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Tractors and machinery for agriculture and forestry — Serial control and communications data network —

Part 14: Sequence control

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

ISO 11783 consists of the following parts, under the general title *Tractors and machinery for agriculture and forestry — Serial control and communications data network*:

- *Part 1: General standard for mobile data communication*
- *Part 2: Physical layer*
- *Part 3: Data link layer*
- *Part 4: Network layer*
- *Part 5: Network management*
- *Part 6: Virtual terminal*
- *Part 7: Implement messages application layer*
- *Part 8: Power train messages*
- *Part 9: Tractor ECU*
- *Part 10: Task controller and management information system data interchange*
- *Part 11: Mobile data element dictionary*
- *Part 12: Diagnostics services*
- *Part 13: File server*
- *Part 14: Sequence control*

Introduction

ISO 11783 specifies a communications system for agricultural equipment based on the ISO 11898-1 protocol. SAE J1939 [1] documents, on which parts of ISO 11783 are based, were developed jointly for use in truck and bus applications and for construction and agriculture applications. Joint documents were completed to allow electronic units that meet the truck and bus SAE J1939 specifications to be used by agricultural and forestry equipment with minimal changes.

General information on ISO 11783 is to be found in ISO 11783-1. The purpose of ISO 11783 is to provide an open, interconnected system for on-board electronic systems. It is intended to enable electronic control units (ECUs) to communicate with each other, providing a standardized system.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this part of ISO 11783 may involve the use of a patent concerning the controller area network (CAN) protocol referred to throughout the document.

ISO takes no position concerning the evidence, validity and scope of this patent.

The holder of this patent has assured ISO that he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from:

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Tractors and machinery for agriculture and forestry — Serial control and communications data network —

Part 14: Sequence control

1 Scope

ISO 11783 as a whole specifies a serial data network for control and communications on forestry or agricultural tractors, mounted, semi-mounted, towed or self propelled implements. Its purpose is to standardize the method and format of transfer of data between sensors, actuators, control elements, information storage and display units whether mounted, or part of the tractor or any implement.

This part of ISO 11783 specifies a sequence control system, such as a headland management system, which includes tractor and implement functions in one system. The system allows recording of multiple sequences of operator-activated functions from a tractor or any other control function on the ISO 11783 network, and replaying them on operator command.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11783-1, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 1: General standard for mobile data communication*

ISO 11783-3, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 3: Data link layer*

ISO 11783-5, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 5: Network management*

ISO 11783-6, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 6: Virtual terminal*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11783-1 and ISO 11783-3 and the following apply.

3.1
abort
halt the sequence play back and immediately stop all motion initiated during the sequence

EXAMPLE The hitch stops at the current position.

3.2
active sequence control master
sequence control master selected by the operator to control the sequence control system

Note 1 to entry: Only one sequence control master (SCM) is permitted to be active at any time.

3.3
cancel
prematurely stop sequence recording

3.4
client command
action that is communicated by the sequence control client during recording and executed by the sequence control client if received during the play back of a sequence

EXAMPLE Start power take-off (PTO), stop PTO, open baler rear gate, close baler rear gate, sprayer master valve on, sprayer master valve off.

3.5
client function
mechanic, hydraulic or electric function of the tractor or implement that may be engaged/disengaged, started/stopped or changed by an operator action and may accept commands from the sequence control master during sequence play back

EXAMPLE PTO, hitch, auxiliary valves, baler rear gate, sprayer master valve.

3.6
disabled sequence control client
sequence control client that does not respond to state changes of the active sequence control master and therefore does not participate in sequence play back and recording

3.7
enabled sequence control client
sequence control client that has been selected by the active sequence control master to participate in sequence play back and recording

3.8
graphical representation object
object of the SCCWS's (sequence control client working set) object pool that is suitable to be referenced by SCD (sequence control data definition) objects in cases where the SCM (sequence control master) is required to display graphical information about the SCC (sequence control client), a client function or a function state

EXAMPLE A Picture Graphic object, a Rectangle object or a Polygon object would be suitable to be referenced by the Graphical representation attribute of an SCD state object.

