

## HITRD RFI Responses, March 15, 2019

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### **ACTION ON INTEROPERABILITY OF MEDICAL DEVICES, DATA, AND PLATFORMS TO ENHANCE PATIENT CARE**

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March 19, 2019  
Mr. Alex Thai  
National Coordination Office  
National Science Foundation  
2415 Eisenhower Avenue  
Alexandria, VA 22314

Subject: Request for Information on Action on Interoperability of Medical Devices, Data, and Platforms to Enhance Patient Care, 2019-02519

Dear Mr. Thai,

Thank you for you for the opportunity to respond to the request for information with respect to Medical Device InterOperability. The response contained herein is a joint effort between Lamprey Networks, a small business, the University of New Hampshire, and the Personal Connected Health Alliance, an industry trade association under the HIMSS umbrella.

The combination of these three organizations brings together a cross functional team with extensive experience in the many facets of health data and interoperability.

The PCHAlliance (<http://www.pchalliance.org>) is able to represent the many stakeholders involved in medical device interoperability giving the team a broad range of input from different perspectives.

LNI has the detailed domain knowledge of the key standards as primary contributors to the work of the IEEE 11073 PHD group, the HL7 FHIR profile for personal health device data, the Continua Design Guidelines, and the Bluetooth Medical Device profiles.

The UNH InterOperability Lab provides an extensive validation facility and a thirty year history of working with industry to resolve interoperability issues in a cost effective and flexible manner.

It is our hope that you will give thought to the concerns and recommendations outlined in this response and that it will stimulate effective discussion between different stakeholders. We also hope that we have properly responded to the request at the level you are seeking.

Please feel free to contact me if you have any questions regarding this response.

Respectfully,

*/\*signed\*/*

Barry Reinhold  
President and CTO

Lamprey Networks



## Executive Summary

To help combat the rising costs of healthcare, and to improve the quality of care, steps can and should be taken to enable ubiquitous use of existing low-cost healthcare technology that is already in the market. Interoperability, especially when taken broadly, is a problem across all aspects of healthcare delivery and strong leadership at the governmental level is needed.

We are providing short responses to the four key questions presented here to summarize the material developed in the response.

Question (1): What is your vision for addressing interoperability issues between medical devices, data, and platforms?

How would this plan to create interoperable systems address your key use cases and pain points?

*At the highest level the key pain point in healthcare delivery is cost. This pain point is likely to persist as the financial incentives seen by healthcare organizations do not encourage the adoption of interoperable solutions that would drive down costs. This is especially true with respect to the semantic health information that is imbedded in healthcare data. We assert that by defining standardized methods to ‘ledger’ how health data has been obtained and transformed, it will become possible to establish a basis for trust in enriched data sets. Trusted health information is a necessary precondition for the acceptance of the associated liability that comes with the transfer of patient care. More importantly, once there is a basis for the exchange of trusted health information, the patient can now more realistically be the “owner” of the information. When patients have ownership of their health information, one can envision the potential for true market competition. Market competition is, within the economy of the United States, foundational to cost control. Thus we assert: Establishing standardized methods to document and trace the transformation of raw health data into enriched data sets that are trusted will lead to a greater health information fluidity, which will lead to greater market competition and cost control.*

*At a more detailed level of concern we believe that fostering better care outside of the clinical setting is an achievable short term objective. Trusted data from simple consumer devices can be achieved with minor enhancements to existing standards and strong leadership from the public sector. In particular, we assert that establishing a center that focuses on the issues that hinder the flow of trusted data from home medical devices into the broader health record systems is a simple and cost effective way for to attack this problem. The center would focus on improving standards, creating validation technology, providing testing services, and generating open source IEC 62304 ready code for incorporation into commercial products. We propose to establish the center at the University of New Hampshire’s InterOperability Lab.*

Question (2): Who are the relevant parties and their contributions to your interoperability solution?

*The primary organizations that are and will contribute to this effort are:*

- 1. The PCHalliance (and sister organizations HIMSS and IHE)*
- 2. LNI Health (Lamprey Networks)*
- 3. IEEE 11073 contributors*
- 4. The University of New Hampshire InterOperability Lab*
- 5. The University of New Hampshire (Center for Broadband Excellence, Computer Science Department, and Electrical Engineering Department)*
- 6. Health Level Seven (HL7) FHIR contributors*
- 7. Bluetooth Medical Device Group contributors*

Question (3): What are the challenges and impediments to making interoperability happen? How might these issues be addressed and by whom?

