Application Guide

Multishuttle Control System (MSC)

Dematic Controls Interface (DCI)

2015-March-09 V1.52.1

Creating Logistics Results

DEMATIC

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Revision overview

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1.22	2011-July-05	Data types of TU length, width, height, weight corrected to “N”.	Cremer

Version	Date	Revision/Comment	Author
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1.52	2015-Feb-19	Revised naming conventions for 2S layout.	Moßner
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1 Introduction

Due to the fact that it is committed to have global concepts and a global interface for all control systems, Dematic is looking for a common interface which is accepted by all regions.

The interface which is specified in this document covers these aspects and is based on the Dematic Communication Interface (DCI); see /1/ for further details.

1.1 Purpose of the Document

The present document provides a complete description of the message interface between the Warehouse Control System (WCS) and the Multishuttle Control System (MCS)[1]. All strategies being employed in the controller are specified.

In addition, basic anomaly handling is described, which can serve as the basis for later customer documentation.

The interfaces for integrating conveyor systems are also described.

1.2 Restrictions

Regional or project specific aspects are not covered within this specification and should be added on a per project base.

The following aspects currently being under discussion are not yet covered. They will be addressed in a forthcoming version of this specification:

- Revised naming schema to better support more than one lifts in the middle of an aisle (drive through scenario)
- Tandem cycle lift scenario.
- Two shuttles on one level (F-EA-PTC-2S scenario)
- Using a pick index instead of a drop index (see chap. 3.9).

[1] Instead of MCS, the notion DMS is simply used for the multishuttle control system.

1.3 How to use the document?

This document covers all functions and features the MSC consists of. It tries to describe the behavior of the system and gives use cases at the end of the document for a better understanding.

1.4 References

This document contains references to the following documents

Ref.	Title	Version
/1/	DCI Common	V 1.42
/2/	DCI Transport	V 1.33
/3/	Dematic Multishuttle – Lift configuration Catalog	January 2014

1.5 General Principles

The MSC is responsible for executing the transport orders. In this regard the MSC manages and controls the necessary equipment (lift, shuttle, rack conveyor, infeed and outfeed lanes).

Conveyor optimizations and avoidance of blockages by equipment are generally performed by the MSC. Should this not be possible at a given time, the transport order is canceled and a new destination is requested from the WCS.

Generally the WCS is responsible for determining the priorities and sequence of transport orders. The MSC maintains sequence by utilizing the drop index, supplied by the WCS when executing transport orders from a lift to a DS.

The WCS directs the MSC exclusively through the specification of transport orders relative to transport units. The WCS controls no equipment, like the fingers of the shuttle telescope

High-capacity Multishuttle systems have a shuttle that never leaves the level. The lift transports only the transport units.

For improving performance each level has at least two rack conveyors for storage and retrieval operations. In addition, each aisle has at least two lift platforms. Each can handle two transport units.

In delivering the containers to the order-picking locations a specific retrieval sequence is often required of the Multishuttle system. In this case the WCS orders the transport unit first up to rack conveyors and then further to the DS, utilizing the drop index.

Depending on the throughput requirements, without a retrieval sequence the transport unit can be directly ordered from the bin to the DS.

1.6 Lift Layouts

This chapter describes the basic lift layouts and their properties.

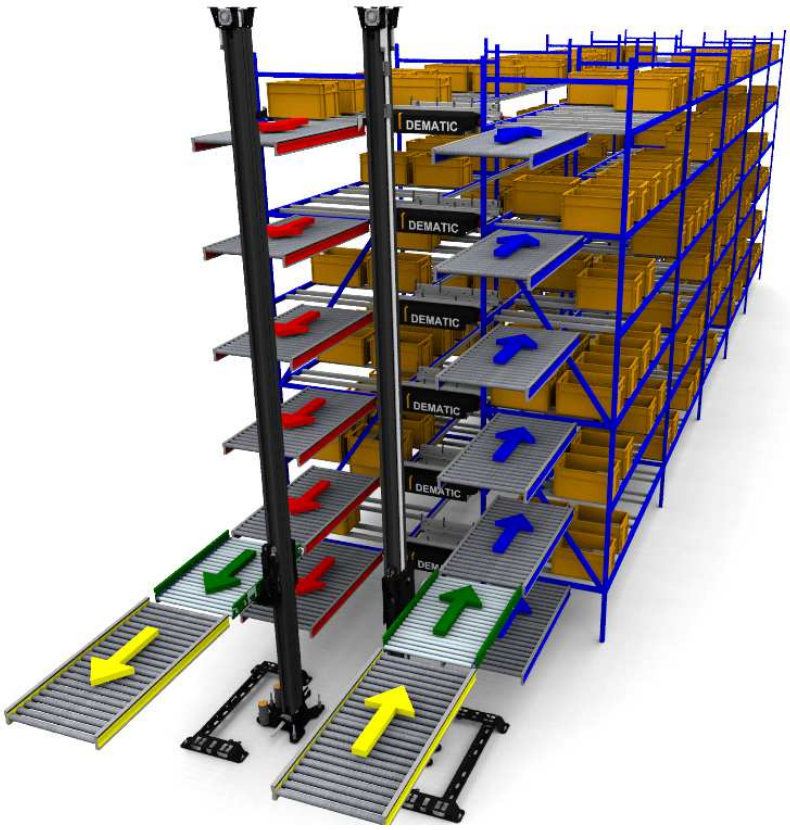
A multishuttle aisle can encompass more than one lift. Though not like to be used in projects, not all lifts being used within an aisle need to be identical.

Lifts can be positions at the beginning or end of an aisle (→ “End Of Aisle” position) or in the middle of an aisle (→ “Drive Through” position). Again it is conceivable that an aisle encompasses “End Of Aisle” as well as “Drive Through” lifts.

The lift configuration is only relevant in the context of naming conventions (see chap. 2). They do not impact the telegram structure or the message sequence

An exact and complete definition of all lift variants can be found in /3/.

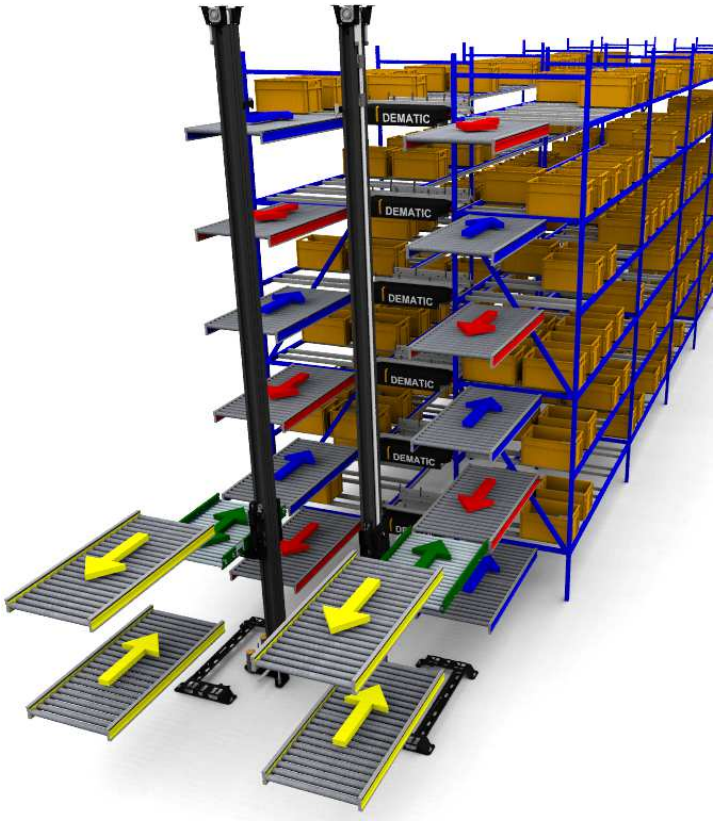
1.6.1 Single Cycle Lift



A single cycle lift layout has the following properties:

- Rack in and rack out conveyor are located on one side of the lift only.
- All rack conveyors on all levels point in the same direction.
- A lift performs either inbound or outbound movements only, i.e. it travels empty 50% of the time

1.6.2 Dual Cycle Lift

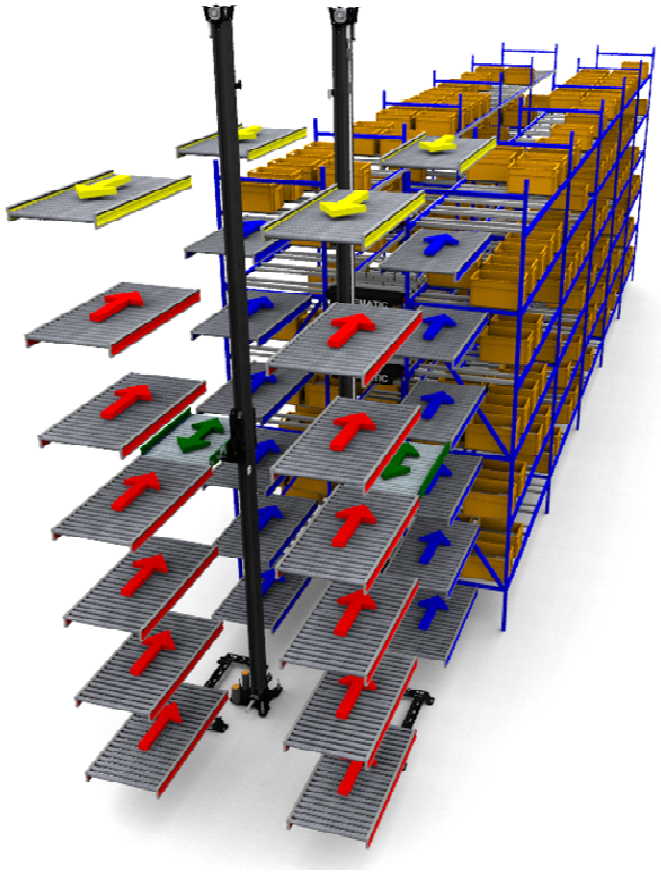


A dual cycle lift layout has the following properties:

- Rack in and rack out conveyor are located on one side of the lift only.
- Rack conveyors on each level point in alternates in direction
- Lift performs both in inbound & outbound movements

In case of one lift fails, an emergency retrieval scenario is possible be reversing the direction of the rack in conveyors of the lift still operable.

1.6.3 Tandem cycle

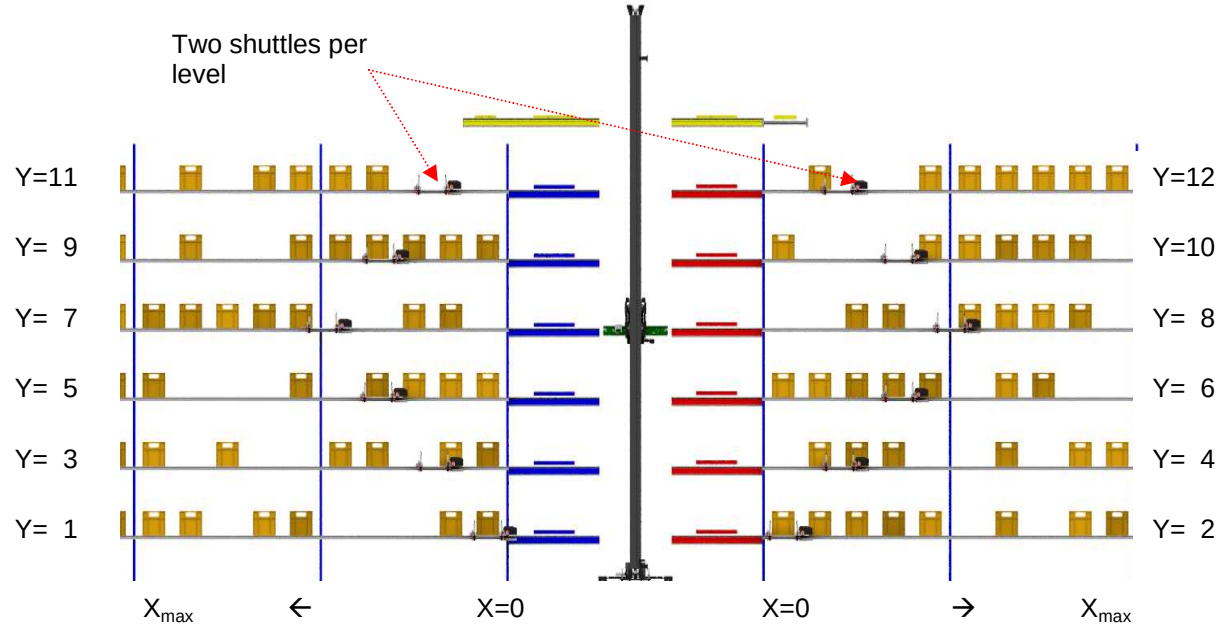


A tandem cycle lift layout has the following properties:

- Rack in and rack out conveyors are located on both sides of the lift.
- The lifts performs both inbound and outbound movements.
- Allows lift to pick and drop simultaneously at each level.

Rack conveyor directions may be aligned or non-aligned for both lifts. For non-aligned lifts a simultaneous movement of the shuttle telescope on/off the shuttle position is possible.

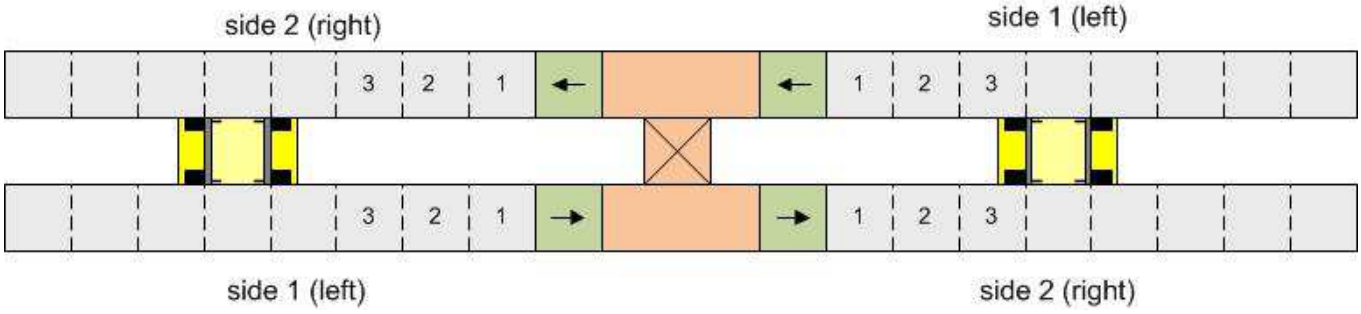
1.7 Tandem Cycle 2S



This setup is modelled as one. On each side of the lift a shuttle resides (two shuttles → 2S). Shuttles are not allowed to travel past the lift.

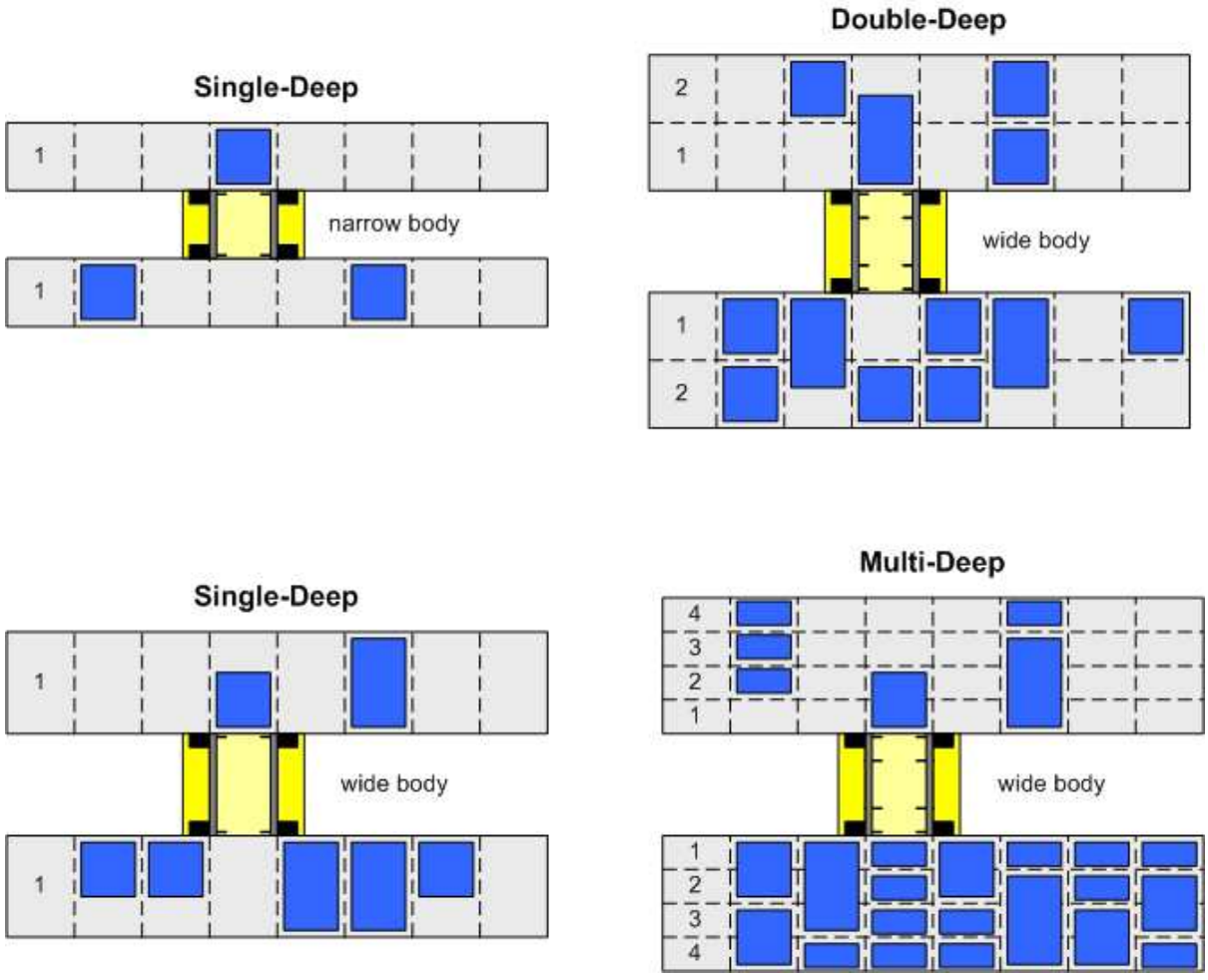
The levels on one side are numbered with even numbers; the other side with odd nummbers. The semantics of even and odd are project specific. The x-values start with X=0 at the lift and increases to their maximum values at the end of the aislse.

The following picture shows a top view of the aisle.



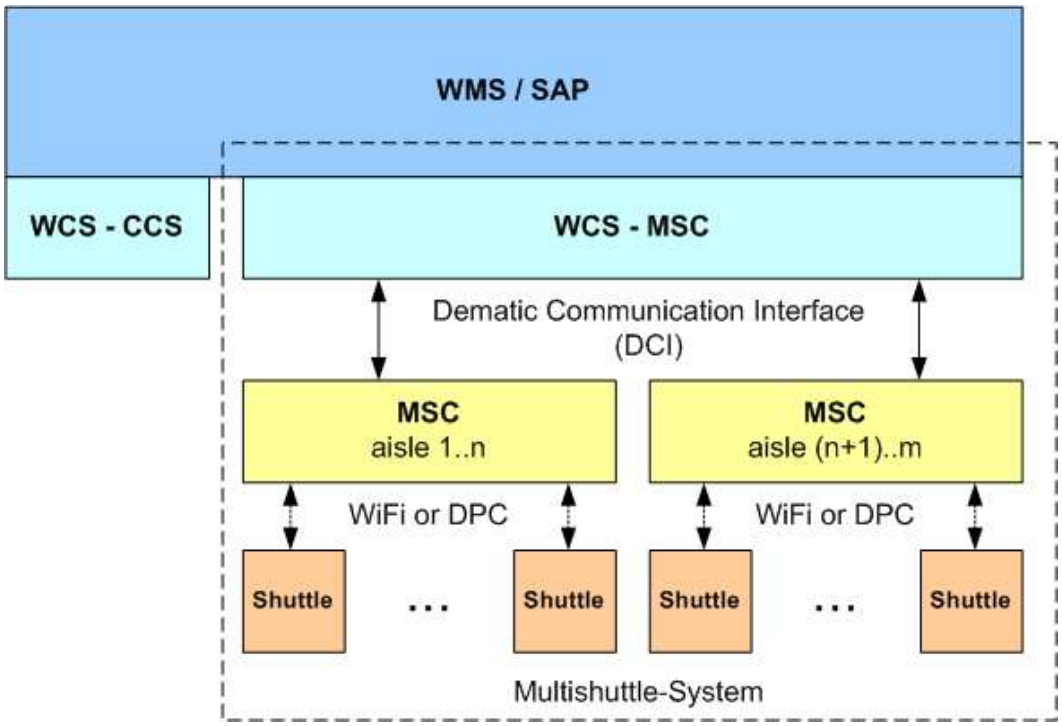
~~1.9~~1.8 Rack- and shuttle variants

The following images illustrate the usage of different type of rack layouts and two different types of shuttle designs.



