

Infusion Pumps on Hospital Networks

Evaluation and wireless test criteria, with scoring

Daniel Pettus. Version 1.0, 29 August 2026. Supersedes version 0.9 DRAFT, 1 January 2020. Open access. Vendor neutral.

Why this version exists

Version 0.9 scored pump network integration. It did not test anything. It asked a vendor what their device could do and scored the answer.

This version adds the other half: **a wireless test protocol that measures what the fleet actually does on the network it will actually live on.** The test schema is not new. It was published in 2008 and it was sound. What has changed is every piece of equipment used to run it, every wireless standard it measured, and the regulatory ground underneath all of it.

The scoring criteria and the test protocol are now in one document because they are one question. A capability a vendor claims and a capability you have measured are different things, and the second is the only one worth funding.

1. What has changed since January 2020, and it is more than the radios

Three items should change how anyone reads a wireless requirement written before this year.

The only international standard specifically about wireless medical device networks no longer exists.

IEC/TR 80001-2-3:2012, *Application of risk management for IT-networks incorporating medical devices, Part 2-3: Guidance for wireless networks*, was **withdrawn on 5 March 2024**. Nothing replaced it. IEC 80001-1:2021 Edition 2 restructured the series around general risk management and did not carry the wireless technical content forward. The audience that document was written for, hospital IT, biomedical engineering and clinical risk, now has no wireless-specific international guidance at all.

The governing FDA guidance was issued thirteen years ago. *Radio Frequency Wireless Technology in Medical Devices*, docket FDA-2006-D-0300, **August 2013**. Its FDA page has not been substantively updated since **30 August 2018**. It is still Final and it is still what a submission is measured against.

FIPS 140-2 ends in three weeks. Every FIPS 140-2 certificate in existence moves to the Historical List on **22 September 2026**. The CMVP stopped accepting new 140-2 submissions on 1 April 2022. Any procurement document that says "FIPS 140-2 validated," including version 0.9 of this one, is now specifying a validation that no longer supports new federal acquisition.

The pattern is worth stating plainly, because it explains why this document has to specify testing rather than cite a standard:

	Date
Reference wireless test methodology published	2008
IEC/TR 80001-2-3 published	July 2012

	Date
FDA RF wireless guidance issued	August 2013
802.11ac published	December 2013
FDA wireless guidance page last updated	August 2018
802.11ax published	February 2021
IEC/TR 80001-2-3 withdrawn, no successor	5 March 2024
802.11be published	22 July 2025
FIPS 140-2 certificates go Historical	22 September 2026

The standards governing wireless medical devices have stood still while everything they govern was replaced twice. In the absence of a current standard, a buyer's only defense is a test protocol and a score.

2. Method

Each criterion carries a point value weighted by the author's judgement and experience. Total the scores to compare vendors and devices. **Do not rely on this document alone.** Use it as the foundation for an evaluation, not as the evaluation.

Sections A through D are claims. They are answered by the vendor from a datasheet. **Section E is measurement.** It is answered by running a test. Where a Section E measurement contradicts a Section A to D claim, **the measurement wins and the claim scores zero.**

The term "pump" means any infusion modality: large volume, syringe, PCA and others. The criteria for successful network implementation are substantially the same across modalities. All criteria assume the device supports wireless connectivity.

Open access, crowdsourced

Other practitioners are encouraged to modify this document, add criteria and share the result. Corrections are more welcome than compliments.

Device under evaluation

Pump vendor	
Model number	
Modality	LVP / Syringe / PCA / Other
Server or gateway version	

Radio module make, model, firmware	
Evaluation date	
Total score	_____ of 217

3. Section A. Pump technology design and architecture

Maximum 24 points.

