NGS POLICY 05-1991

HARN Policy

National Geodetic Survey

Approved by the Executive Steering Committee

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This policy has been retired and is no longer in effect

HIGH ACCURACY REFERENCE NETWORK POLICY

INTRODUCTION

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Backqround

A primary responsibility of the National Geodetic Survey (NGS) is to make available a National Geodetic Reference system (NGRS) to meet the needs of users to relate their measurements to a common coordinate system. In line with this responsibility, NGS completed, in 1986, a new adjustment of the national horizontal reference network relative to a new datum, the North American Datum of 1983 (NAP 83). The coordinates derived from this adjustment, and referred to as NAP 83 (1986) coordinates, provided a substantial increase in accuracy over those previously available, both with respect to differential positions between nearby stations and with respect to absolute positions relative to the chosen coordinate system. However, the recent introduction of Global Positioning system (GPS) surveying technology now permits many users to conduct differential station positioning with accuracies substantially in excess of the accuracies provided by the NAP 83 (1986) adjustment. In fact, NAP 83 (1986) cannot serve as a standard against which to measure the accuracy of high-accuracy GPs surveys. This increased accuracy capability, together with a desire to have available a larger number of reference stations that were both easily accessible (drive-to) and usable for GPS surveying (adequate sky visibility), has led a number of users in several states to express a desire for upgrades in their horizontal reference networks in the form of high accuracy reference networks.

In response to these user requests, NGS has issued two policy statements relative to high accuracy network upgrades. The first policy statement was issued in 1989 (Ethridge, 1989). It provided general policy guidelines, specifying that the existing datum, NAP 83, would be retained, with all NGRS horizontal coordinates continuing to be referred to the NAP 83 coordinate system and ellipsoid, but stating that published NAP 83 coordinates were subject to change in order to provide more accurate NAP 83 positions where there was a public need. This initial policy statement did not give specifics as to how and under what conditions upgrades would be performed or how the high accuracy reference networks and the existing network would beintegrated.

The second policy statement was issued in 1990 (Bodnar, 1990) and gave details as to policies with regard to implementation of high accuracy reference networks and statewide upgrades resulting from the establishment of these networks. The policy guidelines contained in this statement related to requests for high accuracy network upgrades initiated by organizations within a state and dealt with conditions under which NGS would engage in cooperative activities to accomplish such upgrades, relative cost sharing and

ways in which integration of the high accuracy network and the existing network would be accomplished. This second policy statement did not deal with the question of what observational activities associated with network upgrades NGS would undertake independent of cooperative efforts initiated by requests from state organizations.

The policy statement presented here is an extension of the previous policy statements concerning high accuracy reference network upgrades. It covers observation, reduction and adjustment activities associated with a national high accuracy reference network which will be undertaken by NGS as a part of its basic responsibility to establish and maintain a NGRS to meet the needs of users. The activities covered by this policy statement will not be dependent upon initiation of requests from or provision of resources by state or local organizations. However, NGS expects to work closely with state and local groups in undertaking these activities and anticipates that some states may wish to undertake cooperative observational activities in order to produce a denser high accuracy reference network than would result from the NGS activities alone. Also, the rationale for this policy statement takes into account vertical, as well as horizontal, reference network requirements.

Policy Rationale

The policy enunciated here is based upon the conclusion that the establishment of a nationwide high accuracy reference network is an important requirement for meeting the reference system needs of the nation. This conclusion arises from four considerations:

1. The rapid acceptance and utilization of high accuracy reference networks to support horizontal control surveys and problems arising because high accuracy networks are not universally available.

2. The substantive changes in GPS surveying methods and capabilities over the next few years.

3. The increasing use of GPS methods to provide vertical as well as horizontal positional information.

4. The increasing importance of applications of GPS to monitor crustal motion.

As illustrated by Figure l of Bodnar (1990), less than two years ago no high accuracy statewide upgrades had been completed and work was underway in only six states. As shown in Figure l of this policy announcement, high accuracy reference networks have been completed or are underway in 15 states and there are firm plans for networks to be initiated shortly in 5 additional states. Thus, by the end of 1992 approximately 40o~ of the states will have high accuracy networks in place. Groups in a number of other states are actively seeking to establish such networks. There has been wide acceptance and use of high accuracy reference network upgrades in states where final results are available. In Florida a large number of counties have already established dense networks with 3 to 6

mile station spacing which are tied to the high accuracy reference network. Legislation is being introduced to make the upgraded NAP 83 coordinates the legal coordinates for use in Florida. In Oregon and Washington establishment of county and city networks tied to the high accuracy networks has begun. In California, even before reductions of the high accuracy reference network observation have been completed, dense local networks tied to this reference network have been completed by seven counties and the City of Los Angeles and are awaiting publication of high accuracy network station positions.

The wide acceptance and enthusiasm exhibited with regard to high accuracy reference network upgrades makes clear that such upgrades would be established in most states over the next 5 to 10 years. There are several reasons for completing this process as soon as possible. GPS surveying techniques increasingly are being used to establish dense station networks to control county and city Geographic and Land Information Systems (GIS/LIS). By having high accuracy reference networks in place, the requirement to perform later readjustments to remove distortions will be largely avoided. Also, upgrading in a more or less random manner, as requests come in from the states, results in continuing adjustments at state boundaries to preserve network continuity. By proceeding rapidly and in a systematic way to establish high accuracy network upgrades, the number of temporary adjustments at state boundaries and the time period they are in use can be minimized.