*Medical Device interoperability is a multifaceted problem that covers a wide range of issues. The challenges are at multiple levels. Hence this response attempts to create a framework in which the significance and difficulty of the different problems can be seen. Within that framework we propose solutions to two classes of problems, those associated with classical device communications, and those associated with the movement of health information through the healthcare ecosystem. We address device interoperability problems in non clinical settings by proposing the creation of a center that leverages key players currently involved in solving this problem. We assert that detailed technical work needs to be done to create approaches to improve the flow of trusted health information, but do not provide a specific proposal for that work.*

Question (4): Is the federal vision for a medical device, data, and platform interoperability end state outlined in this RFI viable? Please explain why you have reached the conclusion that you have.

*The federal vision is necessary if the United States is going to be able to handle the looming crisis. It is also technically possible. It is not clear what the criteria for “viability” is. There are particular outcomes, costs, and timelines that define viability. We assert that significant progress toward the vision can be made. We also suggest that the interoperability issues associated with delivering trusted health information from non clinical settings should be a top priority as it has lower risk and may have the greatest cost benefit. However, the core vision outlined in this RFI will require unlocking the health information in siloed health data. This is a more complex problem and much work needs to be done to identify approaches, gain experience and consensus within the industry, write the standards along with the associated software and create the validation technology.*

*The integrated systems that provide critical care as discussed in the RFI vision statements will progress in stages and over time, however, true interoperability of these systems, where they can trust and consume information from independent devices and sources, is the farthest stage out.*

# Breaking down the Vision through the lense of interoperability

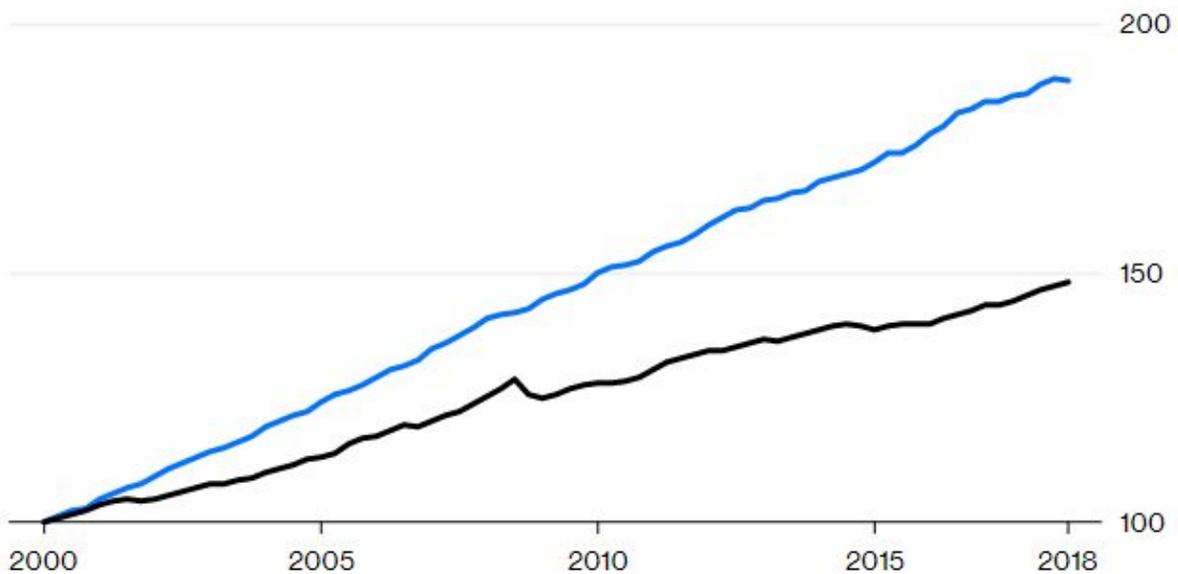
## Vision Refinement

The reality of a graying population and the increasing cost of healthcare delivery continue to point to a healthcare crisis in the United States. Over 18% of the U.S. GDP is spent on healthcare, a rate that continues to be significantly higher than that of other developed countries (11%).

