IHE Patient Care Device (PCD)

White Paper

Optimizing Messages for "Slow" Physical Layers

Version 1.0

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1. Introduction

IHE profiles are typically developed under the assumption that data bandwidth is plentiful and not an issue that needs to be considered.

For legacy point-of-care medical devices, data bandwidth can be a very serious consideration. The great majority of these devices were built with only an RS-232 port for data communication. Many modern devices also support the RS-232 port in addition to Ethernet ports. RS-232 ports support bit rates of 9600 to 115,200 per second which pales in comparison with the slowest Ethernet bit rates of 10,000,000 per second.

This White Paper will explore what is possible using reduced bandwidths and will also investigate whether new transactions are required, existing transactions can be used or options to existing transactions are the best approach for documentation.

1.1 Methodology

This White Paper will establish objectives for the types and quantities of messages that need to be exchanged based on the device type. For example, the data exchange requirements for a patient monitor are different than for an infusion device.

The White Paper will then explore the sizes of IHE PCD messages which can result from taking advantage of all optionality available in current IHE PCD profiles such as DEC and ACM. It will assess whether these resulting messages can be useable on the slow RS-232 ports and achieve the previously established data exchange requirements.

This White Paper also explores mechanisms for time synchronization of the data reporter with the data consumer.

2. Data Exchange Objectives

2.1 Key Use Cases

It is intended that OMS apply to all DEC, ACM and WCM Use Cases where a device is communicating data about a single patient and is directly connected to a DOC or AM.

2.1.1 Use Case 1 – Legacy Device to Anesthesia Information System

A manufacturer has a legacy device that supports a proprietary protocol over an RS-232 physical port which can be directly collected by the Anesthesia Information System OR table located computer. Due to the wide acceptance of IHE PCD, the manufacturer would like to support IHE PCD but cannot since the resulting message sizes will not allow the application to meet its requirements. Instead they decide to use the OMS options to the IHE PCD transactions in order to reduce the payload to more comfortably fit within the available data rates.

2.1.2 Use Case 2 – Legacy Device to Device Integration System

A manufacturer has a legacy device that supports a proprietary protocol over an RS-232 physical port which can be directly collected by the Device Integration System RS-232 data concentrator at the bedside. Due to the wide acceptance of IHE PCD, the manufacturer would like to support IHE PCD but cannot since the resulting message sizes will not allow the application to meet its requirements. Instead they decide to use the OMS options to the IHE PCD transactions in order to reduce the payload to more comfortably fit within the available data rates.

2.2 Scope of Devices Considered

The Optimized Message Syntax (OMS) profile must meet the export requirements of all IHE PCD devices that have a real-time observations export requirement and that are likely to use an RS-232 port for communication. For example, device gateways are not a target device. Candidate devices include:

- Patient Monitors
- Vital Signs Monitors
- Pulse Oximeters, BIS Monitors, NiBP Monitors, etc.
- Ventilators
- Multi-Gas Monitors
- Anesthesia systems
- Infusion Devices

- Etc.

2.2.1 Device Requirements

Each device type has specific requirements:

- Patient Monitors:
  - Export up to 150 parameters every second.
  - Export up to 15 alarm messages every second.
  - Export up to 6 waveforms continuously (optional)
    - If waveform export is selected, parameters may only be sent every 10 seconds.
- Vital Signs (Spot Check) Monitors:
  - Export up to 10 parameters every minute
  - Export up to 2 alarm messages every second.
- Pulse Oximeters, BIS Monitors, NiBP Monitors, etc.
  - Export up to 10 parameters every second
  - Export up to 2 alarm messages every second
- Ventilators:
  - Export up to 20 settings every 10 seconds
  - Export up to 15 measurements every 10 seconds
  - Export up to 5 alarm messages every second.
  - Export up to 2 waveforms continuously (Pressure, Flow)
    - If waveform export is selected, parameter report frequency may be reduced.
- Airway Gas Analyzer:
  - Export up to 10 measurements every 10 seconds
  - Export up to 2 alarm messages every second.
  - Export up to 1 waveform continuously (CO2)
    - If waveform export is selected, parameters report frequency may be reduced.
- Anesthesia Systems:
  - Export up to 20 settings every 10 seconds
  - Export up to 30 measurements every 10 seconds (Vent (20), Airway (10), BIS (10))
  - Export up to 10 alarm messages every second.
  - Export up to 4 waveforms continuously (Vent (2), Airway (1), BIS (1))

- If waveform export is selected, parameter report frequency may be reduced.

It might seem clear that the Patient Monitor Use Case is the worst case, however while waveforms are optional for the Patient Monitor they are not optional for the Anesthesia System. In addition we have to assess what is possible based on the potential speed of the RS-232 port which differs based on the hardware in the device.

2.2.2 Requirements due to the RS-232 Physical Layer

Due to the prevalence of legacy devices, RS232 is currently the most popular physical layer in use for data communications from devices to enterprise systems either directly or via third party device integration systems.

As previously mentioned, the RS-232 port can achieve a maximum bit rate of 115.2 kbps we need to consider that:

- Many devices can only achieve 9.6 kbps.
- We have to take into account start and stop bits which take up 20% of the bits.
- We cannot assume 100% of the available data rate is truly achievable, so we aim for ~75% utilization.

As a result we assume an overall 60% achievable data rate. For example, for a device running at 19.2 kbps this would imply a net data rate of 11.5 kbps or 1,440 bytes/second.

Raw Bit Rate (Bits per second)	Net Data Rate (Bytes per second)
9600	720
19200	1440
38400	2880
57600	4320
72800	5760
115200	8620

3. Lower Layer Protocol

3.1 Overview

Various Lower Layer Protocol options are available to systems employing HL7. Currently most IHE PCD implementations use MLLP though some use Web Services. Both of these assume that the physical layer provides message integrity checking whereas RS-232 does not. As a result a different approach is required, which is outlined in the HL7 specification as the Lower Layer Protocol (LLP).

If for no other reason, an option will need to be documented for the use of LLP with IHE PCD profile transactions.

3.2 Notation Conventions

- Single ASCII characters are enclosed in single quotes.
- Special characters or non-printing ASCII characters are enclosed in angle brackets, <>. Special characters are the LLP Start Block and End Block characters. Non-printing ASCII characters may be written as their abbreviation, e.g., ESC for the Escape character. They also may be written as their hex value in the form 0xXX where X is a hexadecimal digit. For example in Standard ASCII, <ESC> is <0x1B>.

3.3 Message Framing

The following comes from the HL7 2.3 specification:

There are two types of blocks, data blocks and NAK blocks. HL7 messages are transmitted in single data blocks. NAK blocks are used to signal transmission errors.

Both block types have the same format:

<SB>tvv<CR>ddddcccccxxx<EB><CR>

Blocks consist of the following fields. Note that these are LLP fields and are not the same as HL7 message fields.

<SB> =	Start Block character (1 byte) Configurable on a site specific basis. Unless there is a conflict, the value should be ASCII <VT>, i.e., <0x0B>. This should not be confused with the ASCII characters SOH or STX.

t =	Block Type (1 byte) 'D' = data block 'A' = ACK block 'N' = NAK block
vv =	Protocol ID (2 bytes) The characters '2' '3' for this version
<CR> =	Carriage Return (1 byte) The ASCII carriage return character, i.e., <0x0D>.
dddd =	Data (variable number of bytes) In a data block, this is the data content of the block. The data can contain any displayable ASCII characters and the carriage return character, <CR>. Carriage returns that are not part of the HL7 message may be inserted as described in "Carriage Return Stuffing." In a NAK block, this field contains a 1-byte reason code as follows: 'C' - character count wrong in previous data block received 'X' - checksum wrong in previous data block received 'B' - data too long for input buffer in previous block received 'G' - Error not covered elsewhere.
ccccc =	Block Size (5 bytes) Character count of all characters so far in the data block up to and including the last data character. For this version of the protocol this is 5 + the size of the dddd field. Note: HL7 message ends with a <CR> character. This character is considered as part of the data.
xxx =	Checksum (3 bytes) Exclusive-OR checksum of all characters in the block up to and including the last data character. The checksum is expressed as a decimal number in three ASCII digits. If the value of this field is 999, the checksum should not be computed. Processing will proceed as if it were correct. This feature is used for applications where the messages will be translated from one character set to another during transmission.

<EB> =	End Block character (1 byte) Configurable on a site specific basis. Unless there is a conflict, the value should be ASCII <FS>, i.e., <0x1C>. This should not be confused with the ASCII characters ETX or EOT.
<CR> =	Carriage Return (1 byte) The ASCII carriage return character, i.e., <0x0D>.

4. Time Synchronization

4.1 Introduction

For the most part time synchronization is not big issue for many devices. The data can be transmitted from Data Reporter to Data Consumer which can assume near “real-time” delivery and can time stamp the data on behalf of the source.

However many measurements, such as Cardiac Output or Non-Invasive Blood Pressure are not continuous and therefore properly labeling these observations with the correct time both in the data stream and on the user interface is important.