The details of the rack layout and the shuttle type has no influence on the communication interface.

~~1.9.11~~.8.1 System architecture



Task Assignment

System	Hardware	Function
WMS / SAP	Server	Storage management system with the following tasks regarding the Multishuttle system: Stock reconciliation, SKU management, storage management, blocks of transport orders with sequences and priorities.
WCS-MSC	Server / PC	Material flow controller for the Multishuttle system: Specification of individual transport orders on TU basis to the MSC given the priorities and sequence of the TU transports. Specification of the drop index to the MSC, so that the sequence of the TU's will be maintained at the DS. Coordination of the transports across aisles.
WCS-CCS	Server / PC	Material flow controller for the tote conveyor system: Specification of individual transport orders to the conveyor-PLC, in particular specification of the global transport destinations for Collector technology (= interface of external collection conveyor).
MSC	PLC (S7)	Multishuttle controller: Execution of the transport orders on TU basis. Management and actuation of the lifts, shuttles, rack conveyors and infeed and outfeed lanes. Execution of the sequence generation at the lift. Actuation of the shuttles through WiFi or DPC through specification of half cycles.
SC	PLC / onboard controller	Shuttle controller: Positioning of the shuttle, pickup and outfeed of the TU from bin, telescope actuation.

~~1.10~~1.9 Control principles

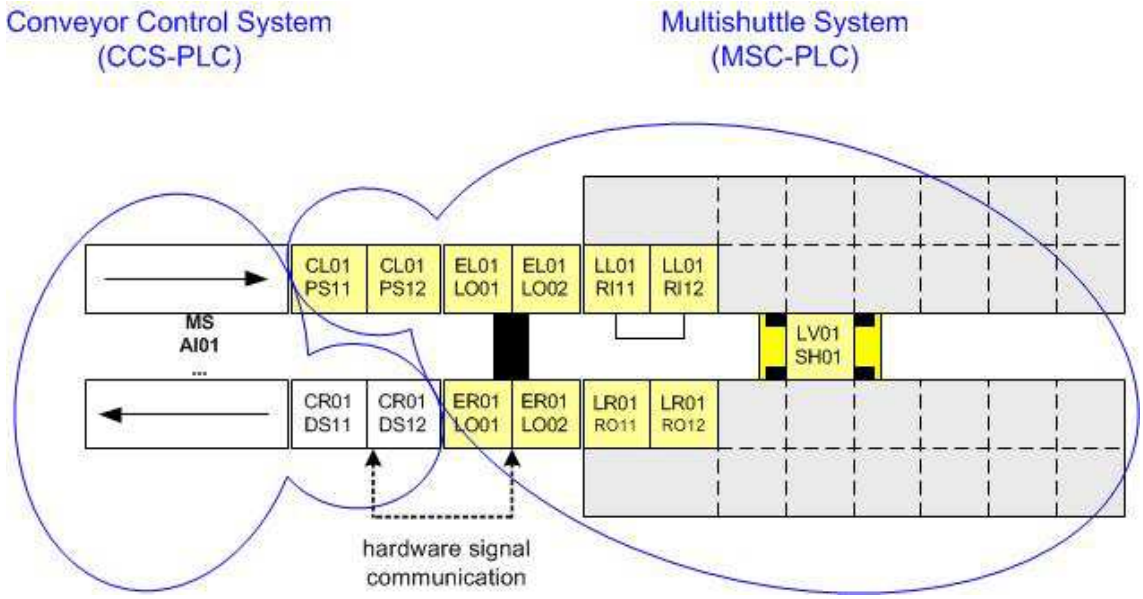
The following list of main features should give a brief overview about the control principles of a Multishuttle System:

- The MSC Controller is able to handle one Multishuttle aisles.
- The MSC Controller handles all machines and equipment of an entire aisle. It coordinates multiple shuttles, lifts, rack conveyors and pick stations.
- Pick stations are belonging to the MCS, drop stations are belonging to the Conveyor Control System (CCS).
- On a project base infeed and outfeed lanes can also be included within the MCS Controller if needed.
- Transport missions from WCS are referring to load units.
- Transport missions are without priority and sequencing. This functionality is handled by the WCS by sending transport missions at the right time or by FIFO for retrieval orders. Only one exception exists during retrieval operation. Due to get a better lift performance a drop index can be used to bring outgoing TU's into a sequence.

~~1.11~~1.10 Supported interfaces to conveyor system

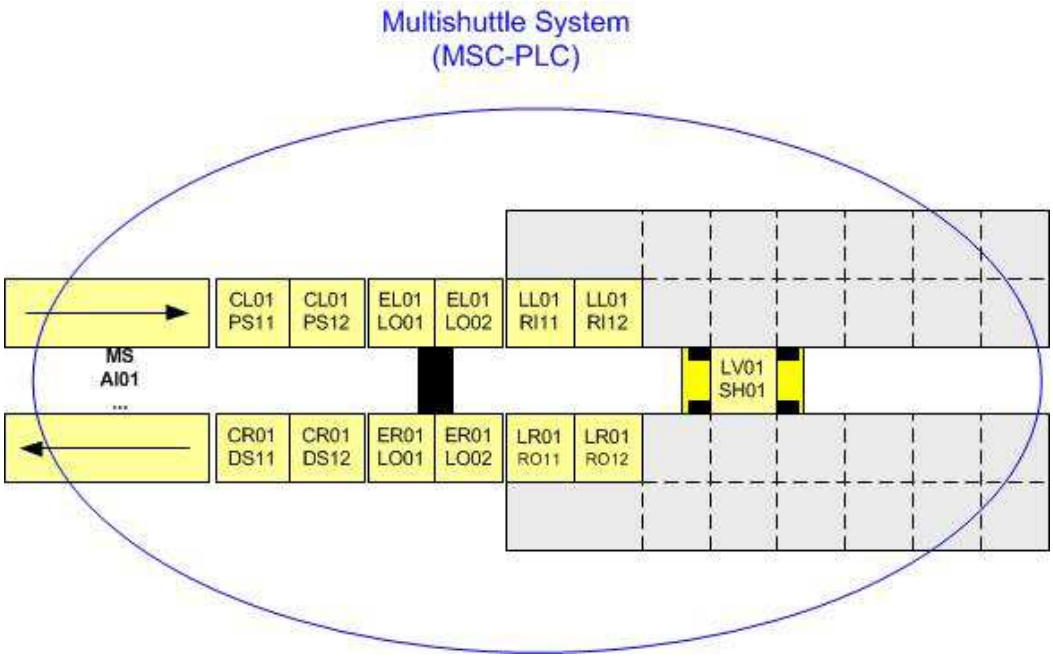
~~1.11.1~~1.10.1 Typical MSC architecture

The following image illustrates the typical Multishuttle architecture which is used for most projects. Pick stations, lift, rack conveyors and shuttles are included into the Multishuttle Controller (MSC). Infeed and outfeed lanes and drop stations are excluded and belong to the Conveyor Control System (CCS).



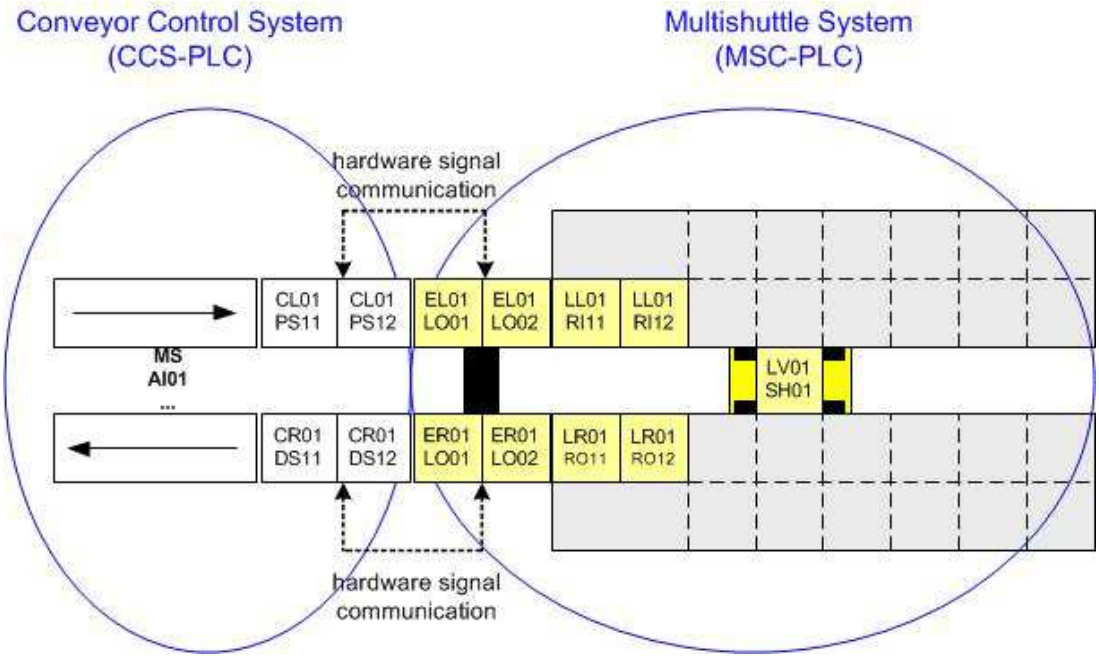
~~1.11.2~~1.10.2 Maximum MSC architecture

The following image illustrates an option for a possible MSC architecture. Entire Infeed and Outfeed lanes including Pick- and Drop stations are belonging to the MSC controller. This architecture should be used for small systems where MS and conveyor system can be included into one PLC.



~~1.11.3~~1.10.3 Minimum MSC architecture

The following image illustrates another possible option to combine the Multishuttle System with the Conveyor System. Only the lift, rack conveyors and shuttles are belonging to the MSC controller. Pick- and Drop stations are excluded and are controlled by the CCS. The communication between MSC and CCS is done via hardware signals. This ensures the proper handover of transport units from Pick locations onto Lift conveyors and vice versa from Lift conveyors onto Drop locations. The TU data are sent within the missions from by WCS to MSC.



2 Naming conventions

The general naming conventions are described in /1/.

2.1 Rack Conveyor

Rack conveyors are named according to the following naming convention:

`MSAI<aa>L<s><ll>R<io><lift><pos>`

where

`<aa>` = aisle: [`01-99`]

`<s>` = side: `R`=right, `L`=left

`<ll>` = number of level: [`01-99`]

`<io>` = in out: `O`=rack out, `I`=rack in

`<lift>` = lift number: [`1..9`]

`<pos>` = conveyor position as seen in the direction of material flow; `0`=virtual location

The virtual position denotes the sum of all individual conveyor zones a rack conveyor might be composed of.

Examples:

- `MSAI01LR08RI10`
  This denotes a rack in conveyor in aisle 01: it corresponds to lift 1 and is located on the right hand side of level 08

`MSAI03LL03RO20`
This denotes a rack out conveyor in aisle 03: it corresponds to lift 2 and is located on the left hand side of level 03

2.2 Lift

Lifts are named according to the following naming convention:

MSAI<aa>E<s>0<lift>LO0<pos>

where

<aa> = aisle: [01-99]

<s> = side: R=right, L=left

<lift> = lift number: [1..9]

<pos> = conveyor position as seen in the direction of material flow; 0=virtual location

The virtual position denotes the sum of all individual conveyor zones a lift carriage might be composed of.

Example:

- MSAI03ER01LO00
  This denotes a lift in aisle 03 aisle 03: the number of the lift is 1 and it is located on the right hand side.

2.3 Pick and Drop Stations

Pick and drop stations are named according to the following naming convention:

MSAI<aa>C<s><cc><dp>S<lift><pos>

where

<aa> = aisle: [01-99]

<s> = side: R=right, L=left

<cc> = conveyor level: may or may not be identical with shuttle level, [01-99]

<dp> = pick or drop; D=drop, P=pick

<lift> = lift number: [1..9]

<pos> = conveyor position as seen in the direction of material flow; 0=virtual location

The virtual location denotes the sum of all individual conveyor zones a pick or drop station might be composed of.

Examples:

- MSAI01CR01PS10
  This denotes a pick station in aisle 01: it is located on the right hand side and corresponds to lift 1.
- MSAI03CL02PS20
  This denotes a drop station on aisle 03: it corresponds on the left hand side and corresponds to lift 2.

2.4 Shuttle

Shuttles are named according to the following naming convention:

`MSAI<aa>LV<ll>SH<pp>`

where

`<aa>` = aisle: [`01-99`]

`<ll>` = number of level: [`01-99`]

`<pp>` = number of shuttle in level [`01-99`]
Since the Tandem Cycle 2S configuration (see chap. 1.7) still has unqiue level numbers for each side, the value of `<pp>` is in general `01`.

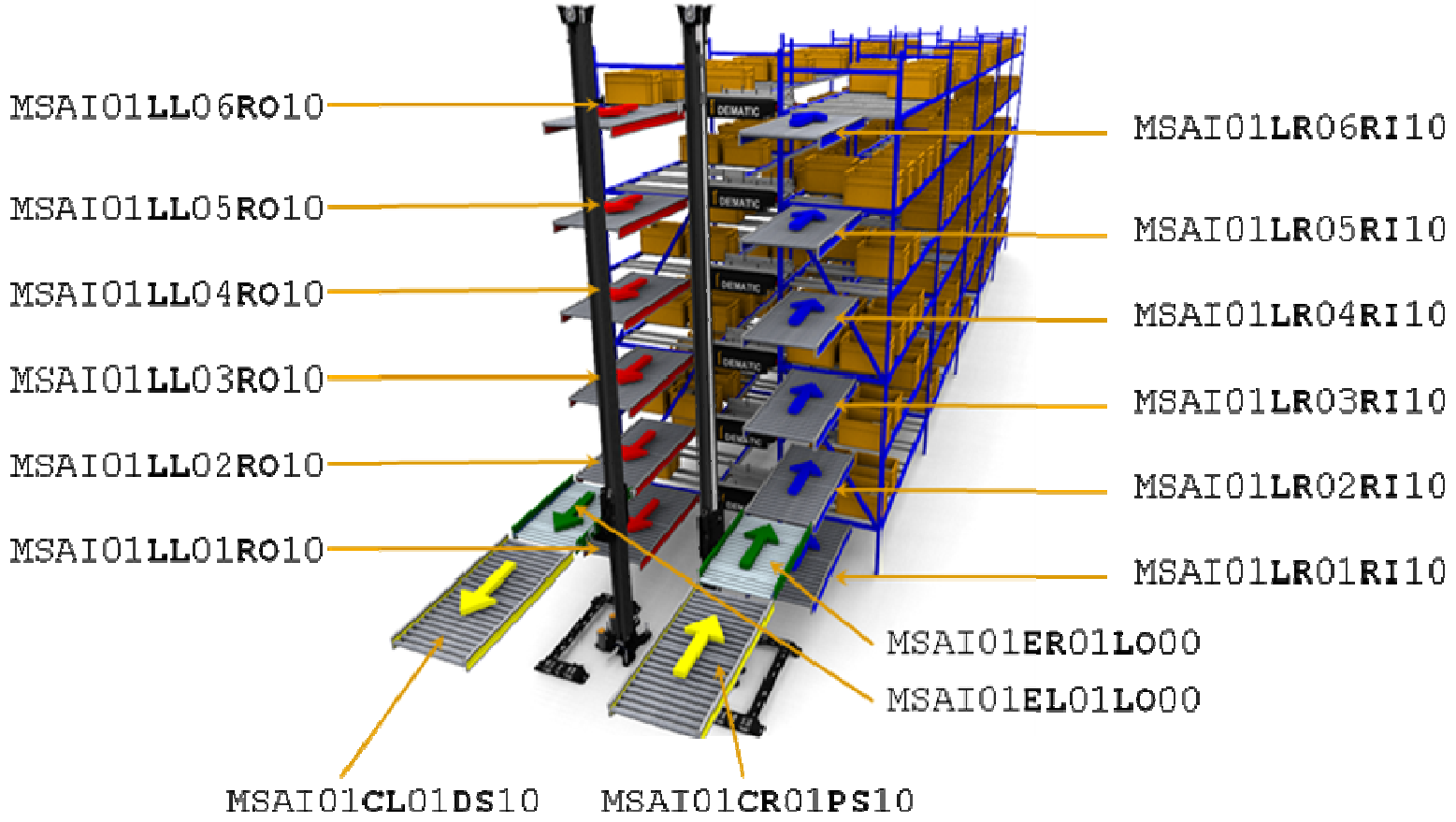
Example:

- `MSAI01LV03SH01`
  This denotes a shuttle in aisle 01 on level 03.

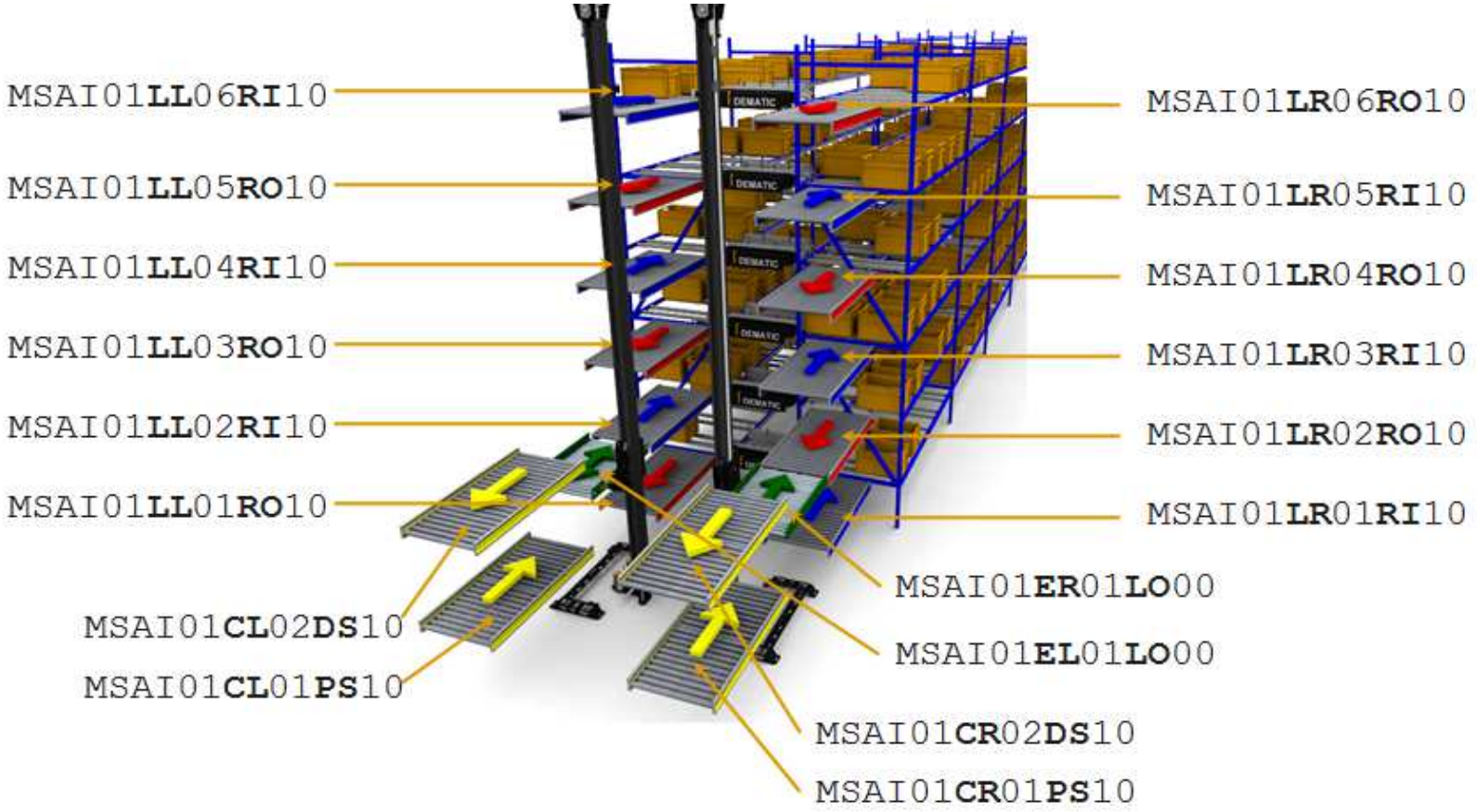
2.5 Examples

The following chapters gives examples how the above mentioned naming conventions are applied to most significant lift layouts

