Report of Trip to FCC Technological Advisory Council Meeting
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For the second meeting of the fourth term of the TAC, I took the opportunity of the trip to Washington, DC to arrange two other meetings in addition to the TAC meeting, the other two related to the work of the ARRL RF Safety Committee. The report of the RFSC-related meetings follows the report of the TAC meeting.

The TAC meeting was held in the Commission Meeting Room in the FCC Building in Washington, DC. The topic for this meeting was Tiered Spectrum Access Rights, organized by Kalle Konston, Dennis Roberson, Dewayne Hendricks and myself.

Kalle Konston, of Alion Corp (formerly IIT Research Institute), introduced the session. Efficient use of spectrum has been a discussion point at past TAC meetings, one of the main goals of the FCC's Spectrum Policy Task Force, and of interest to both spectrum holders who want to "sublet" their spectrum for profit and users who want access to more space in the spectrum. Kalle has been a proponent of the "Intelligent Wireless Device Bill of Rights" for many years at past TAC meetings. The concept behind the bill of rights is that a wireless device may use any frequency as long as it adheres to certain rules:

- **Article 1:** **Any intelligent wireless device may, on a non-interference basis, use any frequency, frequencies or bandwidth, at any time, to perform its function.**
- Article 1, Tenet 1: To exercise rights under this Article, intelligent devices must be mentally competent to accurately determine the possibility of interference that may result from their use of the spectrum, and have the moral character to not do so if that possibility might infringe on the rights of other users.
- Article 1, Tenet 2: To exercise rights under this Article, intelligent devices must actively use the wireless spectrum within the minimum time, spatial and bandwidth constraints necessary to accomplish the function. Squatting on spectrum is strictly prohibited.
- **Article 2:** **All users of the spectrum shall have the right to operate without harmful electromagnetic interference from other users.**
- Article 2, Tenet 1: Priority of rights under this Article may be determined by the proper authorities only in cases of National emergency, safety of life or situations of extreme public interest.
- Article 2, Tenet 2: Rights under this Article may be exercised only when the systems exercising the rights are designed, as determined by the state of the practice, to be reasonably resistant in interference.
- **Article 3:** **All licensing, auctioning, selling or otherwise disposition of the rights to frequencies and spectrum usage shall be subordinate to, and controlled by Articles 1 and 2, above.**

Kalle admitted that this form of communications is still a long way off but such rules serve to provide direction for future operations. In the interim, developing a system of tiered spectrum access rights will take the first step in this direction. His definition is as follows:

Technology-Driven Tiered Spectrum Access Rights: A regulatory model that rewards the implementation and deployment of spectrum-efficient technologies by offering incentives in the form of progressively expanded tiers of spectrum access rights in proportion to device performance.

He likened this to examples such as giving special lane access on busy roads to hybrid and electric cars, allowing higher EIRP for Part 15 devices using directional antennas, and additional

Part 15 spectrum access to devices that employ TPC (transmit power control) and DFS (dynamic frequency selection).

Preston Marshall, of the Defense Advanced Research and Projects Agency (DARPA), spoke next on the characteristics of equipment needed to implement the Tiered Spectrum Access model. He noted that while there are regions of spectrum with heavy local activity interspersed with regions of medium and sparse use, the average activity in the spectrum has been measured to be under 6%. He introduced DARPA's XG (neXt Generation) communications concept: Equipment that Senses (real-time low power {<2W} wideband monitoring), Characterizes (performs rapid {10's of msec} waveform determination), Reacts (formulates the best course of action), and Adapts (transitions the network to new emission plans). He claims that this form of frequency sharing can increase spectrum efficient by a factor of 10, measured as $MHz \cdot km^2$. His approach is to work toward "policy-based network devices" as opposed to software-based devices that dynamically adapt to their environment. His claim is that dynamic adaptation has not been made to work well. However, when policies are first developed and then all devices adapt to them the advantages include asynchronous collaboration, conflict resolution through modeling, and a provable framework. He cautioned that semantics must be normalized across all devices. For example, each device must describe in detail the worst-case interference that it can tolerate. He presented the concept of a "policy engine" that each device must communicate with (or "form a contract with") to report its characteristics and receive its limits of operation. There are two ways to do this: 1) Bound Request, where the device reports to the policy engine that it wants to use a given center frequency with a given bandwidth and power spectral density for a given amount of time (*e.g.* 2.432 GHz, BW 1 MHz, PSD 20 nW/Hz, MaxDuration 100 msec) and the policy engine responds Yes or No. 2) Unbound Request, where the device simply reports to the policy engine that it wants to use a given frequency and the policy engine replies with the acceptable parameters for that frequency's use (*e.g.* Request: 2.432 GHz, Reply: Yes, if and only if: PSD < 12 nW/Hz, BW < 10 MHz, MaxDuration < 100 msec). The question was asked about how the XG concept would deal with unexpected emergent behavior, such as router flapping that was unexpected in the design of the Internet. Preston replied that their system design would cause such behavior to harm the misbehaving equipment and not the other users of the spectrum. Another discussion point was the concept of developing dynamic rather than fixed policies. It was concluded that no policy could be fixed for a long period but should be revisited at least every several years.

