Integrating the Healthcare Enterprise

IHE Patient Care Device (PCD)
Technical Framework Supplement

Waveform Content Module (WCM)

Trial Implementation

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Foreword

This is a supplement to the IHE Patient Care Device Technical Framework V2.0. Each supplement undergoes a process of public comment and trial implementation before being incorporated into the volumes of the Technical Frameworks.

This supplement is submitted for Trial Implementation as of August 16, 2012 and may be available for testing at subsequent IHE Connectathons. The supplement may be amended based on the results of testing. Following successful testing it will be incorporated into the Patient Care Device Technical Framework. Comments are invited and may be submitted at http://www.ihe.net/pcd/pcdcomments.cfm.

This supplement describes changes to the existing technical framework documents and where indicated amends text by addition (**bold underline**) or removal (~~**bold strikethrough**~~), as well as addition of large new sections introduced by editor's instructions to "add new text" or similar, which for readability are not bolded or underlined.

"Boxed" instructions like the sample below indicate to the Volume Editor how to integrate the relevant section(s) into the relevant Technical Framework volume:

Replace Section X.X by the following:

General information about IHE can be found at: www.ihe.net

Information about the IHE Patient Care Device domain can be found at: http://www.ihe.net/Domains/index.cfm

Information about the structure of IHE Technical Frameworks and Supplements can be found at: http://www.ihe.net/About/process.cfm and http://www.ihe.net/profiles/index.cfm

The current version of the IHE Technical Framework can be found at: http://www.ihe.net/Technical_Framework/index.cfm

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Introduction

The Waveform Content Module defines the data structure and semantics to be used by IHE actors that desire to communicate waveforms and other time-series data sets within the context of IHE-PCD actors such as DOC, DOR, AR, AM, etc. Typical use cases include communication of time bounded waveforms (e.g., snapshots) as alarm evidentiary data or continuous waveforms for display.

Open Issues and Questions

- Do we need standard ways of handling data starvation or over-feeding due to the lack of exact clock alignment between data reporters and data consumers?
- Current IEEE 11073 Nomenclature needs to be expanded. The reader will notice a number of unassigned codes which are shown as 0^.
- Current WCM supplement requires the Consumer to consume all information that the Reporter decides to send. In the future we may need to consider filtering and querying schemes. Some possible parameters to filter include:
  - Waveforms types to be sent
  - Sampling rates
  - Latency
  - Duration of waveform snapshot
  - Send only on demand

  Please note that this can also be accomplished by manual configuration and setup at the Reporter side in the absence of a defined Consumer to Reporter configuration approach.

Closed Issues

- First use case to be addressed will be to send the alarm waveform unsolicited when the alarm occurs…
  - There would be a unique cross-links (s/n & session ID) between the ACM message and the corresponding WCM message
  - The WCM message could be sent ‘some time’ after the ACM message but typically within a few seconds…
- Number of waveforms in the WCM package…
  - <Phase 1 - Defined by source>
  - Unlimited number of waveforms…
- Support different sampling rates
  - Defined by source
- How often are the waveform messages sent?
  - Interval TBD – defined by clinical requirements

- How many messages per set of waveforms?
  - All waveforms (and parameter info) for a given time period have to be sent in one message.
  - Multiple messages can be sent to cover a longer time period
  - Example – a ten minute waveform snapshot can be broken into 20-30 second snapshots. Each snapshot must contain all the waveform data for that snapshot. All waveforms should be sent in one message, time aligned
- How to represent the waveform?
  - HL7 NA Data Type which is a series of NMs carat delimited
  - Abnormal conditions (invalid data, out-of-range data, inop data, etc.) will have special values (e.g., 99998, -65,535, etc.) defined using OBXs
  - Only one encoding scheme supported for now, however scheme type (0) will be reported in waveform message which allows for future schemes which would not break parser.
- Do we need an application level checksum?
  - No
- What latency is acceptable to end-user, due to processing time?
  - For alarm evidentiary data, the Consumer should expect the data to lag the alarm message due to clinical issues and not processing issues. For example the waveform message may want to include a few seconds of data post-event.
  - For continuous waveforms, the latency should be such that the consumer does not "starve" for lack of data. However the consumer should have a buffer of at least one message.
- Format should be simple enough such that it could be processable by phone/display device.
  - Decision is that this is not a high priority, most such devices will have an intermediary which can pre-process the data to reduce complexity on the end-device
- It is assumed that all samples in a message are time-wise aligned

Note:

The "caret" or "^" is used throughout as an example of the "component separator", and is not the only "component separator" supported.

Profile Abstract

Waveform information can be optionally included in appropriate IHE PCD transactions. This supplement describes a Content Module which describes how to represent waveform data in DEC, ACM and other Profiles. It should also be noted that the current version of the does not necessarily cover all possible waveform use cases, which have been prioritized as follows:

1. Current Multi-Channel Waveform (MCW) snapshot as defined by the source is created/pushed by alarm source based on event occurrence
2. Current MCW snapshot as defined by source on request to source

3. Continuous MCW streams
4. Waveform MCW snapshot archive query
5. Periodic trend data (very slow waveform…) on request
6. 12-Lead ECG report (out of scope, implementers should refer to the Resting ECG Workflow (REWF) from the IHE Cardiology Domain)

The intent of this supplement is to specify a uniform way of representing waveform data in HL7 V2 messages to facilitate interoperability of systems from different vendors.

Glossary

MCW: Multi-Channel Waveform

WCM: Waveform Content Module

Waveform Snapshot: A limited duration continuous block of waveform data. Typically less than 1 minute in duration.

Bounded Waveform: A limited duration continuous block of waveform data which is bounded in time, synonymous with waveform snapshot or waveform snippet.

Continuous Waveform: A continuous stream of waveform data terminated only on request, on patient disconnect or due to technical reasons.

RGB: Stands for "Red Green Blue." It refers to the three hues of light (red, green, and blue) that can mix together to form any color. When the highest intensity (255) of each color is mixed together, white light is created. When each hue is set to zero intensity, the result is black. Software specifies the specific R, G and B levels to generate specific colors per displayed pixel.

OBXV: OBX visibility indicates whether an OBX must or may be sent or otherwise accounted for at a particular level in the OBX-4 “observation hierarchy”. See the Rosetta Containment Hierarchy document for additional information.

SCO: Stands for Source Cardinality, indicates the cardinality for a particular observation, for example: 0..1, 0..*, 1..1, 1..*, etc.)

Volume 1 – Integration Profiles

This section describes the changes required in Volume 1of the Technical Framework that result from including this Integration Profile.

1.7 History of Annual Changes

Add the following bullet to the end of the bullet list in section 1.7 of Volume 1

- **[WCM] Waveform Content Module** will extend existing IHE PCD profiles to provide a method for passing near real-time waveform data using HL7 V2 observation messages.

Add the following section to section 2.2 of Volume 1

2.2.X Waveform Content Module (WCM)

The Waveform Content Module defines the data structure and semantics to be used for communication of waveforms by IHE actors that require this functionality. Typical use cases include communication of waveform snapshots as alarm evidentiary data or continuous waveform display.

Update section 3, Volume 1as indicated below

3 Overview of Actors and Transactions

The WCM Profile does not introduce any new Actors or Transactions. It can be used as an option for the DOR, DOC, AR and AM actors.

This section shall be added as the latest chapter of Volume 1

X Waveform Content Module (WCM)

The Waveform Content Module defines the data structure and semantics to be used for communication of waveforms by IHE actors that require this functionality.