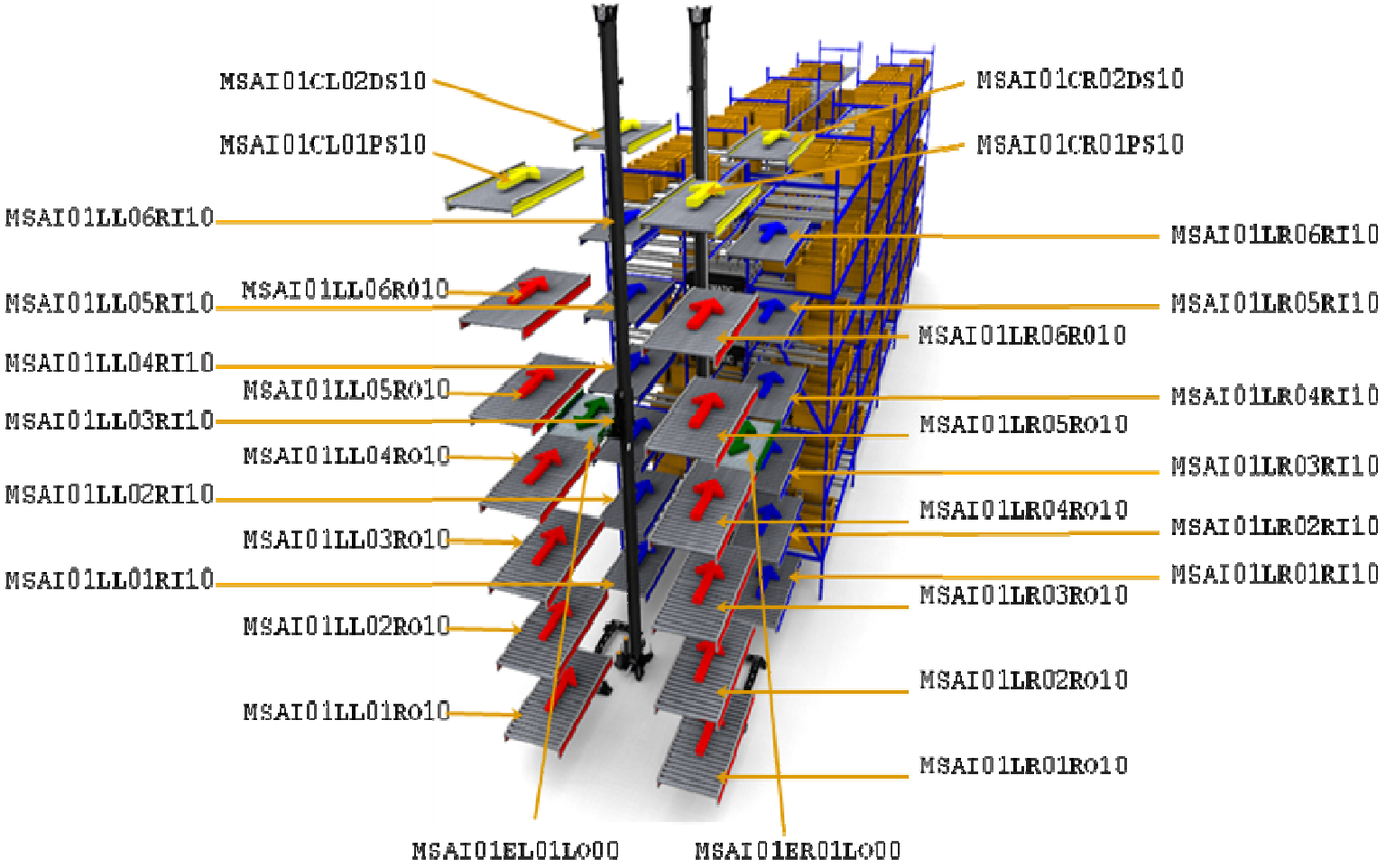
2.5.1 Single Cycle Lift



2.5.2 Dual Cycle Lift



~~2.5.4~~2.5.3 Tandem Cycle Lift



3 Functions and strategies

3.1 Transport Mission Types

The following transport missions are executable:

#	Mission	Description
1	Storage	TU is moved from PS to bin location
2	Retrieval	TU is moved from bin location to DS
3	Shuffle	TU is moved from bin location to another bin location
4	Pass-Through	TU is moved from PS to DS
5	Move orders	Move orders of shuttle to a specified destination

3.1.1 Relocations

The following relocations are possible:

Version	within level	between levels	between aisles
single cylce lifts	YES	NO	if necessary via external conveyor system
dual cycle lifts	YES	50% of the levels	if necessary via external conveyor system

3.1.2 Direct Pick-to-Drop Transfers

The WCS has the possibility, in particular while handling a malfunction, to pass-through transport units, i.e. to transport them directly from the PS to the DS.

Direct pick-to-drop transfers are possible only through the rack conveyors and the shuttle.

In systems with sequence formation, the WCS must make sure that the transport units passed through do not destroy the sequence of the retrieved TU flow.

The following list describes the ordering of direct pick-to-drop transfers by the WCS:

- Possibility 1 (without sequence formation):

Transport order: PSx → DSy

The rack conveyor is selected by the DMS and its capacity monitored.

- Possibility 2 (with sequence formation):

1st transport order: PSx → rack conveyor in level n

2nd transport order: rack conveyor in level n → DSy

The rack conveyor is selected by the WCS and its capacity monitored.

3.2 Quantity of Transport Missions

The MSC is restricted to the following number of transport missions:

- 10 missions per individual shuttle
- 1 mission per conveyor zone (e.g. a rack conveyor consisting of 2 conveyor zones supports two missions)

Due to the fact that transport missions might be canceled or modified by the WCS during normal operation or anomaly situations, it is recommended that the WCS should reduce the quantity of missions as much as possible. On the other hand breaks caused by mission transfer should be avoided.

3.3 Optimization of missions

The MSC does not optimize multiple Transport Missions in any case. All Transport Missions from the WCS are buffered in a FIFO per aisle and level within the MSC.

3.4 Mission processing rules

More than one Transport missions are executed by applying the following rules in order:

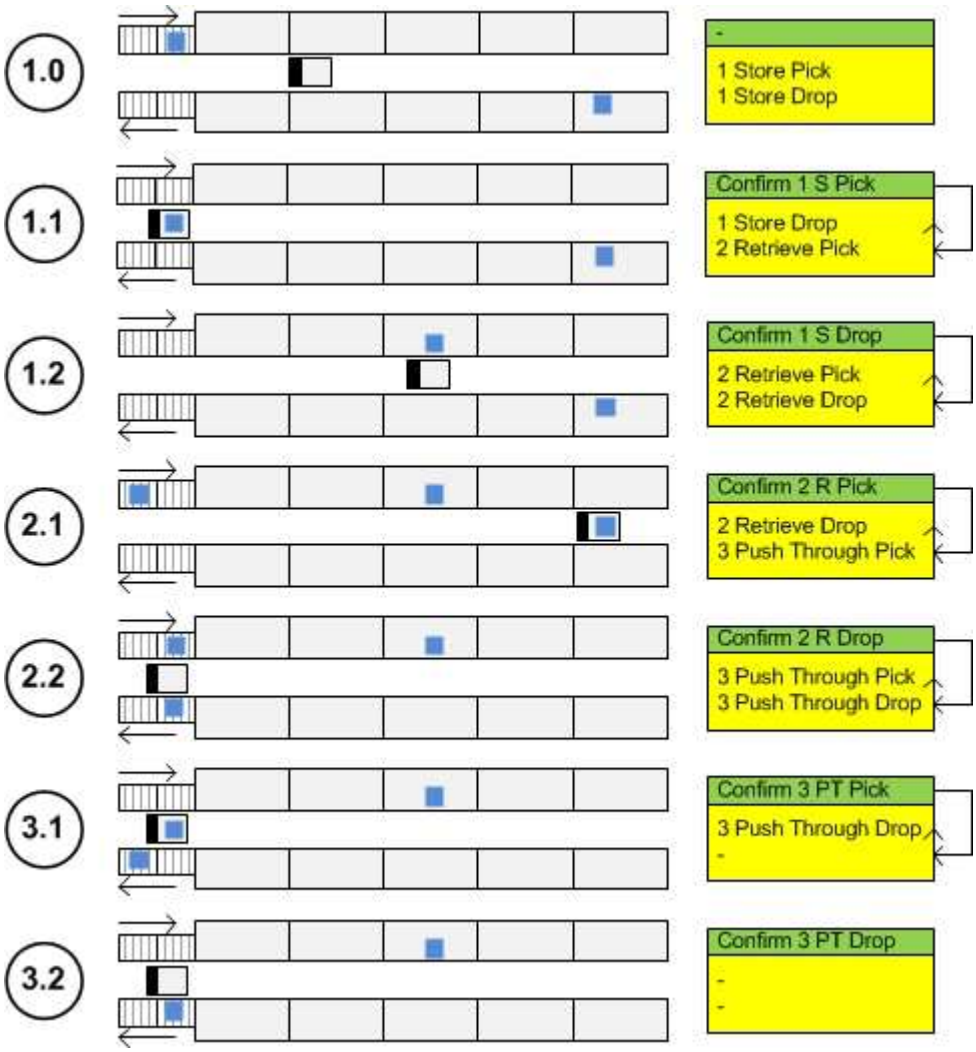
Priority of rules	Description
0	Dual cycle at Pick and Drop Station (after retrieval) or within the rack (after storage)
1	FIFO of received Transport Missions
2	Shuttle move order

Transport missions have always the same priority. Only order to move the shuttle from one position to another has less priority and will be executed if no Transport missions are available.

3.5 Shuttle Gen 2 control enhancements

In order to eliminate message delays between shuttle and stationary controller the shuttle controller is capable to store two half cycle missions. While shuttle is executing the first mission (half cycle) the stationary controller has time to calculate and send the next mission. Once a mission is executed and confirmed by the shuttle the stationary controller sends the next mission.

See the following sketch to understand the mission handling. The yellow box represents the shuttle message buffer (two half cycles) and the green box the confirmation message once a mission is executed.



3.5.1 Change mission procedure

Due to error correction or to changed WCS strategies the following features are provided:

1. Modifications of any of both half cycle missions can done at any time as long as the mission is changeable (see remark).
2. Any of both half cycle missions can canceled at any time as long the mission is changeable (see remark).

   If next half cycle mission is canceled the following one will be canceled by shuttle automatically.

Remark: Changeable means for a pick and drop half cycle missions that telescope operation was not already started. The travel operation which is part of the mission will be abort or changed if modification or cancel request was received.

If mission is changeable the new request will be executed, if not the request will be refused.

3.6 Orders with different priority

In the case transport units have to be moved with different priority, this has to be handled by the WCS by sending the Transport missions in the sequence of priority. That could mean that the WCS has to send it step by step.

3.7 Orders with sequence

In the case transport units have to be moved in a defined sequence, this has to be handled also by the WCS by sending the Transport missions step by step.

3.8 Bin sensor fault

In order to detect bin sensor faults the MSC provides the functionality to stop the shuttle with an error after “Bin empty” or “Bin occupied” is detected many times consecutively.

This function is optional. The number of attempts can be adjusted.

If this function is not set (default), the MSC is waiting for a response (modification or canceling the order) from the WCS for the aborted mission. If the response from WCS times out, the MSC generates an associated warning on the local visualization system. After the response from the WCS (before or after the timeout), the MSC automatically resumes the normal operation.

3.9 Controlling the Rack Out Conveyor

The MSC controls the occupation of rack out conveyor, i.e. the shuttle will not take on a mission in direction of the rack out conveyor if there is no free capacity on the rack out conveyor.

Instead the next shuffle, storage or iAT mission will be carried out according to a FIFO rule.

3.10 Drop Index

Handling

For determining the sequence of the transport units on the outfeed lane, the WCS communicates the drop index of the TU through the transport order.

The MSC uses the drop index to determine which TU to transfer from the rack conveyor to the lift and then to the DS.

The drop index applies per drop destination (DS). It is specified by the WCS in increasing order and must not contain any gaps. The lower its value is, the higher the priority of the TU. Identical drop indices are permissible and provide the MSC opportunities to pair TU's at the rack conveyor. A drop index of "0" indicates that no sequence is specified.

For performance-optimized retrieval operations, the WCS can specify the drop indices so that the transport units are picked up if possible paired from a level and transferred together to the DS. Paired transfers are inherently more efficient and should be used if possible.

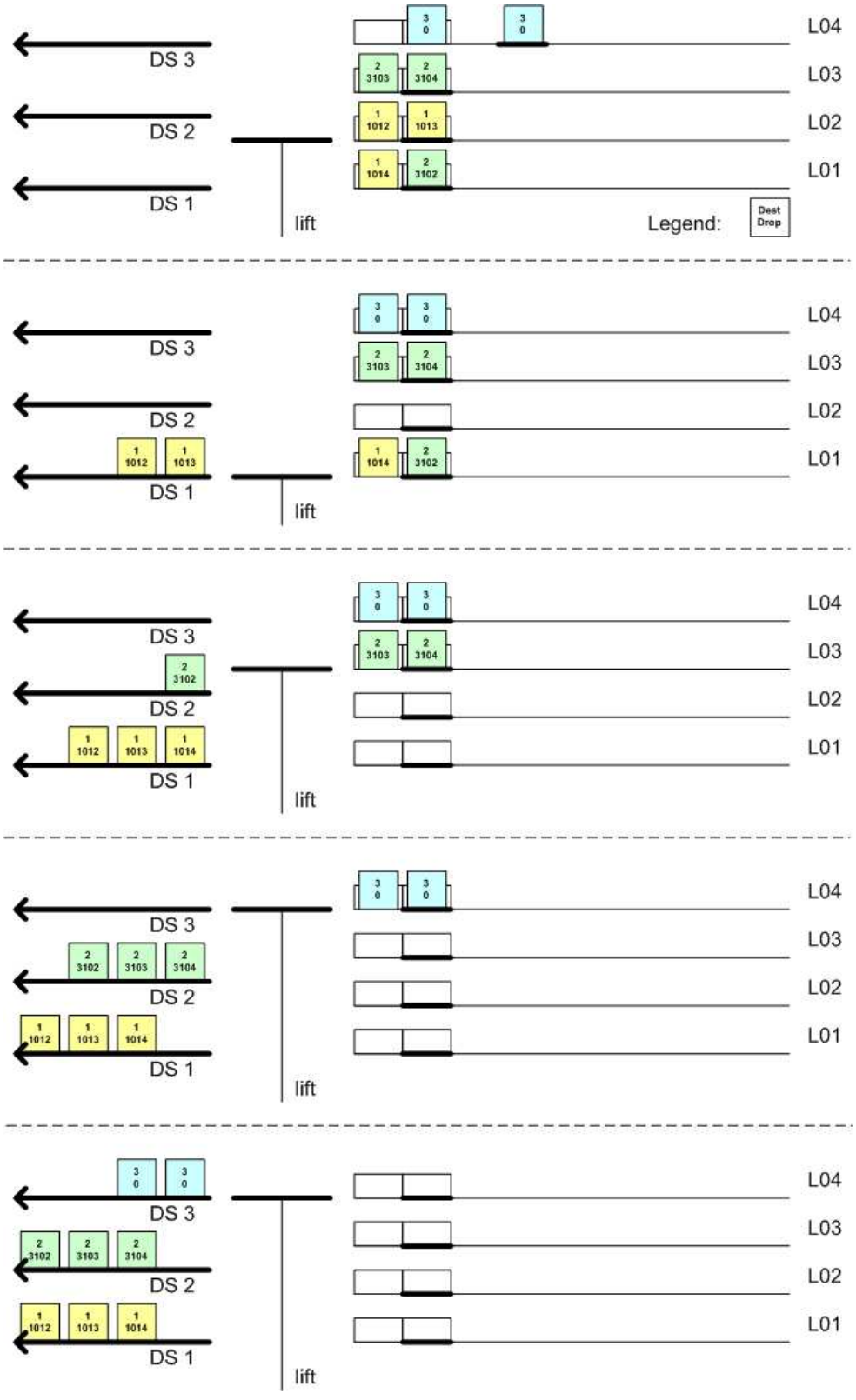
Note: The drop index denotes the sequence in which the TU is to be delivered to the DS. The MSC is responsible for maintaining this sequence.

Note: Only transport units located on outbound rack conveyors are assigned a drop index. The WCS must make sure that the drop index is assigned only after all preceding transport units are arrived on the rack conveyor.

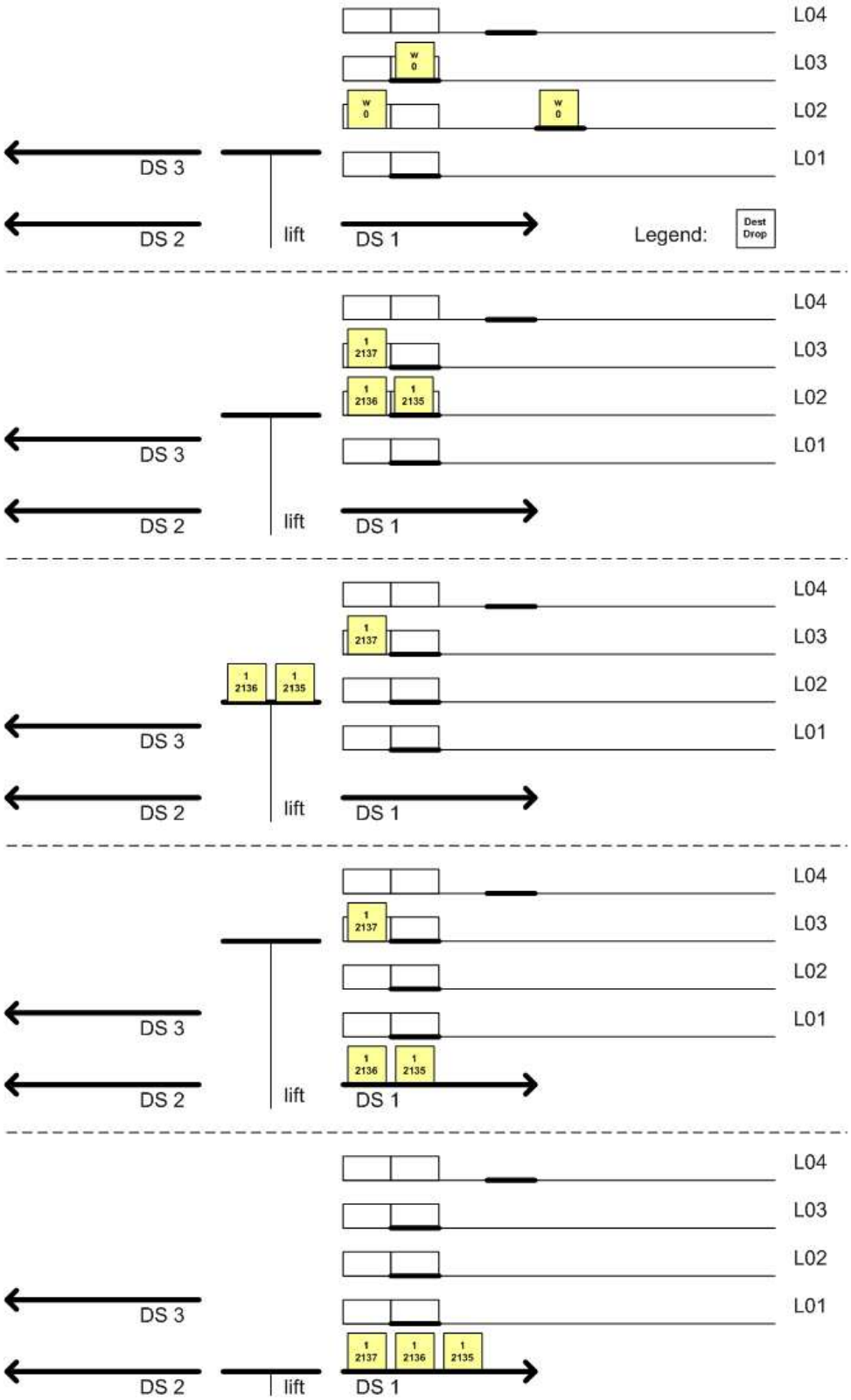
Overflow

The highest value of a drop index is "9999". Thereafter the drop index runs over. The MSC expects a "0001" as the next value.

