# Nepalese Journal on Geoinformatics

**Number: 2**

**Jestha 2060 BS**

**May - June 2003 AD**

**An annual publication of Survey Department, His Majesty's Government of Nepal**

**Cover Page Photo**

**HRH Crown Prince Paras Bir Bikram Shah Dev inaugurating the 23rd ACRS by lighting traditional oil lamp by Sukunda. Seen at the picture are from right Prof. Shunji Murai, General Secretary, AARS, Mr. Ananta Raj Pandey, Secretary, Ministry of Land Reform and Management and Rt. Hon. Mr. Lokendra Bahadur Chand, Prime Minister.**

**Published by**

His Majesty's Government of Nepal

Survey Department

Min Bhawan, Kathmandu

Nepal

Price : **Rs 100**

No. of copies : 500



*Printed at*

Ajima Printers

Bhaktapur

# Members of Advisory Council



# Members of Editorial Board

# *Editorial*

United Nations declared the year 2002 AD as "International Year of the Mountains". Therefore, Survey Department proposed to organize the 23rd Asian Conference on Remote Sensing (ACRS) in Nepal to commemorate this announcement, as Nepal is a mountainous country. Asian Association on Remote Sensing (AARS) accepted the proposal and Survey Department, Nepal and Asian Association on Remote Sensing jointly organized the conference from November 25-29, 2002 in Kathmandu.

The conference was one of the most important events of the Survey Department and was a most challenging task, as the department was going to experience to organize such a big event of international standard for the first time. The event became a very successful one because the department could able to gather a large number of national and international professionals related with Remote Sensing, Global Positioning System, Geographical Information System and Surveying and Mapping and conducted the conference smoothly. Besides, the addresses of the Prime Minister of Nepal, Secretary of Ministry of Land Reform and Management, Director General as well as Convenor of the conference, President of ISPRS and General Secretary of AARS and the keynote speeches from the three eminent professors and the number of exhibitors added the importance of the conference. Furthermore, the overall support and guidance by Prof. Shunji Murai, General Secretary of AARS played also a major role to be able to run the conference smoothly. The presentation of number of technical papers in the conference was also overwhelming.

Therefore, this second issue of Nepalese Journal on Geoinformatics is published as a special issue on the 23rd Asian Conference on Remote Sensing in which the Editorial Board tried to give glimpses of the conference.

As the conference document was limited to the participants, therefore the aim of the publication of this journal as a special issue on the 23rd ACRS is to disseminate information to other professionals from the field of Geoinformatics who missed to participate the event. Therefore, I believe, having a copy of this Journal in hand, he/she should feel that he/she did not miss the conference.

It was a great surprise for us regarding the affirmative responses from the readers of the first issue of the Journal. Due to which, I felt more responsible to improve its quality or at least to maintain the present standards. So, I assure you to provide the Journals, in future, to cheer your face, not to embarrass.

Finally, after successful completion of the 23rd ACRS, I flavor that Survey Department is motivated to organize next international conference in near future and therefore, I am already looking forward to dream the next international event and hope to see you all in that gathering.

**Editor-in-chief**

Jestha 2060 BS

May- June 2003 AD

# Message from Director General of Survey Department

I have a great pleasure in publishing the second issue of Nepalese Journal on Geoinformatics as a special issue of the 23rd Asian Conference on Remote Sensing (ACRS 2002), which was held in Kathmandu, Nepal on November 25-29, 2002 organized jointly by Survey Department, Nepal and Asian Association of Remote Sensing. The successful completion of the conference that witnessed the participants from all over the world has made the Survey Department and Geoinformatics community in Nepal very proud. The conference was very helpful in sharing the knowledge about the technical enhancement in the field of Geoinformatics. In addition, knowledge in handling such a conference participated by professionals of various levels in the subject matters, was of a great value.

Remote Sensing, Global Positioning System and Geographical Information System, being fundamental disciplines of Geoinformatics, the conference encompassed all these aspects focusing on the latest trends in the surveying and mapping. Hence the various professionals, students, researchers, teachers, producers and users of this technology in the Asian region had a great opportunity in sharing the knowledge and experiences through this forum.

I personally believe that this issue of the Journal is particularly aimed in presenting the overall scenario of the conference so that the readers who could not participate in the conference can have insight into it.

