# The Economics of Wireline vs. Wireless Telephone Service

Ed Morrison[1]

Mr. Ed Morrison is a senior economist with the Oregon Public Utility Commission where he participated on the team estimating long-run incremental telephone costs. Formerly, Mr. Morrison was administrator of the telecommunications division. Prior to these positions, he worked as an operations analyst for the Office of Management and Budget, Executive Office of the President. Mr. Morrison has been editor of the *Cost Effectiveness* newsletter of the Operations Research Society of America. He graduated with a B.A. in economics from Grinnell College and an M.A. in operations research from the University of Washington. In 1976, Mr. Morrison passed the CPA exam.

The current pricing framework for regulated wireline telephone service in Oregon, as in other states, averages high-cost rural and low-cost urban services. However, competition from wireless technologies in urban areas where prices are significantly above costs has put downward pressure on wireline prices for urban customers. Correspondingly, it has placed upward pressure on prices for wireline telecommunications services in rural areas.

Recent studies by the Oregon Public Utility Commission (OPUC) staff and Hatfield Associates indicate that the provision of telephone service to rural areas could be provided at a lower cost through the use of wireless technologies. As a result, the OPUC has initiated an investigation to address the question, "Will cellular or another wireless technology provide telecommunications service to rural ratepayers at a lower cost than wireline technology?" A discussion of some of my analyses and conclusions follows.

### Wireless & Wireline Characteristics

The fundamental characteristics of wireless telecommunications delivery systems and markets vary greatly. Wireless systems in use or under development today include cellular, Improved Mobile Telephone Service (IMTS), Personal Communications Systems (PCS), Basic Exchange Telecommunications Radio Service (BETRS), and satellite cellular. (See Table 1 for a comparison of these technologies.)

While BETRS and IMTS have limited appeal in some niche markets, they are most likely nearing the end of their product lives. Satellite cellular, which won't be available until 1997, may become a substitute technology for IMTS if the prices come down. Currently, the trade press estimates prices for satellite cellular will be $3 per minute, with handsets costing over $2,000 each. These prices will no doubt go down as the technology improves.

For the purposes of this article, the focus will be on cellular and PCS because, in this author's opinion, they have the strongest consumer appeal. Table 2 highlights the characteristics of wireline, cellular, and PCS. While the services may look the same to the customer, if current wireless cost trends continue, the price differential for wireline over wireless will be mitigated.

### Cellular Costs

*Telephone Engineering & Management* (*TE&M*) published an article[2] that included the costs for cell sites of several cellular technologies. My analysis indicates that cellular "loop" costs[3] decrease dramatically with the newer digital technologies. Currently, cellular service typically uses an analog technology. However, it allows only one customer per frequency at any given time. Digital technologies, on the other


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Table 1
**Wireless System Characteristics**

| System | Regulator | Frequencies | Customers-Market |
|---|---|---|---|
| Improved Mobile Telephone Systems (IMTS) | FCC | Each customer assigned a frequency | Few business customers. Mature market |
| Cellular | FCC | Reusable frequencies | Many residential and business. Growing market |
| Cordless Telephones | FCC | Low power, short distances, few frequency choices | Many residential and business. Competitive mature market |
| Basic Exchange Telecommunications Radio Service (BETRS) | FCC and State Commissions | Each customer assigned a frequency | Widely scattered rural consumers-regulated utilities. May become obsolete, has experienced limited growth |
| Personal Communications Systems | FCC | Reusable frequencies, may be lower power than cellular | Cross between cordless telephone and cellular. New market-1996 |
| Satellite Cellular | FCC | Reusable frequencies broadcast from a satellite | Not well known, communications where telephone is unknown. New market-1997 |

*Source*: E. Morrison

Table 2
**Features of Personal Communications**

| | *Wireline* | | *Cellular* | | *Personal Communication Systems* | |
|---|---|---|---|---|---|---|
| **Feature** | **Now** | **Future** | **Now** | **Future** | **Now** | **Future** |
| Tetherless | No | No | Yes | Yes | — | Yes |
| Capacity | Yes | Yes | No | Yes | — | Yes |
| Coverage | Yes | Yes | Yes | Yes | — | Maybe |
| Price | Yes | Yes | No | Likely | — | Likely |
| Quality | Yes | Yes | Yes | Yes | — | Yes |
| Personal Number | Not Really | Yes | No | Yes | — | Yes |
| Intelligent Features | Some | Many | Some | Many | — | Many |
| Security | Yes | Yes | Not Complete | No | — | Not Complete |
| Extensions | Yes | Yes | No | Likely | — | Likely |

*Source*: Technology Futures, Inc.

