February 27, 2003 **ET Docket No. 02-135**

Reply Comments on the FCC's
Spectrum Policy Task Force Report
FCC 02-322

I. Introduction and Background

The Short Range Automotive Radar Frequency Allocation Group ("SARA")[1] applauds the FCC's decision to analyze and assess proactively its rulemaking *methods and philosophy* as they pertain to the impact those methods have on the development of emerging electro-technologies, as embodied by the Spectrum Task Force Report, FCC 02-322 (the "Report"). SARA is pleased to submit comments on the Report from the perspective of an organization whose members are bringing radar technology to the public for the purpose of improving road safety.

The Report is concerned with a broad range of spectrum management issues and suggests methods for addressing those issues. Consistent with the Report's goals, these reply comments are intended to be general in nature and should not be construed to apply to any particular frequency band. SARA believes that, in view of existing market realities, the FCC should allow spectrum users a reasonable period of time to develop and deploy their products and services before considering changes to existing frequency allocations. However, SARA recognizes the Commission's need to periodically review its frequency allocations to determine whether they continue to serve the public interest and promote spectrum efficiency. Therefore, nothing in these reply comments should be construed as suggesting that any specific frequency band or bands should be used in perpetuity for any application, including vehicle radar, or that any frequency band should be exclusively used for any purpose. We strive here to address the Report, which discusses spectrum management philosophy and policy, and not specific frequency allocations.

[1] SARA is made up of the following automotive component manufacturers: *A.D.C., Bosch, Delphi Automotive Systems, Hella, InnoSent, Megamos, Siemens VDO, TRW, Tyco Electronics, Valeo* and *Visteon.* It also includes the following automobile manufacturers: *Audi, BMW, DaimlerChrysler, Fiat, Ford, General Motors, Jaguar, MAN, Opel, Porsche, PSA Peugeot Citroën, Renault, Saab, Seat, Skoda, Volkswagen* and *Volvo.*

The members of SARA are leaders in the advanced development, marketing, and manufacturing of radar systems and radar component technology. The goals of these systems and technology include substantially increasing the effectiveness of automobile and other road vehicle on-board safety systems so as to dramatically decrease the number of deaths and injuries caused by motor vehicle accidents. Currently, operation of vehicle radar systems is permitted on an unlicensed basis in (i) the 76-77 GHz band;[2] (ii) the 22-29 GHz band pursuant to the Commission's ultra-wideband ("UWB") rules;[3] and (iii) the Industrial, Scientific, and Medical ("ISM") bands.[4]

II. The Impact of Motor Vehicle Accidents

According to the National Highway Traffic Safety Administration ("NHTSA"), in 2001 there were over 6,300,000 police-reported motor vehicle accidents in the United States. More than 3,000,000 people were injured in those accidents (approximately one injury per every five seconds) and more than 42,000 people died (approximately one death every 12 minutes). For each of the past ten years, from 1992 through 2001, (i) more than 3,000,000 people have been injured in motor vehicle accidents -- meaning that more than 30,000,000 have been injured in motor vehicle accidents over that period of time; and (ii) more than 40,000 have been killed (except in 1992 when there were 39,250 deaths) -- meaning that more than 400,000 people have died over that period of time from motor vehicle accidents.[5] In addition to the injuries and deaths from motor vehicle accidents, there is enormous property damage resulting each year from such accidents, as well as the incalculable loss of productive time by millions of Americans who are stuck in traffic -- often for hours -- because of motor vehicle accidents.

These statistics are not surprising. Human operators, no matter how conscientious, make mistakes. These mistakes occur due to temporary inattentiveness, judgment errors, decision errors in split second accident situations, and the inability of drivers to see clearly under adverse conditions such as in heavy rain at night. As evidenced by the above statistics, regardless of the amount of training and care taken by drivers, humans cannot be excellent drivers 100% of the time. If these statistics are to be reduced significantly, technology -- such as vehicle radar systems -- must play an important role.

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[2] In 1995, the Commission allocated the 76-77 GHz band for the exclusive use of vehicle radar systems, on an unlicensed basis. "Amendment of Parts 2, 15 and 97 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications," First Report and Order and Second Notice of Proposed Rulemaking, 11 FCC Rcd 4481, ¶¶9-20 (1995) "40 GHz Order."

[3] The Commission's UWB rules provide for the operation of vehicular radar in the 22-29 GHz band using directional antennas on terrestrial transportation vehicles provided the center frequency of the emission and the frequency at which the highest radiated emission occurs are greater than 24.075 GHz. "Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems," 17 FCC Rcd 7435, ¶63 (2002).