Vanu Bose, of Vanu Inc, an innovative software-defined radio company, presented the next talk on Variable Spectrum Rights. He attempted to answer the question, "What additional rights can be offered in response to well-designed wireless systems?" He defined "well-designed" from a regulatory perspective to mean a system that uses the spectrum more efficiently. Spectral efficiency, in his point of view, is based on a channel, which is a region in the three-dimensional space of frequency, time and code-space. Code-space refers to the orthogonality of reusing that space, such as hopping or spreading. For example, an FM broadcast station a frequency space of 200 kHz and a code-space of 1, since it is the only user in its frequency space. In contrast, a CDMA IS95 system has a frequency space of 1.25 MHz and a code-space of 1/32. Spatial reuse of the channel is based on a host of factors including power and propagation, and is hard to predict in all cases. Out of the list of parameters of frequency, time, code-space, and the ones related to spatial reuse: power, distance and antenna directionality. An example of incentives for

more efficient use is evident today in the 900 MHz ISM band where spread spectrum stations with a higher hop rate are permitted to use more power. This is a static incentive that only improves use of the code-space. Vanu thinks that we could improve on the incentives to give the user things that would be more desirable, like changing bandwidth depending on the task (*e.g.* data downloads vs. voice on a cellular telephone) or allowing the user to choose to preserve battery live or to communicate over long distances. In-building propagation is improved with lower frequencies and since these are less available efficiency is an important factor in allowing their use. The desires of the user will most likely be dynamic. Implementing these incentives could be performed by a dynamic central authority or by ad hoc collaboration among the devices. Underlay on cellular frequencies could use the central authority model, with the cellular providers acting as the central authority who could make some extra money renting our their underused spectrum.

Dale Hatfield, now from the University of Colorado at Boulder, spoke next on Regulatory and Enforcement Issues. He noted that the incentives for behaving well and being more efficient eventually turn back into economic gain, whether it be to better use your allotted spectrum so that you have excess which you could then lease to others or you could serve more capacity in the same spectrum, which would benefit your customers and also earn you more money. Two types of frequency sharing can exist: voluntary, where you make contracts with other users to pay for use of your spectrum, or involuntary, where the regulatory authority tells you to share your spectrum as long as you don't experience harmful interference. There are basically four regulatory challenges: Defining "efficiency," Defining "good behavior" and providing the appropriate rewards for it, Certifying that equipment and networks will behave efficiently, and Enforcing that equipment and operations actually behave as promised. He made the distinction between technical efficiency and economic efficiency, which are not always in agreement. He believes that in the end it is economic efficiency that is what we want to foster, since in the layered protocol stack he suggested that the business model forms the highest layer. This puts the Commission in a difficult position since it has to rate the relative merits of various communications schemes in order to produce incentives, making the decision of what is innovating and what isn't. They have to look into the design of the system to ensure pre-deployment conformance and they are better at ascertaining static behavior rather than dynamic. Preventing bad behavior may be more realizable than rewarding good behavior. The IEEE 1900 standards effort may be helpful in this task. He also mentioned that social norms play a big part in the behavior, and used Amateur Radio as an example of where social norms lead to relatively efficient frequency sharing.

