BS ISO 11783-6:2018

BSI Standards Publication

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

Part 6: Virtual terminal

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National foreword

This British Standard is the UK implementation of ISO 11783-6:2018. It supersedes BS ISO 11783-6:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AGE/6, Agricultural tractors and forestry machinery.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

Part 6: Virtual terminal

Tracteurs et matériels agricoles et forestiers — Réseaux de commande et de communication de données en série —

Partie 6: Terminal virtuel

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

This fourth edition cancels and replaces the third edition (ISO 11783-6:2014) which has been technically revised. New requirements in this fourth edition are specified as VT version 6. Changes include clarifications to existing VT object and command behaviour, including additional capabilities. One Working Set in collaboration with another Working Set can transfer control of the active mask to the other with the Select Active Working Set command. Additional objects include a Colour Palette object, a Graphic Data object, a Scaled Graphic object, and a Working Set Special Controls object.

A list of all the parts in the ISO 11783 series can be found on the ISO website.

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Introduction

ISO 11783-1 to ISO 11783-14 specify a communications system for agricultural equipment based on the ISO 11898[5] 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. The specifications for virtual terminals given in this part of ISO 11783 are based on DIN 9684-4[2]. 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.

All phrases in this document that refer explicitly to a software term for an object or a command have the first letter of each object or command word capitalized (e.g. Output Linear Bar Graph object, Change Numeric Value command). This aides in the recognition of these terms as a specific item which has a specific definition in this document.

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

Part 6: Virtual terminal

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 sensor, actuators, control elements, information storage and display units whether mounted or part of the tractor, or any implements.

This document describes a universal virtual terminal that can be used by both tractors and implements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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 11783-7, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 7: Implement messages application layer*

ISO 15077, *Tractors and self-propelled machinery for agriculture — Operator controls — Actuating forces, displacement, location and method of operation*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
auxiliary input unit
autonomous control function (CF) providing Auxiliary Controls for common use that can also be physically located within an electronic control unit (ECU), or on the virtual terminal (VT)

3.2
object pool
collection of objects that completely define the operator interface for an implement or a single Working Set

Note 1 to entry: The complete VT definition will be made up of one or more object pools — one for each Working Set.

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3.3
Object ID
numeric value which identifies a specific object within an object pool

Note 1 to entry: Object ID values range from 0 to $FFFF_{16}$ (65535_{10}), with 65535 as the NULL Object ID.

3.4
attribute ID
AID
numeric value which references a specific object's attribute

Note 1 to entry: AID values range from 0 to FF_{16} (255_{10}), with 255 as the NULL_AID.

3.5
char
single character where the size is 1 byte

Note 1 to entry: Commonly used for ISO 8859 characters (e.g. 41_{16} in ISO 8859-1 represents "A") (see Annex K).

3.6
character
single text grapheme or symbol, as in an alphabet

Note 1 to entry: Size is variable based on the encoding scheme [see *char* (3.5) and *WideChar* (3.11)].

3.7
code plane
group of 65536 possible character codes

Note 1 to entry: Unicode/ISO 10464 organizes the characters in 17 code planes numbered 0 to 16.

EXAMPLE Code plane 0 covers characters 000000_{16} to $00FFFF_{16}$

Code plane 1 covers characters 010000_{16} to $01FFFF_{16}$

...

Code plane 16 covers characters 100000_{16} to $10FFFF_{16}$.

3.8
open input object
state of an input object where the object has focus and it is open for operator input

Note 1 to entry: Open input object is used interchangeably with data input.

3.9
selected input object
state of an input object where the object has focus but it is not open for operator input

Note 1 to entry: Selected input object is used interchangeably with "has focus".

3.10
surrogate pair
32 bit code for characters composed of a 16 bit high pair and a 16 bit low pair

Note 1 to entry: UTF-16 encoding of characters in code plane 1 to 16 (see 4.6.19.7).

Note 2 to entry: UTF-16 Character encoding scheme defined by ISO 10646.

3.11
WideChar
single character with a size of 2 bytes encoded in little endian order

EXAMPLE Byte sequence 41_{16}, 00_{16} represents "A" (see Annex K).

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Note 1 to entry: Two WideChars can be combined to indicate character codes exceeding 16-bit (see 4.6.19.7).

3.12
WideString
zero or more characters composed of the primitive type "WideChar" always preceded by the byte order mark $FEFF_{16}$

EXAMPLE Byte sequence FF_{16},FE_{16},41_{16},00_{16},42_{16},00_{16},43_{16},00_{16} represents "ABC". This WideString has a Length of 8 bytes with the number of characters in the presentation equal to 3.

3.13
8-bit string
zero or more characters composed of the primitive type "char"

Note 1 to entry: String length is variable.

3.14
VT Number
number that is used to uniquely identify each connected VT to the operator

Note 1 to entry: See 4.6.25 and D.18.

3.15
User-Layout Data Mask
special Data Masks that are controlled by the VT but laid out by the operator

Note 1 to entry: See 4.1 for information on data mask variations, and 4.7 for User-Layout Data Mask information.

3.16
Window Cell
rectangular presentation cell in a grid on a User-Layout Data Mask

Note 1 to entry: See 4.7.

3.17
Window Mask object
rectangular presentation area composed of one or more adjacent Window Cells

Note 1 to entry: See 4.7.

3.18
User-Layout Soft Key Mask
Soft Key Masks that are controlled by the VT but laid out by the operator

Note 1 to entry: See 4.7.

3.19
Key Cell
cell that is the size of a Soft Key designator in a User-Layout Key Mask

Note 1 to entry: See 4.7.

3.20
Key Group object
area of one or more Key Cells and contains a grouping of one or more Key objects

Note 1 to entry: See 4.7.

3.21
Non-VT Screen
display screen that is not part of the VT application or one in which the layout is controlled by the VT

EXAMPLE A screen that comes from another application within the display (see 4.7).

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3.22
Non-VT Area
visible area outside the normal Data Mask and Soft Key Mask areas

EXAMPLE A display of information related to the vehicle operation (see 4.7).

3.23
referenced WS
working set with an object pool containing objects which are shown by another object pool via the External Object Pointer object

Note 1 to entry: See 4.6.11.6.

3.24
referencing WS
working set with an object pool which shows object(s) from another object pool via the External Object Pointer object

Note 1 to entry: See 4.6.11.6.

3.25
Functionally Identical WS
Working Set(s) with a NAME that exactly matches other Working Sets, when the Self Configurable, Instance fields, and Identity Number are excluded in the comparison

3.26
Line End
"cursor" or text positioning control intended to locate the following displayable character "font height" pixels downward and at the left-most position in the containing object

Note 1 to entry: See 4.6.19.6.

3.27
Model Identification Code
proprietary code defined by the manufacturer that defines a unique model and version of an Auxiliary Input Unit that does not change at runtime, and is revised by the manufacturer when a new and incompatible Auxiliary Input Unit is created

4 Technical requirements

4.1 Overview

A virtual terminal (VT) is a control function (CF) within an electronic control unit (ECU), consisting of a graphical display and input functions, connected to an ISO 11783 network that provides the capability for a CF, composing an implement or a group of implements to interact with an operator. The VT provides the capability to display information and to retrieve data from an operator. The CF, as an implement or a group of implements represented by a Working Set Master acquires storage for objects within the VT and on demand displays this stored information to an operator. In this document, the term *Working Set* will be used for a CF, as an implement or a group of implements either represented by a single ECU or a group of ECUs acting as a Working Set. Working Sets on the network can also acquire the use of input methods of the VT to allow the operator to send signals back to the Working Set.

This document describes the VT with the detail and clarity required for VTs built by different manufacturers to be interchangeable with any implement Working Set that uses its services. The interface protocol of this document also reduces the run-time ISO 11783 communication bus traffic as much as possible. For these reasons, the requirements of this document are organized in an object-oriented manner with specific attributes and behaviour of each object clearly and fully defined. The required behaviour of the VT given certain situations is also detailed.

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In general, the functions, not the design, of the user interface of the VT are defined in order to avoid restrictions on possible designs. However, certain limitations are imposed in order to meet the goal of interchangeability between various manufacturers. Specifications regarding physical layout, components, processing power and the number of physical elements comprising a VT have been omitted in order to avoid restricting manufacturer's designs.

The VT shall have a pixel-addressable (graphical) display. Information from connected Working Sets is shown to the operator on the graphical display. This information is shown in display areas that are defined by Data Masks, Alarm Masks and Soft Key Masks. The data for these masks is contained in object definitions that are loaded into a VT via the ISO 11783 CAN bus, or from non-volatile memory. When the information defined by a mask is required on the display, the mask can be made visible by a single Change Active Mask command from the Working Set, and therefore does not require significant additional network traffic.

The physical size, resolution, orientation and methods of implementing the graphical display are at the discretion of the designer of the VT. Figure 1 shows examples of some possible VT designs and orientations.

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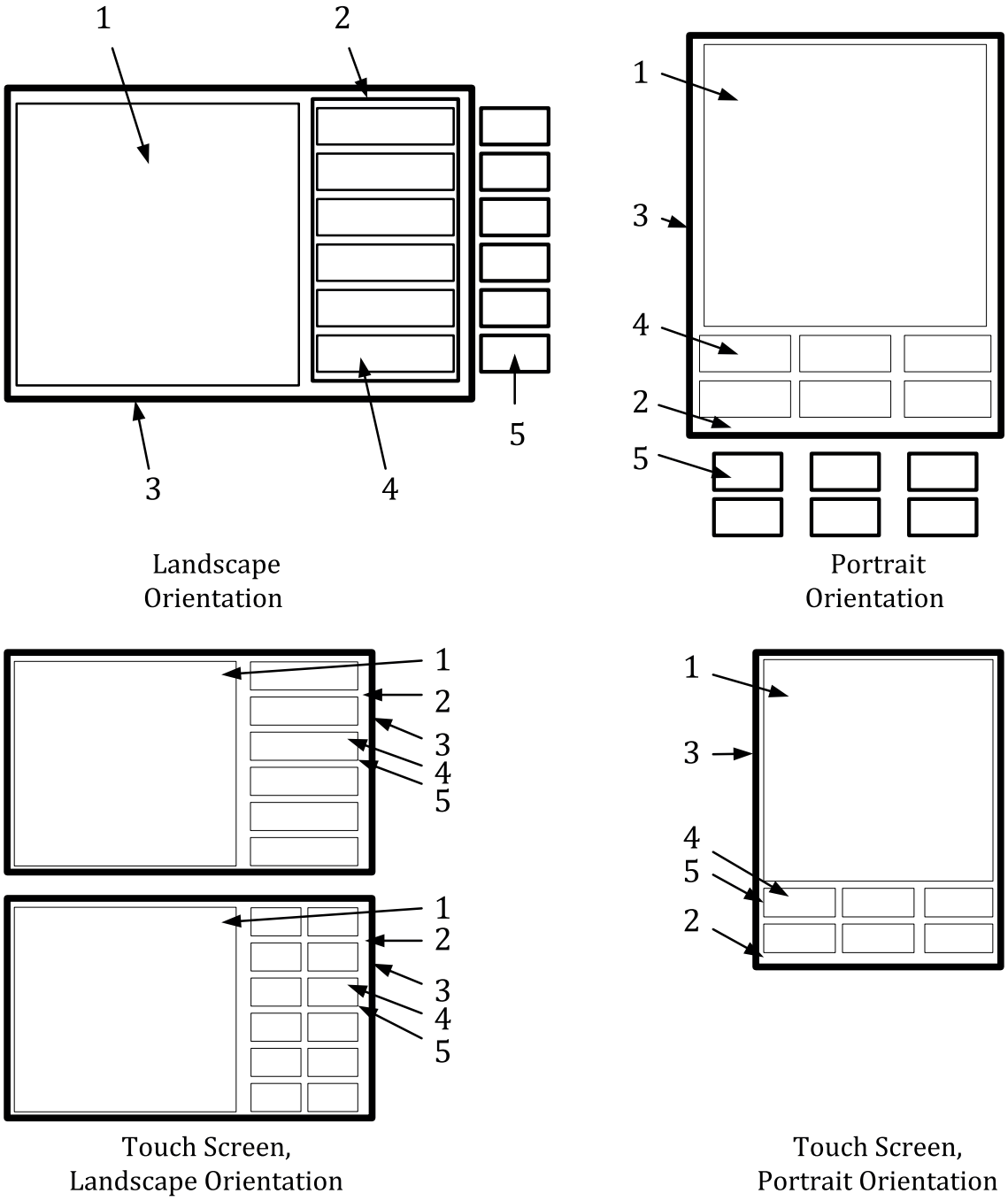

Key

1 data mask area
2 soft key mask area
3 physical screen
4 soft key designator
5 physical soft key

Figure 1 — Virtual terminal — Examples

4.1.1 Technical requirements of VT versions

Essential characteristics and attributes of a VT can be identified using the Technical data messages as defined in Annex D.

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VT version 6 imposed requirements are as follows.

Feature	Detailed requirements and recommendations	Clause(s)
Physical Soft Keys	Minimum 60 × 60 pixels (recommended to be square)	D.5
Text Fonts	All small font sizes, all large font sizes, all font styles.	D.7
Graphic Type	Minimum 256 colours, recommended 16-bit or greater colour capability to support Colour Palette object and Graphic Data object. The VT can downscale the presentation to match the hardware capability (e.g. 24-bit PNG downscaled to 16-bit VT hardware).	D.9
Data Mask Size	Minimum 480 × 480 pixels	4.5.2, D.9
Window Mask object	Fully parsed, presentation is optional.	4.7.3
Key Group object	Fully parsed, presentation is optional.	4.7.9
Graphics Context object	Full presentation support is required	B.18

4.2 Operator input and control

The VT shall provide the operator with means for control and input. There are five means associated with a VT that can be used for the input of data, selection of display data, and the control of connected Working Sets.

See Figure 2.

a) Soft — is a means, most likely keys on the VT, using software-changeable designators (labels). “Soft Keys” have their identity changed depending on which Soft Key Mask is visible. The VT shall make the association between a Soft Key and its designator clearly evident to the operator.

b) Navigation — is a means of selecting an input field or Button within the active Data Mask. If keys are used for “Navigation”, they do not send key activation information to the Working Set and are proprietary to the VT.

c) Data Input — is a means of entering/editing information in an input field within the active Data Mask. If keys are used for “Data Input”, they do not send key activation information to the Working Set and are proprietary to the VT. A means shall be provided for entering any number or character sequence that is valid for the input field.

   During the data input operation, the VT Status message will continue to indicate the active Working Set, and active mask which contains the input object for which the data input operation applies.

   There are two types of Data Input — “editing” and “real time editing”.