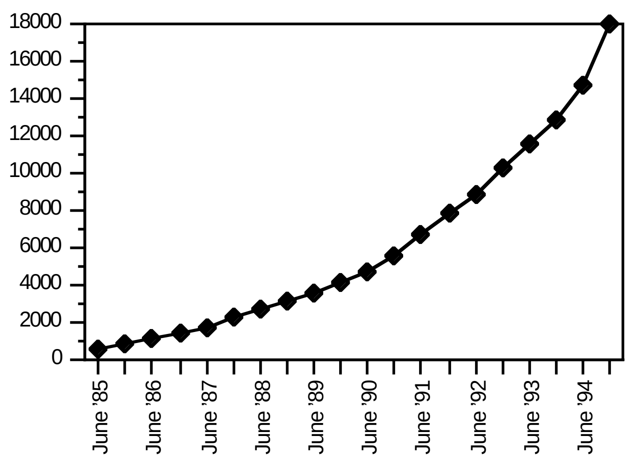
hand, do not face this limitation and therefore increase the capacity of a single site.

Each analog cell site serves about 1,000 customers using 51 frequencies and requires an investment of about $500,000. In comparison, the first digital technology being used—Time Division Multiple Access (TDMA)—costs about $1.4 million per cell site and has capacity for about 3,000 customers. The next generation—half-rate TDMA—will cost about $1.5 million per cell and double the capacity to 6,000 customers. Enhanced TDMA will cost $2.1 million per cell and have the capacity to serve about 19,000 customers. TDMA's likely successor—Code Division Multiple Access (CDMA)—is even more efficient.

In 1984, there were 346 cells in operation in the United States. By the end of 1994, there were 17,926 cells in operation, serving over 24 million cellular telephones. From the data shown in Figure 1, it appears that the year-to-year growth in the number of cells is increasing at a smaller rate. Using this relationship, the number of cell sites in the United States should reach about 40,000 by the year 2000. However, these projections are based on the extension of current technology. Two things are likely to change customer and cell site growth patterns:

- Economies of scale will continue to make consumer prices lower and thereby spur demand.
- The conversion to digital technologies and better antenna design will reduce the high costs of structure, land, and cell construction in city centers where demand is highest.

Figure 1
**Cell Sites in the United States**




*Source*: CTIA

Cell capacity depends on the traffic generated by each customer and technology. A projection of analog-based service to the year 2000 shows a nationwide capacity of 47 million customers. Capacity would be increased to 177 million customers if 1,992 cell sites were converted to enhanced TDMA. However, the new cellular customers are likely to use the service less than the current average. This is a fact obtained by analysis of the data. The time spent (minutes of use) has reduced as more customers have been added to the cellular system. The first customers to obtain cellular services are most likely those that gain the greatest benefit from them. The price per minute serves to ration the service so customers will be able to get a dialtone. As a result, this reduces the average peak air time and increases the capacity per cell site. Also, a time-of-day rate design has been used by cellular companies to reduce peak-time usage. Some cellular companies have greatly reduced off-peak prices to help balance the call load more evenly.

In summary, competition could develop between cellular and wireline-based companies if the price for cellular becomes sufficiently attractive. Pressures to drop cellular prices will increase as conversions to digital systems demand larger customer bases.

## Personal Communications System Costs

The Personal Communications System (PCS) is a low-power adaptation of cellular technology that is not highly mobile. The FCC designed PCS as a service with qualities between cellular service and the cordless telephone. The concept itself has undergone some changes, and it is unclear whether PCS will compete directly with cellular. If PCS frequencies can be used in cellular services, the technologies will blend into a single service. The barriers for use of PCS as a cellular service appear to be the relocation of microwave services that use PCS frequencies. However, sharing frequencies is probably a minor problem if PCS remains low power. On the other hand, if PCS uses higher levels of power to compete with cellular, microwave relocation is likely to be a problem.

The differences between cellular and low-power PCS are summarized in Table 3. The major differences are signal strength and range. The coverage of a single low-power PCS cell is much smaller than that of a cellular cell.[4] Cellular cells cover a radius of 2.5 miles or more; low-power PCS covers one-half mile. One industry expert explained that the signal was so weak that low-power PCS would not work in a car moving more than six miles an hour. In addition, interference between the low-power PCS telephone set and the antenna may be caused by passing trucks. On the other hand, the performance of the technology is likely to improve.