4.2 Alternative Mechanisms

It seems there are a few options:

1. Custom Approach:
    - For unsolicited modes, we can require the DOC to send back an ACK which has a timestamp. The DOR can synchronize its clock to this.
    - For solicited modes, the PCD-02 request has a time stamp which the DOR can use to synchronize its clock.
2. Consistent Time [CT] based Approach:
    - We can implement the NTP protocol which would have the DOR send an explicit time request to the DOC which replies with the current time in an NTP consistent format.
3. Consistent Correction based Approach:
    - The OBR from the DOR contains a timestamp which denotes the time of the message which in general can be interpreted to be the current time of the device. The DOC can use this time to determine an offset to correct all data received. This approach has the disadvantage that the DOR time is never corrected so that the time of day displayed on the device may be incorrect.

5. PCD-01 Message

The DEC profile was developed by the IHE PCD Domain for the reporting of results such as Heart Rate, Non-Invasive Blood Pressure, SpO2, etc.   This message is made up of a number of segments as follows:

MSH Segment – Message Header

PID Segment – Patient Identifier

PV1 Segment – Patient Visit

OBR Segment – Observation Request

OBX Segment – Observation Results

5.1 MSH Segment

The MSH segment defines the intent, source, destination, and some specifics of the syntax of a message.

For purposes of comparison, we should both the “Typical Usage” syntax and semantics which is based on the existing PCD-01, PCD-02 and PCD-04 transactions as implemented by the Mindray anesthesia system compared directly with the new “Optimized Usage” syntax and semantics.

Table 1: MSH Segment

<table>
<tr><th>Element</th><th>Name</th><th colspan="2">Typical Usage</th><th colspan="2">Optimized Usage</th></tr>
<tr><td>MSH-1</td><td>Field Separator</td><td>R</td><td>“|”</td><td>R</td><td>“|”</td></tr>
<tr><td>MSH-2</td><td>Encoding Characters</td><td>R</td><td>“^~\&”</td><td>R</td><td>“^~\&”</td></tr>
<tr><td>MSH-3</td><td>Sending Application</td><td>R</td><td></td><td>R</td><td></td></tr>
<tr><td>MSH-3-1</td><td>Namespace ID</td><td>O</td><td>“<Device>“</td><td>O</td><td>“<Device>“</td></tr>
<tr><td>MSH-3-2</td><td>Universal ID</td><td>R</td><td>“OUI”
+
“FF” + “last six digits of MAC Address in Hex”</td><td>R</td><td>Empty</td></tr>
<tr><td>MSH-3-3</td><td>Universal ID Type</td><td>R</td><td>“EUI-64”</td><td>R</td><td>Empty</td></tr>
</table>

MSH-4	Sending Facility	RE	EMPTY or As Otherwise Acquired	RE	EMPTY
MSH-5	Receiving Application	RE	EMPTY	RE	EMPTY
MSH-6	Receiving Facility	RE	EMPTY	RE	EMPTY
MSH-7	Date/Time of Message	R	YYYY[MM[DD[HH[MM[SS]]]]] [+/-ZZZZ]	R	YYYY[MM[DD[HH[MM[SS]]]]]
MSH-9	Message Type	R		R	
MSH-9-1	Message Code	R	”ORU”	R	”ORU”
MSH-9-2	Trigger Event	R	”R01”	R	”R01”
MSH-9-3	Message Structure	R	”ORU_R01”	R	”ORU_R01”
MSH-10	Message Control Id	R	ACC	R	ACC
MSH-11	Processing Id	R		R	
MSH-11-1	Processing ID	R	“P”	R	“P”
MSH-11-2	Processing Mode	O	EMPTY	O	EMPTY
MSH-12	Version ID	R	“2.6”	R	“2.6”
MSH-13	Sequence Number	RE	EMPTY	RE	EMPTY
MSH-15	Accept Acknowledgment Type	R	“NE”	R	“NE”
MSH-16	Application Acknowledgment Type	R	“AL”	R	“AL”
MSH-17	Country Code	RE	EMPTY	RE	EMPTY
MSH-18	Character Set	RE	EMPTY	RE	EMPTY
MSH-19	Principal Language Of Message	RE	EMPTY	RE	EMPTY

MSH-21	Message Profile Identifier	R		R	
MSH-21-1	Entity Identifier	R	“IHE_PCD_001”	R	“IHE_PCD_001“
MSH-21-2	Namespace ID	RE	“IHE PCD”	RE	EMPTY
MSH-21-3	Universal ID	RE	“1.3.6.1.4.1.19376.1.6.1.1.1“	RE	EMPTY
MSH-21-4	Universal ID Type	RE	”ISO”	RE	EMPTY

5.1.1 MSH-3 Sending Application

Optimized:

MSH-3.1 will default to "<Device>“ where <Device> is the name of the device as determined by the manufacturer.

MSH-3.2 will be equal to “Company Name”

MSH-3.3 will default to "Other”

5.1.2 MSH-7 Date/Time of Message

Optimized:

MSH-7 will not typically include the time zone.

5.1.3 MSH-21 Message Profile Identifier

Optimized:

MSH-21.1 will be populated with "IHE_PCD_001_S" if this becomes a separate profile otherwise “IHE_PCD_001”.

MSH-21.2 will be EMPTY.

MSH-21.3 will be EMPTY.

MSH-21.4 will be EMPTY.

5.1.4 MSH Example

Normal (~160 characters):

MSH|^~\&|ACME_Z-SERIES^OUIFF00589632^EUI-64||||20101124110052-0500||ORU^R01^ORU_R01|16|P|2.6|||

NE|AL|||||IHE_PCD_001^IHE PCD^1.3.6.1.4.1.19376.1.6.1.1.1^ISO

Optimized (~90 characters):

MSH|^~\&|ACME_Z-SERIES||||20101124110052||ORU^R01^ORU_R01|16|P|2.6|||NE|AL|||||PCD_001_S

5.2 PID Segment

The PID segment is used as the primary means of communicating patient identification information. This segment contains permanent patient identifying and demographic information that, for the most part, is not likely to change frequently.

Different devices will obtain patient demographic information in different ways, which is the intent behind the phrase "As Otherwise Acquired". In most "Optimized Usage" cases no demographics are provided which implies that the device must be used in a point-to-point mode where the DOC understands the patient context and takes the responsibility of becoming the OMS device's proxy. In other cases, especially when the device is sitting on a LAN, the user will need to manually enter this information or be provided with a list of potential patients or some other mechanism.

NOTE:

Three scenarios are envisioned:

1. Point-to-Point connection – the OMS DOR connects to a patient monitor or application which collects the data. In this case it is assumed that the DOC is aware of the location and/or patient demographics and the DOR does not need to populate the PID.
2. Point-to- Multi-Point connection – the OMS DOR connects to a local data collection system which consolidates the data from various sources and places it on a network. In this case it is assumed the data collection system has a means of identifying the location or patient demographics and the DOR does not need to populate the PID.
3. Point-to- Network connection – the OMS DOR connects directly to a multi-bed network usually via a device server which converts its serial output to Ethernet. If this is permitted, the device is required to provide either patient demographics (in the PID segment) and/or device location (in the PV1 segment).

Table 2 PID Segment Definition

Element	Name	Typical Usage	Optimized Usage

PID-3	Patient Identifier List	R		RE	
PID-3-1	ID Number	R	EMPTY or Otherwise acquired	R	EMPTY
PID-3-4	Assigning Authority	R	"Hospital"	R	EMPTY
PID-3-5	Identifier Type Code	R	"PI"	R	EMPTY
PID-3-6	Assigning Facility	RE	EMPTY	RE	EMPTY
PID-5	Patient Name	R		RE	
PID-5-1	Family Name	RE	EMPTY or As Otherwise Acquired	RE	EMPTY or As Otherwise Acquired
PID-5-2	Given Name	RE	EMPTY or As Otherwise Acquired	RE	EMPTY or As Otherwise Acquired
PID-5-3	Second and Further Given Names	RE	EMPTY	RE	EMPTY
PID-5-4	Suffix	RE	EMPTY	RE	EMPTY
PID-5-5	Prefix	RE	EMPTY	RE	EMPTY
PID-5-7	Name Type Code	R	"L"	R	EMPTY
PID-5-8	Name Representation Code	RE	EMPTY	RE	EMPTY
PID-6	Mother's Maiden Name	RE	EMPTY	RE	EMPTY
PID-7	Date/Time of Birth	RE	EMPTY or YYYY[MM[DD[HH[MM]]]	RE	EMPTY or YYYY[MM[DD[HH[MM]]]
PID-8	Administrative Sex	RE	EMPTY or "F","M" or "O"	RE	EMPTY or "F","M" or "O"
PID-10	Race	RE	EMPTY	RE	EMPTY
PID-11	Patient Address	RE	EMPTY	RE	EMPTY
PID-11-1	Street Address	R		R	

PID-11-3	City	R		R	
PID-11-4	State of Province	R		R	
PID-11-5	Zip or Postal Code	R		R	
PID-11-7	Address Type	R		R	
PID-13	Phone Number – Home	RE	EMPTY	RE	EMPTY
PID-15	Primary Language	RE	EMPTY	RE	EMPTY
PID-29	Patient Death Date and Time	RE	EMPTY	RE	EMPTY
PID-33	Last Update Date/Time	RE	EMPTY	RE	EMPTY

On patient discharge from the device, the device will clear all the values of all fields to protect patient information.