X.1 Problem Statement and Requirements

Waveform data is an important component of information coming from medical patient care devices. This information can be an important complement to assessing the current status of a patient or the status of a patient during a clinical event. As such waveform information can be provided in a number of forms:

- **Bounded waveforms** - specific forms of waveform snapshots or snippets such as 12-lead ECG associated with a diagnostic encounter, or a snapshot associated with an alarm event

- **Continuous waveforms** - a continuous "real-time" stream of waveform data that would be used for a remote "real-time" waveform display

Independent of the form of waveform, the following information must be accommodated:

- Waveform type (e.g., ECG, Arterial Blood Pressure, CO2, etc.)
- Sampling rate
- Start time
- Event time
- Scaling (e.g., #bits/mmHg in the case of blood pressure)
- Annotations (e.g., pacer, beat-label, QRS, respiration, out-of-range, etc.)
- Status (e.g., lead-off, out-of-range, test mode, etc.)
- Filter status (e.g., low-pass, high-pass, etc.)
- Number of waveform samples
- Suggested waveform display color
- Units of measure
- Patient identification
- Clinician notes

This information also has structure, which will follow the IEEE 11073 Domain Information Model.

As a content profile, WCM only specifies how to represent waveforms in transaction profiles that have requirements to communicate waveform information, such as DEC and/or ACM.

X.2 Key Requirements

In approaching the design of the WCM profile a number of key requirements were identified:

- Leverage existing IHE PCD Profiles and “principles”
  - Use HL7 V2.6 message constructs, avoiding the definition of new datatypes
  - Use ISO/IEEE Nomenclature and Information Model
- Message shall consist of sample values (structured data) and not bit-maps or PDF files
  - Supports rendering at end-client or intermediary
  - Supports further data analysis at end client
  - Supports alternative display types (e.g., ventilation loops) at end-client
- Need to handle simultaneous alarms for same patient
- Support MCW “snapshots”, MCW “streams” as well as “periodic trend” snapshots
- Minimize optional fields and approaches in order to maximize interoperability
  - Focus on simplicity and avoid complexity
- Need to be able to send waveform messages with parameter info, and vice versa

- Need to be able to send waveform messages with alarm info, and vice versa

X.3 Actors/ Transactions

WCM will be used as an option to existing and future transactions and does not define any new IHE Actors or Transactions. Existing Actors (such as DOR, DOC, AR and AM) and Transactions (such as PCD-01 and PCD-04) can use WCM.

X.4 Integration Profile Options

WCM is an option to the DEC and ACM Profiles. There are no options to WCM.

X.5 Key Use Case(s)

Please note that to fully implement these Use Cases additional PCD workflows will need to be addressed which can then apply WCM for the communication of waveform information.

X.5.1 Use Case 1 – Alarm Waveform Snapshot

A patient, post Heart Attack, is walking in his room while being monitored using a patient telemetry system. The system detects a run of ventricular beats and generates an alarm at the central nurse station. In parallel, the alarm information including the waveform, parameter data and alarm information is acquired by a separate alarm communication system which then sends the appropriate information snapshot to a caregiver's portable device.

X.5.2 Use Case 2 – Real-Time Waveform Viewing

A physician would like to review the current status of a patient including his parameter information, waveforms, device settings, etc. He brings up an application on his PDA or personal computer and can view the current information delayed by a maximum of 10 seconds.

X.5.3 Use Case 3 – Archived Waveform Viewing

A physician starting his rounds would like to review the waveforms and associated data for a patient under his/her care. He/she accesses an archive which has stored the continuous waveforms and related vital signs and other parameter data over the past 24 (or more) hours.

X.5.4 Use Case 4 – Mixed Snapshot and Continuous Waveform Viewing

A Remote Monitoring Station, responsible for checking on monitored outpatients, receives an alert on one of its patients. The alert is accompanied by a waveform snippet at the time of the event. If further investigation of the current status of the patient is required, a continuous waveform can be viewed.

X.5.5 Use Case 5 – Waveform Snapshot to EHR

The user of an EHR requests a snapshot of a waveform from the device.

X.5.6 Use Case 6 – 12 Lead ECG

A patient enters the Emergency Room complaining of pressure on the chest wall. A 12-lead ECG is obtained and transmitted via WCM to the Cardiology Management System. The data is reviewed and annotated and sent via WCM to the hospital Clinical Information System as part of the patient's clinical record. (This use case is out of scope. Please refer instead to the Resting ECG Workflow profile from the IHE Cardiology domain.)

X.6 WCM Security Considerations

WCM does not impose specific requirements for authentication, encryption, or auditing, leaving these matters to site-specific policy or agreement.

Appendix A - Actor Summary Definitions

WCM is an option which can be used by the DOR, DOC, AR and AM Actors, at this point in time.

Appendix B - Transaction Summary Definitions

WCM is an option which can be used in conjunction with the PCD-01 and PCD-04 transactions.

Volume 2 – Transactions

WCM does not introduce any new Actors or Transactions.

Volume 3 – Content

Add section X.Y

X.Y Waveform Base Class

The Waveform Content Module defines the data structure and semantics to be used for communication of waveforms by IHE Actors that require this functionality. Typical use cases include communication of time bounded waveform snapshots as alarm evidentiary data or for continuous waveform display.

X.Y.1 Data Model

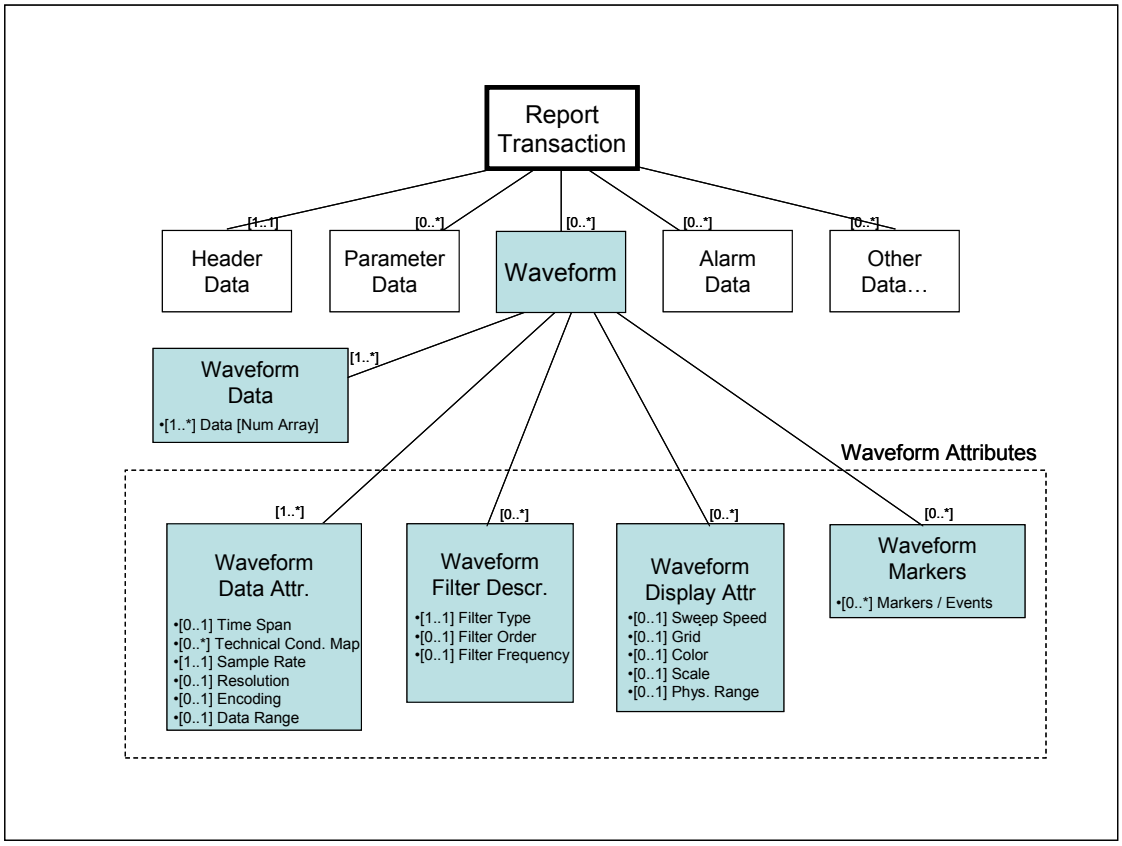

Figure X.Y.1-1: WCM Base Class Object Model

The Data Model follows the IEEE 11073 Domain Information Model, and is different from the previously released HL7 2.3 waveform representation model.