Paul Kolodzy, from Stephens Institute of Technology and the former head of the FCC Spectrum Policy Task force, spoke next on a Review of the Spectrum Policy Task Force. Three years after the SPTF report came out Paul finds that both technology-based and market-based factors play a part. Increased mobility of devices has made the results of the SPTF more relevant. The density of mobile communications devices has greatly increased; three years ago it was about one device per person (cell phone) and today it is often three per person (cell phone, Wi-Fi laptop, Blackberry Email device). Interference avoidance remains a big issue and is getting larger. The SPTF tried to quantitate this (interference temperature) but the interference is not simply a factor of the transmitter, which is what usually gets tested, but is also impacted by the design of the receiver. The SPTF talked about systems that are also good neighbors to other systems. Spectral

efficiency can be improved by making sure that neighbors work together. Spectrum can be Access-Limited or Throughput-Limited and minimizing both these limits improves efficiency. The two paradigms for sharing frequency is licensed spectrum with underlay or shared commons, both of which require frequency sharing but differ in who is in control. He believes that economics should decide which of these is used. The Commission must balance the "adjustable noise floor" to improve efficiency. Different users can specify the acceptable noise floor, and an incentive can be made for a more robust system that coexists with higher noise levels. He also believes that one of the more important issues is to determine the enforcement mechanisms since license holders will be concerned about how they can be assured that the frequency sharing they are being asked to perform will not hurt their own business. A question was asked about how well the FCC has followed the SPTF recommendations and Paul answered that many of the issues have progressed nicely but the main problem that has not been addressed well in the past three years is the definition of interference, which may be the most difficult problem that the SPTF brought up. IEEE 1900 is a good step in the right direction but the FCC done much else. Also, the FCC has not made much progress in using the same measurement techniques and using a standard language across all the offices and bureaus, which is something that SPTF recommended.

My talk was next: "Lessons Learned About Frequency Sharing in the Amateur Radio Service." Bob Lucky introduced my talk by saying, "Here's a group that enforces its own rules." While most of the spectrum has been allocated on an exclusive basis, Amateur Radio spectrum has always been shared by all licensed hams with no inherent "property rights" assigned. Hams have developed fairly efficient procedure for sharing their frequency allocation, which has maximized the spectral efficiency of a fairly limited resource. I related the history of spark gap, which was divided into two effective frequency channels, at 100 kHz and 200 kHz, and was a mass of interference and ineffective communications, and how narrowband CW came about with greater spectral efficiency and had completely supplanted spark gap within a few years. I made the point that listening to a frequency is not enough to ensure that it is free to be used, and illustrated the "hidden transmitter" problem to show why. I closed with a story that brought together the hidden transmitter and Amateur Radio procedures for sharing frequencies to allow a QSO between myself and a station that I was skipping over, mediated by a relatively rare DX station in Tonga (which is one of the locations that Dewayne Hendricks does business in). Comments by Bob Lucky and others following my talk were about how important self-regulation and cooperation between stations is to making frequency sharing effective. I came away from this discussion with the impression that these people have a positive view of our hobby and its value to the art of communications.

Following lunch, Dewayne Hendricks presented the history of spread spectrum in Amateur Radio. He mentioned that the FCC worked closely with AMRAD to develop the SS NOI in 1981 and the NPRM (Parts 15 and 97) in 1985. He also mentioned that this was the last time that the FCC worked directly with the Amateur Radio Service, which is its experimental service and resource, and suggested that the FCC reinstitute this relationship. He gave the ARRL Spread Spectrum Sourcebook as a good reference of the work done by radio amateurs in spread spectrum. He suggested that the relationship between OET and the Amateur Radio Service should be strengthened despite the political reasons that the major relationship is with the Wireless Bureau. He gave the history of the K6KGS SS STA, of which he was a part and there

were over 100 hams working on this project. He also mentioned that nonprofit organizations, like TAPR and ARRL, could not receive STAs to work on this. A discussion ensued about getting Amateurs excited about performing experimentation on new communications technologies and serving as a resource to the FCC prior to the commercialization of a technology. Jeffrey Goldthorp, the FCC Designated Federal Officer to the TAC, took a cue from this discussion and has since pursued discussion on using hams to help the FCC to study communications techniques with Dewayne.

Bob Lucky stated that one of the keys to spectral efficiency is cooperative behavior and he mention Amateur Radio as the paradigm for success and CB radio as the ultimate example of failure. Bill Hancock related a story of how mission critical WiFi networks have been brought down by insertion of bogus packets. He suggested that the engineering must be better to make sure mission critical networks work when needed.