3.9
inactive sequence control master
sequence control master connected to the system but not controlling the sequence control system

3.10
safe state
operating mode of a system with an acceptable level of risk for operator or bystander even when the control system fails or partly fails

3.11
sequence control client
SCC
control functions connected to the ISO 11783 network that provide client functions which may be used for sequence control

Note 1 to entry: The operator is able to activate these client functions manually by inputs such as the user interface soft keys, physical buttons or auxiliary control.

Note 2 to entry: The tractor may identify itself as SCC with its client functions, SCM or as both.

3.12
sequence control client working set
SCCWS
working set as defined in ISO 11783-6, where either the working set master and/or one or more working set members act as SCC

3.13
sequence control data definition
SCD
set of objects describing the recordable functions transferred by sequence control clients to the sequence control master including the function IDs, state IDs, preferred trigger method, icons for the visualization and function name for each of the functions supported

Note 1 to entry: Details are defined in Annex A.

3.14
sequence control master
SCM
controller of the sequence control system that initiates the recording and play back phase of sequences and stores the client commands received from the sequence control clients during recording with one of its provided trigger points

3.15
sequence control master object pool
SCMOP
VT (virtual terminal) object pool sent by the SCM providing the user interface for the interaction of the operator with the SCM

Note 1 to entry: VT and object pools are discussed in ISO 11783-6

3.16
sequence control client object pool
SCCOP
VT object pool sent by the SCCWS containing at least all the objects required by the SCM to display information from the SCC's SCD properly on the VT

Note 1 to entry: These objects are usually referenced in the SCMOP.

Note 2 to entry: VT and object pools are discussed in ISO 11783-6.

3.17
sequence control sequence
SCS
set of functions and/or actions performed by one or more sequence control clients in the system during the recording phase, including the related trigger information for the activation of the functions

3.18
sequence control system
SC
system with an SCM and one or more SCC performing the sequence control functionality as described in this part of ISO 11783

3.19
sequence control trigger
method to activate SCC functions in a sequence control sequence

EXAMPLE 1 For a time trigger, the SCM uses the time between two function activations of the sequence, independent of the distance driven as the method of a function's activation.

EXAMPLE 2 For a distance trigger, the SCM uses the distance driven between the activation of two functions as the method of a function's activation.

3.20
sequence number
number which uniquely identifies the sequence(s) in the SC communication, allowing the use of multiple sequences within one system

EXAMPLE The SCM supports one sequence for entering the headland (sequence number = 1) and one for leaving the headland (sequence number = 2).

3.21
textual representation object
object of the SCCWS's object pool that is suitable to be referenced by SCD objects in cases where the SCM needs to display textual information about the SCC, a client function or a function state

EXAMPLE An Output String object would be suitable to be referenced by the Designator attribute of an SCD.

3.22
transaction number
TAN
method to synchronize the command and response messages

Note 1 to entry: See 4.6 for further information.

4 Technical requirements

4.1 General

This part of ISO 11783 specifies a control system that enables machines to perform automatic functions such as headland turns or water way traverse control in the field. It allows the operator to automate a series of tractor and implement functions being performed each time while reaching or leaving for instance the headland; functions normally activated manually by the operator.

The sequence control system consists of a sequence control master and a number of sequence control clients communicating on the ISO 11783 network. This part of ISO 11783 defines the data formats, requirements and services used for the communication between the CFs participating in the sequence control system.