X.Y.2 Waveform Class Structure

WCM does not attempt to define a new HL7 message type. This section is for illustrative purposes, to demonstrate the high-level structure of the WCM content within the transaction that contains it.

340 The following table provides a static overview of the structure of the Waveform Content Module Option. Note that the facet level (of OBX-4) is used to distinguish between the various attributes of the structure.

Table X.Y.2-1: WCM Base Class Structure

Waveform Segment Structure	Waveform Attribute Structure	Usage	Card.
…other content…			
{	---WAVEFORM begin	O	[0..*]
OBR	WAVEFORM OBSERVATION	R	[1..1]
{OBX	WAVEFORM DATA	R	[1..*]
[OBX]	WAVEFORM TIME SPAN	O	[0..1]
OBX	SAMPLE RATE	R	[1..1]
[OBX]	MEASUREMENT RESOLUTION	O	[0..1]
[OBX]	WAVE ENCODING SCHEME	O	[0..1]
[OBX]	DATA RANGE	O	[0..1]
[{OBX}]	TECHNICAL CONDITION MAP(s)	O	[0..*]
{[	---FILTER begin	O	[0..3]
OBX	FILTER TYPE	O	[0..1]
[OBX]	FILTER ORDER	O	[0..1]
[OBX]	FILTER FREQUENCY	O	[0..1]
]}	---FILTER end		
[OBX]	SWEEP SPEED	O	[0..1]
[OBX]	VISUAL GRID DESCRIPTION	O	[0..1]
[OBX]	WAVE COLOR	O	[0..1]
[OBX]	WAVE SCALE	O	[0..1]
[OBX]	WAVE PHYSIOLOGICAL RANGE	O	[0..1]
[{ OBX }]}	WAVEFORM EVENT/MARKER(S)	O	[0..*]
}	---WAVEFORM end		
… other content…			

345 Note – in the Waveform Structure column:

- [square brackets] indicate item is optional
- {braces} indicate item is repeatable

Table X.Y.2-2: WCM Containment Hierarchy Example

BTYPE (in the 'base type' worksheet)	**OBX-4**	**IEEE Code**	**IEEE Offset**	**Comments**
MDC MDS	M			
. MDC VMD	M.V			
. . MDC CHAN	M.V.C			
. . . . "MDC_WAVE_DATA"	M.V.C.I.			Waveform data
{Data attributes section}				
. . . . MDC_ATTR_WAV_TIME_SPAN	M.V.C.I.1	Tbd		Start and end time for bounded waveforms
. . . . MDC_ATTR_SAMPLE_RATE	M.V.C.I.2	Tbd		Sample rate (typically in samples/sec)
. . . . MDC_ATTR_NU_MSMT_RES	M.V.C.I.3	2409	0	Unit of measurement per sample value
. . . . MDC_ATTR_WAV_ENCODING	M.V.C.I.4	Tbd		Default is signed decimal
. . . . MDC_ATTR_DATA_RANGE	M.V.C.I.5	Tbd		
{Technical condition mapping}				
. . . . "MDC_TECH_COND"	M.V.C.I.6	52	262144	Inop, as an example
. . . . "MDC_TECH_COND"	M.V.C.I.7	22	262144	Disconnect, as an example
{Filter section}				
. . . . MDC_ATTR_FILTER_DESCR	M.V.C.I.8	Tbd		Whether filter is high pass, low pass or notch and type of filter (IIR, FIR, etc.)
. . . . . MDC_ATTR_FILTER_ORDER	M.V.C.I.8.1	Tbd		# of dB at cutoff
. . . . . MDC_ATTR_SA_FREQ_SIG	M.V.C.I.8.2	2408	0	Cutoff frequency in Hz
. . . . MDC_ATTR_FILTER_DESCR	M.V.C.I.9	Tbd		Example high pass, low pass or notch and type of filter
. . . . . MDC_ATTR_FILTER_ORDER	M.V.C.I.9.1	Tbd		# of poles
. . . . . MDC_ATTR_SA_FREQ_SIG	M.V.C.I.9.2	2408	0	Cutoff frequency in Hz
{Display attributes section}				
. . . . MDC_ATTR_SPD_SWEEP_DEFAULT	M.V.C.I.10	2431	0	
. . . . MDC_ATTR_GRID_VIS	M.V.C.I.11	2330	0	NA of grid rows…
. . . . MDC_ATTR_VIS_COLOR	M.V.C.I.12	Tbd		R^G^B
. . . . MDC_ATTR_SCALE_RANGE	M.V.C.I.13	Tbd		Bottom and top of scale
. . . . MDC_ATTR_PHYS_RANGE	M.V.C.I.14	Tbd		Physiological range
{Events/Markers section}				
. . . . MDC_WAV_EVENTS	M.V.C.I.15	3096	262144	Paced Beat
. . . . MDC_WAV_EVENTS	M.V.C.I.16	3072	262144	Start of Apnea
. . . . MDC_WAV_EVENTS	M.V.C.I.17	3204	262144	Premature Ventricular Contraction

Note: “M.V.C.I” in the OBX-4 column, indicates a non-specific “MDS.VMD.Channel.Instance” combination.

X.Y.2.1 Optimized Waveform Structure

By default each waveform will be contained in its own “section” which is started with the Waveform OBR. This can result in considerable repetition and duplicate data since many similar waveforms share many of the same attributes. For example, it is not uncommon to have all ECG waveforms share the same attributes such as sample rate, color, sweep speed, etc.

As an optimization, WCM allows the grouping of identical attributes at the beginning of a particular waveform section that will apply to all waveforms in that section. Any remaining attributes that will change with waveform type are grouped with the affected waveforms.

The following examples illustrate the approach:

Example 1: ECG waveforms which all share the same set of common attributes except for the displayed scale:

Table X.Y.2.1-1: Optimized Waveform Structure - Example 1

Segment	OBR-4
OBR “WAVEFORM”	
OBX Sample Rate (250/sec)	M.V.0.0.1
OBX Sweep Speed (50 mm/sec)	M.V.0.0.2
OBX Filter Type (FIR)	M.V.0.0.3
OBX Filter Frequency (100 Hz)	M.V.0.0.3.1
OBX Tech_Cond Map (Lead Off)	M.V.0.0.4
OBX Wave Data (ECG I)	M.V.1.1
OBX Scale (1 mV)	M.V.1.1.1
OBX Wave Data (ECG II)	M.V.1.2
OBX Scale (0.5 mV)	M.V.1.2.1
OBX Wave Data – ECG III	M.V.1.3
OBX Scale (1 mV)	M.V.1.3.1

Example 2: A number of blood pressure waveforms each with different display colors and some with different display scales:

Table X.Y.2.1-2: Optimized Waveform Structure - Example 2

Segment	OBR-4
OBR “WAVEFORM”	
OBX Sample Rate (50/sec)	M.V.0.0.1
OBX Sweep Speed (25 mm/sec)	M.V.0.0.2

Segment	OBR-4
OBX Resolution (0.1 mmHg)	M.V.0.0.3
OBX Tech_Cond Map (Out of Range)	M.V.0.0.4
OBX Wave Data (Arterial BP)	M.V.1.1
OBX Color (Red)	M.V.1.1.1
OBX (Range 0 – 300)	M.V.1.1.2
OBX Wave Data (Femoral BP)	M.V.2.1
OBX Color (Purple)	M.V.2.1.1
OBX Range (0 – 300)	M.V.2.1.2
OBX Wave Data (Left Venous BP)	M.V.3.1
OBX Color (Blue)	M.V.3.1.1
OBX Range (-10 – 20)	M.V.3.1.2

X.Y.3 Waveform Observation Section

Each Waveform Section start is marked by an OBR which marks the beginning of a single set of Waveform Content. The OBR is then followed by the Waveform Observation data for that waveform, as well as the attributes required to properly describe that waveform. Each Waveform Section stands on its own, which means that all relevant attributes for that waveform must be restated. For an ECG with 12 leads, this implies repeating all the relevant attributes 12 times (see example in Appendix Y).

