Integrating the Healthcare Enterprise

IHE Patient Care Device (PCD)
Technical Framework Supplement

Waveform Content Message (WCM)

Trial Implementation

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Foreword

This is a supplement to the IHE Patient Care Device Technical Framework V1.2. 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 July1, 2011 and will 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 Devices 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

CONTENTS

Introduction

The Waveform Content Message content integration profile 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 waveform snapshots as alarm evidentiary data or continuous waveform 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 highlighted terms such as xyz which will need to be assigned.
- Waveform type specific data may need to be included in the future. For example:
  - ECG electrode hookup
  - EEG electrode hookup
- Current WCM Profile requires Consumer to consume all information that the Reporter decides to send. In the future we will 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

This supplement describes the Content Profile which describes how to represent waveform data in IHE PCD HL7 based transactions. Waveform data can be included in DEC, ACM and other Profiles. It should also be noted that the current version of the profile 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 Message

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

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 Message** is a Content Profile which 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 Message (WCM)

The Waveform Content Message content integration profile 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

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

X Waveform Content Message (WCM)

The Waveform Content Message content integration profile 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:

- **Waveform snapshots** - specific forms of snapshots 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

The WCM Profile is a Content Profile and does not define any new IHE Actors or Transactions. Existing Actors and Transactions (such as PCD-01) can use the WCM Profile.

X.4 Integration Profile Options

No options have been defined by this Content Profile

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

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

Appendix A - Actor Summary Definitions

No actors were created, harmed or mistreated in the creation of this Profile.

Appendix B - Transaction Summary Definitions

No transactions were created, harmed or mistreated in the creation of this Profile.

Volume 2 – Transactions

The WCM Profile does not introduce any new Actors or Transactions.

Volume 3 – Content

Add section X.Y

X.Y Waveform Base Class

The Waveform Content Message content integration profile 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.

