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22 January 2015

VIA ECFS

Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Re: *Wireless E9-1-1 Location Accuracy Requirements*, PS Docket No. 07-114

Dear Ms. Dortch:

T-Mobile USA, Inc. ("T-Mobile"), submits this letter in response to filings by NextNav, LLC[1] and TruePosition, Inc.[2] in the above-referenced docket. Establishing compliance metrics for indoor location accuracy for wireless E911 calling has been one of the Commission's goals for several years. But that task has been stymied by the difficulty of measuring indoor compliance. For instance, it has long been clear that widespread local-level compliance testing, of the kind used for outdoor location accuracy compliance, is simply not feasible for indoor location assessment.[3] Over the years, various entities have proposed using a test bed approach to evaluate indoor performance,[4] though more recently, public safety has focused on the use of actual live call data.

In developing the Roadmap, APCO, NENA and the four nationwide carriers determined that a combination of test bed measurements and live call data would provide the best means of measuring indoor location accuracy. The Roadmap therefore proposes using a test bed to evaluate the performance of various technologies for estimating indoor locations, while also providing live call data to show the percentage of time each technology is used to provide location information for a wireless E911 call.[5] The supplemental proposal by the four

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1 Letter from Bruce A. Olcott, Counsel for NextNav, LLC, to Marlene H. Dortch, Secretary, FCC, PS Docket No. 07-114 (Jan. 22, 2015).

2 Letter from James Arden Barnett, Counsel for TruePosition, to Marlene H. Dortch, Secretary, FCC, PS Docket No. 07-114 (Jan. 21, 2015).

3 *See, e.g.*, ATIS, *Approaches to Wireless E9-1-1 Indoor Location Performance Testing*, ATIS-0500013 at 27 (Feb. 23, 2010) ("ATIS-0500013"); CSRIC III, Working Group 3 Indoor Test Bed Report, at 52, PS Docket No. 07-114, (filed May 14, 2013 ("CSRIC III WG 3 Report").

4 *See, e.g.*, ATIS-0500013; CSRIC III WG 3 Report.

5 Letter from Scott Bergmann, CTIA—The Wireless Association, to Marlene H. Dortch, Secretary, Federal Communications Commission, §§ 1(a)(ii), 4(a), PS Docket No 07-114, (filed Nov. 18, 2014) ("Location Accuracy Roadmap").

nationwide carriers and endorsed by APCO and NENA helps strengthen and make more concrete that plan.[6]

Using live call data is superior to drive testing and to a pure test bed approach because such data allows the Commission and public safety to review the actual yield of heightened location technologies. That said, the use of live call data necessarily presents "an indistinguishable blend of indoor and outdoor emergency calls"[7] because there is simply no way to extrapolate from such data which calls were placed from indoors and which from outdoors. In many locations, even in dense urban city centers, a 50 meter radius from a particular indoor location will encompass both indoor and outdoor locations.

T-Mobile understands and supports the Commission's goal of providing transparency on the extent of indoor locations and the performance of indoor locations. Some have suggested an approach establishing an "indoor only" compliance metric intended to allow evaluation of location technology performance indoors and suggesting that location estimates provided by satellite technologies might be treated as "outdoor only" in furtherance of that goal. But such a distinction would be wholly arbitrary, as it is without rational justification in the record; indeed, the record reflects precisely the opposite of what such a distinction assumes. Satellite-based location technologies provide location estimates outdoors and indoors; the same is true for the non-satellite technologies that would be permitted in such a compliance scheme. Excluding each set of technologies from either indoor or outdoor compliance measurements would do nothing more than establish an arbitrary and capricious distinction[8]—one that would not only fail to provide an adequate picture of actual performance, but that would also be likely to have a detrimental effect on location accuracy improvement overall.

T-Mobile encourages the Commission to instead adopt a compliance benchmark that accounts for the use of blended live call data, such as that set forth in the Roadmap.

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[6] *See* Letter from AT&T Services, Inc., Sprint, T-Mobile USA, Inc., and Verizon, to Marlene H. Dortch, Secretary, FCC, PS Docket No. 07-114 (Jan. 21, 2015).

