP telegrams. The communication between MFCS and WMS is performed via web services. This document convers only the communication with web services.

4 Functions of the system

4.1 Inbound traffic

To store a transport unit to the system the following operations must be done:

1. Operators must manually put a transport unit to the conveyor table T001.
2. The transport unit is then conveyed to T002. During the movement its barcode is read and physical quantities are measured.
3. On conveyor T002 the entry of a new transport unit is reported to WMS.
4. On this stage MFCS will wait for WMS task:
    a. If there is something wrong with the transport unit (no barcode, some dimension is not compliant with the requirements, etc.) MFCS will send the transport unit to T005 via T004 (if preferred, WMS can do it, to be decided).
    b. For transport units, which are ready for storing, WMS should provide the final position in the warehouse R######, where # represents a number.
5. When the command is received, the transport unit continues in in the following way:
    a. For racks R1##### transport units follow conveyors T002, T110, T111, and T112 where they are picked by crane 1 (deck C101).
    b. For all other racks transport units follow conveyors T010, T011, and T012, where they are picked by shuttle 4 (deck C401).
6. In case that the transport unit goes to racks R2#####, shuttle 4 (deck C401) deposits it to conveyor T211 from where it continues to T212. For racks R3#####, the transport unit is dropped to conveyor T311 and then conveyed to T312. Transport unit on conveyor T212 is then picked by crane 2 (deck C201) and transport unit on conveyor T312 by crane 3 (deck C301). In case that a transport unit goes directly to R52##01, it is dropped to conveyor T021.
7. A crane stores a transport unit to required slot in a rack.

4.2 Outbound traffic

To retrieve a transport unit from the warehouse, the following operations must be done:

1. WMS should first give a command to move a transport unit from a slot in high-bay warehouse to a slot in gravitational rack.
2. Crane picks a transport unit from the slot in the warehouse and drops it to the appropriate conveyor: from R1##### to T121, from R2##### to T221, and from R3##### to T321 or T322.
3. Transport units from T121 and T221 are further conveyed to T122 and T222, respectively.
4. A transport unit from T122 or T222 is transferred to shuttle 4.
5. Shuttle 4 deposits a transport unit from its deck C401 to T021.
6. Based on the commands and optimization performed on MFCS, transport units are further conveyed to T023 or T024 via T022.
7. Transport units on conveyors T023 and T024 as well as transport units on conveyors T321 and T322 can be simultaneously picked by shuttle 5 on decks C501 and C502 and finally dropped to the gravitational rack R52##01

It is also possible to directly move a transport unit from input to R52##01. In this case steps 1-4 and 5b of inbound traffic must be completed first, and are then followed by steps 5 – 7 of outbound traffic.

4.3 Warehouse reorganization

To access the transport units in depth 2 or for optimization of the warehouse it is also possible to move transport units between slots in the same aisle – the designation of slots should not differ in the first two symbols. For example, repositioning of a transport unit from slot R222222 to slot R212121 is possible, but from slot R222222 to slot R121212 is not.

Additionally, it is possible to automatically move transport units from slots R1##### to slots R2##### or R3##### and from slots R2##### to slots R3#####.

Movements of transport units from slots R2##### to slots R1##### or from slots R3##### to slots R1##### or R2##### can only be made in two phases by generating two WMS commands:

- with the first command they should be send to the gravitational rack and
- after reentry on the input line (entry notification on T002) to the final destination.

4.4 Command execution

Tasks, given by WMS, are executed by conveyors and the vehicles. The tasks on conveyor lines depend on transport units, which are there. The order of execution is thus irrelevant.

The order of task execution is important only on vehicles. Here MFCS will execute commands based on priority, WMSID and vehicle performance:

- When a vehicle gives a transport unit to a conveyor line or to a rack slot, it can immediately start with execution of the next command.
- When a vehicle finishes the current operation, it will first start executing the feasible commands with the highest level of priority. If there are many commands with the same priority level, the commands will be executed in such a way to optimize the vehicle movements.

It can happen that a task fails due to poor handling, a rack slot empty, a rack slot full, a conveyor full, etc. In such situations MFCS cancels the command and waits for a new command from WMS. To resolve such situations, it is important that WMS:

- is aware of any transport unit movement – must maintain the position of the transport units in its database,
- is able to give a command for a transport unit from its current location (any conveyor table or vehicle deck) to its final location.