Criterion	Points	Notes
Separate and isolated pump processor and communications controller	2	Isolating the infusion processing subsystem from network connectivity helps maintain current-state infusion status through a communications breach or network fault
Number of network ports required to operate the pump	1 port = 2, 2 ports = 1, more than 2 = 0	Fewer ports simplifies maintenance and narrows the attack surface
Telnet, FTP and other unnecessary services disabled	1	Disabling unused operating system functions is basic hardening
Operating system and application firmware updated remotely over wireless	3	Review the vendor's actual workflow, not the claim. Ask how many devices can update concurrently and what happens to a device infusing at the time
Network credentials including certificates provisioned remotely over wireless	3	Weighted heavily on purpose. See Section E-8. Certificate rotation across a fleet of hundreds is the single most under-planned lifecycle task in wireless medical devices
Supports all current hospital Wi-Fi generations, 802.11a/g/n/ac/ax	1	Baseline. See Section B for the standards that now matter
Architecture can support cellular LTE or 5G	Available now = 2, future upgrade = 1	Protects the investment and provides a path independent of hospital RF
Vendor can connect remotely for diagnostics and repair	1	Partnership on problem resolution. Confirm the access path and who audits it

Criterion	Points	Notes
Battery life of 3 hours or more with wireless fully enabled	2	Patients are encouraged to ambulate. On multi-channel devices the minimum still applies. Verify by measurement, Section E-6
Pump publishes IP and MAC address to hospital IT, from device, server or gateway	2	Enables basic location and inventory correlation, with limits
Communications protocol published	3	The payload may be encrypted or proprietary. The handshaking protocol should be published so the hospital can manage, monitor and secure the device with its own tooling rather than the vendor's
Updated drug library downloads wirelessly while infusing	2	Avoids stopping therapy to update safety limits

Note on the published-protocol criterion. This is worth three points because it is the difference between a device a hospital can operate and a device a hospital must host. A vendor is entitled to protect a payload format. A vendor who will not describe how the connection is established, maintained and torn down is asking the hospital to accept an unobservable component on a clinical network.

4. Section B. Wireless capability

Maximum 29 points. This section is new in version 1.0.

Version 0.9 asked whether the pump supported 802.11 a/g/n/ac/ax as a single one-point question and gave a point for 60 GHz. That framing is now backwards. The generation number matters far less than four specific mechanisms, and one of them is worth more than all the rest for a fleet of battery-powered devices sending small payloads.

B-1. Radio and band

Criterion	Points	Notes
5 GHz operation supported and preferred by default	2	2.4 GHz has three non-overlapping 20 MHz channels in the US and shares spectrum with Bluetooth, microwave ovens and ISM equipment. Multiple hospital standards now require 5 GHz for clinical systems
6 GHz supported, Wi-Fi 6E or Wi-Fi 7	3	6 GHz adds 59 additional 20 MHz channels in the US. The classic three-channel constraint that shaped every hospital wireless design since 2003 does not exist in this band
802.11ax (Wi-Fi 6) or later	3	Required to obtain OFDMA and TWT below

Criterion	Points	Notes
802.11be (Wi-Fi 7)	1	Published 22 July 2025. Useful headroom, not yet a requirement
Dual-band concurrent or band-steering aware	1	The device should not camp on 2.4 GHz because it saw it first

B-2. The four mechanisms that actually matter

Criterion	Points	Notes
OFDMA support, uplink and downlink	5	The highest-value single item in this section. A pump sending a 200-byte keep-alive on 802.11n or ac seizes the entire channel for the duration of the frame. Hundreds of pumps doing that is a contention problem, not a bandwidth problem. OFDMA subdivides a channel into resource units, the smallest being 26 subcarriers or about 2 MHz, so nine clients can be served in a single transmission opportunity on one 20 MHz channel . This is the direct technical answer to the traffic pattern a pump fleet creates
Target Wake Time (TWT) negotiated with the AP	3	Lets the device and AP agree exactly when the radio wakes. Requires support at both ends; an AP with TWT and a pump without it yields nothing. Score the claim here, then verify by measurement in Section E-6, because the published evidence is not what the datasheets imply. See the note below
802.11r Fast BSS Transition	4	The largest measurable difference in this document. Full 802.1X re-authentication on roam takes 120 ms to a couple of seconds. 802.11r Fast Transition takes 4 to 50 ms. That is two orders of magnitude, and during the long version a mobile pump has no path to its server
802.11k Radio Resource Measurement	2	Neighbour reports let the client choose a roam target without a full scan
802.11v BSS Transition Management	2	Lets the infrastructure steer a client off a congested or failing AP, and carries the maximum idle period used for power save
BSS Coloring and OBSS-PD	2	Two benefits, and the second is usually overlooked. The device stops deferring unnecessarily to foreign traffic, and it can discard a foreign frame from the PHY header without demodulating it, which is a direct battery saving