After an operator starts the recording phase of the SC, the operator activates all the client functions or actions to be automated in one sequence by using each SCC operator interface (recording of normal manual operation of the functions). The SCM receives on the ISO 11783 network the information about the activated client function or action from the CFs containing the client function (SCC) via client commands. The SCM then stores this activated client function information together with the sequence control trigger information assigned to be used for this function by the SCM. These stored sequences may then be replayed multiple times (e.g. on operator command). The SCM transmits the client command to the SCCs when the referring trigger point is reached after start of sequence replay. On receipt of an associated client command, the SCC performs the commanded client function or actions in the same way as if it were manually activated by the operator via the client's proprietary input. The SCCs are independent from each other; therefore, no direct communication between them is required.

Each sequence has a unique number within the SC; however, it is up to the SCM implementation to determine how operators can identify the individual sequences in case of support for multiple ones (e.g. associate proprietary names to each individual sequence). The SCM may group and save multiple sequences (e.g. one for approaching and one for leaving the headland) under a unique descriptor such as "Seeding". The SCM may indicate the recorded sequence(s) on the user interface with icons and/or text designators provided by the SCC(s) representing each function or action. Depending on the SCM implementation, it is possible for the operator to have the ability to manually define sequences or edit the sequences by changing the timing (trigger point) between the client functions or other function parameters. It is possible for the SCM to provide the ability for the operator to store and reload sequences for later usage using the same machine configuration (e.g. particular tractor-implement combination).

The SCM shall provide a means for setup of sequences (RECORD or EDIT) and to activate the play back of a selected sequence (PLAY BACK); the SCM may provide a means to the operator for SCM configuration (CONFIG).

The SCM may also provide a means to display the identified SCCs and their automated/recordable functions, actions and preferred trigger options for operator review. The SCM may provide a means to the operator to enable or disable certain SCCs (see Figure 9) available on the network to reduce the complexity of the system configuration during recording and edit, and also for reducing the busload. The SCM shall only include the enabled SCCs in the sequence management.

The support of a sequence control system may be implemented by any CF connected to the ISO 11783 network.

4.2 Sequence control user interface

The SCM shall provide a user interface for the purpose of warnings and needed operator interaction by connecting to the VT and uploading its main screen layout (object pool) accordingly (further details on VT and object pools are defined in ISO 11783-6).

To allow optional SCM features, like viewing sequence details, the SCCs have to provide the graphical and textual representation of their sequence control functions, etc. to the SCM. The availability of both a textual designator and a graphic for each SCD object gives the SCM implementation the freedom to be represented with text only, graphic only or a combination of both for displaying SCC objects.

This communication concept uses the External Object Pointer introduced with the VT version 5 (further details are defined in ISO 11783-6) to avoid the requirement that the SCM has to handle large graphic objects or language updates for the individual SCCs. This requires that the individual SCCs or their working set master load their graphic and text objects as part of their SCCOP into the same VT as used by the SCM and provide reference information only in their SCD to the SCM. The SCM adds External Object Pointer references in its data masks at the locations where such objects may be shown. These reference objects point to the objects in the referenced SCCOP to allow the VT to display the desired information in the screen of the SCM.

The SCM and the working set master of the SCCWSs shall connect and upload their object pool to the VT with the function instance 0 to avoid additional synchronization overhead on the VT of choice between the SCM and its SCCs. However, this can mean that an SCCWS has to maintain two VT connections in parallel in case the main operator interaction for the SCCWS is handled by an additional VT (function instance > 0) (see Figure 1). This concept of using the VT with the function instance 0 follows the Auxiliary Control definitions in ISO 11783-6 and allows the SCCWS to merge and share objects between both functionalities in one SCCOP. It also enables the SCC to use different languages and character sets for its representation by using the capabilities provided by ISO 11783-6 (e.g. use of Unicode in the textual representation objects) directly between SCC and VT without SCM interaction.

