swisslog

Swisslog Interface Standard

Communication between MFCS/SPOC and Crane

Maintained by:	Christoph Brändle / Bruno Stampfli
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Address:	Swisslog AG, Bahnhofstrasse 96, CH-5001 Aarau

List of Changes

Note: The detailed list of changes in previous versions can be found at the end of this document.

Version	Date	Author	Remarks
V3.00	12.11.1999	Christoph Brändle	Released version V3.00
V3.01-X1	06.09.2000	Christoph Brändle	Behaviour in case of assignment type CC changed (requested by Accalon (Daniel Graff))
V3.01-X2	18.09.2000	Christoph Brändle	Some minor corrections of the CC assignment Explicitly stated that only PM assignments return measurement info.
V3.01-X3	14.08.2001	Christoph Brändle	New section "Handling of double loads and transport units with different widths" ARQ telegram gets another item "Fork Side"
V3.01-X4	21.08.2001	Christoph Brändle	Changes in the usage of "TU type" and "fork side" in case of handling two TUs together, according to comments from Accalon (Nils Huss / Tommy Bäck) More detailed examples New MSG telegram Typing error in the SDO telegram corrected Reference documents in section 1.3 rearranged
V3.01	05.09.2001	Christoph Brändle	Released version V3.01
V4.0_x4	26.05.2003	Bruno Stampfli	CSR send, when load status changes ACP gets more item's (for width and length) LAB Scanner error and Label length field added Upgraded list for errors and alarms. DER/DEC allowed from MFCS and SPOC Telegrams CSR/CER merged into CSR Request telegram CRQ/CEQ merged into CRQ Complete move send CSR telegram, when the fork is loaded. After DEC telegram ACP error code is set to manual deleted.
V4.0_x5	16.12.2003	Bruno Stampfli	ARQ in field "TU type" change NUM 1 to NUM 2 ARQ field "Fork Side" split into rear and front ARQ in fields "… Fork Side" value FD added ACP behaviour of Profile/Label information changed LAB deleted (included in the ACP) SIN deleted SCE deleted
V4.1 (V4.0_x6)	30.10.2004 (11.05.2004)	Bruno Stampfli	No structural changes (No telegram structure modifications) Modifications and improvements in description. Fetch possibility deleted.

Version	Date	Author	Remarks
			ACP profile values description improved Error codes list definitions in a special file.

Table of Contents

1. Introduction

1.1. Purpose of this Document

This document describes the Swisslog Interface Standard between the MFCS/SPOC and the Crane subsystem. This contains the whole communication between these systems.

1.2. Target Readership

This document is designated to be used by the following persons or functions:

- Systems engineers of Swisslog and related companies
- Project leaders and software engineers of Swisslog
- Systems engineers, project leaders and software engineers of other companies that are implementing a crane subsystem interfacing with a Swisslog MFCS/SPOC

1.3. Reference Documents

1.3.1. General Documents

[1] Swisslog Automation Concept, Overview

1.3.2. Swisslog Interface Standard Documents

These documents can be found on the SIS homepage on Intranet

[2] Swisslog Interface Standard, Base Communication Protocol

[3] Swisslog Interface Standard, Base Communication with SISCOMLIB

[4] Swisslog Interface Standard, Crane Interface (this document)

[4a] Swisslog Interface Standard, Crane Interface, Additional comments and examples

[5] Swisslog Interface Standard, Conveyor Interface

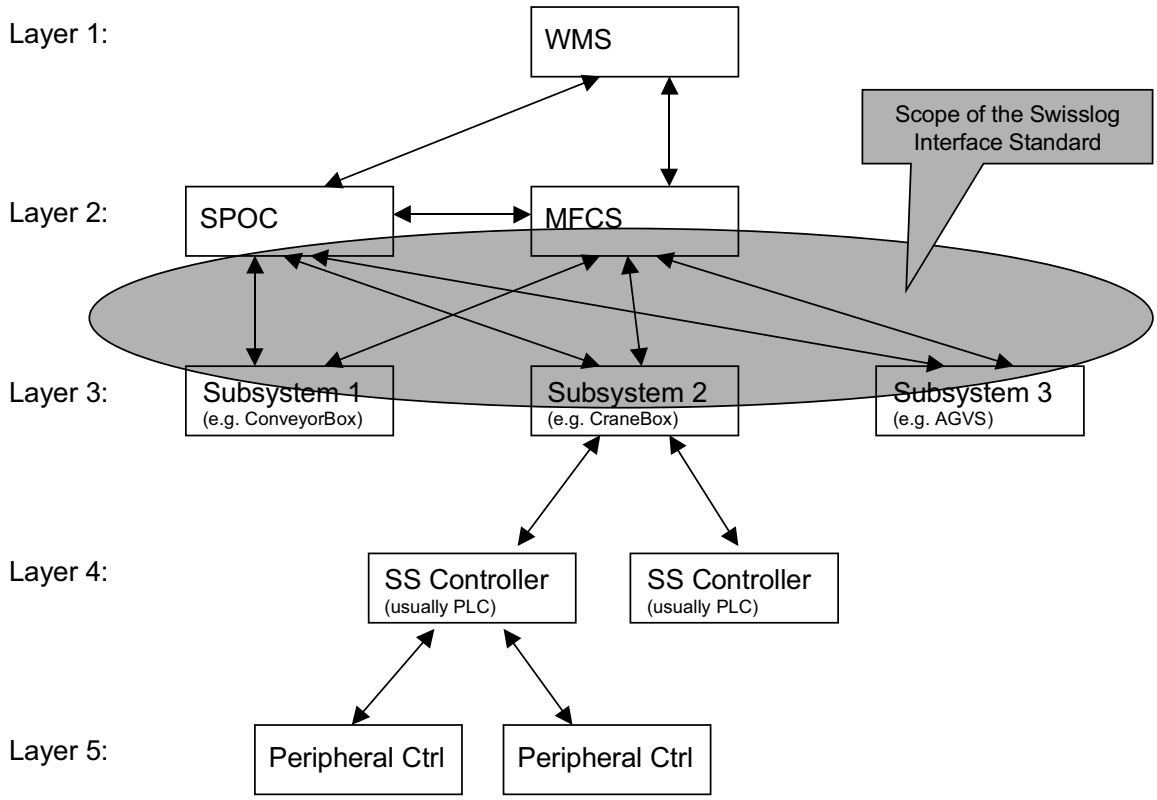
[6] Swisslog Interface Standard, AGVS Interface

[7] Swisslog Interface Standard, Monorail Interface

2. System Overview

2.1. Topology of the involved systems

The Swisslog Automation Concept defines a system hierarchy as follows:



Legend:

WMS Warehouse Management System

MFCS Material Flow Management System - The automatic system that controls the basic material flow in a plant

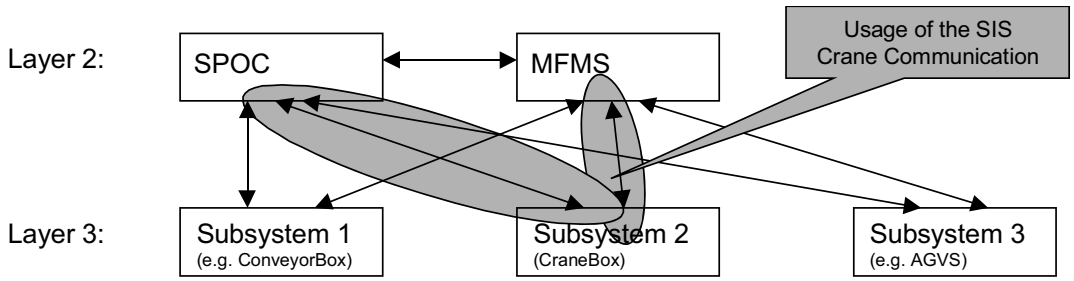
SPOC Single Point Of Control - The work place of people, which is used to visualise and manually influence the material flow.

The Swisslog Interface Standard is used for communication between systems of layer 2 (MFCS / SPOC) and systems of layer 3 (Subsystem Boxes). It does not cover the communication between MFCS and SPOC, or between MFCS / SPOC and WMS or between a subsystem box and the attached controllers.

An Automation System in the context of this document consists of one MFCS, one SPOC, and a number of subsystems. For each type (crane, conveyor, AGVS, etc) there is a different subsystem. It may also be that there is more than one subsystem of a particular type.

SPOC has an independent connection to each of the subsystems; the same applies to MFCS. Each of the subsystems has two independent connections, one to MFCS, one to SPOC.

The part of SIS described in this document covers the communication between MFCS and SPOC on one side, and a Crane Box on the other side:



For more information on the whole SAC structure, and references to other systems and how they communicate with each other, see [1].

2.2. Base communication

2.2.1. SIS Communication Library

Swisslog AG provides the "Swisslog Interface Standard Communication Library" (SISCOMLIB).

This is a library that may be linked to an application program on a system. It provides an application-programming interface containing functions that are used to transmit a telegram between two systems. In detail, this library performs the following tasks:

- Set-up, control and shutdown of the link (TCP/IP stream sockets) between two partner systems.
- Basic data transport on TCP/IP
- Data framing
- Flow control and data buffering
- Sequence numbering
- Retransmission in case of temporarily unavailable connections
- Persistent buffering of data in disk files to survive process or system crashes

Using the SISCOMLIB prevents the application on a system from having to care about low-level communication.

SISCOMLIB is currently available on Windows NT and on various Unix systems (AIX, HP-UX, Compaq UNIX, and Linux).

For more information, see [3].

2.2.2. Base communication protocol

SISCOMLIB implements the "SIS Base Protocol", as described in [3]. If a system works on a platform that is not supported by the SISCOMLIB, the functionality has to be implemented on this platform.

A system using the SISCOMLIB is able to work together with another system that implements this protocol.

The document [2] provides detailed information on this protocol.

3. General Definitions

3.1. Module, Subsystem

A module is one area of the plant controlled by a specific control system. Examples may be conveyor systems, crane systems, AGV systems and the like. In large plants it may also be that there are two or more modules of the same type, each controlled by an own computer system.

In the context of this document, MFCS and SPOC are also considered as modules.

The SIS communication basically handles the exchange of information between modules.

A "subsystem" is often used as a synonym for "module", however this term is reserved for modules in and below layer 3 of the Swisslog Automation Concept; MFCS and SPOC (and other modules of this layer) are never called "subsystems".

Identification:

A module is identified in one of the two following ways:

- As a module number: This is a two-digit number that must be unique throughout the whole concerned system. In this document, a term MM is used to designate the module number. The module number is mainly used in position numbers (see there).
- As a module name: This is a six-character string that also must be unique. The component name is mainly used for communication purpose.

The module name usually starts with four alphabetic characters designating the type of the component, then the two-digit module number as defined above.

The exact values are project specific, since they depend on the structure of the plant. The following ranges should be used in general:

MM Value range	Prefix	Description
00		Reserved for special purpose
01	MFCS	MFCS
02	SPOC	SPOC
03..09	-	Other components on the MFCS/SPOC layer
10..29	CONV	Conveyor systems

MM Value range	Prefix	Description
30..49	CRAN	Crane systems
50..59	AGVS	AGV systems
60..69	MONO	Monorail systems
70..98		Other subsystems
99		Reserved for special purpose

3.2. Position

A position is an identifiable place where one transport unit may be located.

