MAP:GAC & Emergency Management

At the meeting of the Executive Council of the Multinational Andean Project: Geoscience for Andean Communities (MAP:GAC) Lima, Peru, September 2002, the emergency management sub-project was initiated. The objective of the sub-project is to make recommendations at the next Executive Council meeting in March in Toronto on how to interface with emergency management agencies to better meet the stated objectives of MAP:GAC. The stated objectives are:

Improve the quality of life of the Andes by providing updated and integrated geosciences information on natural hazards (volcanoes, earthquakes and landslides) for use in:

- Land use planning; and
- natural hazard mitigation.

The first challenge of the emergency management sub-project is to answer the following questions: who has the responsibility for land use management and for the reduction of losses due to natural disasters? What information do they need from geosciences and in what form? Once our primary clients are identified, the second challenge is to determine what information they need and how best to interface with them. Finally, a plan needs to be developed on how to accomplish this within the parameters of MAP:GAC.

Obviously, it has been necessary to familiarize ourselves with the emergency management systems of the participating countries. This is being accomplished through visits to each country, meeting the relevant emergency management organizations and examining documentation that establishes mandates and responsibilities.

The visits have been completed in a series of trips to South America. The first trip occurred from 20 September to 5 October 2002 during which Peru and Ecuador were visited. The second from 29 October to 21 November was to Venezuela, Bolivia and Argentina. The last visit was to Chile and Colombia from 5 to 16 January 2003.

The visits were highly successful. The MAP:GAC project coordinators of each country visited proved to be most cooperative and hospitable. They organized meetings with their respective emergency management agencies and in many cases with other interested potential partners that permitted fruitful discussions as well as the gathering of the required documentation.

The emergency management sub-project is not yet completed. Nevertheless, it is possible to report at this stage on some of the preliminary findings. The most important are:

-Responsibility for land use management in all member countries lies with local authorities.
-Responsibility for natural hazard mitigation is shared among many agencies at all levels of government. However, all countries have a designated and mandated coordination agency.
-All countries have an emergency management system with a varying number of key players. These are similar but there are some important differences.
-In all countries, local authorities have a crucial role to play in emergency management.
-To maximize the usefulness of the eventual key products of MAP:GAC, local authorities and emergency management agencies will need to be consulted.

The emergency management organizations visited all support the objectives of MAP:GAC and agreed to cooperate with their respective Geoscience Agency. They were also impressed with the degree of cooperation among the Geoscience Agencies within the framework of MAP:GAC and some mused on the possibility of mirroring this cooperation among the participating countries' emergency management organizations.

The emergency management sub-project report is being prepared and will be presented to the MAP:GAC Executive Council in March. Undoubtedly it will generate some interesting discussions on a variety of issues. At this point we can anticipate that one important issue will be centered on the need to maximize the utility and use of hazard mapping. Another will surround the question of advanced tools such as modelling and Hazard, Risk and Vulnerability Assessment methodology. However, the central theme is entrenched in answering the central question: How can we ensure that updated and integrated geoscience information on natural hazards contributes to land use planning and natural hazard mitigation? The name of our project summarizes best: Geoscience for Andean Communities.

Mr. Roberto Gonzalez

GeoSemantica Development Update

Over the last past few months the MAP:GAC GeoSemantica development team has been busy building the prototype of GeoSemantica. The team has made significant progress in several areas including web based mapping interface technologies and distributed computing architectures.

The team has concentrated on integrating today's leading web standards into their application architecture. Some of the standards that have been adopted include Open GIS Consortium (OGC) (http://www.opengis.org) Web Map Server (WMS) specification v1.1.1, Z39.50 for Metadata searching, and XML web services protocols such as SOAP and WSDL.

Our developers have completed a prototype of a search and discovery application that allows users to search and browse hundreds of map layers on distributed OGC compliant Web Map Servers. GeoSemantica builds a catalog of potential map layers every evening by searching WMS compliant services on the Internet. This provides users with a rich collection of map layers that continues to grow as more data gets published by various agencies. The application allows the user to build custom maps using distributed map layers, save maps for later use and even export interactive maps for use in another web page.

Figure 1. Searching the library for WMS layers based on a spatial extents and keyword, and viewing the custom built map.