Criterion	Points	Notes
MU-MIMO	1	Only one point, deliberately. MU-MIMO needs multiple spatial streams and beamforming feedback. Most pumps are 1x1 or 2x2 devices. It is far less relevant to a pump fleet than OFDMA, and a vendor leading with it is selling the wrong feature

B-3. Honest note on Target Wake Time

TWT is marketed as a battery-life feature and it may well be one. But the first published measurement study of TWT on commercial off-the-shelf hardware, presented at IEEE ICC 2023, measured **increased** power consumption in three of four scenarios: 6.5% more in standby, 19% more during video streaming, 20% more during gaming, with only live video chat showing a 14% saving. The authors attribute this to fixed, non-adaptive wake intervals that do not match application behavior, plus the overhead of the TWT management frames themselves.

Those were consumer phones and consumer routers, not enterprise APs with broadcast TWT and not purpose-built low-power device silicon. It does not prove TWT cannot save power on a pump.

It does prove that "supports TWT" on a datasheet is not evidence of anything on your fleet. Score the capability here. Require the measurement in Section E-6.

5. Section C. Wireless performance requirements

Maximum 25 points. This section is new in version 1.0.

These are the numbers a vendor should be willing to put in writing, and the numbers Section E measures. Where no published consensus exists, that is stated rather than papered over.

Criterion	Points	Notes
Vendor publishes a maximum roam time and it is 50 ms or less	4	There is no published consensus standard setting an acceptable roam time for medical devices. The most-cited hospital wireless standard asks the vendor for the number rather than setting one. In that absence, the defensible requirement is the measured 802.11r range of 4 to 50 ms
Vendor states the maximum tolerable link-loss interval before the device declares a communications fault	3	This is the number nobody asks for and everybody needs. It determines whether a five-second RF dropout is invisible or generates a clinical alarm
Vendor publishes minimum RSSI and SNR for reliable operation	3	Required to design coverage. A vendor who cannot state these has not characterized the device

Criterion	Points	Notes
End-to-end latency, device to server, 200 ms or less	2	Aligns with the most widely cited hospital clinical wireless standard
Keep-alive interval is configurable and the range is published	3	A fixed keep-alive is a fleet-wide bandwidth decision made by the vendor. The 2008 reference implementation was configurable from 0.5 to 60 seconds with a 30-second default, and sent a keep-alive only when no other traffic had passed in the interval. That remains the right design and it is still not universal
Aggregate steady-state bandwidth per channel, all online devices	Under 20 KB/min = 3, 20 to 40 = 2, 40 to 60 = 1, over 60 = 0	Measured, not claimed. See Section E-3
Offline store and forward at the device	Over 12 h = 5, 6 to 12 h = 4, 3 to 6 h = 3, under 3 h = 0	The device's ability to retain transactional data through a network outage and resynchronize automatically when it returns. Unchanged from version 0.9 and still the most important single resilience criterion in the document
Multiple infusion channels or modalities carried on a single radio association	4 or more = 2, 2 to 3 = 1, 1 = 0	A multi-channel device that opens one association per channel multiplies its RF footprint by the channel count

6. Section D. Pump server and gateway

Maximum 42 points. Carried forward from version 0.9 with two additions.

