Date: June 2, 2008

TO: Whom it may concern -
Leaders of the New Mexico Computing Applications Center

FROM: Earl F. Burkholder, PS, PE
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RE: Suggestion for that "killer" application being sought for the NMCAC

In the 1960's movie, The Graduate, the magic word was "plastics." This suggestion is that even better opportunities exist today with regard to "spatial data." A book I wrote, *The 3-D Global Spatial Data Model: Foundation of the Spatial Data Infrastructure*, was published in April 2008 by CRC Press (try www.amazon.com or Barnes & Noble). I recommend the content for your consideration. The Preface and Foreword both provide insight.

I attended the IAS conference at NMSU on May 22 and 23, 2008. Oh my…. It was really good – a bit like standing in front of an open fire hydrant to quench a thirst. I was quite impressed by the collection of talent, facilities, and opportunities that were described and discussed.

As I understand it, the purpose of the conference was to "identify specific opportunities that high-performance computing brings to New Mexico and to seed the self-organization of groups and collaborations to actively pursue these opportunities." A common thread I heard as I sat and listened to the presentations was related to spatial data – knowing where thing are (both absolute and relative), knowing how they move, and being assured of spatial data quality.

The digital revolution (see articles #29, #44, & #47 www.globalcogo.com/refbyefb.html) of the past 50 years has had an enormous impact on:

A. Financial/accounting record keeping and smooth operation of our economy.
B. Medical records and operation of the health professions.
C. Biology/chemistry research and nano-technology.
D. Criminal justice records and administration of public policy.
E. Spatial data applications – knowing where things are and how they move.

Basic science and research devoted to the various topics listed above are impressive and some are still ramping up. What about spatial data? The rules of solid geometry have long been "settled" and, because they are so simple and obvious, everyone knows how to use coordinates – in the traditional sense. But, we live in 3-D world and work with 3-D digital spatial data.

Traditional models for spatial data treat horizontal and vertical separately. One reason for doing so is that there are two incompatible references – latitude/longitude for horizontal and the geoid (approximately mean sea level) for vertical. A standard integrated 3-D model for spatial data offers significant improvements in compatibility for spatial data users worldwide – see article #34 on the list of articles referenced above.

Where does the super-computer come in? The GSDM can be implemented in conjunction with a GIS by individual users, by cities/counties, by state agencies, or by national organizations. Implementation can occur either on a piecemeal basis or by way of a carefully designed plan for implementation. A super-computer is not needed for any of those.

But if we look at the big picture and dream about the possibilities, a super-computer could make it possible to solve significant positioning problems now being addressed on a piecemeal basis – or not being addressed at all. Consider:

1. GPS is a huge interpolation tool. The GPS satellites form a "birdcage" constellation around the world and broadcast signals to the Earth simultaneously from all sides.

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2. Autonomous receivers collect the GPS signals and provide real-time absolute position for the user/application. While impressive, the quality of such a position is not ultimate. Such applications can benefit from using the GSDM, but do not need a super-computer to do so.

3. The ultimate accuracy of GPS positioning lies in determining the relative location of one point with respect to another using interferometric processing of the carrier phase signal received simultaneously at two locations. The result is a baseline vector in 3-D space. Building a network of vectors and attaching the network to previously surveyed points of higher accuracy has been a standard method for establishing geodetic control points. High quality monumented GPS positions can now be established worldwide.

4. The hang-up – especially for civilian users: Each vector in 3-D space is a function of the data collected from satellites visible simultaneously from the two receivers. At any time at any place, more than half of the orbiting satellites are obscured from view as being below the horizon or on the other side of the world. As a result, the rule of thumb is that vertical positions are not as accurate as horizontal by about 50%. If a horizontal position is determined within 1 cm, vertical accuracy is typically expected to be within about 1.5 cm.

5. Enter a super-computer. Data received at a global network of stations from all visible GPS satellites at each station are relayed via the internet to a centralized computer. Baseline vectors encircling the world (point-to-point) are computed in real-time. The global network of stations fixed to the Earth's surface is treated as a deformable solid and the entire global network is solved simultaneously using data from all GPS satellites. In that case, vertical (the radial direction) should turn out to be the strongest component in the solution. Having both a functional model component for the positions and a stochastic model component supporting both local and network accuracies, the GSDM is ideally suited for the task.

6. Although other applications are sure to emerge, specific applications include:

    A. Height modernization: The U.S. government is devoting significant resources to height modernization. The results are impressive but being done on a piecemeal basis. If and once implemented on a super-computer, the national network of vertical control points (benchmark elevations for maps, flood plane determinations, and development of civil infrastructure) could be significantly enhanced. A multitude of agencies (federal, state, and local) and spatial data users in many disciplines – even in society at large - stand to share in the benefits.

    B. Earthquake prediction? With a global network of stable points whose positions are monitored continuously, could it be possible to detect irregular crustal movements as a precursor to a catastrophic earthquake. Volcanoes yes, earthquakes???

7. Much of this is already being done on a piecemeal basis. But, a super-computer and talented team could certainly provide invaluable services to many disciplines in various sectors of our national/global economy with an enhanced level of positioning services.