from TRW, Dr. Toh.

We would like to change our focus a little bit, and we are still talking about spectrum efficiency though. We want to look at the technical approaches for improving spectral efficiency.

And we have heard about incidental radiators and interference, and things like that, and things that emit, but the compliment to this are things that receive, and one of the questions that I have always wondered about is what tools could be used for achieving interference protection that are efficient and what are not.

And one of the ones that comes up at least in my mind time and time again is receiver standards. Should there be voluntary receiver standards, or should there be mandatory receiver standards, or should there be receiver standards, period.

So this is one question that I think we could have some fun with here on the panel. So I see Steve Blust over there, but he doesn't have his hand up yet. So I won't ask him. I will ask one of the other members of the panel to kick off this one. Charlie Trimble, please.

MR. TRIMBLE: All right. I will be a lighting rod. Certainly there ought to be receiver standards for services that are in license rebands, because in general those things are going to be inexpensive, and they are going to be consumer.

And the consumer isn't going to have the faintest idea of what the magic is, and clearly there is a lot of room for mischief in terms of Navy radars opening garage door openers; for cheap and dirty implementations.

MR. WEINREICH: Okay. Thanks, Charlie. Anybody else? Merrill.

MR. WEISS: I think we have to recognize that over the years the FCC rules have been built in many ways on what receivers can do. If you look at the causes of spectrum inefficiency -- and again because I come from a broadcast background, I'm thinking about broadcast.

But if you look at th UHF band, for instance, you will find that there are so-called taboos there that essentially only allow 1 out of 6 channels to be used in a market.

And all the other channels, at least when they were originally allotted, would be in adjacent markets, but you couldn't put stations

close together because of the fact that receivers couldn't handle signals on certain channel combinations.

So if you look -- and it is the adjacent channel, and it is the second adjacent, and it is the third adjacent, and then it is plus or minus seven because of local oscillator radiation; and it is plus or minus eight because of intermittent frequency interference. You know, two stations beating and ending up on some other receiver's IF where it is not even tuned.

And it is 14 and 15 channels because of intermod considerations. I'm sorry, because of image considerations. And all of those taboos were generated in the early 1950s based on receivers from the early 1950s.

And so when you want to go and change things, you have to start going out and saying what can receivers do today, and then make the case that, well, receivers are so much better today that we really don't need to be paying attention to that, and this is from a broadcaster point of view wanting to perhaps locate a transmitter where it otherwise would not be permissible.

But we can address this problem in a

couple of ways. We can say, all right, there has got to be some mandatory performance on the part of receivers, and the consumer electronics industry resists that with all their energy.

They don't want to be dictated to, but maybe another way to do it is to allow the taboos to be gradually whittled away so that you can put transmitters where maybe you couldn't have put them before.

And if that happens over time, then maybe receivers will be forced to perform better than they did in the early '50s, and certainly they already do, because they have to work on cable where every channel is in use.

And, for instance, it is the failure to recognize that receivers over the last two decades have gotten so much better because of their use on systems where every channel is occupied, that we still are stuck with those taboos that are a serious loss of efficiency in use of the spectrum.

So some way or another, there is an interplay, I think, between the rules and the capabilities of receivers, and whether it is really necessary to make it mandatory, or you can drive it by what you allow transmitters to do. That is what

I think is the question.

MR. WEINREICH: Thanks, Merrill. Of course, from the engineering standpoint, I think you don't want to allow any more noise into your receiver than you actually or absolutely need.

And you need to cover the band or the channel that you are operating on. So that seems to me to set kind of the narrowest that you want to be, and the question is how much can you relax that and still be efficient when you use the frequency. Dr. Rohde, first.

DR. ROHDE: I believe, number one, we should have some standards, and that is another reason for the protection of the consumer, because you buy 2 or 3 similar or identical devices, you ought to be able to judge them.

But, number two, as was actually pointed out, the technology has vastly improved, and today with multi-layer printed circuit boards, you can now for the same cost, if not for less cost, get higher performance.