In the reporting of waveform data, the Observation Request Segment (OBR) serves as the 'report header' for the ORDER_OBSERVATION segment group, which in its simplest form is an OBR segment followed by a set of OBX segments which represent observations associated with the 'order' represented by the OBR segment.

Table X.Y.3-1: OBR segment

SEQ	LEN	DT	Usage	Card.	TBL#	Element name
1	4	SI	R	[1..1]		Set ID OBR
2	427	EI	C	[0..1]		Placer Order Number
3	427	EI	R	[1..1]		Filler Order Number
4	705	CWE	R	[1..1]		Universal Service Identifier (Identifies this as a Waveform)
5	2	ID	X	[0..0]		Priority – OBR
6	24	DTM	X	[0..0]		Requested Date/Time
7	24	DTM	R	[1..1]		Observation Date/Time of the first sample
8	24	DTM	R	[1..1]		Observation End Date/Time of the end of the last sample *interval*

OBR-1 Set ID OBR

Definition: For the first waveform transmitted in a message, the sequence number shall be 1; for the second waveform, it shall be 2; and so on.

OBR-2 Placer Order Number

As specified in the IHE PCD Technical Framework, Volume 2.

OBR-3 Filler Order Number

As specified in the IHE PCD Technical Framework, Volume 2.

OBR-4 Universal Service ID

This field is used to identify the OBR and the following OBX segments as part of a Waveform Observation Group.

At the current time there is no normative Universal ID.

- For continuous waveforms the ID is set to "CONTINUOUS WAVEFORM".
- For non-continuous waveforms such as snapshots and "snippets" the ID is set to "BOUNDED WAVEFORM".

OBR-7, OBR-8 Observation Date/Time

For a waveform, OBR-7 specifies the start time and OBR-8 the end time of the end of the last sample interval of the waveform in the current message as shown in the following Figure.

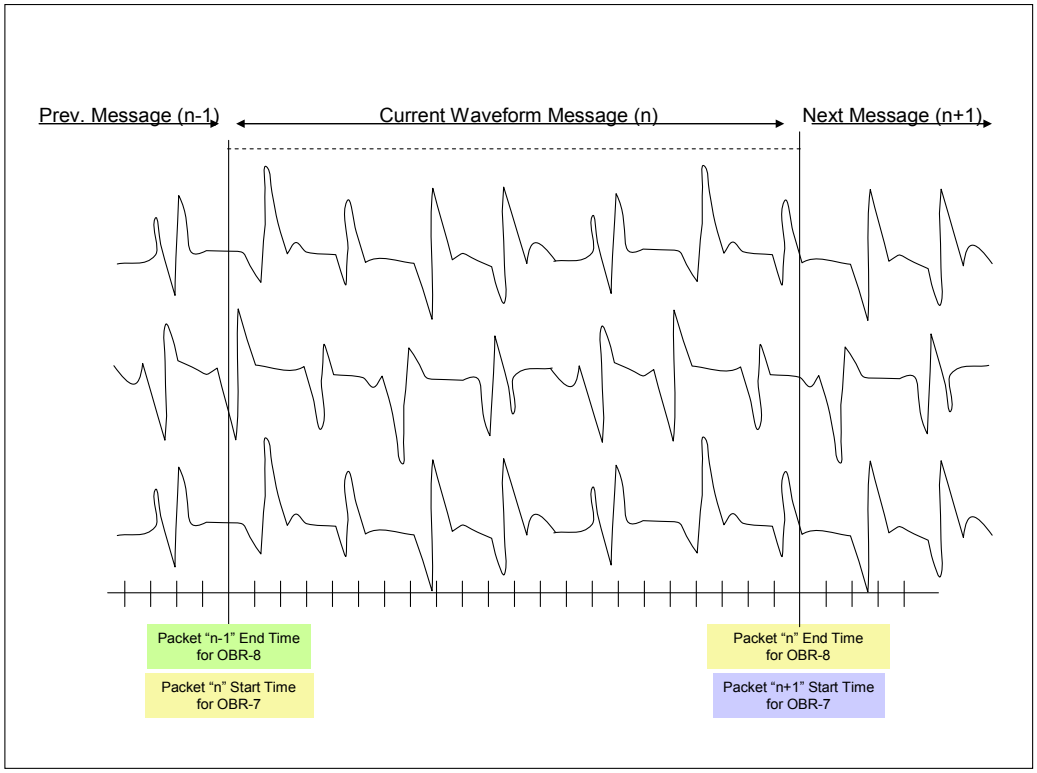

Figure X.Y.3-1: Waveform Timing

X.Y.4 Waveform Data and Attributes

Refer to HL7 V2.5: Section 7.4.2

The HL7 OBX segment is used to transmit a single observation, attribute or observation fragment. Guidance on the use of specific items in the OBX segment for the WCM Class is provided in this section.

Note that this is different than the current HL7 Chapter 7 Waveform approach. This was done for simpler harmonization with the IEEE 11073 Domain Information Model. It also supports easily adding additional attributes as necessary.

Table X.Y.4-1: General IHE PCD OBX segment

SEQ	LEN	DT	Usage	Card.	TBL#	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[0..1]	0125	00570	Value Type
3	705	CWE	R	[1..1]		00571	Observation Identifier
4	20	ST	R	[1..1]		00572	Observation Sub-ID
5	99999	Varies	C	[0..1]		00573	Observation Value
6	705	CWE	C	[0..1]		00574	Units

SEQ	LEN	DT	Usage	Card.	TBL#	ITEM#	Element name
7	60	ST	CE	[0..1]		00575	References Range
8	5	IS	CE	[0..1]	0078	00576	Abnormal Flags
9	5	NM	X	[0..0]		00577	Probability
10	2	ID	CE	[0..1]	0080	00578	Nature of Abnormal Test
11	1	ID	R	[1..1]	0085	00579	Observation Result Status
12	24	DTM	X	[0..0]		00580	Effective Date of Reference Range
13	20	ST	X	[0..0]		00581	User Defined Access Checks
14	24	DTM	RE	[0..1]		00582	Date/Time of the Observation
15	705	CWE	RE	[0..1]		00583	Producer's ID
16	250	XCN	RE	[0..1]		00584	Responsible Observer
17	705	CWE	RE	[0..1]		00936	Observation Method
18	22	EI	RE	[0..1]		01479	Equipment Instance Identifier
19	24	DTM	CE	[0..1]		01480	Date/Time of the Analysis
20	705	CWE	RE	[0..*]	0163	02179	Observation Site

OBX-1 Set ID - OBX (SI), required:

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-2 Value Type (ID), conditional:

This field will specify specific IDs per attribute type. In the case of the waveform data this field contains the metric ID for the waveform.