X.Y.1 Data Model

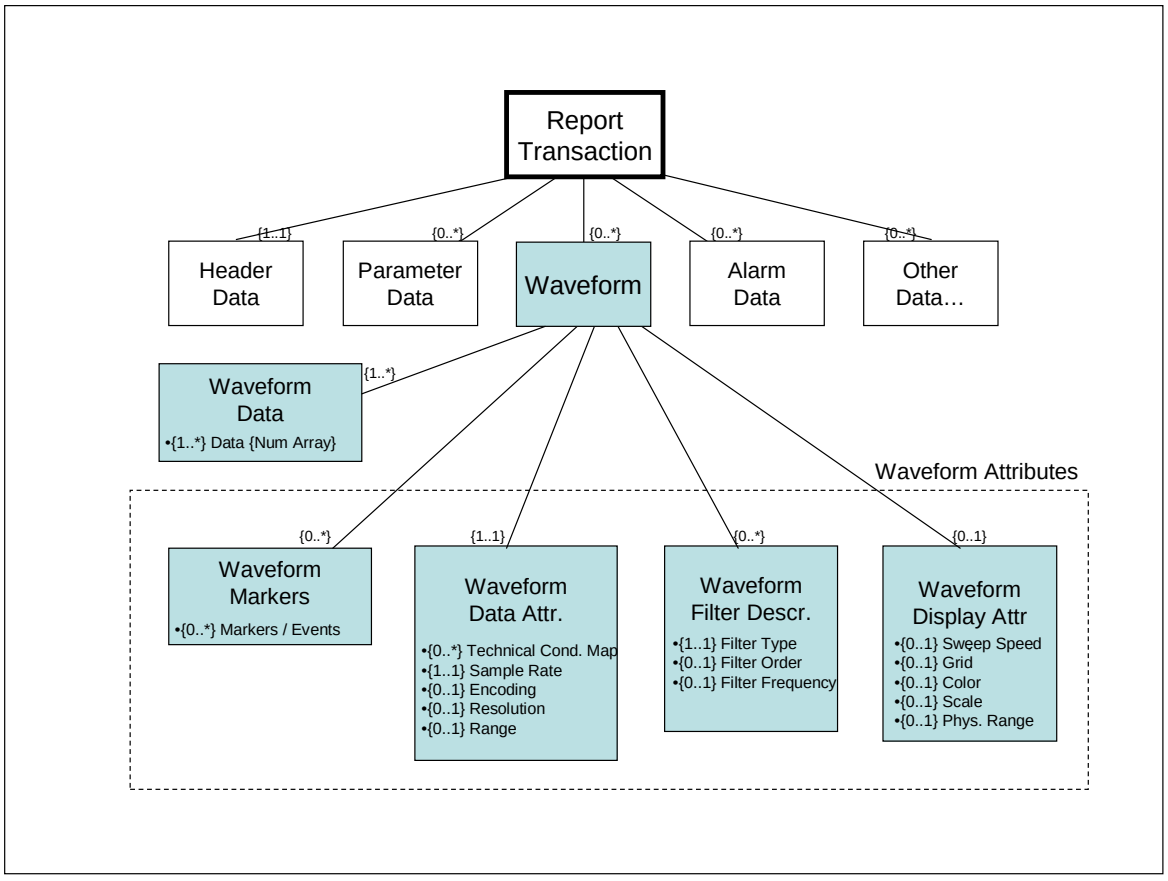

Figure X.Y.1-1 WCM Base Class Object Model

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

X.Y.2 Waveform Class Semantics

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.

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

Waveform OBX	Waveform Class Structure
…other content…	
{	---WAVEFORM_OBSERVATION begin
OBX	WAVEFORM OBSERVATIONS
[{ OBX }]	TECHNICAL CONDITION MAP(s)
OBX	SAMPLE RATE
[OBX]	WAVE ENCODING SCHEME
[OBX]	MEASUREMENT RESOLUTION
[OBX]	DATA RANGE
{[OBX	FILTER TYPE
[OBX]	FILTER ORDER
[OBX]]}	FILTER FREQUENCY
[OBX]	SWEEP SPEED
[OBX]	VISUAL GRID DESCRIPTION
[OBX]	WAVE COLOR
[OBX]	WAVE SCALE
[OBX]	WAVE PHYSIOLOGICAL RANGE
[{ OBX }]	WAVEFORM EVENT/MARKER(S)
}	---WAVEFORM OBSERVATION end
… other content…	

Note:

- [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)	**SCO**	**OBX-4**	**IEEE Code**	**IEEE Offset**	**Comments**
MDC MDS	1..1	1			
. MDC VMD	1..*	1.1			
. . MDC CHAN	1..*	1.1.1			
. . . "MDC_WAVE_DATA"	1..*	1.1.1.1			Waveform data: One waveform at a time
{Technical condition mapping}					