   1) **Editing** — is a means of data input where the new value being entered is composed by the operator using a proprietary means within the VT. During the composition of the new value, changes to the original value are not communicated to the Working Set. A means shall also be provided for ESC from or ENTER of information into a data field.

      The ENTER means shall be provided to indicate to the Working Set the completion of data entry and communication of the new value, and the ESC means shall be provided to indicate that the data entry was aborted. The ENTER and ESC means can either be a permanent key or can only be available during data entry (see Table 5) The VT shall send a VT ESC message to a Working Set for an operator-activated ESC means or an ESC response as a response to receiving an ESC command from a Working Set.

   2) **Real-time editing** — is a means of data input for an Input Number object and Input List object where the object has focus and it is open for operator input and changes by the operator to the value are periodically transmitted to the Working Set while the object is being changed. The VT Change Numeric Value message is limited to a 5 Hz update rate. Each value change sent to the Working Set is considered a complete transaction, as if the ENTER means was activated, and cannot be reverted by the ESC means. The VT is not required to provide steps in uniform

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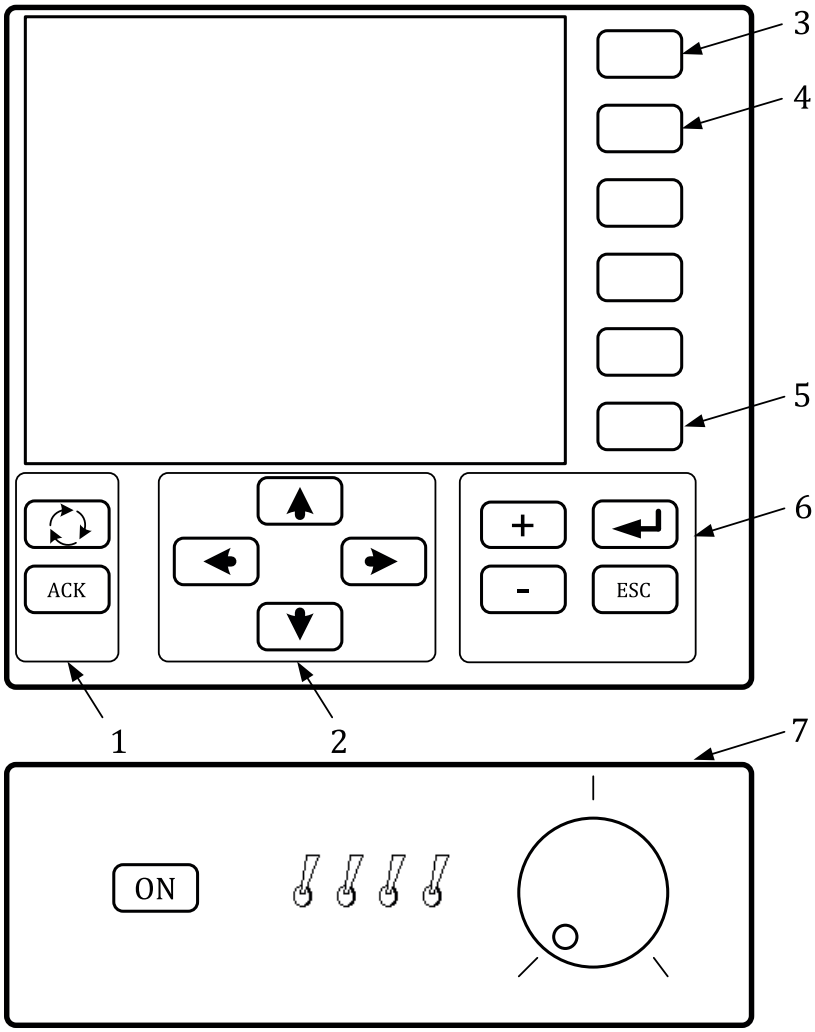
increments, however it shall be possible to set any value (e.g. fast scrolling is allowed to span a wide range of values, with fine adjustment for final setting). If the ESC means is activated during real time editing, the VT shall ensure that the on-screen value is equal to the value last sent to the Working Set. The VT can send a final value to the Working Set prior to sending the VT ESC message, or ESC response message to ensure this synchronization. Real time editing shall meet the operator controls requirement specified in ISO 15077.

d) Control — is a means of selecting between Working Sets whenever a Data Mask is available and for acknowledging alarms. Both means are required. Since more than one Working Set can use the services of the VT, the VT shall provide a means for the operator of selecting between connected Working Sets. The Working Set selection means should be indicated by three circular arrows or a similar graphic. Only the ACK means sends key activation information to the Working Set.

e) Auxiliary Input — is a means available to the operator for communicating input commands to the Working Set(s) using Auxiliary Controls which are assigned to Auxiliary Functions (see Annex J).



Key

1 control
2 navigation
3 soft key 1
4 soft key 2
5 soft key 6
6 data input
7 auxiliary input

Figure 2 — Operator input and control means — Example

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4.3 Acoustic alarm

The VT shall provide an acoustic alarm. The alarm can be a simple on/off type buzzer or an acoustic component capable of either/or variable frequency and audio level (see D.9).

4.4 Coordinate system

Positions and sizes in this document are always given in physical pixels unless otherwise stated. A two-dimensional coordinate plane (x, y) is used, where x is the number of units wide (x increases from left to right) and y is the number of units high (y increases from top to bottom). The coordinates are signed values. The origin (0, 0) for any object's coordinate system is located at the top left-hand corner of the parent object.

4.5 Display areas

4.5.1 General

This section defines standard Data Mask and Soft Key Mask areas of the display. Alternate usage of this area supports displaying data from multiple working sets (see 4.7).

4.5.2 Data Mask

The VT shall reserve an area of the display for displaying Data Masks and Alarm Masks. This area is called the Data Mask area (see Figure 1). Recognizing that the physical orientation of the VT display could be different, depending on the manufacturer of the VT, a square data mask aspect ratio is chosen to ensure correct display in either landscape or portrait orientation. The minimum Data Mask area shall be 200 pixels × 200 pixels (480 × 480 for VT version 6 and later). This requirement does not limit the physical resolution or size of the display, only the useable Data Mask area. Higher resolution mask areas are permitted, but the square aspect ratio shall be strictly enforced.

Examples of Data Mask areas that would meet this requirement are:

— 200 × 200;

— 240 × 240;

— 320 × 320;

— 480 × 480;

— 600 × 600;

— 800 × 800;

— 1 024 × 1 024.

Any other square dimensions would be acceptable.

It is suggested that unused areas of the physical display be used for proprietary information such as vehicle data, VT statistics or other data.

4.5.3 Soft Key Mask area and Soft Key designators

4.5.3.1 Soft Key variants and navigation

The VT shall reserve an area of the display for Soft Key labels, separate from the Data Mask area. This area is called the Soft Key Mask area (see Figure 1). Each Soft Key shall have a reserved display area, called a Soft Key designator, for displaying a label (see Figure 1). The minimum size of the designator field is 60 pixels wide × 32 pixels high regardless of screen orientation (60 × 60 for VT version 6 and

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later). The Soft Key designators can contain text, graphics or both. The Soft Key Mask area can be adjacent to, or physically separate from, the Data Mask area, but shall not be part of the Data Mask area.

The VT shall provide a clearly visible separation between the individual Soft Key designators (for example by drawing a one-pixel line). This visible separation shall be drawn outside of the Soft Key designator area. Only if the minimum size of the designator field cannot be fulfilled due to this requirement, the drawing of a one-pixel line on the border of the Soft Key designator area is acceptable.

The presentation of the Soft Keys can be further described in three groups, with a defined relationship: Navigation Soft Keys < Number of Physical Soft Keys ≤ Number of Virtual Soft Keys.

a) VT Version 3 and prior VTs have no requirement on the number of physical Soft Keys.

b) VT Version 4 and later VTs shall provide at least 6 physical Soft Keys.

c) VT Version 3 and prior shall support a maximum of 64 virtual Soft Keys per Soft Key Mask and shall support as a minimum the number of reported physical Soft Keys (see 4.5.3.3).

d) VT Version 4 and later shall support exactly 64 virtual Soft Keys per Soft Key Mask (see 4.5.3.3).

e) The VT shall provide a means for the operator to navigate and select all defined Soft Keys. For example, if there are six physical keys, some type of paging would be required to allow the operator to navigate to, and select from, any of the 64 virtual Soft Keys using the six physical keys.

4.5.3.2 Physical Soft Keys

Physical Soft Keys is the count of the number of permanently dedicated keys that the VT makes available to active Working Sets. The term “physical Soft Key” does not imply that the VT necessarily provides physical buttons for the Soft Keys. For example on a VT with touch screen, the physical Soft Keys can be located directly on the touch screen as shown in Figure 1.

For VTs with a vertical arrangement of physical Soft Keys, key number 1 shall be on the right and the top-most position. Key number 2 shall be adjacent and below Key 1. Key m shall be at the bottom of the first column. If there are additional physical Soft Keys, the column containing keys m+1 to key n shall be to the left of the first column. Each additional column of physical Soft Keys shall continue to the left.

For VTs with a horizontal arrangement of physical Soft Keys, Key number 1 shall be on the top row and in the left-most position. Key number 2 shall be adjacent and to the right of Key 1. Key m shall be at the far right of the top row. If there are additional physical Soft Keys, the row containing keys m+1 to key n shall be below the first row. Each additional row of physical Soft Keys shall continue below the previous row. Examples of these arrangements are shown in Figure 3.

For VTs without a clear horizontal or vertical arrangement of physical Soft Keys (e.g. physical Soft Keys located in a matrix on the touch screen) the rules for a VT with a vertical arrangement of physical Soft Keys apply.

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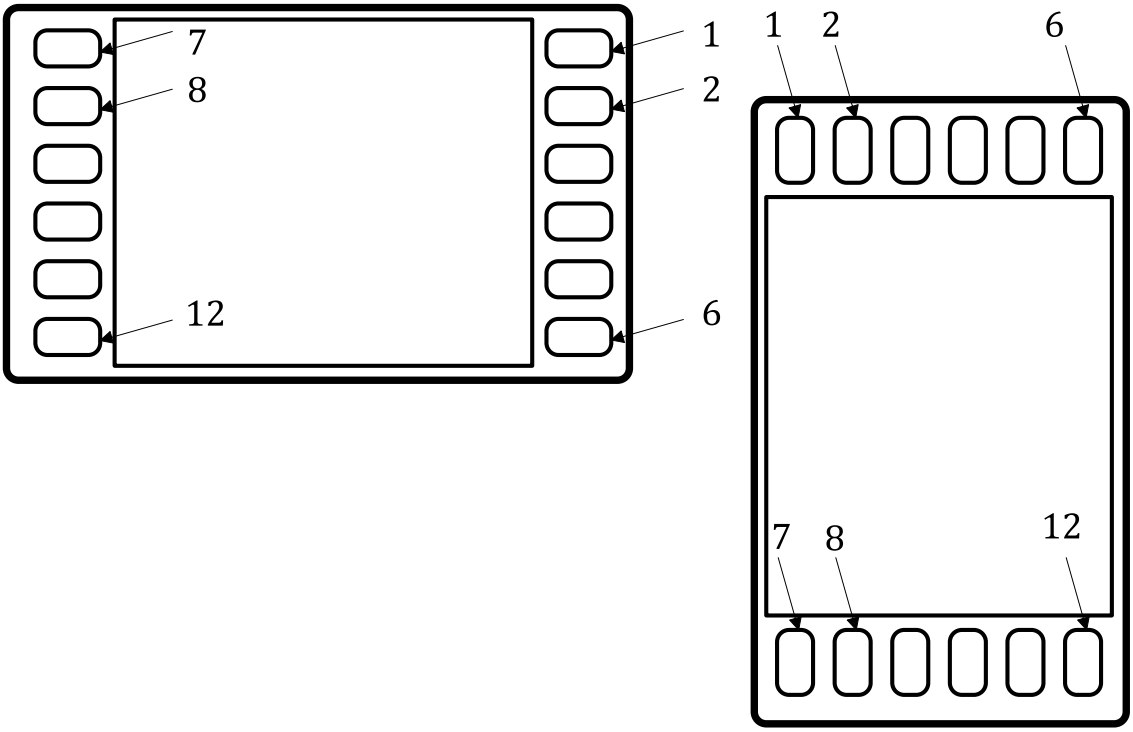

Key

1 key 1 physical location based on soft key arrangement

2 key 2 physical location based on soft key arrangement

6–8 key locations based on soft key arrangement

12

Figure 3 — Physical Soft Key Orientation Examples showing Key Locations

4.5.3.3 Virtual Soft Keys

Virtual Soft Keys is the count of the number of Soft Keys that the VT supports for each active Working Set's Data Mask. If the physical Soft Keys count is less than the virtual Soft Keys count, the VT shall provide a means for navigation to allow the operator to choose from any of the Working Sets Soft Keys.

4.5.3.4 Navigation Soft Keys

Navigation Soft Keys is the count of the number of physical Soft Keys that the VT can allocate for the purpose of navigation among the Soft Keys. The number of navigation Soft Keys shall be less than the number of physical Soft Keys. If the VT provides other means of navigation that does not use the physical Soft Keys, this value shall be zero.

4.5.3.5 Navigation among Soft Keys

If the Working Set provides a number of Soft Keys on a Soft Key Mask equal to or less than the number of physical Soft Keys reported by the VT, then all of the Soft Keys on this Soft Key Mask shall be accessible with the physical Soft Keys. The VT shall not provide any navigation means for this Soft Key Mask.

If the Working Set provides more Soft Keys on a Soft Key Mask than the VT has reported in the number of physical Soft Keys, the VT shall provide navigation for that Soft Key Mask. This navigation among the Soft Keys shall be done by paging through the Soft Keys in groups, not by scrolling. Further, a "group" is defined as the "physical Soft Keys" count minus the "navigation Soft Keys" count. The navigation Soft Keys shall always occupy the same physical Soft Key positions on all pages, although the VT designer can choose to disable (but not remove) the navigation keys on certain pages. The last set of virtual Soft

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Keys (depending on how many Soft Keys the Working Set provided to the VT) might not completely fill the Soft Key Mask. The remainder of the Soft Key designators shall not be used.

As described in B.5 and illustrated in Figure 4, pointers to the NULL Object ID reserve a Soft Key position. Pointers to NULL Object ID that are at the end of the list of Soft Keys shall not reserve a Soft Key position and shall not be considered for paging or navigation.