[4] To date, most approved vehicle radars use one of the ISM bands. There are numerous ones that have been used by the industry, e.g., those at 5.8 GHz, 10.25 GHz, and at 24.1 GHz. These bands typically have more than adequate power allowances, and insufficient bandwidth allocations. The characteristics of the 24.1 GHz ISM band are well suited for many vehicle radar applications with its 250 MHz bandwidth allowance at 20 milli-Watts allowed EIRP.

[5] National Highway Traffic Safety Administration, "Traffic Safety Facts 2001," December 2002 (DOT HS 809 484), 2001 National Statistics and p. 85.

A. The Call for Intelligent Transportation Systems

Responding to these traffic safety statistics, the U.S. Department of Transportation (DOT) formed the Intelligent Vehicle Initiative (IVI), a segment of the larger DOT initiative called the Intelligent Transportation Systems (ITS) program. The IVI program is a cooperative effort between the Federal Highway Administration (FHA), Federal Transit Administration (FTA), and NHTSA. Through the IVI, the DOT hopes to reduce automobile accidents by helping drivers avoid hazardous mistakes. The IVI aims to accelerate the development and commercialization of vehicle-based driver assistance products that will warn drivers of dangerous situations, recommend actions, and even assume partial control of vehicles to avoid collisions.

IVI has proposed several "driver assistance services" to address eight major problem accident types indicated below (the number indicates percentage of the more than 6 million accidents which were of that type):

- **Rear-end Collision Avoidance (26%)***
- **Lane Change and Merge Collision Avoidance (4%)***
- **Road Departure Collision Avoidance (19%)***
- **Intersection Collision Avoidance (29%)***
- **Other (22%)**
    - **Vision Enhancement**
    - **Vehicle Stability**
    - **Driver Condition Warning**
    - **Safety-impacting Services**

It should be noted that driver warning systems are projected by IVI to be useful in preventing 1.4 million of these types of accidents each year. These systems will depend heavily upon exterior front, side, and rear sensing using radar technology.

III. Vehicle Radar: Existing Applications and Future Applications

Until recently, vehicle radar systems had been used exclusively by government agencies and commercial concerns on large expensive vehicles. However, as a result of tremendous cost reductions in microwave and signal processing electronics components that started in the mid 1980's and continue today, it is now possible to make the benefits of radar widely available to the driving public. As a result, the vehicle radar industry is quickly emerging. Today, tens of thousands of vehicle radars are built and/or fielded every month worldwide. In three to five years, that number will have increased significantly, and the numbers will continue to grow as new applications are identified and become affordable.

With respect to vehicle radar, there are important applications that are already being utilized today, future applications that should be available shortly and future applications that will be available further down the road.

A. Existing Applications of Vehicle Radar

The current applications of vehicle radar that are available in the United States today include Back-up Aid (BUA), Forward Collision Warning, Adaptive Cruise Control, and Side Detection Systems. The BUA gives the driver a warning when he or she is backing the car up towards an object (such as a child) in the vehicle's path. The BUA is already helping to prevent collisions and personal injury. It also assists drivers with parking; the radar provides "room to maneuver" information to the driver that is usually more accurate than the driver can discern alone.

The Forward Collision Warning radar is used in commercial vehicle applications to detect obstacles ahead and in the path of the vehicle. Several levels of audible and visual warnings are provided to the driver to indicate an increasing level of urgency for required action to avoid collision.

With Adaptive Cruise Control, the radar, in conjunction with the standard cruise control feature, maintains a preset headway distance from the vehicle in front of the radar-equipped vehicle, and sustains the cruise set speed as dictated by the driver when the road ahead is clear, all without driver intervention. The radar controls the brakes and throttle of the car directly when engaged. There is a feature embedded in the product that can be used in situations where traffic ahead slows very rapidly, and closing speed becomes too high. In this case, the Adaptive Cruise Control will apply significant braking before an inattentive driver would be able to recognize the need to do so, thus helping to increase the accident prevention and mitigation margin. This feature can also operate with the cruise control disengaged to provide a warning to the driver that he or she is approaching slower-moving traffic.

Side Detection Systems continuously observe the side blind spots that typically evade a driver's view. When an object is located in a blind spot, a clearly visible indicator lights up, allowing a quick glance by the driver to see whether he/she has a clear adjacent lane to make a lane change. Without the Side Detection System drivers must turn their heads and look over their shoulders to verify that the blind spot is clear as part of a lane change maneuver. This causes the driver to look away from the front of the motor vehicle, which can lead to an accident. Side Detection Systems simplify and enhance the safety of lane change maneuvers, especially in heavy rain where visibility through the rear view mirrors is poor.