Notes:

- It may be that one TU occupies two or even more positions (e.g. if moving from a position to the neighbouring one, or a large TU may occupy several positions that would be capable of holding

a small TU each).
However, for such TUs, one of the occupied positions must be considered the current position, the other one(s) must be called "additionally blocked".

- It is not possible that more than one TU resides on the same position.
  - If this is nevertheless the case e.g. if TUs are stacked onto each other, for the purpose of the subsystem this is only one TU. The MFCS is responsible for handling this.
  - In case of space that may be variantly used, e.g. if three small positions are occupied by two wide transport units, the middle position is not considered to be occupied by the two TUs, but it is considered blocked by the fact that two other positions contain overhanging load.

Places on special individual objects with very limited space (e.g. on the fork of a crane) are not considered to be positions in the sense of this document.

Identification:

A position is identified with a number in the following format:

MM-RRR-SSS-HH-DD

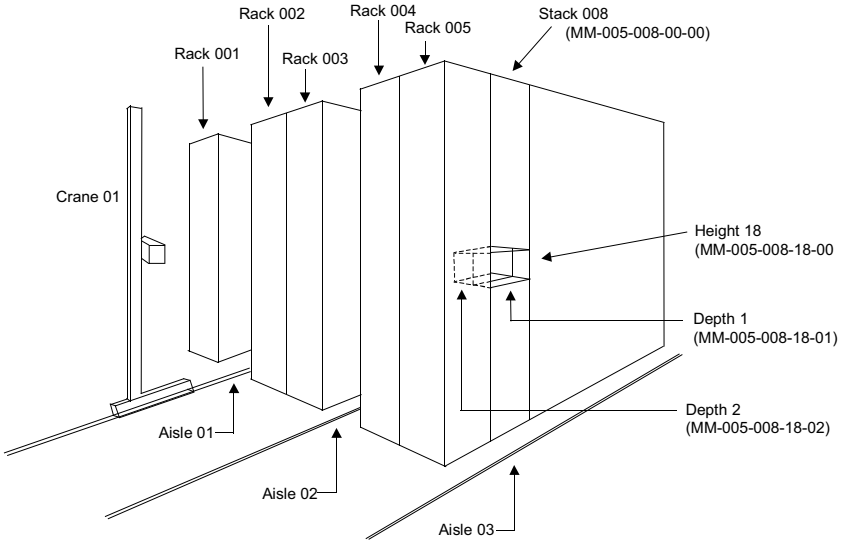
On a crane subsystem the meaning of these items is:

MM	is a two-digit number characterising the subsystem (module). See above for details.
RRR	is a three-digit number characterising the ID number of a rack in the high bay.
SSS	is a three-digit number characterising the ID number of a stack in the rack (X-position). Numbering usually starts from the normal infeed side.
HH	is a two-digit number characterising the height level in the stack (Y-position). Numbering usually starts from the bottom.
DD	is a two-digit number characterising the depth in the rack. The numbering starts with depth '01' to indicate the position closest to the crane. Depth 00 is the (virtual) position in the aisle in front of the rack.

Notes:

1. When physically labelling positions in the system or when numbers are presented to the users on a screen, then the dashes between the different parts of the number are used to make the number more easily to comprehend for the users.
   An example of a printed number is: 30-001-123-00-01
2. The internal representation of the numbers in the software is without the dashes. It is stored as a twelve-digit number with the above interpretation of the different sections. As an example the printed number of note 1 is internally represented as '300011230001'
3. The same position numbering format is used in each subsystem. However, due to the different characteristics of the subsystems, the parts of the number may have different interpretations.
4. When one of the fields is not used, the value zero is used in the software, on operator screens as well as printed labels.

The following drawing shows an example how this looks in a high bay warehouse:

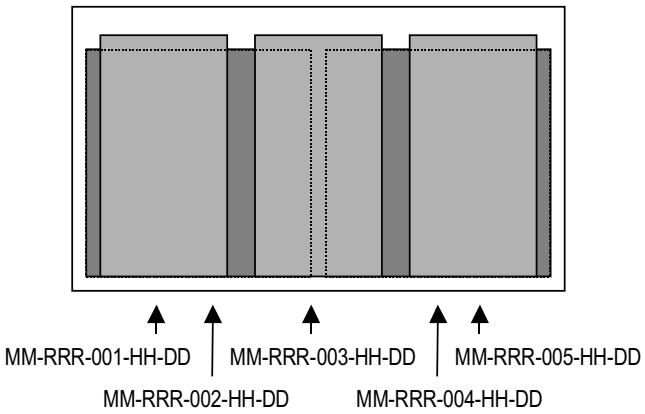


Transfer positions

It may be that one physical position may be accessed by different subsystems. In this case, the same physical position has one unique address for each concerned subsystem. The MFCS / SPOC therefore may know two or even more different identifications of the same position.

Rack compartments with variable subdivision

If one big physical compartment may be used for different types of transport units with variable arrangements, each possible position in x-direction has its own SSS numbering. E.g. if one compartment can be used for either two wide transport units or three narrow transport units, there are five positions defined:



3.3. Crane

The physically existing cranes are numbered from 01 to 98. The following special numbers are reserved:

00: to indicate ‘all cranes’ in certain telegrams,

99: to indicate ‘unknown’ crane number.

3.4. Aisle

If cranes are able to change their aisle, the aisle number must be kept separate, it may be different than the crane number.

The physically existing aisles are numbered from 01 to 98. The following special numbers are reserved:

00: to indicate ‘all aisles’ in certain telegrams,

99: to indicate ‘unknown’ aisle number.

3.5. Transport Unit

A transport unit is an object that is moved by a subsystem as a whole. Usually, this is a pallet or a bin.

The term "load" is used as a synonym for "transport unit".

The terms "pallet" or "bin" are often used as synonyms for "transport unit", even though - to be correct - these are special types of transport units.

Identification:

Transport Units are not identified in the context of the SIS. The subsystems do not have any identification information about transport units. This information is only kept on the host layer.

3.6. Assignment

An assignment is an order executed by a subsystem to transport a load (transport unit) from a defined source position to a defined destination position.

Usually, the subsystem receives the assignment from the MFCS, executes it, and reports completion when this is done. Once the subsystem has received the assignment, it is able to execute the assignment completely without any further influence from the MFCS.

If a decision must be made by the MFCS at some position in the material flow, two assignments must be used: one from the source position to the decision position, then the second one from the decision position to the end destination position.

Identification:

Assignments are identified by an eight-digit number from 00000001 to 99999998. The following special numbers are reserved:

00000000: to indicate ‘no assignment' or 'not applicable',

99999999: to indicate ‘unknown assignment'.

Notes:

1. An assignment number must be unique throughout the whole system at any one time.
2. Assignment numbers may be reused when the previous assignment with a given number has finished.
3. Usually, the MFCS uses the same assignment number for successive assignments with the same transport unit in a chain of assignments, mainly for an easier tracking of what's going on. However, the subsystem may not make any assumption on this.

3.7. Transport unit types

If there are transport units with different dimensions, they are distinguished by a "transport unit type" designation. A two-digit number identifies the transport unit type. Normally, the following values are used:

00: standard transport unit

01..99: plant specific meaning

The exact meaning, in particular whether some types create restrictions on the usage, is plant specific and must be defined before implementation.

Normally, a plant should only use either TU type 00 (if there are only uniform transport units), or types 01, 02, … (if there are different transport unit types). In the latter case, TU type 00 should not be used for any real type.

3.8. Digital I/Os

Digital inputs and digital outputs are identified with a four-digit number from 0001 to 9999. Numbers for inputs and for outputs must be kept separate.

The number 0000 is reserved to indicate "all signals" in certain telegrams.

The exact mapping of these I/O numbers to physical signals is plant-specific and must be defined explicitly before using them.

Notes:

1. If a plant does not use reporting of digital inputs to MFCS/SPOC and setting digital outputs from MFCS/SPOC, no I/O definitions between Crane and MFCS/SPOC are necessary of course.

4. Telegrams Overview

The directions of the telegrams in the following list are the typical directions. In some application not exact one MFCS and one SPOC exist, or some telegrams are not implemented, nor has special sender/receiver addresses. Such untypical definitions must be done plant specific. In general a module accepts telegrams from any module and can send telegrams to any module.

Note: Answer-telegrams must sent back to the request module.

4.1. Normal assignment telegrams

Assignment request, ARQ

Request from MFCS to Crane to initiate a transport assignment.

Assignment completed, ACP

Answer from Crane to MFCS indicating that a specific transport assignment has been completed, aborted, or rejected.

4.2. Data correction telegrams

Assignment delete request, DER

Request from MFCS/SPOC to Crane to delete an existing transport assignment.

Assignment delete report, DEC

Answer from Crane to MFCS/SPOC, indicating that a transport assignment has been deleted, or that it cannot be deleted.

4.3. Control telegrams

Start Crane, STA

Request from SPOC or MFCS to Crane to start an individual crane or a complete crane subsystem.

Stop Crane, STO

Request from SPOC or MFCS to Crane to stop an individual crane or a complete crane subsystem.

4.4. Information telegrams

Crane status request, CRQ

Request from SPOC or MFCS to Crane to report the current status of a single crane or all the cranes.

Crane status report, CSR

Information from Crane to MFCS/SPOC, containing the current status of a crane.

Sent to MFCS:
1. when a crane subsystem is started,
2. as an answer to a CRQ telegram,
3. when a crane changes error status or mode.

Sent to SPOC:
4. as an answer to a CRQ telegram

Assignment completed, ACP

Among to complete an ARQ this telegram contents profile or label information too.

4.5. Auxiliary information telegrams

Digital Input Notification, SDI

Information from Crane to SPOC that a specified digital input has changed its state.

Set Digital Output, SDO

Request from SPOC to Crane to set a particular digital output to a given state.

I/O Status Request, IRQ

Request from SPOC to Crane to report the state of digital signals.

I/O Status Report, ISR

Information from Crane to SPOC, containing the state of digital signals.

Auxiliary Message, MSG

Information from any sender to any receiver, containing plant specific data.