[7] Letter from Bruce A. Olcott, Counsel, NextNav, LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, at 1-2, PS Docket No. 07-114 (filed Jan. 24, 2014) ("NextNav Ex Parte"); *see also* Letter from H. Russell Frisby, Jr., Counsel, TeleCommunications Systems, Inc. ("TCS"), to Marlene H. Dortch, Secretary, Federal Communications Commission, at 2, PS Docket No. 07-114 (filed Jan. 16, 2014) ("TCS Ex Parte').

[8] *See Alliance for Cannabis Therapeutics v. DEA*, 930 F.2d 936, 940 (D.C. Cir. 1991); *see also Nuvio Corp. v. FCC*, 473 F.3d 302, 303 (D.C. Cir. 2006).

I. THERE IS NO RATIONAL BASIS FOR EXCLUDING SATELLITE-BASED HORIZONTAL LOCATION ESTIMATES FROM A MEASURE OF OR PROXY FOR INDOOR LOCATION ACCURACY COMPLIANCE.

A. Undisputed Record Evidence Shows that A-GPS Provides a Substantial Number of High Accuracy Location Estimates for Indoor 911 Calls.

The record evidence clearly shows that Assisted-Global Position System ("A-GPS") location estimates are available for both indoor and outdoor calls. In fact, record evidence shows that an A-GPS location estimate is available for approximately 80 percent of E911 calls that last for more than 30 seconds.[9] Although we do not know the exact percentage of wireless 911 calls that are made from indoors, it is certainly higher than 20 percent—indeed, in last year's FNPRM, the Commission cited two studies indicating that a majority of wireless calls are placed from indoors, and up to 70 percent of wireless 911 calls are placed from indoors.[10]

Assuming 70 percent of wireless 911 calls are made from indoors, we can estimate that at least 56 percent of indoor calls get an A-GPS fix—and that is true even if all outdoor calls get an A-GPS fix. Even if the percentage of indoor calls is lower—say, 60 percent—it would still be the case that a *majority* of indoor 911 calls are receiving an A-GPS location fix. This is far more than a *de minimis* number of indoor calls with an A-GPS location fix, and thus cannot reasonably be ignored. Furthermore, both the percentage of wireless calls getting an A-GPS fix (*i.e.*, A-GPS yield)[11] and the percentage of wireless calls made from indoors are increasing over time[12]—leading to the reasonable conclusion that an even higher percentage of A-GPS fixes will be made indoors in the future. The use of additional satellite constellations (such as GLONASS) will move this indoor Assisted-Global Navigation Satellite System ("A-GNSS") metric even further.

Indoor % of All Wireless Calls	A-GPS % of All Wireless Calls	Outdoor % of All Wireless Calls	A-GPS % of Outdoor Calls	A-GPS % of Indoor Calls
75%	80%	25%	100%	60%
70%	80%	20%	100%	56%
65%	80%	35%	100%	52%

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9 *See* Letter from Scott K. Bergmann, Vice President – Regulatory Affairs, CTIA—The Wireless Association, to Marlene H. Dortch, Secretary, Federal Communications Commission, at 2, PS Docket No. 07-114 (filed Jan. 14, 2015) (collecting citations) ("CTIA Ex Parte").

10 *Wireless E911 Location Accuracy Requirements*, 29 FCC Rcd. 2374, ¶ 29 & n.64 (2014) ("*FNPRM*") (citing J.D. Power & Associates study; Letter from San Francisco Dep't of Emergency Mgmt.).

11 *See* Letter from John T. Nakahata, Counsel, T-Mobile USA, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, PS Docket No. 07-114 (filed Sept. 27, 2013) (Observing that A-GPS yield from all live 911 calls over 30 seconds is not only high, but increasing over time, despite the possible increase in 911 calls originating from indoors.) ("T-Mobile Sept. 2013 Ex Parte").

12 *FNPRM* ¶ 29.

