Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	)	
	)	
Hydroid, Inc.,	)	No. _____
Request for Waiver of Section 15.407(a)(3)	)	
of the Commission's Rules for Maritime	)	
Broadband Communications	)	

REQUEST FOR WAIVER

Hydroid, Inc. requests a waiver of the antenna gain rules in Section 15.407(a)(3) to facilitate broadband communications between maritime vessels, and between vessels and fixed points on shore.

A. INTRODUCTION AND SUMMARY

The revolution in broadband digital communications has been slow to reach the nation's waterways. Ocean-going telegraphy was among the first practical uses of radio, more than a century ago, but high-speed digital connectivity is only now reaching maritime applications. While seaborne radio benefits more from line-of-sight connections than do most land communications, reflections from the water's surface cause "multipath fading" that attenuates signal strength at the receiver. Land-based operators combat atmospheric multipath and achieve long range with high gain, highly directional antennas. The Commission allows operators in the 5725-5850 MHz (U-NII-3) band to install antennas of unlimited gain for communications between pairs of fixed points. High-gain antennas are harder to use at sea, as they require continuous re-aiming as a vessel travels, rolls, pitches, and turns.

Hydroid and its parent company have developed a system for maritime broadband communications that employs high-gain antennas having directional properties similar to those

used for fixed point-to-point land communications. But the antenna construction is very different from the parabolic forms commonly seen on land. Hydroid uses phased-array antennas that continuously steer the beam so to keep the aim steady, while the antenna moves with the vessel.

Hydroid requests a waiver to use 5.8 GHz high-gain, narrow-beam antennas for broadband communications between vessels, and between vessels and fixed points on shore. We explain below and in the Attachment how a pair of communicating antennas will track one another while one or both are in complex motion.

Applications include control of autonomous vessels; harbor and waterway inspections; scientific research in oceanography, fisheries, and marine biology; oil field exploration, operations, and oil spill management; protection of life and property; and more. See Part C.1.

Operation under the waiver will increase the range for reliable communications approximately seven-fold. The radios will incorporate adaptive power control that limits transmitted power to the minimum needed at each moment.

We detail below the several factors that combine to limit the risk of additional interference: operation over open water; unlikely operation over land-based facilities; minimum areas exposed to interference; low probabilities of alignment with an interference victim's receiver beam; and low transmit duty cycles.

The combination of high public interest, low risk of interference, and a lack of workable alternatives justifies a grant of the waiver.

B. ABOUT HYDROID

Hydroid, Inc., the waiver applicant, is located in Pocasset, Massachusetts. The company is a subsidiary of Kongsberg Maritime, based in Norway. Kongsberg has 80+ years of experience in maritime electronics, 7,600 employees across 117 offices in 34

countries, and products installed on 30,000 vessels. Kongsberg's technology leads in advanced marine robotics, specifically autonomous underwater vehicles, for applications including marine research, commercial, and defense. Kongsberg is a market leader in:

- dynamic positioning;
- vessel motion sensors;
- positioning reference sensors;
- marine robotics.

Kongsberg also has strong competence and market share in maritime automatic identification systems, differential GPS, vessel traffic service, navigation bridge systems, maritime power and control systems, hydrographic sensors, and underwater positioning.

Hydroid will be among the companies that market Kongsberg's Maritime Broadband Radio system in the United States.

C. ABOUT MARITIME BROADBAND RADIO

Kongsberg uses phased-array real-time steerable antennas for broadband communication between vessels, and between vessels and fixed points on shore. The system has both commercial and government uses.

1. Examples of applications

Some of the maritime operations that will benefit directly from high-capacity, real-time communications are:

- Autonomous Surface Vessels ("self-driving ships")—data link for command, control, and sensor data;
- hydrographic survey prior to and during dredging of ports and waterways;
- remote inspection of underwater pipelines and other underwater installations;
- monitoring marine life;

- oil and gas exploration;
- scientific research—environmental study of the ocean;
- communications during search and rescue operations;
- fishery research—biomass and sustainability;
- tracking of unmanned underwater vehicles;
- dock and harbor inspections;
- monitoring sediment in river outlets for safe navigational passages.

Long-range line-of-sight communications with broadband capabilities will also facilitate seismic operations, which sometimes use 10,000 meter cables and a spread of several kilometers. Having work boats and chase boats on the same network allows fast action when needed: man overboard, vessel capsizing, vessel sailing into the streamer, etc. Substantial range is also needed for:

- oil spill operations—especially in large fields such as the Gulf of Mexico;
- use in large harbors for work boats, platform supply vessels, and crew vessels to and from oil fields;
- data transfer to and from widely dispersed scientific buoys, which can require real-time sharing of data across multiple land-based and sea-based platforms.

The increasing use of unmanned vessels requires a fast, stable data link for vessel telemetry, navigation, and control, and real-time video for safe operations. Even manned vessels often have advanced sensors that require fast data availability for remote monitoring and operation.

