The Future Potential

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Abstract--**Two inexorable metatrends are driving the telecommunications industry, and will result in significant increases in the size of, and demands on, the III – V class of semiconductors. Both key trends result from digitization of everything. The first metatrend is a series of convergences: voice with data at the device and network levels, wireless with wireless networks, and network architectures converging on packet switching. The second metatrend is an insatiable demand for bandwidth, motivated by the technical demands of digitized multimedia, by the human need for speed, and by cost of capacity.**

Convergence and bandwidth have direct implications for networks and terminal devices. There will be more coax and fiber on the wireline side. To keep pace on the wireless side, we see the rapid rise of large markets at high frequencies – anywhere from 2.4 gHz to 60 GHz. There will also be much more embedded wireless mobility, caused by the blurring of device categories and wireless-wireline convergence. The Bluetooth Group, for example, is sorting out some of the basic architectural issues. Finally, the inevitability of lower costs and prices from the action of Moore's law of digital things means quantities will continue to grow rapidly.

The fundamentals of very significant demand increases are coming into place. This presents some interesting challenges; at least three deserve special note. First, there will need to be technical rationalization of the various flavors and design approaches to III – V semiconductors; they won't be discrete or special purpose parts. They could become mainstream integrated devices. Second, we would like to see much more integration, including resistor, inductor, and capacitor elements. The higher the frequency, the more long circuit traces present design and packaging problems. This will represent major technical challenges. Finally, we think GaAs will see challenges. One of these is the new class of silicon germanium HBT's which may offer some interesting competition at "lower" high frequency. Another is the indium phosphides class which may offer potential at the "higher" frequencies.

It should be an interesting new millennium.

SUMMARY

Two inexorable trends will drive significant future potential for high frequency devices, and therefore the demands – both for and on – III-V class semiconductors. Both trends arise from digitization.

Digitization allows the convergence of telecommunications technologies. Voice networks have traditionally been circuit switched. Already, almost all incremental network capacity additions have been for digital data – fax, pc/internet, and so forth – which is more efficiently packet switched. A packet network for digital data can be implemented for 1/10 to 1/3 the cost of circuit if reliability is not a prime consideration. Most carriers today are building data only network, including ATT, Sprint, and Worldcom in the U.S. (Figure 1)

On packet switched networks digital voice becomes just another data stream with latency issues. These are being solved as streaming audio from Netspeak and Broadcast.com show. IP6 will standardize many of these innovations.

These technical advances enable convergence of voice and data, wireless and wireline systems around a seamless, packet switched digital network architecture. These will be the majority of installations within 5 years. Nortel acquiring Bay, Lucent acquiring Ascend, CISCO supplying Sprint are among the early harbingers of this trend.

Digitization also creates a second trend, an insatiable demand for bandwidth. 12 kbps voice goes to 56 kbps voice plus data in 2.5/3G wireless systems. 56 kbps voice goes to multihundred kilobit data with xDSL. A major threshold at 1.5 mbps enables NTSC quality digital real time video with MPEG2 compression. 8 MBPS provides DVD quality video. And the beat goes on.

Whether it is more subscriber adds creating greater teledensity, or consumer dislike of latency, or demand for multimedia, more bandwidth is needed.

More bandwidth means the growth of hybrid fiber coax systems. xDSL is but a transition to these more capable wireline systems. ATT's acquisition of TCI is one example of this trend. Motorola became the early leader in cable modems for internet access because these terminal devices looked technically like high frequency radio's. Microprocessors and I/O bus capability continues to rise in support of these higher "frequency" demands. On the wireless side, true frequencies must also rise. Higher frequency means shorter propagation range, which means smaller cell sites and more frequency reuse, therefore greater teledensity. Already in Paris we are retrofitting the entire city core with microcells because of teledensity problems. The cost penalties of smaller cells are diminishing as the cells become less costly. More devices are connecting wirelessly, for example our two way pagers, Palm Pilots with our chipset support, automobiles through telematics systems like GM Onstar or Ford Rescu. More capable wireless devices, and more of them mean quantities will vastly expand. Our industry is forecasting over 500 million cellular annual units within 5 years, with increasing proportions at higher frequencies as 3g systems emerge. (Figure 2)