B. Future Applications of Vehicle Radar

The future applications of vehicle radar that are on the foreseeable horizon include the following: Stop & Go, Forward Collision Warning for Cars, Pre-Crash Sensing, Side Detection System for Cars and Lane Change Monitor.

The Stop & Go application will enable a motor vehicle to follow traffic in front of it, maintaining an appropriate headway distance in very low to moderate speed traffic. This feature will help reduce the possibility of a slow speed rear end crash. The reduced driver load in heavy slow traffic afforded by Stop & Go (taking the driver out of the endless accelerate and brake cycles) will be a welcome removal of a level of stress that many people endure every day. Stop & Go is the first step toward a fully automatic car that has no driver, only passengers.

Pre-Crash Sensing is a system that enhances road safety by continuously reading object position, velocity, and acceleration data from one or more radars, and tests that data for predetermined characteristics of an accident situation. When this situation arises, smart airbags can be configured or deployed,[6] and advanced countermeasures such as seat belt tensioners can be engaged to help mitigate the effects of the collision. In the distant future, brakes and steering will be activated to further help reduce crash severity.

The Lane Change Monitor (see figure 1(b) at Appendix A) serves as an extension of the Side Detection System. Where the Side Detection System only observes areas along side the vehicle that include the vehicle's blind spots and slightly beyond, the Lane Change Monitor will extend that coverage to look farther down adjacent lanes. A rapidly approaching vehicle in an adjacent lane will, therefore, be detected and analyzed by the radar, and potentially dangerous lane changes will be blocked by warning the driver. This application should be especially effective, since fast approaching traffic in an adjacent lane opposite the driver's side is typically not visible to even the most observant driver, and is the source of many collisions.

C. Future Applications of Vehicle Radar that Will Be Available Further Down the Road

Once all of the future applications, including those further in the future, are in place, the radar suite will be able to look in all directions continuously and determine the position and velocity vectors of all objects with any substantial mass or size. The vehicle's safety systems will then be able to determine whether the scenario is dangerous or benign, and respond with appropriate action. At Appendix A (attached hereto), Figure 1 demonstrates a future concept of complete surround safety coverage, as mechanized with high performance radars.

IV. Vehicle Radar's Impact on Society

As the discussion above shows, the benefits of vehicle radar technology could be staggering in terms of safety and efficiency. We believe that the dramatic reductions in death and serious injuries, and savings in property losses, that applications of these new sensors can bring to the public should drive usage to high market penetration. In addition to the safety benefits, the radar sensors provide required remote sensing capabilities to future roadway efficiency systems that help mitigate roadway congestion, saving all parties time, money, and the use of fossil fuels. Once vehicle radar sensors have been on the road for a few years, its numerous benefits will be obvious to many sectors of the public.

The Commission's actions with regard to this industry will have a significant impact on the timing and extent of the benefits these systems will provide to the public. Vehicle radar can only reach its full potential if it is widely available to the public.

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[6] "Smart Air Bags" is a large class of more capable air bag systems than those in cars today. They re-configure themselves, depending on numerous factors, to deploy with more or less force and at different times as appropriate. In addition, they could, in certain circumstances, inflate prior to the occurrence of an accident.

V. A Hybrid Spectrum Management Model Is Appropriate for the Regulation of Vehicle Radar Devices

In its Report, the Spectrum Policy Task Force recognized that "the Commission may find it beneficial to incorporate elements from more than one model" of spectrum management when analyzing the regulatory approach "for any given spectrum band or proposed use."[7] As demonstrated herein, SARA submits that in the future the Commission's regulatory treatment of vehicle radar devices other than those presently using frequencies in the 24 GHz band should include the following:

- The Commission should pursue the allocation of additional frequency bands for vehicle radar operations, as well as other equally important unlicensed services.
- Vehicle radar devices that are developed in the future for use in bands other than 24 GHz should be protected from harmful interference due to the technology's ability to address and help resolve the widespread, quantifiable and compelling public safety hazards associated with traffic accidents.
- The global harmonization of frequency band allocations for automotive radar usage is an important policy objective.
- The use of a band manager is not appropriate for vehicle radar.
- Use of vehicle radar devices should be permitted on an unlicensed basis.

The approach outlined above includes aspects of the "Command-and-control" and "Commons" models of spectrum management.[8] Accordingly, the Commission should adopt a flexible regulatory approach with respect to vehicle radar technology that is not limited to a strict category or definition. Specifically, the Commission should employ a "hybrid" spectrum management approach that effectively addresses the specific requirements of vehicle radar technology. Indeed, vehicle radar is a technology with its own peculiarities, including the following characteristics:

1. *A vehicle radar device is designed to be on and transmitting when an automobile is operating*.[9]

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[7] See Report at 37.