5.2.1 PID-3 Patient Identifier List

Optimized:

Generally it is not necessary to send out the patient identification for a device connected by serial port. This is because the data consuming system already knows the location and will probably ignore anything the device sends anyway. However if the device knows the Patient ID (or MRN) it may send it.

5.2.2 PID-5 Patient Name

Optimized:

Generally it is not necessary to send out the patient name for a device connected by serial port. This is because the data consuming system already knows the location and will probably ignore anything the device sends anyway. However if the device knows the Patient Name it can send it in these fields as defined above.

5.2.3 PID-7 Date/Time of Birth

If available, some devices will populate this field with Year, Month and Day of birth.

If available, some devices will populate this field with Year, Month, Day, Hour and Minute of birth (for newborns).

5.2.4 PID Example

Typical with patient demographics (~60 characters):

PID|||012-34-5678^^^Hospital^PI||Smith^William^^^^^L|

Typical without patient demographics (~5 characters):

PID|

5.3 PV1 Segment

The PV1 segment is used to communicate information on an account or visit-specific basis. For and OMS device, this field will typically not be populated.

NOTE:

Three scenarios are envisioned:

1. Point-to-Point connection – the OMS DOR connects to a patient monitor or application which collects the data. In this case it is assumed that the DOC is aware of the location and/or patient demographics and the DOR does not need to populate the PV1.
2. Point-to- Multi-Point connection – the OMS DOR connects to a local data collection system which consolidates the data from various sources and places it on a network. In this case it is assumed the data collection system has a means of identifying the location or patient demographics and the DOR does not need to populate the PV1.
3. Point-to- Network connection – the OMS DOR connects directly to a multi-bed network usually via a device server which converts its serial output to Ethernet. If this is permitted, the device is required to provide either patient demographics (in the PID segment) and/or device location (in the PV1 segment).

Table 3 PV1 Segment Definition

Sequence numbers that are not used are omitted for brevity.

Element	Name	Typical Usage	Optimized Usage

PV1-2	Patient Class	R	"I"	R	"I"
PV1-3	Assigned Location	RE		RE	
PV1-3-1	Point of Care		EMPTY or As Otherwise Acquired		EMPTY or As Otherwise Acquired
PV1-3-2	Room		EMPTY or As Otherwise Acquired		EMPTY or As Otherwise Acquired
PV1-3-3	Bed		EMPTY or As Otherwise Acquired		EMPTY or As Otherwise Acquired
PV1-3-4	Facility		EMPTY or As Otherwise Acquired		EMPTY or As Otherwise Acquired
PV1-3-5	Location Status		EMPTY		EMPTY
PV1-3-6	Person Location Type		EMPTY		EMPTY
PV1-3-7	Building		EMPTY		EMPTY
PV1-3-8	Floor		EMPTY		EMPTY
PV1-3-9	Location Description		EMPTY		EMPTY
PV1-3-10	Comprehensive Location Identifier		EMPTY		EMPTY
PV1-3-11	Assigning Authority for Location		EMPTY		EMPTY
PV1-19	Visit Number	RE	EMPTY	RE	EMPTY
PV1-19-1	ID Number	R		R	
PV1-54	Visit Indicator	RE	EMPTY	RE	EMPTY

5.3.1 PV1-3 Assigned Patient Location

Optimized:

Generally it is not necessary to send out the patient location for a device connected by serial port, and most legacy devices do not provide the ability to set the location or patient demographics. This is because the data consuming system already knows the location and will probably ignore anything the device sends anyway. It is incumbent on the intermediary to provide either location or demographics information on behalf of the connected device(s).

PV1-3.1 "Point of Care" shall be empty or populated.

PV1-3.2 "Room" shall be empty or populated with the Room of the patient if available on the device

PV1-3.3 "Bed" shall be empty or populated with the Bed of the patient if available on the device

PV1-3.4 "Facility" shall be empty or populated.

5.3.2 PV1 Example

PV1 with device location (~50 characters).

```
PV1||I|OR Suite^OR Room 14^Table 14^Lutheran|
```

Typical without device location (~5 characters)

```
PV1|
```

5.4 OBR Segment

The OBR segment is used to transmit a date and time of the OBX segments which follow.

Table 4 OBR Segment Definition

Element	Name	Typical Usage		Optimized Usage	
OBR-1	Set ID OBR	R	ACC	R	ACC
OBR-2	Placer Order Number	O		O	EMPTY
OBR-2-1	Entity identifier	R	Same as MSH-10	R	
OBR-2-2	Namespace ID	R	”<Device>”	R	
OBR-2-3	Universal ID	R	“OUI” + “FF” + “last six digits of MAC Address in Hex”	R	

Element	Name	Typical Usage		Optimized Usage	
OBR-2-4	Universal ID Type	R	”EUI-64”	R	”EUI-64”
OBR-3	Filler Order Number	R		R	
OBR-3-1	Entity identifier	R	Same as MSH-10	R	Same as MSH-10
OBR-3-2	Namespace ID	R	“”Device””	R	“”Device””
OBR-3-3	Universal ID	R	“OUI” + “FF” + “last six digits of MAC Address in Hex”	R	“OUI” + “FF” + “last six digits of MAC Address in Hex”
OBR-3-4	Universal ID Type	R	”EUI-64”	R	”EUI-64”
OBR-4	Universal Service Identifier	R		R	
OBR-4-1	Identifier	R	Device MDC Code	R	Device MDC Code
OBR-4-2	Text	R	Device MDS REF-ID	R	Device MDS REF-ID
OBR-4-3	Naming of Coding System	RE	“MDC”	RE	“MDC”
OBR-7	Observation Date/Time	RE	YYYY[MM[DD[HH[MM[SS]]]]] [+/-ZZZZ]	RE	YYYY[MM[DD[HH[MM[SS]]]]] [+/-ZZZZ]

5.4.1 OBR-2 Placer Order Number

Optimized:

OBR-2 will be EMPTY

5.4.2 OBR-7 Observation Date/Time

The MSH message time cannot be relied on, as it may come from an intermediary and not reflect the true time of the observation. Therefore the OBR time must be supplied.

5.4.3 OBR Example

Normal: {~150 characters}

OBR|1|16^ACME_Z-SERIES^OUIFF00589632^EUI-64|16^ACME_Z_SERIES^OUIFF00589632^EUI-64|70040^MDC_DEV_SYS_ANESTH^MDC|||20101124110052-0500|

Optimized: {~100 characters}

OBR|1||16^ACME_Z_SERIES^OUIFF00589632^EUI-64|70040^MDC_DEV_SYS_ANESTH^MDC|||20101124110052-0500|

5.5 OBX Segment

The OBX segment is used to transmit a single observation or observation fragment. It represents the smallest indivisible unit of a report.

Table 5 OBX Segment Definition

Element	Name	Typical Usage		Optimized Usage	
OBX-1	Set ID-OBX	R	ACC	R	ACC
OBX-2	Value Type	CE	SN, NM, CWE, NA, etc.	CE	SN NM, CWE, NA, etc.
OBX-3	Observation Identifer	R		R	
OBX-3-1	Identifier	R	Nomenclature Code	R	Nomenclature Code
OBX-3-2	Text	R	Reference ID	O	RefID or EMPTY if MDC
OBX-3-3	Name of Coding System	R	MDC or Other	O	Other or EMPTY if MDC
OBX-3-4	Alternate Identifier	O	EMPTY	O	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	O	EMPTY
OBX-3-6	Name of Alternate Coding	O	EMPTY	O	EMPTY

Element	Name	Typical Usage		Optimized Usage	
	System				
OBX-4	Observation Sub-ID	R	Correct Value	O	EMPTY
OBX-5	Observation Value	CE	Correct Value	CE	Correct Value
OBX-6	Units	CE		CE	
OBX-6-1	Identifier	R	Nomenclature Code	R	Nomenclature Code
OBX-6-2	Text	R	Reference ID	O	RefID or EMPTY if MDC
OBX-6-3	Name of coding system	RE	MDC or Other	O	Other or EMPTY if MDC
OBX-7	Reference Range	CE	EMPTY	CE	EMPTY
OBX-8	Abnormal Flags	CE	EMPTY	CE	EMPTY
OBX-11	Observation Result Status	R	“R” or “F”	R	“R” or “F”
OBX-14	Date/Time of the Observation	RE	YYYY[MM[DD[HH[MM[SS]]]]] [+/-ZZZZ]	RE	EMPTY or YYYY[MM[DD[HH[MM[SS]]]]]
OBX-16	Responsible Observer	RE	EMPTY	RE	EMPTY
OBX-16-1	ID Number	R		R	
OBX-16-2	Family Name	RE		RE	
OBX-16-3	Given Name	RE		RE	
OBX-17	Observation Method	RE	EMPTY	RE	EMPTY
OBX-18	Equipment Instance Identifier	RE	EMPTY	RE	EMPTY
OBX-18-1	Entity Identifier	[1..1]		[1..1]	
OBX-18-2	Namespace ID	[0..1]		[0..1]	
OBX-18-3	Universal ID	[0..1]		[0..1]	
OBX-18-4	Universal ID Type	[0..1]		[0..1]	

Element	Name	Typical Usage		Optimized Usage	
OBX-19	Data/Time of Analysis	CE	EMPTY	CE	EMPTY
OBX-20	Observation Site	RE	EMPTY	RE	EMPTY

5.5.1 OBX-3 Observation Identifier

Optimized:

OBX-3.2 text which is usually populated with the REF_ID can be empty.