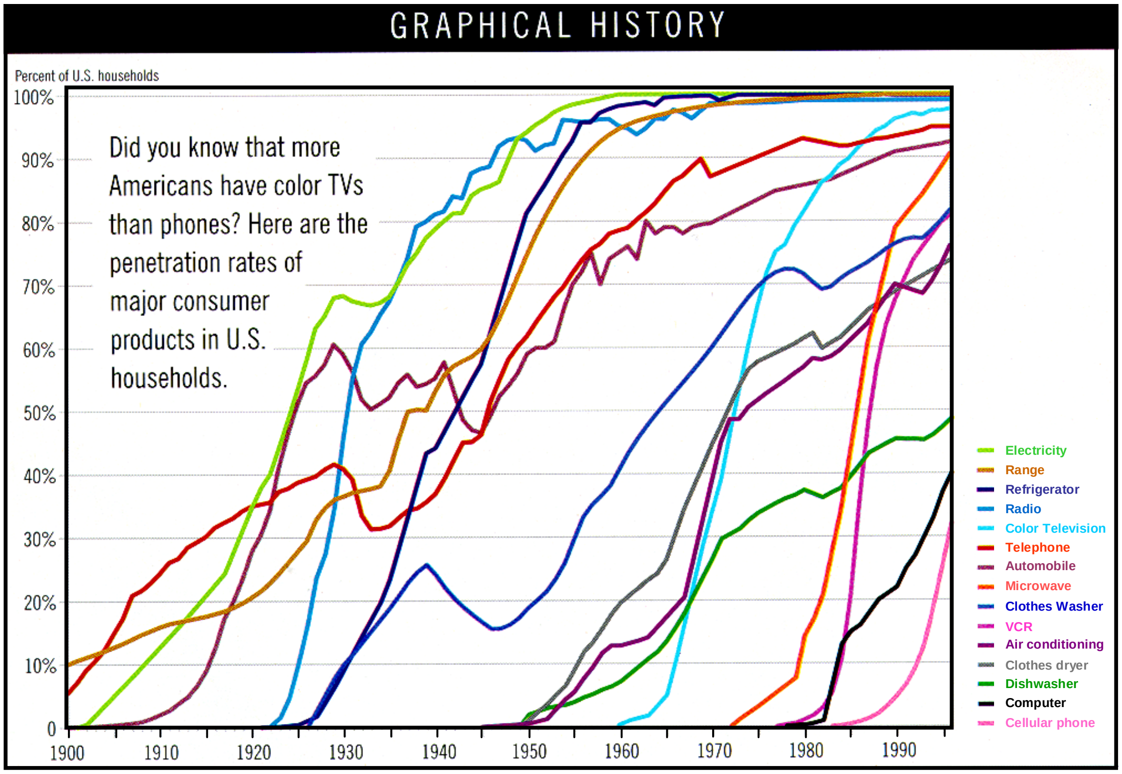
The fundamentals of very significant demand increases are coming into place. This presents challenges for our industry; three deserve special note.

First, there will be pressures for technical rationalization. Motorola already supports 7 different MA's in four different digital standards at 2 different frequencies (iDEN, TDMA, CDMA, GSM, 800-900 and 1800 mhz) with at least two 3G standards at multiple frequencies looming – and this is just for cellular phones. Engineering and design resource constraints as well as product cost pressures will be pushing high frequency parts into common platform specification, mainstream parts.

Second, there needs to be more integration including passive elements. Longer circuit traces are problematic at higher frequencies due to delay, crosstalk, parasitic capacitance, and a host of other design problems. We cannot design around; we must design through. Creation of multichip modules, integration with MCIC (multilayer ceramic integrated circuits) passives, and overall packaging remain large challenges. Our most advanced products – digital StarTacs, two slot GSM's, Iridium handsets – contain only rudimentary solutions to these problems today. We hope the industry will be able to rise to these technical challenges.