[8] For example, presently the ISM bands, where most of the vehicle radars operate and are anticipated to operate, are an example of the commons model. The commons model does not incorporate protection from interference. The exclusive use model would make vehicle radar impossible as a practical business. Since the location of the multitudinous radar transmitters is continuously variable, and includes every location, spectrum access would be effectively blocked in an exclusive use environment. There is no industry that can negotiate the thousands if not hundreds of thousands of agreements necessary under the exclusive use model to field vehicle radar. It is interesting to note that for technical reasons the vehicle radar industry has very little interest in frequency bands below 5 GHz, where the Report inferred that the exclusive use model might be most appropriate.

[9] There are some applications such as Back Up Aid (that assist drivers in safe backing and parking maneuvers) where transmission occurs only when the car is in "reverse", but this is the exception. The rule is that

2. *Vehicle radar radiation characteristics are generally directive in nature*. Vehicle radar emissions, by necessity, are contained within limited elevation and azimuth angles where the maximum radiated power densities are constrained by design to be near the road surface.[10]

The Commission should employ a regulatory philosophy that nurtures the vehicle radar industry while avoiding the use of excessive amounts of spectrum.

VI. The Commission Should Pursue the Allocation of Additional Frequency Bands for Vehicle Radar Operations

As suggested above, vehicle radar has the potential to significantly improve the safety of our nation's roadways and technological development within SARA is occurring at a rapid pace. Therefore, SARA supports the Task Force's recognition that the Commission should allocate additional frequency bands for unlicensed use, and submits that some of the additional spectrum should be made available for vehicle radar. The ISM bands and "any modulation" bands will eventually become saturated. Accordingly, as part of its long term planning, it is in the public interest for the Commission to begin searching for additional allocations for vehicle radar operations.

VII. Vehicle Radar Devices Developed to Operate in Spectrum Bands Allocated in the Future Should Be Protected from Harmful Interference

As demonstrated below, the Commission should take steps to ensure that vehicle radar devices operating in spectrum bands to be allocated for vehicle radar in the future are protected from interference from devices operating in those same frequency bands.

A. Vehicle Radar Technology Addresses And Helps To Resolve Widespread, Quantifiable And Compelling Public Safety Hazards

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most of the vehicle radar applications (e.g Pre-Crash Sensing, Auto-Cruise, Stop&Go, Side Detection System) call for continuous transmission whenever the automobile has its ignition ON.

[10] The vehicle radar system is different from many communications systems, particularly in that the typical radiated bandwidths of vehicle radars are relatively wide by necessity (see below for details). Transmitter power, also discussed below, is also of critical importance. Presently, microwave device and signal processing technology advances enable, by historical standards, very low cost implementation of radar systems that could occupy very wide bandwidths of spectrum at high power levels (relative to Part 15 transmitters). Some applications of vehicle radar absolutely demand high power-bandwidth products (see CFR 47, Part 15.253), where some applications allow room for designs that minimize the power-bandwidth requirement overall with only marginal cost impact. Appendix B gives a detailed discussion of how bandwidth and power allocations directly affect radar performance.

The prevention of highway fatalities is a compelling public interest objective that can be easily distinguished from a "special interest" for which no special regulatory consideration is warranted.[11] Because vehicle radar technology has the ability to address and help resolve the widespread and quantifiable public safety hazards associated with traffic accidents, future applications of this technology should be afforded protection from interference from other devices operating in the same frequency bands. Indeed, in allocating the 76-77 GHz band for the exclusive use of vehicle radar systems, the Commission recognized the need to protect vehicle radar systems from interference due to these same "safety considerations."[12]

Similarly, protecting future vehicle radar devices from harmful interference under the framework described herein would be consistent with the substantial emphasis the Commission has placed on highway safety issues in the "E911" proceeding (CC Docket No. 94-102).[13] In light of the quantifiable public safety risks associated with traffic accidents, the Commission noted in that proceeding that "one specific step the Commission can take in the interest of public safety is to improve wireless 911 call completion, especially in rural areas, and thus to facilitate more efficient and rapid emergency response."[14] Although SARA does not dispute the obvious benefit of having a prompt emergency *response* to traffic accidents, particularly in rural areas, SARA respectfully submits that ***there is an even greater public interest in encouraging the unimpeded development of technologies, such as vehicle radar, which have the capability of helping to prevent accidents in the first instance.*** Accordingly, the development of policies for managing spectrum in this Docket should include an approach which affords interference protection to emerging technologies -- such as vehicle radar -- that will address and help to resolve tremendously widespread, quantifiable and compelling public safety hazards.