Criterion	Points	Notes
Server or gateway deployed in the cloud or on premises	Cloud = 5, on premises = 0	Cloud deployment is the direction of the market. Score reflects the maintenance and update burden the hospital absorbs otherwise
Concurrent connected channels per single server	Over 10,000 = 3, under = 0	A single deployment keeps transactional and analytic data in one environment
Fault-tolerant failover	Active/active = 5, passive/active = 4, offline recovery = 1, none = 0	Pump integration with the EHR is now a clinical dependency. A single point of failure needs to fail over gracefully and quickly

Criterion	Points	Notes
Supports Production, Pre-Production, Test and Training environments concurrently	Multiple = 1, single = 0	Allows training and pre-deployment testing without taking production down
Active Directory or LDAP compliant	1	Server administration should use the hospital's own authentication
Deployable in the existing hospital domain or a separate domain	1	Flexibility to match hospital IT policy
Vendor can connect remotely for diagnostics and repair	1	Confirm the access path and the audit trail
Patching within hospital policy: ordinary patches within 30 days, emergency within 48 hours	2	The vendor may need to validate patches for regulatory reasons. Distribution delay is a different problem and should not hide behind that
Operating system, database and application updated remotely	3	Currency with minimal disruption
Hospital has access to server transactional data, by interface or direct database access	2	Hospitals increasingly require device data in an enterprise repository
Single platform supports multiple hospital infrastructures	3	Common in integrated delivery networks. Reduces complexity and consolidates security
On-premises virtual deployment	Any hypervisor = 3, two = 2, one = 1, none = 0	Ability to meet the hospital's virtualization requirements
Server offline store and forward	Over 12 h = 5, 6 to 12 h = 4, 3 to 6 h = 3, under 3 h = 0	The server side of the same resilience question
Gateway interface throughput	Over 4,000 msg/min = 3, 3,000 to 4,000 = 2, 2,000 to 3,000 = 1, under 2,000 = 0	Must keep pace with the EHR interface under peak load
NEW. Server timestamps are NTP synchronized and the source is documented	2	Event ordering across a fleet is meaningless without it. A stream that says the rate changed before the infusion started is a clock problem, not a device problem
NEW. Server exposes its own health and connection state to hospital monitoring	2	The hospital should learn a gateway is down from its own monitoring, not from a nurse

7. Section E. Wireless test protocol

Maximum 40 points. This section is entirely new in version 1.0 and is the reason for it.

Sections A through D are claims. This section is measurement.

The methodology, and its provenance

The test schema below is adapted from *Wireless Network Considerations: The Alaris PC Unit*, Todd C. Nessen, Cardinal Health 2008, revised under CareFusion. It is cited because it is the published origin of this approach and because it remains, in the author's judgement, the soundest public description of how to measure a large infusion fleet's real footprint on a hospital network. **The criteria below are deliberately vendor neutral.** Where the original describes a specific proprietary implementation, this document specifies the capability instead.

The original method, which is the part that has aged well:

1. Capture real wireless traffic in **operating patient care areas with devices in patient use**, not only in a lab.
2. Capture at **three or more sites with different physical and network configurations**, plus one controlled lab environment.
3. Capture **all** traffic reaching the analyzer, then post-filter to the strongest signals to isolate the local access points and the devices associated with them.
4. Measure over **a full 24-hour cycle**, because the traffic pattern is not uniform.
5. Measure **three distinct traffic classes separately**: steady-state keep-alive, peak file transfer such as a drug library push, and event traffic.

That structure is still correct. What has been replaced is the equipment, the standards being measured, and the assumption that bandwidth is the interesting variable.

What has replaced the 2008 equipment

2008	2026
AirMagnet v7.5 Laptop Wireless Network Analyzer	AirMagnet WiFi Analyzer PRO and Spectrum XT reached end of support 31 December 2025. The product line passed from AirMagnet to Fluke Networks (2009) to NETSCOUT (2015) to NetAlly (2019)
	NetAlly: AirCheck G3 Pro, EtherScope nXG, CyberScope for handheld validation and portable capture
	Ekhau: Sidekick 2 with AI Pro for survey, spectrum and validation. Verify current Wi-Fi 7 support directly with the vendor before specifying it
	Wireshark with a monitor-mode adapter for frame-level analysis. Note the practical limitation: capturing encrypted enterprise traffic requires the session keys, so plan capture points accordingly
802.11b/g, three non-overlapping channels	802.11ax and be, plus 6 GHz with 59 additional 20 MHz channels in the US