OBX-3.3 text can be assumed to be “MDC” if left empty.

5.5.2 OBX-4 Observation Sub-ID

Optimized:

OBX-4 will be EMPTY.

5.5.3 OBX-6 Units

Optimized:

OBX-6.2 text which is usually populated with the REF_ID can be empty.

OBX-6.3 text can be assumed to be “MDC” if left empty.

5.5.4 OBX-14 Date/Time of the Observation

Optimized:

OBX-14 will typically be EMPTY and the time of the Observation will be assumed to be the same as the time in OBR-7. If OBX-14 is not empty, it is for episodic measurements such as CO, NiBP which are not measured continuously.

5.6 ACK / NAK Handling

Depending on the time synchronization method used, the DOC may be required to send back an ACK or NAK of the message with the primary purpose of providing a time of day back to the device. If the device receives a NAK of a PCD-01_S message it will not be able to resend the message due to real-time constraints. So effectively the NAK will be ignored.

5.7 PCD-01 Example

Normal: {~1800 characters; ~125 characters/OBX}

```
MSH|^~\&|ACME_Z-SERIES^OUIFF00589632^EUI-64||||20101124110052-0500||ORU^R01^ORU_R01|16|P|2.6|||
```

```
NE|AL|||||IHE_PCD_001^IHE PCD^1.3.6.1.4.1.19376.1.6.1.1.1^ISO

PID|||012-34-5678^^^Hospital^PI||Smith^William^^^^^L|

PV1||I|OR Suite^OR Room 14^Table 14^Lutheran|

OBR|1|16^ACME_Y-SERIES^OUIFF00589632^EUI-64|16^ACME_Y_SERIES^OUIFF00589632^EUI-64|70040^M
DC_DEV_SYS_ANESTH^MDC|||20101124110052-0500|

OBX|1|NM|151819^MDC_PRESS_AWAY_INSP_MEAN^MDC|1.1.1.20747|7.00|266048^MDC_DIM_CM_H2O^M
DC|||||F|||20101124110052-0500|

OBX|2|NM|151976^MDC_VENT_PRESS_AWAY_END_EXP_POS^MDC|1.1.1.20904|2.00|266048^MDC_DIM_C
M_H2O^MDC|||||F|||20101124110052-0500|

OBX|3|NM|151784^MDC_PRESS_RESP_PLAT^MDC|1.1.1.20712|15.00|266048^MDC_DIM_CM_H2O^MDC|||||F
|||20101124110052-0500|

OBX|4|NM|151957^MDC_VENT_PRESS_MAX^MDC|1.1.1.20885|15.00|266048^MDC_DIM_CM_H2O^MDC|||||F|
||20101124110052-0500|

OBX|5|NM|151880^MDC_VOL_MINUTE_AWAY^MDC|1.1.2.20808|11.7|265216^MDC_DIM_L_PER_MIN^MDC||||
|F|||20101124110052-0500|

OBX|6|NM|151868^MDC_VOL_AWAY_TIDAL^MDC|1.1.2.20796|586|263762^MDC_DIM_MILLI_L^MDC|||||F|||201
01124110052-0500|

OBX|7|NM|151832^MDC_RATIO_IE^MDC|1.1.3.20760|50|262656^MDC_DIM_DIMLESS^MDC|||||F|||2010112411
0052-0500|

OBX|8|NM|151586^MDC_VENT_RESP_RATE^MDC|1.1.3.20514|20|264928^MDC_DIM_RESP_PER_MIN^MDC|
||||F|||20101124110052-0500|

OBX|9|NM|151920^MDC_VENT_CONC_AWAY_O2_INSP^MDC|1.2.1.20848|21|262688^MDC_DIM_PERCENT^
MDC|||||F|||20101124110052-0500|

OBX|10|NM|10000^ACME_FRESH_GAS_O2_COMPONENT^99ACME|1.3.1.10000|0.00|265216^MDC_DIM_L_P
ER_MIN^MDC|||||F|||20090101031518+0800|

OBX|11|NM|10001^ACME_FRESH_GAS_AIR_COMPONENT^99ACME|1.3.2.10001|0.00|265216^MDC_DIM_L_
PER_MIN^MDC|||||F|||20090101031518+0800|

OBX|12|NM|10002^ACME_FRESH_GAS_N2O_COMPONENT^99ACME|1.3.3.10002|2.6|265216^MDC_DIM_L_
PER_MIN^MDC|||||F|||20090101031518+0800|
```

Optimized: {~600 characters; ~50 characters/OBX}

```
MSH|^~\&|ACME_Z-SERIES^OUIFFACME^99ACME||||20101124110052-0500|||16||2.6||||||||001^^^|

PID|

PV1|

OBR|1|16^ACME_Y-SERIES^OUIFF00589632^EUI-64|16^ACME_Y_SERIES^OUIFF00589632^EUI-64|70040^M
DC_DEV_SYS_ANESTH^MDC|||20101124110052-0500|

OBX|1|NM|151819^^||7.00|266048
```

```
OBX|2|NM|151976^^||2.00|266048
OBX|3|NM|151784^^||15.00|266048
OBX|4|NM|151957^^||15.00|266048
OBX|5|NM|151880^^||11.7|265216
OBX|6|NM|151868^^||586|263762
OBX|7|NM|151832^^||50|262656
OBX|8|NM|151586^^||20|264928
OBX|9|NM|151920^^||21|262688
OBX|10|NM|10000^^99ACME||0.00|265216
OBX|11|NM|10001^^99ACME||0.00|265216
OBX|12|NM|10002^^99ACME||2.6|265216
```

6. DEC PCD-002 Message

Each device must support an unsolicited reporting mode; however they can also support a solicited mode using the PCD-002 transaction. If the device supports both modes, a method of mode selection must be provided (through some user configuration).

In solicited mode the PCD-002 message is used to trigger a PCD-001 message whenever the DOC desires an update (with some limitations as to frequency). PCD-002 consists of the following segments

MSH Segment – Message Header

QPD Segment – Query Parameter Definition

RCP Segment – Response Control Parameter

NOTE: While generally the PCD-002 message can also set up subscriptions, for OMS devices it's functionality is currently limited to triggering reports for "slow" devices.

6.1 MSH Segment

The MSH segment defines the intent, source, destination, and some specifics of the syntax of a message.

The fields of the PCD-02 are identical to the PCD-01 except:

6.1.1 X.Y.3.1.1MSH-0 Message Type

Will be populated as:

MSH-9.1 will be QSB

MSH-9.2 will be Z02

MSH-9.3 will be QSB_Q16

6.1.2 X.Y.3.1.2 MSH-21 Message Profile Identifier

Optimized:

MSH-21.1 will be populated with "IHE_PCD_002_S".

MSH-21.2 will be EMPTY.

MSH-21.3 will be EMPTY.

MSH-21.4 will be EMPTY.

6.2 QPD Segment

This segment is generated by the device or system that is setting up the subscription with the device. If the subscriber requests filters that the device does not support, it will ignore the filter and send everything it has.

Table 6 QPD Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
QPD-1	Message Query Name	CE	Z02^PCD-02-Subscription	PCD-02
QPD-2	Query Tag	ST	ACC	ACC
QPD-3	MRN	O	MRN	EMPTY
QPD-4	ActionCode	O	A, D, or EMPTY	EMPTY
QPD-5	PatientLocation	O	Patient Location	EMPTY
QPD-6	DeviceClass	O	List of VMDs	EMPTY
QPD-7	ParameterClass	O	List of Parameters	EMPTY
QPD-8	StartDateTime	O	YYYY[MM[DD[HH[MM[SS]]]]] [+/-ZZZZ]	EMPTY
QPD-9	EndDateTime	O	YYYY[MM[DD[HH[MM[SS]]]]] [+/-ZZZZ]	EMPTY
QPD-10	Interval	O	-1; 10 or >	-1

6.2.1 QPD-3 MRN

Optimized:

Will be assumed to be EMPTY (i.e. ignored if it has contents) since the device is connected point-to-point.

6.2.2 QPD-4 ActionCode

Optimized:

Will be assumed to be EMPTY (i.e. ignored if it has contents).

6.2.3 X.Y.3.2.3 QPD-5 PatientLocation

Optimized:

Will be assumed to be EMPTY (i.e. ignored if it has contents).

6.2.4 QPD-6 DeviceClass

Optimized:

Will be assumed to be EMPTY (i.e. ignored if it has contents).

6.2.5 QPD-7 ParameterClass

Optimized:

Will be assumed to be EMPTY (i.e. ignored if it has contents).