The development team has chosen MapServer (http://mapserver.gis.umn.edu) as the platform for serving maps on the Internet. MapServer is a platform independent well-supported open source development environment that offers our developers the flexibility they need to build powerful web based applications. Our team has developed a Macromedia Flash interface to MapServer that has been released to the open source community and has been very well received by MapServer developers around the world. The Flash interface provides unparalleled performance, platform/browser independence and a high level of functionality.

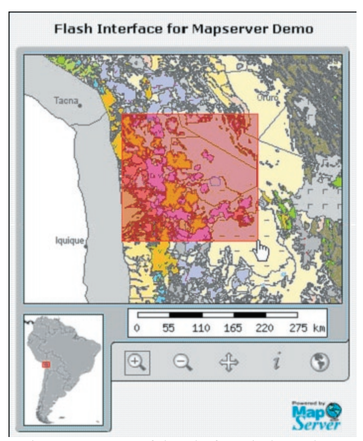

Figure 2. Demo of the platform independent Flash interface for mapserver.

With Flash, we can offer our users an intuitive interface while serving maps faster than what we previously thought possible and we don't have to worry about browser/platform compatibility.

We expect many exciting developments to occur over the next few months so stay tuned. In the mean time, contact us rgrant@nrcan.gc.ca or jvanulde@nrcan.gc.ca if you require more information about current and future developments.

Mr. Ryan Grant and Mr. Joost van Ulden

For further MAP:GAC information please consult the project Web page at http://www.pma-map.com

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MAP GAC

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From the Manager's Desk - February 2003

January has been a busy month for MAP:GAC. Trips by Mr. Otto Krauth to Chile and Argentina to discuss GeoSemantica and Mr. Roberto Gonzalez to Chile and Colombia, for discussions with SERGEOMIN and INGEOMINAS as well as their emergency preparedness partners, finalizes the travel for these two individuals for the 2002 fiscal year. A report will now be prepared by Gonzalez on the geoscience – emergency preparedness linkages, and Krauth will continue his work with the countries on GeoSemantica, preparing to present the progress this fiscal year at the Executive Council meeting. Planning for the council meeting is well underway with letters of invitation sent and other details finalized. Organization is being handled by Mr. Mike Ellerbeck and Ms. Victoria Mazo-Gray. Please see the draft agenda in this Newsletter. A large format poster is being prepared for the meeting with updates from each of the countries on their work. Many thanks to everyone who contributed text and photographs. Photographs not used on the poster will be kept to form part of the growing database of images from the project. This poster is ready for display at the Cordilleran Roundup to be held in Vancouver during the last week in January. The meeting draws over 2000 geoscientists from across Canada and the world, and is an excellent opportunity to show the work of MAP:GAC in each of the countries. Staffing the MAP:GAC booth and answering questions about the project will keep MAP:GAC staff busy during the conference. A Spanish version of the poster will be sent to each country for their own use in February.

Two significant staffing changes have occurred in the member countries. In Ecuador, Dr. Jaime Jarrin has been replaced as the National Director of DINAGE. A new replacement has yet to be announced. We would like to thank Dr. Jarrin for his tremendous support of the project during the development stage and in its first year. DINAGE is making excellent progress on several aspects of the project and we wish the incoming Director every success in maintaining this momentum and continuing the great work of DINAGE. In Chile, Dr. Jose Antonio Naranjo has been replaced as Project Leader. We would like to thank Dr. Naranjo for all of his hard work and excellent progress on the project's goals. Dr. Jose Frutos has been named as Project Leader and Dr. Jorge Muñoz is now the National Coordinator. We look forward to working with these two gentlemen, both familiar to MAP:GAC, having participated in the development stage. To Drs. Jarrin and Naranjo, we extend our very best wishes with their new endeavours and responsibilities.

Dr. Catherine Hickson

The Application of GPS to Geohazards

Introduction

At present, GPS (Global Positioning System), and InSAR (Interferometric Synthetic Aperture Radar) are probably the most popular and powerful geophysical techniques in the toolbox of the geohazards scientist. Their current explosion of application and development was clearly visible at the most recent American Geophysical Union (AGU) Meeting (December 6-10, 2002, San Francisco; Figure 1). At this meeting, more than 60 presentations used or discussed InSAR data. Most of these works also made some use of precise GPS measurements for the purpose of ground-truthing. Compare this with the previous AGU Meeting in Washington only a few months beforehand (May 28-31, 2002) where there were only about 10 abstracts referring to InSAR, and the pace of development becomes clear. Why is this happening? How do GPS and InSAR work and what can they offer? Below and in the next article are some answers to these questions based on the author's: (1) work with precision GPS over the last ten years; (2) work with InSAR in collaboration with Canadian colleagues in the last two years; and (3) discussions at the most recent AGU meeting with some of the world's most experienced workers. This information should help MAP:GAC Project Leaders make decisions about acquiring these techniques in the near future.

