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Software Defined Radio: Prospects for a Bright Future

Keynote Address

by

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Thank you very much _____for the kind introduction. I am very pleased – and honored – to be here in the Washington area for your conference and to have the opportunity to present this morning's keynote address.

As a few of you may recall, I gave a similar keynote at your 19th General Meeting in Seattle in June of 2000 – not long before I retired from my position as Chief of the Office on Engineering and Technology (OET) at the Federal Communications Commission. As you might expect, when I was asked to give this current address, I went back to that earlier speech to get some ideas on points that I might take up here today and, more specifically, to see what I got right or wrong – or missed altogether.

I divided that speech of more than eight years ago into four parts: *First*, I briefly described the role of the office that I headed at that time – the Office on Engineering and Technology. *Second*, I spent the bulk of my time talking about the Commission's – not just OET's – interest in the topic of Software Defined Radio (SDR) technology. *Third*, I talked briefly about the notions or principles of openness that underlay the phenomenal success of the Internet and, *fourth*, and finally, I briefly addressed the importance of developing systems and services that are accessible to persons with disabilities.

Of course there is no reason for me to address the role of OET today and I will spend the bulk of time now – as then – on the status of SDR (and Cognitive Radio – CR) technology and its relationship to broader aspects of spectrum management. But the topics of openness and disability access are still important today, so, if you will indulge me, at the close of my remarks here this morning, I would like to touch briefly on those two topics once again.

In those remarks some eight years ago, I talked about the increased difficulties that the Commission was having in responding to increased demand for access to the radio spectrum resource – especially below 3 GHz. In those days – we, and in particular, the Chairman at the time, Bill Kennard, talked about the need to be creative and innovative in our spectrum management policies in order to avoid a "spectrum drought" that could constrain future growth of wireless services. To illustrate one example of such an innovative policy, I talked at some length in Seattle about the idea of a secondary market in spectrum and how such a market might facilitate greater use of the spectrum resource. Under this notion, the primary market is represented by the initial distribution of a block of spectrum in an auction, for example. The secondary market is represented by entities buying and selling of the spectrum itself after the initial distribution. (Note that I am not talking about talking about the common situation where one company buys or merges with another company and acquires all of its assets in order to gain access to its spectrum – as in the case of the pending Verizon – Alltel merger. Rather I am talking about buying and selling the spectrum rights – the license – alone.)

In the Seattle speech, I broached a slight variation of this idea of a secondary market in spectrum; namely, the potential "lease" of under-utilized spectrum on a temporary basis to meet short or medium term demand for a particular service. To illustrate the notion, I gave the example of how a licensee, holding commercial or private mobile radio spectrum or fixed wireless access spectrum in anticipation of its own growth, might lease spectrum to another entity to allow the latter to meet some spike in demand. The spike in demand might be produced by the presence of a major public event in the area such as national political convention or the Olympic Games. I went on

to note that even more dynamic – or shorter term – exchanges had been suggested – and I pointed out that it was easy to see how arrangements such as these could produce a "win-win" situation for everyone involved.

More specifically, I spoke about how the lessor could gain revenues while maintaining control of spectrum that they felt they needed to meet their long term strategic objectives, while the lessee would be able to make a profit by providing service to otherwise under-served customers. Consumers would benefit from the availability of the service and manufacturers would potentially benefit by the sale of more product. And speaking then as a regulator representing the public, I argued that we would benefit from the greater and more efficient use of the spectrum resource that we at the FCC had been charged with managing in the public interest.

I then went on to point out that, for longer-term leases of the spectrum, the lessee would have the opportunity to recover the cost of the necessary equipment -- including specialized equipment that might be required to provide a particular service in an other-than-normal allocation. This was in contrast to shorter-term leases where the lessee might not be able recover the cost of such specialized equipment -- or even interest a manufacturer in producing it. That is where I envisioned SDR technology playing a major role by reducing the cost (and time) of deploying radio equipment on temporarily under-utilized spectrum. I concluded that by providing the needed flexibility in equipment, SDR could help enable secondary market applications – increase sharing of the resource if you will – and thereby help alleviate the specter of a spectrum drought.

In other words, I envisioned more dynamic – more intense – sharing of the spectrum resource based upon the emergence of a public, secondary market for the

resource and enabled by the technological flexibility of Software Defined Radio equipment and systems. Although parts of that vision are in place, it is obvious that the spectrum leasing market has not developed as I had – perhaps naively at the time – hoped. In the next few minutes, I would like to address some of the reasons that this is true and even touch on some possible remedies. But before I do that, I want to stress two points about that original vision. *First*, at that point in time, I was almost entirely focused on SDR functionality and not on the Cognitive Radio functionality that subsequently developed as a result of the DARPA XG Project and similar efforts. *Second*, I was focused on the voluntary sharing of the resource under a market-driven lease agreement between an existing licensee and an entity with a short to medium term need to access spectrum to be able to communicate.

