*Commentary**

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The Census: It Can Be Done More Accurately with Space-Age Technology

THE 1980 CENSUS cost over a billion dollars and was termed "inaccurate" and "an exercise in futility" by Philip M. Klutznick, the Secretary of Commerce, when the census was taken. He added that the census could have been done more accurately and "at a fraction of the cost."

The census has played a vital role in our country since its inception. But there have been continuous controversies regarding the accuracy of the census since it was first taken in 1790. The census has been conducted essentially in the same manner since 1790, although science and technology have progressed in quantum leaps. It is time to apply the advanced and versatile space technology to the problem.

The adoption of the Constitution precipitated a conflict between the large states which wanted representation in Congress to be determined by population and the smaller states which wanted a one-state, one-vote principle. There was further confusion when the Southern states wanted slaves counted as people for representation, but as property for taxation purposes. The compromise, of course, was a Senate in which each state had equal representation and a House of Representatives in which representation was determined by population. The census, therefore, became the prime factor in determining the number of representatives by states and the Congressional districts within those states. Even more important to the large cities is the fact that federal funds are disbursed based on census figures. Officials of the larger cities are still reluctant to accept the 1980 statistics, claiming their populations have been seriously under-counted. Litigation is pending in several courts at the present time challenging the census figures. The census is based on cooperation by the citizenry, and these officials maintain that the counts are deficient, especially in the minority areas. They also maintain that these statistics do not account for the many illegals living in the larger cities.

Prior to the first census, there had been statements by federal government officials that there were over four million people in the United States. The first census took 18 months to complete and produced a head count of 3,929,214. There was an immediate howl regarding the accuracy of the census. President Washington explained the difficulties in conducting the census and gave assurances that "Our real numbers will exceed greatly the official returns." Each succeeding census has produced its own controversies and apologies. There were complaints that the Indians were not counted; later there were charges that the immigrants were not being properly reflected; and, in the most recent census, charges that the residents of the major cities are not being properly counted.

There were only six questions asked in the census of 1790. In the 1880 and 1890 census, there was a high of two hundred schedules that asked an unbelievable 13,000 questions. In the 1980 census, there were 19 questions asked on the short form and 65 on the long. The agreement in 1790 for a census to be conducted every ten years was a compromise. In today's complex society, census data, for a variety of reasons, are needed on a more frequent basis.

It is time to stop and assess the prospects for better performance of the 1990 census. By using overhead reconnaissance systems which carry sophisticated cameras and remote sensing equipment, and by employing modern interpretation methods backed up by the latest in computer technology, I am convinced that the census can be done more accurately, cheaper, faster, and better than by previous methods.

Space-age technology is already applied to the collection, analysis, and communication of detailed information on a wide range of topics. It is used to create up-to-date maps and charts; develop our natural resources; predict our weather; inventory and protect our forests; assess disasters; count and conserve our wildlife; classify our soils and lands; levy property taxes; chart vegetation growth; locate promising areas for new oil deposits; examine geological structures; control pollution; monitor snow

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melt; inventory surface and subsurface water resources; monitor management of public lands; search for toxic chemical dumps; control flooding; and assess lake, river, and continental shelf conditions. There are over 60 fields of endeavor employing these modern techniques, and they are being applied increasingly to assist in a variety of still other endeavors.

It seems strange that we can accomplish all of the above, and can also map the moon, survey Venus and Mars, accurately chart the details of the bottom of the sea, monitor a SAL agreement, and maintain the Middle East Truce Agreement, but have not attempted to use these same technologies to determine the number of people living in a given area of a U.S. city.

What will motivate the Census Bureau to accept the new technology? First, it must be convinced that the new technology can do a better job; second, that it can be cost effective; and, third, that it can save time.

If Census were to seriously consider a change in methods, then its first concern would be data acquisition. In the development of application techniques, and to demonstrate concepts and feasibility, Census would have to inventory the presently available resources and technologies that would be required to conduct a census. High resolution aerial photography already exists that would be a prerequisite for such a system. This imagery is readily adaptable to digitizing and computerized manipulation and could, therefore, be used in analyzing or selectively enhancing images of areas of concern. This already-available technology can also provide near synoptic views of the United States. The nature of the repetitive coverage of these systems allows for population growth comparisons to be made on a more frequent basis than the present census-taking methods which allow for comparisons to be made every ten years. It is also a fact that the necessary photographs and multispectral information would not have to be specifically requested. They will have been acquired in any case, regardless of census needs, because this information is vital to a number of federal and state agencies engaged in a variety of socio-economic planning and management activities.

Next, a system for classifying and managing data would have to be considered. Federal agencies concerned with space-age systems have already devised extensive computer software and hardware systems to store, process, and analyze the unprecedented volumes of data derived from such technology. Census would, therefore, encounter no major problems in these areas.