### Way Out in Front

Changes in prices\*

Medical care / All items



Source: Federal Reserve Bank of St. Louis  
\* Index 2000 = 100

The US spends \$9,403 per capita on healthcare, nearly double the per capita spending on a comparative basis. [According to the Journal of the American Medical Association](#) the high cost of healthcare is primarily associated with the costs of delivering the care. Specifically the costs associated with professional services, medical goods, and drugs. The administrative overhead is also dramatically higher, running at 8%, compared to a range of 1% - 3% in other countries..

From an evidence based perspective, it is clear that more focus needs to be directed toward reducing the cost of care delivery.

It is the conviction of the authors that technology, in particular medical devices and the information they generate, can be used to significantly reduce the cost of healthcare delivery in the United States, while improving both the availability and quality of care.

The requesting RFI identifies a number of specific ways in which technology could be deployed to improve healthcare outcomes, which are summarized here:

- By enabling new models for patient monitoring, including monitoring in non-clinical settings
- By reducing medical errors due to: incorrect exchange of information, poor diagnostic judgement, and surgical mistakes - resulting in improved patient safety
- By allowing for closed-loop autonomous and semi-autonomous systems that can provide automated care for a range of patient needs.
- By reducing the variability of a procedure as performed in different Healthcare facilities
- By enabling patient mobility across a Continuum of Care in which different medical sensors are involved, without a loss of information.
- By allowing medical sensors to interact with a patient's electronic health record system to provide care tailored for a specific patient.
- By providing audit records that can be analyzed using a black box recorder like process to track adverse events and to examine unexpected positive outcomes
- By supporting higher level capabilities that will enable data collected from medical sensors to be used to better understand population trends, individual responses to interventions, and disease behavior.

Many other possibilities could be enumerated, but the above list underlines the potential role technology could play in improving healthcare delivery.

A portion of the technological infrastructure needed to enable better healthcare delivery is already in place, and continued innovation in medical devices is anticipated. These future medical devices will provide a wider range of capabilities, some specific to clinical settings, but an increasing number will be targeted for use in the home. With the aid of these devices a higher percentage of care can be provided without the patient needing to visit a clinical facility. We use the term "ubiquitous care" to capture the idea that care delivery will be practiced in a broad range of more convenient, less contagious settings. The adoption of ubiquitous care, by itself, should provide helpful downward pressure on costs.

Perhaps even more impacting than the anticipated innovation in medical devices is the development of healthcare analytics and the digitized body. Intelligent systems that monitor health data at the individual level and at the population level could disrupt a wide range of current practices. Everything from tailored home care plans to the early detection and management of disease outbreaks could be improved. The prevention of disease is still the most cost effective and desirable way to deliver healthcare.

At the highest level, the priorities of a medical device interoperability program should focus on enabling ubiquitous healthcare and on making the information contained within medical device data usable in the broad context of a “smart” healthcare ecosystem.

## Framing the Interoperability Problem

The vast majority of interoperability problems fall into one of two categories:

- The inability of devices to operate together as part of an integrated system and,
- The inability to effectively use the information generated by devices.

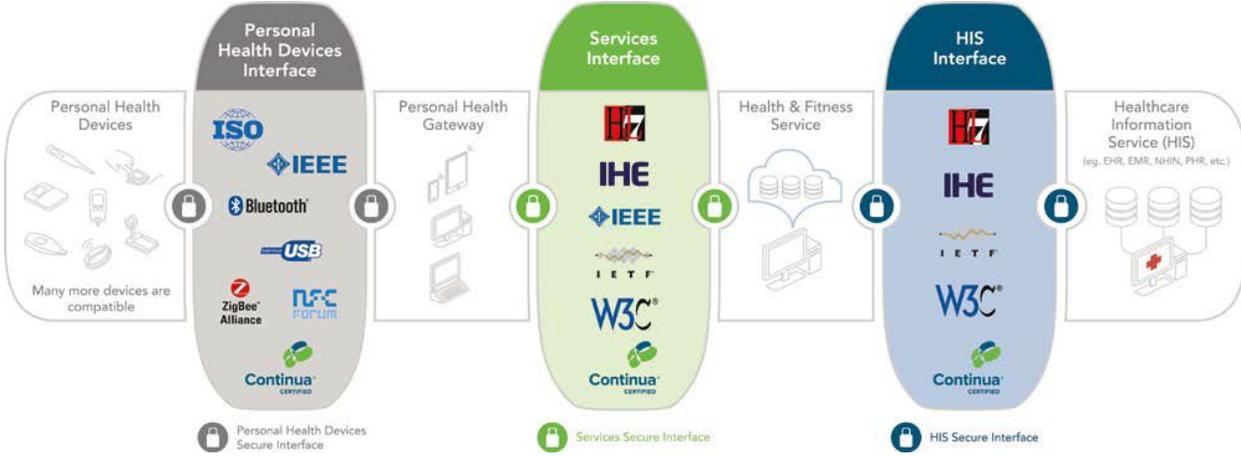
Both of these issues exist with medical devices, and at some level are addressed by creating specifications. Yet it would be naive to believe that standards alone will solve the interoperability problems that inhibit the larger vision outlined herein. Healthcare delivery is a complex issue with a wide range of workflows, privacy and trust concerns, stringent quality and control requirements, as well as economic and usability factors which become more impacting as devices move into home settings.