Moreover, when A-GPS estimates are available, a very high percentage are within 50 meters.[13] And that performance is slated to improve, both as to yields and as to accuracy, as carriers add the ability to access measurements from other satellite constellations.[14] In fact, one study suggests that indoor A-GNSS performance can be improved by up to 200 percent with the addition of a single additional satellite constellation.[15] This means that it is likely that the percentage of indoor calls with highly accurate satellite-based location estimates will only continue to increase.

Given the overwhelming evidence that A-GPS *does* work indoors—and in fact likely provides a "heightened accuracy" location estimate for a majority of indoor calls—it would be arbitrary and capricious to ignore satellite-based estimates for indoor location accuracy compliance purposes. The Commission must not "ignore the past when the past relates directly to the question at issue" when making a decision based on a predictive judgment.[16]

B. It Is Irrational to "Count" All Non-Satellite Based Location Estimates as if They Were from Indoor Locations.

Carriers today measure the location accuracy of outdoor calls through controlled drive-tests that receive location fixes from both satellite and non-satellite technology. In fact, in some locations—as long recognized by the FCC—a satellite-based location fix is not possible, including urban canyons, rural canyons, and areas of heavy forestation.[17] In these areas, high accuracy location estimates, when they can be obtained, are provided using non-satellite based location technologies. The use of non-satellite technologies in these circumstances is well-known and acknowledged in the record.[18]

In addition, technology vendors tout non-satellite technologies for both indoor and outdoor location accuracy improvements. For instance, TruePosition continues to claim that its

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[13] *See* Letter from Steve B. Sharkey, Chief Engineering and Technology Policy – Federal Regulatory, T-Mobile, to Marlene H. Dortch, Secretary, Federal Communications Commission, PS Docket No. 07-114 (filed Aug. 18, 2014); Letter from Bruce A. Olcott, Counsel, NextNav, to , to Marlene H. Dortch, Secretary, Federal Communications Commission, PS Docket No. 07-114 (filed May 12, 2014) (attaching a study concluding 67% of the 2D errors were within 24 meters and 80% were within 36 meters, with a very high aggregate yield rate (96%) over all of the test conditions.). T-Mobile's own data show that, between January and June 2014 in Washington, D.C., it made available to PSAPs an A-GPS estimate within 50 meters for 90.9 percent of calls. In San Francisco, between January and August of 2013, it made available to PSAPs an A-GPS estimate within 50 meters for 87.4 percent of calls.

[14] *See* TCS Ex Parte, Attachment at 12.

[15] *See id.* at 1-2.

[16] *BellSouth Telecommunications, Inc. v. FCC*, 469 F.3d 1052, 1060 (D.C. Cir. 2006).

[17] *See, e.g.*, *Wireless E911 Location Accuracy Requirements*, 25 FCC Rcd. 18,909, ¶¶ 19-29 (2010).

[18] *See id.*

non-satellite technology will improve overall performance, not just indoor performance.[19] Of course, TruePosition's indoor performance claims are unproven, but the record reflects that non-satellite technologies are used in every environment. And as carriers move to Voice over Long Term Evolution ("VoLTE"), the use of non-satellite technologies for outdoor location estimates is likely to increase, as the VoLTE standard allows the simultaneous launch of satellite and non-satellite location estimates, and the selection of the best result. Thus, where VoLTE has been deployed, carriers planning to implement Observed Time Difference of Arrival ("OTDOA") (which includes all Roadmap signatories) would launch both OTDOA and A-GNSS, as well as other location estimating techniques such as Dispatchable Location, for every call, including both indoor and outdoor, allowing non-satellite-based technologies to provide high accuracy locations for many outdoor calls. The result is that the an indoor compliance metric that would look only to results provided by non-satellite technologies would itself actually be a blended measure of indoor and outdoor performance for those calls.[20] Given this reality, it would be arbitrary and capricious to treat all non-satellite-based calls as if they were calls from indoor locations when that will clearly not be the case.

C. Excluding Satellite-Based Locations from a Measure or Proxy for Indoor Location Accuracy Compliance Irrationally Disincents Improving the Percentage of Satellite-Based High Accuracy Estimates.

There are additional problems with any proposal to disallow the use of A-GPS for indoor compliance, including that doing so will disincent carriers from making continued improvements to one of the most valuable location technologies available during a time when key improvements are coming online.