EXAMPLE As shown in Figure 4 a), a VT is designed with 6 physical Soft Keys, 64 virtual Soft Keys, and 1 navigation Soft Key. The Working Set provides 18 Soft Keys to the VT, however there are 3 which are Pointers to the NULL Object ID. To support navigating among the Soft Keys the VT designer alters Soft Key 6 into a "next Soft Key group" button. A navigation group is calculated as sets of 5 Soft Keys [Figure 4 a)], starting with the first Soft Key. When the navigation key is pressed, the VT shows the next group of Soft Keys. Another example [Figure 4 b)] shows a similar example with 2 navigation Soft Keys. Another example [Figure 4 c)] shows an arrangement with two columns of keys and two navigation keys. If the VT provides dedicated navigation keys, the number of navigation Soft Keys reported shall be zero [Figure 4 d)].

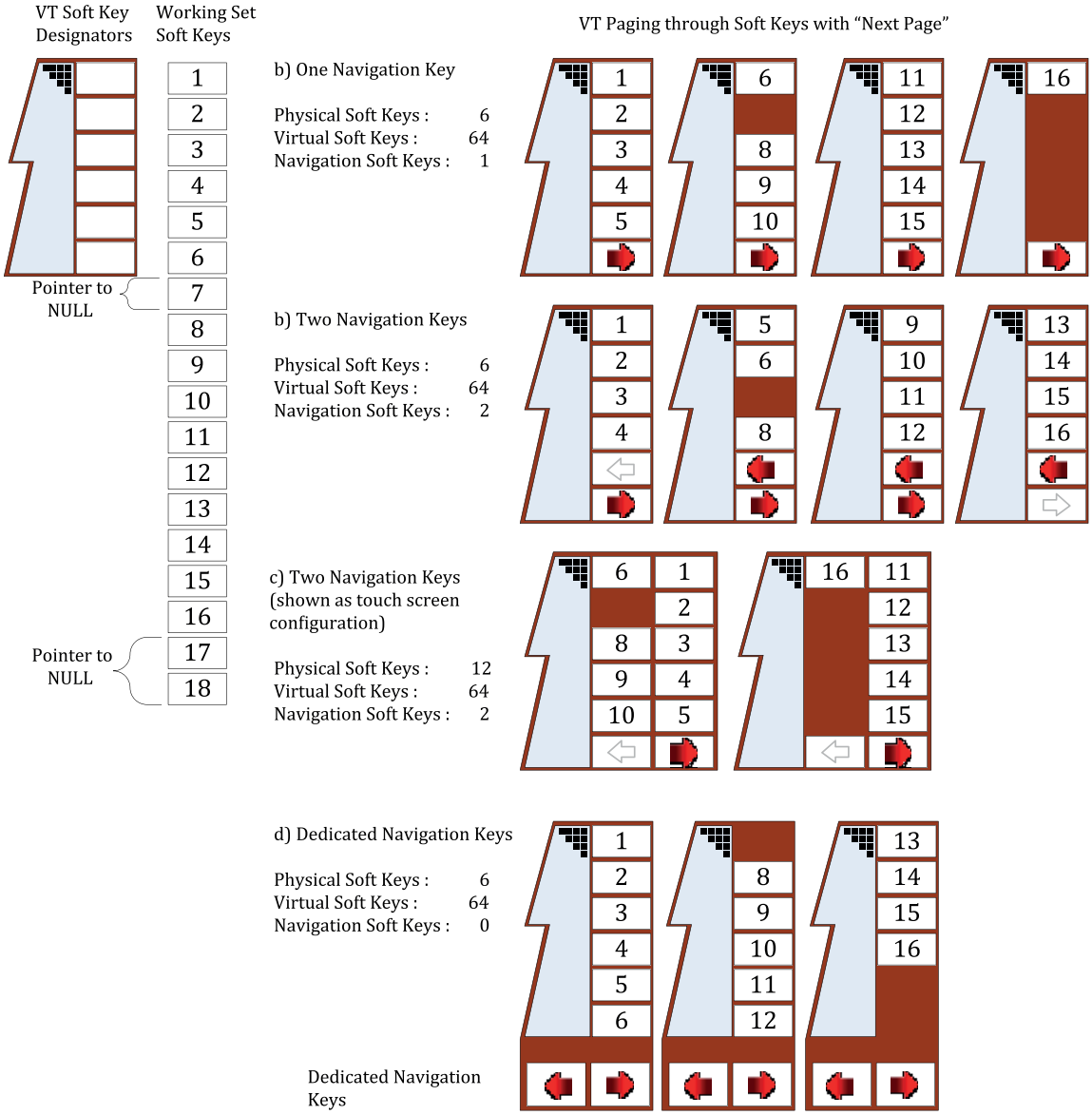

Figure 4 — VT virtual Soft Key paging

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4.6 Behaviour

4.6.1 Object pools

4.6.1.1 General

The operator interface definition for a device of one or more implements represented by either a single ECU or a Working Set consists of a set of objects (hereafter referred to as the Working Set's *object pool*).

A summary of the types of objects defining the operator interface definition, the events that can be triggered when interacting with those objects, and a summary of the network commands between a Working Set and the VT are shown in Annex A.

Interaction with the Working Set, caused by the operator interacting with the VT, can be communicated using the messages in Annex H.

During operation, the VT uses other messages not defined within this document, as referred to in Annex I.

These objects are defined in detail in Annex B and Annex J. Each object contains all necessary attributes and child object references for processing the object to completion. The Working Set assigns a unique Object ID to each object in its object pool so that each object is uniquely addressable. Object IDs shall be unique within a single Working Set's object pool but might not be between different Working Sets.

The object pool is transferred to the VT at initialization by using the procedure described in Annex C. The VT is intended to be capable of storing the object pools in a modifiable memory area. VTs can store multiple pools of a Working Set, in non-volatile memory, if they have unique version labels. For example, multiple pools that differ only by language. All objects shall be fully described before they are made active in a mask on the display.

The behaviour of the VT when no object pools are loaded is proprietary.

4.6.1.2 "NULL" Object ID

Object ID $FFFF_{16}$ (65535_{10}) is reserved for use as the "NULL" Object ID.

In the context of drawing, and unless otherwise stated, when the "NULL" Object ID is used it means that the VT shall draw nothing for the related object.

4.6.1.3 Processing objects

Objects listed in parent objects can also list child objects, thereby creating a tree hierarchy in the object pool. Objects are always processed in the order listed in the parent object in a "depth-first" manner. In other words, if a reference is made to an object that references other objects, the child references are processed to completion before returning to the parent to continue processing.

VT version 5 and later VTs shall support a minimum hierarchy depth of 30 objects. For VT version 4 and prior VTs, the requirement is unspecified.

The hierarchy depth is computed starting with the following objects; Data Mask object, Alarm Mask object, Window Mask object, Soft Key Mask object, Key Group Objects, and increments by one to reach a child object. For the child objects that have child objects the depth increments again. This process continues to the last child object. For computing the hierarchy depth, the object to which a pointer object references is counted as a child object.

Only contained children are included in the hierarchy count. Referenced objects are not considered in the count (for example a Working Set object referencing a Data Mask object as an attribute).

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4.6.2 Working Sets

The Object Pool supplied by a Working Set Master is associated with all members of that Working Set. This allows object information from one CF or all the CFs that make up a Working Set to be collectively presented as a common object pool. One CF shall be designated as the Working Set Master for each Working Set. As coordinator of the communications of a Working Set, the Working Set Master shall secure the use of the VT and provide the object pool definition. It shall also send Working Set messages that provide the NAMEs of the members of said Working Set to the VT. This identifies the members of the Working Set and hence those CFs which can communicate to the VT. Appropriate messages for defining a Working Set are given in ISO 11783-7. If a Working Set Member sends a command or message to the VT that is only allowed from a Working Set Master, the VT shall respond with an Acknowledgement: NACK message (see ISO 11783-3). If a CF is not identified as a member of a Working Set, and where that CF sends a command or message to the VT that is only allowed when from a Working Set, the VT shall respond with an Acknowledgement:NACK message (see ISO 11783-3). Once members of the Working Set have been identified and after the object pool has been loaded into the VT, any member of the Working Set has the ability to provide data for objects and to change attributes in the object pool during run-time. The Working Set Master shall provide the initial object pool definition. Any data input by the operator into input field objects is always transmitted to the Working Set Master.

The VT shall never have Working Set Members and shall not transmit the Working Set Master or Working Set Member messages (see ISO 11783-7).

The handling of VT Response messages defined herein supersedes ISO 11783-1 in reference to responses being directed only to the Working Set Master. See Table 1 for VT Response message behaviour to Working Set messaging.

Table 1 — VT Response message behaviour

Configuration	Working Set Version[a]	VT Version[b]	Behaviour
1	3 and prior	3 and prior	VT response to any command is directed to the WS Master
2	3 and prior	4 and later	VT response to any command is directed to the WS Master
3	4 and later	3 and prior	VT response to any command is directed to the WS Master
4	4 and later	4 and later	VT response to any command is directed to the originator

[a] Working Set Version is reported in the Working Set Maintenance message.

[b] VT Version is reported in the Get Memory response message.

In configurations types 1 through 3, the Working Set Member has the responsibility to monitor all [destination specific] VT to Working Set Master messages in order to pair its commands with responses. The Working Set Master will receive unsolicited responses from the VT (which were originated by its members), and will not be able to pair these with messages the master originated. The Working Set Members also will not be able to pair the messages correctly when originating from another member or from the master.

In configuration type 4, all responses from the VT are directed to the originating nodes. Responses that are communicated via Transport Protocol are now possible (e.g. Get Supported WideChars response). Further, the Working Set Master no longer receives unsolicited response messages. Working Set Members no longer have an obligation to monitor destination specific messages directed to another address.

In order to maintain backward compatibility, Working Sets shall not send higher version messages to a lower version VT (e.g. a version 4 command sent to a version 2 VT). How a lower version VT would respond in such a case should be considered unpredictable. For example some VT designs might respond with an Acknowledgement:NACK message (see ISO11783-3), others might ignore the message. If the connected VT does not support the functional requirements of a Working Set (e.g. VT version 4 features required and the connected VT is version 2, Data Mask size is too small to be functionally useful, etc.), the Working Set shall send a minimally compatible pool to the VT communicating the functional incompatibility to the operator.

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Conversely, the VT shall not send higher version messages to a lower version Working Set (e.g. a version 4 event sent to a version 2 Working Set). How a lower version Working Set would respond in such a case should be considered unpredictable. For example some Working Set designs might respond with an Acknowledgement:NACK message, others might ignore the message.

VT version 5 and higher VT's and Working Sets shall support the VT Unsupported VT Function message, and Unsupported VT Function message, respectively. With this message the VT and Working Set respond in a predictable way. VTs and Working Sets, designed for VT version 4 and prior, can implement these messages.

Additional compatibility information is defined in 4.6.24.

4.6.3 Multiple visually similar Working Sets

When more than one visually similar Working Set from the same manufacturer becomes part of a network, these Working Sets should be uniquely identified to correlate each instance with a location. This shall be accomplished using an Instance field of the NAME (e.g. 2 sprayers from the same manufacturer, or 2 or more visually similar Auxiliary Input units).

For consistent system configuration, the Working Sets should be arranged with the lowest to highest instance from left to right followed by front to rear followed by bottom to top.

The manufacturer shall provide the operator a means to establish a working configuration, using one or more of the following methods or via some other means not specified here.

The operator can correctly locate the Working Set based on its instance with

— an indication on the label of the Working Set unit identifying its Instance, and

— by physical location, via a wire in the harness of the Working Set that automatically sets its instance in increasing values left to right followed by front to rear followed by bottom to top.

The operator can set the Instance based on its location with

— an operator accessible "Instance" switch on the Working Set unit,

— an operator accessible "Instance" setting, such as on a Data Mask, and

— use of the commanded name message (see ISO11783-5) with a provided service tool.

4.6.4 Displayed Working Set number

When more than one visually similar Working Set exists on a network, the Working Set shall indicate its working set number on its Working Set object. Additionally, the Working Set should indicate its working set number on visible masks.

The displayed Working Set number shall be defined by the manufacturer. The Working Set number should be related to the Function Instance, the Device Class Instance, and/or the ECU Instance, as defined by the manufacturer (see ISO11783-5). Other factors defined by the manufacturer can also be used to ensure the Working Set is uniquely identifiable. All visually similar equipment from the same manufacturer shall apply the same relationship.

Example 1 working set number = working set Function Instance + 1

Example 2 working set number = working set Device Class Instance + 1

Example 3 working set number = working set ECU Instance + 1

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4.6.5 Language, formats and measurement units selection

The VT(s):

— Can query the tractor ECU for the Language command if the VT has no language setting, or if the VT has detected a change in the connected TECU.

— Shall send the standard language, format and measurement units messages defined in ISO 11783-7, hereafter “standard setups”.

— Shall build a superset list of supported languages. The superset list presented to the operator is defined as:

  — the list of all languages communicated to the VT from all Working Set(s), and

  — the list of relevant languages supported by the VT.

  Where the VT supports many more languages than those required by the Working Set(s), it is not required to include the entire list, therefore the languages considered not relevant can be omitted from the superset list presented to the operator.

— Can reduce the list of supported languages when a Working Set disconnects from the VT (see 4.6.9), and previously listed languages are no longer required.

— Shall not store the superset list of supported languages in non-volatile memory.

— The VT shall provide a method for the operator to view the superset list, and to select an item from this list. If the VT itself doesn’t support the language the operator selected it shall provide a proprietary method to switch to an appropriate (or default) language.

— Shall also provide a method for the operator to select formats (Time, Date, etc.) and measurement units. The VT shall report the operator selected language, formats and measurement units at power up and any time there is a change. These messages allow the Working Set to modify its object pool to the operator-selected language (.e.g. by updating string fields, selecting units of measure, changing offsets and scales, etc.).

— Shall store the standard setups in non-volatile storage and restore the values during initialization.

— Shall respond to ISO11783-7 “Language Command” requests sent to the global address.

— Shall respond to ISO11783-7 “Language Command” requests directed to this VT.

— Should transmit the Language Command with both the language code (ISO 639-1) and a country code (ISO 3166-1)[14].

The Working Set(s):

— Communicates the initial set of supported languages in the Working Set object.

— Optionally sends the Working Set Special Controls object to supercede the list of languages from the Working Set object which can include both language code and country code.

— Shall configure their standard setups according to the VT to which they are publishing the pool(s). This can cause different standard setups to be published to different VTs. (e.g. auxiliary objects are published to VT with Function instance 0 and the remainder of the pool to other VTs).

— Shall use a proprietary method to select an appropriate (or default) setting if the Working Set does not support the selected language, formats or units.

4.6.6 Initialization

Upon power-up or reinitialization, a specific sequence of events shall occur in order to ensure proper initialization of the VT and Working Sets, as follows.