BTYPE (in the 'base type' worksheet)	**SCO**	**OBX-4**	**IEEE Code**	**IEEE Offset**	**Comments**
. . . . "MDC_TECH_COND"		1.1.1.1.1	52	262144	Inop, as an example
. . . . "MDC_TECH_COND"		1.1.1.1.2	22	262144	Disconnect, as an example
{Data attributes section}					
. . . . MDC_ATTR_SAMPLE_RATE	1..1	1.1.1.1.3	Tbd		Sample rate (typically in samples/sec)
. . . . MDC_ATTR_WAVE_COUNT	1..1	1.1.1.1.4	Tbd		Count of first sample in this message
. . . . MDC_ATTR_WAV_ENCODING	0..1	1.1.1.1.5	Tbd		Default is signed decimal
. . . . MDC_ATTR_NU_MSMT_RES	0..1	1.1.1.1.6	2409	0	Unit of measurement per sample value
. . . . MDC_ATTR_DATA_RANGE	0..1	1.1.1.1.7	Tbd		
{Filter section}					
. . . . MDC_ATTR_FILTER_DESCR	0..*	1.1.1.1.8	Tbd		Whether filter is high pass, low pass or notch and type of filter (IIR, FIR, etc.)
. . . . . MDC_ATTR_FILTER_ORDER	0..1	1.1.1.1.8.1	Tbd		# of dB at cutoff
. . . . . MDC_ATTR_SA_FREQ_SIG	0..1	1.1.1.1.8.2	2408	0	Cutoff frequency in Hz
. . . . MDC_ATTR_FILTER_DESCR	0..*	1.1.1.1.9	Tbd		Example high pass, low pass or notch and type of filter
. . . . . MDC_ATTR_FILTER_ORDER	0..1	1.1.1.1.9.1	Tbd		# of poles
. . . . . MDC_ATTR_SA_FREQ_SIG	0..1	1.1.1.1.9.2	2408	0	Cutoff frequency in Hz
{Display attributes section}					
. . . . MDC_ATTR_SPD_SWEEP_DEFAULT	0..1	1.1.1.1.10	2431	0	
. . . . MDC_ATTR_GRID_VIS	0..1	1.1.1.1.11	2330	0	NA of grid rows…
. . . . MDC_ATTR_VIS_COLOR	0..1	1.1.1.1.12	Tbd		R^G^B
. . . . MDC_ATTR_SCALE_RANGE	0..1	1.1.1.1.13	Tbd		Lowest scale value
. . . . MDC_ATTR_PHYS_RANGE	0..1	1.1.1.1.14	Tbd		Lowest physiological expected value
{Events/Markers section}					
. . . . MDC_WAV_EVENTS	0..*	1.1.1.1.15	3096	262144	Paced Beat
. . . . MDC_WAV_EVENTS	0..*	1.1.1.1.16	3072	262144	Start of Apnea
. . . . MDC_WAV_EVENTS	0..*	1.1.1.1.17	3204	262144	Premature Ventricular Contraction

Note: "*" in the OBX-4 column, indicates a non-specific dot hierarchy starting level

X.Y.3 Waveform Class Field 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.3-1 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
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 section will specify specific IDs per attribute type. In the case of group IDs this field is empty.

OBX-3 Observation Identifier (CWE), required:

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

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

Further guidance in this section per attribute.

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:

Required for Group IDs, optional in other cases..

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.3.1 Waveform Section

Each Waveform Section start is marked by an OBX with the Waveform Observation data for that waveform, followed by the attributes for 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).

The Waveform Data will always be contained 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 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.

Table X.Y.3.1-1 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 Waveform Source ID (e.g., ECG, ABP, Flow, EEG, etc.)
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Waveform values (signed Integer) separated by "^"
6	705	CWE	X	[1..1]		00574	Empty
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.3.2 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	MDC_EVT_INOP^(52+262144)
99998	Out of Range - High	MDC_EVT_RANGE_OVER^(166+262144)
99997	Out of Range – Low	MDC_EVT_RANGE_UNDER^(168+262144)
99996	Disconnected	MDC_EVT_DISCONN^(22+262144)
99995	Error	MDC-EVT_DATA_ACQN_ERR^(482+262144)

This would require 5 Error Condition OBX segments to convey.

Table X.Y.3.2-1 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 3 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.3.3 Sample Rate

Table X.Y.3.3-1 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	Tbd^MDC_ATTR_SAMP_RATE
4	20	ST	R	[1..1]		00572	See Table 3 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.3.4 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.3.4-1 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	MDC_ATTR_WAV_ENCODING
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	= 0 for signed integer

X.Y.3.5 Data Resolution

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.3.5-1 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	MDC_ATTR_NU_MSMT_RES^2327
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	See Table 12

Table X.Y.3.5-2 CSU – Channel Sensitivity and Units

SEQ	LEN	DT	Usage	TBL#	Component name
1	60	NM	R		Channel Sensitivity

SEQ	LEN	DT	Usage	TBL#	Component name
2	20	ST	C		Units of Measure Identifier
3	199	ST	C		Unit of Measure Description
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.3.6 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.3.6-1 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	tbd MDC_ATTR_DATA_RANGE
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Lowest data count^Highest data count