I believe that the existence of such Journal is purely dependent on the contribution, support and co-operation from the Geoinformatics community without which it is not possible to publish such Journals. Thus, I kindly request the community to help us to maintain the continuity of the Journal.

Finally, I would like to extend the gratitude to all who are directly or indirectly related to this Journal.

Jestha 2060 BS **Babu Ram Acharya**

May- June 2003 AD

# Contents

## Opening Address

**Lokendra Bahadur Chand**
Rt. Honorable Prime Minister

Your Royal Highness Crown Prince Paras Bir Bikram Shah Dev, Rt Honorables, Honorables
Distinguished participants
Ladies and gentlemen,

First of all, I would like to express my heart-felt gratitude to His Royal Highness Crown Prince Paras Bir Bikram Shah Dev for his gracious presence at this function and for being so kind as to declare this important event to open.

It gives me great pleasure to address this august gathering of experts, scientists and professionals associated with one of the key resources of our time - information. I would like to thank the organizer for this opportunity.

As I stand here to speak a few words to this dignified assembly of specialists in remote sensing and GIS, representing many countries, institutions and professions, I recall with pleasure the fine morning of 15th December 1984 when I had the opportunity to address the fifth Asian Conference on Remote Sensing, also here in Kathmandu. But as I remember, it was perhaps a smaller gathering then.

Nearly two decades on, I can note with satisfaction that ACRS has not only brought together an increasing number of experts, scientists and professionals, but it has also proved to be instrumental in promoting the use of this ever-advancing technology within Asia and globally.

Admirable as it is for its sophistication, technology remains to be a means, however. The end is the improvement in the quality of life of the people. When we talk about the quality of life of the people, we cannot ignore the fact that many people in our part of the world live in a state of poverty. The life of those who live in mountainous regions is even miserable.

While we could argue over the reasons for poverty, I think that our efforts to alleviate it have been constrained by many factors, especially a lack of knowledge and information to overcome the development challenges posed by difficult terrain conditions and depleting natural resources, among others. This is also where information technology has a crucial role to play.

In particular, remote sensing and GIS can help enhance our understanding of our problems and potentialities, increase our capacity to mobilize natural resources, and also minimize the risk of their overexploitation for one reason or another. It is only through informed policy choice that we can meet the challenge facing us today, namely, reducing poverty while not reducing our resource base.

In my opinion, we need to further our efforts to facilitate the sharing of geo-based information both within Asia and beyond. We need to co-operate in realizing the potential of the remote-sensing technology as presented by its various applications. We need to build our capacity together.

As I speak about the hardship of the people living in mountainous regions, I am very happy to find so many of the eminent personalities meeting here in Nepal, the country of the highest mountain in the world, in this year of the mountains as declared by the United Nations. With your personal presence here, I hope that the difficulties of the people living in fragile and inaccessible mountains will be more visible to you, inviting you to additionally focus your future research on addressing them.

I hope that this meeting will deliberate on these and other emerging issues. I am also confident that the deliberations at this meeting will lead to fruitful conclusions to guide our future course of action in this field. I wish you all the success.

Thank you.
November 25, 2002

**Ananta Raj Pandey**
Secretary
Ministry of Land Reform and Management

Your Royal Highness Crown Prince Paras Bir Bikram Shah Dev
Rt Honorable Prime Minister
Honorable Deputy Prime Minister
Honorable Minister for Land Reform and Management
Honorable Ministers
Rt Honorable Distinguished Guests
Distinguished participants
Ladies and Gentlemen

First of all I would like to express my deeply felt gratitude to His Royal Highness Crown Prince Paras Bir Bikram Shah Dev for the gracing this occasion and for being so kind as to declare this conference open by lighting the lamp.

It is indeed a great honour for me to have the opportunity to speak a few words at this important function.
As we all know, The World Summit on Sustainable Development held in Johannesburg this year reviewed the implementation of Agenda 21 and agreed on a plan of Implementation, covering a wide range of issues involved in achieving sustainable development. One of the agreed on action of this plan of implementation is