Third, we see classic GaAs itself facing technical challenges. Two of them are worth noting. The new class of silicon germanium HBT's offers interesting possibilities for the "lower" high frequencies of a "few" gigahertz. Granted, many problems remain to be solved, but the potential price/performance is attractive. The indium phosphides may offer potential at the 'higher' frequencies in tens of gigahertz. These frequencies will be a staple of picocells, which will be a core feature of seamless connectivity and increased teledensity. For example, we are very attracted to a frequency band just under 60 gigahertz, and are actually designing a picocell architecture for it.

It should be an interesting new millennium. Our industry is rapidly growing and evolving. I hope these comments can stimulate your thinking about the challenges that lie ahead.



Fortune Chart/Source: Federal Reserve Bank of Dallas

Figure 1

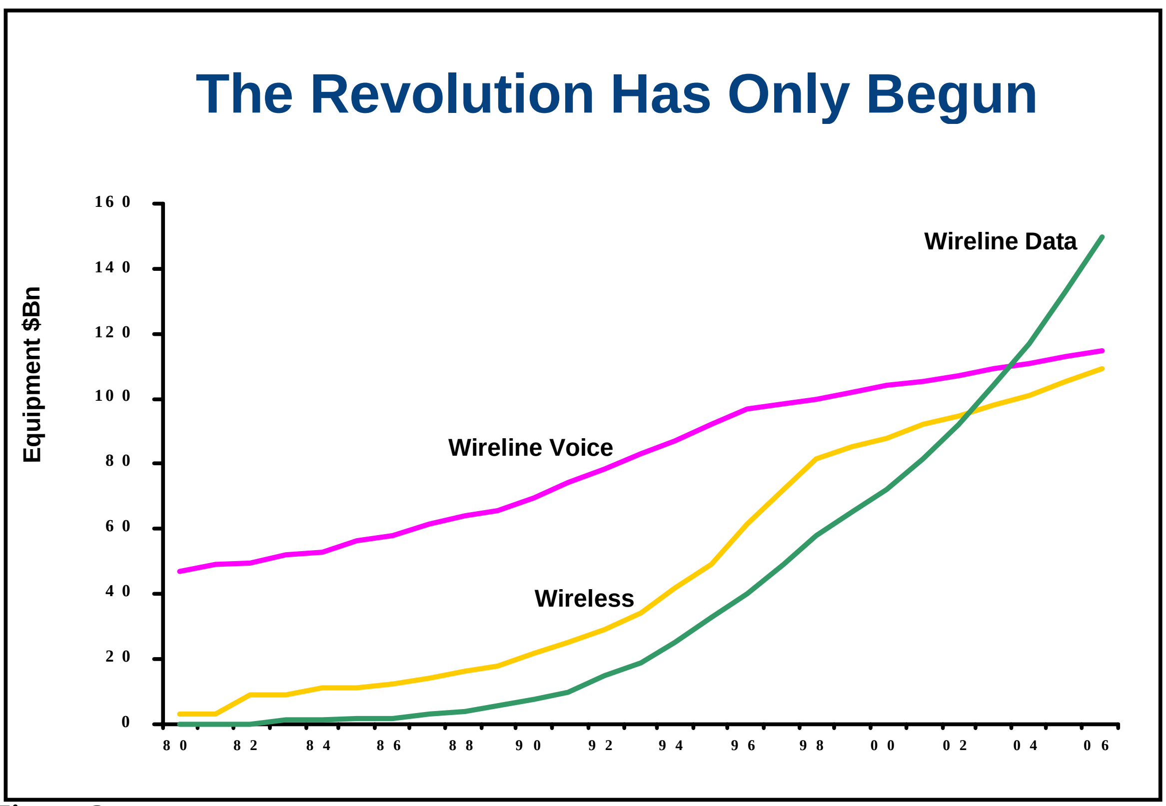


Figure 2