6.2.6 QPD-8 StartDateTime

Optimized:

Will be assumed to be EMPTY (i.e. ignored if it has contents), so the response will be as soon as possible.

6.2.7 QPD-9 EndDateTime

Optimized:

Will be assumed to be EMPTY (i.e. ignored if it has contents), so the subscription will continue indefinitely.

6.2.8 QPD-10 Interval

Specifies the desired interval (in seconds) between reports. If -1 then this is treated as a "one shot" request. We are proposing simplifying the PCD-02 transaction for OMS devices and suggest that -1 be the only supported value for this field.

6.3 RCP Segment

Table 7 RCP Segment Definition

Element	Name	Usage	Typical Usage

Element	Name	Usage	Typical Usage
RCP-1	Query Priority	ID	I
RCP-3	Response Modality	CE	R

6.3.1 RCP-01 Query Priority

Priority will always be set to “I” for Immediate

6.3.2 RCP-03 Response Modality

Modality will always be set to “R” for Real Time

6.4 ACK / NAK Handling

The DOR should properly acknowledge the PCD-002 request from the DOC. If the DOC receives a NAK, it should resend the request.

Handling of the PCD-001 message is the same as described in the previous section. If the DOC receives a message with an error it can send a NAK to the DOR. If it desires that the DOR retransmit the message it can send another PCD-002 request.

6.5 PCD-02 Example

The following would be a request to send data every 60 seconds.

Normal: {~325 characters}

```
MSH|^~\&|ACME_Z-SERIES^OUIFF00589632^EUI-64||||20101124110052-0500||
    QSB^Z02^QSB_Q16|16|P|2.6|||NE|AL|||||IHE_PCD_002^IHE PCD^1.3.6.1.4.1.19376.1.6.1.2.1^ISO
QPD| Z02^PCD-02-Subscription|1001|ABC1|A|3WICU^^305-1|||20070827080000|20070828080000|-1
RCP|I||R
```

Optimized: {~145 characters}

```
MSH|^~\&|ACME_Z-SERIES^ACME^Other||||20101124110052||QSB^Z02^QSB_Q16|16|P|2.6|||NE|AL|||||IHE_PC
    D_002^^^|
QPD| PCD-02|1||||||0|0|-1
RCP|I||R
```

7. ACM Profile - PCD-04 Message

The IHE PCD ACM profile defines a number of transactions of which PCD-04 is used for reporting of alarm events from the source or Device Observation Reporter (DOR) Actor. This message is made up of a number of segments as follows:

MSH Segment – Message Header

PID Segment – Patient Identifier

PV1 Segment – Patient Visit

ORC Segment – Observation Control Segment

OBR Segment – Observation Request

OBX Segment – Observation Results

7.1 General Discussion

Alarm and alert information is episodic and asynchronous, whereas measurement, settings and waveform information can be sent on a regular synchronous basis. If the device is sending data every 10 seconds, you cannot wait and include the alert data on the next update since this will be clinically dangerous. However if you send the alert message as the alert occurs this may delay the sending of the DEC message and if there are too many alerts at the same time may affect the ability of the device to send DEC data at all.

Each device needs to manage this conflict in a way that is clinically appropriate yet minimizes the complexity on the receiver. We recommend sending the alert data as soon as possible while minimally affecting the latency of the clinical observation data. This would mean potentially delaying an alert message if it is time to send a clinical observation message (PCD-01). The maximum delay can be controlled by the bit rate setting; the higher the bit rate the faster the clinical observation message will be sent and the device can then report the alert event.

If the device needs to send multiple alert messages at the same time, it may need to prioritize the messages to avoid delaying DEC PCD-01 messages.

Non-OMS PCD-04 messages may contain observation data as well as waveform snippets. This is not supported for OMS PCD-04 messages due to payload considerations.

7.2 MSH Segment

The MSH Segment is defined similarly to its use in the PCD-01 transaction (see section ??), with the following exception:

7.2.1 MSH-21 Message Profile Identifier

Optimized:

MSH-21.1 will be populated with “IHE_PCD_004_S”.

MSH-21.2 will be EMPTY.

MSH-21.3 will be EMPTY.

MSH-21.4 will be EMPTY.

7.3 PID Segment

The PID Segment is defined identically to its use in the PCD-01 transaction.

7.4 PV1 Segment

The PV1 Segment is defined identically to its use in the PCD-01 transaction.

7.5 ORC Segment

This is an optional segment – not supported by OMS devices.

7.6 OBR Segment

The first OBR segment in a message must contain the OBR-2 and OBR-4 fields, subsequent OBRs can leave them empty. All ACM OBR messages, relating to alerts must have OBR-3 filled.

7.6.1 OBR-3 Filler Order Number

This field needs to be unique to each alarm. It will start at 0 and be incrementally increased with each alarm reported. It will have a maximum value of 99999 and then restart at 0.

7.7 OBX Segment

The use of the OBX in the ACM profile is quite specialized. Each alarm report consists of a group of up to 7 OBX segments which are distinguished both by the contents of the OBX-2 field and by their use of the “facet” in OBX-4. OMS option devices do not support Facets 6 (Evidentiary data such as measurements or wavforms) and 7 (Real Time Location).

7.7.1 OBX Segment – Facet 1 – Event Identification

Table 8 OBX Facet 1 - Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	ST, NM, etc.	ST, NM, etc.
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	Nomenclature Code	Nomenclature Code
OBX-3-2	Text	R	Reference ID	EMPTY
OBX-3-3	Name of Coding System	R	MDC or Other	Other if not MDC
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Please refer to ACM Profile	x.1
OBX-5	Observation Value	CE	Correct Value	Correct Value
OBX-6	Units	CE	EMPTY	EMPTY
OBX-6-1	Identifier	R		
OBX-6-2	Text	R		
OBX-6-3	Name of coding system	RE		
OBX-7	Reference Range	CE	EMPTY	EMPTY
OBX-8	Abnormal Flags	CE	See below	See below
OBX-11	Observation Result Status	R	F	F
OBX-14	Date/Time of the Observation	RE	YYYY[MM[DD[HH[MM[SS]]]]] +/-ZZZZ	EMPTY

7.7.2 OBX Segment – Facet 2 – Source Identification

Table 9 OBX Facet 2 - Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	ST, NM, etc.	ST, NM, etc.
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	Nomenclature Code	Nomenclature Code
OBX-3-2	Text	R	Reference ID	EMPTY
OBX-3-3	Name of Coding System	R	MDC or Other	Other if not MDC
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Please refer to ACM Profile	x.2
OBX-5	Observation Value	CE	Correct Value	Correct Value
OBX-6	Units	CE		
OBX-6-1	Identifier	R	Nomenclature Code	Nomenclature Code
OBX-6-2	Text	R	Reference ID	EMPTY
OBX-6-3	Name of coding system	RE	MDC or Other	MDC
OBX-7	Reference Range	CE	EMPTY or Alarm Limits	EMPTY or Alarm Limits
OBX-8	Abnormal Flags	CE	Same as Facet 1	Same as Facet 1
OBX-11	Observation Result Status	R	F	F
OBX-14	Date/Time of the Observation	RE	YYYY[MM[DD[HH[MM[SS]]]]] +/-ZZZZ	EMPTY

7.7.3 OBX Segment – Facet 3 – Event Phase

Table 10 OBX Facet 3 - Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	ST	ST
OBX-3	Observation Identifer	R		EMPTY
OBX-3-1	Identifier	R	Nomenclature Code	
OBX-3-2	Text	R	Reference ID	
OBX-3-3	Name of Coding System	R	MDC or Other	
OBX-3-4	Alternate Identifier	O	EMPTY	
OBX-3-5	Alternate Text	O	EMPTY	
OBX-3-6	Name of Alternate Coding System	O	EMPTY	
OBX-4	Observation Sub-ID	R	Please refer to ACM Profile	x.3
OBX-5	Observation Value	CE	Correct Value	Correct Value

7.7.4 OBX Segment – Facet 4 – Alarm Current State

Table 11 OBX Facet 4 - Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	ST	ST
OBX-3	Observation Identifer	R		EMPTY
OBX-3-1	Identifier	R	Nomenclature Code	
OBX-3-2	Text	R	Reference ID	
OBX-3-3	Name of Coding System	R	MDC or Other	

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-3-4	Alternate Identifier	O	EMPTY	
OBX-3-5	Alternate Text	O	EMPTY	
OBX-3-6	Name of Alternate Coding System	O	EMPTY	
OBX-4	Observation Sub-ID	R	Please refer to ACM Profile	x.4
OBX-5	Observation Value	CE	Correct Value	Correct Value

7.7.5 OBX Segment – Facet 5 – Alarm Inactivation State

Table 12 OBX Facet 5 - Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	ST	ST
OBX-3	Observation Identifer	R		EMPTY
OBX-3-1	Identifier	R	Nomenclature Code	
OBX-3-2	Text	R	Reference ID	
OBX-3-3	Name of Coding System	R	MDC or Other	
OBX-3-4	Alternate Identifier	O	EMPTY	
OBX-3-5	Alternate Text	O	EMPTY	
OBX-3-6	Name of Alternate Coding System	O	EMPTY	
OBX-4	Observation Sub-ID	R	Please refer to ACM Profile	x.5
OBX-5	Observation Value	CE	Correct Value	Correct Value