5. Functionality

5.1. Starting / Stopping

5.1.1. Generals, Crane Modes

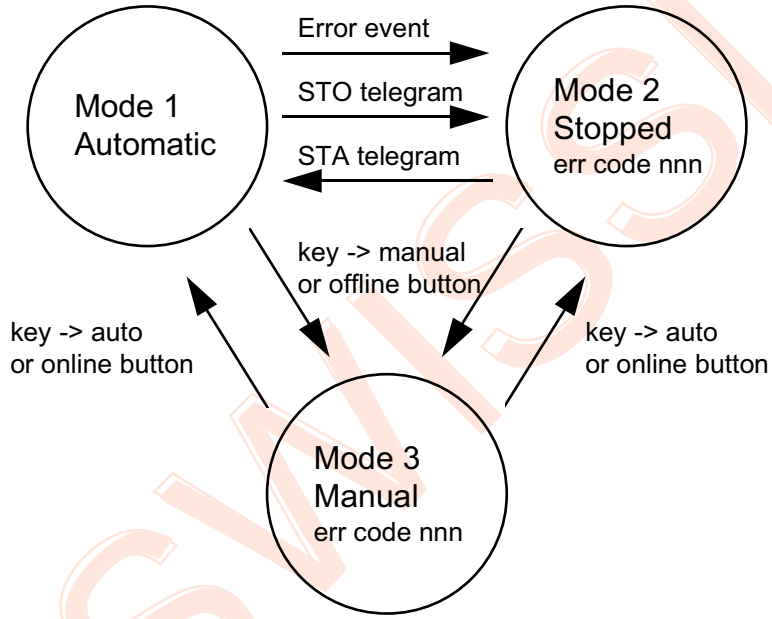
A crane may be in one of the following modes:

Automatic: The crane is up and running, executing assignments, or at least ready to execute assignments.

Stopped: The crane does not execute assignments, due to an error situation or because it is stopped from the host.
Mode stopped is always qualified by a crane status code.

Manual: The crane does not execute assignments, due to being switched to a special state on the crane controls.

The following diagram shows the modes and the possible transitions between them:



Notes:

1. The mode of each crane is kept separately. However, it is also possible to start or stop all cranes together.
2. "Stopped from host" is not a special state, but is state "stopped" with an error code "stopped from host" . "Stopped from host" is sometimes useful and has to be defined plan specific.
3. If a crane is in mode "stopped", and receives a STA telegram, it normally goes back to mode "automatic"; the error disappears either immediately, or the next time the crane executes an assignment.
   However, there are errors where just sending a STA telegram does not recover the crane error. This is the case in particular for serious errors that have to be reset on the crane itself (e.g. motor overheated or similar events). In this case, the crane stays in stopped state.

4. Setting the crane to manual using local controls, then to automatic also sets it back to "automatic", even if it was in state "stopped", and even if it was stopped from the host. However, as above, there are errors that do not just disappear using this procedure; in this case the subsystem goes back to "stopped" state then.
5. Sending an STA telegram in mode "manual" does not set the crane to "automatic". This can only be achieved using local crane controller functions.
6. It may happen that a crane is in mode "automatic", but still has an error code other than zero. This code however will disappear as soon as an assignment is executed.
7. A STO from the host may be overridden by a local transition manual -> automatic.
8. A manual mode however may not be overridden by a STA command.

5.1.2. Start a crane

Main case: Start a crane from SPOC:

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "stopped", no serious error is present
1	STA	SPOC to Crane	SPOC sends a start telegram for one crane or for all cranes together
2	CSR CSR	Crane to SPOC Crane to MFCS	When the crane has finished its start-up processing, a status report (CSR) is sent to MFCS and SPOC
3	ACP (--)	Crane to MFCS	If the crane already has an assignment, it continues processing this, then sends an ACP back to the MFCS. If the crane does not have an assignment, it does not do anything.
4	ARQ	MFCS to Crane	The MFCS may send the next assignment.

Notes:

1. If a STA telegram is sent for all cranes, all cranes of this crane subsystem will be started and will behave as described above. Each crane will send the CSR's telegrams.
   If a STA telegram is sent for one specific crane, only this crane will be started, and will go on as described above. The other cranes will stay as they are.
2. If a crane has a serious error state, it cannot go to "automatic" mode. In this case, CSR's telegrams are sent and indicating this situation, and the crane stays in mode "stopped".
3. If a crane is in mode "manual", it cannot be set to "automatic" mode using a STA telegram. In this case, a CSR indicating this situation is sent, and the crane stays in mode "manual".

Variant: Start a crane from the crane MMI

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "manual", no serious error is present
1			The crane is set to "automatic" using the crane MMI

No	Telegram	Communication	Description
2	CSR CSR	Crane to SPOC Crane to MFCS	When the crane has finished its start-up processing, a status report (CSR) is sent to MFCS and SPOC
3			... processing continues as above

Notes:

4. If the crane is in mode "stopped", it first has to be set to mode "manual" by crane MMI functions
5. If a crane has a serious error state, it cannot go to "automatic" mode. In this case, it will go to mode "stopped", and the CSR's will also indicate this situation.

5.1.3. Stop a crane

Main case: Stop a crane from SPOC

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic"
1	STO	SPOC to Crane	SPOC sends a stop telegram for one crane or for all cranes together
2	ACP (--) (--)	Crane to MFCS	If the crane is currently executing an assignment, it finishes the current movement. If this finishes the assignment, the crane sends an ACP back to the MFCS. If the current movement does not finish the assignment, no ACP is sent back, since the assignment is still present. If the crane does not execute an assignment, no ACP is sent back either, of course.
3	CSR CSR	Crane to SPOC Crane to MFCS	When the crane has finished its stop processing, a status report (CSR) is sent to MFCS and SPOC

Notes:

1. If a STO telegram is sent for all cranes, all cranes of this crane subsystem will be stopped and will behave as described above. Each crane will send the CSR telegrams.
   If a STO telegram is sent for one specific crane, only this crane will be stopped, and will go on as described above. The other cranes will stay as they are.
2. If a crane is already in mode "stopped", nothing special is done. However, a CSR is still sent as an answer, and the crane stays in mode "stopped".
3. If a crane is in mode "manual", it cannot be set to "stopped" mode using a STO telegram. In this case, CSR's telegrams indicating the "manual" mode is sent, and the crane stays in mode "manual".

Variant: Stop a crane from the crane MMI

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic" or "stopped"
1			The crane is set to "manual" using the crane MMI
2	(ACP)	Crane to MFCS	The current movement - if any - is finished as described above. This may cause an ACP to be sent.
3	CSR CSR	Crane to SPOC Crane to MFCS	When the crane has finished its stop processing, a status report (CSR) is sent to MFCS and SPOC

Notes:

4. Stopping a crane from the crane MMI sets it to mode "manual", not to mode "stopped".
5. This in particular means that the crane cannot be started using a STA telegram.
6. If the crane is already in mode "manual", nothing special is done. However, a CSR is still sent to SPOC and MFCS, and the crane stays in mode "manual".

5.2. Assignments

5.2.1. Generals

The main task of the crane subsystem is to execute assignments (transport orders).

There are different types of assignments:

Type	Name	Description
PO	Position	Move the crane to a specific position without load handling
CM	Complete Move	Pickup a transport unit, and deposit it somewhere else
PI	Pickup	Pickup a transport unit from a source position, keep it on fork
DE	Deposit	Dispose the transport unit currently on the fork to a destination position
LR	Location Request	Move the crane to a specific position and report whether this location is occupied or not (without load handling)
PM	Pickup and Measure	Pickup a transport unit, measure the dimensions and report the result.
CC	Complete Move with Check	Pickup a transport unit, measure the dimensions, and perform the rest of the complete move only if the dimensions of the transport unit are in an acceptable range.

Concerning basic handling and communication, there is not much difference between the various types of assignments.

In particular, infeeds, outfeeds and relocations are completely equal; the only difference between them is the kind of the source and destination positions (infeed: interface position to rack position, outfeed: rack position to interface position, etc).

Notes:

1. It is the task of the MFCS to define which crane has to execute an assignment, if more than one crane would be physically able to do this.
2. A crane can only execute one assignment at a time. If the MFCS sends another assignment while the crane still has one, the crane rejects this additional one.
3. Whenever an assignment is terminated on the subsystem, an ACP is sent to MFCS. This is done no matter whether the assignment was successful or not, or who has terminated the assignment and why.
4. The only way to create an assignment on the crane is to send an ARQ telegram (from MFCS)
5. Assignments on the crane can be deleted in the following ways:
   5.1. If the crane completes an assignment successfully, then the crane controller deletes the assignment automatically. An ACP with return code 000 is sent to the MFCS then.
   5.2. If the assignment parameters are invalid, so that the assignment cannot be started correctly at all, then the crane controller deletes the assignment automatically. An ACP with a return code that indicates the specific error (this is other than 000) is sent to the MFCS then.
   5.3. If MFCS or SPOC sends a ‘delete assignment’ telegram and the crane is in mode ‘stopped’, then the crane controller deletes the corresponding assignment. An ACP with a specific return code is sent to the MFCS in this case.
   The crane controller does not execute the delete request if the crane is not stopped. It is

the operator's responsibility to make sure that the deletion of active assignments does not lead to system errors (e.g. deleting an assignment without removing the transport unit from the crane).

Note that an ACP is sent to the MFCS in any case, whenever an assignment is terminated. This also means, that, if an ACP is sent, the assignment does not exist any more on the crane.

6. In most plants only a subset of the possible assignment types are really needed. If an assignment type is not usable since this functionality is just not required, or there is no appropriate hardware, it does not have to be implemented in a particular plant.

In the following sections, only "normal" cases are described. Handling of errors is described below. It is assumed that the crane to be used for the assignment is up and running, and not already executing another assignment.

5.2.2. Position a crane

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present.
1	ARQ(PO)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the starting position.
3	ACP	Crane to MFCS	When the crane has arrived at the destination position, the assignment is finished, and an ACP is sent back to MFCS.
4			The crane is ready to accept the next assignment.

Notes:

1. The "position crane" assignment can be used to intentionally move a crane to another aisle for cranes that are able to change aisle.
2. This assignment can be used while a crane is loaded or unloaded.

5.2.3. Complete move

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present. No transport unit is on the fork(s). A transport unit is located at the source position. No transport unit is located at the destination position.
1	ARQ(CM)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the source position. The crane performs any necessary checks to be able to safely pickup the transport unit from the source position. The crane picks up the transport unit.
3	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is picked on the crane.

No	Telegram	Communication	Description
4			The crane moves to the destination position. The crane performs any necessary checks to be able to safely dispose the transport unit at the destination position. The crane disposes the transport unit.
5	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is deposited in the HBW or on another position.
6	ACP	Crane to MFCS	When the crane has disposed the transport unit, the assignment is finished, and an ACP is sent back to MFCS.
7			No transport unit is on the fork. The crane is ready to accept the next assignment.

5.2.4. Pickup

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present. No transport unit is on the fork to be used. A transport unit is located at the source position.
1	ARQ(PI)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the source position. The crane performs any necessary checks to be able to safely pickup the transport unit from the source position. The crane picks up the transport unit.
3	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is picked on the crane.
4	ACP	Crane to MFCS	When the crane has picked up the transport unit, the assignment is finished, and an ACP is sent back to MFCS.
5			One or more transport units are on the fork. The crane is ready to accept the next assignment.

5.2.5. Deposit

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present. One or more transport unit(s) are on the fork to be used. No transport unit is located at the destination position.
1	ARQ(DE)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the destination position. The crane performs any necessary checks to be able to safely

No	Telegram	Communication	Description
			dispose the transport unit at the destination position. The crane disposes the transport unit.
3	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is deposited in the HBW or on another position.
4	ACP	Crane to MFCS	When the crane has disposed the transport unit, the assignment is finished, and an ACP is sent back to MFCS.
5			No transport units are on the fork. The crane is ready to accept the next assignment.