5 Communication between MFCS and WMS via web services

Communication between MFCS and WMS is performed via SOAP 1.2 web services. For efficient communication web services need to be implemented on MFCS as well as WMS side.

For reliable communication, two web services are created, one on MFCS side and one on WMS side. MFCS is subordinate system to WMS, so WMS initiates jobs, MFCS executes them, and reports statuses back to WMS.

5.1 Web services interface

WMS sends *jobs* to MFCS. Some jobs are simple enquiries and settings of the system, while others include *task,* describing necessary movement of a transport unit.

On MFCS level tasks are split to simple *commands*, executed partially by conveyors, and partially by vehicles.

After completion of job, MFCS informs WMS by calling WMS_status web service. During execution of a job, the WMS_status can be called many times to inform WMS about all changes in the system.

5.1.1 MFCS_submit

Web service MFCS_submit on MFCS side is rather general and is used to transmit all sorts of jobs from WMS to MFCS and its subsystems. The structure of the web service is given in Table 2.

TABLE 2 ARGUMENTS OF MFCS_ SUBMIT WEB SERVICE

Function MFCS_submit			
Name	**Data type**	**Direction**	**Values**
WMSID	String	Input	Unique command ID generated by WMS. When status of a job changes, MFCS reports the change by referring to this value.
Item	String	Input	'JOB' 'SEGEMENT' 'LOCATION' 'TASK'
Instruction	String	Input	Depends on Item, will be detailed later
Arguments	String	Input	Depends on Item and Instruction, will be detailed later
ReturnValue	String	Output	'TRUE' when job is enqueued to MFCS queue; 'FALSE' otherwise

5.1.2 WMS_status

To give a feedback about jobs send to MFCS and to report changes in the system, MFCS calls WMS_status web service on WMS side. Arguments of the web service can be found in Table 3.

TABLE 3 ARGUMENTS OF WMS_STATUS WEB SERVICE

Function WMS_status			
Name	**Data type**	**Direction**	**Values**
WMSID	String	Input	'0' – when spontaneously generated by MFCS WMSID from MFCS_job – when replying to an existing WMS command
Item	String	Input	'JOB' 'SEGMENT' 'LOCATION' 'TASK'
Status	String	Input	Status, depends on Item
Info	String	Input	Additional info
ReturnValue	String	Output	'TRUE' when status is accepted by WMS; 'FALSE' otherwise

5.2 Working with jobs

Whenever the status of a job changes, MFCS informs WMS about it with call to WMS_status. The respond will include

- WMSID: WMSID of the job in question,
- Item: same as in job submission,
- Status: new job status,
- Info: some optional info.

The list of general job statuses is given in Table 4.

TABLE 4 GENERAL JOB STATUSES

Status	Description
'QUEUED'	Job is accepted to MFCS command queue
'EXECUTING'	Job is in execution
'COMPLETED'	Job has completed successfully
'DELETED'	Job was successfully deleted
'ERROR'	Job has completed with error. Details about the error are given in Info field

When the command is added to MFCS command queue, it status becomes 'QUEUED'. When MFCS starts to execute the command, its status changes to 'EXECUTING'. At successful completion MFCS send 'COMPLETED'. When a command is deleted (trough WMS or MFCS user interface), its status changes to 'DELETED'. If during command execution something goes wrong, the command is finished and the returned status is 'ERROR'.

When job completes with error, error details are given in Info field. General error details, regarding the jobs are given in

Table 5.

TABLE 5 GENERAL ERRORS

Info	Description
'WMSID'	The same WMSID already exists in MFCS
'ITEM'	Item not recognized
'INSTRUCTION'	Instruction not recognized or not relevant for the Item
'TIMEOUT'	Job execution takes too long
'OTHER'	Other unhandled faults

Error in the info field can consists of a descriptive keyword, optionally followed by semicolon and some additional info. For example, it can return

- 'OTHER' or
- 'OTHER; unhandled exception' .