The Census Bureau must then consider the development of appropriate interpretation techniques for the detailed analysis of the aerial photography. These have already been developed by the CIA, the Armed Services, NASA, the mapping and charting organizations, and the federal agencies concerned with developing or protecting our natural resources. Techniques used by the United States to monitor the SAL agreements and the truce in the Middle East, by the military in dealing with the development or deployment of weapons systems, and by mapping and charting organizations in the detailed mapping of the United States and foreign territories are proven systems. Using comparative photographic coverage, new change detection computer techniques can spot, delineate, and map all population changes that have occurred since the first coverage. Extensions of this experience and the interpretation techniques for census taking purposes would not be difficult.

Photogrammetric or measurement needs would have to be determined in the basic analysis of private dwellings and apartments and the number of people who live in such structures. The determination of population from aerial photography has been performed on foreign cities by military agencies for some time. Studies on occupancy and building density ranges, population density distribution, projected population, and occupational composition by industrial categories are readily performed with today's aerial photography. Population studies are usually performed by analyzing roof coverage and the number of stories to determine the number of persons living per million square feet. The population density ranges, i.e., the number of persons per hundred, thousand, or million square feet, will vary according to geographic location. For example, the number of people living in the inner city will be higher per million square feet than comparable areas in the suburbs. The heights and areas of buildings can be carefully computed through the science of photogrammetry, categorized as single story, multiple story (by number of stories), special structures (combinations of offices and apartments), single family, multiple family dwellings, etc. Innovative photogrammetric techniques, supplemented with field surveys, along with a broad array of advanced technology used in intelligence operations and in map and chart production, could be applied to this project. Today, most of the United States is mapped at the 1:24,000 scale on orthophoto maps. On these maps, every house in the United States is depicted. Because of repetitive coverage, and with the use of change detection equipment, new areas of population growth would become readily apparent. Today, most of the aerial photography, graphic, and visual information is being turned into digital data by mapping and charting organizations. This allows a stream of data to be combined and correlated with many other sources of data. These will be available as pure digital data to be manipulated and analyzed. The analysis and graphic displays of those data provide up-to-date mapping products to federal, state, and local governments concerned with planning and management. The so-

phisticated mapping and charting equipment used by such organizations as the Defense Mapping Agency, the National Ocean Service, the U.S. Geological Survey, and others could be modified for census purposes.

Ground truthing would have to be included in planning any such system. Ground truth allows the photointerpreters and photogrammetrists to know of the accuracy they are achieving with respect to a known quantity. For example, when the photointerpreter is told the average number of people living in houses in a given block in the suburbs, he can carefully analyze those houses and then proceed to count all the houses of the same size or shape in the entire area. The accuracy of his analysis can be checked against other data bases such as tax records. In the inner city, apartments can be precisely measured and, again, data on the number of inhabitants per hundred feet of living space can be established.

The many studies of foreign urban areas already accomplished by the U.S. military organizations, by the mapping and charting agencies, or by state and local agencies for urban planning, would have applications to this part of the analysis.

Records created from aerial photographic analysis are far more valuable for historical purposes than the records created by the present and past Census systems. Because there is a high frequency of repetitive coverage, the updating of information will be more representative of the actual situation and would be more representative of the kind of information required by federal, state, and local governments in their planning and management activities.

Cost would be considered by Census. Over 300,000 temporary workers were hired in the field and thousands were employed in Washington at a cost of over a billion dollars to produce what Mr. Klutznick called "an inaccurate census." I am convinced that it can be performed at a fraction of that cost using space-age technology. My biggest argument would be that, in enumerating all the activities now performed with space-age technology, it is a proven fact that they are being accomplished at a lesser cost per product than with previous methods. Census would be spared the heavy up-front development costs, tagging on to developmental work done by other agencies. It is true, however, that retraining of a number of Census personnel would have to be undertaken along with a modification of Census reporting techniques.

I seriously doubt that the Bureau of the Census could readily be persuaded to change its anachronistic methods. But just as the intelligence, military, and commercial enterprises have adopted the new scientific methods of this period, so too must Census come of age. Perhaps the most dramatic eventuality would be if some city government would undertake its own census using space age technology developed under federal government auspices to challenge the chronic inaccuracies and discrepancies resulting from existing U.S. Bureau of the Census procedures.

From my nearly 40 years of experience in all phases of reconnaissance and analysis activity, I am thoroughly convince that a census using space-age technology is not only feasible but can be performed better and cheaper, and be more responsive to the needs of modern-day America. The technology is here. Why not use it?

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Charles W. Dull and *William H. Clerke,* Loran-C Navigation as an Aid to Aerial Photographic Operations.

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