And I think that one should really resist the lobby of some of industry's a little bit and do something for the end-user. Of course, I am wearing hats. On one side, I am trying to sell

something in a market with a high profit margin; and on the other hand, I am the user, and like something that works well. So it is kind of schizophrenic.

But the reality is that the bottom technology allow us to do these things, and I think this Commission here and this panel should really put some pressure on the system, and find solutions on how to make not only a transmitter cleaner and to receive a less sensitive to unwanted things.

But also to look from a systems point of view on what is possible and desirable, and to have at least one standard; you are allowed to be better than this, but not worse. And I would highly encourage that something like this comes out of it.

MR. WEINREICH: Steve.

MR. BLUST: I think the other aspect when you look at receiver standards -- voluntary, mandatory, and performance factors -- is what comes down to what is the known environment, or what is the predicted environment of the future.

I think today we are facing an environment as was pointed out is very different than what was perceived to be the known environment

in the past that was set out, because it is only when you have an appreciation of the environment -- I think one of your questions here later, or has already been covered, is should like services be grouped together.

It is a lot of those aspects which come into play when you try to determine what receiver standards or performance criteria might be. In cellular and PCS, for example, within those allocations and those usages, in the standards are generally performance criteria that impact the receivers.

And we as an industry measure those when we do acceptance of product, even to the end level before we pass them on to the consumer. And by and large, we have designed those criteria to work well within our system.

It is when you get interference or perturbations that come from elsewhere, either because it is not a known environment, or the environment has been changed around the known, that you get into a lot of these difficulties and problems.

And even whether they are a voluntary standard, whether you look at a mandatory standard,

you can't determine what that level of standardization, performance, or criteria, is without understanding both what is necessary for that service, what might be impinging on that service from elsewhere, and what might be the future that brings.

So it is a bit of having to have the right crystal ball if you try to develop these standards and extend them for the future.

DR. ROHDE: I think the normal car is a good example. If you buy a new car here and you wonder where the AM and FM antenna is -- I installed an auxiliary shortwave radio because I got bored with all the commercials, and I wanted to hear something else.

And I wasn't able to hear those stations because some much emission came out of the car here. So I don't know what magic -- sometimes the companies do have an AM radio which doesn't get interference, and then you go a little higher in frequency to get those. those.

And the reverse is that if you have a taxi, and you put a radio -- a taxi two-way radio in the car, all of a sudden the microprocessor fails to work. I mean, there is some known areas

what can happen and what cannot happen.

And I am not always sure whether industry takes it that serious to apply a solution. In some of the handbooks and repair manuals, I found a little note saying that if you are in a hostile environment, add those four components.

So the manufacturer in many cases knows what is going on, and he is defensive, and just doesn't want to put those things in for cost reasons, and that is one of those areas which I find it difficult knowingly going into an areas of deficiency.

So I think that some competition is necessary, and I wish the news media, whoever is listening to these panel sessions, would follow up on these, and make a point, saying that the consumer is best served not only by reducing the price of a device by five cents, but also by being able that this appliance can tolerate more levels of interference and other things, and therefore is more likely to be good for you.

I think it is an issue which totally is down-played, and this goes both ways, transmitted and radiated, internally and externally; coming out in the box and going in the box. I wish that the

press were here to cover things like this.

MR. WEINREICH: Thank you, Dr. Rohde. Who else would like -- okay, Paul first, and then Steve.

MR. RINALDO: In the amateur service, most of our stations are in homes; that is, in residential areas. Amateurs are usually interested in technical devices and get the latest technical devices to put in their homes. And then they find out that their amateur radio transmitter interferes with that new gadget.

We have situations where it is not simply an out of allocated band, or a front end overload situation, but it is actually around the same frequencies. For example, Charlie mentioned the unlicensed band at 2.4. Well, actually, it is licensed. It is licensed to the amateur service on a primary basis.

It is also licensed in a way to the ISM -- industrial, scientific, and medical services -- and that they can run all kinds of power. The licensing arrangement is not the same way, of course.