5.2.6. Location request

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present
1	ARQ(LR)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the starting position. The crane performs the necessary checks to be able to determine whether the position is occupied or not.
3	ACP	Crane to MFCS	When the crane has determined the state of the destination position, the assignment is finished, and an ACP is sent back to MFCS, containing this state in the data.
4			The crane is ready to accept the next assignment.

Notes:

1. The "location request" can only determine whether there is a transport unit at the given position. No measurement or scan is performed.
   If more information is needed, PM type assignments must be used.
2. This assignment can be used while a crane is loaded or unloaded.

5.2.7. Pickup and measure

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present. No transport unit is on the fork to be used. A transport unit is located at the source position.
1	ARQ(PM)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the source position. The crane performs any necessary checks to be able to safely pickup the transport unit from the source position.

No	Telegram	Communication	Description
			The crane picks up the transport unit.
3			The crane performs the applicable measurements and scans.
4	CSR CSR	Crane to Move Crane to Spoc	occupied empty
5	ACP	Crane to MFCS	The assignment is finished, and an ACP is sent back to MFCS. This also contains some data of the measurement. If a scanner is installed, an ACP telegram containing the scanner data is sent to the MFCS.
6			One or more transport units are on the fork. The crane is ready to accept the next assignment.

Notes:

1. What exactly can be measured depends on the hardware installed on the crane.
2. If a particular measurement cannot be executed because it is not foreseen (no hardware to perform the measurement), the results are reported as zero.
3. If a scanner is installed, the transport unit label is scanned, and the results are reported in a LAB telegram. If there is no scanner, nothing is scanned, and no LAB telegram is sent.

5.2.8. Complete move with check

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present. No transport unit is on the fork(s). A transport unit is located at the source position. No transport unit is located at the destination position.
1	ARQ(CC)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the source position. The crane performs any necessary checks to be able to safely pickup the transport unit from the source position. The crane picks up the transport unit.
3			The crane performs the applicable checks (measurements) on the transport unit.
4			Assuming that the checks were ok: The crane moves to the destination position. The crane performs any necessary checks to be able to safely dispose the transport unit at the destination position. The crane disposes the transport unit.
5	CSR	Crane to Move	Move knows that the TU is picked on the crane.

No	Telegram	Communication	Description
	CSR	Crane to Spoc	
6	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is deposited in the HBW or on another position.
7	ACP	Crane to MFCS	When the crane has disposed the transport unit, the assignment is finished, and an ACP is sent back to MFCS.
8			No transport unit is on the fork. The crane is ready to accept the next assignment.

Notes:

1. What exactly can be measured and checked depends on the hardware installed on the crane.
2. The terminating ACP does not contain measurement information. If this information is needed by MFCS, a PM assignment followed by a DE assignment must be used.

Variant: the check fails.

Steps and Telegrams:

No	Telegram	Communication	Description
			... start as above
3			The crane performs the applicable checks (measurements) on the transport unit.
4			Assuming that the checks were not ok: The crane stays at the source position.
5	CSR CSR	Crane to SPOC Crane to MFCS	The crane sends an status report telegram to SPOC and MFCS, containing mode "stopped" and status code "pickup check failed" (145 to 149).
6	DER	MFCS to Crane	Since the old assignment cannot be executed correctly, it has to be deleted.
7	DEC	Crane to MFCS	The crane confirms the deletion of the assignment.
8	ACP	Crane to MFCS	The crane reports termination of the original assignment to MFCS. This ACP contains an error code "Assignment deleted by DER" (001).
9	STA	MFCS to Crane	MFCS sends a start telegram for the crane to set it back to automatic mode.
10	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS, mode automatic, no assignment, no error.
			… see below for how this goes on …

Notes:

1. Since this is a non-fatal error in most circumstances, the crane can be restarted remotely from MFCS/SPOC without the needs for manual intervention on the crane itself.

2. Of course there may be situations where the load cannot be transported at all; in this case, manual intervention cannot be omitted.

At this stage, the crane is either loaded or unloaded. The situation depends on what exactly is wrong with the transport unit. The CSR telegrams in step 10 above contain the information whether the crane is now loaded or not. The procedure to continue from here depends on this:

A. Crane is not loaded after detecting a problem:

Steps and Telegrams:

No	Telegram	Communication	Description
10	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS, mode automatic, no assignment, unloaded, no error.
11			Since the crane has not yet picked up the transport unit, it is ready to accept the next assignment.

B. Crane is loaded after detecting a problem:

Steps and Telegrams:

No	Telegram	Communication	Description
10	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS, mode automatic, no assignment, loaded, no error.
11	ARQ(DE)	MFCS to Crane	Since the original assignment is not usable, but the load is already on the fork, a new deposit order is sent from MFCS. The deposit position is of course different to the one before. What exactly can be used depends on the physical situation. Possible variants: - The outfeed conveyor position – The original source position
12			The crane moves to the new destination position. The crane performs any necessary checks to be able to safely dispose the transport unit at the destination position. The crane disposes the transport unit.
13	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is deposited in the HBW
14	ACP	Crane to MFCS	When the crane has disposed the transport unit, the assignment is finished, and an ACP is sent back to MFCS.
15			No transport unit is on the fork. The crane is ready to accept the next assignment.

5.2.9. Handling of double loads and TUs with different sizes

5.2.9.1. Generals

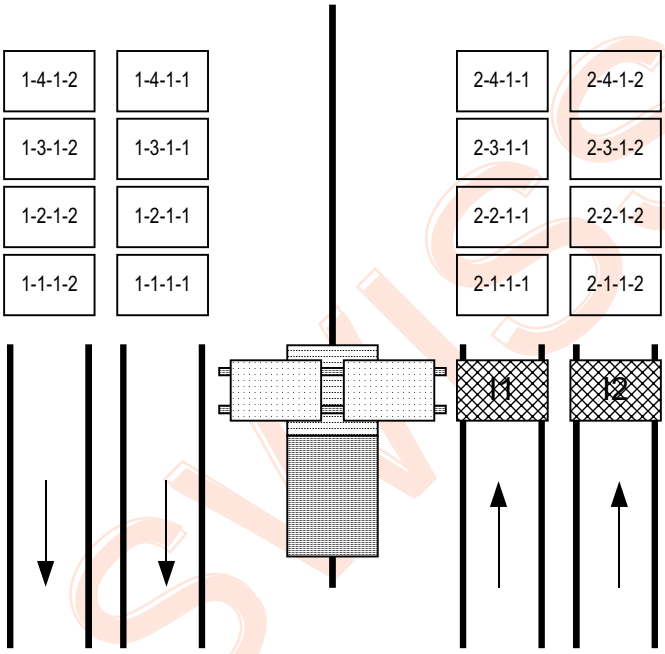
When cranes are able to handle not only single uniformly shaped transport units, but either various different TU types, or multiple TUs at a time on the same fork, it is essential that the assignment information also contains information about how to pickup the transport unit onto the fork, or how to deposit it from the fork.

This in particular covers the following cases:

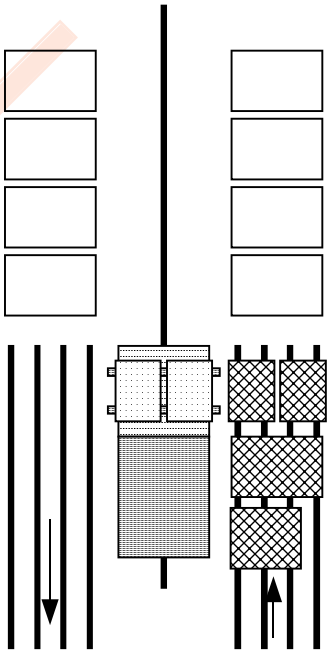
- Cranes that are able to load two TUs besides each others on the same fork, or one TU either on the left side or on the right side of the fork. This is often used with double deep storage.
- Plants where there are various types of transport units that have different dimensions in the rack depth direction (along the direction of the fork movement).

This section contains a description of the behaviour when using one fork. The case of two individual forks is described in section 5.2.11. Double Fork Handling

Of course, double deep storage (or even deeper) is also possible with cranes that are only able to handle one single uniform TU at a time. This however is nothing special than "normal" assignments; the depth field in the rack position specifies where exactly the TU should be disposed to or picked up from.



Double deep storage with uniform TUs



Usage of half TUs or TUs with different sizes

5.2.9.2. Types of Movements, Restrictions

The following movement types are possible:

- moving two transport units as a whole (PI, DE, CM, however the movements involving checks are not very useful).
- moving one single transport unit (all types of assignments)
- picking up one transport unit at one position, then picking up another transport unit at another position; disposing both together or individually.

This however cannot be done in one assignment. There must be at least three individual assignments executed in sequence:
1. PI assignment for the first TU
2. PI assignment for the second TU
3. DE assignment for both TUs
or
3. DE assignment for one of the TUs
4. DE assignment for the other TU

- when loaded with two transport units: disposing one transport unit at one position, then disposing the other transport unit at another position. This also requires individual DE-assignments.

There are different types of crane forks:

- On a rigid fork, when a load is picked up, it cannot be moved (on the fork) any more
- On a dynamic fork (usually equipped with a chain or a similar device), a load may be moved to the left or the right.

This has implications on the way how pickups and deposits of single TUs or half TUs may be done. In particular with rigid forks, some movements are simply not possible due to physical constraints. For details, see below.

For dynamic forks, almost all movements are possible - except of course things like picking up the farther TU while leaving the nearer TU in the rack.

5.2.9.3. Specification

In the ARQ, the field "Fork Side" is used to specify on which side of the fork the TU should be positioned after pickup, or - for deposits - on which side of the fork the TU to be disposed is currently positioned.

RI: The TU should be picked up to, or deposited from, the right side of the fork.

LE: The TU should be picked up to, or deposited from, the left side of the fork.

FU: The TUs should be picked up to, or deposited from, the full fork. If two TUs fit onto the fork, this means that two TUs should be handled simultaneously.

The "TU type" field defines which type of TU is involved, this in particular specifies the dimensions, and therefore how far the fork must be extended for pickup and deposits, and also, whether one or two TUs fit onto one full fork.

The TU types and their meanings must be defined specifically according to the needs of the plant.

Note also that the "nearer" and "farther" position in the rack or on the infeed or outfeed conveyors have different position addresses, so the ARQ clearly specifies which TU to pick, or where to dispose the TU, and how to do this. If two TUs should be picked up together, the depth part of the position address should specify the "farther" position.