In order to provide a framework for presenting recommendations, this document breaks the “interoperability problems” up into focus areas where a focus area is a set of related concerns that inhibit the medical devices from achieving the higher order value propositions identified above.

| Focus Area                                  | Interoperability Issues and impact  | Activity  | Level of difficulty  |
|---|---|---|--|
| Medical Device Data                         | <ul style="list-style-type: none"> <li>• Inability to exchange information content</li> <li>• Inability to communicate semantic content</li> <li>• Lack of acceptance by service providers</li> <li>• Difficulty in using the information within the context of analytics</li> <li>• Insufficient context to properly understand observation</li> <li>• Patient identity</li> </ul> | <ul style="list-style-type: none"> <li>• Enhance and extend the IEEE 11073 data model</li> <li>• Isolate IEEE 11073 data model from other IEEE 11073 elements; extend to cover additional classes of devices</li> <li>• Open source projects appropriate for regulated medical devices</li> </ul> | <ul style="list-style-type: none"> <li>• Easier</li> </ul> |
| Medical Device connectivity and Integration | <ul style="list-style-type: none"> <li>• Poor user experience</li> <li>• Insufficient guidance and validation for developers</li> <li>• Bluetooth/radio platform issues with consumer</li> </ul>  | <ul style="list-style-type: none"> <li>• Improve technical specifications</li> <li>• Additional cost effective validation tools</li> </ul>  | <ul style="list-style-type: none"> <li>• Easier</li> </ul> |

|                                |   |  |  |
|--------------------------------|---|--|--|
|                                | <ul style="list-style-type: none"> <li>medical devices</li> <li>• Proprietary elements in device communications</li> <li>• Time management</li> </ul>                 |  |  |
| Exchange of enriched data sets | <ul style="list-style-type: none"> <li>• Medical device data often has low information density</li> <li>• Processed data is difficult to exchange</li> </ul>          | <ul style="list-style-type: none"> <li>• Research effort to drive standardization efforts on representation of enriched data sets</li> </ul> | <ul style="list-style-type: none"> <li>• Harder</li> </ul> |
| Command and Control            | <ul style="list-style-type: none"> <li>• Connectivity protocols</li> <li>• Messaging formats</li> <li>• Management framework</li> <li>• Security framework</li> </ul> | <ul style="list-style-type: none"> <li>• Support for standards development</li> <li>• Open source projects</li> </ul>                        | <ul style="list-style-type: none"> <li>• Harder</li> </ul> |

Interoperability problems will be discussed within the broad context of the Continua Architecture. We have chosen to use the Continua architecture as we believe that the most achievable interoperability gains in the short term will be associated with the delivery of healthcare outside of the clinical setting (ubiquitous delivery of healthcare). The Continua architecture is a simple logical architecture that has been adopted as an international standard (See <https://www.itu.int/rec/T-REC-H.810>) that can be easily applied and deployed in non clinical settings. One of the advantages of the architecture is that it can be used to create clear boundaries between patient and healthcare provider, facilitating patient ownership and control. The architecture captures common deployment scenarios, and is presented below for reference purposes.



When discussing command and control system in a clinical setting the Continua architecture needs to be augmented by a more specific communications environment, such as the Integrated Clinical Environment (ICE) of ASTM F2761.

## Analysis and Justification

This section presents the rationale that motivates the specific recommendations. The section is divided into the focus areas identified above.