Rapid changes in GPS surveying methods and capabilities are placing increasing importance on having in place a high accuracy reference network to make optimum use of GPS in surveying. As the full satellite constellation and increasingly accurate orbits become available, cost effective GPS surveying methods involving fixed reference stations and kinematic and pseudo-kinematic (rapid static) surveying procedures are coming into increasing use. In the years ahead, photogrammetric positioning of ground points at the decimeter or better level using GPS to position the aircraft will be increasingly important. All of these techniques can involve the direct positioning of unknown points relative to known points many tens of kilometers (and in some cases more than 100 kms) distant from the unknown point. This type of activity makes it essential that very high accuracy differential positions of widely separated reference network stations be available.

Also, GPS positioning is intrinsically three dimensional positioning. Increasingly, GPS is being used to provide vertical as well as horizontal positioning information. The improvement of orbit accuracy, better methods of modeling tropospheric refraction, and the development of high accuracy reference geoids, such as GEOIP90, are leading to the time in the near future when GPS surveying will play a major role in providing vertical reference network information. The high cost of conventional leveling makes it important from an economic viewpoint that NGS move toward a GPS-based vertical reference system as rapidly as possible. Effective use of GPS to support vertical positioning on a national scale will require a nationwide high accuracy reference network providing ellipsoidal heights at the few centimeter level.

Finally, large scale programs are being undertaken by several Federal agencies to monitor crustal motions associated with movement of tectonic plates, seismicity and earthquakes,

volcanic activity, isostatic rebound due to glacial unloading and subsidence due to fluid withdrawal. Increasingly, state, county, etc. surveying organizations are working with university and governmental earth science research groups to develop multi-use reference networks to meet both surveying and scientific goals. A large component of the Order A network established by NGS in cooperation with the Nuclear Regulatory Commission (NRC) is serving the dual purpose of helping to provide a framework for statewide high accuracy reference networks required by the surveying community and providing information on strain deformations in the eastern United States. A nationwide high accuracy reference network can support scientific crustal motion monitoring activities in two ways. It can tie together many of the local crustal motion monitoring networks being established by other agencies and thus allow all motions to be expressed in a common reference frame. Additionally, many crustal motions occur at such slow rates that decades long observation periods are needed to obtain useful scientific information. It is often difficult to justify establishment and monitoring of networks solely for crustal motion monitoring purposes. However, such networks can often be justified where they also provide needed reference networks to support surveying. From the surveying viewpoint it is essential that large, rapid horizontal and vertical crustal motions be modeled to provide an adequate reference system for surveying applications. From the crustal motion viewpoint the sooner high accuracy networks are established the sooner they will provide useful information.

Taken together, the above considerations provide the rationale for the establishment of a nationwide high accuracy reference network as soon as possible.

Policy Implementation

NGS shall establish and monitor a high accuracy reference network of approximately 1200 stations throughout the United States (the contiguous 48 states, Alaska, and Hawaii). This network will be established as rapidly as possible given available resources. Wherever possible, use will be made of existing stations of Order A and Order B networks. About 900 of the stations of the network will consist of a nearly equally spaced grid of stations with a station separation of about 100 km. An estimated additional 300 stations will be placed in areas where significant horizontal and/or vertical crustal motion is occurring to support time- dependent modeling of these motions. The accuracy goal for the positions obtained for these high accuracy reference network stations will be # 3 cm or better relative to the NAP 83 coordinate system.

In the process of establishing the above described network, the normal procedure will be to make connections between each of its stations and a nearby station of the existing horizontal reference network. These connections will then be used to upgrade the existing network by increasing the accuracy of the NAP 83 coordinates of its stations and to bring about compatibility between the coordinate values provided by NGS for all stations in the NGRS. This accuracy upgrade and assurance of compatibility will be accomplished by holding fixed the derived high accuracy network station positions and readjusting the available observational data, together with the connection observations, to obtain more accurate and compatible coordinates for the existing network. NGS has no intent of

abandoning the existing network. In fact, the accuracy upgrade of the network, as described above, will increase the utility of the existing network.

As discussed under the section on rationale, it is believed a large majority of states will wish to have their existing horizontal reference network station positions upgraded to a higher accuracy and made compatible with the high accuracy reference network station positions. However, users in some states have indicated they value stability of coordinate values more than increased accuracy and compatibility between networks, are satisfied with the accuracy of the existing network station positions derived from the 1986 adjustment, and do not wish to have existing network station positions changed by upgrading. It is not the intent of NGS to force changes in station coordinates upon states where, the majority of users of the horizontal reference network wish to retain the existing reference network values derived in 1986. Therefore, where there is a written request from that state's official surveying agency that no readjustment of the existing network be undertaken in a state and it is demonstrated that this is the desire of the majority of users in the state, NGS will treat the existing network and the high accuracy network as separate entities and will continue to publish for the existing horizontal network the NAP 83 coordinates derived in 1986.

At the boundaries between a state which does not wish to have a readjustment, and adjacent states which have chosen to have an upgrade readjustment, some action must be taken to prevent a discontinuity. The procedures used will be those described in Bodnar (1990).

It is anticipated that many states will wish to work cooperatively with NGS to establish more dense high accuracy reference networks than the 100 km station spacing described above. The NGS policy, with regard to such additional stations established through cooperative activities, will remain that presented in Bodnar (1990). In summary, that policy statement specifies that NGS will bear the costs of network planning and adjustment activities associated with these additional stations. However, if NGS performs observation and data reduction activities associated with the establishment of these additional stations, reimbursement for the incremental costs associated with these activities will be required.