Assuming that for TU type 01, only one fits onto the fork, and this fills up the whole fork:

TU type	Pick Pos	Fork Side	Movement
01	-01	RI	(not used; since the TU fills the whole fork, this is not reasonable)
01	-01	LE	(not used; since the TU fills the whole fork, this is not reasonable)
01	-01	FU	Pick one TU from the position near to the crane onto the (full) fork

01	-02	RI	(not used; since the TU fills the whole fork, this is not reasonable)
01	-02	LE	(not used; since the TU fills the whole fork, this is not reasonable)
01	-02	FU	Pick one TU from the position away from the crane onto the (full) fork

Assuming that for TU type 02, only one fits onto the fork, but this does not fill up the whole fork:

TU type	Pick Pos	Fork Side	Movement
02	-01	RI	Pick one TU from the position near to the crane onto the right side of the fork
02	-01	LE	Pick one TU from the position near to the crane onto the left side of the fork
02	-01	FU	(not used; since the TU does not fill the whole fork, it must be positioned either left or right)
02	-02	RI	Pick one TU from the position away from the crane onto the right side of the fork
02	-02	LE	Pick one TU from the position away from the crane onto the left side of the fork
02	-02	FU	(not used; since the TU does not fill the whole fork, it must be positioned either left or right)

Assuming that for TU type 03, two TUs fit onto the fork:

TU type	Pick Pos	Fork Side	Movement
03	-01	RI	Pick one TU from the position near to the crane onto the right side of the fork
03	-01	LE	Pick one TU from the position near to the crane onto the left side of the fork
03	-01	FU	(not used; since when picking two TUs, the farther position should be specified)
03	-02	RI	Pick one TU from the position away from the crane onto the right side of the fork
03	-02	LE	Pick one TU from the position away from the crane onto the left side of the fork
03	-02	FU	Pick two TUs together

There is a special document "SIS Crane Interface – Additional Comments and Examples" which contains detailed examples of such assignments.

Notes:

1. Pickups from the left or right side are handled equally, with mirrored meanings of position depth specifications.
2. For deposits to either side, these definitions are applied in a similar way. The deposit position in the ARQ specifies exactly on which position to dispose the TU.
3. Pickups from / deposits into rack positions or infeed / outfeed conveyor positions are handled equally.

4. Complete moves with one or two TUs are only possible if the fork is empty to start with.
5. The TU types in the description above are only examples. In particular, there might also be other TU types describing other transport units. The exact meaning of these is plant specific.
6. The same TU type is used, regardless of whether just one TU, or two TUs together are involved. In cases where – according to the TU type – one or two TUs might be involved, the fork side contains the necessary information about how many TUs are used.
   (See the example above: TU type 03 is such as the crane may pick up either one or two:
   In this case, if fork side is LE or RI: one TU is picked, if fork side is FU: two TUs are picked).
   In other words: Do not use a "virtual" TU type (e.g. type 04 meaning two TUs of type 02)!
7. On infeed conveyors, transport units are usually presented to the crane on the position nearest to the crane, so usually pickups from the infeed conveyor are done with position -01.
   However, if two TUs are picked up together, the pickup address contains the depth field –02 (the farther position)
   In a rack, also a single TU may be picked up from position –02.
8. On outfeed conveyors, transport units are usually disposed by the crane to the conveyor position nearest to the crane, so usually deposits to the outfeed conveyor are done with position -01.
   However, if two TUs are disposed together, the deposit address contains the depth field –02 (the farther position)
   In a rack, also a single TU may be deposited to position –02.
9. For rigid forks, there are some physical constraints. For example, it is not possible to pickup a TU from the far left rack position to the left side of the fork, because the fork simply cannot be stretched out so far to the right to do this.

5.2.10. Double Half Transport Unit Handling

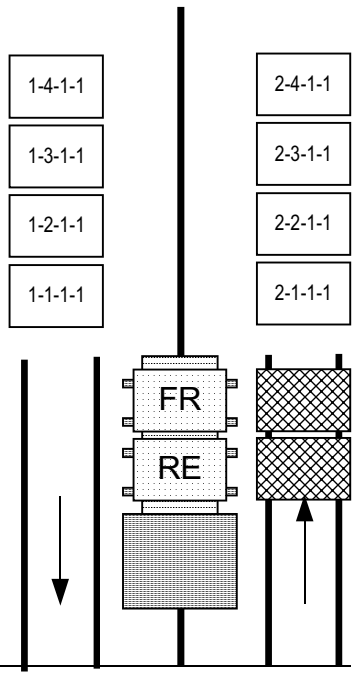
This is just an individual case of the section "5.2.9. Handling of double loads and TUs with different sizes", and requires no special description.

5.2.11. Double Fork Handling

The following description concerns an optional case. If a plant does not use cranes with double forks, this section is not relevant.

The SIS Crane Protocol supports cranes with one or two forks. For cranes with two forks, some additional requirements have to be considered, as follows:

1. For all assignments, it is possible to use only one fork as for single-fork-cranes. Movements with only one transport unit work almost exactly the same as for single-fork-cranes, except for the following:
   - In the assignment, the fork to be used must be clearly defined (either FR or RE, see the description of the telegram)
   - Due to mechanical restrictions, it may be that some positions are not accessible by both forks (usually the positions farthest down the aisle are only accessible by the front fork, not by the rear one). This has to be considered by the MFCS.
2. For position assignments (type PO), the fork item in the ACP defines which fork will at the end be at the given position.



3. Two simultaneous deposits are possible, if there are two free locations adjacent to each other on positions that are really the same spacing away than the forks.
   For rack positions this is usually the case, if the compartment is wide enough to accommodate two or more transport units.
4. For a simultaneous deposit of two transport units, the assignment must specify "both forks". The deposit position given in the assignment defines the location of the rear transport unit; the front transport unit will be deposited at the location adjacent in front to the given position (usually the one with SSS+1).
5. Two simultaneous pickups are possible, if the two transport units are located just adjacent to each other on positions that are really the same spacing away than the forks.
   For rack positions this is usually the case, if the transport units have been disposed simultaneously, or at least could have been.
   For infeed conveyor positions, it depends on the conveyor whether this is possible or not.
6. For a simultaneous pickup of two transport units, the assignment must specify "both forks". The pickup position given in the assignment defines the location of the rear transport unit; the front transport unit will be picked up from the location adjacent in front to the given position (usually the one with SSS+1).
7. Complete moves with two transport units at a time are also possible, this is just a combination of simultaneous pickup and deposit.
8. Transports with two transport units, which are picked up simultaneously, but deposited one after the other (or vice versa) must be broken down into single moves, e.g. as follows:

   ARQ(PI) for two transport units →
   ← ACP
   ARQ(DE) for one of the transport units →
   ← ACP
   ARQ(DE) for the other one of the transport units →
   ← ACP

5.3. Error Handling

5.3.1. Types of errors

The following types of errors may be distinguished:

1. Logical errors: These are errors where the crane software detects something unexpected, and therefore stops the crane.
   The crane may just be restarted, and then retries the same operation. It may be that in the next attempt the operation succeeds, it may however also be that it fails again.
   It may also be that some assignment data must be corrected first, prior to restarting the crane.

   Examples of logical errors are:
   - timeouts
   - unexpected state of interface places (i.e. destination position occupied, source position empty)

   When handling these errors, the procedure may be different, depending on whether it is an error concerning material flow, or whether it is only an issue on the crane itself.

2. Physical errors: These are errors where there is a real mechanical or electrical damage on the crane. Such errors must be checked and corrected on the device itself. They usually have to be acknowledged on the crane controller itself.
   Just restarting the crane does not do anything.

   Examples of physical errors are:
   - motor overheat
   - security protected door open

Physical errors may be subdivided into "short term errors" and "long term errors":

- Short-term errors may be fixed in a short time so that no auxiliary strategies for the transport units currently on the crane, and therefore blocked by this error, are needed. The error is simply fixed, and then processing goes on as before.
- Long term errors may not be fixed within short time so that auxiliary strategies for the transport units currently on the crane, and therefore blocked by this error, are needed. These transport units must be moved (manually?) to somewhere else. In addition, the crane may not be considered for disposition by the MFCS. This may also impose restrictions on the availability of transport units usually accessible by this crane.

The decision whether a particular error is "short-term" or "long-term" must be taken by maintenance staff. How this is done, and what the effects are, is handled on MFCS/SPOC, this has no influence on the crane. Therefore, this is not discussed in detail here.

5.3.2. Handling of errors in general

Most of the errors (at least of the less serious errors) are not really errors, but only temporary states or badly adjusted load (e.g. misreading sensors, "flapping ears", shifted load and the like). After correcting this, it is possible to continue the assignment in the normal way. Therefore, the crane does not just terminate the assignment, but keeps it.

When an error occurs on the crane, normally the following sequence of actions takes place:

1. The crane goes to mode "stopped" with a specific error state, and sends a status report to SPOC and MFCS containing the specified Error State.

2. Someone must manually check the situation. This may involve the following:
   - check the load on the crane, in particular whether it is adjusted correctly
   - check whether there is really something at the pickup and deposit places

3a. If the situation can be (and has been) corrected manually, the pending assignment is reactivated by either
   - sending a start command from SPOC
   - turning a key (or similar device) on the crane
   - giving a command on the subsystem MMI

The crane will continue processing the original assignment.

On the MFCS, the original assignment is also processed normally.

3b. If the situation cannot be corrected manually, the pending assignment must be deleted by sending an assignment delete request.

The subsystem then aborts the assignment and sends an assignment complete message to the MFCS with an appropriate error code 001 (assignment deleted by DER).

It is then up to the MFCS to decide what to do next:

5.3.3. Pickup position empty

Main case: really no load at the pickup position.

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present. No transport unit is on the fork to be used. A transport unit is located at the source position.
1	ARQ(…)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the source position. The crane performs any necessary checks to be able to safely pickup the transport unit from the source position. The crane detects no load at the pickup place.
3	CSR CSR	Crane to SPOC Crane to MFCS	The crane sends a status report telegram to MFCS and SPOC, containing mode "stopped" and status code "pickup position empty".
4			An operator must check manually whether there is really no load at the pickup position, or whether this is just a misreading due to bad scanners or so.
5			Since there is really no load, the operator must perform "position unexpectedly empty" handling on SPOC. This corrects the appropriate data on MFCS.
6	DER	MFCS to Crane	Since the old assignment cannot be executed, it has to be deleted.
7	DEC	Crane to MFCS	The crane confirms the deletion of the assignment.
8	ACP	Crane to MFCS	The crane reports termination of the original assignment to MFCS. This ACP contains an error code " assignment DEC

No	Telegram	Communication	Description
			deleted by DEC" (001).
9			The crane has no assignment any more, but is still in state "stopped".
10	STA	SPOC to Crane	SPOC sends a start telegram for the crane.
11	CSR CSR	Crane to SPOC Crane to MFCS	When the crane has finished its start-up processing a status report (CSR) is sent to MFCS and SPOC
12			Still no transport unit is on the fork. The crane is ready to accept the next assignment.

Variant: there is a load at the pickup position, this was a misreading of the crane.

Steps and Telegrams:

No	Telegram	Communication	Description
			…start as above
5			If the operator detects that this is just a temporary problem, he performs the necessary corrections (clean the sensors, adjust the transport unit etc.). When the operator thinks the situation is ok, he can restart the crane from SPOC or from the crane controls.
6	STA	SPOC to Crane	SPOC sends a start telegram for the crane.
7	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS, mode automatic, no error.
8			The crane continues working on the assignment, i.e. picks up the transport unit. CSR telegrams will be sent as normal ….
9	ACP	Crane to MFCS	When the crane has finished the assignment in the way it should be done, an ACP is sent back to MFCS.
10			The crane is ready to accept the next assignment.