5.2.1 Job info

By calling

MFCS_submit	
WMSID	<wmsid1>
ITEM	'JOB'
INSTRUCTION	'INFO'
ARGUMENTS	<wmsid2>

WMS sends inquiry for a job with <wmsid2>. In this case MFCS will call WMS several times. It will report some status changes of the info job as well as status of a job in question in the following way:

WMS_status	
WMSID	<wmsid1>
ITEM	'JOB'
STATUS	'QUEUED'
ARGUMENTS	''

WMS_status	
WMSID	<wmsid1>
ITEM	'JOB'
STATUS	'EXECUTING'
ARGUMENTS	''

WMS_status	
WMSID	<wmsid2>
ITEM	<item of job <wmsid2>>
STATUS	<status of job <wmsid2>>
ARGUMENTS	''

WMS_status	
WMSID	<wmsid1>
ITEM	'JOB'
STATUS	'FINISHED'

ARGUMENTS	''

5.2.2 Job deletion

To delete a job in MFCS queue WMS has to call

MFCS_submit	
WMSID	<wmsid1>
ITEM	'JOB'
INSTRUCTION	'DELETE'
ARGUMENTS	<wmsid2>

On successful deletion, apart from the statuses of a job <wmsid1>, MFCS will report

WMS_status	
WMSID	<wmsid2>
ITEM	<item of job <wmsid2>>
STATUS	'DELETED'
ARGUMENTS	''

Possible errors, related to JOB are given in Table 6. They will be send to WMS by calling

WMS_status	
WMSID	<wmsid1>
ITEM	'JOB'
STATUS	'ERROR'
ARGUMENTS	'NOWMSID' or 'NODELETE'

TABLE 6 ERRORS, RELATED TO JOBS

Info	Description
'NOWMSID'	Job with given WMSID does not exist in MFCS
'NODELETE'	Job already in execution, deletion is not possible

5.3 Segments

Segments are integral functional units of the system. The warehouse is divided into the following segments:

- T00 - input line: conveyors T001, T002,
- T03 - reject line: conveyors T004, T005,
- T01 - shuttle 4 input: T010, T011, T012,
- T02 - shuttle 4 output: conveyors T021, T022, T023, T024,
- T11 - crane 1 input: conveyors T003, T110, T111, T112,
- T12 - crane 1 output: conveyorsT121, T122,
- T21 - crane 2 input: conveyors T211, T212,
- T22 - crane 2 output: conveyors T221, T222,
- T31 - crane 3 input: conveyors T311, T312,
- T32 - crane 3 output: conveyors T321, T322,
- C1 - crane 1,
- C2 - crane 2,
- C3 - crane 3,
- C4 - shuttle 4,
- C5 - shuttle 5.

Each segment is implemented as finite state automaton, which switches among states according to the scheme in Figure 1.

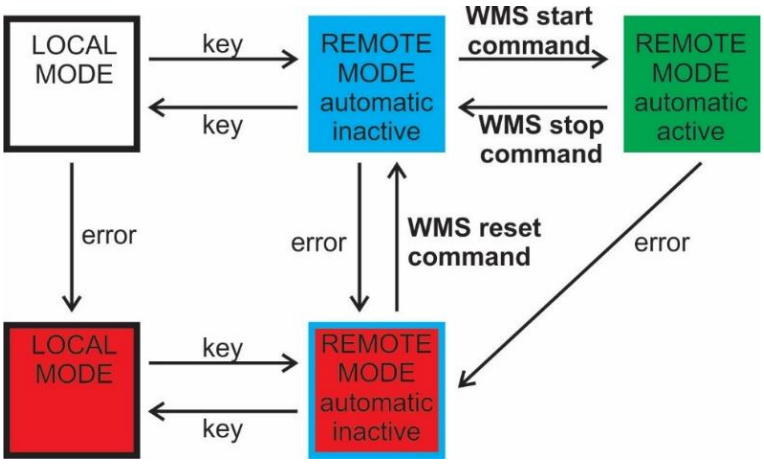

FIGURE 4 SWITCHING AMONG SEGMENT STATES

In order to run any vehicle or any conveyor line in automatic mode by WMS commands, the operator has to switch the key to the remote mode.

When an operator wants to go to a vehicle, he takes the hardware key from the outside cabinet, opens door to the warehouse, closes the door, and puts the key to the key lock on the vehicle. Now the vehicle is in local mode and can be operated manually. It can be operated automatically again by WMS only when the key is back in the outside cabinet in correct position.