So there we have a mixture of licensed services and unlicensed services in the same band,

and it is a problem, and it is a growing problem. So what is not happening is taking into account the proximity of the transmitter.

In other words, an amateur transmitter is in the home, and there are devices in the home, and nobody is going through this stuff to begin with, and we find out these problems after we get on the air, and maybe interfere with ourselves, or the neighbor carrying a shotgun and is looking through the screen door at us.

And actually a formal interference complaint means that he is carrying a white shotgun. So that is the environment that we live in, and I am not so sure that it is getting worse or better, because there has been a history to this.

There was a time when very early television sets were bothered a great deal by amateur transmissions. That has been fixed for the most part, and the biggest contribution was the cable television.

There have been cases where the cables themselves leak on amateur frequencies. So, okay, we complain, and we work with the cable companies, and they take that channel off the air or start

tightening up all their connectors.

There are a number of cases as Ulrich mentioned with cars. Our laboratory works with the car manufacturers from time to time, and when we find out that things like the steering mechanism won't work if you transmit.

These things are worked out, but they are always worked out after the fact, and that is, that they built their equipment, and they have shipped it all, and they have got hundreds of thousands, or millions of them out there, and then we find out that there are problems.

Now, the problems may not be 50 percent of the time. It may be only 1 percent or 10 percent of the time these things could happen. It is very difficult to retrofit these things at the time, although we are sort of forced to.

In effect, a neighbor's telephone is not supposed to pick up, and is not supposed to intercept radio transmissions, but they do. A simple fix sometimes is to put a capacitor there, or wrap the wires around the toroid, and the interference goes away.

But I guess the question is who should be making those repairs, and especially if the

neighbor is really offended, and figures, look, it is very simple.

When you transmit, I hear the interference. When you stop transmitting, I don't hear the interference.

Therefore, you are wrong and I am right. That's the problem that we have. Thank you.

MR. WEINREICH: Thanks, Paul. Steve.

MR. GILLIG: Yes. I do believe there should be some sort of minimum receiver specifications that are put on the units. I think particularly -- well, as was mentioned before, in a lot of license bans, that comes as part of the normal system design and the architecture as it comes into the system.

But particularly in the unlicensed band, which we have now, and which we are considering further on licensed bands, what can happen there is that you would have people -- if they didn't have minimum receiver requirements, you could easily see where you could come in and come up with a unit that has basically no interference protection at all, and is really cheap, and get that out on the market, and everybody just loves it

because it is so darn cheap until everybody has one.

And then they all interfere with each other and everything else. So that is something that we have to look at, is that if you are going to put services, particularly anything that are disk-like services in the same band, you have got to have some interference minimum requirements.

MR. WEINREICH: Thank you, Steve. What about from the audience? Are there -- okay. Marc first.

DR. GOLDBURG: Listening to the discussions, there are really two types of interference issues being addressed. One was co-channel interference, and the other one was adjacent channel interference, and they got mixed a little bit in the discussion.

And while one really can address the issues of adjacent channel interference through better receiver design, and better front end filters, better selectivity, all that, I think the co-channel interference -- it is much harder for me to imagine a general spectrum would work in the unlicensed band.

How do you filter out interference that

is in your band other than -- I don't know, channel coding or something like that.

MR. WEINREICH: Thank you. I think -- let me just comment on that a little bit. You handle a co-channel interference either of two ways. Either you coordinate it amongst the users of the spectrum, or you try and use some kind of modulation scheme that can mitigate the interference.

Over on this side, we had -- please give us your name, please.

MR. FOX: Paul Fox, an independent consultant. I would like to go back to the case of t.v. receivers that Mr. Weiss raised, because I think it is fairly relevant history, and worth considering in terms of our goals of increased spectrum efficiency.

At least circa 1980, when the FCC measured the t.v. receiver performances, there had not been a significant improvement in taboo rejection over what there was, namely because the marketplace was not imposing any challenge upon them.

It turns out that the cable t.v. experience of having a signal on every channel is

not as relevant because they are all equal, and the sound carriers are down by another 10 dB.

