

Civil Infrastructure Systems and GIS Applications: The People Piece

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by Martha Farnsworth Riche, Ph.D.
Farnsworth Riche Associates

Societal databases associated with GIS systems are as much a product of computerization as the GIS systems themselves. The U.S. census, which is the foundation of all geographically-referenced demographic and socioeconomic data, has been conducted every ten years since 1790. However, the data gathered by the census are so voluminous that they did not become available to the public, except in very broad national and state summaries, until the advent of computers.

Indeed, collating such an enormous amount of data made the census a prime driver in the development of computers and computer-based data. It took so long to tabulate the data from the 1880 census that a Census Bureau employee, Herman Hollerith, invented a machine to tabulate the 1890 census using punched cards. The first civilian use of UNIVAC, the first widely-used mainframe computer, was to tabulate the 1950 census. And the 1990 census was conducted with the nation's first computerized street map (commonly known as TIGER, short for "topographically-integrated geographically-encoded reference"), developed by the Census Bureau in partnership with the US Geological Survey—a key step in the development of GIS systems.¹

The nation's first large-scale demographic databases grew from the 1970 and 1980 censuses. The Census Bureau released the data from these censuses on computer tape, summarized to protect the confidentiality of responses, at very small levels of geography.

¹ The classic history of the U.S. census is Margo J. Anderson, *The American Census* (New Haven, 1988).

That is, in addition to the national and state population summaries reported in print publications, similar summaries were made available for counties, cities, towns, and villages, as well as for census tracts (neighborhoods), groups of city blocks, and even single city blocks if enough people lived in them to avoid disclosing information about individuals.

From an infrastructure perspective, this meant that state and local governments now had a detailed portrait of the population they served, updated every ten years. The addition of TIGER, the computerized street map, delivered the 1990 update not just in tables, but linked to computerized street maps. In short, GIS maximizes the unique characteristic of the census as a data collection: the census not only counts people, but it places them where they live.

It is important, it is crucial, to emphasize that the census database does not include information about specific individuals or families, but rather summaries of all the households that live in particular places, whether local governmental units, or areas delineated by user-selected geographic coordinates. For all that is said about it, the Federal government really does not care whether the person living at 101 Main Street is Ms. Gonzalez, Ms. Horowitz, Ms. Jordan, or Ms. Liu. It just needs to know if someone is living at 101 Main Street, and what their characteristics might be, for use in apportioning Congress, allocating more than \$100 billion a year in Federal funds, or implementing multiple Federal legislative and programmatic requirements. Consequently, the database only contains summaries for the smallest piece of geography that contains enough people to mask individual identities.

This may not seem believable just before a presidential election in which potential voters are being targeted in a very personal way by computerized data techniques. And that's because political marketers are joining consumer marketers in buying private databases to gain personal information about individuals. For instance, the Washington Post reported a few weeks ago that the National Rifle Association is identifying likely allies by acquiring "lists of pickup truck owners, people with hunting licenses, concealed weapons permit

holders, gun show exhibitors, and outdoor magazine subscribers.” Similarly, the Post reports, the National Abortion and Reproductive Rights Action League is reaching out to Republican and independent women that visit the same web sites, listen to the same radio stations, or read the same newspapers as the organization’s members.²

Where does this personal information come from? All kinds of public and private organizations derive income from selling their membership or customer lists. Credit bureaus provide information, so do state motor vehicle bureaus. No wonder maintaining personal privacy is such a growing public concern. Fortunately, the official data the Federal government provides is largely sufficient for infrastructure purposes. In fact, that is largely its purpose: fully sixteen Federal agencies band together to collect small-area data for the entire nation via a special, long census form sent to roughly one in six housing units.

The current census asked fewer questions than it has in decades and, for perhaps the first time, all of them were the product of congressional legislation. However, public resentment of government intrusiveness has severely dampened Congress’ enthusiasm for this efficient and cost-effective form of the data it has required. In response, the Census Bureau has developed a new data collection which, if fully funded by the Congress, will add considerably to the societal information delivered via GIS.

It’s called the American Community Survey, and it essentially would replace the census long form with a rolling survey conducted across the country every month, every year. It would provide most localities with census-type data every few years—every year for large ones. However, given the lack of interest most members of Congress have in data, it will require considerable support from the state and local government community to acquire the appropriations necessary to take it to full scale next year.