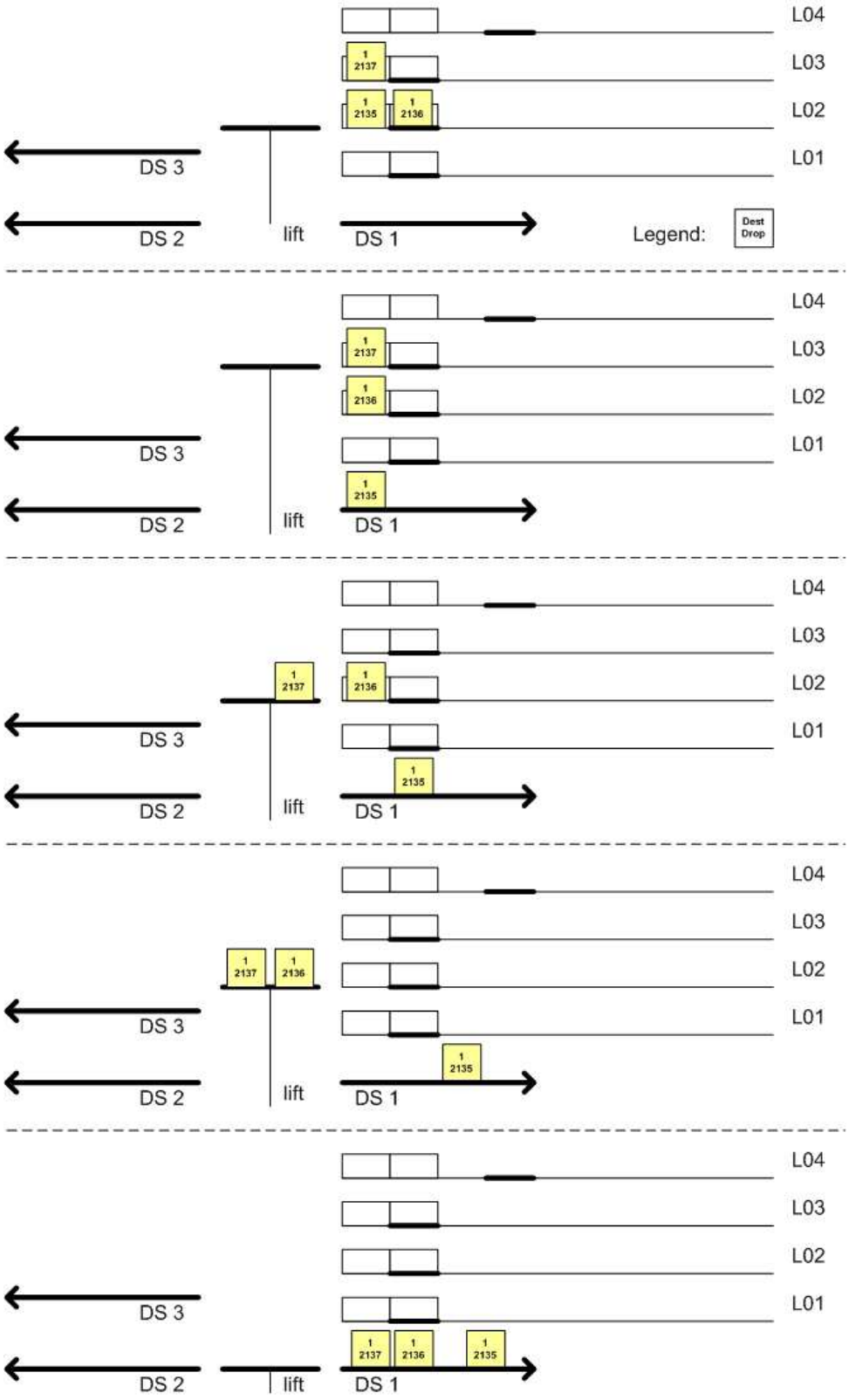
Example 1



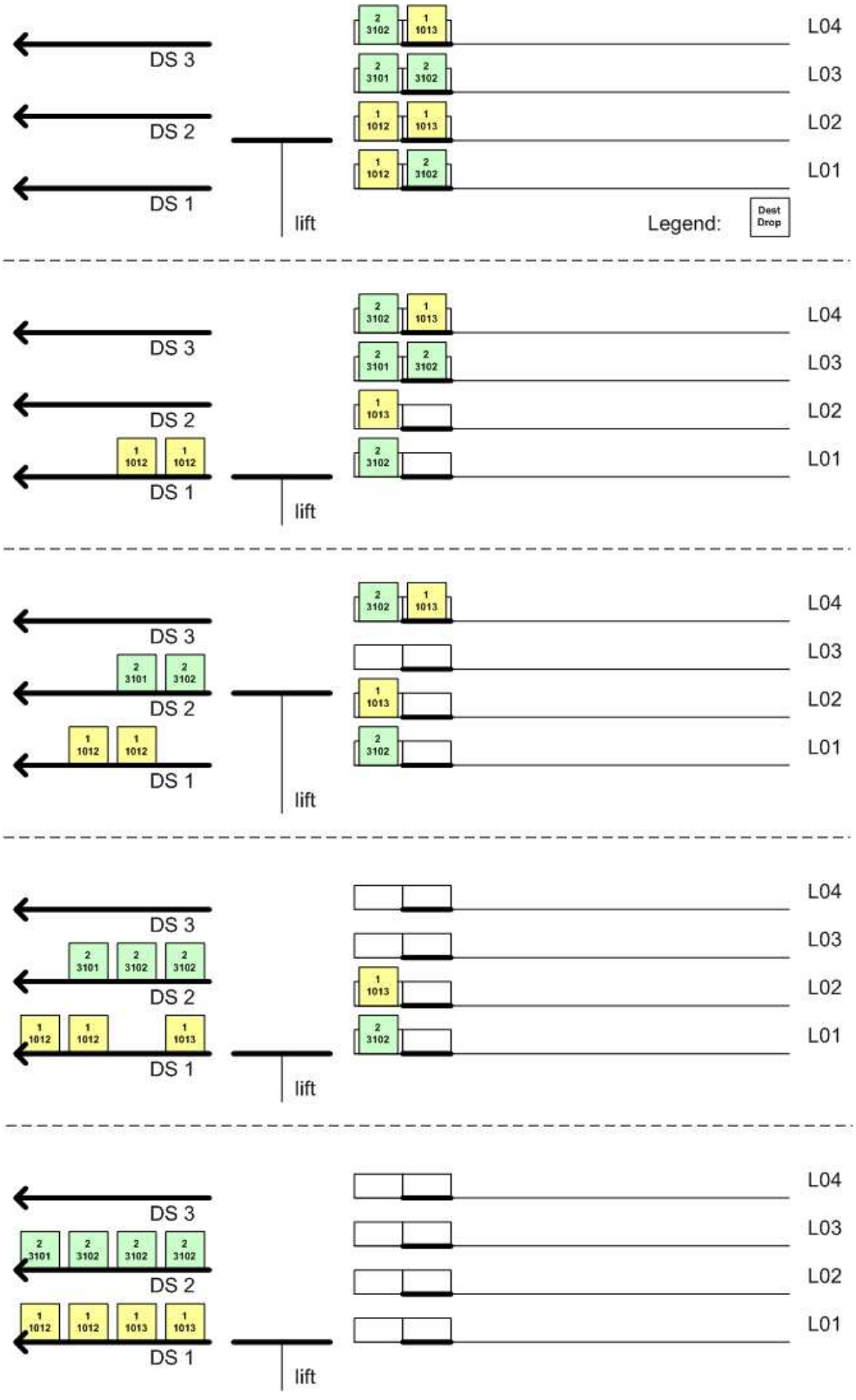
Example 2


L04
L03
L02
L01
DS 3
DS 2
lift
DS 1
Legend:
Dest
Drop
W
0
1
2137
1
2136
1
2135

Example 3


L04
L03
L02
L01
DS 3
DS 2
lift
DS 1
Legend:
Dest
Drop
1
2137
1
2135
1
2136

Example 4



3.11 Settings

The following settings (options) are provided:

Setting	Values	Description
PS empty notification	on / off	The WCS gets a notification message (TULL) that the Pick Station is empty.
DS occupied notification	on / off	The WCS gets a notification message (TURP and TULL) that the Drop Station is occupied.
Bin empty fault	0 .. 9	The operator can choose whether the stacker crane should stop with an error after a “Bin empty” is detected many times consecutively. It is reset on a success. If “0” is selected the stacker crane does not stop at an error. Otherwise it specifies the number of attempts.
Bin occupied fault	0 .. 9	The operator can choose whether the stacker crane should stop with an error after a “Bin occupied” is detected many times consecutively. It is reset on a success. If “0” is selected the stacker crane does not stop at an error. Otherwise it specifies the number of attempts.
Bin empty / occupied time out	x seconds	Determines the duration in seconds when a warning is sent to the local visualization system after a Bin empty or Bin occupied error.
Pairing according to destination level at the PS	on / off	This parameter switches on and off the preferable pairing of transport units according to destination level.
PS waiting time	0 .. 99	Waiting time at the PS in seconds for waiting for the second TU. If waiting time = "0", no waiting occurs.
LL at the PS	on / off	Parameter that switches on and off the departure of a TU from the PS through a "TUNO" message to the WCS.
LL at the rack conveyor	on / off	Parameter that switches on and off the departure of a TU from the rack conveyor through a "TUNO" message to the WCS.
LL at the bin	on / off	Parameter that switches on and off the departure of a TU from the storage bin by a TUNO message to the WCS.
Repeatable messages	on / off	If a request message is sent and no response could be received the sender is allowed to repeat his request every 30 seconds.

3.12 Notification points

In general the following notification points between WCS and MSC are allowed:

- Locations where MSC needs a decision from WCS
- Locations where WCS needs information (notifications and missions response) from MSC
- Locations where MSC is allowed to request a destination

For Multishuttle the following locations are defined as notification points:

Location	Situation
Pick Station	Normal operation
Drop Station	Normal operation
Lift	Anomaly handling
Rack conveyor infeed	Anomaly handling
Rack conveyor outfeed	Normal operation
Shuttle	Anomaly handling
Bins inside rack	Normal operation

3.13 Handling Flex Locations

A flex storage location being addressed by a (x|y) value and having width w_{bay} is subdivided into raster units (RU). A typical value is RU = 50mm.

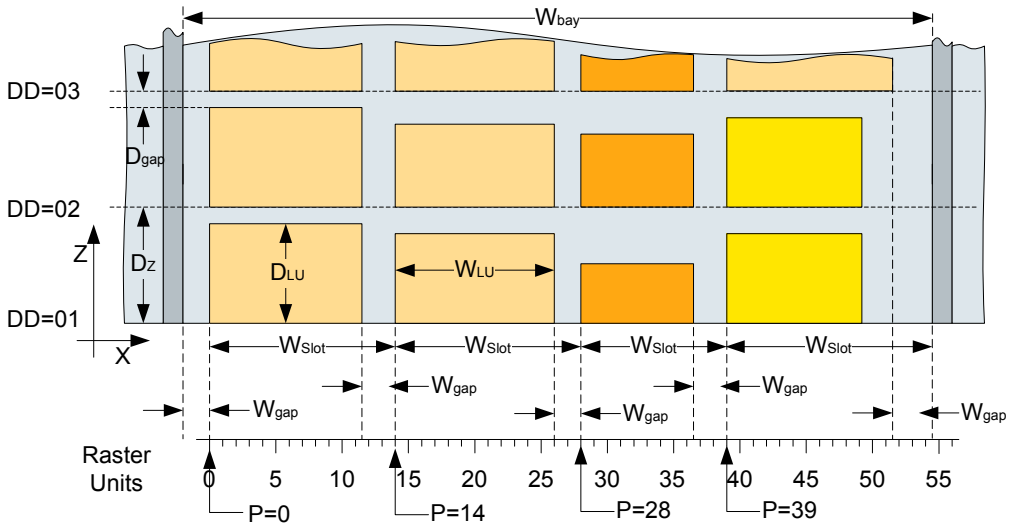
Raster units are used to place slots within the a storage bin. The left hand side of a slot indicates the position of a slot (e.g. P=14 indicates the position of the second slot in the picture below).

The slot width (wslot) is defined as the maximum width of all cases within the slots + a fixed value wgap for the gap necessary for the shuttle telescope. A typical value is wgap = 80 mm.

Slots are not tight to certain raster units but can dynamically be created or deleted. This approach is called dynamic slotting.

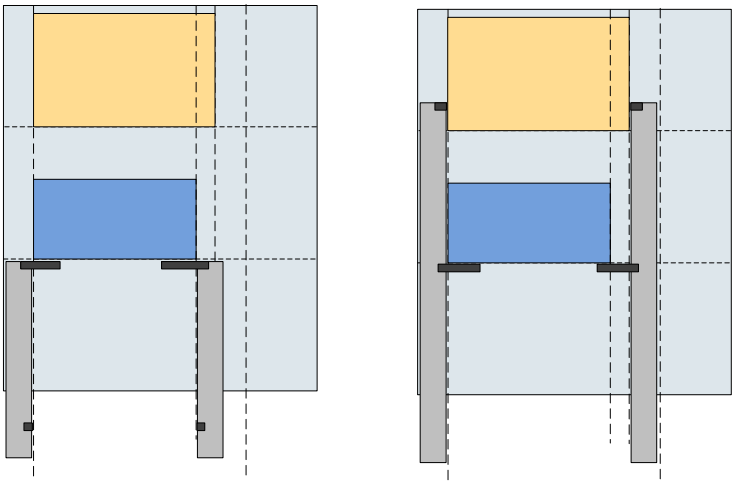
The depth of a bin is subdivided into concrete equally sized parts. The depth values are static, i.e. they do not change dynamically as the slot position. All slots share the same depth values.

The following picture shows the principle layout of a storage bin:



3.13.1 Telescope Optimization

For a mixed size slotting scenario, where a smaller case can be stored in front of a larger one (see picture), special care must be taken to avoid a collision of the telescope with the case in the back. Of course, it is always possible to move the telescope back and use the front fingers to push the case to its final position, but this "finger change" results in a performance degradation.



The two fields "{Source|Destination} Shuttle Extension" in the DCI transport telegram (see chap. 4) specify the extension of the shuttle axis for unrestricted extension of the telescope for both source and destination.

The shuttle extension has the following properties:

- The shuttle extension is always greater or equal the x-extension of the LoadUnit.
- The destination shuttle extension is always greater or equal the source shuttle extension, i.e. no contraction is possible. This is due to the dragon plates scales at the bottom of the shuttle.
- The maximum difference between source and destination extension is d_w = 80 mm

- Mission Telegrams (TUMI)

The extension specifies the telescope width which can safely be used by the PLC to extend the telescope, i.e. without risking a collision with a case.

- Mission Reply (TURP)

In the confirmation telegram the PLC reports back the actually used extension values. WCS stores this value in the corresponding slot entity for later use.

Note: If the case is grabbed with a bigger extension as it actual size it might shift during its travel. Due to this fact, the case must always be picked again with at least the same extension as it has been dropped.

3.13.2 Minimum Shuttle extension

The dragon-scale plates construction of a flex shuttle can only be shrinked upto a minimum extension of about 170 mm.

The WCS has to ensure that the shuttle extension value being sent in the fields “Source Shuttle Extension” and “Destination Shuttle Extension” (see chap. 4) is not smaller than this minimum value (configurable at the WCS side).If WCS sends a smaller value, MCS will generate a regular fault which is visualized in SCADA / GSMi). The operator has to remove the case and cancel the corresponding mission which implies the sending of a TUCA message.

This document only specifies aspects being specific to multishuttle systems. Please refer /2/ for description of the standard message interface for transport missions.

4 Messages

4.1 General format for messages belonging to transport units

Note: For the common part of the message body please refer to document /2/.

Byte	Name	Type	Length	Description
29-118				Common part (see /2/).
119-122	Drop index	N	4	Sequence of the retrieval relative to the drop station. The value is "0" if no sequence is necessary.
123-126	Shuttle dynamics	N	4	Max. dynamics of shuttle in %. "0100" = 100%, maximum speed (default value)
127-130	Lift dynamics	N	4	Max. dynamics of lift in %. "0100" = 100%, maximum speed (default value)
131-134	Source Shuttle Extension	N	4	Due to the need to handle mixed Slots this parameter defines the flex axis extension which the shuttle can use at the source location to fully extend the telescopes and use any fingers for Load Unit handling. If the shuttle has the capability and time to do so, it may also use front fingers for handling and use a narrower flex axis. The minimum flex axis extension is the "TU Length". In confirmation messages the PLC shall set this parameter to the actually used values. The parameter is always equal or larger than "TU-length".
135-138	Destination Shuttle Extension	N	4	Due to the need to handle mixed Slots this parameter defines the flex axis extension which the shuttle can use at the destination location to fully extend the telescopes and use any fingers for Load Unit handling. If the shuttle has the capability and time to do so, it may also use front fingers for handling and use a narrower flex axis. The minimum flex axis extension is the "TU Length". In confirmation messages the PLC shall set this parameter to the actually used values. The parameter is always equal or larger than "TU-length". Destination Shuttle Extension is always equal or larger than Source Shuttle Extension.

The name of messages belonging to a transport unit starts with “TU”.

Legend:

	Common part for all subsystems
	Specific part for MSC

4.2 Status Message <STAT>

This message is used to inform the WCS about the availability of the Multishuttle devices. All devices are structured in a hierarchy scheme as shown. Only the highest hierarchy level is reported.

Device tree			Description
Aisle			Aisle group is sent if an event changes the state of the complete aisle. Aisle group includes all lifts, all levels with its shuttles, infeed and outfeed rack conveyors.
	Lift		Lift is sent if an event changes its state.
	Pick Station		Pick Station is sent if an event changes its state.
	Drop Station		Drop Station is sent if an event changes its state.
	Level		Level group is sent if an event changes the state of the complete level. Level group includes shuttle, infeed and outfeed rack conveyor.
		Shuttle	Status information of shuttle only.
		Infeed	Status information of infeed rack conveyor only.
		Outfeed	Status information of outfeed rack conveyor only.

The hierarchy structure is used to minimise the amount of messages sent for each type of status change event; some events will change the status of several function groups, to send an individual message for each of the function groups that have changed status is time consuming and also in some systems a considerable amount of messages.

The WCS system has to know the following information to enable it to process the status messages correctly:

- Which location names are assigned to each individual system element. I.e. names assigned for infeed rack conveyors, outfeed rack conveyors, lifts.
- Which function group names are within each aisle.
- Which rack conveyors are served by which lift.

- Which function groups are within each level.

With this information the WCS can determine from a single status message exactly what system elements are affected and react accordingly.

The device that the MSC sends the status message for will depend on the event that caused the status change:

- If the access door to a lift is opened, the MSC will only send the status message for the aisle, the WCS knows that as the aisle is unavailable, all of the equipment within that aisle is also unavailable.
- If a fault condition is generated on an lift, the MSC will only send a status message for the lift that is unavailable, the WCS knows that as the elevator is unavailable the infeed rack conveyors that are served by this lift are currently unreachable, and that the outfeed rack conveyors will soon become fully accumulated and therefore retrieval missions will no longer be processed by the shuttles.
- If an access door to a maintenance level is opened, the MSC will send status messages for all levels belonging to this maintenance level that is unavailable. The WCS knows that the shuttles within this maintenance group are no longer available for use.
- If a fault condition is generated on a shuttle the MSC will only send a status message for the individual shuttle that is unavailable.
- If an emergency stop is tripped the MSC will send status messages for all of the aisles that are affected by the emergency stop.
- If the safety circuit of a lift is tripped the MSC only sends a status message for the affected lift.
- If the safety circuit for an aisle is tripped the MSC only sends a status message for the affected aisle.

Although the availability of all affected elements will change due to a higher hierarchy level status change, the MSC will suppress the sending of the lower level messages. E.g. all function group availability will be affected by the change of state of an aisle but only the aisle message would be sent.

Generally the MSC always tries to suppress status messages by clustering devices to the highest possible level. This is done too if faults are gone and the device is available again.

Status messages are sent by the MSC on occurrence or due to a request.