X.Y.3.7 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.7.3.7-1 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	MDC_ATTR_FILTER_NOTCH MDC_ATTR_FILTER_LOW_PASS MDC_ATTR_FILTER_HIGH_PASS
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment Hierarchy…

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
5	9999 9	Varies	C	[1..1]		00573	Example – FIR, IIR, Chebyshev, Kalman,
6	705	CWE	C	[0..1]		00574	Empty

Table X.Y.3.7-2 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	MDC_ATTR_FILTER_ORDER
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment Hierarchy…
5	9999 9	Varies	C	[1..1]		00573	Order at cutoff frequency

Table X.Y.3.7-3 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
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment Hierarchy…
5	9999 9	Varies	C	[1..1]		00573	#
6	705	CWE	X	[0..1]		00574	Hz

460

X.Y.3.8 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.

Table X.Y.3.8-1 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	MDC_ATTR_SPD_SWEEP_DEFAULT^2431

SEQ	LEN	DT	Usage	Card.	TBL#	ITEM#	Element name
4	20	ST	R	[1..1]		00572	See Table 3 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.3.9 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.3.9-1 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	Tbd MDC_ATTR_GRID_VIS
4	20	ST	R	[1..1]		00572	See Table 3 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.3.10 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.3.10-1 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
3	705	CWE	R	[1..1]		00571	MDC_ATTR_VIS_COLOR
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
							Hierarchy…
5	9999 9	Varies	C	[1..1]		00573	R^G^B; Example – 124^69^243
6	705	CWE	X	[1..1]		00574	Empty

480

X.Y.3.11 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
485 consumer to use the specified scale ranges.

Table X.Y.3.11-1 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	MDC_ATTR_SCALE_RANGE
4	20	ST	R	[1..1]		00572	See Table 3 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.3.12 Physiological Range - Optional

490 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.

495 **Table X.Y.3.12-1 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	MDC_ATTR_PHYS_RANGE

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
4	20	ST	R	[1..1]		00572	See Table 3 WCM Containment Hierarchy…
5	99999	Varies	C	[1..1]		00573	Lowest expected Physiological Value^Highest expected Physiological Value
6	705	CWE	R	[1..1]		00574	Units

X.Y.3.13 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.3.13-1 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	MDC_ATTR_EVENT
4	20	ST	R	[1..1]		00572	See Table 3 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.4 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.

510 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.4-1 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	

515

X.Y.5 Applying the Wave Class 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.5.1 General Guidance

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

X.Y.5.1.1 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.5.1.2 Use of the OBR Segment

If a Waveform in included in a transaction OBR-7 and OBR-8 fields are required. OBR-7 specifies the start time and OBR-8 the end time of the end of the last sample *interval* of all waveforms in the message as shown in the next Figure.