### Medical Device Data

A fundamental interoperability issue with a medical device is how the semantic information from the device is exchanged. The exchange of information between a medical device and the entity that receives that information is not only a communications issue, but it is also a knowledge flow (or semantic) interoperability problem. When a medical device exchanges data representing an observation, the entity receiving the observation must be able to understand the meaning of the observation. If the medical sensor taking the reading is a private device using its own proprietary protocol the semantic understanding of the reading may only come via external communications with the developers of the device. If there are a large number of different medical devices an understanding will have to exist for each device. Further complicating the picture is that the receiving entity is often a gateway that must translate the semantic meaning into a different representation before it passes the observation on. Translations may take place multiple times as the observation moves from its source to a “final” destination. Under these conditions health observations become siloed and are only usable by specific applications. A number of steps need to be taken to address the siloed data problem. An obvious first step is to start with health observations where the semantic content is clear.

The ISO/IEEE 11073 committee has established both nomenclature codes (identifiers that have a clearly understood medical meaning) as well as a data model that allows a medical device to communicate observations. The data model incorporates the nomenclature codes into a structure that provides a level of abstraction and metadata about the abstractions. This allows information to be exchanged and translated even when a detailed understanding of the observation is not known.

Work needs to be done to promote the usage of the IEEE 11073 data model. This work breaks down into a number of specific tasks:

1. Support for work within IEEE 11073 with respect to the data model and nomenclature codes to ensure that current and future types of medical devices will be able to use the data model.
2. Work within the Bluetooth SIG to create a specification that allows the IEEE 11073 data model to be exchanged over Bluetooth Low Energy. The Bluetooth SIG currently defines medical device specifications that have been written such that the received data can be mapped back to IEEE data models, but this approach requires the entity communicating with the Bluetooth device to know about each specific Bluetooth profile. A specification that defines how to exchange information using the IEEE 11073 data model would

enable a wide range of devices to use this single specification reducing the need to create multiple specifications significantly enhancing the potential of widespread adoption.

3. Support an open source code project that provides an implementation of the IEEE 11073 data model over Bluetooth Low Energy. This work should be done in a manner that facilitates adoption of the code into an IEC 62304 compliant project to facilitate adoption.
4. Work with the Personal Connected Health Alliance ([www.pchalliance.org](http://www.pchalliance.org)) to ensure that this specification is adopted into the Continua Guidelines and that validation technology is created to ensure that medical devices that adopt the specification can have confidence that it will interoperate with other compliant entities and can deliver the correct information into the broader health ecosystem.
5. Specifications and technology that provides a higher level of confidence that the observation reported by a device is actually associated with the patient identified in the reported observation data.

Unless medical devices provide information that has a clear semantic content, the interoperability issues associated with the movement of health information will continue to be limiting and convoluted.

## Medical Device Connectivity and Integration

The connectivity of medical devices covers a broad range of problems depending on the context in which the discussion is taking place. We are going to look at this issue in the context of the non clinical setting. In particular we are going to focus on the generation of tooling to improve and simplify the validation process of medical devices that are using Bluetooth Health Device Profile or Bluetooth Low Energy in conjunction with the Bluetooth Medical Device Profiles. This area has been chosen as it covers the most commonly selected space in which there is a level of standardization such that interoperability can be expected. Within this context interoperability is impacted by a combination of issues as noted below:

1. Lack of understanding of specifications that govern a behavior
2. Bluetooth platform behaviors (specifically those exposed by Android, iOS, or BlueZ in Linux) that result in communications failures or poor user experiences
3. Time management and synchronization
4. Insufficient specifications to ensure interoperability

The ongoing Bluetooth connectivity issues have hindered the user experience with medical devices and the associated adoption of medical devices into home settings. Further, efforts to resolve these issues have typically focused on creating test suites and certification programs. These tools can be effective, but better solutions can be provided.

Like healthcare itself, the best way to resolve interoperability problems is by preventative action. Preventative action in this context means getting knowledge and tooling into the hands of the

developers of the products. Increasingly, the easiest “knowledge” for a development engineer to have is validated open source code that can be integrated into a product. This dramatically reduces the domain knowledge required of the engineer. Additionally, validation tools should be designed to be used as early in the development cycle as possible. Finally, an ongoing year round facility that can be used to perform direct interoperability testing should be available for testing of Bluetooth Medical devices. The University of New Hampshire’s InterOperability Lab (see [www.iol.unh.edu](http://www.iol.unh.edu)) provides a model by which this could be achieved. The specific recommended actions are:

- Establish a Personal Health Device Interoperability Center that would:
  - Work to improve standards associated with the operation of IEEE 11073, HL7 FHIR, PCHAlliance Guidelines and others as needed
  - Create automated open source tooling that can be pulled into build environments to support early validation of Bluetooth based medical devices
  - Collect and maintain a collection of Bluetooth Medical devices that can be used to perform interoperability testing
  - Provide a service that supports year round low cost access to interoperability testing
  - Establish a diagnostic capability that is able to identify root cause issues for interoperability failures
- Work with key platform vendors to ensure that the exposed APIs and behaviors are appropriate for Bluetooth based medical devices.