7.8 PCD-04 Example

Normal: {~350 characters/alarm OBX}

OBX|1|ST|196648^MDC_EVT_HI^MDC|1.1.1.20885.1|VENT_PRESS_HI|||H~PM~SP|||||20050515121010|||||20080515121000

OBX|2|NM|151957^MDC_VENT_PRESS_MAX^MDC|1.1.1.20885.2|15.00|266048^MDC_DIM_CM_H2O^MDC|||||F|||20101124110052-0500|

OBX|3|ST|EVENT_PHASE|1.1.1.20885.3|start

OBX|4|ST|ALARM_STATE|1.1.1.20885.4|active

OBX|5|ST|INACTIVATION_STATE|1.1.1.20885.5|audio-paused

Optimized: {~160 characters/alarm OBX}

OBX|1|ST|196648|x.1|VENT_PRESS_HI|||H~PM~SP|

OBX|2|NM|151957|x.2|15.00|266048^^MDC|

OBX|3|ST|0^MDC_ATTR_EVT_....||start

OBX|4|ST|0^MDC_ATTR_ALM_...||active

OBX|5|ST|0^MDC_ATTR_INA…||audio-paused

8. Sending Real-Time Waveforms

If a device has waveform output enabled, the measurements, settings and waveform data will be combined in PCD-01 messages. We have to be careful to make transmission of this data as regular and deterministic as possible so that we can easily calculate the maximum data load and do not run the risk of running out of time.

As a result a number of "conventions" are proposed:

- Waveforms will be buffered and sent every second.
- One waveform attribute OBX can be sent every second per waveform.
  - For example if a waveform is transmitted, and it has a Sample Rate, Resolution, Data Range, 3 Technical Condition Maps, Filter Type and Filter Frequency it could take 8 seconds to transmit all attributes.
- Measurements and settings will be distributed over time to minimize the number sent every second.
  - For example if a device has 90 observations and needs to send them every 10 seconds, then 9 will be sent every second.
- Waveform encoding is always the default, so the Encoding OBX is not sent.
  - This attribute is optional in WCM
- Waveform content is not available in Solicited Mode

Waveform Segment Structure	**Waveform Attribute Structure**	**Typical Mode**	**Optimized Mode**
…other content…			
{	---WAVEFORM begin		
OBR	WAVEFORM OBSERVATION	Sent	Sent
OBX	WAVEFORM DATA	Sent	Sent
OBX	SAMPLE RATE	Sent	Sent
OBX	MEASUREMENT RESOLUTION	Sent	Sent
[OBX]	WAVE ENCODING SCHEME	Optional	Not Sent
[OBX]	DATA RANGE	Optional	Optional
[{ OBX }]	TECHNICAL CONDITION MAP(s)	Sent	Sent
{[	---FILTER begin	---	---
OBX	FILTER TYPE	Optional	Optional
[OBX]	FILTER ORDER	Optional	Optional
[OBX]	FILTER FREQUENCY	Optional	Optional

]}	---FILTER end		
[OBX]	SWEEP SPEED	Optional	Optional
[OBX]	VISUAL GRID DESCRIPTION	Optional	Optional
[OBX]	WAVE COLOR	Optional	Optional
[OBX]	WAVE SCALE	optional	Optional
[OBX]	WAVE PHYSIOLOGICAL RANGE	Optional	Optional
[{ OBX }]	WAVEFORM EVENT/MARKER(S)	Sent (ECG)	Optional
}	---WAVEFORM end		
… other content…			

X.Y.5.1 Waveform Observations OBR Segment

The OBR segment is used to identify the following OBXs as associated with a waveform and transmit the start and end times of the waveform. If another OBR segment preceeds it then it can be optimized as shown in Table 13.

Table 13 OBR Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBR-1	Set ID OBR	R	ACC	ACC
OBR-2	Placer Order Number	O		EMPTY
OBR-2-1	Entity identifier	R	Same as MSH-10	
OBR-2-2	Namespace ID	R	”<Device>”	
OBR-2-3	Universal ID	R	“OUI” + “FF” + “last six digits of MAC Address in Hex”	
OBR-2-4	Universal ID Type	R	”EUI-64”	
OBR-3	Filler Order Number	R		EMPTY
OBR-3-1	Entity identifier	R	Same as MSH-10	
OBR-3-2	Namespace ID	R	”<Device>”	
OBR-3-3	Universal ID	R	“OUI” + “FF” +	

Element	Name	Usage	Typical Usage	Optimized Usage
			"last six digits of MAC Address in Hex"	
OBR-3-4	Universal ID Type	R	"EUI-64"	
OBR-4	Universal Service Identifier	R		
OBR-4-1	Identifier	R	TBD	EMPTY
OBR-4-2	Text	R	WAVEFORM	WAVEFORM
OBR-4-3	Naming of Coding System	RE	"MDC"	EMPTY
OBR-7	Observation Date/Time	RE	YYYY[MM[DD[HH[MM[SS]]]]] +/-ZZZZ	YYYY[MM[DD[HH[MM[SS]]]]] [+/-ZZZZ]

8.1.1 OBR-Specifics

If this is the only OBR in a message then it must be formatted as per PCD_001 OBR. Otherwise it can be optimized as follows:

Optimized:

OBR-4.1 will be EMPTY

OBR-4.2 will be set to "WAVEFORM"

OBR-4.3 will be EMPTY

8.1.2 OBR Example

Normal: {~150 characters}

```
OBR|1|16^ACME_Y-SERIES^OUIFF00589632^EUI-64|16^ACME_Y-SERIES^OUIFF00589632^EUI-64|
^WAVEFORM^|||20101124110052-0500|20101124110053-0500|
```

Optimized: {~70 characters}

```
OBR|1||||^WAVEFORM^|||20101124110052-0500
```

8.2 Waveform Data OBX Segment

A single waveform is constructed from a series of OBX segments. One of the segments contains the actual data, while the other segments contain waveform attributes which assist in interpreting the data.

Table 14 Waveform Data OBX Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	NA	NA
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	Nomenclature Code	Nomenclature Code
OBX-3-2	Text	R	Reference ID	EMPTY
OBX-3-3	Name of Coding System	R	MDC or Other	MDC or Other
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Please refer to AWCM Profile	EMPTY
OBX-5	Observation Value	CE	Values separated by "^"	Values separated by "^"
OBX-6	Units	CE		
OBX-6-1	Identifier	R	Nomenclature Code	Nomenclature Code
OBX-6-2	Text	R	Reference ID	EMPTY
OBX-6-3	Name of coding system	RE	MDC	EMPTY
OBX-14	Observation Time	CE		
OBX-20	Observation Site	CE		

8.2.1 Waveform Sample Rate OBX Segment

The following sampling rates are typical for a patient monitor and/or anesthesia system. They are used to estimate the size of the resulting message.

Waveform	Sample Rate
ECG	200 samples/second
Invasive Blood Pressure	50 samples/second
SpO2	50 samples/second
O2	25 samples/second
CO2	25 samples/second
Respiration (Transthoracic)	25 samples/second
Agent	25 samples/second
Airway Volume	25 samples/second
Airway Flow	25 samples/second
Airway Pressure	25 samples/second

Table 15 Waveform Sample Rate OBX Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	NM	NM
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	???	???
OBX-3-2	Text	R	MDC_ATTR_SAMPLE_RATE	MDC_ATTR_SAMPLE_RATE
OBX-3-3	Name of Coding System	R	MDC	MDC
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-4	Observation Sub-ID	R	Please refer to WCM Profile	EMPTY
OBX-5	Observation Value	CE	Value	Value
OBX-6	Units	CE		
OBX-6-1	Identifier	R	264672	264672
OBX-6-2	Text	R	MDC_DIM_PER_MIN	EMPTY
OBX-6-3	Name of coding system	RE	MDC	EMPTY

8.2.2 Waveform Data Resolution OBX Segment

The data resolution expresses the value of each count in the waveform data. Typical example values are as follows:

Waveform	Channel Sensitivity	UoM
ECG	.01	mV
Invasive Blood Pressure	1	mmHg
SpO2	0.1	%
O2	0.1	%
	1	mmHg
	1	kPa
CO2	0.1	%
	1	mmHg
	1	kPa
Respiration (Transthoracic)		ohm
Agent	0.1	%
	1	mmHg
	1	kPa
Airway Volume	0.1	L
Airway Flow	0.1	l/min

Airway Pressure	0.1	cmH2O

Table 16 Waveform Data Resolution OBX Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	CSU	CSU
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	2327	2327
OBX-3-2	Text	R	MDC_ATTR_NU_MSMT_RES	EMPTY
OBX-3-3	Name of Coding System	R	MDC	EMPTY
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Refer to WCM Profile	EMPTY
OBX-5	Observation Value	CE		
OBX-5-1	Channel Sensitivity	R	VALUE	VALUE
OBX-5-2	UoM Identifier	C	UoM Code	UoM Code
OBX-5-3	UoM Description	C	UoM Ref_ID	EMPTY
OBX-5-4	UoM Coding System	C	MDC	EMPTY
OBX-5-5	Alternate UoM Identifier	C	EMPTY	EMPTY
OBX-5-6	Alternate UoM Description	C	EMPTY	EMPTY
OBX-5-7	Alternate UoM Coding System	C	EMPTY	EMPTY