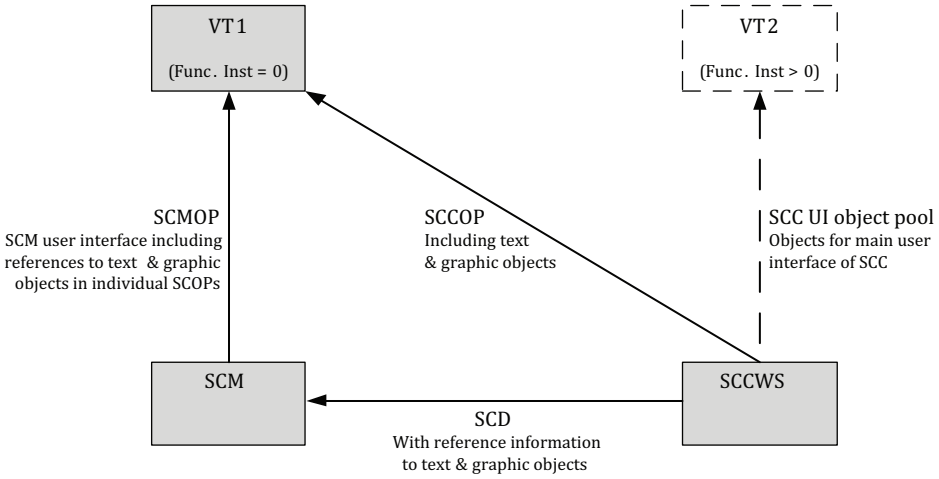

Figure 1 — User interface communication concept

4.2.1 User interface initialization

During initialization, the SCM uploads a new or reactivates its previous loaded object pool to the VT.

The SCM may use external object pointer references to the text and graphic objects in the SCCOP of its clients to display for instance sequence details (details on the external reference objects are defined in ISO 11783-6).

The external object pointer concept is NAME-based to ensure appropriate identification of the SCCOP and SCCWS in the object references. The SCMOP includes External Reference NAME Objects (details are defined in ISO 11783-6) to avoid the frequent communication of the complete NAME with each change of a reference to an object in an SCCOP. The communication of the SCM to the VT includes the two byte object ID of the External Reference NAME Object instead (see keys 22 and 25 in Figure 3).

The SCM has no means to check for the object type in the individual object references provided in the SCD. It knows the object IDs only. Therefore, it is the responsibility of the SCC to ensure the use of appropriate objects for the graphical and textual representation. SCMs shall provide provisions to deal with object references rejected by the VT.

NOTE 1 Despite the fact that multiple SCCs may be included in one SC and each one provides a number of references to different graphics and textual objects in a structure as shown in Figure A.2, the following example focuses only on an SC with one SCC and two referenced objects to explain the concept applying to all of those objects involved in a true system.

During the initial SCM object pool upload to the VT, the External Reference NAME Objects shall be disabled and the External Object Pointer object attributes shall be set to the NULL Object Id (see ISO 11783-6 for details).

Figure 2 shows an example of the object hierarchy in the Object Pools loaded into the VT for a simple SCC and an SCM connected to the VT. Key 31 represents the SCCOP including one text object (key 33) and one graphic object (key 34) in the VT's memory. The SCC also loaded its SCD (key 36) into the SCM memory; while the SCM transferred its default object pool into the VT memory (key 21). In this example, the SCM includes two external reference pointers in its screen layout (one graphic with key 23 and one text with key 24), both of which are disabled after start-up.