OBX-3 Observation Identifier (CWE), required:

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-4 Observation Sub-ID (ST), required:

As specified in the IHE PCD Technical Framework, Volume 2. In addition WCM utilizes the Facet level to describe the hierachy between OBXs in the same waveform object.

OBX-5 Observation Value (varies), conditional.

Further guidance in this section per attribute.

OBX-6 Units (CWE), conditional

Further guidance in this section per attribute.

OBX-7 References Range (ST), required if available.

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-8 Abnormal Flags (IS), required but may be empty:

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-11 Observation Result Status (ID), required if available:

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-14 Date/Time of the Observation (DTM), required but may be empty:

Further guidance in this section per attribute.

OBX-16 Responsible Observer (XCN), required but may be empty:

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-17 Observation Method (CWE), conditional:

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-18 Equipment Instance Identifier (EI), required but may be empty:

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-19 Date/Time of the Analysis (DTM), conditional but may be empty:

As specified in the IHE PCD Technical Framework, Volume 2.

OBX-20 Observation Site (CWE), required but may be empty:

As specified in the IHE PCD Technical Framework, Volume 2.

X.Y.4.1 Waveform Data

The Waveform Data will always be contained as an Instance in the Channel at dot level 4 (see Table 3).

This segment contains the actual waveform data. For many waveforms the OBX-3 will be adequate to identify the waveform but others will also require OBX-20. Usually the start time of the waveform will be the start time of the message; however, the OBX-14 shall always be used to specify the start time.

The Waveform Data will be a Numeric Array of decimal values. Since IEEE 11073 Nomenclature does not necessarily specify waveform IDs as distinct from parameter IDs, the RefID and Code associated with the waveform can be used in OBX-3. For example the SpO2 measurement RefID and Code can be used, which are interpreted in this context as a waveform ID.

If the ADC values are sent, then the Units field is empty, however if the real values are sent then the Units field must include the units of measure for the waveform data. If the waveform is dimensionless then the Units field should be “262656^MDC_DIM_DIMLESS^MDC”.

Table X.Y.4.1-1: OBX segment for Waveform Data

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NA
3	705	CWE	R	[1..1]		00571	Specific Source ID (e.g., ECG, ABP,

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
							Flow, EEG, etc.)
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Waveform values (signed Integer) separated by "^"
6	705	CWE	C	[1..1]		00574	Units
7							
8							
9							
10							
11							
12							
13							
14	24	DTM	RE	[0..1]		00582	Date/Time of the Observation
15							
16							
17							
18							
19							
20	705	CWE	RE	[0..*]	0163	02179	Observation Site if necessary

X.Y.4.2 Waveform Time Span - Optional

This segment is required for bounded waveforms. It specifies the start time and end time of the complete waveform snapshot/snippet which may be transmitted over multiple messages each with their own start and start time stated in OBR-7 and OBR-8.

Table X.Y.4.2-1: OBX segment for Waveform Time Span

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = DR (Date Range)
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_WAV_TIME_SPAN^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Start Date^End Date

X.Y.4.3 Sample Rate

This required segment communicates the number of samples per unit time for the current waveform.

Table X.Y.4.3-1: OBX segment for Sample Rate

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NM
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_SAMP_RATE^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	#samples per unit time
6	705	CWE	C	[0..1]		00574	Units – typically /second or /minute

X.Y.4.4 Measurement Resolution - Optional

The resolution of the waveform data stream is the nominal value that corresponds to one unit in the waveform data. This can be traced directly to the least significant bit of the ADC, or some other conversion can be used. The units of measure must be specified in accordance with the IHE Rosetta Terminology specifications. Additional information on the CSU data type can be found in paragraph 2.A.12 of HL7 V2.6 documentation.

Table X.Y.4.4-1: OBX segment for Data Resolution

SEQ	LEN	DT	Usage	Card.	TBL#	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = CSU
3	705	CWE	R	[1..1]		00571	2327^MDC_ATTR_NU_MSMT_RES^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	See Table X.Y.4.3-2

Table X.Y.4.4-2: CSU - Channel Sensitivity and Units

SEQ	LEN	DT	Usage	TBL#	Component name
1	60	NM	R		Channel Sensitivity
2	20	ST	C		Units of Measure Identifier
3	199	ST	C		Unit of Measure Description

SEQ	LEN	DT	Usage	TBL#	Component name
4	20	ID	C	0396	Unit of Measure Coding System
5	20	ST	C		Alternate Units of Measure Identifier
6	199	ST	C		Alternate Unit of Measure Description
7	20	ID	C	0396	Alternate Unit of Measure Coding System

X.Y.4.5 Waveform Encoding Specification - Optional

Waveforms can be encoded in many different ways. While the HL7 default is Decimal, Hex Binary, Floating Point or Integer forms could be used. In addition there are numerous ways of compressing waveforms.

Currently WCM only supports one encoding scheme which is a simple signed decimal format, which aligns with the HL7 default. Signed Decimal Encoding is the default if this segment is omitted.

MDC_ATTR_WAV_ENCODING = 0 Signed Decimal Encoding

MDC_ATTR_WAV_ENCODING = 1..n Future use

If this field is not included, then a default value of "0" is assumed.

Table X.Y.4.5-1: OBX segment for Specifying Waveform Encoding Scheme

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NM
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_WAV_ENCODING^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	= 0 for signed integer

X.Y.4.6 Waveform Data Range - Optional

These optional segments specify the data acquisition range for a waveform or waveform group, expressed in terms of sample values.

Table X.Y.4.6-1: OBX segment for Data Range

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NR
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_DATA_RANGE^MDC

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Lowest data count^Highest data count

X.Y.4.7 Waveform Technical Condition Mapping Section - Optional

Waveform technical error conditions can occur anytime in the waveform data stream. WCM requires that these will be encoded in the Waveform Observation Data using special codes which are specified in one or more OBX segments. The Observation ID will be the coded representation of the error condition.

The following example illustrates the waveform source reserving the values 99995 through 99999 as follows:

99999	Inop (52+262144)	262196^MDC_EVT_INOP^MDC
99998	Out of Range–High (166+262144)	262300^MDC_EVT_RANGE_OVER^MDC
99997	Out of Range–Low (168+262144)	262302^MDC_EVT_RANGE_UNDER^MDC
99996	Disconnected (22+262144)	262166^MDC_EVT_DISCONN^MDC
99995	Error (482+262144)	262626^MDC-EVT_DATA_ACQN_ERR^MDC

This would require 5 Error Condition OBX segments to convey.

Table X.Y.4.7-1: OBX segment for Specifying a Technical Condition Mapping

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NM
3	705	CWE	R	[1..1]		00571	MDC (Table A.9.3.1) or other code for special condition
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Value in waveform data stream which will be used to represent the special condition.
11	1	ID	R	[1..1]	0085	00579	Observation Result Status = O

X.Y.4.8 Waveform Filter Group(s) - Optional

Transmission of filter information is optional. If transmitted the Filter Description marks the beginning of the filter specification and must be included, however the Filter Frequency and Filter Order can each still be optional.

Table X.Y.4.8-1: OBX segment for Filter Description Attribute

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = ST
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_FILTER_NOTCH^MDC 0^MDC_ATTR_FILTER_LOW_PASS^MDC 0^MDC_ATTR_FILTER_HIGH_PASS^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Example – FIR, IIR, Chebyshev, Kalman,
6	705	CWE	C	[0..1]		00574	Empty

Table X.Y.4.8-2: OBX segment for Filter Order Attribute

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NM
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_FILTER_ORDER^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Order at cutoff frequency

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Table X.Y.4.8-3: OBX segment for Filter Frequency Attribute

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NM
3	705	CWE	R	[1..1]		00571	2408^MDC_ATTR_SA _FREQ_SIG^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	#
6	705	CWE	X	[0..1]		00574	Hz

X.Y.4.9 Waveform Displayed Sweep Speed - Optional

This segment is optional from both the reporter and consumer standpoint. There is no requirement on the receiver to display waveforms at the specified sweep speed.