Byte	Name	Type	Length	Description
29-42	Device identifier	A	14	Identifier of device. The device names are following the specified naming convention for locations. Possible devices could be: Entire aisle, Pick station, Drop station, Stacker crane machine or components of them
43-44	Availability status	A	2	Operation mode and fault state: "AU" = Automatic mode without any fault. Device is available. "MA" = Manual mode without any fault "FL" = Short term fault "OF" = Long term not available (off or long term fault) ".." = No operation mode

In addition to the physical objects which can be faulty, there is a set of “special” objects, which can hinder production if they are not in a healthy state. Their status is also reported via a STAT telegram:

Name	Function	Impact
MSAI<*xx*>ESTOP	When any emergency stop is pressed this objects status will change to FL. An error code is also reported (STAX message sent).	The whole aisle is inoperable.
MSAI<*xx*>PROFIBUS	The health of the Profibus network is continually monitored. If any problems are detected the status of this object changes to FL. An appropriate error code is also reported via STAX message.	The whole aisle is inoperable.
MSAI<*xx*>ASI	The health of the Asi networks are continually monitored. If any problems are detected the status of this object changes to FL. An appropriate error code is also reported via STAX message.	The amount of aisle functionality depends on which Asi node is faulty.

Name	Function	Impact
MSAI<*xx*>SYSTEM	Where applicable inputs from the fire warning system and Air Pressure healthy inputs can be monitored. If configured these items can cause the system object to report a change in status. An error code is also reported (STAX message sent).	Depends on individual site requirements.
MSAI<*xx*>WCS	If an error in communication with the WCS is detected the status of this object changes to FL An error code is also reported (STAX message sent).	System remains operational – but will not receive any new commands from WCS.
MSAI<*xx*>MLxx	If for any reason the maintenance level becomes Inoperable the status of this object changes to FL. Included in this group are the gate, PSU temperature monitoring and circuit breakers. An error code is also reported (STAX message sent).	The individual maintenance level is inoperable.

For each maintenance level there exists a maintenance level object.

The MSAIxxWCS is to allow local status reporting on HMI.

4.3 Extended Status Message <STAX>

This message is used to report detailed status information about the availability of PLC devices. In contrast to the STAT message (see TODO), the STAX message is not intended to control the material flow, but is for visualization purposes (SCADA) only.

The STAX message is sent unsolicited by the PLC whenever the status of a device changes.

In addition to that, it is sent upon request by the WCS (e.g. due to a STRQ telegram with device identifier ALL, see /2/). In this context, the STAX telegrams are sent after the STAT but before the STEN.

To be completely independent of the STAT telegram, a STAX with 'Fault Code' 0 is sent, when the fault has been reset.

This message is optional.

Byte	Name	Type	Length	Description
29-42	Device Identifier	A	14	Identifier of device. The device names are following the specified naming convention for locations. Extended status message are always sent for concrete locations (i.e. not for virtual locations).
43-48	Fault Code	N	6	Fault code of the device identifying the current fault of the device
49-50	Classification	A	2	The priority of the fault • ER: Error • WA: Warning • IN: Info
51-52	Text Version Counter	N	2	The text version counter (01-99) is increased whenever a new version of the message text is available within the PLC. WCS can use this to request new versions of the text by sending a FTRQ telegram.
53-74	TUID	A	22	Barcode currently held by this device ?????????????????????? – if no load present
75-70	ABS X Pos	N	6	Holds the X axis position in mm if this STAX relates to a shuttle. 000000 – if this STAX is not from a Shuttle
81-86	ABS Y Pos	N	6	Holds the vertical height of the lift in mm if this STAX relates to a lift / lift conveyor 000000 – if this STAX is not from a lift / lift conveyor

Byte	Name	Type	Length	Description
87-92	ABS Z Pos	N	6	Holds the LHD position in mm if this STAX relates to a shuttle. This value can range from -09999 to +09999 000000 – if this STAX is not from a Shuttle

A device can be reset by sending a SETD telegram using the ‘Forced Status’ = ‘ON’ (see /2/ for further details).

5 Use Cases

The following pages give an overview about typical operation procedures which might happen in an MSC System.

Each operation is illustrated by an image which shows the physical situation and the corresponding Message sequence diagram.

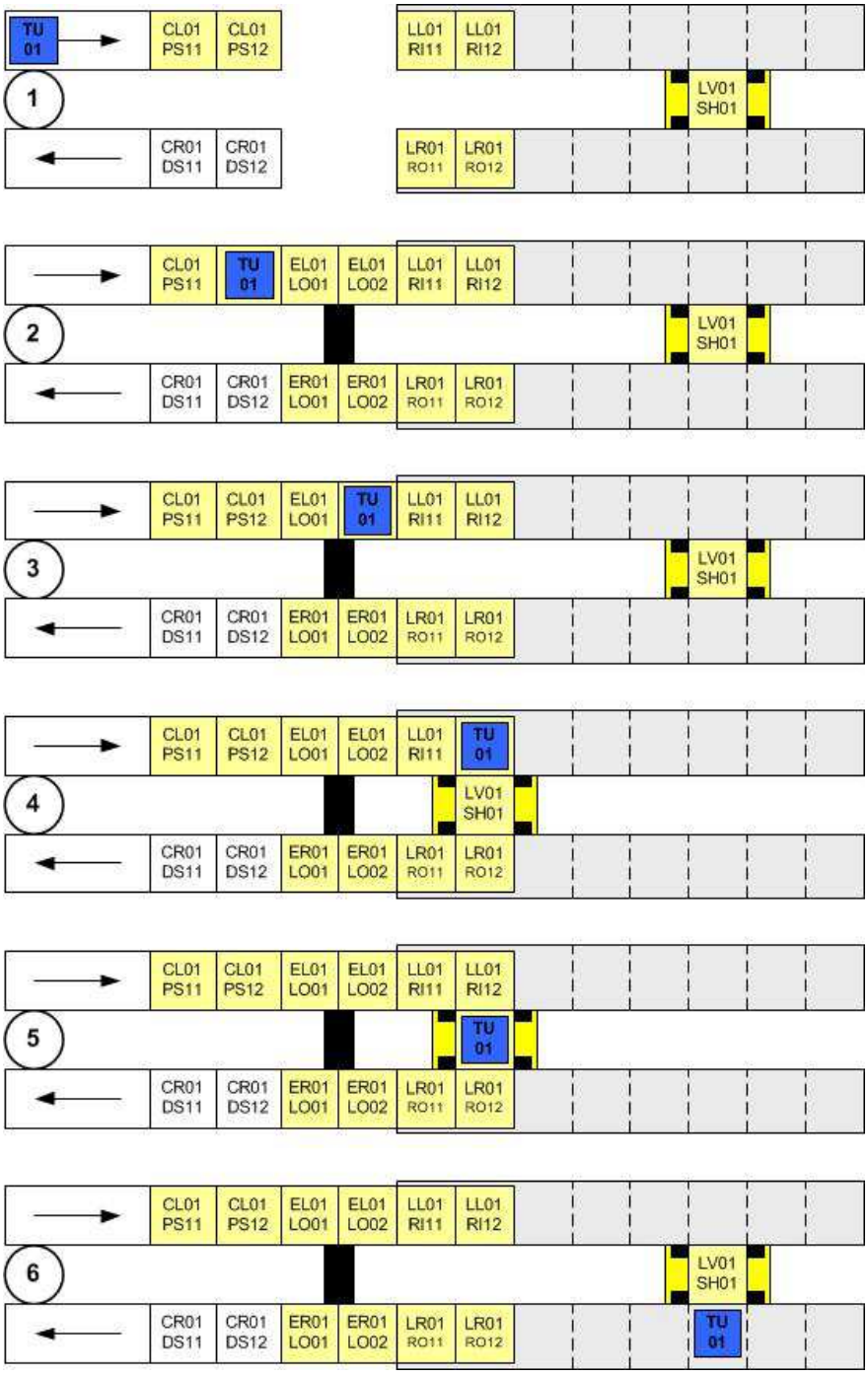
The Use Cases are divided into two classes:

- Normal operations which describes sunny cases
- Anomaly operations which describes the error handling

5.1 Normal operations

5.1.1 Storage – Scenario 1

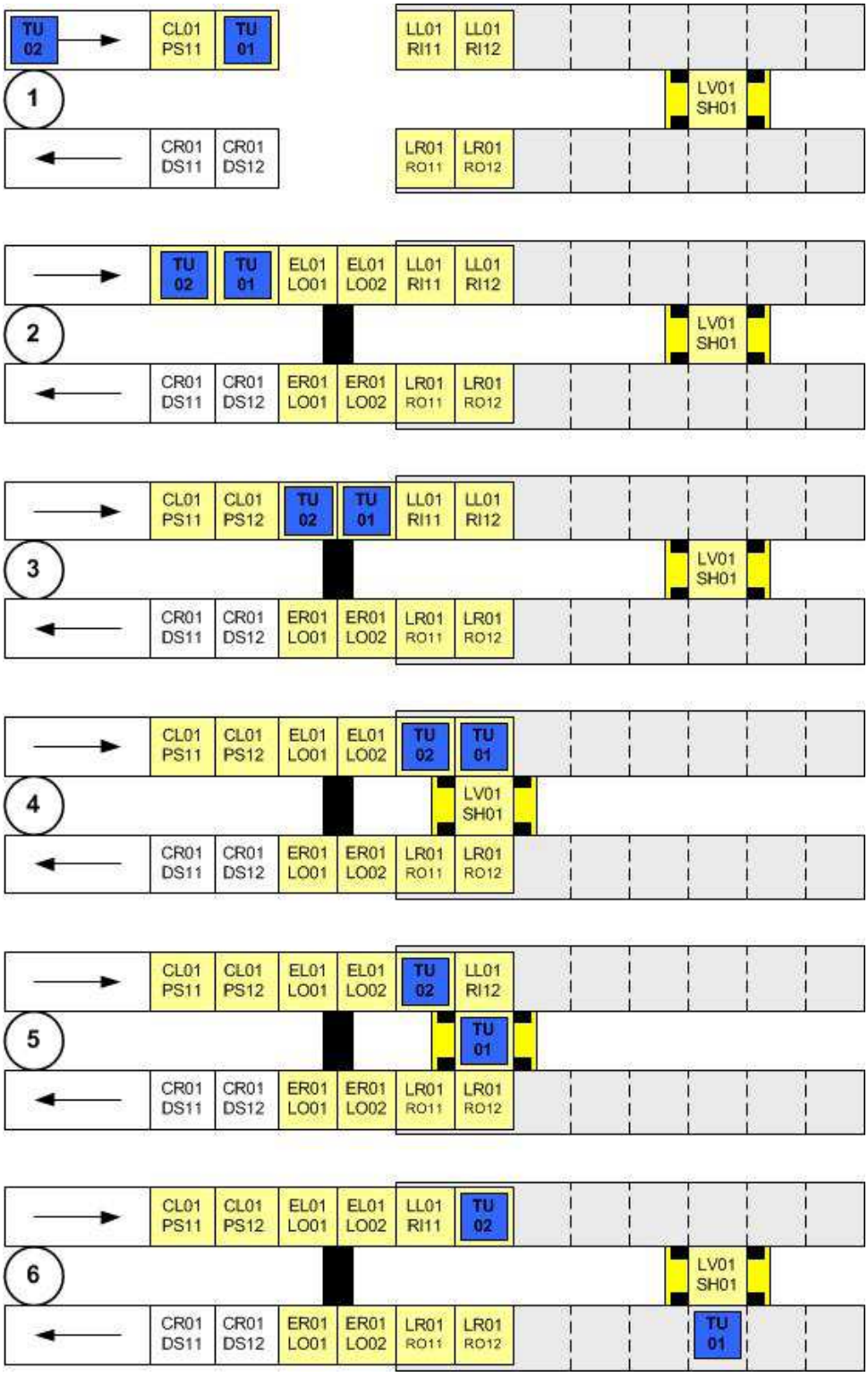
Simple storage mission for a Multishuttle Systems is shown.



#	WCS	MSC	CCS
1.1	Transport Mission Msg: **TUMI** CLoc: **CC xxxx xxx** DLoc: **MS AI01 CL01 PS10** TUID: **TU01**	→	→
1.2			Store mission or update TU destination and move TU to aisle.
2.1	←	Arrival Message Msg: **TURP** CLoc: **MS AI01 CL01 PS10** DLoc: **MS AI01 CL01 PS10** TUID: **TU01**	
		The arrival message could also be sent by the CCS.	
3.1	Find storage location		
3.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 CL01 PS10** DLoc: **MS 01 2 004 01 01** TUID: **TU01**	→	
3.3		Update TU destination and move lift to PS. After that move TU onto lift conveyor.	
4.1	←	Arrival Message (optional) Msg: **TUNO** CLoc: **MS AI01 EL01 LO00** DLoc: **MS 01 2 004 01 01** TUID: **TU01**	
4.2	Update TU location and recalculation of infeed line capacity.	Move lift to specified level and drop TU onto rack conveyor. Shuttle picks up TU from last rack conveyor location.	
5.1	←	Arrival Message (optional) Msg: **TUNO** CLoc: **MS AI01 LV01 SH01** DLoc: **MS 01 2 004 01 01** TUID: **TU01**	
5.2	Update TU location and recalculation of infeed line capacity.	Shuttle moves to destination and drops TU into bin location.	
6.1	←	Arrival Message Msg: **TURP** CLoc: **MS 01 2 004 01 01** DLoc: **MS 01 2 004 01 01** TUID: **TU01**	
6.2	Update warehouse.		

5.1.2 Storage – Scenario 2

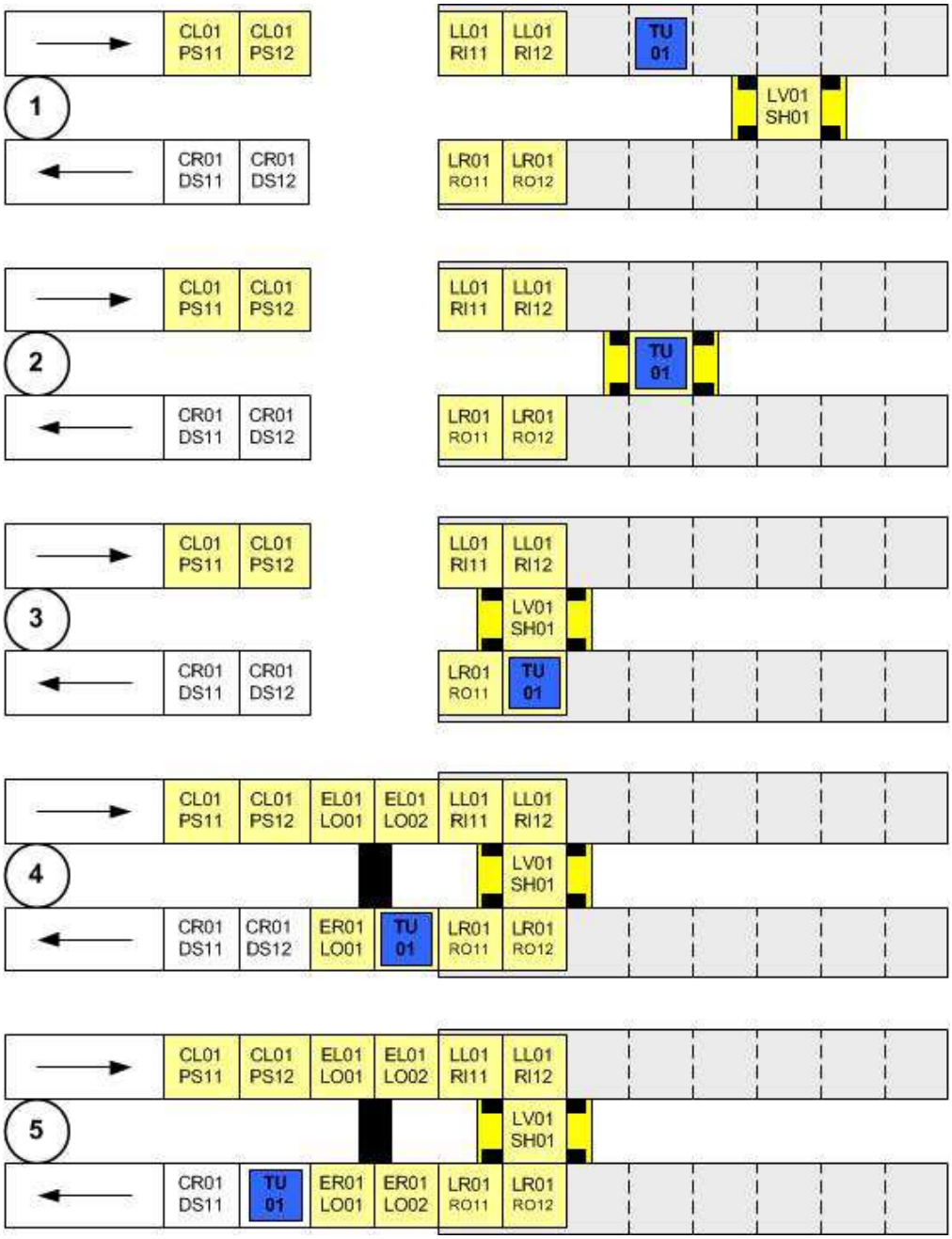
Two TU's are combined at PS and moved simultaneously onto the lift conveyors.


TU 02
CL01 PS11
TU 01
LL01 RI11
LL01 RI12
LV01 SH01
1
CR01 DS11
CR01 DS12
LR01 RO11
LR01 RO12
TU 02
TU 01
EL01 LO01
EL01 LO02
LL01 RI11
LL01 RI12
LV01 SH01
2
CR01 DS11
CR01 DS12
ER01 LO01
ER01 LO02
LR01 RO11
LR01 RO12
CL01 PS11
CL01 PS12
TU 02
TU 01
LL01 RI11
LL01 RI12
LV01 SH01
3
CR01 DS11
CR01 DS12
ER01 LO01
ER01 LO02
LR01 RO11
LR01 RO12
CL01 PS11
CL01 PS12
EL01 LO01
EL01 LO02
TU 02
TU 01
LV01 SH01
4
CR01 DS11
CR01 DS12
ER01 LO01
ER01 LO02
LR01 RO11
LR01 RO12
CL01 PS11
CL01 PS12
EL01 LO01
EL01 LO02
TU 02
LL01 RI12
TU 01
5
CR01 DS11
CR01 DS12
ER01 LO01
ER01 LO02
LR01 RO11
LR01 RO12
CL01 PS11
CL01 PS12
EL01 LO01
EL01 LO02
LL01 RI11
TU 02
LV01 SH01
6
CR01 DS11
CR01 DS12
ER01 LO01
ER01 LO02
LR01 RO11
LR01 RO12
TU 01

#	WCS	MSC	CCS
1.1	←	Arrival Message (blocked) Msg: **TURP** CLoc: **MS AI01 CL01 PS10** DLoc: **MS AI01 CL01PS10** TUID: **TU01** --- Msg: **TURP** CLoc: **MS AI01 CL01PS10** DLoc: **MS AI01 CL01PS10** TUID: **TU02**	
2.1	Find storage location.		
2.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 CL01PS10** DLoc: **MS 01 2 004 01 01** TUID: **TU01** --- Msg: **TUMI** CLoc: **MS AI01 CL01PS10** DLoc: **MS 01 1 004 01 01** TUID: **TU02**	→	
2.3		Update TU destinations and move lift to PS.	
3.1		Move both TUs onto lift conveyor.	
3.2	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 EL01 LO00** DLoc: **MS 01 2 004 01 01** TUID: **TU01**	
3.3	Update TU location and recalculation of infeed line capacity.		
3.3	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 EL01 LO00** DLoc: **MS 01 1 004 01 01** TUID: **TU02**	
3.4	Update TU location and recalculation of infeed line capacity.		
4.1		Move lift to specified level and drop both TUs onto rack conveyor. Shuttle picks up first TU from rack conveyor location.	
4.2		Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 LV01 SH01** DLoc: **MS 01 2 004 01 01** TUID: **TU01**	
5.1		Shuttle moves to destination and drops TU into bin location.	
5.2	←	Arrival Message Msg: **TURP** CLoc: **MS 01 2 004 01 01** DLoc: **MS 01 2 004 01 01** TUID: **TU01**	
6		Same procedure for second TU.	

5.1.3 Retrieval – Scenario 1

Simple retrieval order for a Multishuttle Systems is shown.



Note: In this first retrieval example the CCS message is included to describe the full process. In the other retrieval examples this message is omitted.