I quote :
Promote the development and wider use of earth observation technologies, including satellite remote sensing, global mapping and geographic information systems, to collect quality data on environmental impacts, land use and land-use changes.
Unquote
Poverty reduction is the overall development goal of His Majesty's Government of Nepal. As all our efforts are being geared to achieving this national development goal, we are also facing problems of growing population and degrading environment. Utilisation of land and land-based natural resources, while preventing their over exploitation, is therefore a priority of His Majesty's Government of Nepal.
More specifically, our efforts are aimed at ensuring socially just land distribution, so that poor families have access to this vital basis of livelihood, and encouraging proper land-use practices, so that increase in agricultural productivity is sustainable, and modernising the system of land management and record-keeping, so that land administrative services are more scientific and better accessible to all.
It is also in this process of natural resource management that the geographic information system, with its wide-ranging applications, becomes very important. The Ministry of Land Reform and Management has therefore given priority to remote-sensing technology and the geographic information system (GIS), and also to the use of valuable spatial information generated through such advanced means to assist decision making at various levels. We are already in the process of creating national geographic infrastructures. I may also mention here that we are a participatory to Global Mapping Initiatives.
In my opinion, information technology in general, remote-sensing and geographic information technology specifically, present an area for fruitful cooperation among countries within our vast continent and beyond. This is also an area where a variety of institutions, academic disciplines and professions can have common grounds for making collective efforts to help achieve sustainable development as envisaged in the plan of implementation adopted by the Johannesburg Summit. We, in Nepal, remain committed to supporting such initiatives at regional and international levels.
I am confident that all of us- scientists, academics and professionals assembled here are from all over Asia and the world will benefit from our interactions during these five days. The conclusion drawn through these scholarly interactions will also provide a useful basis for our future course of action.
Finally, I wish this conference a success and also hope that all our distinguished guests will find their stay in Nepal pleasant.

Thank you.

November 25, 2002

**Prof. J C Trinder**
President, ISPRS

Your Royal Highness Crown Prince Paras Bir Bikram Shah Dev
Rt. Honorable Lokendra Bahadur Chand, Prime Minister of Nepal
Distinguished guests
Ladies and gentlemen

I want to thank firstly everybody for the opportunity to represent the International Society for Photogrammetry and Remote Sensing at the opening of this Asian Conference on Remote Sensing held in this fascinating city of Kathamandu. I think for many of us, this is the first time we have the chance to visit Kathmandu and we certainly very glad of the opportunity to visit the city and participate in the activities of this Asian Conference on Remote Sensing. I would thank specially the organizers and secretariat of the Asian Association on Remote Sensing for their warm welcome here today and specially the members of the Survey Department here in Nepal who made a welcome really warm and easy to fit into the conference here in Kathmandu.

Firstly, a little bit about ISPRS. ISPRS is what we call a society of societies. It brings together people from more than 100 countries through its congresses technical commission in symposia and workshops organized by working groups. There are nearly 50 working groups in ISPRS whose specific area of study assigned to them for the four-year period from 2000 to 2004.

The Asian Association on Remote Sensing is a regional member of ISPRS. Regional members are an important component to the community of experts in ISPRS. In particular, the contribution of AARS enhances the ISPRS aim to achieve its mission which is devoted to the development of international co-operation for the revengement_of knowledge, research, development education and training in the Photogrammetry, Remote Sensing and Spatial Information Sciences. ISPRS is looking at ways to improve its effectiveness and one of these to work more closely with regional members. We are therefore encouraging working group chairs and technical commission president in ISPRS to collaborate more with the regional members and AARS is being an important one of them. Achievement of this collaboration is depend upon personalities to initiate them and I have the encouragement from the leadership of these organizations who have joint meetings, and joint research activities being undertaken between ISPRS and AARS. The potential area of this collaboration can be found on website in the Internet.

There are a numbers of topics that ISPRS is pursuing. We would encourage cooperation from members of the Asian Association on Remote Sensing. I just like to mention one of them and I think it is an important one particularly given in the conference as just been in Johnsberg recently. There were some advance substantial development, we propose on the topic of sustainability should be formulated by sustainability indicators measured by Remote Sensing. Early Warning indicators need to be developed that will identify and monitor impact before excessive damage occurs up to the environment. Environmental indicators derived by Remote Sensing technologies should enable mapping, monitoring, and determination of the status of the condition at the natural and managed ecosystem in order to right time information to identify risk to the environment. These indicators should improve environmental decision making by contributing to implementation of sound sustainability developmental practices through more important environmental management. Determination of these indicators primarily requires inter-disciplinary phase involving inputs from specialist on the physical environment and that is socioeconomic environment. This issue, just being addressed by the Remote Sensing community is complex one. Not only involving the physical aspects in the environment but also the sociological aspects of people living on the planet.

