**IEEE P802.15**

**Wireless Specialty Networks**

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| Project | IEEE P802.15 Working Group for Wireless Specialty Networks (WSN) |
| Title | **IEEE 802.15.6a PAR draft** |
| Date Submitted | May 18th, 2021 |
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| Re: | Amendment to IEEE Std 802.15.6 Wireless Body Area Networks |
| Abstract | Draft of IEEE 802.15.6a PAR |
| Purpose | For discussion in IG-DEP |
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**Revision History**

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| **Revision** | **Date** | **Edits** |
| 0 | 13 May 2021 | Edits to Doc 21-0180-00 reflected in Doc 21-0180-01 |
| 1 | 18 May 2021 | Edits to Doc 21-0259-00 |

**P802.15.6a**

**Submitter Email:** Kohno@ynu.ac.jp

**Type of Project:** Amendment to IEEE Standard 802.15.6-2012.

**PAR Request Date:**  20 May 2021

**PAR Approval Date:**

# PAR Expiration Date:

**Status:** Draft

* 1. **Project Number:** P802.15.6a
	2. **Type of Document:**  Standard
	3. **Life Cycle:** Full Use

**2.1 Project Title:** IEEE Standard for Local and Metropolitan Area Networks Part 15.6: Wireless Body Area Networks.

 Amendment: Dependable Human and Vehicle Body Area Networks.

* 1. **Working Group:**  Wireless Specialty Networks (WSN) Working Group (C/LM/WG802.15)

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* 1. **Type of Ballot:** Individual

# Expected Date of submission of Draft to the IEEE-SA for Initial Standards Association Sponsor Ballot: December 2022

* 1. **Projected Completion Date for Submittal to RevCom:** December 2023
	2. **Approximate number of participates to be actively involved in the development of this project:** 12
	3. **Scope:**

This amendment enhances the Ultra-Wideband (UWB) physical layer (PHY) and medium access control (MAC) to support enhanced dependability to human body area networks (HBAN) and adds support for vehicle body area networks (VBAN), operating under strict compliance to standards and limits for electromagnetic compatibility (EMC) and electromagnetic interference (EMI).

Areas of enhancement: multiple piconets coexisting, which includes intra-BAN interference and inter-piconets interference. Simpler and more reliable MAC protocol.  Sensing and feedback control loop delay. Enhancements to dependability against interference and contention in such critical use cases as overlaid same and/or different piconets, ​and to support higher performance requirement of reliability, security, coexistence and efficiency in​ the​ ​operation​​ and maintenance ​of​ ​HBAN and VBAN​. Support for station-to-infrastructure protocols and infrastructure synchronization mechanisms. This amendment includes safeguards so that the high throughput data use cases will not cause significant disruption to low duty-cycle ranging use cases.

# Is the completion of this standard dependent upon the completion of another standard: No.

* 1. **Purpose:**

Medical healthcare and automotive manufacturers manifest interest on applications regarding UWB technologies beyond the current standard 802.15.6-2012 with new capabilities and functionalities supporting vehicle area networks. The amendment enhances dependability for medical and automotive use cases such as remote medical healthcare monitoring and therapy to help combat Covid-19 pandemic and to support quality of life (QoL) in aging population.​ The interaction between HBAN and VBAN support​s​ mechanisms​​ to ​help prevent incidents by elderly​/senior ​ drivers​​.​ The automotive industry manifests the need to enhance dependability of automotive sensing and controlling in autonomous vehicular driving and factory automation.  ​

Coexistence of multiple BANs due to current standard 802.15.6-2012 is not dependable enough against contention and interference among overlaid BANs. Coexistence with other UWB-based standard implementations, and with other piconets sharing the same frequency band.  Feedback sensing and controlling loop dependability for remote sensing and diagnosis loop and a remote vehicle sensing and actuators with robotics controlling loop. More flexible network topology. Capability of ranging and positioning.

* 1. **Need for the Project:**

This project provides dependability against interference and contention in such critical use cases as overlaid with the same and/or different piconets. Focus use cases: multiple BANs, where user’s devices cross each other among different BANs within range. Multiple piconets, where narrowband and wideband devices cross each other within the same coverage range. Interference management among BANs. This amendment for enhanced dependability supports automotive use (vehicular body area network) with primary medical use for a human body and additionally non-medical use with common enhanced dependability. This amendment helps remote medical healthcare monitoring and therapy to combat Covid-19 pandemic and to support QoL in aging population and people with medical conditions.

* 1. **Stakeholders for the Standard:** The stakeholders include silicon vendors, manufacturers and users of telecom, medical, automotive, environmental, energy, and consumer electronics equipment and manufacturers and users of equipment involving the use of wireless sensor and control networks.