Option 1: One mission without sequencing scenario

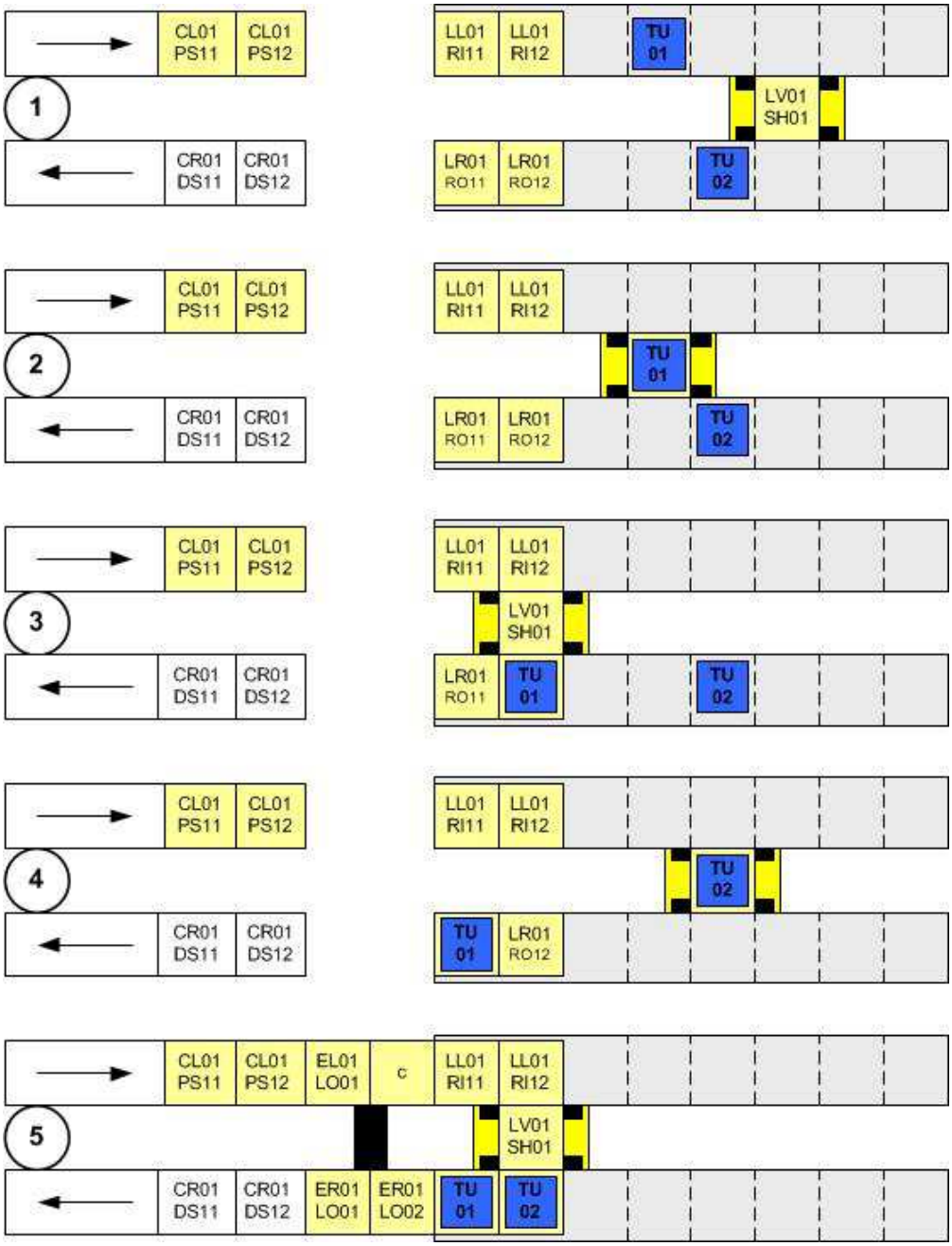
#	WCS	MSC	CCS
1.2	Transport Mission Msg: **TUMI** CLoc: **MS 01 1 002 01 01** DLoc: **MS AI01 CR01 DS10** TUID: **TU01**	→	
1.2		Store TU mission, move shuttle to bin location and pick it up.	
2.1	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 LV01 SH01** DLoc: **MS AI01 CR01 DS10** TUID: **TU01**	
2.2	Update TU location. and warehouse locations.	Shuttle moves to rack conveyor and drops TU.	
2.3	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 LR01 RO10** DLoc: **MS AI01 CR01DS10** TUID: **TU01**	
3.1	Update TU location.	Lift moves to source position. After that TU moves onto lift conveyor.	
3.2	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 ER01 LO00** DLoc: **MS AI01 CR01DS10** TUID: **TU01**	
4.1	Update TU location and recalculate rack conveyor capacity.	Lift moves to destination position. After that TU moves onto DS conveyor.	Handover TU and TUID via digital handshake. ↔
4.2	←	Arrival Message Msg: **TURP** CLoc: **MS AI01 CR01 DS10** DLoc: **MS AI01 CR01 DS10** TUID: **TU01**	
5.1	Update TU location and search for further CCS destination.		
5.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 CR01 DS10** DLoc: **MS …. ….** TUID: **TU01**	→	→
5.3			Update TU mission, move TU towards its destination.

Option 2: Two mission with sequencing scenario

#	WCS	MSC	CCS
1.2	Transport Mission Msg: **TUMI** CLoc: **MS 01 1 002 01 01** DLoc: **MS AI01 LR01 RO10** TUID: **TU01** →		
1.2		Store TU mission, move shuttle to bin location and pick it up.	
2.1	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 LV01 SH01** DLoc: **MS AI01 LR01 RO10** TUID: **TU01**	
2.2	Update TU location. and warehouse locations.	Shuttle moves to rack conveyor and drops TU.	
2.3	←	Arrival Message Msg: **TURP** CLoc: **MS AI01 LR01 RO10** DLoc: **MS AI01 LR01 RO10** TUID: **TU01**	
3.1	Update TU location and search for further destination. Determine drop index.	TU moves infront of lift. No request to lift.	
3.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 LR01 RO10** DLoc: **MS AI01 CR01 DS10** TUID: **TU01** Drop: **0001** →		
3.3		Update new TU destination and request lift according to drop index.	
4.1		Lift moves into position. After that TU moves onto lift conveyor.	
3.2	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 ER01 LO00** DLoc: **MS AI01 CR01 DS10** TUID: **TU01** Drop: **0001**	
4.1	Update TU location and recalculate rack conveyor capacity.	Lift moves to destination position. After that TU moves onto DS conveyor.	Handover TU and TUID via digital handshake. ↔
4.2	←	Arrival Message Msg: **TURP** CLoc: **MS AI01 CR01 DS10** DLoc: **MS AI01 CR01 DS10** TUID: **TU01**	

5.1.4 Retrieval – Scenario 2

Two retrieval missions with sequenced totes for a Multishuttle Systems are shown.



#	WCS	MSC	CCS
1.2	Transport Mission Msg: **TUMI** CLoc: **MS 01 1 002 01 01** DLoc: **MS AI01 LR01 RO10** TUID: **TU01** →		
1.2		Store TU mission, move shuttle to bin location and pick it up.	
2.1	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 LV01 SH01** DLoc: **MS AI01 LR01 RO10** TUID: **TU01**	
2.2	Update TU location. and warehouse locations.	Shuttle moves to rack conveyor and drops TU.	
3.1	Transport Mission Msg: **TUMI** CLoc: **MS 01 2 003 01 01** DLoc: **MS AI01 LR01 RO10** TUID: **TU02** →		
3.2		Store TU mission.	
4.1		Shuttle moves to rack conveyor and drops TU.	
4.2	←	Arrival Message Msg: **TURP** CLoc: **MS AI01 LR01 RO10** DLoc: **MS AI01 LR01 RO10** TUID: **TU01**	
4.3	Update TU location. Wait for second TU.	TU moves infront of lift. No request to lift.	
5.1		Meanwhile shuttle moves to second bin location (TU02) and picks it up.	
5.2	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 LV01 SH01** DLoc: **MS AI01 LR01 RO10** TUID: **TU02**	
5.3	Update TU location. and warehouse locations.		
6.1		Shuttle moves to rack conveyor and drops TU.	
6.2	←	Arrival Message Msg: **TURP** CLoc: **MS AI01 LR01RO10** DLoc: **MS AI01 LR01 RO10** TUID: **TU02**	
7.1	Update TU location and search for further destination. Determine drop index.		
7.2	Transport Mission (blocked) Msg: **TUMI** CLoc: **MS AI01 LR01 RO10** DLoc: **MS AI01 CR01 DS10** TUID: **TU01** Drop: **0001** --- Msg: **TUMI** CLoc: **MS AI01 LR01 RO10** DLoc: **MS AI01 CR01 DS10** TUID: **TU02** Drop: **0002** →		

#	WCS	MSC	CCS
7.3		Update new TU destination and request lift according to drop index.	
7.4		Lift moves into position. After that both TU moves onto lift conveyor.	

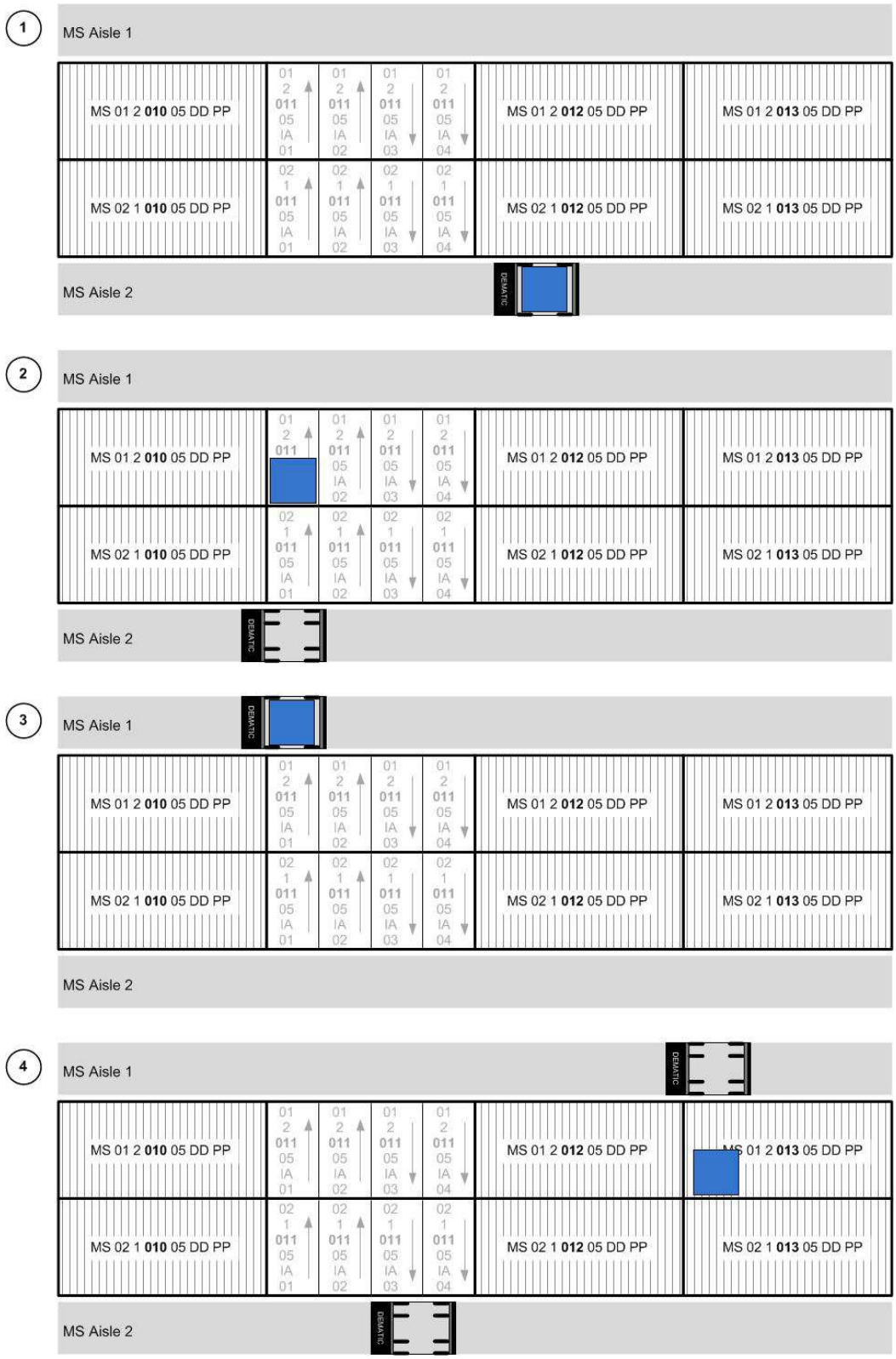
5.1.5 Shuffle order

#	WCS	MSC	CCS
1.2	Transport Mission Msg: **TUMI** CLoc: **MS 01 1 002 01 01** DLoc: **MS 01 1 012 01 01** TUID: **TU01** →		
1.2		Store TU mission, move shuttle to bin location and pick it up.	
2.1	←	Notification Message (optional) Msg: **TUNO** CLoc: **MS AI01 LV01 SH01** DLoc: **MS 01 1 012 01 01** TUID: **TU01**	
2.2	Update TU location. and warehouse locations.	Shuttle moves to destination bin drops TU into it.	
3.1	←	Arrival Message Msg: **TURP** CLoc: **MS 01 1 012 01 01** DLoc: **MS 01 1 012 01 01** TUID: **TU01**	
4.3	Update TU location. and warehouse locations.		

5.1.6 Pass-through at Pick Station

#	WCS	MSC	CCS
1.1			A TU arrives at the pick station.
1.2		←	Arrival Message Msg: **TURP** CLoc: **MS AI01 CL01 PS10** DLoc: **MS AI01 CL01 PS10** TUID: **TU01**
1.3	Update TU location.		
2.1	Out of any reason WCS cannot determine a destination bin in the aisle.		
2.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 CL01 PS10** DLoc: **MS AI01 CR01 DS10** TUID: **TU01**	→	
2.3		Store TU mission.	
3.1		Determine level and move TU in direction to drop station. Drop TU on drop station.	
3.2	←	Arrival Message Msg: **TURP** CLoc: **MS AI01 CR01 DS10** DLoc: **MS AI01 CR01 DS10** TUID: **TU01**	
4.1	Update TU location and search for further destination.		

5.1.7 Inter-Aisle-Transfer (iAT)



#	WCS	Multishuttle
1.1	Create transport mission for shuttle in aisle #2 to pick up case from pick station.	
	Transport Mission Msg: **TUMI** SLoc: **CCRE01IS01** CLoc: **MS AI02 CL01 PS10** DLoc: **MS 01 2 011 05 IA 01** TUID: **123450000000000** Event: **OK**	→
1.2		Shuttle in aisle #2 picks case from pick station and moves to the specified IAT lane.
1.3	←	Notification Message Msg: **TUNO** SLoc: **CCRE01IS01** CLoc: **MS AI01 LV05 SH01** DLoc: **MS 01 2 013 05 02 03** TUID: **123450000000000** Event: **OK**
2.1		Shuttle drops case through to aisle #1.
	←	Arrival Message Msg: **TURP** SLoc: **CCRE01IS01** CLoc: **MS 01 2 011 05 IA 01** DLoc: **MS 01 2 011 05 IA 01** TUID: **123450000000000** Event: **OK**
2.2	Create transport mission for shuttle in aisle #1 to pick up case from IAT lane.	
	Transport Mission Msg: **TUMI** SLoc: **CCRE01IS01** CLoc: **MS 01 2 011 05 IA 01** DLoc: **MS 01 2 013 05 02 03** TUID: **123450000000000** Event: **OK**	→
3.1		Shuttle in aisle #1 picks case from IAT lane.
	←	Notification Message Msg: **TUNO** SLoc: **CCRE01IS01** CLoc: **MS AI01 LV05 SH01** DLoc: **MS 01 2 013 05 02 03** TUID: **123450000000000** Event: **OK**
4.1		Shuttle in aisle #1 drops case into the specified bin location.
	←	Arrvial Message Msg: **TURP** SLoc: **……..** CLoc: **MS 01 2 013 05 02 03** DLoc: **MS 01 2 013 05 02 03** TUID: **1234500000000000** Event: **OK**
4.2	Update case location.	

Note: To minimize handover time the rack structure must be designed in this way that the IAT locations on both sides of the aisle are on exactly the same x-position. This allows the shuttle to do the handover from one aisle to the other aisle without any travel movement.

Note: The WCS controls the occupation of the iAT-locations. No further mission will be sent to an iAT-location until it gets freed by the opposite shuttle.

Note: The PLC is responsible to avoid shuttle telescope collisions during pick- and drop operations carried out simultaneously. Furthermore the PLC has to prevent deadlock situations if an IAT location is used bidirectional.

5.2 Anomaly operations

5.2.1 General Principles

Fundamentals

Malfunctions (short and long-term malfunctions) are always compiled and reported by the MSC to the WCS via STAT.

Transport orders are not automatically canceled; the MSC waits for manual correction by the operator. In this case the transport order in question can be manually canceled.

Malfunctions that cannot be corrected by the worker in a short period of time can be declared within the MSC as long-term malfunctions. In this case the MSC automatically sends cancellations (i.e. EventCode != "OK") for the affected transport orders.

Scheduled locks are uncoupled from malfunctions and set on the WMS.

Short-term malfunctions

The following short-time malfunctions of the MSC are reported to the WCS:

- Rack conveyor infeed
- Rack conveyor outfeed
- PS
- DS
- Level or shuttle
- Lift

Long-term locks

Long-term locks are generally set and visualized on the MSC via the central visualization (SCADA).

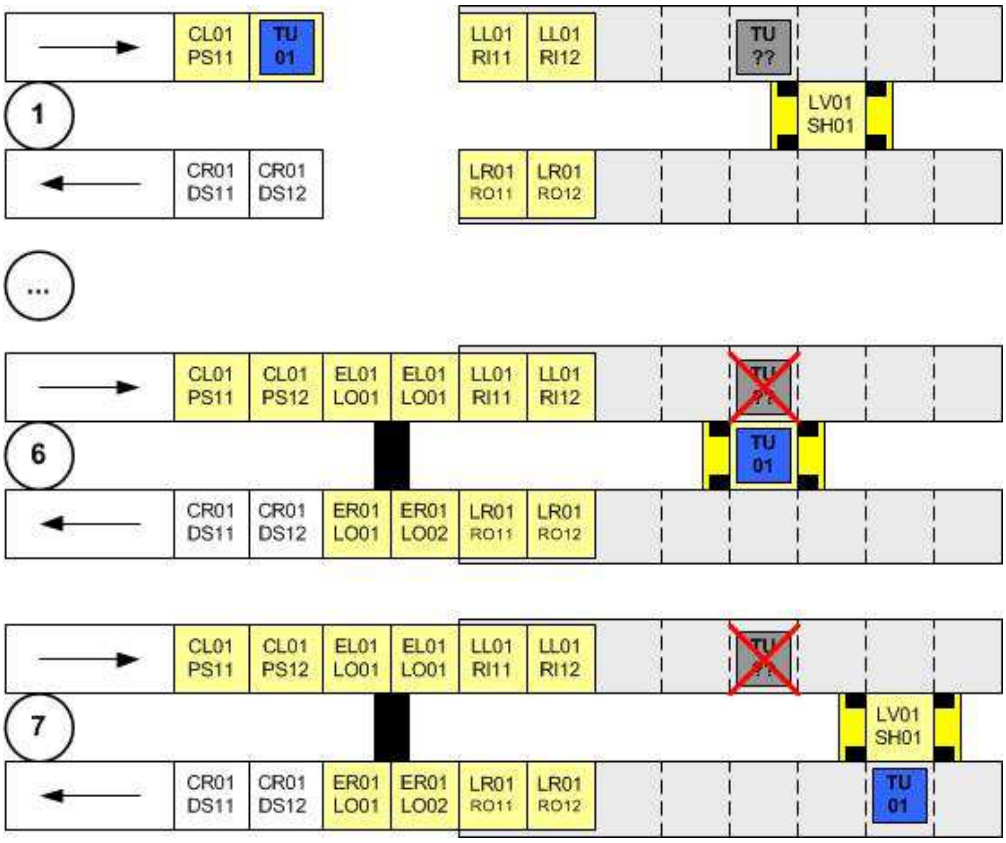
Scheduled locks

Scheduled locks are set and displayed within the WCS.

5.2.2 Bin occupied / Destination not Reachable

TU has to be stored but bin location is unexpected occupied.

In an multi-deep scenario: a TU in front of the destination location is unexpectedly blocking the drop of the TU.



#	WCS	MSC	CCS
1.1	Transport Mission Msg: **TUMI** CLoc: **MS AI01 CL01 PS10** DLoc: **MS 01 1 003 01 01** TUID: **TU01**	→	
1.2		Update TU destination and move TU to shuttle via lich and rack conveyor.	
2.1		Shuttle moves to bin location which is detected as full.	
2.2	←	Exception Message Msg: **TUEX** CLoc: **MS AI01 LV01 SH01** DLoc: **MS 01 1 012 01 01** TUID: **TU01** EventCode: **BO** (bin occupied) resp **DN** (destination not reachable)	
3.1	Lock bin and search for new destination.		
4.1	Transport Mission Msg: **TUMI** CLoc: **MS AI01 LV01 SH01** DLoc: **MS 01 1 013 01 01** TUID: **TU01**	→	
4.2		Update destination and release shuttle.	
5.1		Move shuttle to new storage location and drop TU.	
5.2	←	Arrival Message Msg: **TURP** CLoc: **MS 01 1 013 01 01** DLoc: **MS 01 1 013 01 01** TUID: **TU01**	
5.3	Update TU location. and warehouse locations.		