As a scientist working in International Human Development Programme that is IHDP, which is part of IGBP, comment is necessary to socialize the pixels. That is to realize the social activities of the humans to the physical characteristics of the pixels on the ground. So, sustainable development is an inter disciplinary matter that requires co-operation/ co-operative research from many scientists, Remote Sensing being one of them. I would hope we could see development in those areas in this area of Asia in the future.

Hopefully the programme this Asian Association on Remote Sensing symposium is interesting one, covering important topics in Remote Sensing particularly related to Asia. The continuing development of Remote Sensing is essential for the application of technology for the benefit of mankind.

I wish you all a fruitful week to join this symposium. I also look to continue increased co- operation between ISPRS and AARS in the future.

Thank you very much ladies and gentlemen for your attention.

ACRS 2002
Kathmandu, Nepal
25-29 Nov. 2002

**Prof. Emeritus Shunji Murai**
General Secretary
Asian Association on Remote Sensing

Your Royal Higness crown Prince Paras Bir Bikram Shah Dev
Rt. Hon Prime Minister, Mr. Lokendra Bahadur Chand
Distinguished Delegates,
Distinguished Guests,
Distinguished Participants,
Ladies and Gentlemen,

First of all, I would like to thank Nepalese Organizing Committee, Particularly Mr. Babu Ram Acharya, Director of Survey Department and his team for their tremendous effort to make this conference possible with limited budget. I congratulate the organizing committee to have accepted 238 papers, such many papers beyond our expectation. I also appreciate the council of International Society for photogrammetry and Remote Sensing (ISPRS) for their positive participation. All Keynote speakers are strongly related to ISPRS.

I did remember clearly about the fifth ACRS held in Kathmandu in 1984. Because the scheduled airplane with the majority of participants including me could not land at Kathmandu airport on the previous day of opening ceremony, those participants missed the inauguration presided by the then Prime Minister Rt. Hon Mr. Lokendra Bahadur Chand. It was indeed confusion for us to have landed and stayed over night in Calcutta in stead of Kathmandu. At that time, it was not easy to use telephone and facsimile for communication between Japan and Nepal tape TELEX for urgent communication. Now eighteen years passed since the previous conference. Nowadays I had no difficulty to communicate Nepalese Organizing Committee by E-mail.

Though time has changed like this particularly since information technologies (IT) was introduced into our life, the spirit of ACRS has not changed. This is why we can continue this conference. Friendship first and Money after" still remain as our spirit" Understanding not only scientific issues but also Asian multi-cultures" has always entertained participants from Asia as well as Western countries. We should accept differences among Asian countries, which are sometimes exaggerated to a critical level. For these more than twenty years since I started ACRS in 1980, I had hard times but no conflicts with Asian remote sensing scientists. We are always happy to meet our old and new friends at every ACRS where we can feel that ACRS is our own home made conference.

Every year, I received so many mails from Asian remote sensing scientists who request me to support their travel fund to Join the ACRS. However as Asian Association on Remote Sensing has limited fund, I could not support those Asian scientists. Therefore we have to realize that there are many scientists behind us, who wanted to participate in this conference but could not make it. We must make this gathering more effective and fruitful on their behalf.

Ladies and Gentlemen, I as General Secretary of ACRS, Would like to ask your understanding that this conference is being organized in Nepal, one of the most difficult countries in economics and finance. I sincerely request overseas participants to understand some inconvenient matters, which are not always American standard. However, I believe that Nepalese is one of the richest nation in hospitality and kindness in the world. I do hope all of you to enjoy this unique and cultural country with a long history.

On behalf of all participants, I wish all the success. We do look forward to having an exciting week from today.

Thank you for your kind attention.

ACRS 2002
Kathmandu, Nepal
25-29 Nov. 2002

**Babu Ram Acharya**
Director General
Survey Department, HMG, Nepal

Your Royal Highness Crown Prince Paras Bir Bikram Shaha Dev
Rt Honorable Prime Minister Mr.Lokendera Bahadur Chand
Rt. Honorables, Honorables and Distinguished Guests
General Secretary of the Asian Association on Remote Sensing (AARS) Professor Shunji Murai
Respectable Academics, Professors, Scientists, Engineers, Developers and group of Co-professionals
Media Friends,Ladies and Gentlemen !