The FCC did, however, contract with Texas Instruments and RF Monolithics for t.v. receivers, which were demonstrated that they could essentially have eliminated the need for the taboo.

The FCC could, and I think should have, back then regulated t.v. receivers, and mandated an improvement in t.v. receivers. The only thing that has in a sense saved the commission has been the migration to digital, which has the lack of a coherent carrier in its carrier; i.e., less interference potential.

And a better resilience to beats from analog t.v. sets. But if the Commission had back in 1980 in mandating improvements in t.v. receivers. I think the current problems with 700 megahertz public safety would be a lot easier to solve. Thanks.

MR. WEINREICH: Thank you. Carl, you wanted to add something.

MR. STEVENSON: Yes. There was a comment before of something to the effect that consumer electronics folks have resisted receiver

standards, and the manufacturers of devices for use in the unlicensed bands, the Part 15 type devices, tend to get lumped in with that.

And I just want to make it clear that in its comments to the task force, IEEE 802 stated that we believed that the development of receiver performance standards or guidelines as part of equipment type acceptance would be beneficial in addressing the issue of harmful interference.

Also, knowing the minimum's performance characteristics of equipment operating in a particular ban can be essential to conducting sharing feasibility studies, and designing devices that can share with existing systems, which will promote new applications and increased spectrum sharing and efficiency.

We are going back to the idea of using unused spectrum in a dynamic way, and if the manufacturers and the developers of the standards know what minimum performance they can expect, because the commission requires it, then it is much easier to design systems that can live together happily in that environment through a combination of modulation and coding techniques, and protocols that allow -- you know, cooperative dynamic sharing

and co-existence.

So of the candidate criteria for receiver performance standards would include selectivity, susceptibility, dynamic range, local oscillator phase noise, and unwanted emissions.

These are all things that we believe the commission should look at developing minimum standards for in the equipment authorization process. Thank you.

MR. WEINREICH: Thank you, Carl. I think the things that you mentioned are things that -- at least the communications users of the spectrum routinely look at as far as trying to make sure that their system is going to provide the performance that they have told their customers that will happen.

I know that it is that way in the satellite industry, and I am sure it is that way also in Sabre mobile radio. Steve first, and then Ulrich.

MR. BLUST: I think from the previous comments that when you look at dynamic usage and utilizations, and a sort of a laissez-faire approach to systems and services, I go back to the fact that you have got to know what you are

designing for.

Most of the situations that we begin to see time and time again are because we are increasingly adding things in, around, or on top of what we already had out there, and we are changing that design problem.

So, again, when you begin to look at how to be totally dynamic, and you look at the number of different combinations of things on the board today, plus the technology advances of the future, I am not sure that you can ever build the right matrix that says these are all the things that I am designing for, and if you could build that matrix, does that product match the economics of the marketplace that those products need to be in.

MR. WEINREICH: Thanks, Steve. Ulrich.

DR. ROHDE: That is a good question, that if they can afford to build everything, you can do it. But I wanted to add one more thing. The FCC has given a great possibility and responsibility to the radio amateurs and their playground.

And I think if the FCC would analog to

what has been used for tech instruments, and to develop a front, and if the FCC would work close together with the American Radio Relay League, as an example, to look at possible things, I think that this would make the league very happy, and would make the consumer very happy, because these things would all be looked at prior to their occurrence.

And that is something that I am not sure why the specifications and tests specifically, when the FCC knows that the league has these capability measurements is not used. Has the FCC ever looked at actually asking to do the league something for their privileges? I think I would look into this.

MR. ENGELMAN: I think we will look into that. I know that we have had a partnership with the league on a number of issues, but whether we have asked them to look at this specific issue in the past, or worked with them, I'm not sure.

DR. ROHDE: They are quite capable of doing it.

MR. ENGELMAN: Paul might know actually.

MR. RINALDO: Well, I don't know about

the general or this specific question, but we certainly have worked with the FCC on a number of issues over the years.