Before I describe the specific societal data the government offers for use in infrastructure planning, I’d like to alert you to some important changes in society that will affect its

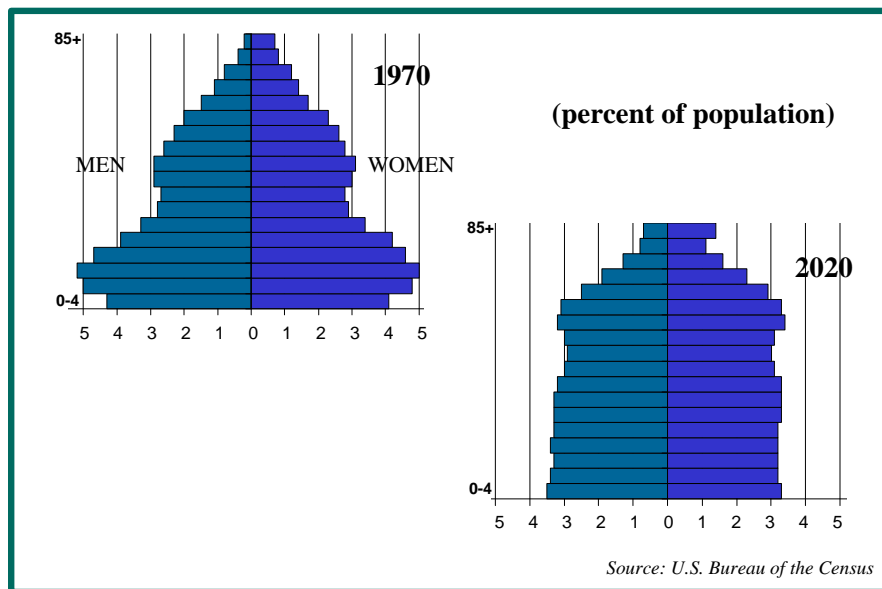
² *The Washington Post*, October 10, 2000; pp. A1 and A6.

infrastructure needs. Although the census data have not been tabulated yet, we already know the broad trends they will describe.

Perhaps the most important trend is something totally new in our society. Steady growth in life expectancy, combined with stable fertility rates, is producing a population with a greater share of older people relative to young people. The numbers of young people are not declining, as more babies are born in the U.S. each year than the year before.

However, their share of the population is declining, since the growth in the older population is so great.³ As a result, for the first time ever, American society is reaching a point where there are virtually the same number of people in each age group, except the very oldest. [Chart: From Pyramids to Pillars].

From Pyramids to Pillars



Demographers call an age picture a population pyramid, because populations have a traditionally had a relatively small group of older people, a middling amount of middle-

aged people, and large numbers of young adults, teenagers, and children. Now, thanks to the health improvements of the 20th century, the pyramid is turning into a pillar. Babies routinely survive childhood and adolescence, most adults traverse middle-age in relatively good health, and studies show that each group entering old age is healthier and more active than its predecessors.

When I tell policy makers that our population is close to having roughly equal numbers of people in every age group but the very oldest, no matter what their political persuasion they respond, “That’s bad.” They don’t really think it’s bad that people aren’t dying young anymore. But they know that this realignment has the potential to be more politically challenging than any demographic realignment we’ve experienced before. Every institution will experience its effects, and civil infrastructure is one of them.

The most obvious effects may be the differential physical capacities of older people. Take driving: for example, on-ramps need to accommodate more tentative drivers, and signs need to be enlarged, or repeated, for people who are slower to react to information. Changes from previous patterns—whether in driving, road layout, or signaling—need to be introduced in ways that both older and younger can understand. Just communicating change is more complicated when there are multiple audiences.

Another aspect of this trend is a need to design and manage infrastructure with an understanding not just of the different needs of older and younger people, but also of any potential conflicts between them. In the past, the predominance of younger people meant that planners could focus on their needs and their capabilities for most aspects of infrastructure, while older people had to make do. Now, older people are demanding that their needs be accommodated too, and they have the numbers to enforce their demand. In many, perhaps most instances, such accommodation may suit all age groups. But in some, it may not be accepted by all; and designers may need to offer multiple options to avoid or reduce potential conflict.

³ This is due to increasing life expectancy, but also to the aging of the baby boom. However, even after the baby boom departs, this trend will persist, as life expectancy continues to grow.