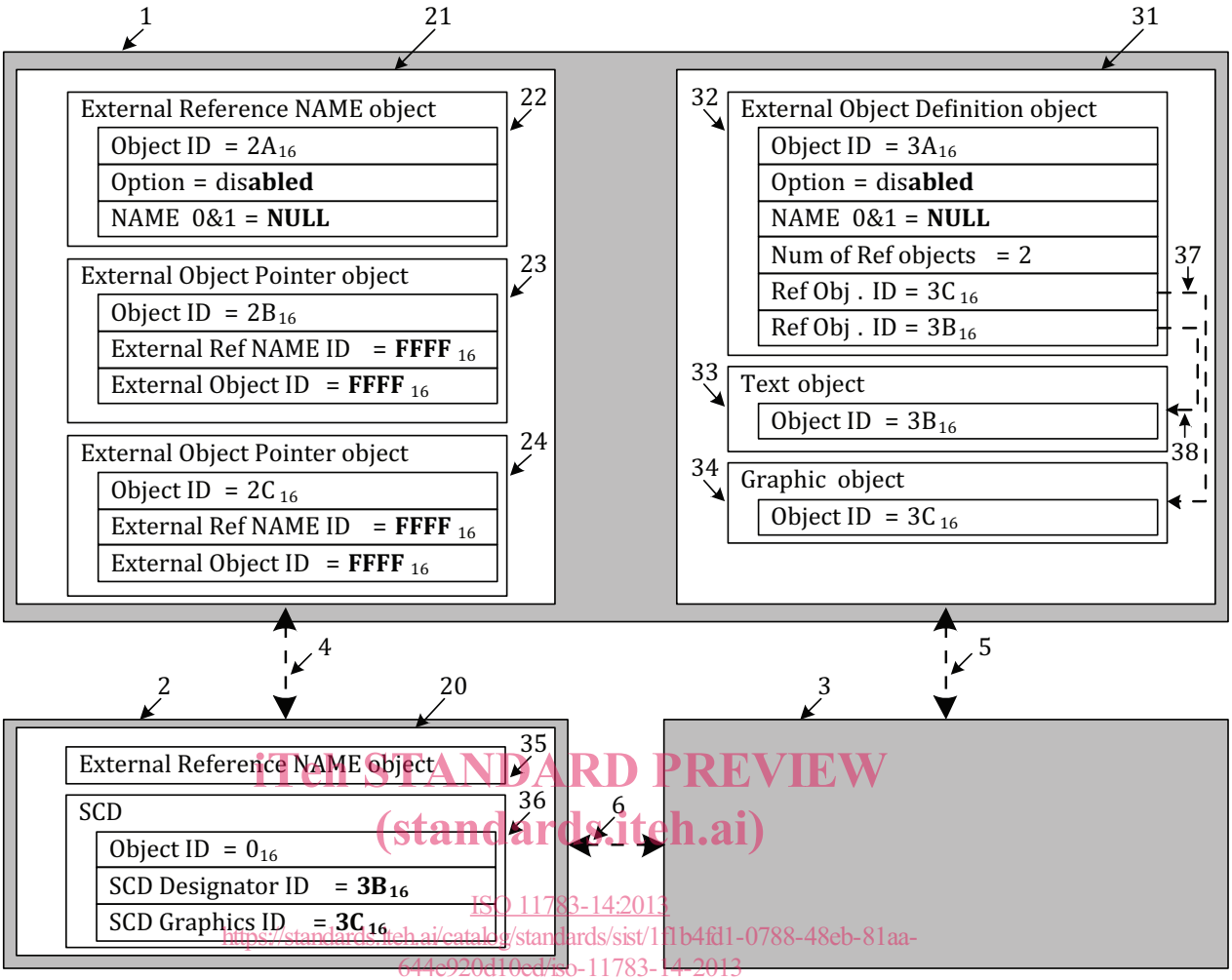

Figure 2 — Initial status of external object pointer — Example

NOTE 2 The keys for Figures 2 and 3 are listed under Figure 3.

The SCCWS shall validate the NAME of the active SCM followed by an update of the NAME field in its External Object Definition object (key 32) via Change Attribute command. The activation of the External Object Definition object (Option = enabled; key 32) allows the VT to establish references from the SCMOP to the defined referenced objects (key 37 and 38) in the SCCOP (key 31). Key 39 in Figure 2 represents the established reference to the SCMOP.

The SCM shall also validate the NAME of the referenced SCCs followed by an update of the related NAME field in its External Reference NAME object. The activation of the External Reference NAME object via Change Attribute command established the general connection to the SCCOP. Key 26 in Figure 2 represents the established reference to the SCCOP.