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Table X.Y.4.9-1: OBX segment for Sweep Speed

SEQ	LEN	DT	Usage	Card.	TBL#	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NM
3	705	CWE	R	[1..1]		00571	2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Example – 12.5 or 25 or 50
6	705	CWE	C	[1..1]		00574	Units – typically mm/sec

X.Y.4.10 Displayed Waveform Grid - Optional

This optional segment describes the horizontal position(s) of reference lines if appropriate for a specific waveform. They are described in terms of data counts (see Data Range), so that if the scale is different in actual value for 2 different waveforms, the grid can still be the same. There is no requirement that the consumer use the specified grid.

Table X.Y.4.10-1: OBX segment for Grid Lines

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NA
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_GRID_VIS^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Series of Data Counts separated by "^"
6	705	CWE	X	[1..1]		00574	Empty

X.Y.4.11 Waveform Displayed Color - Optional

This optional segment specifies the color to be used when displaying the waveform or waveform group. The RGB (Red, Green, Blue) encoding scheme is used. Each of R,G and B has a range from 0 to 255. (Please refer to the glossary for a definition). There is no requirement that the consumer use the specified color.

Table X.Y.4.11-1: OBX segment for Displayed Color

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NA

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_VIS_COLOR^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	9999 9	Varies	C	[1..1]		00573	R^G^B; Example – 124^69^243
6	705	CWE	X	[1..1]		00574	Empty

X.Y.4.12 Waveform Displayed Scale Range - Optional

These segments specify the lowest value and highest value for the displayed scale of a scaled waveform. For example the displayed scale for an Arterial Blood Pressure may range from a low value of -30 mmHg to a high value of +270 mmHg. There is no requirement on the consumer to use the specified scale ranges.

Table X.Y.4.12-1: OBX segment for Displayed Scale Range

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NR
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_SCALE_RANGE^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	9999 9	Varies	C	[1..1]		00573	Lower scale value^Upper scale value
6	705	CWE	R	[1..1]		00574	Units

X.Y.4.13 Waveform Physiological Range - Optional

These optional segments specify the range of expected physiological values for the waveform. For example the while the displayed scale for an Arterial Blood Pressure may range from a low value of -30 mmHg to a high value of +270 mmHg, the physiological range could be -40 to +350 mmHg.

Table X.Y.4.13-1: OBX segment for Physiological Range

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NR
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_PHYS_RANGE^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
5	9999 9	Varies	C	[1..1]		00573	Lowest expected Physiological Value^Highest expected Physiological Value
6	705	CWE	R	[1..1]		00574	Units

X.Y.4.14 Waveform Markers/Events - Optional

The Reporter may want to specify instantaneous events and markers that occur in the waveform. Examples include Pace Pulse, Start of Breath, J-Point, Start of Asystole, etc. Possible event types are documented in Tables A.9.2.1 and A.9.3.1 of IEEE 11073-10101.

Table X.Y.4.14-1: OBX segment for Instantaneous Waveform Events

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00569	Set ID – OBX
2	3	ID	C	[1..1]	0125	00570	Value Type = NM
3	705	CWE	R	[1..1]		00571	0^MDC_ATTR_EVENT^MDC
4	20	ST	R	[1..1]		00572	See Table X.Y.2-2: WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Event types from A.9.2.1 and A.9.3.1
6	705	CWE	X	[0..1]		00574	Empty
7							
8							
9							
10							
11							
12							
13							
14	24	DTM	RE	[0..1]		00582	Date/Time of the Observation

X.Y.5 Comparison with IEEE 11073-10201

IEEE 11073-10201 is the 11073 series Domain Information Model. It provides an object model for a Sample Array object which then is specialized into a Real-Time Sample Array for continuous waveforms and a Time Sample Array for waveform snapshots. The constructs in the 11073 Standard are used as guidance in the WCM Profile, however there is not a one-to-one mapping in all cases.

The following table compares the 11073 Model with the current WCM model. Future updates to the WCM may add additional attributes if implementations require them.

Table X.Y.5-1: Comparison of 11073 with WCM

11073 SA Attribute	WCM Attribute	Comment
-Sample Array object	**WCM object**	
Sa-Observed-Value		Supported by combination of MDC_WAV_OBSERVATION and a separate MDC_STATUS_MAP which maps abnormal states to waveform values.
Compound-Sa-Observed-Value	Supported	Use the HL7 "NA" Data Type
Sa-Specification	Not supported	# of samples can be counted in message
Compression	Supported	Replaced with WAV_ENCODING. While WCM initially supports integer encoding only, future implementations could use Hex, Binary or different compression schemes.
Scale-and-Range-Specification	Supported	
Sa-Physiological-Range	Supported	Mapped into 2 OBXs. One for Phys_Range_Lo and a second for Phys_Range_Hi
Visual-Grid	Supported	Use "NA" type to specify multiple rows
Sa-Calibration-Data	Not supported in v1	
Filter-Specification	Supported	Used to signify additional filter attributes to follow.
Filter-Label-String	Supported	
Sa-Signal-Frequency	Supported	
	Additional	Filter Type
	Additional	Filter Order
Sa-Measure-Resolution	Supported	
Sa-Marker-List	Supported	Use Annotation mechanism
	Additional	Color
-Real Time SA object		
Sample-Period	Supported	Sample rate is used instead of Sample Period
Sweep-Speed	Supported	
Average-Reporting-Delay	Not supported in v1	
Sample-Time-Sync	Not supported in v1	
HiRes-Sample-Time-Sync	Not supported in v1	
-Time SA object		
Absolute-Time-Stamp	Supported	
Relative-Time-Stamp	Not supported in v1	
HiRes-Time-Stamp	Not supported in v1	
Sample-Period	Supported	Sample rate is used instead of Sample Period
Sweep-Speed	Supported	

Tsa-Marker-List	Not supported in v1	

X.Y.6 Applying the Waveform Module to Use Cases

Inclusion of waveform data in an HL7 message also creates some additional requirements on other segments of that message. This depends on the waveform type and Use Case.

X.Y.6.1 General Guidance

In any transaction with a Waveform Group Section, specific use of the MSH and OBR segments are Required.

X.Y.6.1.1 Frequency of Transmission

Currently the DEC Profile limits transmission of PCD-01 messages to no more than 6 times per minute (i.e., every 10 seconds). This may not make sense for waveform transmissions, especially of continuous waveforms, where an update of every second may make more sense.

X.Y.6.2 Waveform Snapshot – Alarm Trigger

When an alarm occurs, evidentiary data such as the parameter set and waveforms at the time of the alarm may want to be transmitted in support. In some cases this information is available at the time of the alarm, and can be included Directly in the Alarm Message. In many other cases the waveforms, especially, may be delayed, since it is desirable to view a waveform snapshot that includes data that preceded the event as well as a number of seconds of waveform data post-event. Rather than delay communicating the alarm event itself, a separate message may be sent Associated with the Alarm Message, delayed by some seconds.

X.Y.6.2.1 Directly in the Alarm Message

If the waveform data is available at the time of the alarm, the Alarm Reporter can include any number of Waveform Group Sections in the PCD-04 transaction.

X.Y.6.2.2 Associated with the Alarm Message

If the waveform data is not available at the time of the alarm, the Alarm Reporter can send additional transaction(s) when the data is available. In order to associate these Observations with the appropriate Alarm, the OBR-3 field of a separate PCD-04 Transaction is filled with the Filler Order # which corresponds to the original Placer Order # of the appropriate alarm.