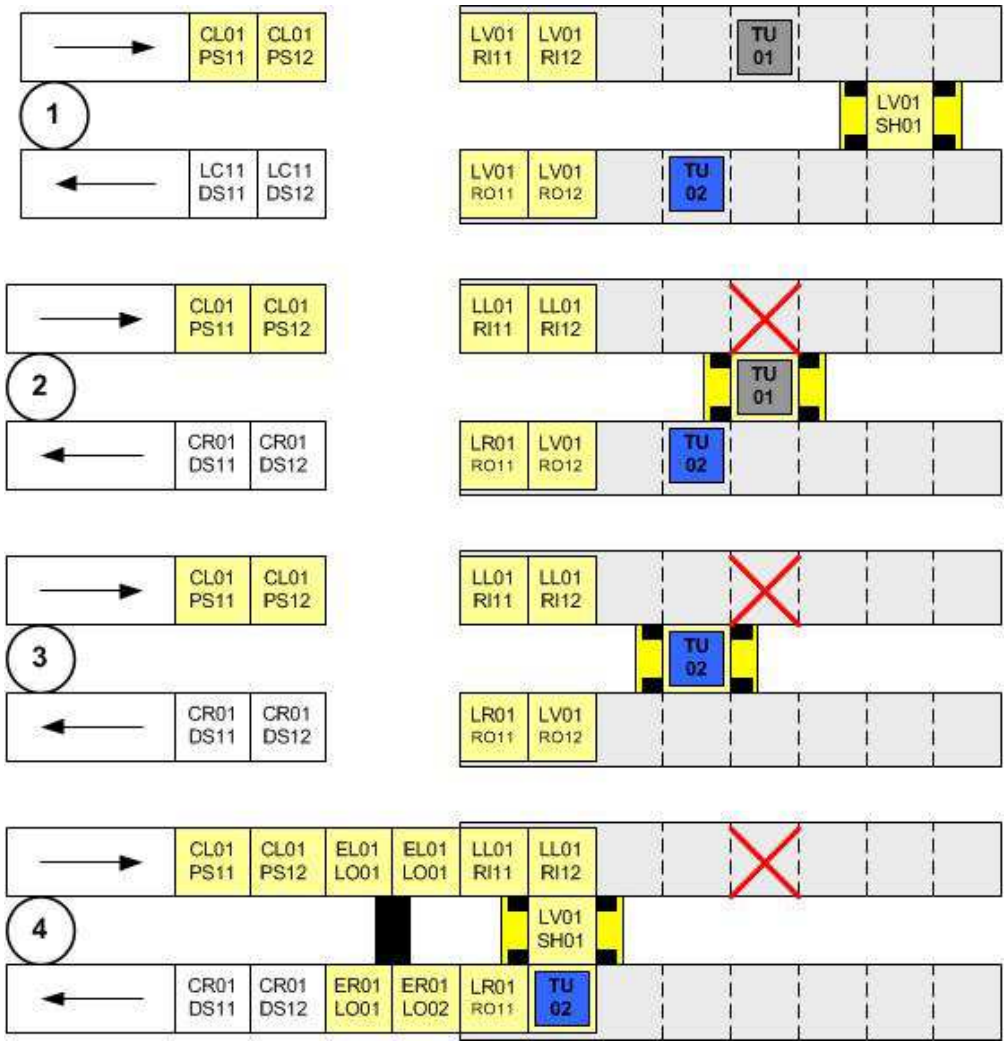
INFO In case of a iAT location no TUEX:BO can be sent. Since the case needs to be pushed with the front fingers onto to iAT-Location, the sensors on the telescope cannot see any occupation of the destination. If the movement fails, a logical fault will be generated and visualized in the SCADA system.

After the fault having been cleared by an associate the transport will continue to its original destination. Alternatively, the mission can be canceled at PLC level. A TUCA telegram will be sent.

5.2.3 Bin empty / Source not Reachable

Bin empty scenario during retrieval operation. WCS sends an alternative mission.

In an multi-deep scenario: a TU in front of the source location is unexpectedly blocking the pick of the TU.



#	WCS	MSC	CCS
1.1	Transport Mission Msg: **TUMI** CLoc: **MS 01 1 003 01 01** DLoc: **MS AI01 LR01 RO10** TUID: **TU01**	→	
1.2		Store mission and move shuttle to bin location.	
2.1		Shuttle detects bin as empty after positioning in front.	
2.2	←	Exception Message Msg: **TUEX** CLoc: **MS 01 1 003 01 01** DLoc: **MS AI01 LR01RO10** TUID: **TU01** EventCode: **BE** (bin empty) resp **SN** (source not reachable)	
		Cancel destination for TU01. Shuttle stopped.	
3.1	Lock bin, cancel other missions of necessary and cancel mission for TU01 to release shuttle.		
3.2	Mission Cancel Msg: **TUMC** CLoc: **MS 01 1 003 01 01** DLoc: **MS AI01 LR01RO10** TUID: **TU01**	→	
4.1		Cancel mission of TU01 and release shuttle.	
4.2	←	Mission Cancel Ack Msg: **TUCA** CLoc: **MS 01 1 003 01 01** DLoc: **MS AI01 LR01RO10** TUID: **TU01**	
5.1	Determine new retrieval order.		
5.2	Transport Mission Msg: **TUMI** CLoc: **MS 01 1 013 01 01** DLoc: **MS AI01 LR01RO10** TUID: **TU02**	→	

INFO In case of a iAT location no TUEX:BE will be sent. Instead a logical fault will be generated and visualized in the SCADA system.

After the fault having been cleared by an associate the transport will continue to its original destination. Alternatively, the mission can be canceled at PLC level. A TUCA telegram will be sent.

Consecutive bin errors

Situation

The shuttle reports one of the following errors for a pre-determined number of consecutive attempts:

- bin full,
- destination bin cannot be reached,
- bin empty or
- source bin cannot be reached

to the WCS, which repeatedly attempts to determine a substitute bin.

Following a period of time that can be parameterized, the MSC triggers a message not requiring acknowledgment on the visualization system as long as the shuttle remains in this state and receives no feasible order from the WCS.

Correction

Generally it may be assumed with such a malfunction that the "bin full" sensors of the shuttle have become misadjusted.

The sensors must be checked by a technician on site and readjusted if necessary.

5.2.4 Shuttle cannot deliver

Situation

The situation of a loaded shuttle not being able to deliver onto the DS of an outfeed lane or onto a rack conveyor outfeed can occur as follows:

1. The station is occupied because of a jam. A malfunction may occur in the further course of the material flow.
2. The station is faulted.

Rectification of situation 1

Generally the MSC avoids situation 1 by starting retrieval operations only given the capacity at the destination location.

Should situation 1 occur, however, the malfunction must be located and corrected. If storage orders are thereby hindered, cancellation of the retrieval operation and subsequent re-storage in a storage bin by the WCS are also possible.

Rectification of situation 2

In situation 2, a worker must decide on site whether the malfunction is short term or long term. Long-term malfunctions are to be treated as described in the corresponding section.

5.2.5 Lift cannot deliver

Situation

The situation of a loaded lift not being able to deliver at the DS of the outfeed lane or PS of a rack conveyor can occur as follows:

1. The station is occupied because of a jam. A malfunction may occur in the further course of the material flow.
2. The station is faulted.

Rectification of situation 1

Generally the MSC avoids situation 1 by starting retrieval operations only given the capacity at the destination location.

Should situation 1 occur, however, the malfunction must be located and corrected. If other storage or retrieval operations are thereby hindered, cancellation of the order and an alternative order by the WCS are also possible.

Optionally, the MSC can report such an error situation at the WCS, cancel the transport order and request a new destination from the WCS.

Rectification of situation 2

In situation 2, a worker must decide on site whether the malfunction is short term or long term. Long-term malfunctions are to be treated as described in the corresponding section.

5.2.6 Wrong height class of the TU

Situation

If transport units are used with different height classes, the current height class of the TU is checked on the shuttle, to avoid a collision with the storage bin. If the height of the TU exceeds the height of the bin, the storage operation is canceled.

Procedural sequence

#	WCS	MSC	CCS
1.1	Storage order.		
1.2	Transport Mission Msg: **TUMI** CLoc: **CC AI01 CL01 PS10** DLoc: **MS 01 1 003 01 01** TUID: **TU01** →		
1.3		The PLC detects: TU too high for bin.	
2.1		Cancel mission for TU.	
2.2	←	Exception Message Msg: **TUEX** CLoc: **MS AI01 LV01 SH01** DLoc: **MS 01 1 003 01 01** TUID: **TU01** EventCode: **TH** (too high)	
3.1	Determine new location.		
3.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 LV01 SH01** DLoc: **MS AI01 CR01 DS10** TUID: **TU01** →		
		Move shuttle to new destination.	

5.2.7 Transport order not executable

Situation

If the MSC receives a transport order that is not feasible (source bin not known, destination bin not known, source or destination are physically not reachable), the transport order is denied.

Note: This case can occur only if the system is incorrectly configured.

Procedural sequence

#	WCS	MSC	CCS
1.1	Storage order.		
1.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 CL01 PS10** DLoc: **MS 01 1 003 01 01** TUID: **TU01** →		
1.3		Transport order not executable.	
2.1		Cancel mission for TU before starting.	
2.2	←	Exception Message Msg: **TUEX** CLoc: **MS AI01 CR01 DS10** DLoc: **MS 01 1 003 01 01** TUID: **TU01** EventCode: **CE** (current location doesn't exist) **DE** (dest. location doesn't exist) **DU** (dest. unreachable)	
3.1	Determine new destination for the case. In general, this will be a clearing station, i.e. this results in a mission to the drop sstation		
3.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 CL01 DS10** DLoc: **MS 01 1 003 01 01** TUID: **TU01** →		

5.2.8 Incorrect location

Situation

The WCS sends a transport order to the MSC. The MSC then checks only whether the TU is known and not its current location.

A check with the actual location of the TU occurs merely at the retrieval rack conveyors and at the PS. If this location does not match, the order is rejected by the MSC.

The MSC updates the current location of the TU to give the WCS the possibility to update its data.

Procedural sequence

#	WCS	MSC	CCS
1.1	Storage order.		
1.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 LL01 RI10** DLoc: **MS 01 1 003 01 01** TUID: **TU01** →		
1.3		Transport order not executable.	
2.1		Cancel mission for TU before starting. The CLoc field encompasses the updated current location.	
2.2	←	Exception Message Msg: **TUEX** CLoc: **MS AI01 LL02 RI10** DLoc: **MS 01 1 003 01 01** TUID: **TU01** EventCode: **TU** (TU unknown)	

5.2.9 TU physically removed

Situation

When correcting malfunctions it may be necessary to physically remove a TU from the system.

The worker must then make this known at the MSC.

Procedural sequence

#	WCS	MSC	Operator
1.1	Storage order.		
1.2	Transport Mission Msg: **TUMI** CLoc: **MS AI01 LL01 RI10** DLoc: **MS 01 1 003 01 01** TUID: **TU01** →		
1.3		Transport order is started, TU located onto conveyor.	
2.1		←	TU removed from location and system manually and physically.
2.2	←	Exception Message Msg: **TUCA** CLoc: **MS AI01 LL01 RI10** DLoc: **MS 01 1 003 01 01** TUID: **TU01**	
2.3		TU removed logically within MSC	
3	Delete transport order, correct inventory, and perhaps create new TO.		

5.2.10 Shuttle or Level out of order (long-term malfunction)

Situation

A shuttle is defective and taken out of operation.

A level of a Multishuttle aisle is faulted for a longer period of time (decision of maintenance stuff). Possible causes of faults:

- Power supply to the level failed
- Shuttle failed, blocking the level, and cannot be quickly replaced
- Other mechanical or electrical defects in the level

Handling of malfunction

The following cases can arise, and are handled as follows depending on the conditions:

Case	Handling
Shuttle can be replaced.	The defective shuttle is replaced by one in proper condition. Acknowledge malfunction; normal operation will resume.
Shuttle cannot be replaced.	Remove level from operation. WCS is notified via STAT.

Procedural sequence

#	WCS	MSC	Operator
1.1			Check manually: Level cannot be used.
2.1	←	←	GUI: dispositive locking of level for storage and retrieval.
2.2	Dispositive locking of level for storage and retrieval. Destination is no longer used.		
3.1		←	GUI: long term locking of level
3.2		Lock level for storage & retrieval.	
3.3	←	Status Message Msg: **STAT** Device: **MS AI01 LV01** Status: **OF** (long term fault)	
4.1	Cancel retrieval orders of level.		
4.2	Cancel Mission Msg: **TUMC**	→	
4.3		Cancel retrieval orders of level.	
4.4	←	Cancel Mission Ack Msg: **TUCA**	
5.1	Change destination of already started TUs.		
5.2	Transport Mission Msg: **TUMI**	→	
5.3		Change destination for TUs.	
6.1		Lift is not able to reach destination because of disturbed level.	
6.2	←	Exception Message Msg: **TUEX** Cloc: **MS Ai01 EL01 LO00** Dloc: **MS AI01 LL01 RI10** EventCode: **DN** (destination not reachable)	
6.3	Change destination of already started TUs.		
6.4	Transport Mission Msg: **TUMI**	→	

5.2.11 Rack Conveyor Infeed out of order (long-term malfunction)

Situation

The infeed rack conveyors are faulted and must be removed from operation.

Procedural sequence

#	WCS	MSC	Operator
1.1			Check manually: infeed rack conveyor cannot be used.
2.1	←	←	GUI: dispositive locking of level for storage.
2.2	Dispositive locking of level for storage. Destination is no longer used.		
3.1		←	GUI: long term locking of level
3.2		Lock level for storage.	
3.3	←	Status Message Msg: **STAT** Device: **MS AI01 LL01 RI10** Status: **OF** (long term fault)	
4.1		Lift is not able to reach destination because of disturbed level.	
4.2	←	Exception Message Msg: **TUEX** Cloc: **MS Ai01 EL01 LO00** Dloc: **MS AI01 LL01 RI10** EventCode: **DN** (destination not reachable)	
4.3	Change destination of already started TUs.		
4.4	Transport Mission Msg: **TUMI**	→	

5.2.12 Rack Conveyor Outfeed out of order (long-term malfunction)

Situation

The outfeed rack conveyors are faulted and must be removed from operation.

Procedural sequence

#	WCS	MSC	Operator
1.1			Check manually: outfeed rack convey-or cannot be used.
2.1	←	←	GUI: dispositive locking of level for retrieval.
2.2	Dispositive locking of level for retrieval. Level is no longer used as source.		
3.1		←	GUI: long term locking of level
3.2		Lock level for retrieval.	
3.3	←	Status Message Msg: **STAT** Device: **MS AI01 LR01 RO10** Status: **OF** (long term fault)	
4.1	Cancel retrieval orders of level.		
4.2	Cancel Mission Msg: **TUMC**	→	
4.3		Cancel retrieval orders of level.	
4.4	←	Cancel Mission Ack Msg: **TUCA**	
5.1	Change destination of already started TUs.		
5.2	Transport Mission Msg: **TUMI**	→	
5.3		Change destination for TUs.	

5.2.13 Single Cycle Lift out of order (long-term malfunction)

Situation

The single cycle storage or retrieval lift must be removed from operation.

Procedural sequence

#	WCS	MSC	Operator
1.1			Check manually: lift cannot be used.
2.1	←		GUI: dispositive locking of level for storage.
2.2	Dispositive locking of level for retrieval. Destination is no longer.		
3.1		←	GUI: long term locking of lift
3.2		Lock lift.	
3.3	←	Status Message Msg: **STAT** Device: **MS AI01 EL01** Status: **OF** (long term fault)	

5.2.14 Dual Cycle Lift out of order (long-term malfunction)

Situation

The dual cycle storage or retrieval lift must be removed from operation.

Procedural sequence

#	WCS	MSC	Operator
1.1			Check manually: lift cannot be used.
2.1	←	←	GUI: dispositive locking of level for storage.
2.2	Dispositive locking of level for retrieval. Destination is no longer.		
3.1		←	GUI: long term locking of lift
3.2		Lock lift.	
3.3	←	Status Message Msg: **STAT** Device: **MS AI01 EL01** Status: **OF** (long term fault)	

5.2.15 DS out of order (long-term malfunction)

Situation

The DS must be removed from operation.

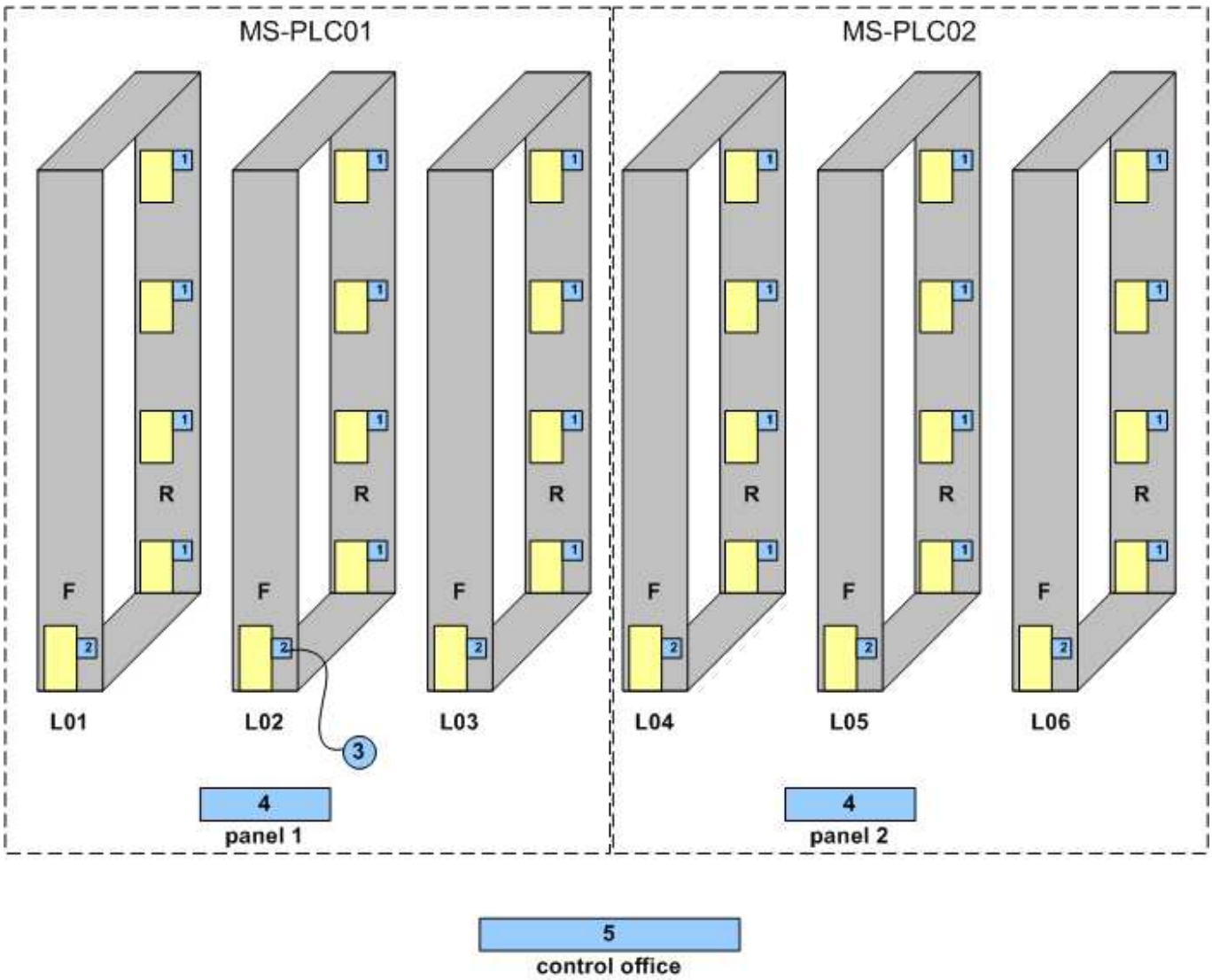
Procedural sequence

#	WCS	MSC	Operator
1.1			Check manually: DS cannot be used.
2.1		←	GUI: long term locking of lift
2.2		Lock lift.	
2.3	←	Status Message Msg: **STAT** Device: **MS AI01 CR01 DS10** Status: **OF** (long term fault)	

6 User Interface

6.1 Overview

The following diagram gives an overview of all theoretical user locations of a Multishuttle system.