An important related trend is that Americans' family and household patterns are more diverse than ever. Just as America's society has, until now, been dominated by younger people, so too it has been dominated by the "traditional" family—couples raising children. However, the same two demographic developments—longer life expectancy combined with stable fertility rates—have erased that historic dominance, making the traditional family just one of many numerous household types.

Because Americans are living longer, they are spending a decreasing share of their adult life with children in their home. In fact, since two children continue to be the norm, Americans spend an average of only 35 percent of the years between ages 20 and 70 in parenting. So most of the nation's households have no children in them. The nation's most numerous household today is a married couple without children, mostly couples whose children have grown.⁴ And the second most numerous household is made up of people living alone, whether before or, more frequently, after marriage. Each of these nontraditional household types accounts now for more than 25 percent of the nation's households.⁵

Infrastructure planners need to understand the household characteristics of the populations they serve. People often choose different housing and locations according to the kind of household they live in. To the extent that similar households concentrate in particular locations, their needs and capabilities may well drive infrastructure planning. For example, park and recreation planners have traditionally focused on serving families. However, recreation needs for neighborhoods filled with single-person households are very different; so are those for neighborhoods filled with empty-nest couples. Similarly, transportation needs may differ, along with law enforcement and public safety needs.

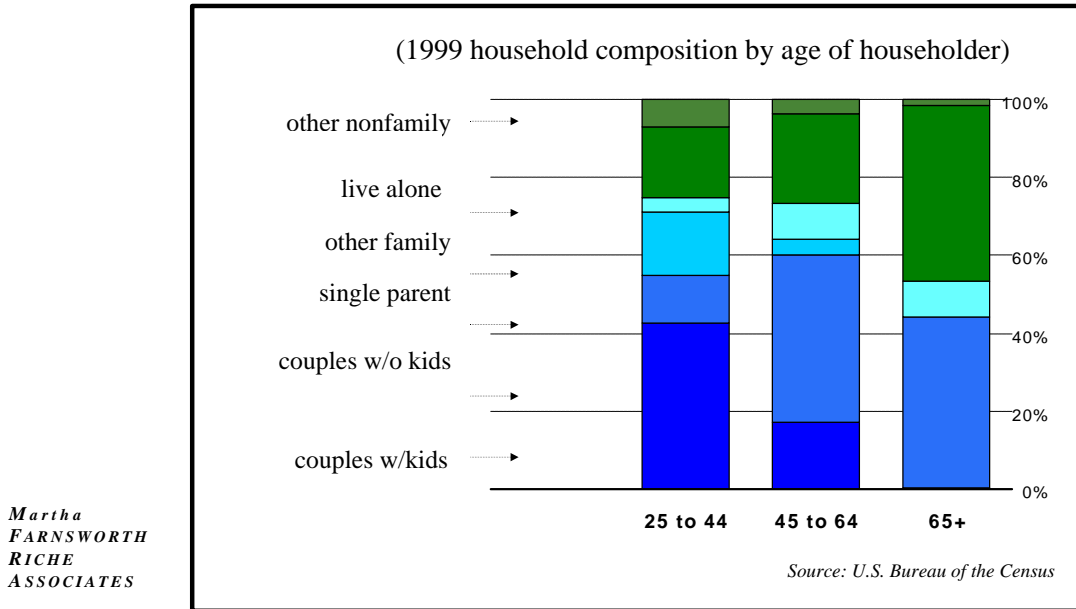
For planning purposes, it's helpful to think of age diversity and household diversity together, as households tend to vary throughout the life stage. [Chart: The Lifestage of

⁴ Statistically, children become adults at age 18.

⁵ U.S. Census Bureau, Current Population Survey, March 2000.

Households] Households with children in them are generally headed by people under age 45. Over age 45, single-person and empty-nest households predominate, with more of one in some neighborhoods, more of the other in other neighborhoods.