GPS: How It Works

GPS, for Global Positioning System, is a network of 24 satellites that encircles the globe at a height of about 20200 km. They were launched by the U.S. military starting in 1978 in order to provide accurate position information anywhere near the surface of the Earth, 24 hours a day, and remain a U.S. military service to which the global public has been given partial access. The U.S. military retains the ability to alter or locally jam the signals to prevent their use by adversaries. GPS satellites are essentially highly accurate flying clocks, and their main task is to transmit the time via radio signal pulses, called epochs, once each second. Contained in their

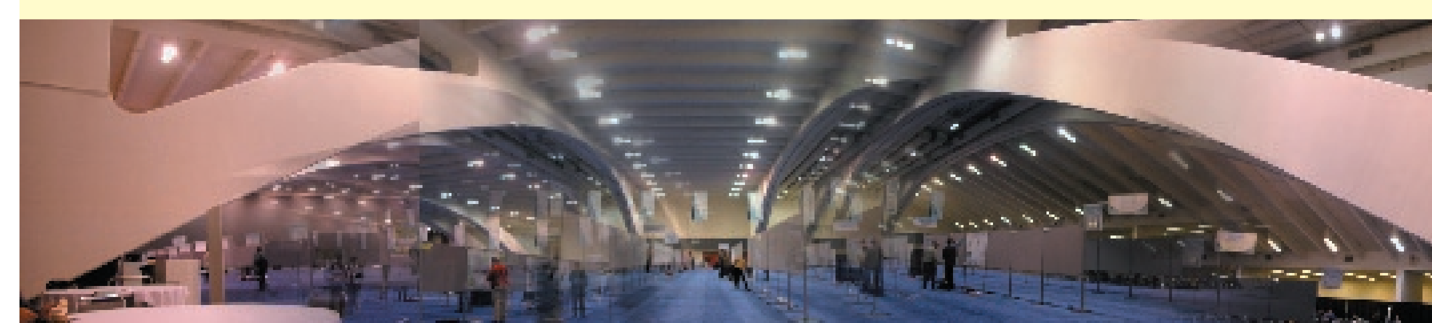


Figure 1. The poster hall at the December 2002 American Geophysical Union meeting in San Francisco. The meeting hosted a large array of research involving applications of GPS and InSAR to geohazards science.

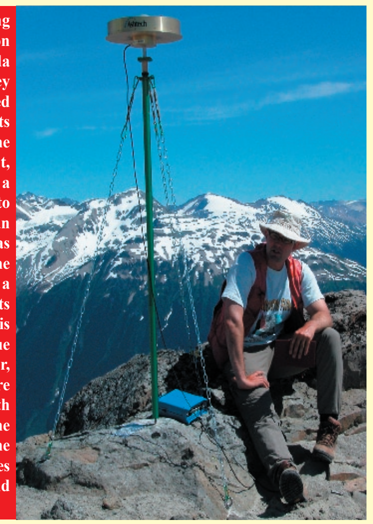
signal is a variety of other information besides the time, such as their identity and the estimated orbit location information for all the satellites. This information is called the GPS satellite "code".

GPS devices receive satellite data and determine the distance to each satellite. The satellite distance is calculated as the product of the signal speed and the transmission time, where the transmission time is the difference between the receiver's internal clock and the time in the received code. If the receiver's clock were perfectly synchronized with the satellite clocks, then it could calculate its position with just three satellite signals, in exactly the same way that earthquake hypocenters are located – three distances from one point to known locations uniquely defines the three coordinates (x,y,z) of the unknown point. Unfortunately, the clocks are not perfectly synchronized, and so determining the location also requires solving for the time offset between clocks. The extra variable to be calculated means that an additional, fourth satellite signal is needed to determine a unique location. The number and orbits of GPS satellites were calculated so that there would be at least four in view at all times, anywhere on the Earth, provided they are not blocked by topography, vegetation or buildings. Typically there are more than four in view, and there can be up to twelve. This is why GPS receivers are designed to receive up to twelve signals simultaneously. From this point the technical story is one of reducing the error on the location. For example, yet more satellite signals and a long time series of emitted pulses reduce random errors, resulting in locations with accuracy of a few tens of metres. This is essentially how inexpensive handheld GPS devices work.