Our laboratory is always available to look at these issues. We have solved problems together, and we have an ongoing dialogue concerning enforcement, and I guess that is another thing that we have not mentioned here.

But sometimes some users of the spectrum get out of hand, and once they start interfering too greatly with others, they have to be found and dealt with in some manner.

And we have identified some of those cases, and the FCC enforcement has improved over the years, and they are still improving. So there is a feedback loop going, and as I said, my moat is always open.

MR. WEINREICH: To go back to something that Steve said about designing for what you -- for the environment that you know, that kind of gets to the question of, well, what about what you don't know, and what about what would come after you finish your design.

And that I think would lead us to something like the software designed radio, or the

software defined radio, where it would be adaptable or readily adaptable to different schemes, and perhaps different interference schemes that might able a user with a specific spectrum allocation to combat or to mitigate some kind of an interference situation that arises.

DR. ROHDE: Can I add one more thing here? Last year, I bought a sailboat, and the sailboat has a refrigeration system on it. And I will tell you that I have never seen a better transmitter than this refrigeration system, and I am absolutely at the end of my wit, because I don't know what to do.

Is the FCC regulating this, because I have a shortwave radio which is for global marine distress purposes, and so it is a legalized radio, and I can't use it. The refrigeration system hates me. The deep freezer hates me. The radar unit sends out clocks every one second.

I am really sitting in the middle of noises in a sailboat somewhere in the Atlantic. The satellite telephone doesn't work, and so I am out of reach. The cell phone doesn't work, and I have no idea what to do.

So that is an interesting question.

Yes, as a consumer, you sit there, and you are in trouble. So this is an environment that you do know, and it is a sailboat, and it has no shielding, and it has a lot of things here.

MR. TRIMBLE: But aren't you the consumer and can't you decide what you want to have interfere with yourself?

DR. ROHDE: Well, at the time you buy this, you have no idea what they are doing.

MR. TRIMBLE: That was a rhetorical question.

DR. ROHDE: I know, but it is a serious question.

MR. TRIMBLE: It is a serious question. It is a problem.

MR. WEINREICH: Right. The problem is that the engineer goes out and designs his system to work a certain way, and then is confronted with this unknown that pops up like in the freezer. And I think it leads us to somehow ask the Commission to provide some guidance at least on how do we make things more electromagnetically compatible.

EMC or electromagnetic compatibility seems to becoming more and more of an issue as far as the devices that we use on a day to day basis.

Steve Gillig first, and then Blust. I'm sorry.

MR. GILLIG: Since we finally brought up the issue of software defined radio, which is a controversial topic, and once you have one, this Holy Grail, why then all the other questions kind of go away.

I would have to say that first off on that, there is two parts to a software defined radio. There is a software in the signal processing, and then there is all these RF hard components which you don't really just change by going in and tweaking the atoms and things like that in software.

So there is some things that you can do in software and software defined radio. You can get rid of certain types of interference, but there is a whole lot of them, and a lot of the types of interference that you are talking about here from out of band interference that you really can't get rid of because you have to protect those in the receiver hardware before it ever gets in to where you are doing the signal processing.

So software defined radio is a great thing, but I think what we have heard in some of the side conversations, too, is that the aspects of

software defined radio are starting to come in.

Radios are becoming more flexible, and they are having adaptable modulation schemes and things like that, and that's true. But to wait for a Holy Grail that just says this software defined radio can overcome whatever interference is out there is something that we shouldn't count on.

And even if we technically could do it, whether it is something that economically would make sense is another thing altogether.

MR. WEINREICH: Mr. Blust, please.

MR. BLUST: To continue on that same thought, when we look at having to -- when we get expansion and additional spectrum for a lot of services, often times just because the nature of spectrum is full, we are looking at it being on different and varied frequency bands.

So when we begin to design receivers or transmitters for that matter that have to operate over 3, 4, or 5 different discreet frequency bands, the trade-off there may be the costs associated with having to put in the front ends to handle four frequency bands, versus being able to put in a very high performance front end and other techniques which may improve on a single frequency band.