Notes:

1. It is also possible to start the crane from the crane controls or from the crane MMI; in this case no STA telegram comes from SPOC of course, but still a CSR is then sent to SPOC and MFCS.

5.3.4. Pickup position blocked by another transport unit

This is a case when the crane should pick up a transport unit from position MM-RRR-SSS-HH-02 (the position farther away from the aisle), but detects that there is unexpectedly a load on position MM-RRR-SSS-HH-01 (the position closer to the aisle). This can happen with double deep racks or when using half transport units.

Main case: really a load at position -01, but this is not the one that should be at -02.

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present. No transport unit is on the fork to be used. A transport unit is located at the source position.
1	ARQ(…)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the source position. The crane performs any necessary checks to be able to safely pickup the transport unit from the source position. The crane detects that there is a load at the position before the pickup position.
3	CSR CSR	Crane to SPOC Crane to MFCS	The crane sends a status report telegram to MFCS and SPOC, containing mode "stopped" and status code "outer load in rack at pickup inner".
4			An operator must check manually whether there is really a load at position -01, or whether this is just a misreading due to bad scanners or so.
5			Since there is really a load, and this is not the one that should be at position -02, the operator must perform "position blocked by another load" handling on SPOC. This corrects the appropriate data on MFCS.
6	DER	MFCS to Crane	Since the old assignment cannot be executed, it has to be deleted.
7	DEC	Crane to MFCS	The crane confirms the deletion of the assignment.
8	ACP	Crane to MFCS	The crane reports termination of the original assignment to MFCS. This ACP contains an error code "Assignment deleted by DER" (001).
9			The crane has no assignment any more, but is still in state "stopped".
10	STA	SPOC to Crane	SPOC sends a start telegram for the crane.
11	CSR CSR	Crane to SPOC Crane to MFCS	When the crane has finished its start-up processing, a status report (CSR) is sent to MFCS and SPOC.
12			Still no transport unit is on the fork. The crane is ready to accept the next assignment.
13			Now, it is the task of the MFCS to do something useful. Depending on the actual situation, there are two possible ways to continue: 1. Search for another transport unit that can be used instead of the original one, and get this one out. Leave the original transport unit in the rack. At some convenient time, send another assignment to get this blocking transport unit out to an inspection place. 2. Immediately submit an assignment to remove the blocking transport unit, and dispose it either at a spare location in the

No	Telegram	Communication	Description
			rack, or send it immediately out to an inspection place. When this has been done, re-send the original assignment to get the load originally requested out.

Variant 1: there is no load at the position in front, this was a misreading of the crane.

Steps and Telegrams:

No	Telegram	Communication	Description
			…start as above
5			If the operator detects that this is just a temporary problem, he performs the necessary corrections (clean the sensors, adjust the transport unit etc.). When the operator thinks the situation is ok, he can restart the crane from SPOC or from the crane controls.
6	STA	SPOC to Crane	SPOC sends a start telegram for the crane.
7	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS, mode automatic, no error.
8			The crane continues working on the assignment, i.e. picks up the transport unit. CSR telegrams will be sent as normal ….
9	ACP	Crane to MFCS	When the crane has finished the assignment in the way it should be done, an ACP is sent back to MFCS.
10			The crane is ready to accept the next assignment.

Variant 2: there is a load at position -01, and this is the one that should be at -02.

Steps and Telegrams:

No	Telegram	Communication	Description
			…start as above
5			Since this is the load that should be at -02, the operator should pickup this load onto the crane using manual crane controls. When this is done, he can restart the crane from SPOC or from the crane controls.
6	STA	SPOC to Crane	SPOC sends a start telegram for the crane.
7	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS, mode automatic, no error.
8			The crane detects that the load has already been picked up, and therefore continues working on the assignment. CSR telegrams will be sent as normal. ….

No	Telegram	Communication	Description
9	ACP	Crane to MFCS	When the crane has finished the assignment in the way it should be done, an ACP is sent back to MFCS.
10			The crane is ready to accept the next assignment.

Notes:

1. It is also possible to start the crane from the crane controls or from the crane MMI; in this case no STA telegram comes from SPOC of course, but still a CSR is then sent to SPOC and MFCS.

5.3.5. Deposit position occupied

Main case: deposit position really occupied.

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present. No transport unit is on the fork to be used. A transport unit is located at the source position.
1	ARQ(…)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane moves to the source position, picks up the transport unit, and drives to the destination position. The crane performs any necessary checks to be able to safely dispose the transport unit at the deposit position. The crane detects a load at the deposit place.
3	CSR CSR	Crane to SPOC Crane to MFCS	The crane sends a status report telegram to MFCS and SPOC, containing mode "stopped" and status code "delivery position occupied".
4			An operator must check manually whether there is really a load at the deposit position, or whether this is just a misreading due to bad scanners or so.
5			Since there is really a load, the operator must perform "position unexpectedly occupied" handling on SPOC. This corrects the appropriate data on MFCS.
6	DER	MFCS to Crane	Since the old assignment cannot be executed correctly, it has to be deleted.
7	DEC	Crane to MFCS	The crane confirms the deletion of the assignment.
8	ACP	Crane to MFCS	The crane reports termination of the original assignment to MFCS. This ACP contains an error code "Assignment deleted by DER" (001).
9	STA	MFCS to Crane	MFCS sends a start telegram for the crane to set it back to automatic mode.
10	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS, mode automatic, no error.

No	Telegram	Communication	Description
11	ARQ(DE)	MFCS to Crane	A new deposit order is sent from MFCS. The deposit position is of course different to the one before.
12			The crane moves to the new destination position. The crane performs any necessary checks to be able to safely dispose the transport unit at the destination position. The crane disposes the transport unit.
13	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is deposited in the HBW or on another position.
14	ACP	Crane to MFCS	When the crane has disposed the transport unit, the assignment is finished, and an ACP is sent back to MFCS.
15			No transport unit is on the fork. The crane is ready to accept the next assignment.

Notes:

1. Depending on the implementation, it may also be in step 9 that the STA telegram is sent from SPOC, not from MFCS.

Variant: there is no load at the destination position.

Steps and Telegrams:

No	Telegram	Communication	Description
			…start as above
5			If the operator detects that this is just a temporary problem, he performs the necessary corrections (clean the sensors, adjust the transport unit etc.). When the operator thinks the situation is ok, he can restart the crane from SPOC or from the crane controls.
6	STA	SPOC to Crane	SPOC sends a start telegram for the crane.
7	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS
8			The crane continues working on the assignment, i.e. really deposits the transport unit. ….
9	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is deposited in the HBW or on another position.
10	ACP	Crane to MFCS	When the crane has finished the assignment in the way it should be done, an ACP is sent back to MFCS.
11			The crane is ready to accept the next assignment.

Notes:

2. It is also possible to start the crane from the crane controls or from the crane MMI; in this case no STA telegram comes from SPOC of course, but still a CSR is then sent to both SPOC and MFCS.

5.3.6. Other logical errors without mismatch of transport unit locations

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present.
1	ARQ(…)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane works on the assignment. At some time, the crane software detects a problem.
3	CSR CSR	Crane to SPOC Crane to MFCS	The crane sends a status report telegram to MFCS and SPOC, containing mode "stopped" and a status code describing the situation.
4			An operator must check manually what the situation is.
5			If the operator detects that this is just a temporary problem, he performs the necessary corrections (clean the sensors, adjust the transport unit etc.). When the operator thinks the situation is ok, he can restart the crane from SPOC or from the crane controls.
6	STA	SPOC to Crane	SPOC sends a start telegram for the crane.
7	CSR CSR	Crane to SPOC Crane to MFCS	An status report is sent to SPOC and to MFCS
8			The crane continues working on the assignment.
9	CSR CSR	Crane to Move Crane to Spoc	Move knows that the TU is deposited in the HBW or on another position.
10	ACP	Crane to MFCS	When the crane has finished the assignment in the way it should be done, an ACP is sent back to MFCS.
11			The crane is ready to accept the next assignment.

Notes:

1. It is also possible to start the crane from the crane controls or from the crane MMI; in this case no STA telegram comes from SPOC of course, but a CSR is then sent to both SPOC and MFCS.

5.3.7. Physical errors that can be handled in short time

This works in the same way as with logical errors without mismatch of transport units. After fixing the problem, the crane is just restarted, and continues its work.

For details, see above.

Note however that some errors cannot be reset by sending a STA command from SPOC. They have to be reset on the crane controller.

5.3.8. Physical errors that take a long time to correct

How much time it will take to fix a problem, and whether this is considered "long", is up to the maintenance staff.

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic", no assignment is present.
1	ARQ(…)	MFCS to Crane	MFCS sends the command to the crane.
2			The crane works on the assignment. At some time, the crane software detects a problem.
3	CSR CSR	Crane to SPOC Crane to MFCS	The crane sends a status report telegram to MFCS and SPOC, containing mode "stopped" and a status code describing the situation.
4			An operator must check manually what the situation is.
5			The operator detects that there is a problem on the crane, which most probably takes a long time to repair. On SPOC, the "set crane to long term error" handling must be performed. This is only a matter on SPOC/MFCS and maybe above, and does not exchange any telegrams with the crane subsystem.
6	DER	MFCS to Crane	It is advisable to delete the current assignment on the crane, and to move the transport unit currently on the fork manually to a defined place. The data on the MFCS has to be corrected accordingly.
7	DEC	Crane to MFCS	The crane confirms the deletion of the assignment.
8	ACP	Crane to MFCS	The crane reports termination of the original assignment to MFCS. This ACP contains an error code "Assignment deleted by DER" (001).
9			The crane must be repaired.
10	STA	SPOC to Crane	When the crane is ok again, SPOC sends a start telegram for the crane to set it back to automatic mode.
11	CSR CSR	Crane to SPOC Crane to MFCS	A status report is sent to SPOC and to MFCS, mode automatic, no error.
12			No transport unit is on the fork. The crane is ready to accept the next assignment.

Notes:

1. It is also possible to start the crane from the crane controls or from the crane MMI; in this case no STA telegram comes from SPOC of course, but still a CSR is then sent to both SPOC and MFCS.

5.4. Informational messages, status messages

5.4.1. Crane Status, spontaneous message from Crane

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in any mode
1	CSR CSR	Crane to SPOC Crane to MFCS	Something happens on the crane that changes its mode or its error status. The crane sends a status report telegram to MFCS and SPOC, containing the new current status.

Notes:

1. A CSR is sent to SPOC, and a CSR is sent to MFCS.
2. Whether this has any further effect on the behaviour of the crane, and whether the MFCS has to take special actions, depends on the error. This here is only a general description. For more information about possible errors that have effects, and what happens then, see section 5.3. Error Handling
3. A CSR is sent to MFCS and SPOC, each time any load status changes.

5.4.2. Crane Status, after requested from SPOC/MFCS

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in any mode
1	CRQ	SPOC to Crane	SPOC requests the current state of one crane or of all cranes.
2	CSR	Crane to SPOC	The crane sends a status report telegram for each requested crane.