With those two points as background, I will now turn to a brief examination of the status of the two major components of my vision – the creation of a more dynamic market in spectrum with SDR as the technological enabler. Let me take up the status of the latter – the status of the technology – first. As a result of (a) governmental support of research on dynamic spectrum access technologies through DARPA, NSF, and NIJ among others, (b) the demonstrated need for such technologies to solve very real problems in the national defense and, increasingly, in the commercial arena (e.g., in the TV white space proceeding), (c) the delivery of real products and systems demonstrating the key concepts associated with SDR and CR functionality, and (d) the crucial supporting work of your organization – the SDR Forum, I believe that we are in quite good shape in terms of the technology needed to enable the market that I envisioned when I spoke to you more than eight years ago. Indeed, the addition of the Cognitive

Radio functionality – capabilities that I did not fully anticipate at the time of my earlier speech – makes it even more likely that a potential lessee of under-utilized spectrum can successfully demonstrate that he or she will not cause unacceptable interference to any existing or future operations of the licensee of the under-utilized spectrum. As you all know much better than I, the dynamic spectrum access concept has been successfully demonstrated in the field and, to name just one example, has been incorporated into the spectrum sharing arrangements between federal government and non-federal government users in the 5 GHz range. Just in the last few years, I have noticed that the general tenor of the conversations at industry conferences such as DySPAN and this one have changed – moving from PowerPoint-oriented possibilities full of optimism based on yet-to-be deployed ideas, to decidedly more practical demonstrations of key concepts and people searching for the right business cases to support deployment. In short, I am convinced that technology is no longer a major barrier to the market oriented vision that I had back in 2000.

The other part of my vision – the development of a secondary market for spectrum in the U.S. is, quite frankly, a bit of a disappointment – at least to this point in time. To its credit, in the period following my earlier speech, the Commission took a number of actions to further encourage the development of a secondary market and it is my understanding that a fairly large number of longer term secondary market lease transactions have occurred to, for example, support the eventual outright sales of spectrum licenses. Moreover, as I and other proponents of secondary markets foresaw, brokers and dealers have emerged as intermediaries to facilitate secondary market transactions. Early on, Cantor Fitzgerald got into the business and, more recently,

another firm, SpectrumBridge entered the market as well. While these are indeed promising developments, the fact of the matter is that we still do not have a vibrant short-term market in the resource. In the financial sector of the worldwide economy, Nations are concerned about liquidity. Liquidity – as you know – is concerned with how quickly and cheaply one can convert an asset into cash and here I am talking about a somewhat similar ability to buy and sell access to spectrum the same way – quickly and cheaply. I should mention that John Chapin of Vanu and Bill Lehr of MIT made a similar point regarding liquidity in a 2007 paper of theirs. As they put it, "There are three enablers for market liquidity: available spectrum, customer demand, and low transaction costs."

I would like to explore this lack of "liquidity" in spectrum in a little more detail. Because of the way we choose to manage the spectrum resource here in the US, potential leasors can be divided into two categories – private sector licensees (including state and local governments) who hold spectrum managed by the Federal Communications Commission and federal government "licensees" who hold spectrum managing by the National Telecommunications and Information Administration (NTIA) in the US Department of Commerce.

On the commercial or FCC side, evidence suggests that there are still relatively large blocks of spectrum that are not being fully utilized and which are not being offered for lease on a short term or long term basis even though (a) the Commission has taken significant steps to facilitate such transactions and (b) the technology is available to allow the spectrum to be used or shared on a non-interference basis as I argued a moment ago. When you talk to entrepreneurs who would like to gain access to such licensed spectrum – say Wireless Internet Service Providers using unlicensed spectrum in more rural areas –

they often complain that it is very difficult to identify who the licensee of a given block of vacant commercial spectrum really is and, even if they can identify the licensee, it is often very difficult to identify someone in the company that has the necessary authority to discuss lease opportunities. The difficulty in identifying the actual licensee often stems from the fact that the spectrum is legally held by a company with a name like "ABC Spectrum Holding Co." which is a subsidiary of some well known -- but difficult to ascertain in the FCC data base – company. This difficulty in tracking down potential leasors clearly adds to transaction costs – as an economist would say – and discourages otherwise beneficial exchanges from occurring. Thus I would support the notion – as others have recommended – that the Commission require licensees to file additional information on the status of their spectrum holdings, including a person to contact regarding potential leasing (or sale). If budgetary considerations permit, I would also support the idea of the Commission making increased use of spectrum occupancy measurements to identify under-utilized spectrum.

In fact – because, unlike other resources such as coal or oil, spectrum is infinitely renewable and not consumed by use – it may be justifiable in exceptional cases to require a holder of unutilized or vastly underutilized spectrum to offer that spectrum for lease under specified terms and conditions – not totally unlike a compulsory copyright license in the entertainment industry. I recognize that this latter step raises all kinds of policy issues but, on the other hand, having large blocks of infinitely renewable spectrum sitting idle when others crave it for productive uses is a drag on the economy – and on public safety and homeland security – that we can ill afford as a nation.