**Intellectual Property**

* + 1. **Is the Sponsor aware of any copyright permissions needed for this project?** No.
		2. **Is the Sponsor aware of possible registration activity related to this project?** No.
	1. **Are there other standards or projects with a similar scope?** No.
	2. **Is it the intent to develop this document jointly with another organization?** No.

**8.1 Additional Explanatory Notes (Item Number and Explanation):**

**8.2 Scope:**

Criteria for DBAN:

1) General requirements:

* Number of sensors: up to 4096 and 256 per piconet for high and low data rate, respectively,
* Support for multiple piconets co-existence & interoperability: single, i.e. no overlaid and up to 3 piconets for high and low data rate, respectively,
* Types of topologies: two pairs of star and single star pulse multiple hops for high and low data rate, respectively
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* Latency:

 in normal operation mode; 10-20 msec,

 in critical operation mode; 5-10 msec.

* Association delay: up to 30 msec and 60 msec for high and low data rate, respectively,
* Authentication and security delay: 50 msec and 100 msec for high and low data rate, respectively,
* Delivery ratio requirement: more than 99.9% and more than 99% for high and low data rate, respectively,
* Disconnection ratio (of time): up to 0.01% and 2% for high and low data rate, respectively,
* Synchronization recovery time: up to 10 msec for high data rate,
* Coverage range: 10 cm and 50 cm for high and low data rate, respectively,
* Feedback loop response time: up to10 msec and 100 msec for high and low data rate, respectively,
* Handover capability: N/A
* Ranging and positioning capability: Yes, accuracy dependent on each use case
* Data packet size: compatible for 802.15.6 for medical use and compatible for CAN and LIN for automotive use
* Fraction of MLME requests successfully delivered: more than 99.9 %
	+ Inter-piconet success rate; more than 99 %
* Jitter: up to 50 msec. in regular case, 5 % outliers acceptable.
* Permissible no. of overlaid piconets:

- Multiple BANs overlaid considering intra piconets interference and contention: 2 and 3 BANs for high and low data rate, respectively,

- Different PANs overlaid considering inter piconets interference and contention: 2 and 3 piconets for high and low data rate, respectively,

* Channel model resilience: Line of sight(LOS) and no line of sight(NLOS) for high and low data rate, respectively.
* Study how to include Time-Sensitive Networking (TSN) protocol of IEEE 802.1 into the MAC enhancements.

 Application-specific requirements:

* Data packet sizes (typical, maximum),
	+ Medical: (same as 802.15.6, in addition 802.11 compatible)
	+ Automotive: (10 bytes, 300 bytes),
		- ~4 – 68 bytes for extended CAN frame format
		- 5 – 11 bytes for LIN
		- 8 – 264 bytes for FlexRay
		- Compatibility with CAN and LIN buses for intra-vehicle communications,
	+ Factory line: (100 bytes, 1000 bytes)
* Feedback loop response time
	+ Collision avoidance radar: 10 ms
	+ Factory line: less than 1 s
* Handover capability: seamless between piconets, factory line speed,
* Security considerations: Handover peers need to have trust relationship (in factory line).
	+ Factory line: pre-shared key
	+ Vehicle: pre-shared key
	+ Modular vehicles (trucks, trailers, etc.): key exchange
* Factory line sensor lifetime: minimum 1 year, up to equipment lifetime,
	+ Batteries may be recharged/replaced once per month.
* Coverage range: optional scalability
	+ Factory line: 20 m.
	+ Intra-vehicle: 20 m.
		- Inside enclosed objects line engine compartment 2 m.
	+ Inter-vehicle:
		- Modular vehicle: 30 m.
		- Adjacent vehicles 100 m.

2) Channel models.

2.1) HBAN channel models from 802.15.6 Channel Model Document.

2.2) New VBAN channel models.

2.3) EMC/EMI technical requirements for UWB radio equipment operation.

In the interaction between HBAN and VBAN, careful consideration of EMC and EMI should be considered. We seek to partner with automotive manufactures to study and test EMC/EMI vehicle environment effect on radio equipment, specifically UWB technologies on HBAN and VBAN radio equipment.

EMC and EMI studies are categorized into four areas, conducted/radiated emissions and conducted/radiated susceptibility for on-board and off-board sources, with their specific compliance standards and limits for internal combustion engine vehicles, electrics vehicle and hybrid-electric vehicles.

3) Support for synchronization infrastructure, for instance 802.1 TSN MAC Bridge, to enhance dependability and reliable latency.