X.Y.6.3 Continuous Waveform

Continuous waveform data will typically be embedded in PCD-01 transactions. In order to support applications which desire near real-time access to the waveform data, it is recommended that messages be sent approximately every second. Outside of the guidance mentioned for the MSH and OBR segments there are no additional requirements.

X.Y.6.4 Waveform Snapshot – Request Trigger

Out of scope in current version.

X.Y.6.5 Waveform Snapshot – Archive Query

Out of scope in current version.

X.Y.6.6 Waveform Snapshot – ECG 12 Lead

Out of scope in current version.

Appendix Y - Example Messages

Example 1: Snapshot Waveform Data in ACM message

An observation result, including 20 seconds of waveform data, from a simple finger plethysmographic pulse monitor with no other VMDs or channels. Minimal information beyond required fields populated.

MSH|^~\&|||||20080515123100||ORU^R01^OR_R01|MSGID5432346754|P|2.5|||NE|AL|||||IHE PCD ORU-R01 208^HL7^2.16.840.1.113883.9.n.m^HL7

PID|||123456789||Doe^John^Joseph||19630415

PV1|||SICU^301^2|||||||||||||||11772233

/* Since this message has a waveform with a duration of 20 seconds, the OBR segment specifies both the start time and end time of the waveform. In this case the precision is milli-seconds. */

OBR|1||09780979a9879^ACME HEALTH^ABCD002343785379^EUI-64|MDC_ALARM_EXAMPLE^Sample alarm^MDC^979879-9879^Example^SNM3|||20080515121000.100|20080515121020.100|||||||800 555 2323

/* This alarm message contains the current Pleth Pulse Rate observation. */

OBX|1|NM|149538^MDC_PLETH_PULS_RATE^MDC|1.1.1.1|83|264896^MDC_DIM_PULS_PER_MIN^MDC|||||R|| |20060713095715-0400|||264896^MDC_UPEXT_FINGER^MDC

/* This alarm message contains the Pleth Pulse Rate at the time of alarm, as well as the related event information. */

OBX|2|ST|196648^MDC_EVT_HI^MDC|1.1.1.1.1|PLETH PULSE HIGH|||H~PM~SP|||||20050515121010||||CD12345^ORIGatewayInc ICU-04^AECF114477885323^EUI-64|20080515121000

OBX|3|NM|149538^MDC_PLETH_PULS_RATE^MDC|1.1.1.1.2|160|264896^MDC_DIM_PULS_PER_MIN^MDC|40-140|H~PM~SP|||||20080515121000||||||264896^MDC_UPEXT_FINGER^MDC

OBX|4|ST|EVENT_PHASE|1.1.1.1.3|start

OBX|5|ST|ALARM_STATE|1.1.1.1.4|active

OBX|6|ST|INACTIVATION_STATE|1.1.1.1.5|audio-paused

/* This alarm message also contains the Finger Pulse waveform information which starts here. Note that some optional segments and fields are not included since they do are not usually available for a Finger Pulse Waveform. These include filters, data resolution, grids, scales, etc. The pulse waveform is unitless, and ranges from 0 to 16383.

OBR|2||09780979a9879^ACME HEALTH^ABCD002343785379^EUI-64|WAVEFORM BOUNDED|||20080515121000.100-400|20080515121001.100-400

/* The actual waveform raw data, as delimited signed integers */

OBX|7|NA|149504^ MDC_PULS_OXIM_PLETH^MDC |1.1.1.2.1| 1027^3504^4586^6612^8234^10592^11250^12183^11490…(etc.)||||||||| 20080515121000.100

/* Sample rate is 50 samples/sec. MDC code is 262144+2464 */

OBX|8|NM|0^MDC_ATTR_SAMP_RATE^MDC |1.1.1.2.2|50|264608^MDC_DIM_PER_SEC

/* Waveform encoding is default – integer */

OBX|9|NM|0^MDC_ATTR_WAV_ENCODING^MDC |1.1.1.2.3|0

/* Range of raw data (i.e., A/D) values to be encountered. */

OBX|10|NR|0^MDC_ATTR_DATA_RANGE^MDC |1.1.1.2.4|0^16383||

/* The next 3 messages map special waveform values to specific abnormal conditions. This starts with a group delimiter. */

OBX|12|NM|262196^MDC_EVT_INOP^MDC |1.1.1.2.5|32767||

OBX|13|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.2.6|32766||

/* Sweep speed, in this case 25 mm/sec. Units are m/sec (2816) + milli (18) + offset (262144) */

OBX|14|NM|2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC
|1.1.1.2.7|25|264978^MDC_DIM_MILLI_M_PER_SEC|

/* Waveform display color at source, in this case a shade of purple */

OBX|15|NA|0^MDC_ATTR_VIS_COLOR^MDC |1.1.1.2.8|124^69^243||

Example 2: Continuous Waveform Data including Multiple Waveforms

The following example is an observation result, including 1 second of waveform data which is part of a continuous waveform stream. The data includes heart rate and blood pressure vital signs as well as multi-lead ECG and a single invasive blood pressure waveform.

MSH|^~\&|ORIGatewayInc^ACDE48234567ABCD^EUI-64|ICU-
04|EnterpriseEHRInc|DowntownCampus|20060713095730-
0400||ORU^R01^ORU_R01|MSGID1233456789|P|2.5|2||NE|AL|USA|ASCII|EN^English^ISO639||IHE PCD ORU-R01 2006^HL7^2.16.840.1.113883.9.n.m^HL7

PID|||12345^^^^PI^Downtown
Campus||Doe^John^Joseph^JR^^^L^A^^^G|Jones^Mary^Roberta^^^^^G^^^G|19440712|M||2028-9^Asian^HL70005|10&Market Street^^San Fransisco^CA^94111^USA^M||^PRN^PH^^1^415^1234567||EN^English^ISO639|M^Married^HL70002

OBR|1|AB12345^ORIGatewayInc ICU-04^ACDE48234567ABCD^EUI-64|CD12345^ORIGatewayInc ICU-04^ACDE48234567ABCD^EUI-64||||20060713095715-0400|20080515121000.100-400|20080515121001.100-400

OBX|1|NM|16770+^MDC_ECG_HEART_RATE^MDC|1.1.1.1|83|264896^MDC_DIM_PULS_PER_MIN^MDC|||||R|||20080515121000.600-400

/* In this example the pulse rate is derived from the invasive blood pressure. Ref ID is 18442 + offset (131072) */
OBX|2|NM|149514^MDC_BLD_PULS_RATE_INV^MDC|1.1.1.2|83|264896^MDC_DIM_PULS_PER_MIN^MDC|||||R|||20080515121000.600-400

/* Arterial Blood Pressure – Systolic. Ref ID is MDC_PRESS_BLD_ART (18960) + offset for systolic (1) + coding space offset (131072) */

OBX|3|NM|150033^MDC_PRESS_BLD_ART^MDC|1.1.1.3|153|3872+^MDC_DIM_MMHG^MDC|||||R|||20080515121000.600-400

/* Arterial Blood Pressure - Mean */

OBX|4|NM|150035^MDC_PRESS_BLD_ART^MDC|1.1.1.4|111|3872+^MDC_DIM_MMHG^MDC|||||R|||20080515121000.600-400

/* Arterial Blood Pressure - Diastolic */

OBX|5|NM|150034^MDC_PRESS_BLD_ART^MDC|1.1.1.5|94|3872+^MDC_DIM_MMHG^MDC|||||R|||20080515121000.600-400

/* First ECG Waveform */

OBR|2||09780979a9879^ACME HEALTH^ABCD002343785379^EUI-64|WAVEFORM|||20080515121000.100-400|20080515121001.100-400

/* This is the start of the ECG waveform information marked by the waveform data. The ECG waveform is in uV, and ranges from -16382 to +16383. ECG name space starts at 256 with offsets for the various leads. So that ECG I is 131072+256+1. */