The SCM configures its External Object Pointer objects (key 23 and 24) with the reference data received in the SCD (key 36). Usually, two Change Attribute commands are needed per External Object Pointer object; one to set the ID of the External Reference NAME object (key 25) to point to the correct WSOP and the second to set the External Object ID (key 27 and 28) of the desired object.

Figure 2 shows the established references to a graphic object (e.g. a working set designator icon) and a text object (e.g. a working set designator) in the SCCOP of the connected SCC. The VT finds the referenced SCCOP for each External Object Pointer object in the screen layout of the SCM via keys 25 and 26 while key 39 allows a check if the SCC permitted the SCM to reference its objects. With an established reference to the SCCOP, the External Object IDs are unambiguously connected to the referenced objects. Keys 27 and 37 and 28 and 38 represent this connection, while going through the External Object Definition

object (key 32) reflects the additional checking for access permission; only objects listed in the External Object Definition object may be referenced.

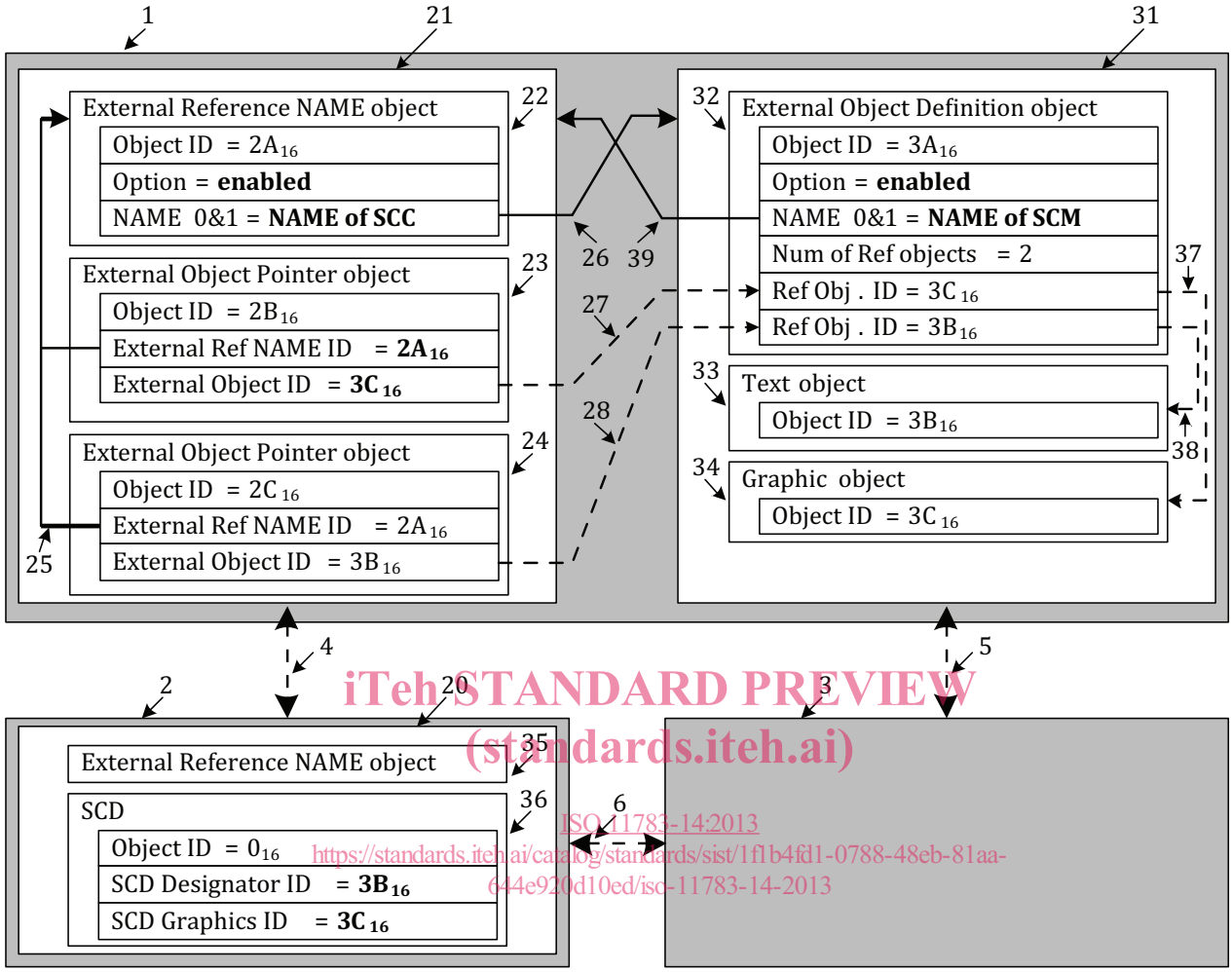

Figure 3 — Status of External Object Pointers after initialization — Example

Keys for Figure 2 and Figure 3:

1 VT Object Pool volatile memory

2 SCM

20 SCM volatile memory

21 SCM Object Pool

22 External Reference NAME object including NAME of referenced SCCWS;
one object per referenced SCCWS needed

23 External Object Pointer object to reference a graphic object (placeholder in the data mask)

24 External Object Pointer object to reference a text object (placeholder in the data mask)

3 SCC

31 SCCWS Object Pool

32 External Object Definition object defining the objects which may be referenced by the SCM specified in the NAME 0&1 attributes

33 Working Set Designator of SCCWS

34 Working Set Icon of SCCWS

35 NAME of SCC received through Address Arbitration

36 SCD of connected SCCWS

Keys for Figure 2 and Figure 3:

25 Virtual reference to External Reference NAME object to identify referenced Object Pool to VT

26 Virtual reference to the SCCOP established by the enabled External Object Pointer object in the SCMOP

27 Virtual reference to e.g. the Working Set Icon of SCCWS in SCCOP established by the enabled External Reference NAME and External Object Pointer