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4.6.6.1 VT initialization

1) The VT shall complete the address claim procedure in accordance with ISO 11783-5 and shall also send an address claim request to the global destination address (255).

2) The VT shall begin transmission of the VT Status message. In the case of a reset or recovery, the VT shall ensure that greater than 3 s have elapsed between this initial VT Status message and the previous VT Status message.

3) If language selection has not been entered by an operator, the VT can attempt to request the default language setting from the tractor ECU, or it can interact with the operator to select a language.

4) The VT shall allow Working Sets to initialize and to load their object pools.

4.6.6.2 Working Set initialization with VT

1) The Working Set, if equipped with Auxiliary Functions, shall clear any assignments in volatile memory.

2) The Working Set Master (and Working Set Members) shall complete the address claim procedure in accordance with ISO 11783-5.

3) The Working Set Master shall wait until the VT begins transmission of the VT Status message.

4) The Working Set Master shall identify itself and its members to the VT using messages given in ISO 11783-7.

   I) The Working Set Master can send these messages for other purposes (e.g. Task controller initialization).

   II) If the Working Set Master has a need to reconfigure the list of Working Set Members after the initialization is complete, the Working Set Master shall send the Working Set Master and Working Set Members messages. The Working Set Master can use this to add or remove members from the set. No Working Set initialization is required.

5) The Working Set Master shall begin the periodic transmission of the Working Set Maintenance message. As identified in Byte 2 and 3 of the Working Set Maintenance message, only the first message can indicate the initiating state.

   NOTE The initiating bit was introduced in Version 3 to provide a clear indication of a Working Set restart.

   If the VT had previously detected a shutdown and was transmitting the Acknowledgement:NACK in response to the Working Set Maintenance message (see 4.6.9), there are two cases where the VT shall stop transmitting the Acknowledgement:NACK:

   I) If the Working Set Maintenance message indicates compliance with VT version 3 and later, and if the initiating bit (Byte 2 Bit 0) is set and the VT received a Working Set Master message since the prior maintenance message, the Acknowledgement:NACK is discontinued.

   II) If the Working Set Maintenance message indicates compliance with VT version 2 and prior, and the VT received a Working Set Master message since the prior maintenance message, the Acknowledgement:NACK is discontinued.

6) The Working Set Master can request the language and format messages from the VT (see ISO 11783-7) if it has not already received this message from the VT and the Working Set has presentation that is language or unit specific.

7) The Working Set Master can query the VT as necessary to determine its capabilities. Based on the VT's responses, the Working Set Master shall adjust its object pool for scaling, available fonts, supported colours, etc.

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8) The Working Set Master can query the VT to determine if its object pool already exists in non-volatile memory.

9) Object pool transfer shall commence and be completed. This can be done either by asking for the object pool to be transferred from non-volatile memory (see Annex E) or by using the protocols detailed in Annex C.

10) The Working Set Master can indicate the languages supported by the object pool.

4.6.6.3 Working Set initialization on networks with multiple VTs

A Working Set Master shall have a means to perform a "Move to another VT" function on networks with multiple VTs. This function shall allow movement of the Working Set to each of the available VTs in sequence. For example, this function could be accomplished with a "Next VT" Soft Key or Button in the user interface and/or in combination with the Identify VT message. The function behaves as follows:

1) "Move to another VT" is enabled if the Working Set Master detects more than one VT on the network.

2) When "Move to another VT" is activated, the Working Set Master:

   I) Puts itself in a safe state, or prevents activation of this feature unless it is in a safe state.

   II) Shall send the Delete Object Pool command to the VT and wait for the response.

   III) Shall stop sending the Working Set Maintenance message to the VT.

   IV) Starts the initialization process with another VT on the network.

   V) The Working Set Master shall save the new VT as the preferred VT for a next power cycle. If the preferred VT is not available within a certain time period after startup, the Working Set Master can initialize connection to any other VT on the network. The Working Set can provide a means for the operator to set the maximum wait time period or it can be obtained from the boot time specification in the "Get Hardware response" message of the preferred VT.

4.6.7 System shutdown

4.6.7.1 General

In this context "System Shutdown" is defined as the period of time when the Key Switch state indicates the key is off and yet ECU Power remains on. Actuator Power might or might not remain on concurrent with ECU Power (see ISO 11783-7).

When the Key Switch state indicates the key has been turned off, and while ECU Power has not been terminated, it is expected that systems might transition to a shutdown state that is appropriate for that system. In some devices, this can cause immediate termination of all network communications, where other devices might request power to remain on for a more orderly shutdown. Others still might ignore the Key Switch state and continue normal operation until power is interrupted.

The relevant PGNs defined in ISO 11783-7 for determining the Key Switch state is the Wheel-based speed and distance (PGN 65096) and for requesting power maintenance is the Maintain power (PGN 65095).

The following are recommended practices.

4.6.7.2 VT behaviour

The VT can expect that applications on the network can terminate communications without warning.

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A recommended behaviour of the VT is to monitor the Key Switch state and take the following actions as a result of the transition from “Key switch not Off” to “Key switch Off”.

1) The VT should disable unexpected shutdown detection logic to avoid unnecessary notification to the operator as a result of one application shutting down immediately while another maintains the ECU Power beyond the normal 3 s timeout (see 4.6.9).

2) The VT should maintain services while “Key Switch Off” and for a minimum of 2 sec following the last “Maintain ECU Power” request from those ECUs which have object pools in the VT volatile memory.

3) The VT should continue to monitor the Key Switch state and reinitialize if turned from “Key switch Off” to “Key switch not Off”, ensuring that if the VT Status message was discontinued, the standard Initialization process is performed (see 4.6.6).

NOTE VT version 3 and prior did not specify shutdown behaviour, therefore, these VTs can discontinue all communications with the network, including discontinuing the VT Status message.

4.6.7.3 Working Set behaviour

Working Set behaviour can vary significantly depending on the design of the specific set.

One variation of a Working Set design might not monitor the Key Switch state and might continue as normal until power is lost.

A recommended behaviour of a Working Set is to monitor the Key Switch state and take the following actions as a result of the transition from “Key switch not Off” to “Key switch Off”:

1) The Working Set can send a “Maintain Power” message (see ISO11783-7) to inform the system of the state of the Working Set, and optionally as the means to request power be maintained.

2) The Working Set can monitor the “Maximum time of tractor power” parameter (see Wheel-based speed and distance message in ISO11783-7) and use this information during any power management processes it executes.

3) The Working Set can send a Delete Object Pool command to the VT to eliminate the possibility of an unexpected shutdown indication (see 4.6.9).

4) The Working Set should not consider the lack of the VT Status message or other VT to ECU messages as an unexpected shutdown of the VT, and therefore should not attempt a connection to any other VT that are available.

5) The Working Set should continue to monitor the Key Switch state and reinitialize if turned from “Key switch Off” to “Key switch not Off” (see 4.6.6).

4.6.8 Working Set object and active masks

In the initial object pool definition, each Working Set Master shall provide one, and only one, Working Set object in order to define a descriptor, active mask and supported languages for the Working Set. The descriptor can be graphical; text or both but shall fit inside the area defined by the VT for a Soft Key designator. Any object or part of an object located outside of the Working Set descriptor shall be clipped. The descriptor can be used by the VT any time the Working Set needs to be represented to the operator.

EXAMPLE Communication alarms, Auxiliary Control setup.

When a Working Set is “active”, it has exclusive input focus and is displayed on the VT display. When the Working Set is “inactive”, it can also be visible on the VT display but does not have input focus. The VT shall provide some means to allow the operator to select the Working Set that is to be active. Only one Working Set is active at any given time. The Working Set cannot force any of its masks to be visible when the Working Set is not visible, and it cannot force its Working Set to be active when another Working Set is active. Setting the active mask to an Alarm mask shall make the owner Working Set active, unless

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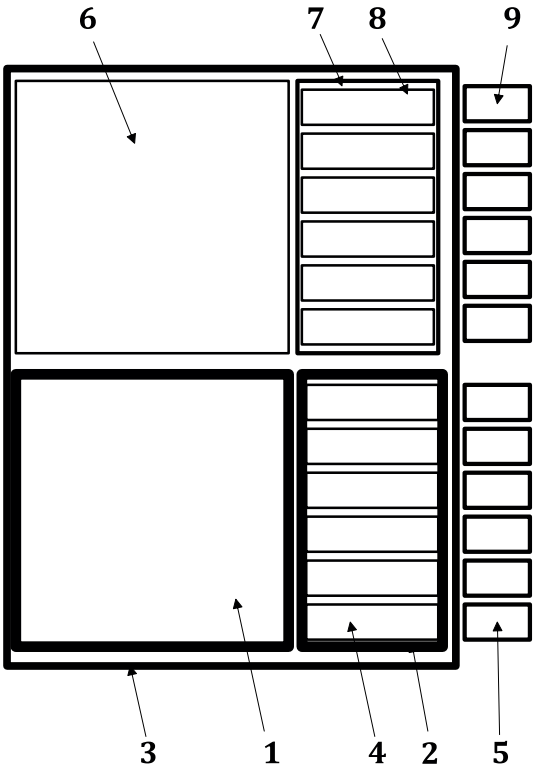
the active mask of the currently active Working Set is an alarm mask with the same or higher priority (see 4.6.14 Alarm handling).

For VT version 4 and later, a VT can also display one or more Working Sets which are not active in addition to the Active Working set. (See Figure 5, which displays an active and an inactive Working Set simultaneously.) The VT uses the VT On User-Layout Hide/Show message to inform the inactive Working Set to update its Data Mask and or Soft Key Mask when it is visible.

If a Working Set responds with a hidden state for the corresponding Data Mask or Soft Key Mask then the VT knows that the Working Set does not support this feature for this Data Mask or Soft Key Mask. If the Working Set does not support this feature for this Data Mask or Soft Key Mask, the VT shall inform the operator that the displayed information might not be updated. The VT can still display the inactive Working Set, because the inactive Working Set can update its data (see 4.6.10).



Key

1 Data Mask area of active Working Set
2 Soft Key Mask area of active Working Set
3 physical screen
4 Soft Key Designator of active Working Set
5 Physical Soft Key of active Working Set
6 Data Mask area of inactive Working Set
7 Soft Key Mask area of inactive Working Set
8 Soft Key Designator of inactive Working Set
9 Physical Soft Key of inactive Working Set

Figure 5 — Example VT which displays an active and an inactive Working Set simultaneously

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Table 2 — Working Set state changes (VT Supports only Active Mask)

Working Set state change	VT Behaviour
Active to Inactive	1) Hide the Working Set's currently active Data/Alarm Mask and associated Soft Key Mask. 2) Send the VT Status message to the global address (255) to inform Working Sets of the change[a].
Inactive to Active	1) Display the Working Set's currently active Data/Alarm Mask and display the associated Soft Key Mask. 2) Send the VT Status message to the global address (255) to inform Working Sets of the change[1]
[a] When the state of a Working Set changes from inactive to active and this causes the state of another Working Set to go from active to inactive, there shall be only one VT Status message (not two), which shall specify the new active Working Set.	

Table 3 — Working Set state changes (VT Supports Multiple Working Sets or Window Masks Visible Simultaneously)

Working Set state change	VT behaviour
Active to Inactive and Visible	1) Remove visual indication that the Working Set is the active Working Set. 2) Send the VT Status message to the global address (255) to inform Working Sets of the change [a]. 3) Send the VT On User-Layout Hide/Show message (state: Shown) to the Working Set.
Inactive and Visible to Active	1) Send the VT On User-Layout Hide/Show message (state: Hidden) to the Working Set (state Hidden is a special case here—refer to H.20). 2) Display the Working Set's currently active Data/Alarm Mask and display the associated Soft Key Mask. 3) Visually indicate to the operator that the Working Set is the active Working Set. 4) Send the VT Status message to the global address (255) to inform Working Sets of the change [a].
Hidden to Active	1) Display the Working Set's currently active Data/Alarm Mask and display the associated Soft Key Mask. 2) Visually indicate to the operator that the Working Set is the active Working Set. 3) Send the VT Status message to the global address (255) to inform Working Sets of the change[a].
Active to Hidden	1) Hide the Working Set's currently active Data/Alarm Mask and associated Soft Key Mask. 2) Send the VT Status message to the global address (255) to inform Working Sets of the change [a].
Inactive and Visible to Hidden	1) Send the VT On User-Layout Hide/Show message (state: Hidden) to the Working Set.
Hidden to Inactive and Visible	1) Send the VT On User-Layout Hide/Show message (state: Shown) to the Working Set.
[a] When the state of a Working Set changes from inactive to active and this causes the state of another Working Set to go from active to inactive, there shall be only one VT Status message (not two), which shall specify the new active Working Set.	

The Working Set can select different Data Masks or activate Alarm Masks by changing the active mask attribute of the Working Set object with the Change Active Mask command. The Working Set can change the active mask even if the Working Set is inactive. This allows the appropriate mask to be displayed when the Working Set becomes visible. When a Working Set is inactive, its active mask might not be visible, but still remains as the active mask for that Working Set.

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4.6.9 Connection management

The VT transmits the VT Status message once per second. The Working Set uses the message to ensure the VT is present and to determine the current status of the VT. If a Working Set does not receive this message for a period of 3 s it is determined to be a shutdown of the VT. When this happens the Working Set shall enter a safe state. The safe state is defined as the state in which all functions dependant on the VT operator interface are put into a known state that will not put the operator or machine at risk. The Working Set can re-establish connection to the VT. If the Working Set is designed to re-establish connection to the VT it shall do so by restarting the initialization procedure (see 4.6.6).

Each Working Set Master sends the Working Set Maintenance message once per second. The VT uses this message to ensure that each Working Set is still present. If the VT does not receive this message for a period of 3 s or it receives it a second time with the Initiating bit set it is determined to be an unexpected shutdown of the Working Set Master (see Figure 6) and the following rules apply.

The VT shall not alert the operator:

— If the Working Set has commanded the VT to delete the object pool, and the Working Set then stops sending Working Set Maintenance messages. This allows the Working Set to silently remove itself from the VT.

— If the VT can detect the ignition key state and the ignition key is reported as off.

— If there is no pool loaded by the Working Set into the VT volatile memory.

The VT shall alert the operator:

— If the pool has not been commanded to be deleted and the ignition key is not detected as off and the Working Set's object pool is present in the VT. This is detected as an unexpected shutdown of the Working Set and the VT shall alert the operator to this condition after which the VT shall delete the Working Set's object pool from volatile memory to free the memory for other uses. The means to alert the operator is proprietary to the VT.

When a visible Working Set's object pool has been deleted all presentation from that Working Set is removed (Data Masks, Window Masks, etc.). If there was an active Alarm Mask for the removed Working Set the VT deselects the Alarm Mask automatically. The VT can give control to another connected Working Set or to a VT proprietary presentation and it shall update the VT Status message.