I would like to extend our deepest gratitude to His Royal Highness Crown Prince Paras Bir Bikram Shaha Dev for graciously consenting to inaugurate this twenty-third Asian conference on Remote Sensing (ACRS). We have been highly honoured and encouraged by the presence of His Royal Highness Crown Prince in this inaugural session. I would like to express our Hearty Welcome, Your Royal Highness !

I would also like to express our sincere gratitude and welcome to Rt. Honourable Prime Minister Mr. Lokendra Bahadur Chand and Rt. Honourables, honourables, Excellencies and other respectable dignitaries who have honoured our invitation to be present here to grace this auspicious occasion.

It is a matter of pleasure for me personally, my organization Survey Department of Nepal and my Co-professionals in the field of Surveying, Photogrammetry, Geoinformation and Remote Sensing to say WELCOME to this august gathering, on behalf of the Survey Department, Nepal and Asian Association on Remote Sensing in this inaugural Session of the Twenty-third Asian Conference on Remote Sensing, here, in Kathmandu.

After the Fifth Asian Conference on Remote Sensing, first time in Nepal in 1984 we have long been aspiring for an event like to be organized bringing in World Scientists, Professionals and developers in the field of Geo-information Sciences, in Nepal. Let us hope that this ***SAPTAHA*** – a week long professional activities of presentations, listening, discussions and sharing of knowledge and views, will open up new avenues in broader application of Remote Sensing and in coordinating the efforts of development in this region.

We consider, the decision to hold the conference second time in Kathmandu, as an appreciation of the strong association of the Nepali Co-professionals with AARS since its birth to this adulthood of 23 years. Holding this annual international conference of AARS in Nepal reinforces our commitment to the objectives of the association and in the same time we take it as an expression of solidarity and faith on us from our Co-professionals in Asia and the World-over.

We are delighted to receive this rare gathering of more than 400 professionals, academics, scientists and developers from more than 30 countries. We feel proud that the rays of ACRS are not limited to Asia but are reaching beyond. Professor J.C. Trinder, President of the International Society for Photogrammetry and Remote Sensing has kindly accepted our invitation and is here with us, today. We are privileged to have eminent dignitaries Professor Ian Dowman from University College London, United Kingdom, Professor Gottfried Konecny from Hannover University, Germany and Professor Martien Molenaar of ITC, The Netherlands, who will be delivering their keynote addresses in this conference. As I remain to be one of the many ex-pupils of Professor Martien, I consider your visit and participation in this conference will be valuable in assessing the role and contribution of ITC in the field of GIS and Remote Sensing in Asia and Nepal in particular. I would like to extend a warm welcome to you all.

On behalf of the organizing committee, I would like to welcome the leading personality behind the creation of AARS and ACRS, General Secretary of AARS Professor Shunji Murai , this year in Nepal. ACRS Kathmandu was conceptualized when we met in Taipei in December 2000. ACRS 2002 was formally declared to be held in Kathmandu last year in the annual conference in Singapore. Nepal is celebrating many activities and events in cognition of the United Nation’s declaration to observe Year 2002 as International Year of the Mountains. Professor Shunji Murai, has been very considerate and instrumental in holding this conference in Kathmandu, the Capital of Nepal, the country of highest mountains in the world in this International Year of the Mountains.

I think the weather now is quite friendly to you all as the winter chill and dry is yet to find its way in Kathmandu. Despite the very hectic conference schedule, I hope, You will find time to enjoy the nature and go around in this city with centuries old temples, stupas and other architecture. I wish you a pleasant stay in Kathmandu.

Let us hope that this conference will be successful in benefiting us all through the deliberations. Lastly, I once again extend SUSWAGATAM – a grand welcome to you all.

Thank You !

**Rabin K. Sharma**
Member Secretary
23rd ACRS

Your Royal Highness Crown Prince
Rt. Hon. Prime Minister
Hon. Minister
Hon. and Respectable Guests
Distinguished Delegates and Participants
Media Friends, Colleagues, Ladies and Gentlemen

**Namaskar and Good Morning!**

The gracious presence and inauguration of this historical event of 23rd ACRS by Royal Highness Crown Prince made us pride and feel glory. Due to which we also feel that the value of this conference reached at the top as high as Mount Everest. Therefore, please allow me to offer sincere and deepest gratitude to Royal Highness Crown Prince which was emerge from core of my heart.