One such enhancement is the adoption of A-GNSS technology wherein carriers use measurements from additional satellite constellations to improve location estimates. As recently noted by TCS, adoption of A-GNSS (adding an additional satellite constellation to satellite-based location technologies) "can generate over two-times improvement in location accuracy."[21] But under the Commission's proposal, if a carrier instituted A-GNSS improvements that substituted a 25 meter uncertainty A-GNSS estimate for a 45 meter "non-satellite" estimate, the carrier could actually end up worse off from a compliance perspective. In that scenario, while an indoor A-GNSS location fix would typically be much more accurate than the non-satellite estimate, the A-GNSS fix would not be counted for compliance purposes. In this situation, carriers might, quite rationally, choose not to invest in improvements to satellite technologies that would have, at best, no effect and, at worst, a negative effect on a carrier's compliance. Furthermore, counting only the non-satellite estimate—with its higher uncertainty factor—would reduce the carrier's overall

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[19] *See, e.g.*, TruePosition Comments in Response to Phone Company Plan, at 14, PS Docket No. 07-114 (filed Dec. 15, 2014) ("if the carriers installed a mere 400 UTDOA receivers at their own cellsite locations they would have blanket E911 coverage throughout essentially all of Manhattan") ("TruePosition, Inc. Comments on Roadmap"); Comments, at 7, PS Docket No. 07-114 (filed May 12, 2014) ("[UTDOA] works well both indoors and outdoors in most urban and suburban environments") ("TruePosition May 2014 Comments").

[20] CTIA Ex Parte at 2.

[21] TCS Ex Parte at 2.

reported accuracy. The results would be detrimental to actual location accuracy performance and the public interest. Thus not only would a technology-specific compliance regime be counter to the record evidence regarding use of those technologies, but it would also undermine the public interest rationale for implementing new indoor location accuracy rules. This would be irrational.

D. Given the Assumed Large Percentage of Indoor 911 Calls, "Blended" Live Call Metrics Will Not "Mask" Low Levels of High Accuracy Indoor Call Estimates.

A technology-specific metric may appear to address concerns that "blended" indoor/outdoor metrics will allow excellent outdoor performance to "mask" poor indoor performance. But such concerns are disproven by the simple arithmetic, leaving such a proposed metric without rational justification. For example, at the Roadmap's ultimate benchmark for 80 percent of live calls to have a blended "heightened accuracy" (*i.e.*, dispatchable location, A-GNSS, or accuracy of 50 meters or better) determined from test results, and assuming both that 65 percent of calls come from indoors and that 100 percent of outdoor 911 calls get a "heightened accuracy" result, at least 69 percent (*e.g.*, over 67 percent, the proposed 2-year benchmark) of indoor calls would have to have "heightened accuracy" test bed performance. Notably, as the percentage of assumed indoor calls goes up, so does the percentage of indoor calls that must get a "heightened accuracy" estimate. This means that, under the Commission's stated assumption that indoor wireless calls will only increase, the percentage of indoor calls that must get a "heightened accuracy" fix will also increase—up to 73 percent of such calls, assuming indoor wireless calls reach 75 percent of all calls.

Total Blended Performance Benchmark for 911 Calls with Location Estimates <=50m	**Outdoor Calls as a % of All 911 Calls**	**Percentage of Outdoor 911 Calls with Location Estimates <=50m**	**Indoor Calls as % of All 911 Calls**	**Percentage of Indoor Calls with Location Estimates <= 50 m to Achieve Blended Performance Benchmark**
80%	25%	100%	75%	**73%**
80%	30%	100%	70%	**71%**
80%	35%	100%	65%	**69%**

Of course, the converse is also true: if indoor calls are a lower percentage than the Commission has presumed, outdoor performance will "weigh" more in the blended results, allowing for a compliant blended measurement despite indoor performance that does not meet the 67 percent benchmark. But in that case, the Commission would be obligated to reconsider the scope of the so-called "indoor problem." The public interest benefits in imposing a new indoor location mandate on carriers is premised on the assumption that indoor wireless 911 calls are a substantial percentage of all wireless 911 calls. If that premise is unfounded, the Commission must reconsider any proposal designed to address that premise.

