**IEEE P802.15**

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) |
| Title | **IEEE 802.15.6a PAR draft** |
| Date Submitted | March 16th, 2021 |
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| Re: | Amendment of 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 | 11 March 2021 | Edits to Doc 21-0030r0 reflected in Doc 21-0030r1 |
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**P802.15.6a**

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

**Type of Project:** Amendment of IEEE Standard

**PAR Request Date: 9-March-2021**

**PAR Approval Date:**

# PAR Expiration Date:

**Status:** UnapprovedPAR. PAR for amendment of IEEE 802.15.6.

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

**2.1 Title:** Standard for Dependable 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: March 2022

* 1. **Projected Completion Date for Submittal to RevCom: December 2022**
	2. **Approximate number of participates to be actively involved in the development of this project:** 10
	3. **Scope:**

This new amendment defines enhanced dependability of std. IEEE 802.15.6 body area network(BAN) , that is to say Dependable BAN(DBAN), for medical stakeholders, healthcare medical manufactures, research institutions, automotive stakeholders, automotive manufacturers, and car electronic manufacturers.

1. Enhanced dependability in case of multiple piconets coexisting,
	1. Intra-BAN interference
	2. Inter-piconet interference between narrowband and wideband
	3. Inter-piconet between same wideband

For these interference immunity UWB PHY of std. IEEE 802.15.6-2012 to be updated.

1. Simpler and more reliable MAC protocol such as contention-free protocol or simplified hybrid contention-free and contention-access protocol of std. IEEE 802.15.6-2012 MAC to be implemented
2. Sensing and feedback control loop delay
3. Introduction of ranging and localization or positioning capability

Focus use cases: Multiple-BAN where user devices cross each other among BANs coverage range, multiple pico-networks, where narrowband and wideband devices cross each other within the same coverage range, interference management among BANs,

Use cases of IEEE 802.15.6 BAN is primarily medical use and additionally non-medical uses. This amendment for enhanced dependability DBAN focuses automotive use for a vehicular body as well as primary medical use for a human body with common enhanced dependability.

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

* 1. **Purpose:** This project focuses on amendment of PHY and MAC of std. IEEE 802.15.6 medical body area network(BAN) to enhance dependability against interference and contention in such critical use cases as overlaid same and/or different piconets and to ensure higher performance requirement of reliability, security, predictability, coexistence, efficiency for human body in medical healthcare use and vehicular body in automotive use in addition.
	2. **Need for the Project:** Medical healthcare and automotive equipment and manufacturers need BAN with enhanced dependability, that is, dependable BAN(DBAN) beyond std. IEEE802.15.6-2012 BAN under dense coverage of multiple piconets overlaid and new capabilities and functionalities while keeping interoperability with or extension of std. IEEE802.15.6-2012 BAN. Need for the amendment of std. IEEE802.15.6-2012 to enhance dependability for medical and automotive uses increases drastically. In background, DBAN can apply for remote medical healthcare monitoring and therapy to combat with pandemic and to support quality of life (QoL) in population ageing in medical and pharmaceutical industry. In automotive industry, need to enhance dependability for automotive sensing and controlling in autonomous vehicular driving and factory automation. Particularly needs for dependability in critical use cases such as overlaid same and/or different piconet and new use case such as
1. In case of coexistence of multiple BANs

BAN std. IEEE802.15.6-2012 is not good enough dependable against contention and interference among overlaid BANs. The more BAN uses in dense area, the more contention and inference cause performance degradation.

1. In case of coexistence with other radios

UWB PHY of BAN std. IEEE802.15.6-2012 is not good enough dependable to avoid performance degradation due to interference with coexisting other narrow band and UWB radio networks in overlapped frequency band.

1. In case of feedback sensing and controlling loop

MAC of BAN std. IEEE802.15.6-2012 is not good enough efficient and stable for remote sensing and feedback controlling loop such as remote vital sensing and diagnosis loop and a remote vehicle and factory sensing and actuators and robotics controlling loop.

 In addition, new need for interoperability and functionality such as

1. Interoperability and transparency

Interoperability with other radio networks, more flexible network topology, and transparency with other standards such as ETSI SmartBAN

1. Capability of ranging and positioning

Enhanced dependability for mobility of BAN in various environment needs ranging and tracking capability and for security of BAN needs location information.

* 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:**

**1)** Criteria for DBAN:

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
* Data rate requirement: up to 12 Mbps and 2 Mbps per sensor, for high and low data rate, respectively,
* Aggregate data rate per piconet: 47 Mbps and 2 Mbps, for high and low data rate, respectively,
* 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.

 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.

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* 1. **Projected Completion Date for Submittal to RevCom:** Jan-XXXX
	2. **Approximate number of participates to be actively involved in the development of this project:** 100
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**5.2 Scope:**

1)

2)