The AHD shall use ‘consistent time’ for MSH-7, OBR-7, OBR-8 and OBX-14. ‘Consistent time’ is based on a known reference time source such as NTP or similar service and must include a valid time zone offset relative to UTC.\(^1\) \(^2\)

<table>
<thead>
<tr>
<th>Msg Segment</th>
<th>Description and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSH..........</td>
<td>MSH-7 Date/Time of Message created/sent (DTM(_m), required) M</td>
</tr>
<tr>
<td>PID..........</td>
<td>M</td>
</tr>
<tr>
<td>OBR..........</td>
<td>(OBR-7, OBR-8) Default time interval for child OBXs (DTM(_m), required) M</td>
</tr>
<tr>
<td>OBX. 0.0.1</td>
<td>MDC_ATTR_TIME_ACCURACY (known or estimated accuracy of AHD time) O</td>
</tr>
<tr>
<td>OBX. 1</td>
<td>MDS for device #1 M</td>
</tr>
<tr>
<td>OBX. 1.0.1</td>
<td>MDC_ATTR_TIME_CAP_STATE (BITS-16, using MdsTimeCapState) O</td>
</tr>
<tr>
<td>OBX. 1.0.3</td>
<td>MDC_ATTR_TIME_ACCURACY (device absolute time accuracy) O</td>
</tr>
<tr>
<td>OBX. 1.0.4</td>
<td>MDC_ATTR_TIME_ABS (displayed time and OBX-14 DTM(_m), required) O</td>
</tr>
<tr>
<td>OBX. 1.0.5</td>
<td>MDC_ATTR_TIME_REL (relative time and OBX-14 DTM(_m), required) O</td>
</tr>
<tr>
<td>OBX. 1.0.6</td>
<td>OBX-14 (DTM(_m), optional, overrides default (OBR-7, OBR-8) time interval) O</td>
</tr>
<tr>
<td>OBX. 1.0.9.2</td>
<td>OBX-14 (DTM(_m), optional, overrides default, can be at any level in OBX-4 hierarchy) O</td>
</tr>
<tr>
<td>OBX. 0.0.0.0</td>
<td>OBX-7, OBR-8 Default time interval for child OBXs (DTM(_m), required) M</td>
</tr>
<tr>
<td>OBX. 2</td>
<td>MDS for device #2 M</td>
</tr>
<tr>
<td>OBX. 2.0.1</td>
<td>MDC_TIME_CAP_STATE O</td>
</tr>
<tr>
<td>OBX. 2.0.2</td>
<td>MDC_ATTR_TIME_ACCURACY O</td>
</tr>
<tr>
<td>OBX. 2.0.3</td>
<td>MDC_ATTR_TIME_ABS O</td>
</tr>
<tr>
<td>OBX. 2.0.4</td>
<td>OBX-14</td>
</tr>
<tr>
<td>OBX. 2.0.1.1</td>
<td>OBX-14</td>
</tr>
<tr>
<td>OBX. 2.0.1.2</td>
<td>OBX-14</td>
</tr>
<tr>
<td>OBX. 2.0.1.3</td>
<td>OBX-14</td>
</tr>
<tr>
<td>OBX. 3</td>
<td>MDS for device #3 (no time info =&gt; timestamps are unsynchronized) M</td>
</tr>
<tr>
<td>OBX. 3.0.0.1</td>
<td>OBX-14</td>
</tr>
<tr>
<td>OBX. 3.0.0.2</td>
<td>OBX-14</td>
</tr>
</tbody>
</table>

Notes:

a. DTM\(_m\) is the HL7 V2.6 ‘date/time’ formatted as YYYY[MM][DD][HH][MM][SS][SS][SS][SS]]][+/−ZZZZ]. A timestamp resolution of at least one second and a time zone offset are required for ‘consistent time’, e.g. YYYYMMDDHHMMSS[SS][SS][SS][SS] [+/−ZZZZ] (required items in bold font).

b. Within the time scope of each OBR, time discontinuities in the MDC_ATTR_TIME_ABS displayed time are prohibited. Discontinuities due to daylight savings or other clock adjustments require that data on the new displayed timeline be sent as a separate OBR.

c. The OBR establishes the default time context for all its child OBXs, and may be overridden by a timestamp in OBX-14.

\(^1\) Consistent time is also isochronous; it does not exhibit discontinuities such as daylight savings transitions or other user or clinician adjustments. UTC+timeZoneOffset has this property, and relative and hi-res relative time can also be considered isochronous within the context of the device association.

\(^2\) As a consequence, the AHD and WAN-Device-Recevier must support a time protocol such as NTP or equivalent.

\(^3\) The OBX-4 ‘dotted-values’ shown here are shown here as informative examples.
d. The time interval specified by (OBR-7, OBR-8) is a mathematically 'closed' interval for OBR-7 and 'open' for OBR-8. A datum that occurs exactly at the time specified by OBR-8 would be sent in the next time epoch.
Discussion

The key idea is that the HL7 timestamps sent in MSH-7, OBR-7, OBR-8 and OBX-14 must use ‘consistent time’ based on NTP or other reference time source that provides traceability to NTP. As a consequence, the AHD itself must support synchronized time as an NTP or SNTP (or other time service) client so that it (1) can apply consistent time stamps to the data reported over the WAN interface and (2) provide a time synchronization service to the agents connected to it [ideally, the agents would synchronize their clocks to an S/NTP-like service provide by the AHD.]