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[11] See Report at 41.

[12] 40 GHz Order, ¶20.

[13] In that proceeding, the Commission required, *inter alia*, that wireless telephones manufactured after February to 13, 2000 be designed to comply with certain requirements that will enhance the likelihood that wireless 911 calls are completed. See 47 C.F.R. §22.921. In adopting those requirements, the Commission cited a number of highway accident statistics, including those statistics demonstrating a significantly higher fatality rate for accidents occurring on rural interstate highways.

[14] See "Revision of the Commission's Rules To Ensure Compatibility with Enhanced 911 Emergency Calling Systems", Second Report and Order, CC Docket No. 94-102, RM-8143, ¶¶17-19 (1999).

Vehicle radar should be distinguished from communications devices (the majority of which are devoted to entertainment, personal communications, and commerce) and industrial devices, which are not designed with safety-related issues in mind. As a safety-related device, vehicle radar should have spectrum access priority over devices of convenience, leisure, and commerce, yet vehicle radar should have subordinate spectrum access rights to classical "public safety systems".[15] Although not rising to the level of classical public safety systems, vehicle radar systems should receive interference protection because vehicle radar belongs to the very limited class of technologies that can address and can help to resolve the tremendously widespread, quantifiable and compelling public safety hazards associated with highway traffic accidents.

B. The FCC's Interference Temperature Model Should Not Be Applied In a Manner that Impedes the Operation of Vehicle Radar Devices

SARA supports, subject to the technical considerations discussed below,[16] the Commission's establishment of pre-defined interference temperature limits for the bands in which vehicle radar devices operate. The Report's introduction of an interference temperature concept reflects an encouraging philosophy that should promote more efficient use of spectrum. In that regard, the vehicle radar industry suggests that in the future the FCC effect spectrum allocations for vehicular radar within which guaranteed maximum interference levels will not be exceeded. Moreover, due to (i) vehicle radar's potential for greatly reducing traffic accidents and (ii) the fact that vehicle radar devices should be functional at all times and in all places where vehicles travel, SARA believes that future generations of vehicle radar devices should be allowed appropriate radiated emissions bandwidth and power levels, even if such operations interfere with other, non-safety-related devices.[17] Accordingly, any interference temperature model must not impede the operation of vehicle radar devices by adhering to the following requirements:

- Any given interference temperature limit must not degrade a vehicle radar's signal-to-noise environment beyond operational limits.

- Vehicle radar devices must be protected from harmful interference from all other non-safety-related devices subject to the same interference temperature limit.

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[15] "Public safety system", as used herein, refers to police, fire, and ambulance radio communications systems, aircraft radio navigation and communications systems, and shipboard navigation and communications systems.

[16] There is a "random signal" model of interference implicitly embedded in the interference temperature concept, where many interference signals are deterministic and narrowband in nature. To resolve this, any interference temperature regulation should also incorporate amplitude limits for deterministic and/or narrowband signals, as many receivers will fall victim to narrowband deterministic interference levels that would, if divided by some arbitrary bandwidth, meet power spectral density limits hence interference temperature limits. The interference temperature concept would be more viable if specifications on interference bandwidth were applied that assured a good approximation to the random signal assumption.

[17] Certain limited exceptions, i.e. in the vicinity of a radio telescope, may exist without harm to the industry.

- When necessary, an interference temperature limit should be modified to reflect changes in the "worst case" emissions requirements of vehicle radar.

- There must be a good "noise floor" data base for all locations in the US based on the "interference temperature" concept. Preferably, this database would be worldwide. Good and current data regarding interference levels at various (all) locations will require substantial coordination among, and cooperation between, various manufacturers and the Commission.

There is concern in the vehicle radar industry that today's allocations, primarily those based in ISM (common) bands, do not limit interference levels to the service. Therefore, should other radio applications that bring millions of unlicensed transmitters into being also use the same "common bands", there may be a serious and unresolvable conflict among the services based on current and projected technology available for vehicle radar. Other than the 76 – 77 GHz band, in which implementation of vehicle radar systems is inherently expensive, vehicle radar has no exclusive frequency allocation. Although today the situation is not critical because the ISM bands are not intensely utilized, the situation may rapidly change in the future unless the Commission takes steps to ensure that interference to vehicle radar devices is prohibited.