/* Sample rate is 250 samples/sec. Unit of measurement MDC code is 262144+2464 */

OBX|6|NM|0^MDC_ATTR_SAMP_RATE^MDC |1.1.1.6.1|250|264608^MDC_DIM_PER_SEC

/* Data resolution: 1 mV = 2048 counts. Unit of measure MDC code is volts (4256) + milli (18) + offset (262144) */

OBX|7|NM|0^MDC_ATTR_NU_MSMT_RES^MDC |1.1.1.6.2|2048|266418^MDC_DIM_MILLI_VOLT

/* Waveform encoding is default – integer */

OBX|8|NM|0^MDC_ATTR_WAV_ENCODING^MDC |1.1.1.6.3|0

/* Range of raw data (i.e., A/D) values to be encountered. */

OBX|9|NR|0^MDC_ATTR_DATA_RANGE^MDC |1.1.1.6.4|-16382^+16383||

/* The next 2 messages map special waveform values to specific abnormal conditions. */

OBX|10|NM|262196^MDC_EVT_INOP^MDC |1.1.1.6.5|32767||

OBX|11|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.6.6|32766||

/* The following section describes the filters applied to this ECG, which is a low-pass of 30 Hz and a high-pass of 0.5 Hz. Each filter starts with a Filter group “marker” */

OBX|12|ST|0^MDC_ATTR_FILTER_LOW_PASS^MDC|1.1.1.6.7|FIR

/* Filter order (number poles), in this case 1 , which is unitless */

OBX|13|NM|0^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.6.7.1|1||

/* Filter cutoff frequency, in this case 30 Hz. Units are Hz (2496) + offset (262144) */

OBX|14|NM|2408^MDC_ATTR_SA_FREQ_SIG ^MDC|1.1.1.6.7.2|30|264640^MDC_DIM_HZ

OBX|15|ST|0^MDC_ATTR_FILTER_HIGH_PASS^MDC|1.1.1.6.8|FIR

/* Filter order (number poles), in this case 1 , which is unitless */

OBX|16|NM|0^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.6.8.1|1||

/* Filter cutoff frequency, in this case 0.5 Hz. Units are Hz (2496) + offset (262144) */

OBX|17|NM|2408^MDC_ATTR_SA_FREQ_SIG^MDC|1.1.1.6.8.2|0.5|264640^MDC_DIM_HZ

/* Sweep speed, in this case 25 mm/sec. Units are m/sec (2816) + milli (18) + offset (262144) */

OBX|18|NM|2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC
|1.1.1.6.9|25|264978^MDC_DIM_MILLI_M_PER_SEC|

/* Waveform display color at source, in this case a shade of blue */

OBX|19|NA|0^MDC_ATTR_VIS_COLOR^MDC |1.1.1.6.10|0^102^255||

/* Range of displayed data, in this case +/- 1 mV . Unit of measure is volts (4256) + milli (18) + offset (262144) */

OBX|20|NR|0^MDC_ATTR_SCALE_RANGE^MDC |1.1.1.6.11|-1^+1|266418^MDC_DIM_MILLI_VOLT

/* Range of physiological data, in this case +/- 5 mV */

OBX|21|NR|0^MDC_ATTR_PHYS_RANGE|1.1.1.6.12|-5^+5|266418^MDC_DIM_MILLI_VOLT

/* First ECG Waveform*/

OBX|21|NA|131329^ MDC_ECG_LEAD_I^MDC |1.1.1.6|
24^72^12^-24^-56^200^1250^1900^2056^1432…(etc.)||||||||| 20080515121000.100

/* Second ECG Waveform*/

OBX|22|NA|131330^ MDC_ECG_LEAD_II^MDC |1.1.1.7|
24^72^12^-24^-56^200^1250^1900^2056^1432…(etc.)||||||||| 20080515121000.100

/* Third ECG Waveform*/

OBX|22|NA|131331^ MDC_ECG_LEAD_III^MDC |1.1.1.7|
24^72^12^-24^-56^200^1250^1900^2056^1432…(etc.)||||||||| 20080515121000.100

/* Pressure Waveform */

OBR|3||09780979a9879^ACME HEALTH^ABCD002343785379^EUI-64|WAVEFORM|||20080515121000.100-
400|20080515121001.100-400

/* This message also contains an Arterial Blood Pressure waveform which starts here, with the waveform raw data. The ABP waveform is in mmHg, and ranges from -100 to +400 mmHg. */

OBX|23|NA|18960+0+(…)^MDC_PRESS_BLD_ART^MDC I^MDC |1.1.1.9.1|
1027^3504^4586^6612^8234^10592^11250^12183^11490…(etc.)||||||||| 20080515121000.100

/* Sample rate is 50 samples/sec. MDC code is 262144+2464 */

OBX|24|NM|0^MDC_ATTR_SAMP_RATE^MDC |1.1.1.9.2|50|264608^MDC_DIM_PER_SEC

/* Data resolution – 1 mmHg = 16 counts. Unit of measure is mmHg (3872) + offset (262144) */

OBX|25|NM|0^MDC_ATTR_NU_MSMT_RES^MDC |1.1.1.9.3|16|266016^MDC_DIM_MMHG^MDC

/* Waveform encoding is default – integer */

OBX|26|NM|0^MDC_ATTR_WAV_ENCODING^MDC |1.1.1.9.4|0

/* Range of raw data (i.e., A/D) values to be encountered. */

OBX|27|NR|0^MDC_ATTR_DATA_RANGE^MDC |1.1.1.9.5|-8192^+8191||

/* The next 3 messages map special waveform values to specific abnormal conditions.*/

OBX|28|NM|262590^MDC_EVT_SIG_OUT_OF_RANGE^MDC |1.1.1.9.6|32767||

OBX|29|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.9.7|32766||

OBX|30|NM|268334^MDC_EVT_STAT_UNCALIB^MDC |1.1.1.9.8|32766||

/* The following section describes the filters applied to this pressure, which is a low-pass of 16 Hz */

OBX|31|ST|0^MDC_ATTR_FILTER_LOW_PASS^MDC|1.1.1.9.9|FIR

/* Filter order (number of poles), in this case 1. */

OBX|32|NM|0^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.9.9.1.|1||

/* Filter cutoff frequency, in this case 16 Hz. Units are Hz (2496) + offset (262144) */

OBX|33|NM|2408^MDC_ATTR_SA_FREQ_SIG ^MDC|1.1.1.9.9.2|264640^MDC_DIM_HZ

/* Sweep speed, in this case 25 mm/sec. Units are m/sec (2816) + milli (18) + offset (262144) */

OBX|34|NM|2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC
|1.1.1.9.10|25|264978^MDC_DIM_MILLI_M_PER_SEC|

/* Waveform display color at source, in this case a shade of red */

OBX|35|NA|0^MDC_ATTR_VIS_COLOR^MDC |1.1.1.9.11|255^51^0||

/* Range of displayed data, in this case -30 mmHg to +270 mmHg */

OBX|36|NR|0^MDC_ATTR_SCALE_RANGE^MDC |1.1.1.9.12|-30^+270|266016^MDC_DIM_MMHG

/* Range of physiological data, in this case -50 mmHg to +350 mmHg */

OBX|37|NR|0^MDC_ATTR_PHYS_RANGE^MDC |1.1.1.9.13|-50^+350|266016^MDC_DIM_MMHG