8.2.3 Waveform Technical Condition Mapping OBX Segment(s)

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 9995 through 9999 as follows:

	9999	Inop	MDC_EVT_INOP^(52+262144)
	9998	Out of Range - High	MDC_EVT_RANGE_OVER^(166+262144)
	9997	Out of Range – Low	MDC_EVT_RANGE_UNDER^(168+262144)
	9996	Disconnected	MDC_EVT_DISCONN^(22+262144)
	9995	Error	MDC-EVT_DATA_ACQN_ERR^(482+262144

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	NM	NM
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	Nomenclature Code	Nomenclature Code
OBX-3-2	Text	R	Reference ID	
OBX-3-3	Name of Coding System	R	MDC	
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Please refer to WCM Profile	EMPTY
OBX-5	Observation Value	CE	Special Condition Value	Special Condition Value
OBX-6	Units	CE	EMPTY	EMPTY
OBX-11	Observation Time	CE	“O”	EMPTY

8.2.4 Waveform Filter Group OBX Segments

These attributes are only used for ECG waveform.

8.2.4.1 Waveform Filter Type OBX Segment

Filter Type will either be:

- MDC_ATTR_FILTER_HIGH_PASS
- MDC_ATTR_FILTER_LOW_PASS
- MDC_ATTR_FILTER_NOTCH.

Table 17 Waveform Filter Type OBX Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	ST	ST
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	???	Nomenclature Code
OBX-3-2	Text	R	Filter Type	EMPTY
OBX-3-3	Name of Coding System	R	MDC	EMPTY
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Please refer to WCM Profile	EMPTY
OBX-5	Observation Value	CE	"FIR", "IIR", …	"FIR", "IIR", …
OBX-6	Units	CE	EMPTY	EMPTY

8.2.4.2 Waveform Filter Order OBX Segment

Table 18 Waveform Filter Order OBX Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-2	Value Type	CE	NM	NM
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	TBD	TBD
OBX-3-2	Text	R	MDC_ATTR_FILTER_ORDER	EMPTY
OBX-3-3	Name of Coding System	R	MDC	EMPTY
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Please refer to WCM Profile	EMPTY
OBX-5	Observation Value	CE	Value	Value
OBX-6	Units	CE	Unitless	Unitless

8.2.4.3 Waveform Filter Frequency OBX Segment

Table 19 Waveform Filter Frequency OBX Segment Definition

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	NM	NM
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	2048	2048
OBX-3-2	Text	R	MDC_ATTR_SA_FREQ_SIG	EMPTY
OBX-3-3	Name of Coding System	R	MDC	MDC
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Please refer to WCM Profile	EMPTY
OBX-5	Observation Value	CE	Value	Value
OBX-6	Units	CE		
OBX-6-1	Identifier	R	68032	68032
OBX-6-2	Text	R	HZ	EMPTY
OBX-6-3	Name of coding system	RE	MDC	EMPTY

8.2.5 Waveform Event Markers OBX Segment(s)

The Reporter may want to specify 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.

Element	Name	Usage	Typical Usage	Optimized Usage
OBX-1	Set ID-OBX	R	ACC	ACC
OBX-2	Value Type	CE	NM	NM
OBX-3	Observation Identifer	R		
OBX-3-1	Identifier	R	Event Type from A.9.2.1 and A.9.3.1	Event Type from A.9.2.1 and A.9.3.1
OBX-3-2	Text	R	Reference ID	EMPTY
OBX-3-3	Name of Coding System	R	MDC or Other	EMPTY
OBX-3-4	Alternate Identifier	O	EMPTY	EMPTY
OBX-3-5	Alternate Text	O	EMPTY	EMPTY
OBX-3-6	Name of Alternate Coding System	O	EMPTY	EMPTY
OBX-4	Observation Sub-ID	R	Please refer to WCM	EMPTY

Element	Name	Usage	Typical Usage	Optimized Usage
			Profile	
OBX-5	Observation Value	CE	Sample # of Event in waveform data stream*	Sample # of Event in waveform data stream*
OBX-6	Units	CE	EMPTY	EMPTY

*Sample # is relative to the first sample in the current message which has a value of 0. Sample # can be negative in which case it is referring to a data sample in a previous message.

8.2.6 Other Waveform OBX Segment(s)

Other attributes can be transmitted. Each possibility is not investigated in detail the resulting size and optimizations will be similar to the OBX segments already analyzed above.

8.3 Waveform Message Example

8.3.1 ECG Waveform Example

OBR Normal: {~150 characters}

```
OBR|1|16^ACME_Z-SERIES^OUIFF00589632^EUI-64|16^ACME_Z-SERIES^OUIFF00589632^EUI-64|
^WAVEFORM^|||20101124110052-0500|20101124110053-0500|
```