VIII. The Global Harmonization of Frequency Band Allocations for Vehicle Radar Usage Is An Important Policy Objective

SARA strongly supports the Task Force's conclusion that "regional and world wide harmonization of band use can have significant advantages, both in terms of truly ubiquitous services and economies of scale…."[18] The consideration of such economic factors in adopting technical parameters applicable to the operation of vehicle radar systems is consistent with Commission precedent.[19]

Establishing common frequency allocations for vehicle radar technology in North America and Europe greatly enhances the business case for developing and marketing vehicle radars. There currently is no wideband common allocation. Accordingly, vehicle radar applications like Back-up Aid, that require 3 GHz or more bandwidth in the next generation designs, are limited to one continent only. Although the Commission's actions in the UWB proceeding were a major step towards a common wideband low power allocation, only a narrow classification of vehicle radar systems will be able to benefit from the UWB rules due to the technical restrictions imposed by the Commission.[20] SARA respectfully submits that in the future the Commission should adopt regulations with respect to vehicle radar that further the necessary and appropriate goal of global harmonization.

[18] See Report at 42.

[19] See 40 GHz Order at ¶¶15-17 (1995) (where the Commission considered economies of scale as a major factor in allocating the 76-77 GHz vehicle radar system band).

[20] An important aspect of the UWB allocation is that the 24.1 GHz ISM band is within the UWB automotive band (22 to 29 GHz), which opens up possibilities for "multi-mode" designs.

IX. The Use of A Band Manager Is Not Appropriate for Vehicle Radar

SARA believes that the Commission, not a band manager, should be responsible for oversight with respect to vehicle radar allocations, including any new unlicensed bands the Commission may approve. As Commissioner Copps eloquently explained last year:

> "I recognize the potential theoretical benefits of band managers…. But I also see grave risks. The spectrum is a public asset. The Commission's stewardship of the spectrum is a public trust. Congress gave the Commission the responsibility to allocate spectrum for a reason. While there are often downsides to government management when it comes to speed and innovation, there are sometimes very important advantages. This Commission is legally obligated to operate transparently. Our charter commands us to promote the public interest. And we are accountable to the American people. Our charter is different than a band manager's. A band manager need not reveal its decisions to the public. It is legally obligated to maximize profits for its shareholders rather than serve primarily the public interest. Band managers are accountable to those private interests that control them, not to the people…. Congress understands the costs and benefits of government versus private stewardship of various assets. Here, I believe, Congress chose the FCC to manage spectrum because the protections inherent in FCC allocation of spectrum outweigh the costs…. I do not believe that Congress wanted the FCC to delegate its spectrum authority to private speculators who can turn public spectrum into private profits with no intention of providing communications services. I believe that significant questions about the enforcement of our rules and the effect of band managers on the public interest are too uncertain to support an extension of our reliance on band managers at this time."[21]

In light of the critical public interest issues involved in the vehicle radar service, SARA strongly believes management of the spectrum assigned to the service should be left to the Commission.

X. Use of Vehicle Radar Devices Should Be Permitted On an Unlicensed Basis

The use of vehicle radars must continue to be permitted on an "unlicensed" basis. The radar transmitters on motor vehicles, of course, go wherever the motor vehicles go, which is essentially anywhere in the country.[22] Other than (i) the 22-29 GHz band under which vehicle radar devices may operate on an unlicensed basis under the "ultra-wideband" allocation; and (ii) the 76-77 GHz vehicle radar allocation under which vehicle radar systems may operate on an unlicensed basis, vehicle radars have been typically approved for unlicensed operation in the Industrial, Scientific, and Medical (ISM) type bands at 10.5 GHz and 24.1 GHz. These devices differ from typical ISM devices, as they are typically ON whenever the vehicle ignition is on and operate strictly outside of buildings.

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[21] "In the Matter of Amendments to Parts 1, 2, 27, and 90 of the Commission's Rules to License Services in the 216-220 MHz, 1390-1395 MHz, 1427-1429 MHz, 1429-1432 MHz, 1432-1435 MHz, 1670-1675 MHz and 2385-2390 MHz Government Transfer Bands," Report and Order, Separate Statement of Commissioner Michael J. Copps, 17 FCC Rcd 9980 (2002).

[22] However, the area densities of vehicle radar transmitters are somewhat predictable. As the industry evolves, and the number of car buyers that opt to have vehicle radars becomes better known, one can draw a timeline of transmitter densities for different areas based on operating automobile densities (i.e., low density in rural areas, higher densities in urban / city areas).