The MDC_ATTR_TIME_ABS (in OBX-3) provides traceability between the displayed time shown on the device (as a DTM datatype in OBX-5) and the consistent time is reported in OBX-14. [Using an OBX to report this as an observation of the time correlation is much simpler than attempting to use other HL7 V2 message segments such as TQ1 or TQ2, which are intended more for scheduling and expressing periodic time points.]

The MDC_ATTR_TIME_REL or MDC_ATTR_TIME_HI_RES timestamps (in OBX-3) provide traceability between the relative and hi-res relative values, reported as an integer value in OBX-5, and the corresponding consistent time reported in OBX-14. By convention, the time counts are initially cleared during association (although that doesn’t matter, especially when we extract data subsets of an ongoing stream later on). The units-of-measure are μs or ms, expressed MDC units for PHD and MDC or UCUM units for PCD.

**AHD Absolute Timestamp Accuracy**

Absolute timestamp ‘accuracy’ may be reported by the MDC_ATTR_TIME_ACCURACY as a child FACET OBX of the MDC_ATTR_TIME_ABS METRIC OBX if the agent’s clock has been synchronized by the Internet ‘Network Time Protocol’ (RFC-1305), ‘Simple Network Time Protocol’ (RFC-2030), the HL7 v2.4 ‘NCK’ system clock segment, or other time synchronization protocol or method that is ultimately traceable to UTC. Estimated values for accuracy may be reported in cases where the agent had acquired and stored data while disconnected from a time synchronization source.

The NTP timestamp accuracy can be estimated from the NTP variables = root dispersion + ½ root delay plus the cumulative clock drift (typically 100 ppm times the elapsed time since the agent had last synchronized to NTP). For other absolute time distribution protocols (e.g. cell phone) other methods may be used (and are currently beyond the scope of this document).

Timestamp accuracy shall not be reported if the agent clock has not been synchronized, as devices may rely on this value to determine whether they should update their own clocks and to otherwise qualify the accuracy of its time stamps. Timestamp accuracy does not include the communication latency between the AHD and the timeserver; it only specifies the known accuracy of the AHD’s time stamp relative to a primary reference clock source.

**Example:**

OBX|3|DTM|67984^MDC_ATTR_TIME_STAMP_ABS^MDC|1.0.0.1|20091028123702+0000|||ACDE5432567ABC^EUI-64 (agent identifier)

OBX|4|NM|TBD^MDC_ATTR_TIME_ACCURACY^MDC|1.0.0.1.1|264320^MDC_DIM_SEC^MDC||||GPS^RFC-2030 (absolute reference clock source identifier)

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The value of the absolute reference clock identifier reported in OBX-18 shall be the four byte code reported in the SNTP or NTP timestamp provided to the agent by the AHD that it had last synchronized to. Any non-null four letter code reported in OBX-18 except those listed below indicate a synchronized time source, using the codes and conventions specified by RFC-1305 or RFC-2030, identified as ‘RFC-1305’ or ‘RFC-2030’ in OBX-18.2.

<table>
<thead>
<tr>
<th>OBX-18</th>
<th>Non-synchronized agent clock</th>
<th>Default Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCL^RFC-2030</td>
<td>An uncalibrated and unsynchronized local clock source</td>
<td>± 300 s (5 min)</td>
</tr>
<tr>
<td>EBWW</td>
<td>The agent time has been set manually by the eyeball-and-wristwatch method</td>
<td>± 120 s (2 min)</td>
</tr>
<tr>
<td>NTP^RFC-1305</td>
<td>Network Time Protocol (version unknown)</td>
<td>calculate</td>
</tr>
<tr>
<td>NTP^RFC-1769</td>
<td>Network Time Protocol (RFC-1305)</td>
<td>calculate</td>
</tr>
<tr>
<td>NTP^RFC-2030</td>
<td>Network Time Protocol v3 (RFC-1769)</td>
<td>calculate</td>
</tr>
<tr>
<td>NCK^HL7-V2</td>
<td>HL7 V2 ‘NCK’ System Clock Segment in NMD message</td>
<td>± 5 s / -0 s</td>
</tr>
<tr>
<td>GPS^RFC-2030</td>
<td>Global Positioning Service</td>
<td></td>
</tr>
<tr>
<td>CELL</td>
<td>or GSM, CDMA, ...</td>
<td></td>
</tr>
</tbody>
</table>

If the timestamp reported by the MDC_ATTR_TIME_STAMP_ABS OBX is not synchronized, OBX-8 shall contain the code ‘LOCL’ or ‘EBWW’. If the timestamp is traceable to a time reference source, OBX-8 shall be empty.