## Analytics

Interoperability fails in a dramatic fashion when we consider the ability to use medical device data in higher levels of abstraction. Medical devices that are actively monitoring a patient in a continuous fashion can overwhelm systems with data that has little usable information. Before the higher level objectives outlined in the RFI can be achieved it will be necessary to address the interoperability of data sets that have been created through some form of algorithmic processing as the observations from medical devices is often low in actionable content. Consider the simple problem of taking data from a health watch. Depending on the measurements being report the data may need to be filtered to take into account the motion of the arm while walking. The health watch might provide three axis accelerometer information at a rate of 64 observations per second. It may provide light intensity levels at a particular wavelength. Data at this level has a very low information content, but an approved, well understood algorithm could be applied to this data to return a derived data set that provides blood oxygen levels in which the artifacts due to motion have been removed. It would be desirable if this new data set could be understood and used by other entities. Perhaps a second algorithm that looked at blood oxygen levels as a function of activity based on the initial accelerometer data and the filtered blood oxygen levels. Due to the lack of any accepted way to represent and express the modified data set, it is currently highly unlikely that the software entities can interoperate with each other. As the computing world is shifting toward microservice

architectures in which entities are increasingly independent of one another and these entities present their services through REST APIs interoperability of software services will become a compelling issue that will need to be solved. Without meaningful interoperability of health data sets the potential for improved health outcomes will again be locked into siloed systems.

The interoperability of health data sets is a different class of interoperability problem. The work that needs to be done is therefore significantly different. Given the current state of technology in the industry the focus should be on surfacing the issues associated with meaningful use of health data sets so that proposals and pilot projects have a reasonable set of requirements to address. In particular solutions must not only look at issues of representation and self description, but must also take into account concepts such as ownership of data, privacy concerns, integrity of the information communicated in the data set, and potential intellectual property concerns that may be associated with generated health data set.

We recommend that work be undertaken to address the interoperability of health data sets. This work should start with research efforts focused on creating approaches that help to identify and refine concerns. The projects should at some level define representational forms by which data sets created by algorithmic transformations can be expressed. The proposed solutions will need to address:

- The core technical issues associated with how the data sets are represented and described
- The ability to regenerate the data set, and traceability as a requirement related to non repudiation.
- Security related concerns such as authenticity and integrity - would blockchain technology be required?
- Does the proposed solution need to address potential concerns such as ownership of information and intellectual property created as the result of the use of a transformation service?

Addressing the useability of health data as an interoperability problem can be compared to using testing as an approach to software design. The useability of the information by different entities, which is the core value proposition, becomes the starting point and focus of the work.

## Patient Identity and Privacy Concerns

We recognize that patient identity and privacy are key concerns and must be incorporated into any viable solution. Due to the limited space and broad scope of this issue we feel that a detailed discussion of this topic is out of scope. However, the impact of addressing the patient identity and privacy issues will result in the establishment of standards that incorporate ways of communicating biometric observations about patients in ways that allow for different levels of privacy disclosures. Work will need to be done to identify these standards, and to validate the ability to communicate them between authorized parties.

## Medical Device Control

The detailed control of medical devices is significantly different within the context of an open internet and a controlled medical facility. The RFI response form the Center for Medical Device InterOperability is anticipated to

## Information on Submitters

### LNI Health (Lamprey Networks)

LNI is a provider of standards based, consumer and patient centric, end-to-end connectivity and interoperability solutions marketed under the brand name “Health@Home”. LNI is a unique organization with a deep background in the resolution of interoperability issues, the impact of user experience on the adoption of healthcare technology, and the integration of open standards based solutions into the workflows of healthcare organizations.

LNI staff have been responsible driving and contributing major portions of the IEEE 11073-20601 and associated 11073-10xxx standards, the Continua Design Guidelines, the HL7 FHIR specification for Personal Health Device Uploads, and Bluetooth Medical Device Profiles. LNI has also consulted with Google to help define and create APIs for the Android platform that will support the Bluetooth Health Device Profile and to resolve Bluetooth connectivity issues.