Beside the low power and range problems, there may also be some consumer resistance to purchasing low-power PCS.

Table 3
**Comparison Between Cellular and Low-Power Personal Communications Systems**

| Function | Low-Power PCS | Cellular |
|---|---|---|
| Mobile handoff between cells | No | Yes |
| Range | .5 miles | 2.5-15+ miles line-of-sight |
| Signal strength | .1 watts | .6 - 3 watts |
| Digital transmission | Yes | Both digital and analog |
| Network interface | Yes | Yes |
| Number transfer | Not yet | Not yet |

*Source*: E. Morrison

(1) The cost of low-power PCS is likely to be high given the inherent risk businesses face in establishing a new service.
(2) Low-power PCS quality is not likely to be as clear as cellular or wireline service.
(3) Low-power PCS does not offer the mobility of cellular.

In summary, costs for low-power PCS systems are currently unknown. However, costs per PCS cell must be well below $100,000 to be lower than enhanced TDMA costs serving the same population density. If the market is large enough, low-power PCS costs, on a per customer basis, could be lower or similar to digital cellular prices. Certainly, some niche markets for low-power PCS will emerge.

## Wireline vs. Wireless Costs

A study conducted by Hatfield Associates, *The Cost of Basic Universal Service*, concluded that the investment cost of wireless basic service was lower than the cost of wireline service in areas where the population density was below 100 persons per square kilometer.[5] Annual investment costs where population density was above 100 persons per square kilometer were lower for wireline. My own analysis of data from the publicly-available articles confirms the Hatfield study conclusion that *population density is a significant driver for loop costs.*

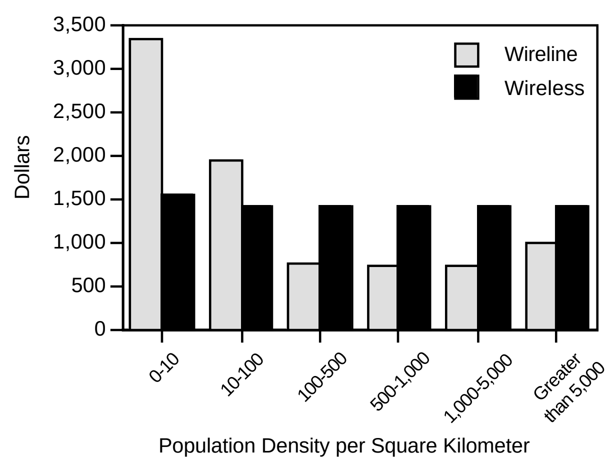
### Hatfield Study

The costs in the Hatfield Study of wireline and wireless services were estimated by density. Investment per customer is shown in Figure 2. Investment per line for wireless is less than wireline for population densities smaller than 100 persons per square kilometer.

There was an assumption that the system was built from scratch, for example, new service to an area. All of this was investment in outside plant that was assumed to be depreciated over 20 years. Also, it was assumed that there would be no subsidy for wireless services.

With these assumptions, the cost of a competitive wireless system might be less than the present wireline system. The FCC common carrier line charge defrays 25% of this cost. That subsidy comes from interstate access charges of $3.50 per line per month. The amount paid the wireline telephone company is based on the cost of outside plant. Rural exchanges operated by smaller telephone companies receive much more than the $3.50 paid. The common carrier line charge subsidy flows from urban customers to rural customers.

Figure 2
**Investment Per Line as a Function of Population Density**




*Source*: Hatfield Associates

OPUC STUDY

In Docket UM 351 Phase 1, OPUC faced the task of estimating the Total Service Long Run Incremental Cost (TSLRIC) of the basic elemental functions used to provide wireline telephone services. U S WEST estimated costs of the loop (services between the switch and the consumer's location) as a function of both density and the distance between the consumer and the serving switch. In thinking about loop costs, one can surmise that the major costs are: splicing, wire (both fiber and copper), ditches, conduit, and telephone poles. These elements are distance sensitive. Ditches, splices, and telephone pole costs consist largely of labor. The productivity in the production of outside plant has historically been relatively flat. One telephone industry employee stated that the "ditch witch" is the last major improvement of productivity in the installation of the loop.

Cellular costs, in contrast, appear insensitive to distance within the cell. The number of cells seems dependent on the total number of cellular subscribers in the area. The more dense areas are covered by many smaller cells.

To aid us in estimating costs, we examined population densities by exchange in Oregon. The data relating to exchange area and number of lines was provided by Oregon telephone companies. Table 4 summarizes our estimates.