Joseph Nowack from Motorola Labs presented "Advances in Mobile Broadband Wireless Access Systems." He mentioned IEEE 802.16e, which should be completed this year for deployment in 2008. This is a family of modulation modes under the name of WiMax. Most of the current work is involved in interoperability. They make measurements on the traffic over Internet and have found that there is a great increase in file sharing traffic. Individual users are increasing in their traffic by about 10% per year. About 50% of the uplink bandwidth is peer-to-peer file sharing and this accounts for 25% of the downlink bandwidth, with a 1.4:1 downlink to uplink bandwidth ratio. They also found that 3% of the users generate 80% of the traffic. A comment was made that many of the high bandwidth users have no idea that they are using so much bandwidth because their computer have probably been hijacked by viruses and spybots. They are also studying multi-hop mesh-cellular networks to improve coverage. They are also looking at broadband wireless for public safety. They see this application working as a combination of networks and protocols, which would include WiMax.

Super 3G wireless will attempt to have 100 Mbps downlink and 50 Mbps uplink with 10 msec roundtrip latency. OFDM works well in uplink and wireless LAN but when the distance increases beyond about 100 yards interleaved FDMA looks better as a mobile uplink technique. Asian countries (Japan, Korea and China) are being very aggressive in implementing 4G cellular. Motorola is experimenting with 4Gx in Chicago.

Meeting with Kenneth Cantor, Ph.D., Epidemiologist at the National Cancer Institute

On Wednesday, July 27 I went to Bethesda, MD to meet with Kenneth Cantor. Dr. Cantor is the lead investigator of a long-running retrospective epidemiological study of Amateur Radio operators. By comparing death records from the State of California to the FCC Amateur Radio Service License Database, the study hopes to ascertain whether or not there is a connection between being a radio amateur and disease. Dr. Cantor visited ARRL Headquarters and met with members of the RF Safety Committee on April 28, 2000 to discuss his pending study. While this has been a long running study due to its low priority, the investigators have not given up trying to get conclusive results.

Dr. Cantor and I first spent about half an hour discussing the study with Dr. Peter Inskip, who is a collaborator on this study and is better know as the lead author of a ground-breaking study of cellular telephone users that showed no excess of disease among those subjects. Dr. Cantor then showed me an abstract of the first set of results that were assembled from this study. In short, they studied 108,586 subjects who had lived in California any time between 1966 and 1995. California death records, the National Death Index, and the Social Security Administration mortality listings were used to track which of these people had died, resulting in 1,734,930 person-years of study. This group was subdivided into subgroups based on license class, with the expectation that high license classes indicated more intense activity on the radio and a likelihood of employment in broadcasting or electronics industries. Deaths were compared to standard population death rates, subdivided by disease and results were expressed as SMRs, or Standard Mortality Ratios. An SMR of 1.0 means that the test group has the same rate of death from a particular cause as the standard population. An SMR of 2.0 means that the test group is twice as likely to die from a particular cause than the standard population, and an SMR of 0.5 means that the test group is half as likely to die from a particular cause than the standard population. Because these are statistical calculations, a 95% confidence interval was calculated for each SMR. Thus an SMR of 2.0 with a confidence interval of 1.0-3.0 means that the test group seems to be twice as likely to die of a disease than the standard population but the uncertainty of the numbers is such that the SMR could have been anywhere between 1.0 and 3.0. Such a results is not considered to be statistically significant because 1.0 is within the 95% confidence limits.

The relevant results from the study so far are as follows:

Cancer Deaths: 0.79 (0.76-0.81) - this is a significant result that hams are less likely to die of all cancers than the standard population.
Glioma Deaths: 1.14 (0.97-1.30) – this is a non-significant result that hams are more likely to die of this type of brain tumor than the standard population.
Leukemia Deaths: 0.89 (0.80-1.03) – this is a non-significant result that hams are less likely to die from any form of leukemia (blood cancer) than the standard population.
Chronic Myelogenous Leukemia Deaths: 1.2 (0.90-1.70) – this is a non-significant result that hams are more likely to die from this specific form of leukemia than the standard population.
Hodgkin's Disease Deaths: 1.3 (0.90-1.90) – this is a non-significant result that hams are more likely to die from this form of lymphatic cancer than the standard population.
ALS Deaths: 1.21 (0.90-1.60) – this is a non-significant result that hams are more likely to die from this form of nervous system degeneration (Lou Gehrig's disease) than the standard population.
Laryngeal Cancer Deaths: 0.60 (0.40-0.80) – this is a significant result that hams are less likely to die from this often smoking-related disease than the standard population.
Lung Cancer Deaths: 0.65 (0.61-0.69) – this is a significant result that hams are less likely to die from another disease that is often related to smoking than the standard population.