2. Technical specifications

Prior to modification for use under the waiver, the basic radio is software tunable over the frequency range 4900-5900 MHz. Radios marketed under the waiver will have a locked EPROM that limits transmissions to 5725-5850 MHz (U-NII-3 band). The frequency range cannot be

altered in the field—not by the installer, the end user, the application, or normal software upgrades.

Designed specifically for maritime operations, the radio provides IP connectivity. Each unit operates on a single 20 MHz channel bandwidth in half-duplex TDMA mode. Multiple nodes can operate in the same network through spatial addressing (antenna aiming) and sequential TDMA transmissions. Each communication is between two points, with no simultaneous point-to-multipoint applications.

The wireless bit rate is 20 Mbps over a 20 MHz channel. Payload throughput available to users is 16.5 Mbps.

Maximum conducted transmit power is 1 W. Across the product family, antenna arrays range from 4 to 76 elements. Antenna gains vary between 6 and 24 dBi. Typical operating EIRPs are in the range of 36-54 dBm. Always-on, adaptive power control limits the transmit power at each instant to the minimum needed for communication.[1]

3. Antenna tracking

The use of high-gain, narrow-beam antennas for point-to-point communications between moving vessels requires the transmit antenna to first locate the intended receive antenna, and then to continuously re-aim both antennas to track the relative motions between the two. See the Attachment for details.

D. REQUEST FOR WAIVER

Section 15.407(a)(3) provides, in part:

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[1] The wireless headers exchange information on received link margin, so that each transmitter can continuously reduce its power to the minimum needed to maintain a target margin. The system can operate with a target link margin of up to 20 dB and a maximum reduction of 25 dB. Typical link margins are about 8 dB.

> [F]ixed point-to-point U-NII devices operating in this band [5.725-5.85 GHz] may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power.[2]

Hydroid seeks a waiver so as to use directional gains in excess of 6 dBi, without reducing transmitter power, for two-way communications between vessels, and between shore points at fixed locations and vessels, under the conditions described here.

The system complies with all other applicable Commission rules, including limits on out-of-band emissions.

Useful range with and without the waiver

The worst conditions for propagation are a calm, flat sea, which produces well-ordered signal reflections off the water and multipath interference at the receiver. This "sea fading" can amount to 30 dB. Taking it into account, along with free-space propagation loss, the useful range for reliable communications in good weather without the waiver (*i.e.*, with a maximum EIRP of 36 dBm) is about 1.2 km. With the higher EIRP available under the waiver, communication with the same link margin extends to 9 km—approximately a seven-fold increase in range. Bad weather reduces sea fading, and hence increases the potential range, but it also increases rolling, pitching, and vessel obstructions. Over a wide set of weather and ocean conditions, the higher EIRP under the waiver consistently increases the reliable range by about the same factor of seven.

E. PUBLIC INTEREST

The applications listed in Part C.1 above include several that directly promote the safety of life and property: search and rescue, man-overboard alerts, oil spill management, and the like.

[2] 47 C.F.R. § 15.407(a)(3).

Others further scientific research in oceanography and marine life. Still others have immediate economic benefits, such as the use of autonomous vessels for undersea inspection of pipelines and harbor facilities.

There are no adequate alternatives. Offshore vessels today must rely on satellite communications or, if close enough to land, commercial LTE service. These have limited data speeds, and also become prohibitively expensive when handling large amounts of data. Some scientific applications must transport several gigabytes per day, exceeding all but the most costly data caps. The latency inherent in LTE and satellite data communications raises concerns for some safety-critical applications, such as steering autonomous vessels through congested waterways. Moreover, some end users are reluctant to trust safety-critical communications to a third party, whose traffic management and outage restoration priorities may not match the user's needs.

The U.S. military has shown interest in the Hydroid/Kongsberg technology, seeing advantages in private network, off-grid communications with highly directional, steerable links that can provide resilience and resistance to interception.[3] Grant of a waiver will enable military users to deploy these systems quickly, bypassing the time-consuming NTIA spectrum approval processes by invoking Section 7.8(1) of the NTIA Redbook.[4]

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[3] Pending experimental application file no. 0357-EX-CN-2019 seeks authority to operate the system described here in support of U.S. Navy and Marine Corps Advanced Naval Technology Exercise 2019 at Camp Lejeune, NC, in mid-July. The exercise will explore "command and control, force protection, tactical diction within littorals, operational distribution to the littoral, cross-domain mobility, signature management and deception, logistical support, and medical," according to a federal solicitation notice. Each such exercise culminates in a field demonstration phase where emerging technologies are assessed and evaluated by engineers, scientists, Marines, and sailors.

[4] "Federal Government agencies may, without further authority from the Assistant Secretary, purchase 'off-the-shelf' non-licensed devices that conform to the applicable edition of

There will be little or no additional risk of interference to offset these benefits. Every link path will be over open water, where there are few potential interference victims. To achieve the necessary range, land locations must be near the coast, typically in sight of the water, sited to avoid any structures between the antenna and the water, which largely eliminates any risk of interference to land-based residences or businesses. Even on the water, the combination of narrow, steerable beams and adaptive power control will minimize the areas exposed to interference. The probability is low that a highly directional transmit beam will align with an interference victim's receiver beam. Only one radio in a network transmits at a time, creating a low transmit duty cycle, which further reduces the probability of interference.