Notes:

1. It is also possible to send a CRQ from MFCS. In this case, the CSR(s) will be sent to MFCS instead of SPOC.
2. If the PLC is in an error state, SPOC will receive the same error several times. SPOC detect this situation and do not execute each time the error program.

   After a CRQ telegram a single CSR telegram is returned back to the sender. (Chapter 6)

5.5. Handling of digital I/O

The usage of digital I/Os is highly plant-specific. In particular, the numbering of the I/O signals (i.e. which number means what) must be defined for each plant.

It is also possible that MFCS / SPOC do not consider digital I/Os at all. In this case, the following section, and the appropriate telegram descriptions, are not relevant.

However, if digital I/Os are to be used from MFCS/SPOC, this should be done in the way described below.

5.5.1. Reading digital I/O (inputs)

The SIS specifies two different ways to report information about the state of digital I/O signals from Crane to SPOC:

1. Polling from SPOC using IRQ (I/O Request) and ISR (I/O Status Report) telegrams; ISR contains a bitmap of the current state.
2. Reports of such events via SDI (Digital Input Notification).

The mapping of signal numbers to physical signals is defined plant-specific; since each plant looks different in this respect, there is no usable standard.

5.5.1.1. I/O Status Bitmaps

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in any mode
1	IRQ	SPOC to Crane	SPOC requests the current state of digital I/Os.
2	ISR	Crane to SPOC	The crane sends a bitmap of the requested statuses

5.5.2. Setting digital I/O (outputs)

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in any mode
1	SDO	SPOC to Crane	SPOC requests that a specific digital I/O is set to a particular state.
2			The crane controller sets this digital I/O to the requested state.

Notes:

1. It is also possible for the MFCS to set digital outputs.

5.6. Special tasks

5.6.1. Fire Alarm

Steps and Telegrams:

No	Telegram	Communication	Description
0			Crane is in mode "automatic"
1			The fire alarm relay in the crane control is activated.
2	CSR CSR	Crane to SPOC Crane to MFCS	The crane sends a status report telegram to MFCS and SPOC, containing mode "stopped" and status code "fire alarm".
3	(ACP)	Crane to MFCS	The current movement - if any - is finished. This may cause an ACP to be sent.
4			The crane drives to a configurable position.
5	CSR CSR	Crane to SPOC Crane to MFCS	When the crane has finished this movement, it goes to mode "manual" with status code "fire alarm". A status report is sent to SPOC and to MFCS

Notes:

1. If the crane was in mode "manual" or "stopped" to begin with, no movement takes place. Only step 5 is executed, i.e. mode is set to "manual", state "fire alarm", and a CSR is sent to SPOC and MFCS.
2. In the same way as if the crane is stopped while currently executing an assignment, it finishes the current movement. This may or may not cause the assignment to be finished; if it is finished, an ACP is sent to MFCS.
3. In theory, the crane should free the fork(s) to allow a better fire fighting. However, there are quite a lot of situations where disposing the load currently on the fork is not possible for the crane with the current information, therefore this is not done automatically just so.

6. Telegrams

6.1. Normal Assignment Telegrams

6.1.1. Assignment request, ARQ

Request from MFCS to Crane to initiate a transport assignment.

Sent from MFCS to Crane every time a new assignment should be started.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	ARQ	
Crane number	NUM 2	01-98	
Assignment ID	NUM 8	00000001 to 99999998	
Assignment type	ALPHA 2	PO: position CM: complete move PI: pickup DE: deposit LR: location request PM: pickup & measure CC: complete move with check	Depending on the installed hardware, some types cannot be used.
TU type	NUM 2	00-99: 00 if not used	project specific
Starting position	NUM 12	MM-RRR-SSS-HH-DD	Relevant for types PO, CM, PI, LR, PM, CC. Ignored for type DE
Destination position	NUM 12	MM-RRR-SSS-HH-DD	Relevant for types CM, DE, CC Ignored for types PO, PI, LR, PM
Fork	ALPHA 2	RE: rear fork FR: front fork BO: both forks	If there is only one fork, RE is used.
Speed	ALPHA 2	HI: high speed LO: low speed	Ignored, if the crane only supports one speed.
Rear Fork Side	ALPHA 2	LE: left side of fork RI: right side of fork FU: full fork	Default: FU for single fork Used for cases where multiple TUs can be placed on the fork, or one
Front Fork Side	ALPHA 2	LE: left side of fork RI: right side of fork FU: full fork -	Default: FU for single fork Used for cases where multiple TUs can be placed on the fork, or one TU does not completely fill the fork. - note 11

Notes:

1. If the data in the ARQ telegram is wrong, so that such an assignment just cannot be executed by the crane, an ACP is sent back immediately, containing an appropriate error code.
2. If the data is correct, the crane performs the necessary actions for the given assignment. When the assignment is finished, an ACP is sent back to MFCS.
3. The physical movements of the crane for each of the assignment types are:

Type	first to	then to	position when finished
PO, PI, LR, PM	Starting	-	Starting
CM, CC	Starting	Destination	Destination
DE	Destination	-	Destination

4. At the end, the crane retracts the fork(s), only then the assignment is considered finished. This is also true for assignments that end with a deposit movement.
5. For assignment type PO, the depth field in the position is ignored; the crane always ends with retracted forks (depth 00).
6. As long as there is still an assignment on the crane, the MFCS is not allowed to send another one. Otherwise, the crane will reject this.
7. If a single TU fitting onto the whole fork should be handled, fork side must be specified as "FU".
8. If a single TU not filling the whole fork should be handled, fork side must either be "LE" or "RI", indicating on which side of the fork the TU should be picked up to / deposited from.
9. If two TUs should be handled together, fork side should be specified as "FD". Cause the FD value, the crane can handle more complex load device such as chain/belt conveyor.
10. For pickups/deposits of two TUs together, the depth part in the pickup/deposit position must specify the outermost position of these TUs (usually depth 02)
11. Further codes have to be defined plant specific. E. g. for complex multi-load handling FD, etc.

6.1.2. Assignment completed, ACP

Answer from Crane to MFCS indicating that a specific transport assignment has been completed, aborted, or rejected.

Sent whenever an assignment is finished.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	ACP	
Crane number	NUM 2	01-98	
Assignment ID	NUM 8	00000001 to 99999998	
Crane position	NUM 12		Position where the crane is after the assignment is finished.
Load status rear fork left	ALPHA 2	LO: loaded; UL: unloaded	
Load status rear fork right	ALPHA 2	LO: loaded; UL: unloaded	
Load status front fork left	ALPHA 2	LO: loaded; UL: unloaded	
Load status front fork right	ALPHA 2	LO: loaded; UL: unloaded	
Return code	NUM 3	000: ok For other values: see special list.	
Number of TU's with info block	NUM 1	0-4: number of info blocks	0: No info block is appended
Fork	ALPHA 2	RE: rear fork FR: front fork	Used in case of multiple forks
Position on fork	ALPHA 2	LE: left side of fork RI: right side of fork	Used for multiple TU's on a fork
Result after location request	NUM 1	0: position free 1: position occupied	Only valid for an assignment type LR
load height	NUM 1	0: Default, if no photocell 1-8: Valid height categories 9: Not measured due to an error	Valid height categories as well as over-height to be defined by the projects
load width right	NUM 1	0: Default, if no photocell 1: Ok 2: Not ok 3-8: Project specific 9: Not measured due to an error	If there is more than one TU type leading to other values then Ok / Not ok (1 and 2), a project specific definition shall be agreed.
load width left	NUM 1	Ditto as "Width right"	Ditto as "Width right"

	load length front	NUM 1	Ditto as "Width right"	Ditto as "Width right"	
	load length back	NUM 1	Ditto as "Width right"	Ditto as "Width right"	
	load weight	NUM 7	0000000: no scale, not measurable 9999999: Not measured due to an error	Unit of measure: grams or as agreed by the projects Projects having no absolute values need to define "weight categories" and "over-weight" respectively	
	Scanner error	NUM 3	000: ok 001: no read … plant/scanner specific		
	Label length	NUM 3	length of the scanned label strings in this telegram	999: If not used	
	Label	ALPHA 18	scanner data as read	Length is plant specific	

Notes:

1. When an assignment on the crane is terminated for any reason (finished successfully, deleted by an operator, deleted by SPOC, not accepted at all, etc), an ACP is sent to MFCS.
2. If the data in the ARQ telegram is wrong, so that such an assignment just cannot be executed by the crane, or if there is already an assignment present, an ACP is sent back immediately, containing an appropriate error code.
3. An ACP indicates that this assignment does not exist on the crane any more. Non-fatal errors during the execution of an assignment, where the assignment may probably be restarted, are not reported via an ACP.
4. If single full pallets (or two half pallets together) are used, the load status left and load status right are identical.
5. The meaning of load "width left or right", "length front or back" can changes in depend of the pick side. So it is necessary to define this profile fields plant specific.
6. The "crane position" is transmitted as a full position number. The depth item is set to 00 to indicate retracted forks and not the value of the ARQ.
7. A "Return code" value 000 indicates a successful termination of the assignment. Other values indicate an error.
8. The possible return codes are defined in a separate list. Of course, not all defined values may really appear here. ACP related errors are:

   001 Assignment deleted by DER

   020 Job interruption
   021 Deposit location full
   022 Pickup location empty

   320 Load check
   321 Fork check
   322 Load failure after deposit

323	Load failure after pickup
400	Profile failure
401	Load too high
402	Load too wide
403	Load too long
404	Load too heavy
405	Other or combined failure
701	Crane busy with assignment
702	Crane not in AUTO
703	Position blocked
704	Position not accessible
705	Position not found
900	Invalid crane number
901	Invalid assignment ID
902	Invalid assignment type
903	Invalid TU type
904	Invalid starting position
905	Invalid destination position
906	Invalid fork
907	Invalid speed
908	Other error in ARQ

9. The ACP telegram can have a variable length. If one field of the information block is used the complete block is transmitted. For a single crane the length of an ACP telegram is 37 characters long.
10. Each info block is 47 characters long. (Except plant specific changes of the lable-info)
11. If the scanner should have read the label, but could not do this (unreadable label), a label string containing all dashes ('----------') is returned.
12. The field "label length" reflects the valid datastring length of all labels concatenated. Per default this field is not used, and is set to "999".
    This field allows you to use a fix telegramlength for a variable label or labels, without parsing.
13. The 18 characters are the recommended TU number length.

6.2. Data correction telegrams

6.2.1. Assignment delete request, DER

Request from MFCS/SPOC to Crane to delete an existing transport assignment.

Sent from MFCS/SPOC when a particular assignment should be deleted.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	DER	
Crane number	NUM 2	01-98	
Assignment ID	NUM 8	00000001 to 99999998	

Notes:

1. An assignment can only be deleted when the crane is in mode stopped or manual.
2. The crane will report a DEC as an answer to a DER.
3. If the assignment is really deleted, an ACP is sent back to MFCS to indicate that this assignment does not exist any more.
4. The error code in a ACP after a successful DER is always status "assignment deleted by DER"

6.2.2. Assignment delete report, DEC

Answer from Crane to MFCS/SPOC indicating that a transport assignment has been deleted, or that it cannot be deleted.