II. THERE IS NO RATIONAL BASIS FOR EXCLUDING ANY TECHNOLOGY THAT GENERATES 50 METER OR BETTER HORIZONTAL LOCATION ACCURACY FROM THE COMPLIANCE ANALYSIS.

To the extent that some location technologies that do not meet an arbitrary threshold for 50 meter or better accuracy in an indoor test bed may be excluded from compliance evaluations under an "indoor" accuracy metric, that would also be arbitrary and capricious. A "heightened accuracy" location estimate is a "heightened accuracy" location estimate, regardless of the technology used to generate the estimate.

If the Commission were to adopt such an exclusion and ignore estimates created by technologies with fewer than, for instance, 50 percent of location estimates within 50 meters, and if OTDOA (or any other technology) for some reason did not meet the required threshold percentage of test bed calls within 50 meters, the Commission would then ignore all "heightened accuracy" estimates generated by OTDOA in determining compliance, solely because OTDOA did not meet an arbitrary threshold in a test bed. This would even be true when the ignored "heightened accuracy" estimates had uncertainty estimates (determined at 90 percent confidence) well below 50 meters (*e.g.*, 20 meters). Of course, that estimate—20 meters at 90 percent confidence—would give a PSAP answering the call a very high degree of confidence that the caller was at or close to the estimated location. But the Commission would nevertheless ignore that estimate entirely for compliance purposes.

It is simply irrational to pretend that such "heightened accuracy" location estimates do not exist, simply because other location estimates provided by that technology might not be as accurate. And this exclusion cannot be justified on the grounds that PSAPs would not rely on less reliable technologies. First, PSAPs do not control the technology used to generate an estimate for a given call. The carrier provides the most accurate information available. Second, PSAPs can utilize for each call an estimated uncertainty, which indicates to the PSAP the likelihood that the caller is close to the estimated location—and which is given for every Phase II estimate transmitted, irrespective of the technology used. Thus, a PSAP has no need to distinguish between a highly accurate estimate from a technology that is arbitrarily deemed less reliable and a highly accurate estimate from a more reliable technology.

III. THERE IS NO RATIONAL BASIS FOR A PREDICTIVE JUDGMENT THAT CARRIERS CAN MEET 3 METER VERTICAL LOCATION ACCURACY THROUGH BAROMETRIC PRESSURE MEASUREMENTS OR SOLUTIONS OTHER THAN DISPATCHABLE LOCATION.

The Commission cannot issue requirements that are technically infeasible; to do so is arbitrary and capricious.[22] The Commission must base a predictive judgment that compliance will be technically feasible on more than mere speculation.[23] Moreover, the Commission cannot simply ignore technical and scientific evidence that raise significant questions as to whether it

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[22] *See Nuvio*, 473 F.3d at 303; *Cannabis Technologies*, 930 F.2d at 940.

[23] *BellSouth*, 469 F.3d at 1060.

would be technically feasible to achieve vertical location accuracy in all indoor environments within 3 meters.[24] But that is precisely what is at risk with respect to z-axis compliance. As of today, there is no evidence that barometric pressure sensors in wireless handsets can generate 3 meter z-axis fixes in all indoor environments. To the contrary, there is substantial evidence that, while barometric pressure sensors may be viable for high accuracy vertical location at some point in the future, they are today largely untested, not incorporated into E911 location standards, and far from wide-spread integration into wireless handsets and networks.

Though NextNav touts its z-axis performance in the CSRIC III test bed, the Commission must remember that the CSRIC III test bed did not test z-axis location performance under conditions that would most challenge barometric pressure-based methods.[25] In addition, the z-axis information generated by NextNav network was not obtained from a production handset but rather from a prototype "sleeve" connected to the handset.[26] Even with these substantial caveats, NextNav was unable to meet a 3 meter, 67 percent vertical accuracy standard in all indoor morphologies—including a standard deviation of over 9 meters and a maximum vertical error approaching 200 meters in the urban morphology.[27] Given these observations, it would be arbitrary and capricious for the Commission to rely on the CSRIC III test bed data to impose a near-to-mid-term 3-meter z-axis benchmark, particularly given the other information in the record.