When a Working Set's object pool has been deleted and there exists auxiliary assignments mapped to this Working Set, the VT shall remove them.

When the VT receives a Working Set Maintenance message from a Working Set where the initiating bit is not set, and in which the VT had detected an unexpected shutdown, it shall send Acknowledgement: NACK to the message. The Acknowledgement:NACK message is sent to the Working Set Master. The Working Set can re-establish connection to the VT by restarting the initialization procedure (see 4.6.6).

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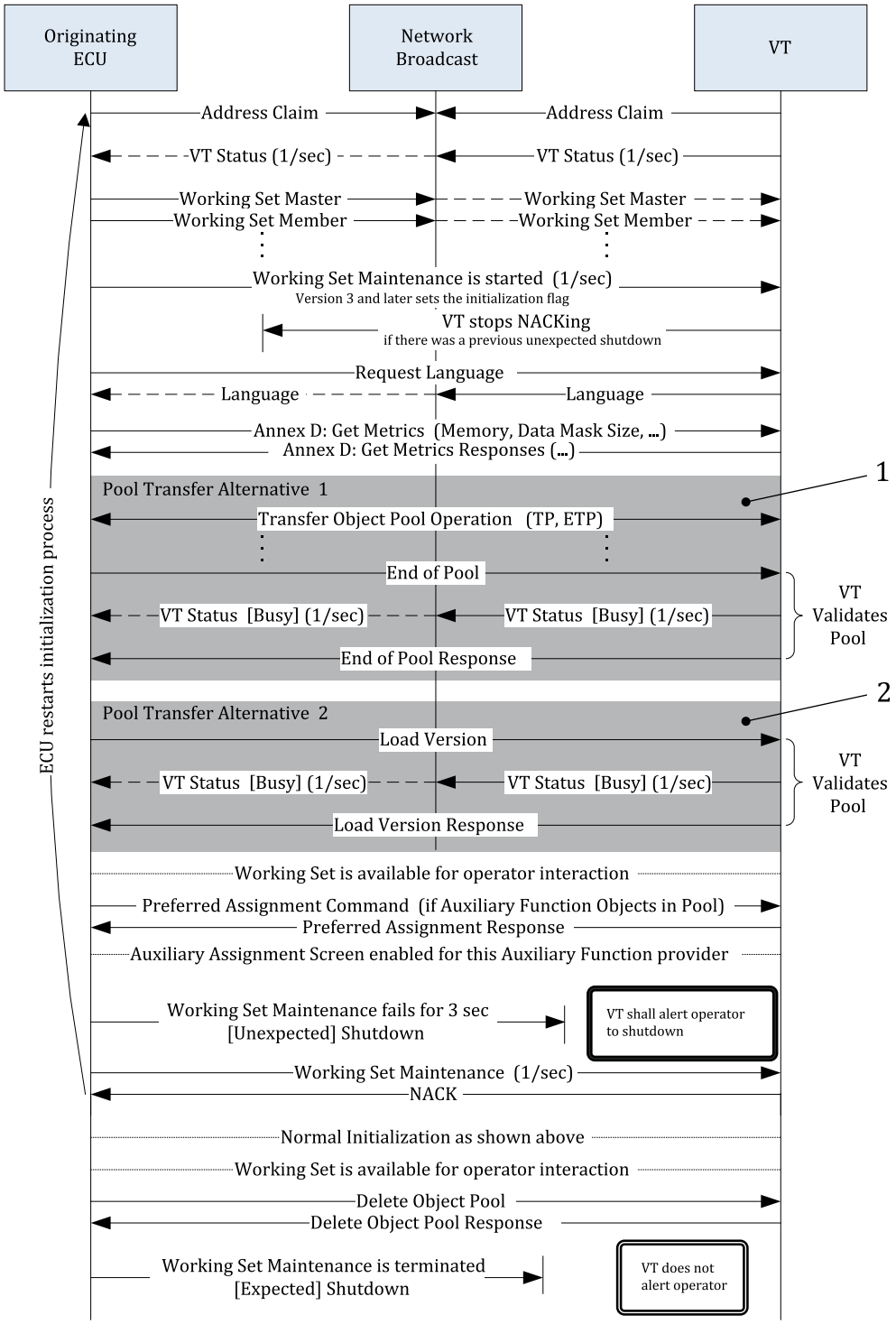

Key

1 working Set reboots unexpectedly and within the time-out limit of the Working Set Maintenance message, Object Pool is still in VT volatile memory, Initiating bit is set

2 working Set discontinues communication

NOTE Solid arrows indicate destination specific messaging, dashed arrows indicate global message.

Figure 6 — Initialization, unexpected shutdown, and expected shutdown

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4.6.10 Updating the operator interface

4.6.10.1 General

CAN has finite bandwidth available in support of all services (e.g. ISO 11783-3 to ISO 11783-14). Further, the VT has finite bandwidth that is shared by all Working Sets using its services. In order to best manage the system bandwidth, it is recommended that:

— Active Working Sets, or those that are inactive but visible, should issue commands to the VT only when the data has changed in a way which is visible to the operator (e.g. only update objects actively displayed).

— Inactive Working Sets, which have no active Data Mask and Soft Key Mask displayed should reduce the frequency of, or eliminate, updates to the VT.

4.6.10.2 Changing attributes and values

Attributes of objects can be changed during operation by Working Set Masters and Working Set Members using the defined change attribute messages. Certain attributes in each object are assigned an attribute ID. The Change Attribute command allows any attribute with an AID to be changed if not designated as a read-only attribute. In addition, attributes are sometimes grouped together into a single "change" command for efficiency purposes. (e.g. Change Font Attributes command F.28).

Even when the associated Data Mask is not visible, the Working Set can continue to change the attributes (including value) so that when the mask is made active and visible, the necessary output data are current and ready to display.

Objects that are altered by both the Working Set and the operator can be susceptible to a race condition. While the Working Set can know when an object was opened for input (see H.8), processing delays (e.g. inbound and outbound FIFOs) permit the possibility that the Working Set issued a command just as the operator began an interaction. It is the Working Set responsibility to validate commands from the VT.

In VT version 5 and prior the requirements were inconsistent. Some commands provided an error code response "object in use", which is deprecated in VT version 6 and later.

In VT version 6 and later, object attributes can be changed even if the object is "in use". The VT design can apply the change immediately, or the VT design can cache the change until it can be applied. The Working Set can be aware of the current activity (e.g. an object opened for input), and should avoid race conditions that could adversely affect the interaction.

While permissible, changes to specific objects and attributes while "in use" should be avoided:

— Key object; Key code,

— Button object; Key code,

— Input field objects; Value and Variable references,[1), 2)]

— Input String object; Input attributes, Extended Input attributes,[1)]

— String Variable object; when referenced by an Input String object,

— Input Number object; Minimum, Maximum, Offset, Scale,[1)]

---

1) When a non-atomic means is used to edit Input field objects (e.g. a pop-up dialogue), these attributes shall be transferred to the proprietary edit means as an atomic set, and run-time changes are applied when the edit is completed.

2) The VT Change Numeric Value message has an optional response in VT version 5 and prior. A race condition could occur where the Working Set and VT apply a change, resulting in the VT presentation being out of sync with the Working Set internal value.

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— Font Attributes object: font type; when referenced by an Input object,[1)]

— Number Variable object; when referenced by an Input Number object or an Input List object.[2)]

EXAMPLE An Input Number object is being edited with a VT proprietary means such as a pop-up keypad. The Working Set sends a command to change the background colour of the Input Number object being edited. The VT shall accept the command without error, even if the VT design prevents displaying the updated colour while the proprietary editing means is in use. When the editing has completed, and the presentation has been restored where the Input Number object is visible, the applied colour change shall be visible.

4.6.10.3 Changing, adding and deleting objects

Working Sets can replace objects at run-time; however the replaced objects shall be of the same type. New objects can be added by initiating a transport protocol session to send one or more objects to the VT. When the VT receives an object with an existing Object ID, the existing object is replaced (the VT can determine the owner from the source address of the message). Resizing objects is permitted but can cause the VT to run out of memory (see C.2.6).

To delete a single object in the object pool, the entire object pool has to be deleted from the volatile memory in the VT by the Working Set sending a Delete Object Pool command. The object pool has to be uploaded again without the object that should be deleted.

4.6.11 Special objects

4.6.11.1 Container objects

A Container object is a special object used to

— logically group objects in order to identify and reuse the container, or

— hide and show objects.

Figure 7 shows an example of container reuse. Mask 1 and Mask 2 both need the information displayed in Container 1. The Working Set first creates the container, and then inserts the container into Mask 1 and Mask 2 using the Object ID of the container.

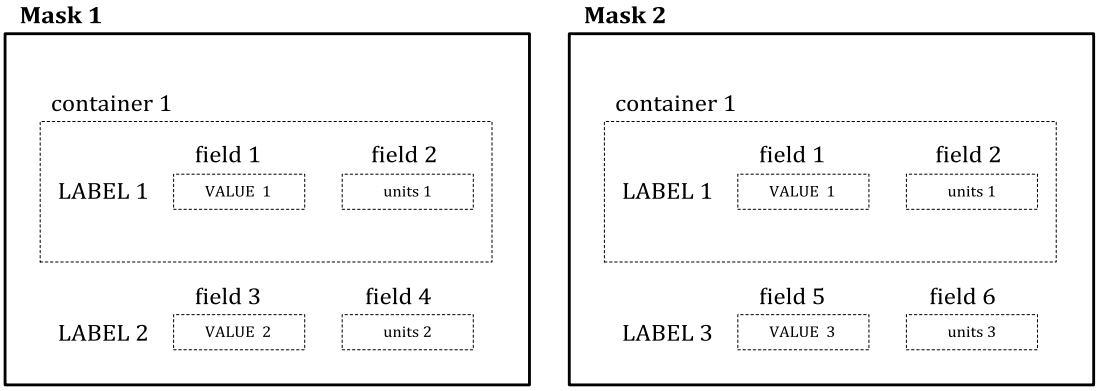

Figure 7 — Container reuse

Figure 8 a) shows an example of using a container to hide a group of objects. In the example, Text 1 and Text 2 should be visible at all times. Text 3 and Text 4 should be visible only if a particular feature of an implement is available. Therefore, the Working Set creates a container containing Text 3 and Text 4 to be inserted in the mask. At run-time, the Working Set determines whether or not the particular feature is available. If not, the Working Set hides the container [see Figure 8 b)].

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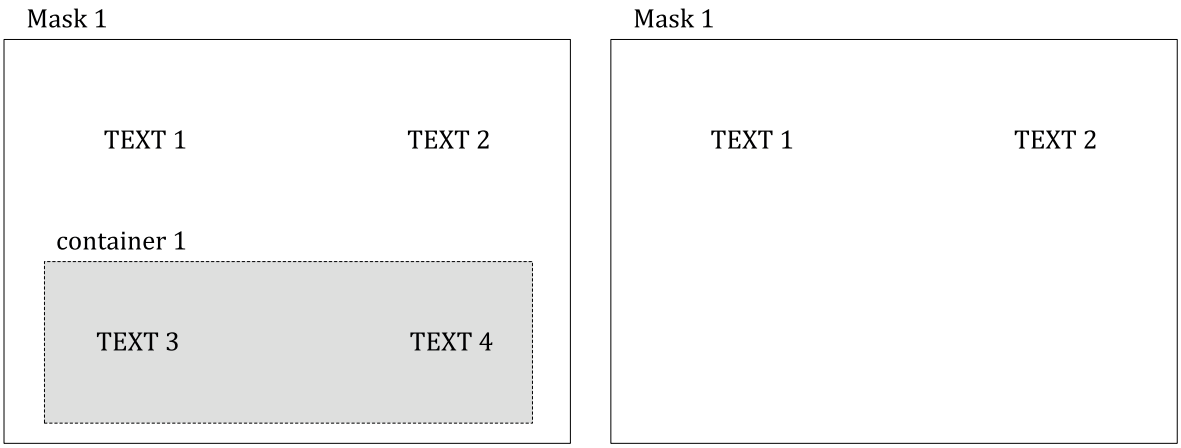

a) Particular feature available **b) Feature not available: container hidden**

Figure 8 — Container used to hide objects — Example

4.6.11.2 Attribute objects

There are five types of attribute objects: font, line, fill, input, and extended input. Attribute objects are referenced by other objects. This allows one set of attributes to be shared with many objects to create and maintain a common look across those objects. All objects using a given attribute object are updated when the attribute object is changed.

4.6.11.3 Variable objects

Variable objects can be used to share data between two or more other objects. Changing the value in only one object can reduce bus traffic. For example, it could be desirable to draw a Meter object and also to show its current value as a numeric under the meter. In this case, a Number Variable object could be referenced by both the Meter object and an Output Number object. By doing this, a change in the value of the variable will be reflected in both the meter and output field at the same time and the change will require only a single Change Numeric Value command.

4.6.11.4 Macros

Macro objects are used to improve the performance of the operator interface. Macro objects have the following properties:

a) Macros can only contain the commands listed in Annex F.

b) If a Macro triggers an event that causes another Macro, the current Macro is completed first before another is started.

c) Macros are executed in the order they were triggered.

d) If a Macro executes an Execute Macro command or an Execute Extended Macro command, the macro in the Execute command is executed, before the remaining commands in the current Macro.

e) Macros triggered by the execution of a command shall be completed before the next bus command is started.

f) Macro Object IDs shall be in the range 0 to 255 for VT version 4 and prior. Macro Object IDs can be in the range of 0 to 65534 for VT version 5 and later.

g) Macros do not trigger response messages. When executing the command messages in a macro, the VT shall not send response messages on the CAN bus for the messages contained in the macro.

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Therefore macros reduce CAN traffic. For example, a Macro that executes a Change Active Mask command will trigger a VT Status message, but will not trigger a Change Active Mask response.