LNI research includes user experience with different methods of biometric patient identity and defining trust models supporting non repudiation of data transforms in health data.

### **History**

Lamprey Networks, Inc. (LNI) was founded in 1999 to offer technical services related to interoperability and compliance for emerging technology standards. LNI was founded with the goal of delivering industry best compliance and interoperability solutions, while working closely with nearby University of New Hampshire for cooperative software development, testing, and compliance. In 2008 LNI started a focused effort to address the “siloes” nature of Healthcare from an interoperability perspective. This brought the organization into a close working relationship with the Continua Alliance (currently the PCHAlliance) and the IEEE 11073 Personal Health Device group, which continues to this day.

### **Industry Experience**

Since its founding, LNI has developed technical testing and certification processes as well as standards-based network protocols and solutions.

LNI is currently the primary contractor responsible for the design, development and maintenance of the HIMSS CODE (Continua Open Development Environment) for Healthcare

project. The CODE for Healthcare project seeks to provide “IEC 62304 ready” source code that implements the Continua Design Guidelines framework reducing the domain knowledge required to implement standards based, interoperable healthcare solutions.

LNI has led standards groups, developed software, authored test suites and created test tools for numerous organizations including Advanced Switching Interconnect, Digital Living Networks, Open Fabrics Alliance, InfiniBand™ Trade Association, iWARP (RDMA over IP) Consortium, Fibre Channel Industry Association, and the PCI-Express SIG, PCHAlliance, and HIMSS.

## University of New Hampshire

Founded in 1886, the University of New Hampshire (UNH) is the land grant, sea grant, and space grant public institution of the State of New Hampshire. More than 16,000 students from all 50 states and 71 countries engage with an award-winning faculty in top-ranked programs in business, engineering, law, health and human services, liberal arts and the sciences across more than 200 programs of study. As one of the nation’s Very High Research Carnegie-classified universities, UNH partners with NASA, NOAA, NSF, and NIH, and receives more than \$110 million in competitive external funding every year to further explore and define the frontiers of land, sea and space. The UNH Colleges of Health and Human Services (CHHS) and Engineering and Physical Sciences (CEPS) are partnering in the development of the UNH TelePractice Center to teach health care practitioners how and when to incorporate medical devices into the regular support of patients in the areas of aging in place, behavioral health, home health, and general practice. Two different organizations within UNH are interested in commenting for this RFI, the Broadband Center of Excellence and the IOL.

## UNH Interoperability Laboratory (UNH-IOL)

Founded in 1988, the University of New Hampshire InterOperability Laboratory (UNH-IOL) provides independent, broad-based interoperability and standards conformance testing for data, telecommunications, and storage-networking products and technologies. Combining extensive staff experience, standards bodies’ participation and a 28,000+ square foot facility, the UNH-IOL helps companies save money and deliver products to market more quickly than they could by themselves.

The UNH-IOL consists of roughly twenty-five different year-round standards-based testing programs. Each of these programs represents a collaboration of industry forums, service providers, test equipment vendors and otherwise competing companies. In addition, the UNH-IOL also hosts multi-vendor group tests (called “Plugfests”) as often as four times a month.

### ***Mission of the UNH IOL***

To provide a neutral environment to foster interoperability, standards conformance, and

development for the interconnected world, while attracting students to and preparing them for careers in cutting-edge technology. Students are fully involved in the development and execution of the different activities of the lab, allowing them to be engaged with both industry and emerging technology early in their professional carriers. The IOL has spent decades developing process that effectively balance the training of students while meeting standards for testing and delivery required by commercial and governmental clients.

**HEADQUARTERS**

The UNH-IOL occupies a 28,000+ usable square foot facility located on the first floor of 21 Madbury Commons building in Durham, New Hampshire. The lab space is physically shared between each of the currently operating technology groups on an as-needed basis. Since its founding in 1988 the UNH-IOL has built an extensive collection of new and legacy test beds and test equipment valued at over \$20 million. The lab also hosts some special-purpose space, including two walk-in wireless isolation chambers. This facility accommodates reference devices, equipment under test, storage, and visiting engineers. Visiting engineers have extensive connectivity and ample space in which to set up and work, with access to telephone lines, the Internet, and a soldering station. Engineers are also able to work with the laboratory’s technicians to troubleshoot any potential issues and receive real-time feedback. Access to a large classroom and several conference rooms equipped with speaker phones and wired and wireless network access is also available. The entire facility is climate and humidity controlled to ensure that all areas of the laboratory remain within 22-25 °C (68-72 °F).