The most important next level of error involves systematic errors, for example errors in the satellite clocks and orbits. Since systematic errors will be the same for two receivers running simultaneously and near to each other (getting the same satellite data), by comparing receiver positions most systematic errors can be removed. This produces a very accurate relative position between the receivers and is the basis for differential GPS, or "dGPS". With no further refinements, the position errors using dGPS may be reduced to the sub-metre level. Usually the position must be calculated by processing the data streams from both receivers after collecting all the data, which is referred to as "post-processing". These systems can also make use of improved orbit positions for the satellites, called "precise ephemerii", which are measured during flight and published on the Internet some days or weeks later. Using dGPS means using at least two simultaneously running stations, where one station is used as a base or reference location and the other is the location that is being determined (the "rover"). The base is normally placed in an unobstructed location expected to be highly stable, and usually not more than 15 km away from the rover. The errors in rover location are proportional to the inter-station distance. It is ideal to survey with two base stations since this allows a post-survey network adjustment that evenly distributes the errors.

Higher quality antennae and receivers also are able to use both code and the frequency / waveform ("phase") information of the GPS signals, so that they can calculate positions with accuracies below the wavelength of the signals (centimetre-scale accuracy). Another source of error is the bending, or refraction, of the radio signal paths as they pass through the ionosphere. This effect is dealt with largely by having the satellites transmit their information simultaneously on two frequencies, called the L1 and L2 bands. Since the ionospheric refraction is frequency-dependent, the use of two frequencies allows for correction of the refraction effect.
Another control on the location error is the distribution of the satellites, called the "constellation", at the time of measurement. The best conditions are where the satellites are numerous and well spread in the sky, allowing for the reduction of errors, whereas a poor constellation is when the satellites are clustered in the sky. The constellation quality is reflected in a quantity called the Positional Dilution of Precision, or PDOP, which is essentially equivalent to the inverse of the volume surrounded by the satellites. Large values of the PDOP represent poor constellations – with high quality equipment, during post-survey processing the data stream can be edited to remove data segments with high PDOP and thus improve the results.

Figure 2. Photograph showing a high quality GPS station operating in the field in Canada during a differential GPS survey in summer 2002, designed to monitor slope movements related to landslides. The green metal pole is the mast, and is held firmly in place on a survey pin by chains bolted to the rock. At the mast top is an antenna, which is just visible as a small white dome. Around the dome is a metal "choke ring", a structure that reduces the effects of multipathing. The signal is fed via the black cable to the blue box on the ground, the receiver, where the satellite signals are recorded for processing with the base station data after the survey. This system is the Ashtech Z Extreme, and uses both satellite frequencies and both code and phase.



Finally, high quality antennae (Figure 2) and receivers incorporate design structures and software to filter out GPS signals scattered off the surroundings. This effect is known as "multipathing" because the antenna receives multiple signals with different distances from a single satellite. With all major errors dealt with, it is possible to derive locations to sub-centimetre accuracy. Typical results achieve horizontal accuracies in the range of 2 to 10 mm and vertical accuracies of 5 to 15 mm for base-rover distances of 5 to 15 km. At the lower ends of the accuracy scales, the technique becomes more accurate than it is reasonably possible to set up the stations in exactly the same way as a previous survey. In fact, dGPS surveys now employ highly engineered portable support systems (Figure 2) to address the "set up repeatability" error.