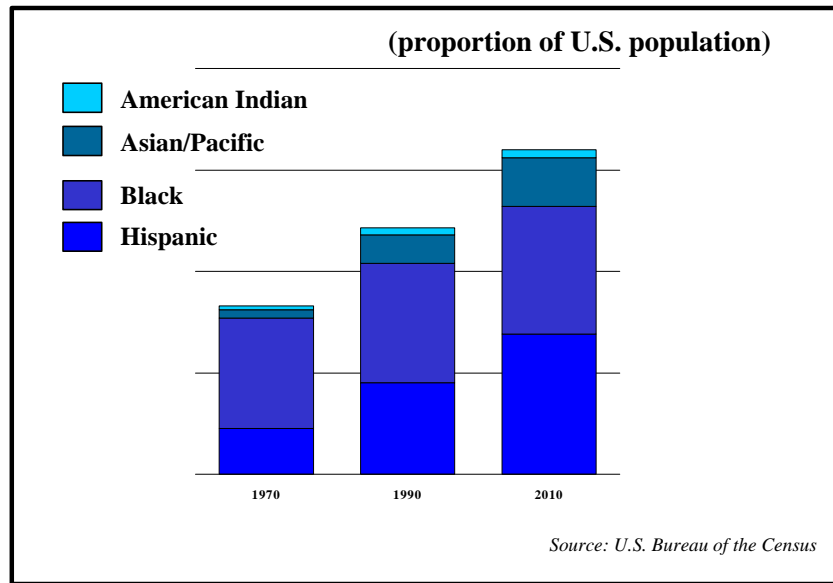
The Life Stage of Households



The third major trend is also a trend away from dominance by a particular group, and that is the trend toward more racial and ethnic diversity. In one sense, this is not new.

Although Americans have usually considered themselves a nation populated by white people, as much as a quarter of the population at the nation's founding was black or American Indian. Now, however, the large number of immigrants from nonEuropean countries is pushing the minority share of the population to new levels. [Chart: Growing Diversity] Non-Hispanic whites now represent 72 percent of the population, while the minority population is more diverse as well as more numerous.

Growing Diversity

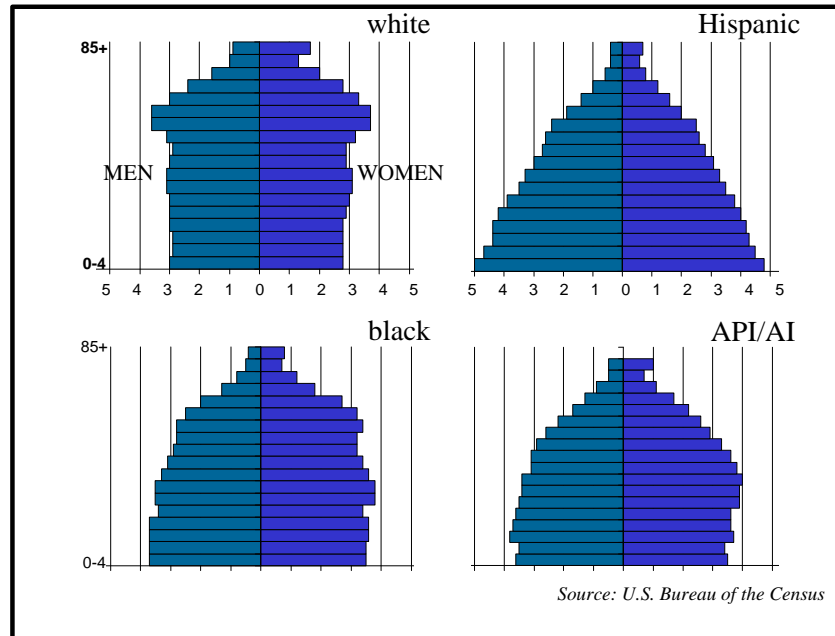


Martha
FARNSWORTH
RICHE
ASSOCIATES

Perhaps the most obvious concern for infrastructure planning is the large number of people who do not speak English well, or even not at all. Where people connect infrastructure to people, as in 911- emergency service or law enforcement, they must speak the same language. Other impacts are less obvious but still need to be investigated. One important consideration is that minority populations are considerably younger than the majority population.⁶ [Chart: Minorities Will Be Younger in 2020] For this and other reasons, minority groups make up a much larger share of families with children than they do of the population as a whole.

⁶ In 1999, the average white Non-Hispanic was 38, compared to 32 for Asian-Americans, 30 for African-Americans, 28 for American Indians, and 26.5 for Hispanics. (Riche, p. 18)

Minorities will be younger in 2020



Martha
FARNSWORTH
RICHE
ASSOCIATES

Finally, all these trends vary across the United States, largely because of different migration and settlement patterns. Children account for nearly a third of the population in Utah and Alaska, for example. In contrast, five states have a relatively large share of people ages 65 and older. By extension, states with younger populations have more traditional families, while states with older populations tend to have more households with no children in them. The nation's racial and ethnic distribution is even more uneven, with minorities generally concentrated on both coasts and along the nation's southern border.