Dr. Cantor and I discussed how these results should be interpreted. To him it was pretty clear that these numbers were interesting to report as is, but I cautioned him that in the hands of a layman it would be easy to imply that hams had increased incidence of certain diseases. The layman, or lay press person, usually does not appreciate the statistical uncertainties represented

in the confidence interval. Dr. Cantor was pleased that his numbers, which were based on the largest study population to date, were in good agreement with past studies of hams and also of electrical, electronics, and broadcasting industry workers. I mentioned that the studies by Milham, which were presented as being very damning of our hobby, had many flaws but we concluded that the study was not so much flawed as were Dr. Milham's conclusions, which were unwarranted based on the statistical uncertainties but seemed to be designed to give him a lot of press coverage. I reminded Dr. Cantor that the lay public usually does not appreciate the distinctions between a preliminary study and one with full information about the subjects. He agreed and told me that in many of the studies that NCI performs beyond the preliminary stage they regularly collect DNA samples of the subjects so that they will be able to go as far as to look for genetic predisposition toward various diseases.

We also discussed the effects of Socio-Economic Status (SES), since hams tend to be from higher SES groups, which have been associated with lower incidence of disease. The smoking-related diseases also tracked well with license class, with the highest license classes having the lowest incidence of lung cancer (only 0.40 for Amateur Extras compared to 0.80 for all hams). We noted that even though this is the biggest study of its kind, errors in the results are possible due to some very small numbers. For instance, ALS is such a very rare disease, and this study only found 40 cases of ALS in 108,586 subject deaths, that a single misdiagnosis could throw off the results considerably.

The next stage in this study will be to select interesting disease subgroups and to add occupation as a factor. I suggested that these number, which very inconclusive, could be dangerous in the wrong hands. Dr. Cantor agreed and told me that the NCI has added a public relations office with experts in presenting this type of data to the press with the correct interpretations. He assured me that he plans to work with this office before releasing data from this study. I also asked him a question that was obvious to him but not so to me and certainly not to the general public. In his usual studies, what does he see as a truly dangerous SMR? He noted that the SMR for smokers getting various diseases is as high as 10-15. When he studies environmental disease (such as diseases that might be caused by contaminated water supplies), further action is usually taken when the SMR exceeds 5. Thus, even if the SMR's seen above in the studies of ham mortality were statistically significant, he would not be very concerned about them. Dr. Cantor promised to stay in touch and keep me apprised of future developments.

<u>Meeting with Robert Cleveland, Ph.D., Chief Scientist, RF Safety Office, FCC OET</u>

After the TAC meeting I spent several hours with Robert Cleveland, the scientist in charge of the RF Safety program at OET. Dr. Cleveland and I discussed the current status of the new revision of the IEEE C95.1 RF Safety Standard. We talked about how ARRL voted and our problems with the new induced and conducted emissions limits. I took the opportunity to discuss our view of the over-conservative limits of the first draft of the induced and conducted emissions limits and how they could be translated into new FCC regulations that would be impossible for radio amateurs to comply with. Dr. Cleveland, who was the main author of the current FCC Environmental Exposure regulations, is the person who may be called upon to revise those regulations after the new version of C95.1 is released.

Dr. Cleveland told me about his concerns with the relaxing of cellular telephone absorption limits. He would prefer that the IEEE standard not be revised until after the series of epidemiological studies currently taking place in the European Union be completed before the IEEE goes out on a limb with a new standard. If the EU studies have any negative results it will make the IEEE standards committee look bad and will take away from the acceptance of the C95.1 document. Dr. Cleveland also discussed the current political situation within OET and the unusual departure of Ed Thomas.