The situation on the federal government side – the NTIA side if you will – is even more challenging. It is even more difficult to find out what agency – or group of agencies – is authorized to utilize a particular block of apparently vacant federal government spectrum and still more difficult to find a person authorized to explore a potential sharing arrangement based upon dynamic spectrum access principles. Since I am – along with Bryan Tramont – co-chairing the Commerce Department's Spectrum Management Advisory Committee (CSMAC), I am hesitant, at this point of time in our deliberations, to go into too much detail, but I personally think it is clear that – just as in the case of commercial spectrum – more transparency is needed on the Federal government side.

But let me make myself perfectly clear. I strongly believe that the Department of Defense and other agencies charged with the safety of life and property, the national defense and homeland security must have access to adequate spectrum to carry out their vital responsibilities. On the other hand, we are all rather confident -- based upon spectrum occupancy measurements -- that their spectrum is not always fully utilized and that sharing/leasing opportunities abound. The problem on the federal government side, however, is not just a lack of transparency – as important as that is – it is the lack of normal financial or other incentives for agencies to enter into sharing arrangements. On the commercial side, if an entity purchases spectrum at auction and carries it as an asset on its books, there is an incentive to maximize the return on that asset. In other words, a CFO doesn't like "lazy assets." We need the same sort of carrot – or perhaps more accurately – a collection of carrots and sticks – incentives and penalties – to encourage increased sharing between the federal government and non-federal government sides in

ways that ensures the former with the spectrum resources they need to carry out their vital missions while providing much greater opportunities for the continued growth of commercial services. We are looking at such incentives as part of CSMAC work that I mentioned a moment ago. Some of the alternatives we are looking at there include carrots in the form of new equipment or systems for agencies that agree to share their spectrum and sticks in the form of spectrum use fees like those that have been imposed on governmental users of spectrum in the United Kingdom. I might add that the former, carrots in the form of new equipment or systems were successful in encouraging the reallocation of AWS spectrum under the Commercial Spectrum Enhancement Act. Our deliberations in the advisory committee are still on-going and we are trying to learn from some of that earlier experience. Hopefully we will have our final set of reports done fairly soon as our last meeting is scheduled for early December. I would also hope that our work in this area would continue in the next iteration of the advisory committee.

As I indicated, I would like to close by commenting briefly on the "openness" and "disability access" issues that I touched upon in my remarks eight years ago. With regard to openness, in that earlier speech, I talked about the notion of openness in network architectures and how openness had contributed so heavily to the phenomenal success of the Internet. In effect, I indicated some discomfort with the more closed architectures that had emerged in commercial wireless networks and how it might stifle innovation in application development by entities other than the carriers and their equipment suppliers. While I fully appreciate the fact that the carriers must earn sufficient revenues to support the build-out of their capital intensive networks, I remain convinced that empowering bright people to innovate at the edge of the network can produce important overall

benefits compared to a walled garden approach. Therefore, I am personally very pleased to see the recent emergence – whether motivated by the marketplace or by regulation or a combination thereof – of more open approaches such as Verizon's Open Development Initiative, the emergence of the Android operating system and the formation of the Open Handset Alliance and release of Google's Gphone, and, finally, Apple's release of the iPhone Software Development Kit (SDK) that allows independent development of new applications.

With regard to providing access to persons with disabilities, I argued that the increasingly capable wireless networks coupled with powerful, software programmable terminal equipment at the edge of the network, gives application developers an extremely powerful set of tools with which to work. I urged the attendees to consider accessibility issues early in their design efforts and, among other things, argued that universal design principles not only benefit persons with disabilities, but also result in products and services that are better suited for all. For example, cell phones that give us a choice of whether they vibrate or play ringtones allow us all to be more polite during meetings or concerts, while allowing people who are deaf to gain the benefits of the technology as well. Likewise, a simple nib on the "5" key of a keypad not only allows a person who is blind to orient their finger accurately on a keypad, it allows those of us fortunate to have normal vision to do the same thing in the dark.

To be more personal, when I argued for early consideration of disability access issues in wireless design efforts, I did so because I thought it was ethically and morally the right thing to do and because the Section 255 of the Telecommunications Act required it as a matter of law. I had no way of knowing then that my wife would be diagnosed

with ALS – or Lou Gehrig's disease – just a few years later. As I watch my wife heroically fight this increasingly debilitating and ultimately terminal disease and as I see how good universal design principles in the products she depends makes her life more enjoyable and productive, I am more convinced then ever that my advocacy back then was sound. So once again – some eight years later – I would urge you to be conscious of disability access issues – it matters to a lot of Americans.

Thank you again for inviting me here this morning and thank you all for your kind attention.