Taken together, all three of these trends mean that infrastructure planners can no longer operate on assumptions about the needs and capabilities of the society they serve, whether because their populations are different from the national average, or because assumptions about particular population groups may be outdated. Even such basic assumptions as widespread frailty among the elderly are outdated, as ongoing research says that each subsequent group of Americans to enter their 80s is healthier and

“younger” than its predecessors. For socially related activities like infrastructure planning, it is important to have a solid, up-to-date knowledge of who the target population is.

Census-based GIS systems are ideal for identifying these and other social characteristics of particular localities, whether governmental units, neighborhoods, or a radius around a bridge, a park, or an intersection. First and perhaps most important, the census reports how many people live in the designated locality. People questioned before the 2000 census rarely said they would participate because they valued its primary purpose—apportioning political representation, but they almost universally valued it for another important use: disaster relief. Whether for earthquakes in Los Angeles or hurricanes in Miami, block-by-block population counts allied to geographic information give disaster relief organizations needed information about the numbers and location of people in hard-hit areas.

Second, the census offers planning-related information about the characteristics of people who live in a particular locality: their ages, household types, educational level, income level and so on. It contains information about disability: such as how many people need help with day-to-day activities of living, or help getting to work. It contains information about people who have trouble speaking English, and what language they normally speak at home. It identifies households where people work, where they are retired, and whether they go to school or are unemployed. It even tells us how many cars they have, so planners can think sensibly about transportation, about energy use, and about pollution potential.

The census gathers information about people who live in housing without adequate kitchen or plumbing facilities, or a telephone to call for help in an emergency. It gathers information on people’s housing, including when the structure was built, how many units or rooms it contains, and what kind of fuel people use for heating. And the census gets information about whether people own or rent their homes and how much they pay,

including utility costs. These questions are very unpopular with the public, but they serve many infrastructure uses. For example,

- the National Energy Modeling system forecasts energy consumption on the basis of this information;
- emergency planners get ready for disaster by identifying such things as concentrations of mobile homes in tornado- and hurricane-prone areas;
- and school planners predict school-age populations, according to whether housing units are single-family or multi-unit structures.

Census data are key for planning civil infrastructure because they measure not just where people live, but also where they work, and their journeys between. One of the most highly criticized questions on the census form is, “What time does this person usually leave for work in the morning?” Combining the answer to that question with answers to questions about where people work produces what is known as the “journey to work” database, disseminated by the Department of Transportation to local road and traffic planners. This data lets planners measure “daytime” populations, as opposed to residential, or night-time populations, as well as the flows between.

No state or local planner will find all the information they’d like because the census is a federal activity, and serves the needs of federal agencies. On the other hand, each of these agencies generally asks the Census Bureau to cross-tabulate the information they use against demographic statistics for each local area, so that local planners can devise an infrastructure that suits their segment of society. That’s the beauty of combining demographic and geographic information: a GIS system lets planners tailor civil infrastructure civilly—to the people who use it.

Finally, GIS systems are evolving into a useful tool for communicating with the general public. The U.S. population is more highly educated than ever before, and seems more willing to challenge public decision-making. Wise infrastructure planners will build a communications component into their projects, and GIS systems can be very helpful in navigating different levels of understanding.

A new system called Pictometry is one example. It uses a new form of aerial photography to take oblique orthogonal photos so that users can literally view and analyze any house, building, intersection, fire hydrant, tree, or indeed any physical feature of their county from at least four different angles or directions on a laptop or work station. This system has obvious uses for basic infrastructure planning, like water and sewer districts, watershed management, and so on, especially when it is allied with census or other demographic databases. However, because people with no technical training can easily perceive the relationship of a given activity to places they know, the system is ideal for helping the public understand how new or revised plans might affect them, or serve them.

References

Except where otherwise noted, all demographic information contained in this paper may be found, in greater detail, in “America’s Diversity and Growth: Signposts for the 21st Century,” by Martha Farnsworth Riche, *Population Bulletin*, Vol. 55, no. 2 (Washington, DC: Population Reference Bureau, June 2000).