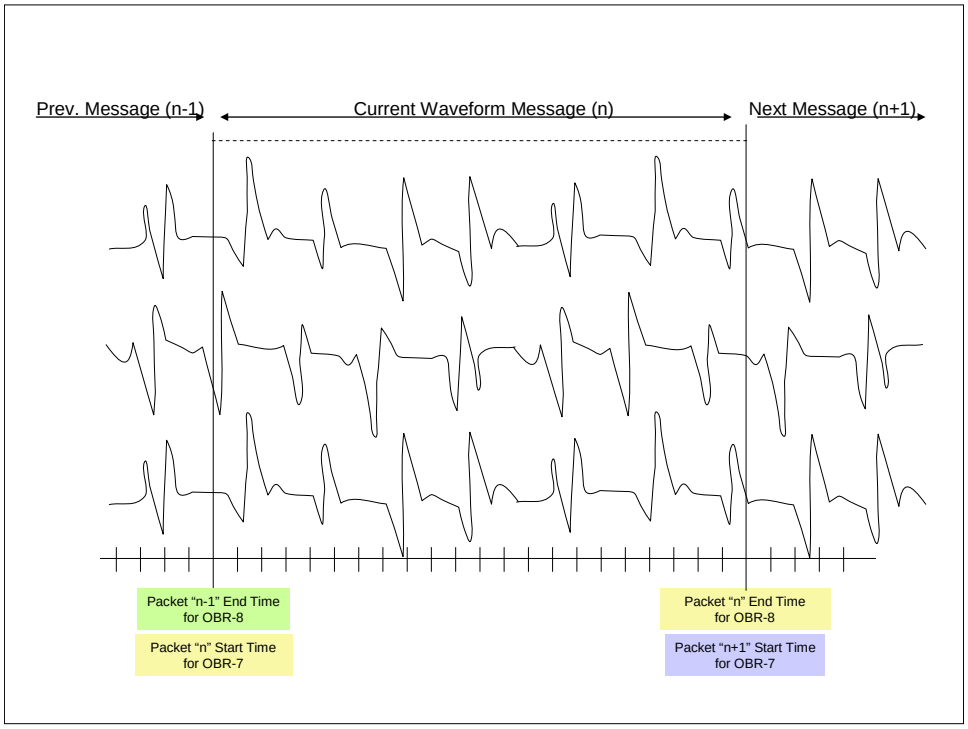

Figure X.Y.5.1.2-1 Waveform Timing

If some of the waveforms start later than others, or end earlier than others, then the sender may want to fill the waveform data with "Disconnect" Status data values (see Status Mapping). In any case, OBR-14 should be specified.

Table X.Y.5.1.1-1 OBR segment with Waveform Section(s)

SEQ	LEN	DT	Usage	Card.	TBL #	ITEM#	Element name
1	4	SI	R	[1..1]		00237	Set ID OBR
2	427	EI	RE	[1..1]		00216	Placer Order Number
3	427	EI	RE	[1..1]		00217	Filler Order Number
4	705	CWE	R	[1..1]		00238	Universal Service Identifier
5	2	ID	X	[0..0]		00239	Priority – OBR
6	24	DTM	X	[0..0]		00240	Requested Date/Time
7	24	DTM	R	[1..1]		00241	Observation Date/Time of the first sample
8	24	DTM	R	[1..1]		00242	Observation End Date/Time of the end of the last sample *interval*

X.Y.5.2 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.5.2.1 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.5.2.2 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.5.3 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.5.4 Waveform Snapshot – Request Trigger

Out of scope in current version.

X.Y.5.5 Waveform Snapshot – Archive Query

Out of scope in current version.

X.Y.5.6 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^PHILIPS^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.

/* Finally the actual waveform raw data, as delimited signed integers */

OBX|7|NA|149504^ MDC_PULS_OXIM_PLETH^MDC |1.1.1.2| 1027^3504^4586^6612^8234^10592^11250^12183^11490…(etc.)||||||||| 20080515121000.100

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

OBX|8||xyz^MDC_TECH_COND_MAP_GROUP^MDC |1.1.1.2.1||O

OBX|9|NM|262196^MDC_EVT_INOP^MDC |1.1.1.2.1.1|32767||

OBX|10|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.2.1.2|32766||

/* Sample rate is 50 samples/sec. MDC code is 65536+2464 */

OBX|11|NM|xyz^MDC_ATTR_SAMP_RATE^MDC |1.1.1.2.2|50|68000^MDC_DIM_PER_SEC

/* Waveform encoding is default – integer */

OBX|12|NM|xyz^MDC_ATTR_WAV_ENCODING^MDC |1.1.1.2.2|0

/* Count of first sample in message. Since this is a stand-alone message the count =0. */

OBX|13|NM|xyz^MDC_ATTR_WAV_COUNT^MDC |1.1.1.2.3|0||

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

OBX|14|NR|xyz^MDC_ATTR_DATA_RANGE^MDC |1.1.1.2.4|0^16383||

/* Sweep speed, in this case 25 mm/sec. Units are m/sec (2816) + milli (18) + offset (65536) */