**Plugfest Space**

Included within the IOL’s facility is a 4,100+ square-foot area dedicated to group test events and Plugfests for up to 60 companies at a time. It can hold up to 120 engineers in a single event or in multiple simultaneous events. This space is equipped with individually patched stations, and a flexible cabling infrastructure that can accommodate many copper and fiber optic based technologies.

**Industry Engagement**

Over twenty-five different technology areas are currently tested at the UNH-IOL:

| IP Networking         | Ethernet/Enterprise    |
|-----------------------|------------------------|
| IoT                   | 2.5/5/10 Gigabit       |
| IPv6                  | 10BASE-T               |
| IPv6 Application      | 25/40/100 Gigabit      |
| OIF UNI Certification | 50/100/200/400 Gigabit |

|  |  |
|--|--|
| Routing<br>SDN<br>SIP  | Automotive Ethernet<br>Cable/Channel Testing<br>Fast<br>Gigabit<br>Power over Ethernet |
| <b>Home Networking</b>   | <b>Storage</b>   |
| IPv6 CE Router<br>TR-069<br>Wireless   | NVMe<br>PCIe<br>iSCSI<br>Fibre Channel<br>SAS<br>SATA                                  |
| <b>Open Networking</b>   | <b>Broadband Systems</b>   |
| Open Networking (OCP)<br>ONIE<br>OpenFlow (ONF)<br>OPNFV   | Gfast<br>DSL<br>GPON<br>VDSL2 Vectoring  |
| <b>Switching/Timing</b>  | <b>Mobile/Wireless</b>   |
| Carrier Ethernet<br>Ethernet Switching Protocol<br>Avnu<br>Automotive Networking<br>Industrial Networking<br>ProAV Networking<br>IEEE 1588 | Wireless<br>MIPI   |
| <b>High Performance Computing</b>  |  |
| OpenFabrics  |  |

See <https://www.iol.unh.edu/testing> for a full list of testing partners and programs.

### LABORATORY CERTIFICATIONS

The UNH-IOL is an A2LA certified to ISO/IEC 17025. The scope of the certification currently covers the following test programs, but can be expanded to cover any relevant technologies.

## Individuals

### Barry Reinhold

Barry Reinhold serves as the Chief Technology Officer and President of Lamprey Networks a small business that focuses on providing standards based interoperable solutions for ubiquitous healthcare. Barry is engaged in a number of standards groups and industry associations, including the PCHAlliance, IEEE 1103, IHE, and HL7. Barry is the founder of the University of New Hampshire Interoperability Lab and of Lamprey Networks. He earned a BS in Physics and Computer Science from the University of New Hampshire, as well as a MS in Computer Science. Barry's professional interest focus on user experience, medical workflows, communications protocols, software development, and interoperability architectures.

### Scott Valcourt, PhD

Scott Valcourt serves as the Director of IT Strategic Technology at the University of New Hampshire and is the chief visionary for UNH's investment in cyberinfrastructure. Named "one of the most powerful people in networking" by NetworkWorld Magazine in 2001, Scott has developed and managed over \$100 million in grant funds focused on the creation of next generation infrastructure and applications utilizing broadband across the region. He has a BA in Computer Science with Mathematics Emphasis, *cum laude*, from Saint Anselm College in Manchester, NH, and a MS in Computer Science and a PhD in Engineering: Systems Design with a Cognate in College Teaching from the University of New Hampshire.

### Mike Kirwan

Mike is the Vice President of Continua at PCHAlliance and has served as the technical director of Continua for over seven years. In this role Mike has had technical and management oversight of the development of the Continua Design Guidelines. Previous to his work at the PCHAlliance Mike managed the development of the testing and validation program at Bluetooth SIG. Mike currently is co chair of the IEEE 11073 PHD group.

Tim Carlin

<https://www.iol.unh.edu/about/leadership/timothy-carlin>

Bob Noseworthy

<https://www.iol.unh.edu/about/leadership/bob-noseworthy>

Jeff Lepak

<https://www.iol.unh.edu/about/leadership/jeff-lepak>