2008	2026
WEP, WPA, WPA2	WPA3-Enterprise, mandatory on 6 GHz
FIPS 140-2	FIPS 140-3. 140-2 certificates go Historical 22 September 2026

The tests

Test	Points	What to measure and what good looks like
E-1. Site survey before deployment	4	Predictive plan plus a validation survey of every patient care area where pumps will operate. Record RSSI, SNR, channel utilization and co-channel interference at pump height, not at laptop height on a cart. Pumps live at 1 metre next to a metal bed frame and a human body
E-2. Keep-alive footprint, steady state	4	Capture 24 hours in an operating patient care area. Report bytes per second per device and aggregate per access point. The 2008 reference measured 3 to 4 bytes per second per device. Any modern device materially above that should explain why
E-3. Aggregate bandwidth at realistic density	4	Scale to the actual planned fleet. Report aggregate kilobytes per minute per access point and per channel. Score against the Section C threshold
E-4. Peak transfer, drug library push	4	Push a full library update to the largest group that will ever receive one simultaneously. Measure duration, peak bytes per second, and the effect on other clients on the same AP. Verify that a device infusing at the time completes the update without interrupting therapy
E-5. Roam time under load	5	Walk a device between access points on a defined route, twenty transitions minimum, while the pump is infusing and reporting. Measure time from last frame on the old AP to first data frame on the new one. Requirement: 50 ms or less. Report the distribution, not the mean. One two-second roam matters more than nineteen fast ones
E-6. Battery life under the negotiated wireless configuration	5	Measure runtime to shutdown with wireless enabled, associated, and reporting at production intervals, on the actual security configuration. If the vendor claims TWT, measure with TWT negotiated and again with it disabled, and report both. See Section B-3

Test	Points	What to measure and what good looks like
E-7. Network fault and recovery	5	Disconnect the fleet from the network for the vendor's claimed store-and-forward duration. Verify no data loss, automatic resynchronization, correct event ordering after recovery, and that no device required manual intervention. Then do it again at 150% of the claimed duration and record what is lost
E-8. Certificate and credential lifecycle	5	Rotate certificates across the entire test fleet remotely. Measure elapsed time, failure count, number of devices requiring physical touch, and whether any device dropped its association during infusion. This is the criterion most likely to be failed by a device that scores well everywhere else
E-9. Coexistence and interference	2	Verify operation with the RF sources actually present: other medical telemetry, ultrasound, electrosurgery, staff and patient devices. ANSI C63.27-2021 <i>Evaluation of Wireless Coexistence</i> and AAMI TIR69:2017/(R)2020 provide the framework
E-10. Repeat at 12 months	2	The hospital RF environment changes continuously. A deployment validated once and never re-measured is a deployment nobody understands. Re-run E-2, E-3 and E-5 annually

8. Section F. Interoperability

Maximum 57 points as scored. See the note below.

Criterion	Points	Notes
IHE Devices profile support	PCD-01 = 2, PCD-10 = 2, PCD-03 = 5, PCD-04 = 3, PCD-05 = 3	Sum for a subtotal. Ask which Technical Framework revision and which options. A profile named without a transaction number or an options column is a claim, not a statement of conformance
CPOE IV order synchronization to the pump safety library for PCD-03 auto-programming, including multi-ingredient and secondary orders	4	IV orders are complex. A mismatch between the CPOE order and the pump library exposes gaps and defeats the safety limits auto-programming is supposed to preserve

Criterion	Points	Notes
Supports multiple EHR hosts, same or different vendors, on one unified platform	Different vendors = 5, same vendor multiple = 3, single = 0	Common in integrated delivery networks
Commercially available bi-directional auto-programming, in production, per EHR vendor	7 each	Sum for a subtotal. Require a named reference site, not a capability statement
Commercially available alarm management, PCD-04 and PCD-05, per vendor	6 each	Sum for a subtotal

9. Score summary

Section	Maximum	Score
A. Pump technology design and architecture	24	
B. Wireless capability	29	
C. Wireless performance requirements	25	
D. Pump server and gateway	42	
E. Wireless test protocol (measured)	40	
F. Interoperability	57	
Total	217	

A scoring flaw carried over from version 0.9, which you should decide about

Three criteria in Section F instruct the evaluator to **sum a point value per vendor**: 7 points for each EHR with production auto-programming, and 6 points for each alarm management vendor. Those sums are **unbounded**. A pump vendor integrated with five EHRs and three alarm platforms scores 53 points from two rows, which is more than all of Section E.

