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## **THE ISRAELI 1995 CENSUS-GIS INTEGRATION PROJECT**

Submitted by the Israeli Central Bureau of Statistics <sup>1</sup>

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## I. INTRODUCTION

1. The main objective of this paper is to present the advantages in integrating the national GIS project - which was designed to supply a geographic base for management of population statistics - within the planning and implementation of a national population census. The principal strategies that were used by us in integrating these two projects, as well as a description of the key phases will be presented.

2. In the case of Israel, **integration of a national GIS and a population census** enabled the utilisation of census resources to solve the problems inherent in setting up the GIS while, at the same time, it enabled the census to take advantage of GIS technologies to solve census problems. The integration significantly improved the field work during the census, as it relates to covering buildings, thus improving population coverage, which is and always has been the main objective of the census. In addition, it brought significant saving in costs. Actually, the cost of the GIS project was absorbed within the cost of the census budget, without requiring an increase in funding.

## II. PROBLEMS WHICH OCCURRED

### 3. Difficulties with the GIS Project

There are two main difficulties in establishing a National (or local) GIS:

- digitisation is the problem of entering the basic geographical data infrastructure in the computerised system or, in other words, the digitisation of the maps at the level of buildings and roads; and
- the problem of entering addresses, matching names and symbols of streets and house numbers with buildings on a digital map.

### 4. Difficulties with the Census Project

The preparation of complete mapping of all residential buildings in the country is very difficult. Identification of all buildings which may be inhabited by people is one of the most important and most difficult tasks during the preparation and implementation phases of the census, regardless of the actual census method employed.

### 5. Integration as a Solution

Since there is a clear connection between the structured problems in the two projects, the census planners faced the question of how to come up with a combined solution which would serve both of the projects equally well.

## III. STRATEGY OF INTEGRATING GIS IN THE CENSUS

6. There is an asymmetry between the national GIS project and the population census project. The GIS can only be a relatively small part of the population census project. Therefore, the task should be to integrate the GIS project into the census project, and not the other way around. In this light, it was decided from the very beginning that the census project would be the lead project. This strategy guided the integration. Another important principle was modesty in the requirements for accuracy and the scope of the collected information and maximum standardisation of the work processes and results.

#### IV. MAJOR STEPS WHEN INTEGRATING GIS INTO THE CENSUS

##### 7. Planning

This stage included investigation of how the GIS could be utilised by the census, both in Israel and around the world, formulation of a conception and determination of phases of work, along with a series of trials. Some trials examined the feasibility of various planning components, and included two census-related field experiments: one conducted in 1991 on a locality with 20,000 residents, and another in 1993 with 60,000 residents. Fruitful cooperation was launched with the Survey of Israel (the national agency for mapping). At the same time during this early stage, there was a fundamental examination of the existing inventory of maps of all types, in all the relevant media (digital, paper, aerial photographs).

##### 8. Digitisation of maps (streets and buildings)

Digitisation of maps was carried out by private companies in close co-operation with the Survey of Israel. Digitisation was primarily done on the basis of current aerial photographs. The existing digitised maps were used whenever possible. Paper maps were also digitised. A request was made for the digital maps to include streets and buildings, no text, and a limited number of characteristics (categories of streets and roads, type of building, etc.). An important step was planning and implementing the procedures for receiving, checking and entering the digital maps into the computers.

##### 9. Adding addresses to maps

The most efficient source of addresses is the Population Register. For the purpose of adding addresses to maps, a special application was developed which made use of the addresses file within the Population Register. This application saved considerable work during the map editing and reduced errors to a minimum. During this process, the addresses were ascribed to building shapes and street lines, thereby becoming an integral part of the geographical database. These addresses were then applied to their proper place on the map.

##### 10. Adding administrative borders and dividing into enumeration areas (EAs)

For the division into EAs, a special system was developed. It used the National Population Register to add the size of the population and address to the polling district. Additional data included population estimates in statistical areas. The redistricting was performed in a computer-assisted procedure. In order to divide a locality area into EAs, the area divider received information on the standardised population in each polling district within a given statistical area (polling districts are included in their entirety within statistical areas). Division into polling districts was used as a system default. A polling district was defined as an EA if it met the criteria of population size. This application enabled the arranging of polling districts to the desired size of about 275 households in each EA, creating additional EAs and the uniting of existing areas by changing the borders of the polling district. This method was used for most of the EAs, except in those cases where prior information indicated that the data from the Population Register was out of date. In such cases, the same system was used for division but without relying on the Population Register data.

11. The result of this process was impressively accurate: of the approximately 6,000 EAs enumerated during the census, in only about 130 cases (some 2%) were particularly large EAs discovered, forcing field workers to split them up. Also, the number of small EAs was less when compared to the previous census.

##### 12. Generating outputs prior to field work

During the field, the census project benefited from two main GIS products: printed maps and address files. About 6,000 maps of EAs were produced through a process which was mostly automated. Furthermore, the system supplied maps for supervisors, and locality maps and other types of maps for senior management. The maps were of a much higher quality than

those from the previous census. The address files were used during the process of controlling the enumerators' work, in order to improve coverage of the buildings. The files were integrated into the computerised field work system, so that each supervisor could question the enumerators under his responsibility in cases where there was a lack of information on any building found on the EA map.

13. Geographic coding

The addresses file was also used for geographic coding performed during the questionnaire data entry. The addresses reported on the questionnaire were linked with GIS addresses file. Cases where links were not possible were identified and coded by the geographic experts using a computer-assisted procedure.