On conveyor lines there is no extremely dangerous movements, so switching between local and remote mode will be done over control panel by pressing appropriate buttons (a software key, separate for each segment), or a hardware switch on some cabinets.

The segments are basically handled by MFCS. For better end-user experience we encourage the WMS to put segment functionalities also on WMS interfaces like operator's panels, handheld units.

When in remote mode, WMS can send appropriate command to each segment separately (vehicles, conveyor segments) or to all segments at once as detailed in Table 7.

TABLE 7 MFCS_SUBMIT (SEGMENT)

Function MFCS_submit		
Name	**Values**	**Comments**
WMSID	Unique command ID generated by WMS	
Item	'SEGMENT'	
Instruction	'INFO' 'RESET' 'START' 'STOP'	Request a segment status Request to reset active alarms on a segment Request to switch segment to automatic active mode Stop automatic operation of a segment
Arguments	'ALL' 'T00' 'T01' 'T02' 'T03' 'T11' 'T12' 'T21' 'T22' 'T31' 'T32' 'C1' 'C2' 'C3' 'C4' 'C5'	Instruction is sent to all segments Instruction is only sent to segment T00 …

On response to instruction 'INFO', MFCS reports the status of the segment and also the status of each location (a table, a deck) of the required segments (see Section 0 for details). In all cases WMS_status is called with WMSID := '0'. Only when all status updates are submitted to WMS, WMS_status of the initiating job with STATUS := 'COMPLETED' is called.

Instructions START, STOP, or RESET try to change the status of a segment. Depending on the situation in a field, the status can change or not. Anyway, MFCS spontaneously reports the status after applying the instruction by calling WMS_status with WMSID := '0'. Only when all statuses are submitted to WMS, the initiating job is finished and WMS_status with STATUS := 'COMPLETED' is called. At that time WMS should have the latest status of a segment.

Feedback about the segment status is given by calling WMS_status as detailed in Table 8.

TABLE 8 WMS_STATUS (SEGMENT)

WMS_status		
Name	**Values**	**Comments**
WMSID	'0'	
Item	'SEGMENT'	
Status	'COMPLETED'	
Info	<mode>; <automatic>; <alarm>	<mode> := 'LOCAL' or 'REMOTE' <automatic> := 'INACTIVE or 'ACTIVE' <alarm> := 'ALARM' or 'NOALARM'

Additional errors, related to segments are given in Table 8.

TABLE 9 ADDITIONAL ERRORS, RELATED TO SEGMENTS

Info	Description
'SEGMENT'	Segment does not exist

5.4 Locations

WMS can check or modify occupancy information of a locations handled by MFCS (T###, C###, R######, where # is a number). Only location, specified in Chapter 2 are valid.

Item 'LOCATIONS' help to identify which transport unit occupies a certain location in the warehouse. When WMS asks for a certain location, MFCS return the ID of the transport unit (TUID) currently occupying the location in question.

To synchronize the material picture between WMS and MFCS, WMS can also modify the TUID at the given location.

By vaguely using this functionality, the material picture of the warehouse can be completely destroyed and all information of transport units lost!

The syntax of calls to MFCS_submit and WMS_status regarding location information is given in Table 10 and Table 11, respectively.

TABLE 10 MFCS_SUBMIT (LOCATION)

Function MFCS_submit		
Name	**Values**	**Comments**
WMSID	Unique command ID generated by WMS	
Item	'LOCATION'	
Instruction	'INFO' 'MODIFY'	Check the status of a <location> Request to change current TUID in location <location> with <tuid>
Arguments	<location> <location>; <tuid>	For instruction 'INFO' For instruction 'MODIFY' <location> is a string 'T###', 'C###', or 'R######', <tuid> is a string of numbers of appropriate format, i.e. '#########', or ''

TABLE 11 WMS_STATUS (LOCATION)

WMS_status		
Name	**Values**	**Comments**
WMSID	'0'	
Item	'LOCATION'	
Status	'COMPLETED'	
Info	<location>; <tuid>	<location> is a string 'T###', 'C###', or 'R######', <tuid> is a string of numbers of appropriate format, i.e. '#########', or ''

Errors, related to locations are detailed in Table 12.