OBX|15|NM|2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC |1.1.1.2.6|25|68370^MDC_DIM_M_PER_SEC|

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

OBX|16|NA|xyz^MDC_ATTR_VIS_COLOR^MDC |1.1.1.2.7|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 */

/* 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. */

OBX|6|NA|131329^ MDC_ECG_LEAD_I^MDC |1.1.1.6|
24^72^12^-24^-56^200^1250^1900^2056^1432…(etc.)||||||||| 20080515121000.100

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

OBX|7|NM|262196^MDC_EVT_INOP^MDC |1.1.1.6.1|32767||

OBX|8|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.6.2|32766||

/* Sample rate is 250 samples/sec. Unit of measurement MDC code is 65536+2464 */

OBX|9|NM|xyz^MDC_ATTR_SAMP_RATE^MDC |1.1.1.6.3|250|68000^MDC_DIM_PER_SEC

/* Count of first sample in this waveform */

OBX|10|NM|xyz^MDC_ATTR_WAVE COUNT^MDC |1.1.1.6.4|12345500

/* Waveform encoding is default – integer */

OBX|11|NM|xyz^MDC_ATTR_WAV_ENCODING^MDC |1.1.1.6.5|0

/* Data resolution: 1 mV = 2048 counts. Unit of measure MDC code is volts (4256) + milli (18) + offset (65536) */

OBX|12|NM|xyz^MDC_ATTR_NU_MSMT_RES^MDC |1.1.1.6.6|2048|69810^MDC_DIM_VOLT

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

OBX|13|NR|xyz^MDC_ATTR_DATA_RANGE^MDC |1.1.1.6.7|-16382^+16383||

/* 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|14|ST|xyz^MDC_ATTR_FILTER_LOW_PASS^MDC|1.1.1.6.8|FIR

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

OBX|15|NM|xyz^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.6.8.1|1||

/* Filter cutoff frequency, in this case 30 Hz. Units are Hz (2496) + offset (65536) */

OBX|16|NM|2408^MDC_ATTR_SA_FREQ_SIG ^MDC|1.1.1.6.8.2|30|68032^MDC_DIM_HZ

OBX|17|ST|xyz^MDC_ATTR_FILTER_HIGH_PASS^MDC|1.1.1.6.9|FIR

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

OBX|18|NM|xyz^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.6.9.1|1||

/* Filter cutoff frequency, in this case 0.5 Hz. Units are Hz (2496) + offset (65536) */

OBX|19|NM|2408^MDC_ATTR_SA_FREQ_SIG^MDC|1.1.1.6.9.2|0.5|68032^MDC_DIM_HZ

/* Sweep speed, in this case 25 mm/sec. Units are m/sec (2816) + milli (18) + offset (65536) */

OBX|20|NM|2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC |1.1.1.6.10|25|68370^MDC_DIM_M_PER_SEC|

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

OBX|21|NA|xyz^MDC_ATTR_VIS_COLOR^MDC |1.1.1.6.11|0^102^255||

/* Range of displayed data, in this case +/- 1 mV . Unit of measure is volts (4256) + milli (18) + offset (65536) */

OBX|22|NR|xyz^MDC_ATTR_SCALE_RANGE^MDC |1.1.1.6.12|-1^+1|69810^MDC_DIM_VOLT

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

OBX|23|NR|xyz^MDC_ATTR_PHYS_RANGE|1.1.1.6.13|-5^+5|69810^MDC_DIM_VOLT

/* Second ECG Waveform*/

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

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

OBX|25|NM|262196^MDC_EVT_INOP^MDC |1.1.1.7.1|32767||

OBX|26|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.7.2|32766||

/* Sample rate is 250 samples/sec. Unit of measurement MDC code is 65536+2464 */

OBX|27|NM|xyz^MDC_ATTR_SAMP_RATE^MDC |1.1.1.7.3|250|68000^MDC_DIM_PER_SEC

/* Count of first sample in this waveform */

OBX|28|NM|xyz^MDC_ATTR_WAVE COUNT^MDC |1.1.1.7.4|12345500

/* Waveform encoding is default – integer */

OBX|29|NM|xyz^MDC_ATTR_WAV_ENCODING^MDC |1.1.1.7.5|0

/* Data resolution: 1 mV = 2048 counts. Unit of measure MDC code is volts (4256) + milli (18) + offset (65536) */