XI. Other Issues

A. Frequency Band Use Dimensions

The Report notes that in addition to the classical spectrum dimensions of space, power, and frequency, there should be added to these the dimension of time. Timesharing of spectrum resources is implied here, and SARA supports this line of thinking. In addition to the time dimension, SARA believes there should also be a modulation domain dimension added into the equation. Clearly, it is feasible to operate two different services in the same power, frequency, location, and time co-ordinates where their modulations are so different in nature that the two modulation schemes are orthogonal in practice, allowing simultaneous use of a band without interference. This could be a very important factor in band sharing, since cost impacts of "compatible" vs. "cheapest" modulation schemes may be minimal. In the Commission's UWB proceeding, the Commission explored this concept, which is a specific version of the general principal of spectrum reuse via spread spectrum modulation across narrowband modulation service bands. Vehicle radars that are being fielded today use frequency, phase, and amplitude modulation.

B. Receiver Performance Rules

SARA agrees that receiver performance requirements or guidelines regarding receiver selectivity are appropriate – especially those performance rules that would facilitate the guarantee of a maximum interference level to a particular service.

C. Transition Issues

The Report discusses at length the impact of new frequency management methods on incumbent licensed services,[23] and suggests methods for transitioning from the old rule paradigms to the new when the application of new band management models either requires "band clearing" or the addition of other services to an incumbent's band. Although vehicle radars are not licensed incumbents, incumbent vehicle radar manufacturers will have concerns similar to those of licensed incumbents.

Vehicle radars developed under the current rules cannot be re-tuned to accommodate band clearing. However, attrition of equipment in a vehicle radar band will occur as the vehicles in which they are embedded age and are taken off the road. Through planning and the passage of time, any band presently used by vehicle radars may be cleared, if necessary, simply by making future frequency allocations elsewhere and requiring manufacturers to cease production of radars that utilize the band to be cleared by a future date. Given adequate notification, the vehicle radar industry should be able to manage band allocation changes with minimal adverse impact.

The act of "band clearing" is not the only mechanism that may require the vehicle radar and other industries to be frequency flexible in their product lines. Under an interference temperature frequency management scheme, predetermined interference limits will be approached in a band as

[23] See Report at 46 – 51.

utilization of that band increases. When that predetermined maximum interference level in a particular band is approached, manufacturers of equipment in such bands will be required to cease further sale of equipment using that band by a specified date. In such a case, limiting the total number of devices using the older band would be necessary in order to maintain aggregate interference levels under desired limits, and product introductions and continued distribution of older products would have to occur in newly allocated bands.

Appendix A

Figure 1 demonstrates a future concept of complete surround safety coverage, as mechanized with high performance radars.

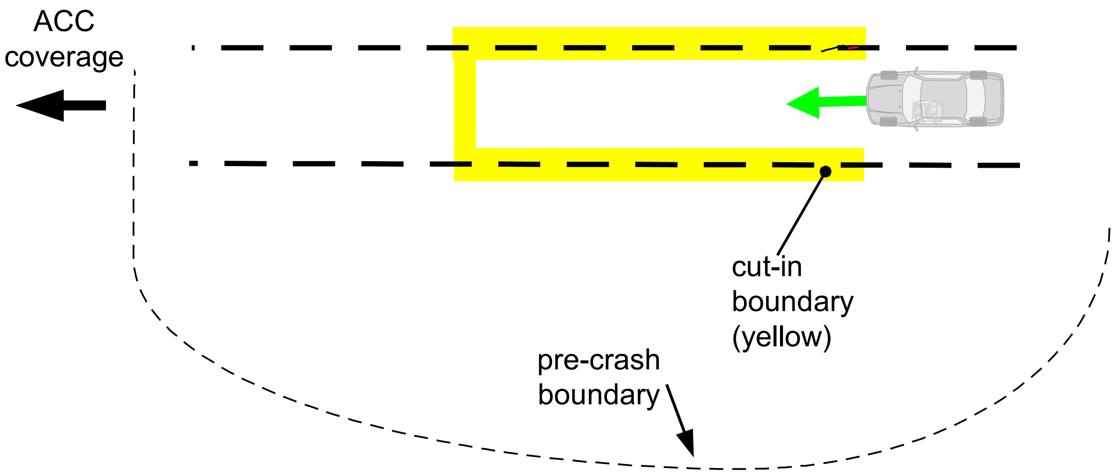
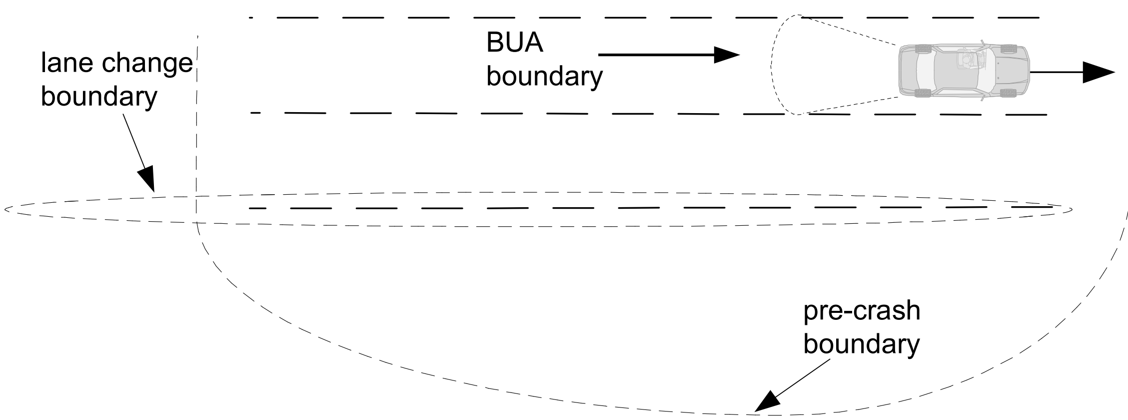