14. Post-census updating of the GIS

With the completion of the field work, a great deal of information collected by the enumerators had been stored. This data included addresses that were not in our possession at the time the maps were prepared, as well as many corrections and revisions, which enabled updating of the maps as of the day of the census. This activity is now underway.

15. Matching updated GIS data with the census questionnaires

Another stage in the census process is the matching of addresses from the census questionnaires with the addresses in the GIS. Also during this stage, the final linkage between the building records within the GIS and the data from the questionnaires is performed. The result is that each respondent is linked to co-ordinates and through them, to all the geographical information which is included. At the same time, each building in the GIS is linked to a population along with its census characteristics.

16. Producing cartographic products based on census data

With the publication of the provisional census data in March 1996 (the census took place in November 1995), maps were produced for the large localities. Today, the process of producing other cartographic products is in progress and many maps, which will join the various publications of the census, are currently being prepared.

17. Integrating the GIS into the Bureau's ongoing work

This last stage is expected to begin when the activities described above have been completed, and will enter full gear in 1998.

## V. SCHEDULE (AND COSTS)

18. The stages involved in setting up the GIS were integrated into the census schedule. Below is a schedule of the principal phases of the work. There is an internal dependence between the activities. For example, a delay in the census by one year made it necessary to repeat the update on the original maps, which required allocation of special resources. A large portion of the activities took longer than planned. The main reason for this was that, even in the private professional sector, people did not have prior experience in many of the necessary activities, particularly considering the scope of such a large undertaking.

19. The cost of setting up the GIS did not exceed the costs of the alternatives that would have been required to map the residential areas prior to the census. In total, the cost of setting up the GIS was absorbed within the census budget, without requiring any special additional funding.

## VI. ADVANTAGES FOR THE CENSUS OF INTEGRATING THE GIS PROJECT

20. One of the important characteristics of the project described here is that the GIS was integrated within the census project from the initial planning stages of the census (inclusive). This integration enabled the planners to gain the maximum benefit from the investment in setting up the GIS. Actually, there wasn't a single census phase that did not benefit from the GIS integration. I will point out the main advantages:

### 21. Planning on the basis of standardised maps

Planning an enumerator's work on the basis of a map that has been designed in the same way for each of the EAs, is an advantage of using maps from the GIS. Furthermore, the fact that the planners could determine with certainty the contents of the maps and know that each enumerator had in his possession exactly the same type of map, made the planning easier. It is difficult to estimate the contribution of this type of standardisation. But, based on experiences from the previous census, it can be stated that in previous censuses the quality of the maps used did not allow the enumerator in some cases to fulfil his role as planned. This situation was prevented from occurring in the 1995 census thanks to the contribution of the GIS.

### 22. Organisational structure and uniform work packets for the enumerators

In comparison with previous census polls, the new method described above enabled a significant saving in the size of the infra structure which served the census field setting. Furthermore, the fact that almost all enumerators were allocated reasonable work packets contributed to improving the work process and, in the final analysis, did much towards improving the quality of the results.

### 23. Supervising the work of the enumerators

This was one of the main contributions of the system. The match between the enumerators' maps and the addresses file located in the computers in the sub-regional offices enabled efficient supervision of the enumerators' work, primarily as it relates to covering buildings. An enumerator was required, through the use of computer reports, to supply the supervisor with an explanation concerning each building found on the map, either using the questionnaires from the respondents, if the building was for residential use, or by some other reasonable explanation concerning other uses of the building. This process not only enabled monitoring of the enumerator's work, but also made an important contribution towards freeing the supervisors for additional duties, resulting in additional improvement in the quality of the data collected.

### 24. Contribution of the addresses file to the geographic coding

The national addresses files enabled automatic coding of most residences, places of work and places of residence from five years ago that were reported in the questionnaires.

### 25. Producing new census products

The census products improved in quality and variety. Without examining all the advantages of producing census products on the basis of the GIS, the flexibility in defining the new geographical units should be mentioned. We can retrieve data on new geographical units from the resolution of a digital map (from the building level and beyond). In practical terms, a client can request data on any geographical unit he defines (subject, of course, to the limits resulting from the need to protect the confidentiality of individual data).

## VII. POST-CENSUS ADVANTAGES AND CHALLENGES FOR THE FUTURE

26. The contribution of establishing a national GIS for the management of population statistics in the context of the census is, indeed, a large part of the contribution which the project made to the organisation, but is not the entire contribution. It can be argued that even if the census had not benefited from the GIS, the mere fact that at the end of the census a computerised geographical system with the characteristics described above was created justifies the integration between the GIS and the census project. But this is not the case. The contribution by the GIS to the future management of official population statistics can not be exaggerated; its contribution will not only be felt in population statistics, but in other areas as well.

27. The first challenge for the future lies in the establishment of an updating process which will enable us to maintain good matching between the contents of the GIS and the situation in the field at any time. A second challenge is matching the GIS to the needs of the other CBS units. We are only beginning to face these two challenges. The third challenge is to help the organisation provide GIS-based services to an ever-growing population of data consumers. This challenge has already been seriously considered in our plans for distributing the census data. From the experience we accumulate, we hope to learn ways to market the non-census geographical statistical data.

28. As a result of the GIS the statisticians may face new professional challenges. On the one hand, we will have to develop tools which will enable geographical sampling based on the GIS. Addition of the spatial component is likely to lead to interesting developments. A second area is the integration of the spatial component in statistical analysis. Preliminary steps have been taken around the world in this field, in which Israeli researchers have played an important role. This area is, however, still in its infancy.