OBX|30|NM|xyz^MDC_ATTR_NU_MSMT_RES^MDC |1.1.1.7.6|2048|69810^MDC_DIM_VOLT

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

OBX|31|NR|xyz^MDC_ATTR_DATA_RANGE^MDC |1.1.1.7.7|-16382^+16383||

/* 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. */

OBX|32|ST|xyz^MDC_ATTR_FILTER_LOW_PASS^MDC|1.1.1.7.8|FIR

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

OBX|33|NM|xyz^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.7.8.1|1||

/* Filter cutoff frequency, in this case 30 Hz. Units are Hz (2496) + offset (65536) */

OBX|34|NM|2408^MDC_ATTR_SA_FREQ_SIG ^MDC|1.1.1.7.8.2|30|68032^MDC_DIM_HZ

OBX|35|ST|xyz^MDC_ATTR_FILTER_HIGH_PASS^MDC|1.1.1.7.9|FIR

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

OBX|36|NM|xyz^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.7.9.1|1||

/* Filter cutoff frequency, in this case 0.5 Hz. Units are Hz (2496) + offset (65536) */

OBX|37|NM|2408^MDC_ATTR_SA_FREQ_SIG^MDC|1.1.1.7.9.2|0.5|68032^MDC_DIM_HZ

/* Sweep speed, in this case 25 mm/sec. Units are m/sec (2816) + milli (18) + offset (65536) */

OBX|38|NM|2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC |1.1.1.7.10|25|68370^MDC_DIM_M_PER_SEC|

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

OBX|39|NA|xyz^MDC_ATTR_VIS_COLOR^MDC |1.1.1.7.11|0^102^255||

/* Range of displayed data, in this case +/- 1 mV . Unit of measure is volts (4256) + milli (18) + offset (65536) */

OBX|40|NR|xyz^MDC_ATTR_SCALE_RANGE^MDC |1.1.1.7.12|-1^+1|69810^MDC_DIM_VOLT

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

OBX|41|NR|xyz^MDC_ATTR_PHYS_RANGE|1.1.1.7.13|-5^+5|69810^MDC_DIM_VOLT

/* Third ECG Waveform*/

OBX|42|NA|131335^ MDC_ECG_LEAD_V5^MDC |1.1.1.8|
24^72^12^-24^-56^200^1250^1900^2056^1432…(etc.)|||||||| 20080515121000.100