Figure 1 (a)



(b)

Figure 1. Surround coverage of vehicle radars in the future. Forward applications are shown in (a), and rear applications are shown in (b). Side coverage is not explicitly shown, but is achieved with the advanced sensors. Only partial coverage is shown for clarity – the future will have sensor coverage that entirely surrounds the car.

Appendix B

Technical Characteristics of Vehicle Radar

Radar (RAdio Detection And Ranging) devices differ from all communications devices in that they are active "remote sensors." Radars illuminate their environment with microwave energy and analyze the received back-scattered energy to draw conclusions as to the presence and range of an object. Most radars, including many vehicle radars, are also capable of measuring the velocity of the various objects within the radar field of view. Additional features include positioning information (target range and azimuth coordinates), and measuring target velocity directional components such as azimuth rate and acceleration in range and azimuth. Even more sophisticated radars (currently beyond the scope of vehicle radar cost constraints) have object classification / identification capabilities and 3D capabilities where range, azimuth, and elevation coordinates of targets are measured.

Like communications devices, radar effectiveness and usefulness benefits from both bandwidth and power levels in the transmit signal. The following discussion explains how transmit signal power and bandwidth affect the performance of a radar.

Radar Emissions Bandwidth

The greater the bandwidth of a radar signal, the greater the radar's capability to separate closely positioned objects in the range dimension. This ability ("radar range resolution") is a necessary requirement for acceptable radar performance. The resolving power of the radar is of utmost importance in automotive applications because numerous closely spaced objects are always present. A low resolution radar will become confused in this environment, and will not be able to feed accurate reliable data to a safety system that utilizes the radar data.[24]

To achieve adequate radar range resolution there is no substitution for signal bandwidth, regardless of the cost one is willing to spend on the radar. The radar is constrained to resolution that is directly proportional to bandwidth by physical law. This is in contrast to, say, a communications link that can in principle make up for reduced channel bandwidth by using more transmitter power, albeit at more cost. Naturally, radar designers / manufacturers seek bandwidth in the FCC rules when high range resolution is required for a given application. Different applications of vehicle radar demand different range resolution performance.

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[24] A simple illustrative example is where one is backing up a car toward a small (not visible to the driver) pole that is a couple of feet in front of a wall. A low resolution radar will not be able to "see" the pole for the presence of the wall, and the car driver will back into the pole while the radar is telling him there is enough distance to the wall to proceed. A high resolution (wideband) radar will clearly see the pole and the wall at their respective distances, will warn the driver of the pole, and will provide distance information regarding the pole (and the wall if desired) to the driver.

Transmitter Power

The situation regarding transmit power is straightforward. Target detectability[25] depends solely on the nature of the target and the total amount of microwave energy imparted to it by the transmitter. Radar detection response time, i.e., the time between the target's first entry into the radar field of view and the first detection and reporting of the object by the radar, is a critical performance parameter. Higher transmitter *average* power allows the required amount of illumination energy to occur more quickly than otherwise, thus enabling quicker response times. Transmitter average power influences the radar response time and probabilities of detection, where there are no other trades that can be made to achieve the same ends with less average transmit power. The varying applications of vehicle radar demand a wide variety of response times and maximum detection ranges.

We have the situation for radar in general where, regarding performance, spectrum bandwidth and radiated power levels are orthogonal in nature. Signal bandwidth facilitates range resolution; signal power facilitates longer detection ranges or quicker response times. One parameter cannot assist or deter the effects of the other; hence there is no benefit to having high power-bandwidth product signals if one of those two parameters falls short of the application demands.

[25] "Target" is the term used to identify an object of interest that the radar observes. "Detectability" refers to the ease at any moment in time with which the process of determining the presence of the object within the radar field of view is accomplished.