F. WAIVER STANDARD

"Good cause … may be found and a waiver granted 'where particular facts would make strict compliance inconsistent with the public interest.'"[5] That is the case here.

The Commission assesses waiver requests according to the standards set out in *WAIT Radio v. FCC*.[6] In that case, as here, the applicant sought to operate in contravention of the rules while explaining how it would nonetheless accomplish the purpose of the rules.[7] The court required the Commission to consider the request:

Part 15 of the Federal Communication Commission's (FCC) Rules and Regulations (47 CFR, Part 15) or non-licensed devices for which the FCC has granted a waiver of specific requirements of Part 15. …" *Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook)* at § 7.8(1) (Sept. 2017 rev. of the Sept. 2015 ed.) (emphasis added).

5 *SafeView, Inc*., 25 FCC Rcd 592 at ¶ 15 (2010), *citing Northeast Cellular Telephone Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

6 418 F.2d 1153 (D.C. Cir. 1969). *See also 2002 Biennial Regulatory Review*, 18 FCC Rcd 13620 at ¶ 85 n.130 (2003) (citing *WAIT Radio* as setting out criteria for waivers of Commission rules.)

7 WAIT Radio operated an AM broadcast station. It was limited to daylight hours so as to afford protection to "white areas" that had no local service, and that relied on nighttime skywave

> [A] general rule, deemed valid because its overall objectives are in the public interest, may not be in the "public interest" if extended to an applicant who proposes a new service that will not undermine the policy, served by the rule, that has been adjudged in the public interest.[8]

The meaning is clear: Waiver is appropriate where the applicant furthers the public interest inherent in the underlying rule.

The waiver requested here meets the *WAIT Radio* standard: it proposes a "new service" that will not undermine the policy served by the rule. That policy serves to protect other U-NII users from interference. Kongsberg's Maritime Broadband Radio accomplishes that through other means, described in the preceding section. The requested waiver fits easily into the boundaries drawn by *WAIT Radio*.

The Court of Appeals emphasized the importance of waiver procedures as part of the regulatory scheme:

> The agency's discretion to proceed in difficult areas through general rules is intimately linked to the existence of a safety valve procedure for consideration of an application for exemption based on special circumstances.[9]

Thus, it said, "allegations such as those made by petitioners, stated with clarity and accompanied by supporting data . . . must be given a 'hard look.'"[10]

Here, too, the request fully qualifies. The "safety valve" of the waiver procedure is needed to make available an important tool that will bring safety, operational, and economic benefits to maritime radio. The requested waiver is in the public interest, not only in terms of

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propagation from another station. WAIT Radio proposed to transmit at night using a directional antenna that would limit its signal in the white areas. *WAIT Radio v. FCC*, 418 F.2d at 1154-55.

8 *WAIT Radio v. FCC*, 418 F.2d at 1157.

9 *Id.*

10 *Id.* (citation footnote omitted).

benefits to the public, but also in the absence of any likely increase in interference. The request is entitled not only to the "hard look" mandated in *WAIT Radio,* but to a grant of the waiver.

G. PROPOSED WAIVER CONDITIONS

To ensure adequate interference protection, we propose the following waiver conditions:

1. Maritime operation only: between vessels, and between vessels and land; no land-to-land applications under the waiver.
2. Requirement for always-on adaptive power control.
3. No sales to consumers.
4. Not to be used for cruise ship passenger communications.
5. Integral, non-replaceable antennas; no antennas used other than those tested with the transmitter for certification.
6. U.S. sales to non-governmental customers not to exceed 200 units per year for five years.

CONCLUSION

The requested waiver offers substantial public interest benefits, balanced against a very low risk of added interference. We ask the Commission to consider and grant the waiver expeditiously.

Respectfully submitted,

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ATTACHMENT

Antenna Tracking

To send to a unit at an unknown location, a transceiver emits a sequence of 16-32 very short symbols (100 μs each) in different directions, each with a beamwidth of approximately 9 degrees. When the intended transceiver responds, the originating unit evaluates the incoming phases and amplitudes across 60 individual receiver circuits in massive-parallel-processing chips, and uses that information to extract the intended receiver's location. The entire search process takes less than 5 ms. Thereafter, both transceivers evaluate the others' phases and amplitudes on each received wireless frame so as to continuously update the others' location, and thereby keep their antennas closely aligned, notwithstanding the relative motions of the vessels, for the duration of the two-way communication. The search process restarts only when a transceiver seeks to initiate a new transmission after there has been no data flowing for a set time.

TECHNICAL CERTIFICATION

I am a technically qualified person who contributed to and/or reviewed the foregoing Request for Waiver. I certify that the technical statements therein are correct to the best of my knowledge.

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