Population distribution was estimated as a function of the number of lines. This estimate is biased toward understating density in rural areas and slightly overstating density in urban areas because urban areas have a higher proportion of business lines (including cellular).

The cost of wireless is less than wireline in the 0-10 and 10-100 population per square kilometer ranges. It is surprising how few Oregon exchanges are in the greater than 1,000 per square kilometer range. Tigard is the most dense exchange, with about 1,700 per square kilometer.

Less than 38% of the population lives in exchanges where wireless appears to be less costly. However, the bulk of the exchanges (242) appears to be in density classes that could be served at less cost using a wireless technology. Only a small proportion (6.9%) of the population lives in the 142 least dense exchanges. The investment per line for wireless appears to be less than 50% of the wireline cost.

I made estimates of loop costs based on cell site cost estimates found in *TE&M*, now known as *America's Network*.[6] Private sources updated the analog cell site costs. Figure 3 shows the cost estimates.

The estimates used in Figure 3 were based on *TE&M* investments adjusted for inflation (80% per year decrease in cost) and an investment burden of 100%.

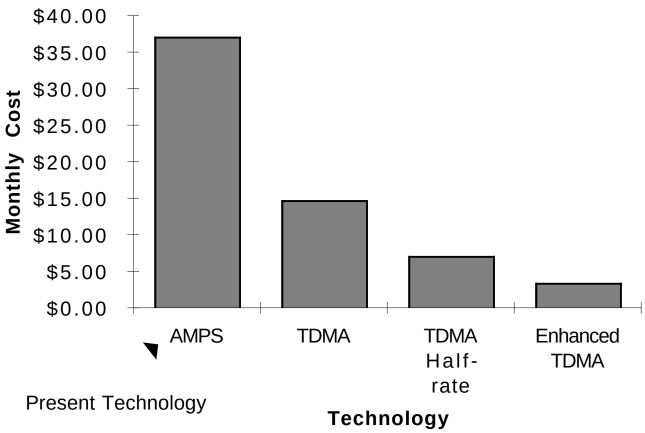
Table 4
**Estimated Oregon Exchange Population Density***

| Density | Exchanges Number | Exchanges Percentage | Population Number | Population Percentage | Lines Number | Lines Percentage |
|---|---|---|---|---|---|---|
| 0-10 | 142 | 53.99% | 207,075 | 6.90% | 117,384 | 6.90% |
| 10-100 | 100 | 38.02% | 945,347 | 31.51% | 535,885 | 31.51% |
| 100-500 | 16 | 6.08% | 994,180 | 33.14% | 563,567 | 33.14% |
| 500-1000 | 0 | | 0 | | 0 | |
| 1000-5000 | 5 | 1.90% | 853,397 | 28.45% | 483,762 | 28.45% |
| 5000+ | 0 | | 0 | | 0 | |
| Total | 263 | 100.00% | 3,000,000 | 100.00% | 1,700,598 | 100.00% |

* Per square kilometer of Oregon exchanges

*Source*: E. Morrison

Figure 3
**Cell Site Costs**




*Source*: *TE&M*

The investment burden represents other variable loop-like costs that I did not directly measure, including telephone set maintenance and repair. Monthly costs were estimated from investment costs by using a fill factor and operating ratio. An operating ratio of 35% was used to cover maintenance, advertising, depreciation, and overhead. Fill factors (percent of capacity) used were assumed to equal:

(1) 80% for analog.
(2) 75% for TDMA.
(3) 60% for half-rate TDMA.
(4) 50% for enhanced TDMA.

## Conclusions

With technology bringing customers more choices, the regulated telephone utilities will incur greater technological risk. One question that remains unanswered is, "How can the regulators maintain equity between rural and urban customers?" Should the rural customer look to the free market to provide services? Should the rural customer look to the regulator to keep prices low?

For the regulator, the challenge is to try to balance the interests of all of the parties involved, both wireless and wireline, with consumer interests and needs. However a few things are becoming clear:

- Communications technologies costs are converging.
- Stranded plant will be a problem for regulators.

### Converging Communications Technologies

Today, the regulated telephone industry faces a very different prospect than in the past. Large urban customers are being wooed by competitive telephone carriers. Many customers have dual capabilities, and residential and rural customers may have both mobile cellular and wireline telephone service.