TABLE 12 ADDITIONAL ERRORS, RELATED TO LOCATIONS

Info	Description
'LOCATION'	Location does not exist
'TUID'	Wrong format of TUID or TUID already exists in the system
'LOCEMPTY'	Cannot create TUID, sensors are not occupied
'LOCFULL'	Cannot delete TUID, sensors are occupied

With call

MFCS_submit	
WMSID	<a unique WMSID>
ITEM	'LOCATION'
INSTRUCTION	'INFO'
ARGUMENTS	<location>

WMS requests occupancy information of a given location.

When a transport unit is physically removed from the system, its data must be cleared. This is done by calling

MFCS_submit	
WMSID	<a unique WMSID>
ITEM	'LOCATION'
INSTRUCTION	'MODIFY'
ARGUMENTS	<location>; ''

When an operator wants to delete data on some location and its occupancy sensor still sees a physical transport unit, the request is rejected with LOCFULL.

When a new transport unit is put to the system or, due to an error, ID of a transport unit on a particular place must be updated, WMS must call

MFCS_submit	
WMSID	<a unique WMSID>
ITEM	'LOCATION'
INSTRUCTION	'MODIFY'
ARGUMENTS	<location>; <tuid>

When an operator wants to create data on a place and its occupancy sensor does not see it, the request is rejected with LOCEMPTY.

Before command completion, MFCS will always inform WMS about the location occupancy.

WMS_status	
WMSID	'0'
ITEM	'LOCATION'
STATUS	'COMPLETED'
ARGUMENTS	<location>; <tuid>

5.5 Tasks

With this option WMS instructs MFCS about transport unit relocations. The relocation task includes a transport unit ID (TUID), a source location, a target location, and a priority.

MFCS takes care of executing a task by splitting it to the corresponding PLC subsystems as well as breaking it into simpler commands which are understood by PLCs. During the execution of a task many spontaneous calls to WMS_status are used to inform WMS about each relocation of a transport unit or change in a segment status.

To submit tasks to MFCS, WMS has to call MFCS_submit in a format given in Table 13.

TABLE 13 MFCS_SUBMIT (TASK)

Function MFCS_submit		
Name	**Values**	**Comments**
WMSID	<wmsid>	Unique command ID generated by WMS (string)
Item	'TASK'	
Instruction	'MOVE'	
Arguments	<tuid>; <source>; <target>; <priority>	<tuid> is a identification of a transport unit given as string of numbers of appropriate format, i.e. '#########', or '' <source> is a warehouse location: 'T###', 'C###', or 'R#######' <target> is a warehouse location: 'T###', 'C###', or 'R#######' <priority> is '1'…'9' with '1' being least important

To double check the material picture of the warehouse between MFCS and WMS, before execution of a task MFCS can check if transport unit with <tuid> is really on <source> location.

Whenever a status of a task changes, MFCS it to WMS by calling WMS_status as detailed in Table 14.

TABLE 14 WMS_STATUS (TASK)

WMS_status		
Name	**Values**	**Comments**
WMSID	<wmsid>	Unique WMSID from the MFCS_submit
Item	'TASK'	
Status		General command statuses and errors
Info	''	No additional info

To inform WMS about the problems during the execution of a task, errors, related to tasks are detailed in

Table 15Table 12.

TABLE 15 ADDITIONAL ERRORS, RELATED TO TASKS

Info	Description
'TUID'	Wrong format or TUID not exist in the system
'SOURCE'	Wrong format of source location
'TARGET'	Wrong format of target location
'PRIORITY'	Wrong format of priority
'PATH'	It is not possible to move a transport unit from source to target
'DIMENSION: *nlrfbthwm*'	Dimensions of a transport unit are not proper for storing. If present, letters in italic give the reason: *n:* no read – bar code was not successfully read, *l*: left – pallet to wide on left side, *r*: right – pallet to wide on right side, *f*: front – pallet to wide at font, *b*: back – pallet to wide at back, *z*: top – pallet to high, *h*: height class – measured height class does not match task *w*: weight – pallet to heavy *m*: MFCS – rejected by MFCS or WMS
'SOURCETUID'	The required TUID is not on SOURCE location (optional)
'SOURCEEMPTY'	Source location is empty
'TARGETFULL'	Target location is occupied; transport unit remains on a deck!
'PLC'	Command cannot be executed due to some problems on PLC level

6 Document change history

6.1 Version 0.5, 10. 8. 2016

- The original document (first draft)