For instance, it is simply unclear whether z-axis information is viable at all. Various sources cited in the record make different predictions about the viability of z-axis information from barometric pressure sensors. For instance, iPosi points out that only one barometric pressure sensor vendor claims absolute accuracy capable of meeting the 3-meter requirement, but that "even this low absolute error value virtually exhausts the 3 meter error budget, a budget that must include other sensor accuracy and indoor air-column effects."[28] T-Mobile has provided a sworn declaration from Dennis Roberson highlighting similar concerns related to margins of error, the stack effect, and calibration, which have been raised in the existing technical literature.[29] At the same time, NextNav argues that the datasheets provided by sensor vendors are "conservative" and that the performance of such sensors likely exceeds the information provided on those datasheets.[30] But it provides no evidence that that is the case other than the results of its own testing under very limited conditions.

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[24] *See., e.g., Motor Vehicle Manufacturers Assn. of the U.S. v. State Farm Mutual Auto Ins. Co.*, 463 U.S. 29, 43-44 (1983).

[25] *See generally* CSRIC III WG 3 Report.

[26] CSRIC III WG 3 Report at 42, 54 (noting that "Technical performance of some position methods was determined in the test bed using non-production form factor hardware." and that "Care must be exercised in applying these results to production handsets").

[27] CSRIC III WG 3 Report at 36.

[28] Comments of iPosi, Inc., at 16, PS Docket No. 07-114, (filed May 12, 2014) ("Comments of iPosi, Inc.").

[29] T-Mobile USA, Inc. Reply Comments on Third FNPRM on Location Accuracy, Exhibit 2, PS Docket No. 07-114, (filed July 14, 2014) ("T-Mobile Roberson Declaration").

[30] Reply Comments of NextNav, LLC, at 18, PS Docket No. 07-114 (filed July 14, 2014).

Similarly, the Commission must have a reasonable basis for its prediction that compliance can be achieved by the compliance deadline it sets, and cannot simply ignore contrary evidence. In the case of barometric pressure sensors, no standards work has been completed for their use for E911, so there is no sense of how such sensors and the information they generate will be used in production handsets, in wireless networks, and in the emergency communications ecosystem. In short, there is no rational basis for concluding that barometric pressure altitude estimation methods can be deployed in carrier networks and handsets sufficient to meet a 3 meter benchmark in 3 years or even 6 years.

Equally critically, there is no evidence in the record that z-axis information in the form of absolute altitude measurements will have any utility for PSAPs. It is unclear whether barometric pressure sensors can generate sufficient z-axis vertical measurements to provide any utility to PSAPs and it is unknown whether additional infrastructure will be needed to allow PSAPs to use this information. Such additional infrastructure could include building a reference network for calibration including possibly placing reference sensors inside buildings—a significant undertaking—or generating floor maps and other reference materials to allow PSAPs to convert an absolute altitude measurement into an accurate building floor reference. Reverse geocoding would also be required and represents yet another source of potential error for these estimates. T-Mobile questions whether adoption of a compliance obligation to generate information without any evidence that such information can be used by the agency or public safety would be approved by OMB.

In contrast to the many open questions about the utility of absolute altitude measurements to PSAPs, the dispatchable location solution proposed by the carriers ensures that PSAPs receive an actual street address with floor and/or unit information if applicable, without any need for conversion or equipment changes reverse geocoding. And there are no open questions about how the dispatchable location solution works—the only open questions relate to who will maintain the NEAD.

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T-Mobile is committed to working with the Commission and public safety to improve wireless E911 location accuracy—including indoors. But the proposals described herein will not result in improvement. Any mandate that excludes satellite-based location fixes from indoor compliance measurements, completely excludes location estimates from any technology that does not meet an arbitrary threshold in testing, and that requires adoption of unproven and non-standardized z-axis technology in a short time frame that cannot possibly be met would be an abuse of discretion. T-Mobile urges the Commission adopt rules that reflect the consensus benchmarks and milestones set forth in the Roadmap.

Respectfully submitted,

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