OBX|43|NM|262196^MDC_EVT_INOP^MDC |1.1.1.8.1|32767||

OBX|44|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.8.2|32766||

OBX|45|NM|xyz^MDC_ATTR_SAMP_RATE^MDC |1.1.1.8.3|250|68000^MDC_DIM_PER_SEC

OBX|46|NM|xyz^MDC_ATTR_WAVE COUNT^MDC |1.1.1.8.4|12345500

OBX|47|NM|xyz^MDC_ATTR_WAV_ENCODING^MDC |1.1.1.8.5|0

OBX|48|NM|xyz^MDC_ATTR_NU_MSMT_RES^MDC |1.1.1.8.6|2048|69810^MDC_DIM_VOLT

OBX|49|NR|xyz^MDC_ATTR_DATA_RANGE^MDC |1.1.1.8.7|-16382^+16383||

OBX|50|ST|xyz^MDC_ATTR_FILTER_LOW_PASS^MDC|1.1.1.8.8|FIR

OBX|51|NM|xyz^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.8.8.1|1||

OBX|52|NM|2408^MDC_ATTR_SA_FREQ_SIG ^MDC|1.1.1.8.8.2|30|68032^MDC_DIM_HZ

OBX|53|ST|xyz^MDC_ATTR_FILTER_HIGH_PASS^MDC|1.1.1.8.9|FIR

OBX|54|NM|xyz^MDC_ATTR_FILTER_ORDER^MDC|1.1.1.8.9.1|1||

OBX|55|NM|2408^MDC_ATTR_SA_FREQ_SIG^MDC|1.1.1.8.9.2|0.5|68032^MDC_DIM_HZ

OBX|56|NM|2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC |1.1.1.8.10|25|68370^MDC_DIM_M_PER_SEC|

OBX|57|NA|xyz^MDC_ATTR_VIS_COLOR^MDC |1.1.1.8.11|0^102^255||

OBX|58|NR|xyz^MDC_ATTR_SCALE_RANGE^MDC |1.1.1.8.12|-1^+1|69810^MDC_DIM_VOLT

OBX|59|NR|xyz^MDC_ATTR_PHYS_RANGE|1.1.1.8.13|-5^+5|69810^MDC_DIM_VOLT

/* Pressure Waveform */

/* 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|60|NA|18960+0+(…)^MDC_PRESS_BLD_ART^MDC I^MDC |1.1.1.9|
1027^3504^4586^6612^8234^10592^11250^12183^11490…(etc.)||||||||| 20080515121000.100

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

OBX|61|NM|262590^MDC_EVT_SIG_OUT_OF_RANGE^MDC |1.1.1.9.1|32767||

OBX|62|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.9.2|32766||

OBX|63|NM|268334^MDC_EVT_STAT_UNCALIB^MDC |1.1.1.9.3|32766||

/* Sample rate is 50 samples/sec. MDC code is 65536+2464 */

OBX|64|NM|xyz^MDC_ATTR_SAMP_RATE^MDC |1.1.1.9.4|50|68000^MDC_DIM_PER_SEC

/* Count of first sample in this waveform */

OBX|65|NM|xyz^MDC_ATTR_WAVE COUNT^MDC |1.1.1.9.5|456650

/* Waveform encoding is default – integer */

OBX|66|NM|xyz^MDC_ATTR_WAV_ENCODING^MDC |1.1.1.9.6|0

/* Data resolution – 1 mmHg = 16 counts. Unit of measure is mmHg (3872) + offset (65536) */

OBX|67|NM|xyz^MDC_ATTR_NU_MSMT_RES^MDC |1.1.1.9.7|16|69408^MDC_DIM_MMHG^MDC

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

OBX|68|NR|xyz^MDC_ATTR_DATA_RANGE^MDC |1.1.1.9.8|-8192^+8191||

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

OBX|69|ST|xyz^MDC_ATTR_FILTER_LOW_PASS^MDC|1.1.1.9.9|FIR

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/* Filter order (number of poles), in this case 1. */
OBX|70|NM|xyz^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 (65536) */
OBX|71|NM|2408^MDC_ATTR_SA_FREQ_SIG ^MDC|1.1.1.9.9.2|668032^MDC_DIM_HZ
/* Sweep speed, in this case 25 mm/sec. Units are m/sec (2816) + milli (18) + offset (65536) */
OBX|72|NM|2431^MDC_ATTR_SPD_SWEEP_DEFAULT^MDC |1.1.1.9.10|25|68370^MDC_DIM_M_PER_SEC|
/* Waveform display color at source, in this case a shade of red */
OBX|73|NA|xyz^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|74|NR|xyz^MDC_ATTR_SCALE_RANGE^MDC |1.1.1.9.12|-30^+270|3872+^MDC_DIM_MMHG^MDC
/* Range of physiological data, in this case -50 mmHg to +350 mmHg  */
OBX|75|NR|xyz^MDC_ATTR_SCALE_RANGE^MDC |1.1.1.9.13|-50^+350|3872+^MDC_DIM_MMHG^MDC
```