Major Advantages and Limitations

Accurate locations are fundamental to field work, and GPS is perhaps the most simple, fast, flexible and reliable of any technique with comparable accuracy. The main alternate techniques are the total station method, using an infrared laser for distance measurements, and levelling. Both of these are actually more accurate than dGPS, but they have a variety of compelling limitations. The most substantial advantage of GPS over more traditional surveying techniques is that it does not require line of sight between stations, so that results can be determined despite severe topography or weather. This is a limitation of the total station method. In addition, dGPS yields unique positions of points, and when changes are detected, they can be determined as true vectors of motion. This is a limitation of levelling, which results only in measurements of height difference. Even advanced techniques such as InSAR have difficulty matching this feature, which is one main reason why dGPS and InSAR make strong partner techniques. This partnership will be expanded in the next article. Modern, high quality dGPS equipment also has an advantage in its flexibility. Recent technical advances have led to low power consuming receivers, so that with a mast as shown in Figure 2 a station can left to run continuously for two or three weeks. This means base stations need little maintenance during surveys. A 3-station network could be left to obtain continuous data for volcano or post-seismic deformation studies. The same equipment can also be run in a less accurate mode ("kinematic") in which the rover may be continuously moved, but still produces sub-metre locations as frequently as every second. This allows collection of ground control points for detailed geological observations, calculation of topographic profiles for slope stability, calculation of landslide volumes, or determination of a digital elevation model.

A limitation of dGPS is that it provides sparse, point locations rather than dense areal coverage, and to get frequent data either means frequent field trips to the GPS benchmarks ("stations") or installation of a continuously-measuring instrument with expensive data telemetry. In addition, GPS stations require unobstructed sky to avoid blocking of the satellite signals, so that they cannot be placed indiscriminately. These limitations make the most accurate mode of the technique best for providing ground truth and complementing another technique, such as InSAR. So, for example, a small dGPS network on a quiescent volcano could be remeasured every year or two and if significant differences are found this may warrant an expansion of the network and application of InSAR to establish the pattern of ground deformation. Alternatively, another technique such as InSAR may reveal unanticipated ground deformation, thus triggering and guiding the installation of a dGPS network to precisely monitor the situation and provide ground truth.

Costs of the Technique

There is a significant direct cost of investment required to acquire the dGPS technique. A single, complete survey set of high quality equipment, including receivers, antennae, memory cards, batteries and masts, plus the processing software and a laptop computer for downloading and processing data in the field, can cost from CDN$60,000 to CDN$100,000, depending on the brand and features. After this investment, the cost of using the technique is low and amounts to the cost of time in the field for two to three workers. The technique is sufficiently simple that training is not a large component of the cost. In many countries it is also now possible to rent reasonably good dGPS equipment. Rentals with unknown histories and performance are adequate for surveys with sub-metre accuracy requirements and probably to the centimetric scale, but for sub-centimetre geodetic-type surveys, it is best for the equipment to be owned and maintained by a controlled and well-trained user group.

The Future

The dGPS technique is growing in use and so we can expect to see further developments. For example, the geodetic community plans a denser satellite network, a third signal bandwidth to further reduce ionospheric effects, and yet better measurement of satellite orbits. Perhaps most important, manufacturers are reducing costs, and working towards a situation where antennae and receivers will be inexpensive enough to purchase networks of permanently-installed, continuously measuring, real-time systems. For the moment, the cost of these (approx. US$5000 per station) is too great to be realistically considered by the MAP:GAC project, but in the next few years this may change. In the meantime, the best way forward appears to be a portable, campaign-style system that would allow the same equipment to be rotated among multiple field areas and used for a broad range of activities, thus delivering an abundance of results for the initial investment of equipment.

Dr. Mark Stasiuk

References:

Hofmann-Wellenhof, B., Lichtenegger, H., Collins, J., 2001, GPS Theory and Practice, 5th Edition (revised), Springer-Verlag Wien New York, 382p.

Hanssen, R.F., 2001, Radar Interferometry: Data Interpretation and Error Analysis, 308p. Remote Sensing and Digital Image Processing, Volume 2, F. van der Meer, Series Editor.

Executive Council Meeting
March 9 - 14, 2003

If you have suggestions for additional topics or changes to the suggested topics please forward them to mellerbe@nrcan.gc.ca
Please note the requirement for work plans and case studies.

The first three days of the meetings will be spent working on reviewing the work plans of each country in individual country meetings. Dr.'s Hickson and Stasiuk require at a minimum, the presence of the project leader (or designate) for these meetings.