OBX Normal: {~750 characters + 200*5 data characters = ~1750 characters total }

```
/* Example ECG Waveform */
OBX|1|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|2|NM|262196^MDC_EVT_INOP^MDC |1.1.1.6.1|32767||
OBX|3|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|4|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|5|NM|xyz^MDC_ATTR_WAVE COUNT^MDC |1.1.1.6.4|12345500
/* Waveform encoding is default – integer */
OBX|6|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|7|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|8|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|9|ST|xyz^MDC_ATTR_FILTER_LOW_PASS^MDC|1.1.1.6.8|FIR

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

OBX|10|NM|2408^MDC_ATTR_SA_FREQ_SIG ^MDC|1.1.1.6.8.2|30|68032^MDC_DIM_HZ

/* High Pass Filter */

OBX|11|ST|xyz^MDC_ATTR_FILTER_HIGH_PASS^MDC|1.1.1.6.8|FIR

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

OBX|12|NM|2408^MDC_ATTR_SA_FREQ_SIG^MDC|1.1.1.6.9.2|0.5|68032^MDC_DIM_HZ

/*More attributes are possible, but they all relate to waveform display attributes which are typically not supported in OMS implementations so are omitted here for the comparison*/

OBR Optimized (~70 characters} – assumes this is not the first OBR segment in the message:

OBR|1||||^WAVEFORM^|||20101124110052-0500

OBX Optimized: {~45 characters + 5*200 data characters = ~1045 characters/wvfm/sec}

/* This message contains an ECG waveform which starts here. */

OBX|1|NA|131329||
24^72^12^-24^-56^200^1250^1900^2056^1432…(etc.)

/* Only 1 of the following attribute segments is sent every second */

OBX|2|NM|262196 ||32767

OBX|3|NM|262166||32766|

OBX|4|NM|tuvxyz||250|68000

OBX|5|NM|tuvxyz ||12345500

OBX|6|NM|tuvxyz||0

OBX|7|NM|tuvxyz||2048|69810

OBX|8|NR|tuvxyz||-16382^+16383

OBX|9|ST|tuvxyz||FIR

OBX|10|NM|2408 ||30|68032

OBX|11|ST|tuvxyz||FIR

OBX|12|NM|2408 ||0.5|68032

8.3.2 Airway Flow Waveform Example

OBR Normal: {~150 characters}

OBR|1|16^ACME_Z-SERIES^OUIFF00589632^EUI-64|16^ACME_Z-SERIES^OUIFF00589632^EUI-64|
^WAVEFORM^|||20101124110052-0500|20101124110053-0500|

OBX Normal: {~350 characters + 5*25 data characters = ~475 characters/wvfm/sec}

/* This is a good example of a typical non-ECG waveform such as invasive pressure, SpO2, etc.*/

/* The waveform data is contained in the following OBX. The code for the Airway Flow is 20868+131072. */

OBX|1|2|151940^MDC_VENT_FLOW^MDC I^MDC |1.1.1.9.1|
0.22^0.51^0.84^1.23^1.6^1.32^1.02^…(etc.)|

/* Sample rate is 25 samples/sec. MDC code is 65536+2464 */

OBX|2|NM|xyz^MDC_ATTR_SAMP_RATE^MDC |1.1.1.9.2|25|68000^MDC_DIM_PER_SEC

/* Data resolution – 1 l/min = 100 counts. Unit of measure is l/min (3072) + offset (65536) */

OBX|3|NM|xyz^MDC_ATTR_NU_MSMT_RES^MDC|1.1.1.9.3|100|68608^MDC_DIM_X_L_PER_MIN^MDC

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

OBX|4|NM|262590^MDC_EVT_SIG_OUT_OF_RANGE^MDC |1.1.1.9.6|32767||

OBX|5|NM|262166^MDC_EVT_DISCONN^MDC |1.1.1.9.7|32766||

OBR Optimized (~70 characters} – assumes this is not the first OBR segment in the message:

OBR|1||||^WAVEFORM^|||20101124110052-0500

OBX Optimized: {~45 characters + 5*25 data characters = ~170 characters/wvfm/sec}

OBX|1|2|151940|||0.22^0.51^0.84^1.23^1.6^1.32^1.02^…(etc.)|

/* Only 1 of the following attribute segments is sent every second */

OBX|2|NM|tuvwxyz||25|68000

OBX|3|NM|tuvxyz||100|68608

OBX|4|NM|262590||32767

OBX|5|NM|262166||32766

9. Analysis and Summary

9.1 Available Bandwidth

As previously derived in section 2, a conservative estimate of the achievable data rate is summarized in the following table.

Raw Bit Rate (Bits per second)	Net Data Rate (Bytes per second)
9600	720
19200	1440
38400	2880
57600	4320
72800	5760
115200	8620

9.2 Summary of Optimized Segment Sizes

Segment	Typical Size	Optimized Size
MSH	160	25
PID	60	5
PV1	50	5
Alarm OBX	350	160
Alarm OBR	150	70
Parameter OBX	125	35
Parameter OBR	150	100
Waveform OBX (25 s/s)	475	170
Waveform OBX (200 s/s)	1750	1045
Waveform OBR	150	70

9.3 Examples

9.3.1 SpO2 Monitor Example

We can consider a legacy SpO2 monitor which outputs 3 parameters, a SpO2 waveform (25 s/s) and no alarms. It has an RS-232 port which only supports a 9600 baud rate. Assume that all parameters are sent every second along with the waveform segment.

	Quantity	Size	Total
MSH	1	25	70
PID	1	5	5
PV1	1	5	5
Parameter OBR	1	100	100
Parameter OBX	3	35	105
Waveform OBR	1	70	70
Waveform OBX (25 s/s)	1	170	170
TOTAL			525

The required data rate of 430 bytes/second is well within the limit of 720 bytes/second for a 9600 baud port.

9.3.2 Ventilator Example

The ventilator can send a mix of parameter, alarm and waveform data. We assume a maximum load of:

- 20 parameters
- 5 alarms
  - if more than 5 alarms are present, only 5 are sent every second with new alarms taking priority.
- 3 waveforms

All information is reported every second. The ventilator can support a baud rate of 19,200 baud.

	Quantity	Size	Total
MSH	1	25	70
PID	1	5	5
PV1	1	5	5

Parameter OBR	1	100	100
Parameter OBX (20 / second)	20	35	700
Waveform OBR	3	70	210
Waveform OBX (25 samples/sec)	3	170	510
TOTAL			1600
Alarm OBR	5	70	350
Alarm OBX (5 / second)	5	160	800
TOTAL w/Alarms			2750

The required data rate of 1430 bytes/second (w/o alarm information) is within the limit of 1440 bytes/second for a 19,200 bit rate port so a higher bit rate port would be required such as 38,400. If the parameter data is only required every 10 seconds, then 2 parameters can be sent every second (rather than 20) which would result in a required data rate of 800 bytes/second which is well within the limit of 1440 bytes/second.

Similarly if only 1 alarm update is sent every second then the required data rate is 1200 bytes/second which is within the limit of 1440.

	Quantity	**Size**	**Total**
MSH	1	25	70
PID	1	5	5
PV1	1	5	5
Parameter OBR	1	100	100
Parameter OBX (2 / second)	2	35	70
Waveform OBR	3	70	210
Waveform OBX (25 samples/sec)	3	170	510
TOTAL			970
Alarm OBR	1	70	70
Alarm OBX (1 / second)	1	160	160
TOTAL w/Alarms			1200

9.3.3 Anesthesia System Example

The ventilator can send a mix of parameter, alarm and waveform data. We assume a maximum load of:

- 40 measurements/settings (including anesthesia gas and agent readings)
- 5 alarms
    - if more than 5 alarms are present, only 5 are sent every second with new alarms taking priority.
- 5 waveforms, each 25 samples/second

If this information is reported every second:

	Quantity	**Size**	**Total**
MSH	1	25	70
PID	1	5	5
PV1	1	5	5
Parameter OBR	1	100	100
Parameter OBX (20 / second)	40	35	1400
Waveform OBR	5	70	350
Waveform OBX (25 samples/sec)	5	170	850
TOTAL			2780
Alarm OBR	5	70	350
Alarm OBX (5 / second)	5	160	800
TOTAL w/Alarms			3930

Not surprisingly a relatively high raw data rate of 57,600 bit rate would be required to communicate all this data. An optimization similar to the Ventilator example could be used if this is not possible.

	Quantity	**Size**	**Total**
MSH	1	25	70
PID	1	5	5
PV1	1	5	5
Parameter OBR	1	100	100
Parameter OBX (4 / second)	2	35	140
Waveform OBR	5	70	350
Waveform OBX (25 samples/sec)	5	170	850

TOTAL			1520
Alarm OBR	1	70	70
Alarm OBX (1 / second)	1	160	160
TOTAL w/Alarms			1750

Using these optimizations parameter and waveform data can be supported by a 9600 bit rate line, while alarm data can be supported by a 19,200 bit rate port.

9.3.4 Patient Monitor Example

The patient monitor can send a mix of parameters and alarms. No waveforms are sent in optimized mode, though it would seem that a few could be sent if required. We assume a maximum load of:

- 120 parameters
- 5 alarms
    - if more than 5 alarms are present, only 5 are sent every second with new alarms taking priority.

This information is reported every second.

	Quantity	Size	Total
MSH	1	25	70
PID	1	5	5
PV1	1	5	5
Parameter OBR	1	100	100
Parameter OBX (120 / second)	120	35	4200
TOTAL			4380
Alarm OBR	5	70	350
Alarm OBX (5 / second)	5	160	800
TOTAL w/Alarms			5530

As shown a bit rate of 115,200 would be required. As done previously the parameter and alarm data can be spread out over a number of seconds.

	Quantity	Size	Total
MSH	1	25	70
PID	1	5	5

PV1	1	5	5
Parameter OBR	1	100	100
Parameter OBX (12 / second)	12	35	420
TOTAL			600
Alarm OBR	1	70	70
Alarm OBX (1 / second)	1	160	160
TOTAL w/Alarms			830
Waveform OBR	10	35	350
Waveform OBX (25 samples/sec)	7	170	1190
Waveform OBX (200 samples/sec)	3	1045	3135
			5500

Using these optimizations the patient monitor export of parameters and alarms can be accomplished with a relatively moderate speed 19,200 baud port. If waveforms are also required a port speed of 115,200 is needed.

9.4 Summary

It is clear that with the optimizations considered in this white paper a wide variety of devices with varying export port baud rates can be easily accommodated. Adoption would increase the interoperability of medical devices with consuming systems such as EMRs, bedside integration systems and patient monitors.

10. Is OMS an IHE Profile?

10.1 Analysis of Proposed Optimizations

This White Paper proposes a large number of optimizations to reduce the size of messages. We need to consider whether these optimizations are "legal" within the constraints of HL7 and IHE PCD Technical Framework. If they are then we can treat OMS as a set of recommendations and leave it at that. If not, then OMS needs to be documented as a specific profile.

10.2 Key Optimizations

10.2.1 Optimized Time Synchronization

OMS devices cannot use CT as proposed by IHE so an alternative approach is proposed. While serial versions of NTP are available, the preferred approach is to use the ACK/NAK time-stamp for unsolicited implementations and the PCD-02 request time-stamp for solicited implementations.

10.2.2 Lower Layer Protocol

OMS devices will require a framing approach which is different from MLLP. We already support Web Services so LLP can be introduced as another option.

10.2.3 Message Interleaving

It can be seen from the previous section that not requiring all observations to be sent together is a powerful optimization. Unclear whether this is OK according to existing profiles.

10.2.4 Nomenclature

It is assumed that OMS devices will use the MDC nomenclature, and will only provide the MDC numeric code and not the RefID or Name of Coding System unless an alternative coding system is used. This convention is currently used by Continua devices.

10.2.5 PID and PV1 Usage

Currently we require providing some form of location or patient demographics information. To accommodate OMS we would have to loosen this requirement, without necessarily requiring a new profile.

10.2.6 OBR Optimizations

The Filler Order number and the Universal Service ID are required in only the first OBR segment in a message and optional in subsequent OBRs in a message.

10.2.7 Measurement OBX Optimizations

A number of "conventions" are proposed which may or may not be in conflict with the DEC profile:

- Time in the OBR is used as the default time of all observations unless a timestamp is included in the OBX segment itself, for intermittent measurements.
  - This is acceptable in HL7.
- If there are too many observations for a specific repeat interval then they can be spread out over multiple time intervals and messages.
- The Observation Sub-ID is not provided and is Empty

10.2.8 Waveform OBX Optimizations

A number of "conventions" are proposed for waveforms which may or may not be in conflict with the WCM profile:

- Waveforms will be buffered and sent every second.
- A variable number of waveform attribute OBXs can be sent every second per waveform, therefore it may take up to 20 seconds to see all the attributes`.
- Waveform content is not available in Solicited Mode

10.2.9 Alert OBX Optimizations

A number of "conventions" are proposed for alerts which may or may not be in conflict with the ACM profile:

- The number of alarms/alerts sent at the same time may need to be throttled and spread out over a number of seconds.