The effect is that **market presence outscores measured performance**. For a purchasing hospital that may be the right weighting, because an integration that already exists is worth more than one that is possible. For a research evaluation it is almost certainly wrong.

The maximum of 57 above assumes 3 EHR vendors and 2 alarm vendors. **I have not changed the scoring, because it is yours and the choice is a real one.** Two options if you want it changed: cap each sum at a stated maximum, or move both rows to a separate "market presence" subtotal reported alongside the technical score rather than inside it.

Read Section E first when comparing two vendors. A device scoring 130 on claims and 12 on measurement is a worse choice than one scoring 100 on claims and 34 on measurement, and the first one will be the better demonstration.

10. Sources

Methodology origin. Nessen, Todd C. *Wireless Network Considerations: The Alaris PC Unit*. Cardinal Health, 2008; revised under CareFusion, R3. Test schema, three-hospital plus lab design, and the keep-alive and peak-transfer measurement approach.

Wireless standards and mechanisms. IEEE 802.11ax published February 2021; 802.11be published 22 July 2025; 802.11k, 802.11r and 802.11v incorporated in 802.11-2012. Roam-time figures from Cisco Catalyst 9800 enterprise WLAN roaming documentation: full 802.1X re-authentication 120 ms to a couple of seconds; 802.11r Fast Transition 4 to 50 ms. OFDMA resource-unit behavior and BSS coloring OBSS-PD from Cisco Meraki Wi-Fi 6 technical documentation.

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Medical device wireless standards. IEC/TR 80001-2-3:2012, *Guidance for wireless networks*, withdrawn 5 March 2024. IEC 80001-1:2021 Edition 2, September 2021. IEC 60601-1-2:2014+AMD1:2020 CSV Edition 4.1, 1 September 2020. ANSI/USEMCS C63.27-2021. AAMI TIR69:2017/(R)2020.

Regulatory. FDA, *Radio Frequency Wireless Technology in Medical Devices*, docket FDA-2006-D-0300, August 2013, Final, page content current as of 30 August 2018. NIST SP 1800-8, *Securing Wireless Infusion Pumps in Healthcare Delivery Organizations*, final 17 August 2018. NIST CSRC FIPS 140-3 Transition Effort: FIPS 140-2 certificates placed on the Historical List 22 September 2026.

Hospital wireless practice. Johns Hopkins, *Clinical Wireless Device Standards*, original November 2011, revisions approved May 2018. Philips, *Networking IntelliVue Patient Monitors* technical data sheet, PN 4522 962 90231, November 2012.

11. Items requiring verification before this document is used in procurement

Stated plainly, because a criteria document that hides its own gaps is worse than no document.

- **Ekahau AI Pro and Sidekick 2 support for Wi-Fi 7 (802.11be) is not confirmed** from a primary source. Published datasheets reference Wi-Fi 6E. Confirm directly with the vendor before naming a required tool.
 - **AirCheck G3 versus G3 Pro** differentiation and current pricing were not obtained.
 - **No published consensus standard sets an acceptable roam time for medical devices.** The 50 ms requirement in Section C is this author's position, derived from measured 802.11r performance, not a citation.
 - The **aggregate bandwidth thresholds** in Section C are carried forward from version 0.9 and reflect 2020 fleet assumptions. They should be re-derived against a modern fleet size.
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Daniel Pettus. Forty years in medical device and health IT. Contributor to IHE Patient Care Device interoperability standards. This document is offered open access and vendor neutral. The author has no financial interest in any infusion pump vendor.