Sent from the crane as an answer to a DER.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	DEC	
Crane number	NUM 2	01-98	
Assignment ID	NUM 8	00000001 to 99999998	
Return code	NUM 3	000: ok For other values: see special list.	

Notes:

1. A "Return code" value 000 indicates a successful deletion of the assignment. Other values indicate an error.
2. The possible return codes are defined in a separate list. Of course, not all defined values may really appear here.
3. If the assignment is really deleted, an ACP is sent back to MFCS (in addition to this DEC) to indicate that this assignment does not exist any more.

6.3. Control telegrams

6.3.1. Start Crane, STA

Request from SPOC or MFCS to Crane to start an individual crane or all cranes of a subsystem.

Sent from SPOC or MFCS whenever a crane should be set to normal operation.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	STA	
Crane number	NUM 2	00: all cranes 01-98: one particular crane	

Notes:

1. Trying to start a crane, which is already in mode "automatic", does not change the mode of the crane.
2. Trying to start a crane, which is in mode "manual", does not change the mode of the crane. It stays "manual" and must be started on the crane controller or crane MMI.
3. If the crane has a serious error, it may be that an attempt to start a crane does not work. The crane then stays in mode "stopped".
4. The crane will report a CSR to MFCS and SPOC as an answer to a STA. If the STA command included all cranes, an individual CSR is reported for every single crane to MFCS and SPOC.
5. These CSRs are sent regardless of whether starting did work or not; the mode and return code in the CSR telegrams tell what the current state is.
6. The CSRs are sent to MFCS and SPOC, no matter who has sent the STA.

6.3.2. Stop Crane, STO

Request from SPOC or MFCS to Crane to stop an individual crane or a complete crane subsystem.

Sent from SPOC or MFCS whenever a crane should not work any more.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	STO	
Crane number	NUM 2	00: all cranes 01-98: one particular crane	

Notes:

1. If the crane is currently executing an assignment, it finishes the current movement before stopping. If this also finishes the whole assignment, an ACP is sent to the MFCS.
   If this does not finish the assignment, the assignment is still kept, and will be continued as soon as the crane is started again.
2. Trying to stop a crane, which is already in mode "stopped", does not change the mode of the crane.
3. Trying to stop a crane, which is in mode "manual", does not change the mode of the crane. It stays "manual" and must be started on the crane controller or crane MMI.
4. The crane will report a CSR to MFCS and SPOC as an answer to a STO. If the STO command included all cranes, individual CSR's are reported for every single crane.
5. These CSRs are sent regardless of whether stopping did work or not; the mode and return code in the CSRs telegrams tell what the current state is.
6. The CSRs are sent to MFCS and SPOC, no matter who has sent the STO.
7. A stop command may be overridden by local commands on the crane MMI.

6.4. Information telegrams

6.4.1. Crane status request, CRQ

Request from SPOC or MFCS to Crane to report the current status of a single crane or all the cranes.

Sent from SPOC or MFCS whenever information about the current state of the crane is needed.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	CRQ	
Crane number	NUM 2	00: all cranes 01-98: one particular crane	

Notes:

1. The crane will report a CSR to as an answer to a CRQ. If the CRQ command included all cranes, an individual CSR is reported for every single crane.

6.4.2. Crane status report, CSR

Information from Crane to MFCS/SPOC, containing the current status of a crane.

Sent from Crane at the following events:

To MFCS:
1. when the crane subsystem is started,
2. as an answer to a CRQ telegram,
3. when a crane changes error status or mode.
4. when load status changes

To SPOC:
1. when the crane subsystem is started,
2. as an answer to a CRQ telegram
3. when a crane changes error status or mode.
4. when load status changes

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	CSR	
Crane number	NUM 2	01-98	
Assignment ID	NUM 8	00000000 to 99999998	00000000 indicates "no assignment"
Crane mode	NUM 1	1: automatic 2: stopped 3: manual	
Crane position in aisle	NUM 6	000000 to 999999	Units: crane increments. The meaning of this value is plant specific.
Load status rear fork left	ALPHA 2	LO: loaded; UL: unloaded	
Load status rear fork right	ALPHA 2	LO: loaded; UL: unloaded	
Load status front fork left	ALPHA 2	LO: loaded; UL: unloaded	
Load status front fork right	ALPHA 2	LO: loaded; UL: unloaded	
Current aisle	NUM 2	00..99	00 indicates "not in an aisle"
Return code	NUM 3	000: ok For other values: see special list.	

Notes:

1. When the crane subsystem is started, and the communication to MFCS/SPOC is established, an individual CSR for every single crane is reported to MFCS/SPOC.

2. When a crane changes mode or error status, a CSR for this crane is reported to MFCS and SPOC.
3. When a CRQ request has been received from SPOC or MFCS, a CSR is reported as an answer. If the CRQ command included all cranes, an individual CSR is reported for every single crane.
4. If the CRQ came from SPOC, the CSR(s) is/are reported to SPOC, if it came from MFCS, the answer also goes to MFCS.
5. If the crane is currently not executing an assignment, a value 00000000 is returned for the assignment ID.
6. For a detailed discussion of the crane modes see section 5.1.1. Generals, Crane Modes
7. The crane position is returned in increments. The exact meaning is plant specific.
8. For cranes that are able to change their aisle, a value of 00 is returned, if the crane is currently not in a particular aisle.
9. A return code of 000 means that the crane does not have an error. A return code other than 000 means that there is an error situation on the crane. See the special list of crane codes for more information.
10. This telegram can be used for SPOC for the visualisation of the load status. It is plant specific to define, that SPOC use CSR or ISR telegrams.

6.4.3. Digital Input Notification, SDI

Information from Crane to SPOC that a specified digital input has changed its state.

Sent from Crane at the following events:
1. when a defined digital input changes its state.

Optional telegram, only used if digital input notification is used.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	SDI	
Signal number	NUM 4	0001-9999	Must be defined plant specific
Signal state	NUM 1	0: low, 1: high	
Return code	NUM 3	000: ok For other values: see special list.	

Notes:

1. The behaviour of the SDI telegram after start-up of the crane subsystem must be defined plant specific.

2. 6.4.4. Set Digital Output, SDO

Request from SPOC or MFCS to Crane to set a particular digital output to a given state.

Sent from SPOC or MFCS whenever a particular digital output should be set to a given value.

Optional telegram, only used if digital output setting is used.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	SDO	
Signal number	NUM 4	0001-9999	Must be defined plant specific
Signal state	NUM 1	0: low, 1: high	

Notes:

2. Only signal numbers that are defined to be usable output signals can be used in this way. An attempt to set an undefined signal is ignored by the crane.
3. The exact behaviour of a signal, i.e. whether a signal that has been set to a given state, will stay in this state until another SDO, or whether the crane subsystem itself may change this signal due to any reason, must be defined plant specific.
4. The states of the signals just after start-up of the crane subsystem must be defined plant specific.

6.4.5. I/O Status Request, IRQ

Request from SPOC to Crane to report the state of a range of digital signals.

Sent from SPOC whenever SPOC wants to know the state of a range of digital inputs, outputs or positions.

Optional telegram, only used if digital input polling is used.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	IRQ	
Signal type	NUM 1	0: inputs, 1: outputs, 2: positions	see below
Starting signal number	NUM 4	0001-9999	see below
Data length	NUM 2	01..99	see below

Notes:

1. See the description of the ISR telegram for more information about the "signal type", "starting signal number" and "data length" signals.

6.4.6. I/O Status Report, ISR

Information from Crane to SPOC, containing the state of digital signals.

Sent from Crane when an IRQ request has been received from SPOC.

Optional telegram, only used if digital input polling is used.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	ISR	
Signal type	NUM 1	0: inputs, 1: outputs, 2: positions	see below
Starting signal number	NUM 4	0001-9999	see below
Data length	NUM 2	01..99	see below
Information	ALPHA 99	99 hex characters	see below

Notes:

1. If "signal type" is 0, the state of digital inputs is reported.
   If "signal type" is 1, the state of digital outputs is reported.
   "Signal type" 2 is not relevant for the crane subsystem.
2. The "information" field contains the status of a range of digital input signals, digital output signals, or positions; starting with the signal or position number as specified in "starting signal number".
3. Each character in the "information" field contains the state of four successive signals, coded as a four-bit hex character as follows:

Value	Sig. n+3	Sig. n+2	Sig. n+1	Signal n
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
B	1	0	1	1
C	1	1	0	0
D	1	1	0	1
E	1	1	1	0
F	1	1	1	1

4. The "data length" item specifies how many characters in the "information" field are relevant.
5. Since each character in the "information" field contains the state of four signals, the whole information contains the state of four times "data length" signals.

6. The "information" field always contains 99 characters. If less information is requested or available, it is padded with zeroes at the end.
7. Undefined or unavailable signals are returned with state 0.

Example:

If "starting signal number" is 0291, and "data length" is 03, then
- information[0] contains the state of 0291..0294
- information[1] contains the state of 0295..0298
- information[2] contains the state of 0299..0302
- information[3] and following contain all zeroes

6.4.7. Auxiliary Message, MSG

Information from any sender (Crane, MFCS or SPOC) to any receiver, containing plant specific data.

Sent whenever the partner system should be informed about a plant specific event.

Optional telegram, only used if specified in the plant specification.

Layout of the telegram:

Data description	Field type	Value	Remarks
Telegram type	ALPHA 3	MSG	
Subtype	NUM 3	000-999	Must be defined plant specific
Information	CHAR n	Plant specific	The length and structure of this item must be defined

Notes:

1. This telegram is assigned for cases that cannot be handled by the standard SIS crane telegrams.
2. Most plants should be able to work without this MSG telegram. This telegram is assigned to have a standard way to specify required extended functionality, to prevent every plant from defining something of their own.
3. If it is used, there must be a project specific extension document to this standard SIS Crane Interface document, describing exactly:
   - which subtypes are used

   For each subtype:
   - what is the length, structure, and meaning of the "information" field
   - who is sender, and in which case this telegram is sent
   - who is receiver, and what exactly the receiver should do then.
4. Before such telegrams are defined in a project, the people responsible for the Swisslog Automation Concept and the Swisslog Interface Standard should be involved in the design and specification. There might be cases that are general enough to be implemented by a next version of the standard SIS Crane Interface, and not by project specific extensions.

7. Return Codes in Telegrams (Error List)

Whenever the crane subsystem encounters an error of any type, the appropriate return code is reported in the ACP, or CSR telegram.

The possible values of the return codes are the same for all telegrams and situations.

Note:

1. For specific implementations it may be that other codes than the ones defined in the error file may be returned under certain conditions.
2. Swisslog offer a template file on the Swisslog Intranet with common return codes. This file should be used. This file structure is used to load errors into the SPOC database as template.
3. Defined plant specific return codes has to implement in this file. The error code file belongs to the plant documentation.

7.1. General errors

Definition of code 000:

Return Code	Text	Used with	Description
000	OK, no error	any	No error, everything is ok.