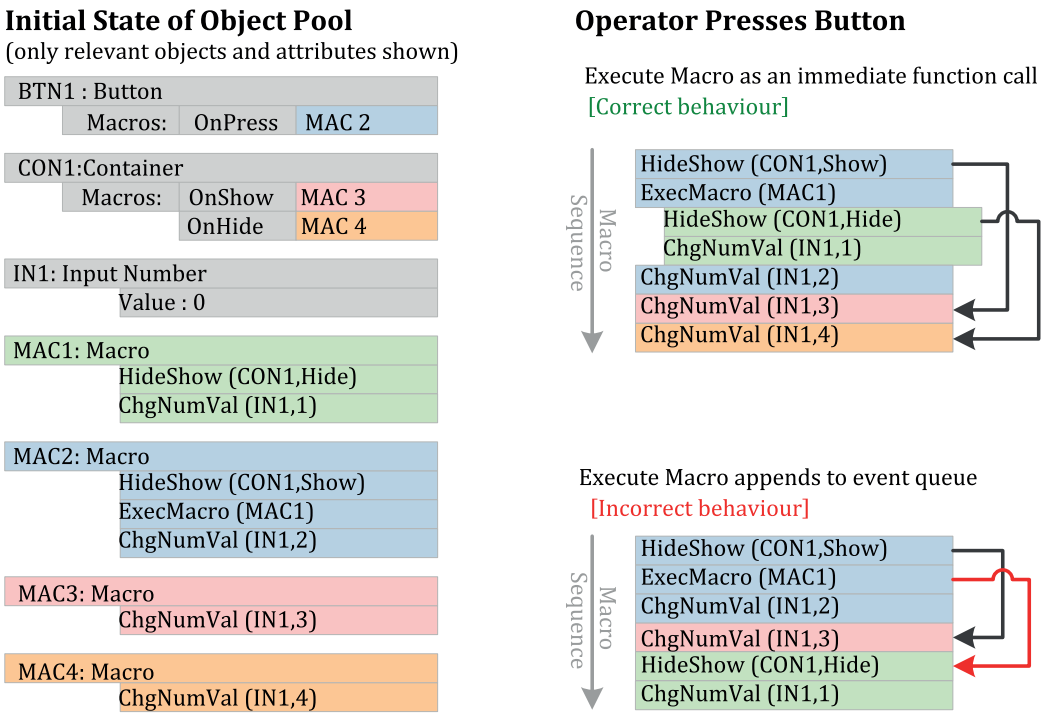

Figure 9 — Macros; The effect of Execute Macro in a Macro — Example

As can be seen in the example of Figure 9, the correct execution of this sequence results in an Input Number containing the value 4.

CAUTION — Objects that are altered by both a Working Set and a Macro can be susceptible to a race condition and should be evaluated for predictable behaviour.

EXAMPLE 1 An Input String object has a Macro to clear the Input String object—On Input Field Deselection. The "Enter" means on an Input String object of length greater than 3 characters causes the VT to send the data using Transport Protocol (TP) to the Working Set (WS). The operator quickly navigates away from the Input String object. "On Input Field Deselection" causes the VT to notify the WS with a VT Select Input Object message (Deselect). An On Input Field Deselection Macro alters the Input String object value. The WS receives the TP data asynchronous to the VT Select Input Object message (Deselect). The outcome is based on the asynchronous processes in the VT, the message processing methods in the VT, including TP processing and potential latencies, and the WS implementation.

EXAMPLE 2 An On Key Press Macro associated with a Button object changes the active Data Mask. An On Show Macro attached to the new Data Mask changes the numeric value in an Input List object on this new Data Mask to initialize it to a known setting. The operator presses the Button, which causes a Button Activation message to be sent to the WS. The WS sends a Change Numeric Value command to the Input List object. The Input List object can end up with either value, due to the asynchronous processes.

Circular references are not permitted since they create infinite Macro loops inside the VT and could render the VT inoperable for all Working Sets.

EXAMPLE 3 When a Macro triggers an event that references the same Macro, a circular reference is created.

4.6.11.5 Object pointer

The Object Pointer object allows run-time modification of included objects. By changing the value of the Object Pointer object, a different object can be drawn at the same location. The type of object that the Object Pointer is allowed to reference is limited and depends on the parent object. Refer to valid parent objects of the Object Pointer for a list of objects that can be referenced. An Object Pointer can always

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point to another Object Pointer. An Object Pointer can point to the NULL Object ID and in this case nothing shall be drawn.

When an Object Pointer is modified at run-time, resulting in an invalid object reference, the VT is not required to detect this object pool error immediately but can delay error detection until the Data Mask object or Alarm Mask object which contains the Object Pointer is activated. At activation of a data or Alarm Mask containing the invalid object reference the VT sends the F.35 "Change Active Mask response" or H.14 "VT Change Active Mask message" to inform the Working Set and can delete the object pool.

The VT can also detect the error immediately upon Object Pointer value modification, and in this case shall send an F.23 Change Numeric Value response with "invalid value" indicated in the error codes.

4.6.11.6 External Object Pointer

The External Object Pointer object allows a WS to display objects from an object pool of another WS.

To ensure that the external references are valid even after software updates of the participating WS, the referenced WS and the referencing WS shall exchange information about the referenced objects before enabling the external references. The information exchange shall be repeated every time either the referencing WS or the referenced WS is restarted. As a minimum the object identifiers shall be transferred from the referenced WS to the referencing WS.

NOTE Some devices (e.g. the SCC/SCM — ISO 11783-14) have a standardized method for exchanging object information. If a standardized method does not exist, then a proprietary method shall be agreed between the manufacturers of the referencing and the referenced WS.

To protect against unsolicited references the referenced WS shall use the External Object Definition object to list the objects which are allowed to be referenced by another WS. The External Object Definition object is assigned to one and only one referencing WS. If a referenced WS will allow multiple WS to reference objects it shall have multiple External Object Definition objects.

The referencing WS shall use the External Reference NAME object to identify the WS it plans to reference.

The attribute values of the External Object Definition object, the External Object Pointer object and the External Reference NAME object shall all be valid before the external object can be displayed. Some of the information in the objects depends on the exchange of object information and therefore the objects shall be in the reset state until the object information is complete.

Reset state is defined by:

— External Object Pointer object : External Object Id attribute is the NULL object id

— External Object Definition object : Enable bit in the Options attribute is cleared

— External Reference NAME object : Enable bit in the Options attribute is cleared

When the object pool is loaded from non-volatile storage in the VT there is no guarantee that the attribute values are valid, and therefore the VT shall set all occurrences of the External Object Pointer, the External Object Definition and the External Reference NAME to the reset state.

When the object pool is uploaded from the WS master, the VT shall not set the objects to the reset state. If the information exchange between the referenced and the referencing WS is not completed before the object pool is uploaded, the WS master shall set the objects to the reset state before uploading the pool.

Before displaying an external object the VT shall check the validity of the external reference. The external reference is considered to be valid when all of the following are fulfilled:

— The External Reference NAME ID attribute of the External Object Pointer object identifies an enabled External Reference NAME object.

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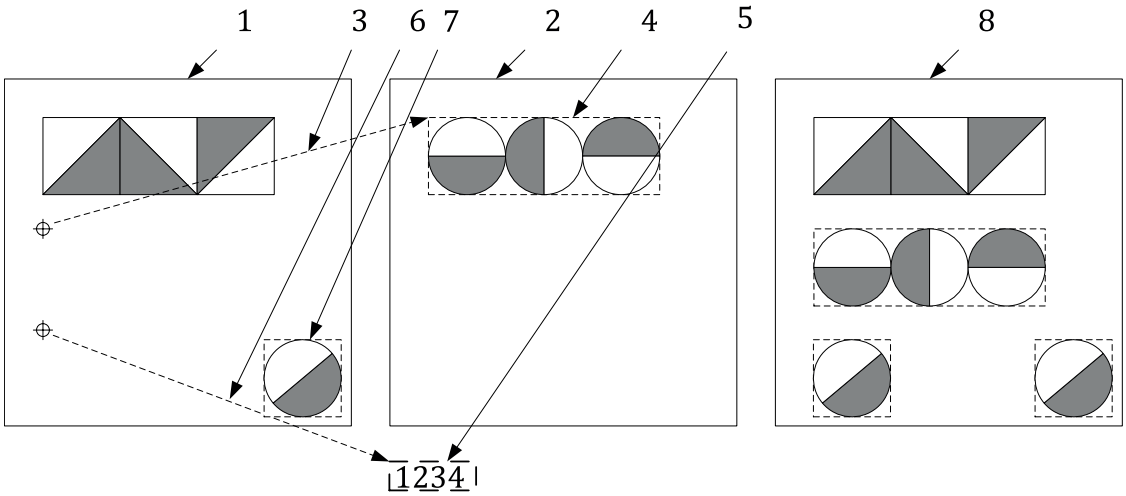
— The referenced WS has an object pool in volatile memory on the VT (referenced object pool).

— The referenced object pool contains an enabled External Object Definition object where the NAME attributes identifies the referencing WS.

— External Object Id is listed in the object list in the above mentioned External Object Definition object.

If the referenced object is NULL or not valid the VT shall draw the object identified in the Default Object ID attribute of the External Object Pointer object.

There can be multiple instances of the External Object Definition object in an object pool. If multiple External Object Definition objects are assigned to the same NAME, then an external reference shall be considered valid if made valid by one or more External Object Definition objects.



Key

1 VT presentation from Working Set 1

2 VT presentation from Working Set 2

3 External Object Pointer with reference to object in Working Set 2 Object Pool

4 Referenced object in Working Set 2 (container that contains several objects), all of which are valid

5 Number Variable on Working Set 2 object pool

6 External Object Pointer with reference to object in Working Set 2 Object Pool

7 Default Object to be shown when External Objects are invalid

8 VT presentation from Working Set 1 after references are established, enabled and resolved

Figure 10 — External Object References — VT Example

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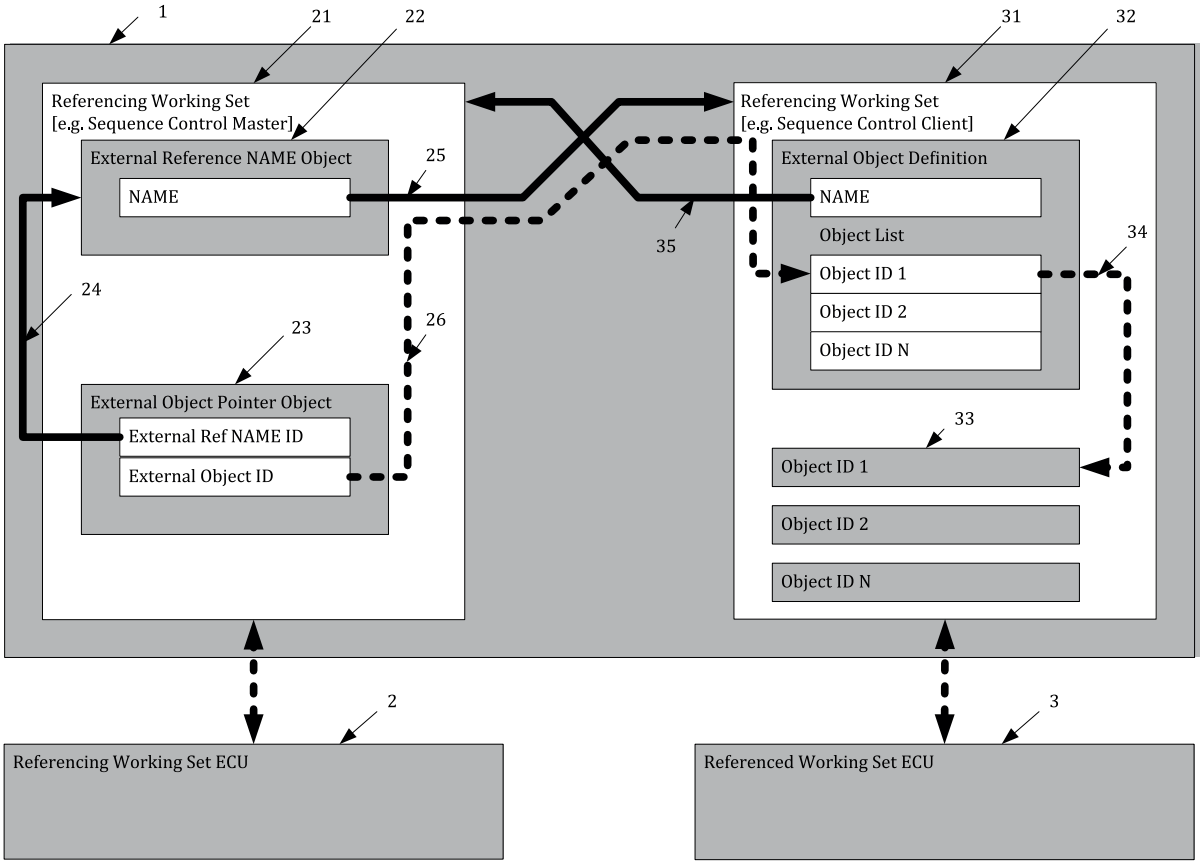

Key

1 VT Object Pool volatile memory

2 Referencing Working Set ECU (ECU 2)

3 Referenced Working Set ECU (ECU 3)

21 Referencing Working Set in VT memory

22 External Reference NAME Object, including NAME attribute that references ECU 2s

23 External Object Pointer Object

24 Reference to the External Reference NAME object

25 Virtual reference established by External Object Pointer object that informs VT to the Working Set containing the referenced objects

26 Virtual reference established to the External Object of interest

31 Referenced Working Set in VT memory

32 External Object Definition object

33 Object Pool Object that can be referenced from an external Working Set

34 Reference to the Object Pool object that can be referenced

35 Virtual reference established that allows ECU 2 to reference ECU 3 objects

Figure 11 — External Object References — Relationship Example

Example 1 Two External Object Definition objects have the same value in the NAME attributes. Both objects are enabled, only one of the objects includes 1234 in the Object ID list. Object Id 1234 can be referenced.

Example 2 Two External Object Definition objects have the same value in the NAME attributes. Both objects include 1234 in the Object ID list, only one of the objects is enabled. Object Id 1234 can be referenced.

4.6.12 Relative X/Y positions

The X, Y position attribute determines where an object is drawn on the display. This position is always relative to the upper left corner of the parent object. The X,Y position is always found in the parent object. Figure 12 shows an example Data Mask with the relative locations of several objects.