Sunday, March 9	2:00-4:00 Argentina
Monday, March 10	10:00-12:00 Bolivia
	2:00 – 4:00 Chile
	4:00-6:00 Colombia
Tuesday March 11	10:00-12:00 Ecuador
	2:00 – 4:00 Peru
	4:00-6:00 Venezuela

In preparation for the work plan meetings MAP:GAC Management requires the first draft of each country's 2003/04 work plans in digital format (email to mellerbe@nrcan.gc.ca) no later than February 15, 2003. This will allow sufficient time for management to review the work plans and prepare for the meetings in Toronto.

The work plans are to include general information on project goals for the fiscal year as well as information on:

- proposed scientific field and office activities,
- proposed short courses and work shops including suggestions of names of possible instructors or lecturers,
- types and quantity of analysis to be carried out on samples,
- equipment and software required for carrying out the proposed activities.

Below is a list of items for the Agenda for the Executive Council Meeting which will be held March 12 - 14, 2003.

1) Review of Action Items from Previous meeting:
Action: Copies of work plan for GeoSemantica presentations to be distributed to all member countries.
Action: Countries to put forward names of working group to be presented at the Executive Council Meeting in Toronto in March 2003. (see item #5)
Action: Krauth to visit each participating country and assess their internet and computing capacity. (see item #5)
Action: Gonzalez to table report on assessment of links between Emergency Management Organizations and Geoscience Agencies in Toronto. (see item #13)
Action: All countries to submit their lists of national experts at the Puerto Varas meeting. (see item #9)
Action: Stasiuk to prepare a list of multinational projects and products for discussion and approval at the next Executive Council Meeting (Toronto 2003). (see item #4)
Action: South American countries to prepare proposals for field workshops for approval and scheduling at the Toronto 2003 meeting. (see item #4)
Action: South American countries to prepare a case study of their experiences in dealing with the community in natural hazards for presentation at the Toronto 2003 meeting. (see item #14)
Action: Ellerbeck to establish contact with the natural hazards departments of international organizations and groups, and to regularly update them with project developments. (see item #10)
Action: All countries to supply Ellerbeck with names and contacts of any other groups who should be added to the list international organizations to be regularly updated on MAP:GAC activities.

2) Country presentations on 2003/04 work plans (30 minutes/country, including questions). Plans must be submitted prior to the meeting so that attendees can review and be prepared to ask questions. Presentations are to focus on work to be conducted and proposed products. Details will be discussed with Hickson and Stasiuk prior to the meetings.

3) Sub-Project Management update:
For administrative purposes the project has been divided into sub-projects (see below) each with a designated sub-project manager. These managers will be responsible for budgeting and reporting on their sub-project.

Executive Council Meeting	Ellerbeck
Administrative Reports	Ellerbeck
MAPAS (see below)	Krauth
Project Communications	Ellerbeck
Supplemental Travel Fund	Hickson
Hazard Mapping	Hickson
Geophysical Hazard Monitoring	Stasiuk
Hazard Communication Strategies	Hickson
Emergency Response and Preparedness	Hickson
Hazard Simulation	Stasiuk
Hazard Response	Hickson
Remote Sensing	Stasiuk
Earthquake Hazards	Hickson
Landslide Hazards	Hickson
Volcanic Hazards	Hickson
Data Standardization (see below)	Krauth
Administration	Ellerbeck
Project Profile Enhancement	Hickson

4) Binational and Multinational Sub-projects & Binational and Multinational Products - Hickson, Stasiuk

5) GeoSemantica - update by Krauth
-Video Presentation and discussion
-Creation of Geosemantica Project Working Group
-Activity Plan for 2003/04 fiscal year

6) MAPAS - MAP:GAC Management System update - Hickson, Krauth, Ellerbeck. Discussion of verifiable indicators module.

7) Standardization of Terminology

8) Publications - (ie. preparing scientific information for non-scientific audience)

9) Discussion of Technical Advisors - Technical Coordinator - Lic. Roberto Page

10) Discussion of Project External Relations with other international projects and governments (press releases, invitations to meetings, propositions of joint activities etc.) - Ellerbeck

11) Discussion of Regional Emergency Fund for Executive Council Meeting attendance. - Ing. Ricardo Troncoso

12) Discussion of ISO 9003 certification for Geochemical Reference Materials. - Hickson

13) Gonzalez report - Gonzalez

14) Case studies - Countries

Mr. Mike Ellerbeck