Larger customers may be served by competitive providers as well as wireline telephone service. The number of competitors is likely to take market share from the local regulated telephone utility. Cable television companies have replaced coaxial cable with fiber optics that could provide the basis for them to compete with regulated telecommunications markets. Cellular and perhaps low-power PCS will grow quickly. Price competition between cellular and low-power PCS might eventually result in wireline telephone losing customers.

If the regulator could promote least-cost planning for telephone, at least some, if not many, rural customers would be served by some form of wireless service. Promotion of least-cost technologies should position rural customers to benefit from least-cost technology. The regulator should encourage the transition to wireless technologies where it is to the advantage of consumers.

### Stranded Plant

Stranded plant will occur when the customers of regulated telephone companies avoid high regulated wireline costs by switching to competitive carriers. The utility must raise prices (or increase the subsidy) to cover its inability to recover the costs of its undepreciated and underused plant. At this point, the regulated utility must write-off plant without compensation or risk losing further market.

AT&T wrote off a large part of its microwave system as it transitioned to a fiber optic system. Had long distance remained a monopoly, AT&T's plant would not have been stranded. Some rural customers benefit by the application of federal and state high-cost funds. Will those funds last forever? As long as bypass of the subsidy system is minimal, the subsidy can likely be maintained, and the high-cost rural areas will be subsidized by the lower cost urban areas. However, the demands of the information economy may encourage consumers with high long distance use to bypass the (subsidy) long distance tax. The more traffic that "leaks" around the tax, the harder it will be to maintain.

When the pressure becomes too great, the FCC or Congress will most likely act. FCC participation will be required in order to allow regulated wireline companies to transition to wireless for their own customers. The greatest risk may be a small telephone company with a large customer that bypasses the network through use of cellular or a direct line. Those rural wireline companies that are on cellular corridors (major highways) have the most to risk because the marginal cost of providing wireless service to customers in those areas is minimal.

Finally, will wireless meet the needs of the information superhighway of the future? Proponents of "fiber-to-the-barn" argue that fiber will transform American society. However, the cost of subsidizing fiber-to-the-barn is high. So far, the rapid progress in technology has been kind to the regulated telephone industry. Divestiture and competition in the long-distance business have benefited all customers. The future might not be so kind. Recent cellular developments include high-speed data transmission similar to that available over copper.

My major concern will be that stranded plant could force average regulated wireline rates significantly higher. I believe wireline companies face both technological and economic risks.

## Recommendations

Our policies today position us well for the future. In the past, the regulator has been concerned with minimizing the differences between rural and urban service because rural multi-party services blocked customers from many of the choices urban customers could obtain. The industry reached the point where it was less expensive to provide single party service to rural customers. It may be a mistake to translate these past precedents into supporting a fiber-to-the-barn philosophy. The regulator should look to the functionality of telephone services. Fiber-to-the-barn may be a step that provides little additional function for a very high price and risk. Wireless rural service options should be examined as reasonable substitutes for the functions provided to urban telephone customers.

The regulator should encourage the application of wireless technology by all regulated telephone companies in rural areas where it appears to meet the long-term, least-cost criteria. The regulator should ensure that either prices for wireline services in high-cost areas be no less than cost, or theoretically, the subsidies provided to high-cost areas should be made available to all providers including unregulated providers. Regulated telephone utilities need to plan plant replacements in a minimum cost context. Regulators should recognize both technological and economic risk in setting depreciation. When stranded plant becomes a burden, regulated telephone companies must resort to writing it off. Competition is unforgiving, and regulators cannot protect regulated utilities from competition. ntq

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[1] The opinions expressed in this article are those of the author and do not necessarily reflect opinions or policy of the Oregon Public Utility Commission.

[2] A. D. Roscoe and P. Rhyner, "Digital Conversion: A Necessity for Cellular," *TE&M* (August 15, 1993):54.

[3] Given the relatively low price of analog cellular phones today, that cost was not taken into account in my analysis. Customers using analog-based systems currently must purchase digital cellular telephones to use any of the newer digital technologies. Though these digital handsets cost more, they can be used for either digital or analog cell technologies. The retail price of an analog set is less than $100 without including a subscription to a cellular carrier. This price represents a drop from about $2,500 in 1986. Digital cellular telephone sets are currently priced about $400, and digital service is usually priced lower than analog.

[4] Cells are small because of the low power of the PCS telephone set (0.1 amp). Low power results in longer battery life and lighter weight sets.

[5] Hatfield Associates, Inc., *The Cost of Basic Universal Service* (Washington, DC: MCI, 1994).

[6] Roscoe and Rhyner, "Digital Conversion."