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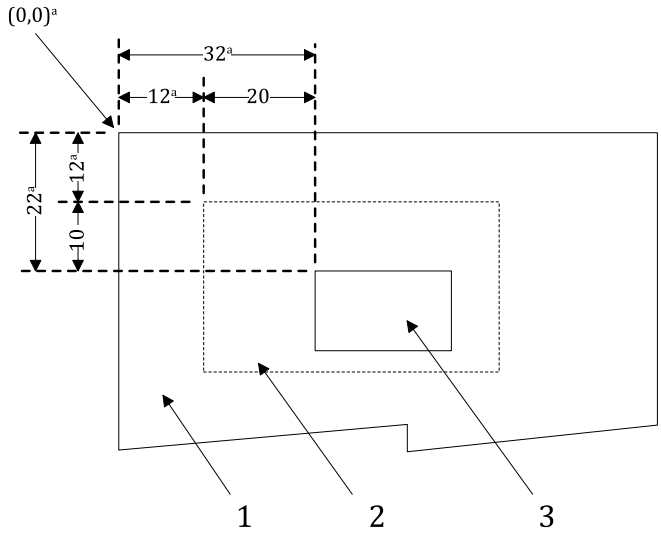


Key

1 data mask

2 container

3 input field

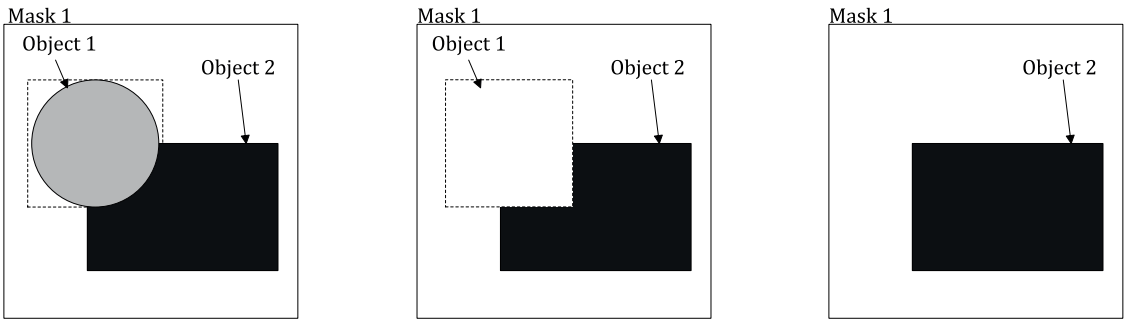
[a] Absolute.

Figure 12 — Relative and absolute location of objects

4.6.13 Overlaid objects

A mask can be built such that two objects will occupy the same or overlapping space on the display. This can require extra processing in the VT, but could be necessary in some cases and shall be supported by the VT. For this reason, the hierarchy or layering of objects shall be understood. Some objects have a list of contained objects. Objects listed first are considered to be lower in the hierarchy than objects listed later. When an object is changed, all objects that overlay it and which have been corrupted shall be redrawn (this is called a refresh event). All objects defined by this part of ISO 11783 have a rectangular size either defined or implied to simplify the VT's task of finding overlaid objects.

Objects shall be drawn such that objects listed later appear to overlay objects listed earlier, so that the entire image of the object listed last is visible, while only those areas of the object listed earlier that do not coincide with areas of the object listed last will be visible.



a) Initial presentation **b) Intermediate operation** **c) Final presentation**

Figure 13 — Object changed or hidden — Display update

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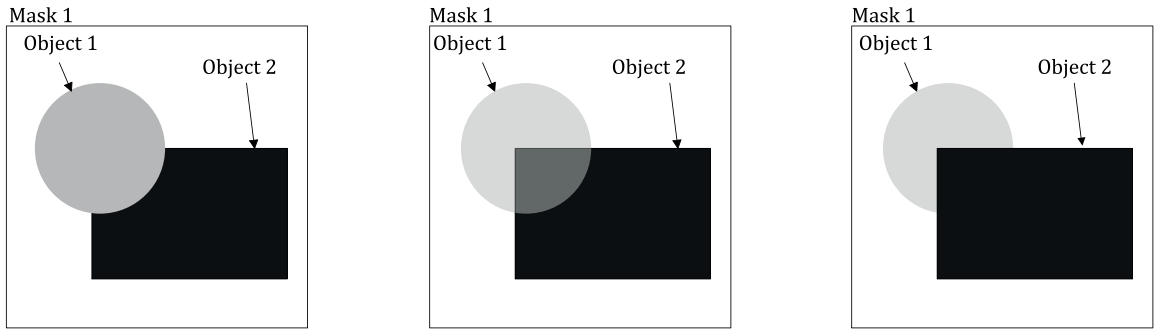
EXAMPLE Referring to Figure 13, where (a) shows the initial presentation before any command is received. The Working Set then commands object 1 to be hidden. As an intermediate step shown in Figure 13 b), the VT deletes object 1 and all child objects by filling the object's area with the background colour of the parent mask. The VT then redraws the object along with all child objects. The VT then refreshes any other object (e.g. object 2) that could have been visually altered in the deletion process as shown in Figure 13 c). The VT can implement this refresh in a manner where the intermediate display is never seen by the operator.

Additionally, VT version 6 and later supports redefinition of the VT standard colour palette with one that includes alpha channel (transparency) values. This causes alpha blending in the area of the overlaid objects when the top object is defined with a non-opaque alpha channel.



a) Filled Ellipse overlaid on a Rectangle

b) 50 % Alpha filled Ellipse overlaid on a Rectangle

c) Opaque filled Rectangle overlaid on 50 % Alpha filled Ellipse

Figure 14 — Overlaid Objects including Alpha channel effects

EXAMPLE Referring to Figure 14, where a) shows the presentation when an Ellipse is filled with an opaque colour, Figure 14 b) shows the presentation when the fill colour has been redefined with a 50 % alpha value, and Figure 14 c) shows that an opaque object on top of an object with a 50 % alpha value does not cause blending.

Alpha channel values range from fully transparent (0) to fully opaque (255). Where the alpha channel information affects the display, the blended value is defined as follows:

— Source colour is the colour of the top object (the object listed later).

— Destination colour is the rendered colour of the underlying (bottom) object (the object listed earlier), which can have been blended with other underlying objects.

— Blended colour = (source colour × alpha/255) + [destination colour × (255 – alpha)/255][3].

Two or more objects can be positioned in an overlay. Starting from the bottom-most object each blended colour layer shall be computed individually, thus defining the destination colour for the next object in turn.

Referring to Figure 14, the background is opaque white RGB(255,255,255), the rectangle is black RGB(0,0,0), and the ellipse is grey RGB(128,128,128). In drawing b, the ellipse is 50 % Alpha A(128). Where the ellipse overlays the white background, the blended colour is RGB(191,191,191) and where the ellipse overlays the black rectangle, the blended colour is RGB(64,64,64).

4.6.14 Alarm handling

Alarms allow a Working Set to display alarm information at any time. If several Working Sets have an Alarm Mask activated, the VT shall display the masks in order of priority. Priority is determined, first, by the priority attribute defined in the Alarm Mask object and, second, by chronological order of activation. The highest priority alarm is always displayed until the owner Working Set changes the active mask. When more than one Working Set has activated an Alarm Mask with the same priority attribute, the first of these, as processed by the VT, shall become the active mask. When the active

3) The algorithm employed can round or truncate in the production of the Blended colour.

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Working Set changes to a lower priority alarm or Data Mask, the next in turn highest priority Alarm Mask is processed.

When the Working Set and the VT are compatible with VT version 6 and later (see D.3, G.3), A Working Set that is not selectable can activate an Alarm Mask (using the Change Active Mask command). To deactivate the Alarm Mask, the Working Set would activate a Data Mask. The VT shall apply normal Alarm Handling rules.

Operator input disturbed by the activation of an Alarm Mask can be left intact for resumption once all Alarm Masks have been acknowledged. A Soft Key Mask is associated with the Alarm Mask via an attribute in the Alarm Mask object. Whenever the alarm is displayed, the associated Soft Key Mask is also displayed. The following describes the protocol requirements between the VT and the Working Set raising the alarm.

a) The Working Set Master activates an Alarm Mask by using the Change Active Mask command on the Working Set object. Only one Alarm Mask can be active per Working Set.

b) The VT responds with a Change Active Mask response.

c) Based on priorities, at some point, the VT displays the Alarm Mask and the Soft Key Mask associated with the Alarm Mask. When a mask change occurs that causes an Alarm Mask to appear or reappear, the acoustic signal associated with the Alarm Mask shall be activated. The VT shall terminate any acoustic signal from a lower priority Alarm Mask that can be in process, even if the higher priority Alarm Mask is set for silent. The VT shall terminate any acoustic signal from a Control Audio Signal command that can be in process if the VT does not support multisound (see F.10) and if the acoustic signal is not set for silent (version 4 and later VTs shall send the VT Control Audio Signal Termination message to indicate the termination). If the Alarm Mask acoustic signal completes, or if it is set to none for silent signal, then control audio commands from ECUs shall be accepted as defined in the Control Audio Signal command (see Table 2 and Table 3).

d) The VT notifies the Working Set with a VT Status message sent to the global address.

e) At some point the operator can acknowledge the alarm with the proprietary ACK means on the VT. The VT sends a Soft Key Activation message to the Working Set with key code set to zero (0) based on the operator action (see 4.6.18). Alternately, the Working Set can deactivate the Alarm Mask using the Change Active Mask command to activate a Data Mask; based on its internal logic.

f) The Working Set can choose to ignore the ACK means if the ACK is not allowed or the Working Set can change the active mask to either an Alarm Mask or a Data Mask by using the Change Active Mask command on the Working Set.

g) The VT responds with the Change Active Mask response.

h) The VT displays a new mask (see Table 4).

Table 4 — VT behaviour on mask transition

Working Set's active mask attribute From/To	Is requester the Current active Working Set?	VT behaviour
Data to data	Yes	Hide current Data Mask, show new Data Mask.
Data to data	No	If the VT design supports only one visible Data Mask, then no visual change. If the VT design supports multiple visible Data Masks and this Working Set is currently visible, then hide the current Data Mask, show new Data Mask.
Data to alarm	Yes	Hide Data Mask, show Alarm Mask.
Data to alarm	No	If this is the highest priority alarm, deactivate the current Working Set and activate this Working Set.

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Table 4 *(continued)*

Working Set's active mask attribute From/To	Is requester the Current active Working Set?	VT behaviour
Alarm to alarm	Yes	If this is the highest priority alarm, hide current Alarm Mask, show new Alarm Mask. Otherwise, deactivate this Working Set and activate the Working Set of the highest priority alarm.
Alarm to alarm	No	If this is the highest priority alarm, deactivate the current Working Set and activate this Working Set.
Alarm to data	Yes	If an alarm exists in another Working Set, deactivate this Working Set and activate the Working Set with the highest priority alarm. Otherwise, if this Working Set had the last visible Data Mask, hide the Alarm Mask and show the Data Mask. Otherwise, deactivate this Working Set and activate the Working Set which had the last visible Data Mask. If there is no Working Set which had the last visible Data Mask, the VT presentation shall be the same as when there is no Working Set mask to display.
Alarm to data	No	No visual change.

4.6.15 Clipping

Most objects defined in this part of ISO 11783 have a given or implied size. The VT shall clip anything drawn outside the defined size of the object. Clipping is always done on a graphical (i.e. pixel) basis.

These clipping rules also apply to text and numeric objects. When the text does not completely fit inside the defined object area, in both wrapping and non-wrapping cases, the graphical clipping rules apply and the presentation is clipped on a graphical (i.e. pixel) basis (see Figure 15).

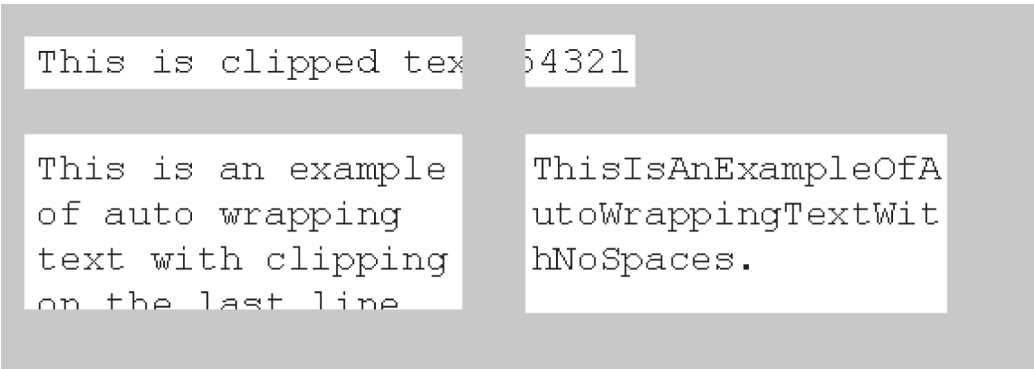

Figure 15 — Clipping examples

4.6.16 Scaling

4.6.16.1 General

The Working Set shall determine the size of the VT's Data Mask area and Soft Key designator and make appropriate adjustments to its object definitions. These adjustments can be applied either before or after transmission of its object pool to the VT, as long as the transmitted pool is not invalid for the VT (e.g. cannot transmit colour objects to a black and white VT and then change object to black and white). This gives complete control of the appearance of the masks to the Working Set.

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4.6.16.2 Positions and sizes

The Working Set shall scale positions and object sizes to adapt to the VT's Data Mask area and Soft Key designator(s).

4.6.16.3 Fonts

The Working Set shall apply a best-fit algorithm to determine and select the best font for the defined area. The Working Set shall also ensure that the VT supports the selected fonts and font styles. The smallest font size is 6 × 8. If the scaled height and width of the original font is less than 6 × 8, the 6 × 8 font shall be used. This could result in clipping if the text is near the edge of the field object, or in text overlap if two occurrences of text are too close together after scaling the object size independently of the font size. Working Set designers shall be aware of this limitation and shall take the necessary steps. (See 4.6.19.3 and 4.6.19.4.)

4.6.16.4 Picture graphic objects

Picture Graphic objects are automatically scaled by the VT according to the width attribute in the Picture Graphic object.

4.6.17 Operator input

Whenever the VT displays a Data Mask that contains one or more enabled visible input objects or Buttons, it shall be in one of the following states:

a) Navigating;

b) Data input[4)].

When determining the visibility of an input object, the object shall be considered visible even under the following conditions:

— the object's width or height equals zero;

— the object is covered in its entirety by another object;

— the object is wholly outside the clipping limits of the parent object hierarchy as defined by the width and height attributes of all the parents in the hierarchy.

Objects with width or height of zero, and objects that are wholly outside the clipping limits of the parent object hierarchy are discouraged as activation might not be possible (e.g. touch screen). The Working Set designer can consider enabling and disabling these objects as needed so the Working Set navigation is more predictable in operation.

When a new active data-mask is selected the state is reset to "Navigating". If an Alarm Mask is selected then the VT might remember the state and if the Working Set returns to the same data-mask after showing the alarms then the state can be restored. If this approach is implemented and the Working Set returns to a different Data Mask after showing alarms, the VT shall consider it as a normal Data Mask change and send the appropriate messages (see Table 5).

The initial focus point, if any, and the tab order for navigating to the various input fields, buttons or soft keys is VT proprietary, but the Working Set shall be aware that the tab order can be defined by the definition order of the input objects in the parent object.

NOTE VT version 3 and prior do not support selection of a Button object or a Key object using the VT Select Input Object message.