Relative and Hi-Res Timestamp Accuracy

Relative and hi-res timestamp ‘accuracy’ may be reported as the child FACET of the MDC_ATTR_TIME_REL and MDC_ATTR_TIME_HI_RES OBX if it is known. The MDC_ATTR_TIME_ACCURACY attribute should specify the hi-res reference clock source identifier to provide traceability for all agents connected to the same clock distribution tree.11

Example:

```
OBX|3|DTM|67984^MDC_ATTR_TIME_STAMP_HI_RES^MDC|1.0.0.3|20091028123702+0000| | | | | | ACDE48234567ABCD^EUI-64 (agent identifier) 
OBX|4|NM|TBD^MDC_ATTR_TIME_ACCURACY^MDC|1.0.0.3.1|0.8|264338^MDC_DIM_MILLI_SEC^MDC| | | | | | ACDE766544ABCD^EUI-64 (hi-res reference clock source identifier, e.g. Bluetooth piconet) 
```

7 In OBX-18, the second subfield specifies the vocabulary for the term
8 The current prototype draft for NTPv4 defines ‘Kiss of Death’ codes. Due to the uncertain implementation status, these should be replaced by ‘LOCL’. Contact David Mills?
9 The ‘EBWW’ code was defined in ISO/IEEE 11073-30200. Consider using ‘LOCL’ instead?
10 NTP and SNTP define additional four-letter codes that can be used, including user-defined codes, as long as they denote a time synchronization source that is traceable to UTC time. Also, NTP and SNTP report the four octet IP address of the server for stratum 2 and higher servers, and in this case the IP address or the code NTP or SNTP should be specified in OBX-18.
11 That is, the 2-tuple OBX-18.1 and OBX-18.2 in MDC_ATTR_TIME_ACCURACY discloses the common synchronization node for applications that require precise time synchronization between multiple agents.
DEFERRED ITEMS

1. Additional optional OBX specifying date-time that AHD received data from agent? Is there a REFID?

2. Time synchronization service provided by AHD to devices - can we standardize on at least one service that every device can count on when they are connected to an AHD?

3. Provide further guidance and simplification of clock identifier node identification in OBX-18?

4. Include an explicit synchronization boolean flag as a simpler (but less informative) alternative to reporting MDC_ATTR_TIME_ACCURACY? That is, can we further simplify and align this proposal with -20601 without limiting the ability of an agent and AHD to fully disclose its clock synchronization status if the agent and/or AHD has direct access to an NTP, GPS, cell, or other time reference that is independent of -20601?

[An excerpt from -20601 is attached on the following page.]

Todd:

Why not use ‘AbsoluteRelativeTimeSync’
Background Information from -20601

UuidIdent ::= OCTET STRING(SIZE(16))

-- time-sync-accuracy allows an agent to report how closely synchronized its clock is with
-- respect to the clock sync master when time synchronization is used.
MdsTimeInfo ::= SEQUENCE {
    mds-time-cap-state MdsTimeCapState,
    time-sync-protocol TimeProtocolId, -- this is a nomenclature code from
        -- nom-part-infrastruct partition
    time-sync-accuracy RelativeTime, -- 0xFFFFFFFF if unknown
        -- 0 if better than 1/8 ms
    time-resolution-abs-time INT-U16,-- Resolution of the agent’s
        -- absolute time clock.
        -- 0 if unknown; otherwise,
        -- the number of 1/100 s
        -- that elapse with each clock
        -- increment. For example, if an
        -- agent has a clock that clicks at
        -- 1 s intervals, this value
        -- would be 100.
    time-resolution-rel-time INT-U16,-- Resolution of the agent’s
        -- relative time clock. 0 if
        -- unknown; otherwise, the number
        -- of 125 μs that elapse
        -- with each clock increment. For
        -- example, if an agent has a clock
        -- that clicks at 1 s intervals,
        -- this value would be 8000.
    time-resolution-high-res-time INT-U32 -- Resolution of the agent’s
        -- high-resolution time clock.
        -- 0 if unknown; otherwise, the
        -- number of microseconds
        -- that elapse with each clock
        -- increment. For example, if an
        -- agent has a clock that clicks
        -- at 1 s intervals, this value
        -- would be 1 000 000.
}

-- All unassigned " MdsTimeCapState " bit values are reserved for future expansion and shall be set to zero.
MdsTimeCapState ::= BITS-16 {
    mds-time-capab-real-time-clock(0), -- device supports an internal RTC
    mds-time-capab-set-clock(1), -- device supports Set Time Action
    mds-time-capab-relative-time(2), -- device supports RelativeTime
    mds-time-capab-high-res-relative-time(3), -- device supports HiResRelativeTime
    mds-time-capab-sync-abs-time(4), -- device syncs AbsoluteTime
    mds-time-capab-sync-rel-time(5), -- device syncs RelativeTime
    mds-time-capab-sync-hi-res-relative-time(6), -- device syncs HiResRelativeTime
    mds-time-state-abs-time-synced(8), -- AbsoluteTime is synced
    mds-time-state-rel-time-synced(9), -- RelativeTime is synced
    mds-time-state-hi-res-relative-time-synced(10), -- HiResRelativeTime is synced
    mds-time-mgr-set-time(11) -- manager is encouraged to set the time
}