Key

Position	Function	Number
1	Operator console for maintenance access	per maintenance level in an aisle
2	Operator console for aisle	per aisle
3	Mobile terminal for manual functions of the aisle	per system
4	Local visualization system / operation for PLC zone (optional)	per PLC zone
5	Control station visualization (optional)	per workstation (server + clients)

6.2 Shuttle Sensor Adjustment

Owing to the fact that entry of the maintenance aisle cuts off power to the bus-bars of the correlated shuttles, the sensors of the shuttle can be adjusted only by means of an external battery.

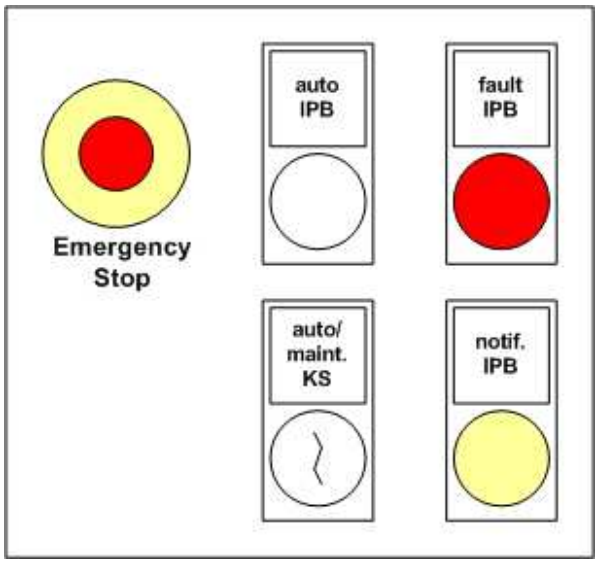
For this reason delivery includes an external battery that, when connected to the shuttle, temporarily supplies it with power. During this time the sensors can be adjusted.

6.3 Reference Point Trip of the Shuttle

Following an emergency STOP situation or opening of the door to the maintenance aisle, the MSC launches a reference trip of all affected shuttles.

This trip occurs at crawl speed and, depending on the position of the shuttle and the length of the aisle, takes up to several minutes.

6.4 Operator Console for Maintenance Access

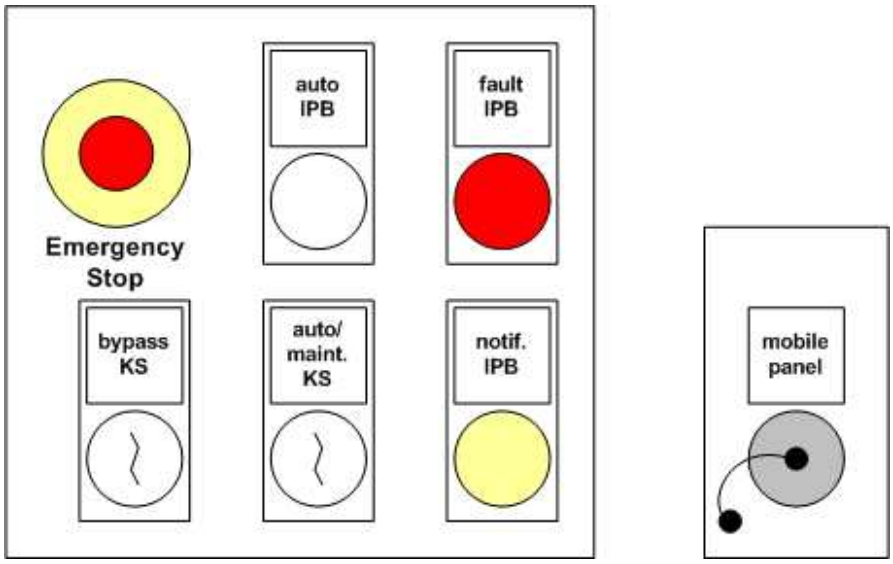


This operator console is located at all doors to a maintenance level at the rear of a Multishuttle aisle and regulates access.

Legend

Element	Function	Type
Emergency STOP	Switches aisle to emergency STOP.	Pushbutton
Auto	Switches on and displays the automatic mode when key switch in "automatic" position	Illuminated pushbutton
Malfunction	Displays collective faults of the aisle, and acknowledgment.	Illuminated pushbutton
Auto / maintenance	Switches between "automatic mode" and "maintenance mode". The key can be removed only in the "maintenance mode" position.	Key switch
Notification	Notification for maintenance level. On actuation of the notification for access to the maintenance level all begun transport orders are halted in the home position. OFF: access prohibited FLASHING: notification in progress LIGHTS UP: notification permitted. The door to the maintenance level can be opened with the key.	Signal lamp

6.5 Operator Console for Aisle



This operator console is located at the entrance door on the front of a Multishuttle aisle, controls access to it and permits connection of the mobile terminal for manual mode.

Legend

Element	Function	Type
Emergency STOP	Switches aisle to emergency STOP.	Pushbutton
Auto	Switches on and displays the automatic mode when key switch in "automatic" position	Illuminated pushbutton
Malfunction	Displays collective faults of the aisle, and acknowledgment.	Illuminated pushbutton
Auto / Maintenance	Switches between "automatic mode" and "maintenance mode". The key can be removed only in the "maintenance mode" position.	Key switch
Notification	Notification for maintenance level. On actuation of the notification for access to the maintenance level all initiated transport orders are halted in the home position. OFF: access prohibited FLASHING: notification in progress LIGHTS UP: notification permitted. The door to the maintenance level can be opened with the key.	Signal lamp
Bypass	Bypass safety circuit lift	Key switch

Element	Function	Type
Mobile terminal	Jack for mobile terminal at an external plug.	Jack

6.6 Mobile Terminal for manual functions of the Aisle

The manual functions of all units of an aisle can be executed by means of the mobile terminal in service cases.

The terminal must first be plugged into the corresponding jack of the aisle operator console.

Following selection of manual mode and selection of a unit, its functions can then be executed in manual mode.

Function

The functions in detail:

- Selection and deselection of manual mode
- Overview of the status of all conveyor elements of an aisle
  - Operating mode
  - Malfunction
  - Load state (number of TUs)
- Selection of a conveyor element and control of the corresponding function in the manual function:
  - Lift
    a. LIFT, LOWER
    b. ROLL FORWARDS, BACKWARDS
  - Rack conveyor
    a. ROLL FORWARDS, BACKWARDS
  - Shuttle
    b. FORWARD, BACK
    c. FORK FORWARD, BACK (automatic stop at each position)
    d. FINGERS (Pins) UP, DOWN
- Error messages of the aisle

Hardware and Software

Siemens Multi-Panel MP177 with Windows operating system

6.7 Local Visualization System

Local operation (optional) is an integrated part of the operator console of the particular MS PLC zone and allows the worker to display relevant status information and permits manipulation of TU information.

For the subordinate test operation (without master computer) orders can be entered and executed in automatic mode.

Function

Local operation of the MSC offers the following functions relative to the assigned aisles:

- System overview of the overall status
- Selection and deselection of the test mode "automatic without WCS"
- Overview of the status of all conveyor elements (conveyors, shuttles, lifts):
  - Operating mode
  - Malfunction
  - Load state (number of TUs)
- Error messages of the assigned aisles
- View of all active orders (storage, retrieval and relocation orders)
- Display of all station data (TU number, destination)
- Correction of the station data:
  - Deletion of the station data
  - Input or correction of the TU number
  - Manual destination specification in automatic mode without WCS

Hardware and Software

PC with touchscreen (17 inch) and Windows operating system

Visualization via Siemens WinCC or Iconics

Alternatives

For reducing costs only one local operation is conceivable for all aisles.

6.8 Central Visualization (SCADA)

If system visualization (optional) of the overall system belongs to the scope of delivery of an order, the Multishuttle part includes the same functions as that of the local operation, with the difference that

- all aisles are visualized,
- no interventions or data manipulation by the worker are possible.

Hardware and Software

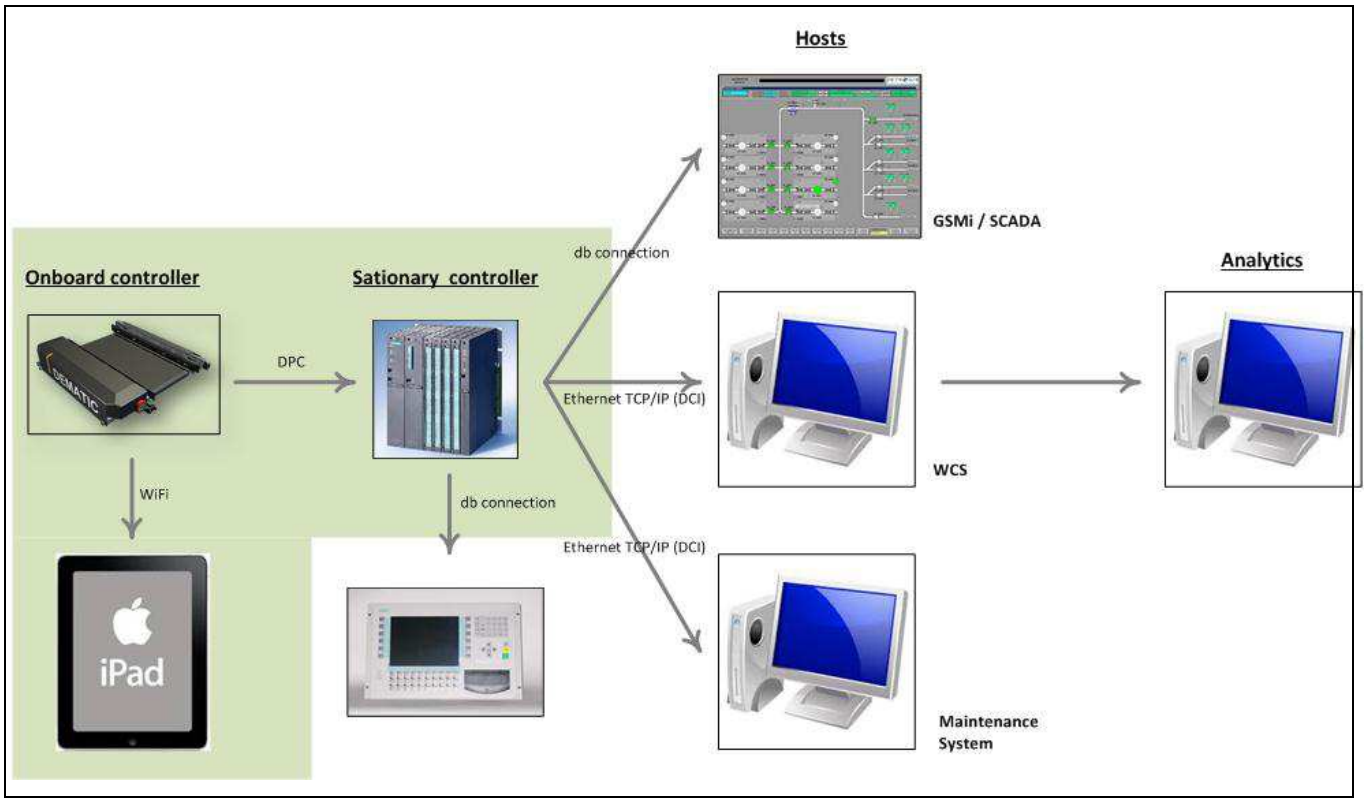
Server and client PCs with 21-inch monitors and Windows operating system

Visualization via Siemens WinCC or Iconics

7 Statistics

The multishuttle controller collects statistical data for individual shuttles and lifts. The collected data are reported cyclically (typically once per hour) or upon explicit request to the host system.

The following picture denotes the flow of information.



The parts having a green background are in the scope of supply of the MSC.

All collected data values are summarized until they are reported to the host. Once the data has been sent to the host, the counters are reset and the summarizing restarts from 0 again. It is the responsibility of the host system to display and further aggregate the data (per day, per shift, per device, …).

In addition to that, all data can be accessed read only by special devices (e.g. the local HMI). In this case the counters are not reset.

7.1 Request Statistics Data <DCRQ>

The DCRQ telegram requests statistics data for the specified device identifier.

Byte	Name	Type	Length	Description
29-42	Device Identifier	A	14	Device identifier of the shuttle the statistics data are collected for.

7.2 Shuttle Statistics <DCSH>

The DCSH telegram report statistics data for an individual shuttle.

Transport Units can be relocated within a level or between two levels. Relocation between two levels is counted in each level in which the TU was moved.

After DCSH has been acknowledged, the counters are reset.

INFO The data encompass two kind of idents:

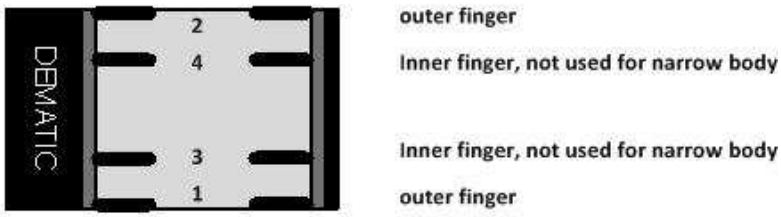
- The ‘device identifier’ can be used to create a logistically focused analysis, like how many storage movements have there be been in a certain level (independent which concrete shuttle device have resided in the level).
- The hardware identifier can be used to create analysis related to a particular shuttle device, like how long was shuttle ‘…’ active in any kind of level (independent in which level the shuttle was).

Byte	Name	Type	Length	Description
29-42	Device Identifier	A	14	Device identifier of the shuttle the statistics data are collected for.
43-58	Hardware Identifier	A	16	Physical Device Identifier of the shuttle. Currently, the MAC address without ‘:’; 4 bytes reserve
59-62	Storage Cycles	N	4	Number of storage cycles defined as: ● Source = rack in conveyor or iAT location ● Destination = bin
63-66	Retrieval Cycles	N	4	Number of retrieval cycles defined as: ● Source = bin or iAT location ● Destination = rack out conveyor
67-70	Re-shuffling Cycles	N	4	Number of re-shuffling cycles defines as: ● Source = bin ● Destination = bin

Byte	Name	Type	Length	Description
71-74	iAT Cycles	N	4	Number of iAT cycles defined as: ● Source = anywhere ● Destination = iAT location
75-78	Bypass Cycles	N	4	Number of bypass cycles defined as: ● Source = rack in conveyor ● Destination = rack out conveyor
79-84	X Travel Distance	N	6	Summarized travel distance for shuttle. Dimension: m
85-90	Z Travel Distance	N	6	Summarized travel distance for telescope. Dimension: m
91-96	W Travel Distance	N	6	Summarized travel distance for telescope width. Dimension: cm
97-102	Finger Moves Pair 1	N	6	Number of finger movements of pair 1.
103-108	Finger Moves Pair 2	N	6	Number of finger movements of pair 2.
109-114	Finger Moves Pair 3	N	6	Number of finger movements of pair 3.
115-120	Finger Moves Pair 4	N	6	Number of finger movements of pair 4.
121-124	Downtime	N	4	Time in which the shuttle is not active. Dimension: min
125-128	Time active	N	4	Summarized time during which voltage is applied. Dimension: min
129-132	Time running	N	4	Summarized time during which the shuttle is actually moving. Dimension: min
133-136	Number of faults	N	4	Number of faults.
137-140	Number of warnings	N	4	Number of warnings
141-146	Fault Code 1st important fault	N	6	Id of the 1st important fault
147-150	Quantity 1st important fault	N	4	Number of the occurrence of the 1st important fault.
151-156	Fault Code 2nd important fault	N	6	Id of the 2nd important fault
157-160	Quantity 2nd important fault	N	4	Number of the occurrence of the 2nd important fault.

Byte	Name	Type	Length	Description
161-166	Fault Code 3rd important fault	N	6	Id of the 3rd important fault
167-170	Quantity 3rd important fault	N	4	Number of the occurrence of the 3rd important fault.
171-176	Fault Code 4th important fault	N	6	Id of the 4th important fault
177-180	Quantity 4th important fault	N	4	Number of the occurrence of the 4th important fault.
181-186	Fault Code 5th important fault	N	6	Id of the 5th important fault
187-190	Quantity 5th important fault	N	4	Number of the occurrence of the 5th important fault.
191-196	Fault Code 6th important fault	N	6	Id of the 6th important fault
197-200	Quantity 6th important fault	N	4	Number of the occurrence of the 6th important fault.
201-206	Fault Code 7th important fault	N	6	Id of the 7th important fault
207-210	Quantity 7th important fault	N	4	Number of the occurrence of the 7th important fault.
211-216	Fault Code 8th important fault	N	6	Id of the 8th important fault
217-220	Quantity 8th important fault	N	4	Number of the occurrence of the 8th important fault.
221-226	Fault Code 9th important fault	N	6	Id of the 9th important fault
227-230	Quantity 9th important fault	N	4	Number of the occurrence of the 9th important fault.
231-236	Fault Code 10th important fault	N	6	Id of the 10th important fault
237-240	Quantity 10th important fault	N	4	Number of the occurrence of the 10th important fault.

The following picture defines the finger number.



The number are always relative to the body of the shuttle. They are independent of the driving direction.

The “importance” of a fault is not measured since the last reset of the counters, but is infinite.

7.3 Lift Statistics <DCLI>

The DCLI telegram report statistics data for an individual lift.

After DCLI has been acknowledged, the counters are reset.

Byte	Name	Type	Length	Description
29-42	Device Identifier	A	14	Device identifier of the shuttle the statistics data are collected for.
43-48	Up Moves	N	6	Number of up moves.
49-54	Down Moves	N	6	Number of down moves
55-60	Y Travel Distance	N	6	Summarized travel distance for shuttle. Dimension: m
61-66	Infeed cycles	N	6	Number of infeed cycles, i.e. number of transport units travelling onto the lift.
67-72	Outfeed cycles	N	6	Number of outfeed cycles, i.e. number of transport units travelling from the lift.
73-76	Downtime	N	4	Time in which the lift is not active. Dimension: min
75-80	Time active	N	4	Summarized time during which voltage is applied. Dimension: min
81-84	Time running	N	4	Summarized time during which the lift is actually moving. Dimension: min
85-88	Number of faults	N	4	Number of faults.
89-92	Number of warnings	N	4	Number of warnings
93-98	Fault Code 1st important fault	N	6	Id of the 1st important fault
99-102	Quantity 1st important fault	N	4	Number of the occurrence of the 1st important fault.
103-108	Fault Code 2nd important fault	N	6	Id of the 2nd important fault
109-112	Quantity 2nd important fault	N	4	Number of the occurrence of the 2nd important fault.

Byte	Name	Type	Length	Description
113-118	Fault Code 3rd important fault	N	6	Id of the 3rd important fault
119-122	Quantity 3rd important fault	N	4	Number of the occurrence of the 3rd important fault.
123-128	Fault Code 4th important fault	N	6	Id of the 4th important fault
129-132	Quantity 4th important fault	N	4	Number of the occurrence of the 4th important fault.
133-138	Fault Code 5th important fault	N	6	Id of the 5th important fault
139-142	Quantity 5th important fault	N	4	Number of the occurrence of the 5th important fault.
143-148	Fault Code 6th important fault	N	6	Id of the 6th important fault
149-152	Quantity 6th important fault	N	4	Number of the occurrence of the 6th important fault.
153-158	Fault Code 7th important fault	N	6	Id of the 7th important fault
159-162	Quantity 7th important fault	N	4	Number of the occurrence of the 7th important fault.
163-168	Fault Code 8th important fault	N	6	Id of the 8th important fault
169-172	Quantity 8th important fault	N	4	Number of the occurrence of the 8th important fault.
173-178	Fault Code 9th important fault	N	6	Id of the 9th important fault
179-182	Quantity 9th important fault	N	4	Number of the occurrence of the 9th important fault.
183-188	Fault Code 10th important fault	N	6	Id of the 10th important fault
189-192	Quantity 10th important fault	N	4	Number of the occurrence of the 10th important fault.

The “importance” of a fault is not measured since the last reset of the counters, but is infinite.

Appendix

Abbreviations

Abbreviation	Definition
A	Alphanumeric field justified left. Fill rest (end) with default data.
CCS	Conveyor Control System
DCI	Dematic Communication Interface
DPC	Dematic Powerlink Communication
DS	Drop station
MCS	Multishuttle Control System
N	Numeric character field justified right. Fill rest (beginning) with default data.
PLC	Programmable Logic Controller
PS	Pick station
SC	Shuttle Controller (onboard)
TU	Transport unit
WCS	Warehouse Control System
WMS	Warehouse Management System