The VT can choose not to send the VT Select Input Object message for every object that the operator passes through while navigating. E.g. if the navigation means is a rotary control, the focus will change

4) The nature of buttons means that the VT cannot be in the Data input state when a button has focus.

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rapidly while the operator is spinning the control. In such a case the VT can choose only to send the VT Select Input Object message to the input object which loses focus and the one which eventually gets focus.

In the "Navigating" state the VT shall indicate to the operator which (if any) input, Button, or Key object is selected (has focus). The method of indication is proprietary to the VT. The VT can open an input object for data input as soon as the object gets focus, and it can remove focus when input is done. This is common, but not required, behaviour for touch screens.

Examples of focus-indicators include (but is not limited to) adding a frame around the input field, changing the background colour of the input field, or momentarily highlighting the input field on a touch screen VT.

The VT designer should be aware that the use of the Select Input Object command by the Working Set can be a means by which the Working Set designer intends to focus the operator attention to an input field (e.g. a setup wizard where the recommended action is highlighted).

The VT shall indicate the disabled input objects. The means to represent disabled input objects is VT proprietary. Visual changes to disabled objects to indicate the disabled state shall not extend beyond the width/height of the object and the object shall remain legible.

Working Sets can apply a frame around, or distinct background colour to, input objects as an aid to the operator in identifying input fields.

In the "data input" state the VT behaviour is proprietary, and the VT can cover part or all of the Data Mask while the object is open for data input. Changes to the attributes of an input object during the data input process shall not affect the value currently being input (e.g. changes to an Input Number Scale shall not alter the apparent value being input).

The VT reacts to navigation related events (see Table 5). The VT shall respond with all messages indicated in Table 5 for each specific scenario. The sequence order of the response messages in Table 5 is not a requirement and Working Set Masters shall be designed to handle the responses in any order.

Table 5 — VT Reaction to navigation and data input events

Current state	Command/Event	New state	Response frames
Navigating	Select Input Object command (byte 4 = FF_{16})	Navigating	Select Input Object response
Navigating	Enable/Disable Object command (to disable the object which has focus)	Navigating	(The object becomes disabled and loses focus—VT can move focus to the next input object) Enable/Disable Object response VT Select Input Object message (on object which loses focus) VT Select Input Object message (on object which gets focus — if any)
Navigating	Change Active Mask command (only if new mask is a new Data Mask, or if the new mask is an Alarm Mask and the VT does not store the state of the input object)	Navigating	VT Select Input Object message (on object which loses focus — if any) Change Active Mask response VT Status message (with new Data Mask — if received from the active working set) VT Select Input Object message (on object which gets focus — if any)

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Table 5 *(continued)*

Current state	Command/Event	New state	Response frames
Navigating	Select Active Working Set command	Navigating	VT Select Input Object message (on object which loses focus — if any) Select Active Working Set response VT Status message (with new WS and Data Mask) VT Select Input Object message (on object which gets focus — if any)
Navigating	ESC command	Navigating	ESC response (with error code indicating that no input is open for input)
Navigating	Operator activates a selected Button object	Navigating	Button Activation message
Navigating	Operator navigates to a new object	Navigating	VT Select Input Object message (on object which loses focus — if any) VT Select Input Object message (on object which gets focus — if any)
Navigating	Operator opens the object for data input	Data input	VT Select Input Object message (on object which has/gets focus)
Navigating	Select Input Object command (byte 4 = 00_{16})	Data input	Select Input Object response
Data input	Select Input Object command (Selecting an object that does not currently have focus)	Data input	Select Input Object response (with error code indicating that another input field is currently being entered)
Data input	Enable/Disable Object command (to disable the object which has focus)	Data input	(the input object stays enabled and maintains focus) Enable/Disable Object response (with error code indicating that operator input is active)
Data input	Change Numeric Value command (on the object that has focus)	Data input	Change Numeric Value response
Data input	Change String Value command (on the object that has focus or the Input Attribute that is referenced by the object that has focus)	Data input	Change String Value response
Data input	Change Active Mask command (only if new mask is a new Data Mask, or if the new mask is an Alarm Mask and the VT does not store the state of the input object)	Navigating	VT ESC message VT Select Input Object message(on object which loses focus) Change Active Mask response VT Status message (with new Data Mask) VT Select Input Object message (on object which gets focus — if any)

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Table 5 *(continued)*

Current state	Command/Event	New state	Response frames
Data input	Select Active Working Set command	Navigating	VT ESC message VT Select Input Object message (on object which loses focus) Select Active Working Set response VT Status message (with new WS and Data Mask) VT Select Input Object message (on object which gets focus — if any)
Data input	Change Attribute command (of the object that has focus)	Data input	Change Attribute response
Data input	Change List Item command (on the object that has focus)	Data input	Change List Item response
Data input	Pool Update alters the object which has focus	Navigating	VT ESC message VT Select Input Object message (on object which loses focus — if any) VT Select Input Object message (on object which gets focus — if any)
Data input	Parent Container is hidden	Navigating	VT ESC message VT Select Input Object message (on object which loses focus — if any) VT Select Input Object message (on object which gets focus — if any)
Data input	Pointer to this object is changed to not reference this object	Navigating	VT ESC message VT Select Input Object message (on object which loses focus — if any) VT Select Input Object message (on object which gets focus — if any)
Data input	ESC command	Navigating	ESC response VT Select Input Object message (on object which has/loses focus)
Data input	Operator activates the ESC means	Navigating	VT ESC message VT Select Input Object message (on object which has/loses focus)
Data input	Operator activates the ENTER means	Navigating	VT Change Numeric Value message or VT Change String Value message (even if the new value is the same as the old) VT Select Input Object message (on object which has/loses focus)

4.6.18 Soft Key and Button activation

Whenever a Key object or Button object or ACK key is pressed, released, or latched, the VT sends a Soft Key Activation message or Button Activation message to the working Set Master. If a Macro is associated with the key press, the VT executes it. Performance of the operator interface can be improved by associating a Macro with the key press event to cause another event, such as activating a different mask. See Table B.11 and Table B.13.

NOTE 1 For VT version 5 and later, the ACK key sends messages (pressed, held, released) consistent with Key and Button objects. In VT version 4 and prior, this was not well defined and led to variations in implementation.

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If a Key object or non latchable Button object is erased from the screen (e.g. due to a Change Active Mask command, Change Soft Key Mask command, Hide/Show Object command, etc) while it is activated, the VT shall send a Soft Key Activation message or Button Activation message indicating released to the erased object on its parent Data Mask. The VT shall then ignore the physical key until the operator has released it. If a Button object is moved to a new location on the active mask, while it is still held, the behaviour depends on the method of activation. If the Button object was activated by a physical key, then the Button object stays pressed. If the Button object was activated by touch screen, pointing device or similar, and the object is moved to a location that is no longer under the touch point, the VT shall send a Button Activation message indicating released and shall then ignore the touch until the operator physically releases. On touchscreen VTs, if the operator presses, then slides his/her finger or pointing device off of the Button or Key object, and if the VT is capable of tracking the operator's finger or pointing device, the VT shall send a Soft Key Activation message or Button Activation message indicating abort. If a pressed Button object is moved such that it is no longer under the touch point while the operator is still pressing or holding the button, AND the operator also slides his/her finger or pointing device off of the Button object, whichever event occurs first shall take priority and the prior described rules shall apply. If the operator is able to track the move, and continue to hold a Button object while it is being moved, the rules above still apply and if the Button moves away from the original touch point, the VT shall auto generate a release event as described above.

For example, when changing the visible Data Mask, the VT shall send the Soft Key Activation message indicating released for the activated object for the previous mask. It shall not send a Soft Key Activation message for the new mask.

Soft Key Masks are considered to be child objects of the Data/Alarm Masks. If the Active Data/Alarm Mask is changed, then the Soft Key Mask is also changed — even if the new Data/Alarm Mask happens to use the same Soft Key Mask.

For example, if a Soft Key is pressed and the Data/Alarm Mask is changed to a new Data/Alarm Mask that is using the same Soft Key Mask, the VT shall send a Soft Key Activation message indicating released and shall then ignore the Soft Key until it has been released. The VT shall also execute the On Hide and On Show macros for the Soft Key Mask.

If a Change Active Mask command or a Change Soft Key Mask command results in no change of the current Active Data/Alarm Mask or Active Soft Key Mask, then there is also no change to the pressed/held/released state of any Buttons or Soft Keys, and the On Hide and On Show macros are not executed either.

NOTE 2 In VT version 5 and prior, this was not well defined and led to variations in implementation.

When the "VT supports simultaneous activation of all combinations of Physical Soft Keys" bit (see D.9) is zero, the VT shall only support the activation of a single Soft Key at a time and only in the prescribed sequence of <no Keys pressed>:<Key pressed>: [<Key held>]:<Key released>:<no Keys pressed>. If a second Soft Key is pressed while a first Soft Key has already been detected as pressed/held, it shall be ignored. When simultaneous activation is supported, the VT sends overlapping messages (e.g. <no Keys pressed>:<Key 1 pressed>: [<Key 1 held>]:<Key 2 pressed>:<Key 1 released>:<Key 2 released>:<no Keys pressed>).

When the "VT supports simultaneous activation of all combinations of Buttons" bit (see D.9) is zero, the VT shall only support the activation of a single Button at a time and only in the prescribed sequence of <no Buttons pressed>:<Button pressed>: [<Button held>]:<Button released>:<no Button pressed>. If a second Button is pressed while a first Button has already been detected as pressed/held, it shall be ignored. When simultaneous activation is supported, the VT sends overlapping messages (e.g. <no Buttons pressed>:<Button 1 pressed>: [<Button 1 held>]:<Button 2 pressed>:<Button 1 released>:<Button 2 released>:<no Buttons pressed>).

If a Key or Button is found to be pressed at power on, it shall not be reported as held; however this can be cause for VT to report a diagnostic message to the operator.

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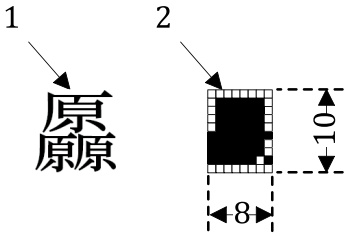
4.6.19 Font rendering

4.6.19.1 General

Annex K contains the required, and optional, character sets that the VT shall support. Presentation requirements are defined in this section.

The working set design should consider that the character set that can be accessible in version 4 and later VTs can include characters, symbols, and ideograms that cannot render legibly for all font sizes (see Figure 16). In cases where the working set design needs to ensure the presentation at a lower resolution, it can be necessary to deliver the information in a different language, encoding, or with a picture graphic object.



Key

1 high-resolution ideogram

2 illegible representation of high resolution

Figure 16 — Font Detail compared to Resolution

The precise definition of the text presentation, for WideString encoded text, is beyond the scope of this document, and will typically be employed by an advanced layout and/or font rendering engine. UNICODE has many “control codes” defined that can affect the presentation of the text. As a result, the text layout is deferred to the UNICODE layout engine and/or font rendering engine and might not precisely match the requirements defined herein. It is expected that justification will be preserved, and it is recognized that auto-wrap and non-printing character rules might not match those defined in the following sections. In the case of a conflict between embedded control codes and the attributes described below, the UNICODE control codes shall take precedence if supported. Control codes that are not supported should not take up any space in the presentation. Some rendering engines allow justification to be set before WideString text is rendered.

4.6.19.2 Text justification

Text based objects have a justification attribute. Field justification indicates how a text string is positioned horizontally and vertically within the field defined by the width and height attributes. In version 3 and prior VTs, text justification was done on a character basis but was not precisely defined. In version 4 and later VTs, text justification is always done on a graphical (i.e. pixel) basis.

The extents of a text character (see Figure 17) shall be graphically justified as described in the following sections but some white space is permissible if the VT’s font rendering engine reserves space for ascenders and descenders or for the character itself.

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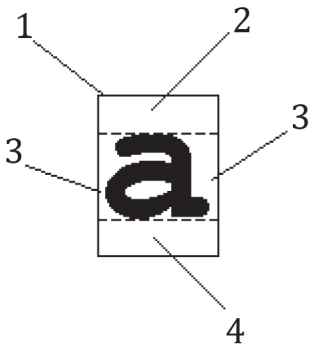

Key

1 graphical extents of the character

2 ascender area can create white space depending on VT design

3 character rendering itself can create white space depending on VT design

4 descender area can create white space depending on VT design

Figure 17 — Graphical Extents of a Character

During data input of a text based object, the VT designer can choose to suppress justification until the field is closed after data input.

NOTE These modifications are done for visual justification — the stored value is not modified.

Table 6 — Space handling based on justification

	No auto-wrap			Auto-wrap		
	Left justification	**Middle justification**	**Right justification**	**Left justification**	**Middle justification**	**Right justification**
Spaces at the beginning of the first line of a text	n	r	+	n	r	n
Spaces at the end of the last line of a text	+	r	r	+	r	r
Spaces at the beginning of a line after an auto-wrap	–	–	–	r	r	n
Spaces at the end of a line before an auto-wrap	–	–	–	+	r	r

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Table 6 *(continued)*

	No auto-wrap			Auto-wrap		
	Left justification	**Middle justification**	**Right justification**	**Left justification**	**Middle justification**	**Right justification**
Spaces at the beginning of a line after a forced line break	n	r	+	n	r	n
Spaces at the end of a line before a forced line break	+	r	r	+	r	r
<Space> handling legend: n = spaces are not removed r = spaces are removed – = spaces do not exist + = spaces do not have an effect on layout NOTE The NBSP character (0xA0) provides a "non-breaking space" and behaves as other non-space characters.						

4.6.19.2.1 Horizontal left justification

When left justified, the VT shall not remove any leading spaces and the first character in the string is positioned and visible at the left side of the text field area. If auto-wrapping is enabled, the rules of auto-wrapping overrule and leading spaces on subsequent lines are trimmed before justification. If the string does not fit in the defined text field area, and auto-wrapping is not enabled, the string shall be graphically clipped on the right side. If auto-wrapping, justification rules apply to each new line. Blank lines are not removed.

In the examples below, the box represents the extents of the defined text field area.

EXAMPLE 1 Left justification, no auto-wrap, no leading spaces, "Left Justified":

```
Left Justified
```

EXAMPLE 2 Left justification, no auto-wrap, one leading space, "Left Justified":

```
 Left Justified
```

EXAMPLE 3 Left justification, no auto-wrap, clipping on the right, "Left Justified Text":

```
Left Justified Te
```

EXAMPLE 4 Left justification, auto-wrap, no leading spaces:

```
This is left
justified,
wrapped text
```

EXAMPLE 5 Left justification, auto-wrap, one leading space:

```
 This is left
justified,
wrapped text
```


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