28 Virtual reference to e.g. the working set Designator of SCCWS in SCCOP established by the enabled External Reference NAME and External Object Pointer

37 Virtual reference to Working Set Icon that may be referenced by the SCM

38 Virtual reference to Working Set Designator that may be referenced by the SCM

39 Virtual reference to the SCMOP established by the enabled External Object Pointer object in the SCCOP

4 SCM-VT communication including SCMOP upload and attribute updates

5 SCCWS-VT communication including SCCOP upload and attribute update

6 SCC-SCM communication including addresses arbitration for NAME identification and SCD upload to SCM

4.3 Working sets with master/member configuration

In system configurations with a working set master and one or more working set members (as defined in ISO 11783-6), the responsibilities for the connections from the SCC to the VT and from the SCC to the SCM have to be considered separately.

4.3.1 SCC as working set master

In cases where an SCC is the working set master, the SCC is responsible for managing the VT connection as well as the connection to the SCM.

The SCCWS Master NAME field in the SCD basic object (defined in A.3) shall be set to the NAME of the SCC itself.

4.3.2 SCC as working set member

In cases where the SCC is a working set member, the SCC's working set master is responsible for managing the VT connection (its object pool is the SCCOP including graphical and textual objects referenced by the SCC in its SCD). The SCC is responsible for the connection to the SCM (including the SCD upload).

The SCC needs to know the object IDs of graphical representation objects and textual representation objects from the working set master's object pool to reference them in its SCD. The communication of this information is not subject of this part of ISO 11783.

The SCCWS Master NAME field in the SCD basic object (defined in A.3) shall be set to the NAME of the working set master.

4.4 Sequence management functionality

Sequence management functionality is described as logic entity of software residing in any CF connected to the ISO 11783 network.

The SCM may limit the access and sequence control data definition uploads of SCCs due to memory limitations or other restrictions. The SCM shall hold only one SCD per SCC in non-volatile memory.