Now, I would like to express my sincere gratitude to Rt. Hon. Mr. Lokendra Bahadur Chand, Prime Minister for the directives given to us and also would like express my sincere thanks to Mr. Ananta Raj Pandey, Secretary, Ministry of Land Reform and Management for the kind words.

I request Honorable and respectable guests to accept my sincere gratitude for their presence in this hall.

I would like to offer my sincere gratitude to Prof. Shunji Murai for his understanding, cooperation and above all his continuous guidance right from the day of the Singapore conference 2001 till today. In his address he praised the Nepalese people for their hospitality so I feel proud to hear it and would like to express my humble appreciations to Prof Shunji Murai for such a kind statement. I am confident to receive such affection to us in future as well.

I would also like to express my sincere thanks to Prof. J. C. Trinder, President ISPRS who has kindly accepted our invitation and deliver the lecture in this ceremony. His presence signifies that mutual relationship between AARS and ISPRS has been strengthen and we feel that we succeeded to adding value to enhance ACRS activities with this relationship.

We are very much excited to receive such an overwhelming response from the participants therefore it is my privilege and honour to offer my sincere gratitude to all the national and international participants for their enthusiastic participation.

The conference become possible also because of the sponsors, namely ESA, CNES, ERDAS, FINNMAP and HP, the exhibitors and the other supporters, so we owe them and at the same time we are very much thankful to them. Now I would like to request these organizations and invite other such organizations to sponsor in future when the conference is organize in a developing or under developed countries in order to roll ACRS non stop.

To make my list for vote of thanks shorter, I express my sincere thanks to all to whom I must thank.

Finally, I wish for all the foreign delegates and participants that their stay in Nepal be a pleasant and memorable one.

Once again I would like to thank you all for your kind attention.

God bless us all! Thank you!

# MAPPING FROM SPACE

**Gottfried Konecny,** em. Prof.
University of Hannover, Germany
Invited Paper
**23rd Asian Conference on Remote Sensing**
Kathmandu, Nepal
November 25 to 29, 2002

**ABSTRACT**

Traditional mapping by photogrammetry has been successful to provide a near global coverage at the 1:200 000 scale. For the more useful scale 1:50 000 only 2/3 of the globe were covered, however, there is a serious lack of update of these maps in the developing world. Mapping from satellites can bridge the existing gap in providing timely information.

The paper lists the historical development of optical and radar satellite sensors. The present high resolution satellite sensors are more expensive than aerial photography products. In the future there will be competition to existing systems by small satellite operators. Advances in digital mapping technologies have led to the efficient creation of software systems for the restitution of aerial and satellite images. Radar interferometer technology has proved useful for small scale digital elevation model creation. The advantage of using satellite data is in its integration with data from other sources.

## 1. MAPPING

The objective of mapping is to provide a model of the earth's surface which can be used for the purposes of navigation and for depicting and for planning the natural and the socio-economic environment with the aim of a sustainable development. In historical times the progress of mapping was limited by the technical abilities for geocoding the features of interest on the earth's surface. In the old ages this has resulted in only local surveys of settlements. In the 14th and 15th century the emphasis was placed on navigational charts for the purposes of exploration. In the 17th century the method of triangulation permitted to determine distances via angular measurements. Paired with astronomic positioning this resulted in the first geocoded maps for area coverage of countries compiled because of military interests. It took at least a century to compile medium scale maps of the countries of Europe by terrestrial plane table surveys.

For the mapping of the vast non-European continents accurate mapping required a new technology. This technology has been made possible by the invention of the airplane in 1903, and by the invention of the aerial mapping camera in 1915. The technology of photogrammetry permitted to map entire continents during world war II. After 1945 the benefits of this technology have been applied to the developing continents of Latin America, Asia and Africa.

The U.N. Secretariat has followed worldwide mapping progress in its reports published in World Cartography. The 1990 status of topographic mapping in the scale ranges 1:200 000, 1:100 000, 1:50 000, and 1:25 000 has been summarized by the data contained in fig. 1.

| Continent / Scale | Africa | Asia | Australia & Oceania | Europe | former USSR | North America | South America | World |
|---|---|---|---|---|---|---|---|---|
| 1:200 000 | 89.1% | 100% | 100% | 90.9% | 100% | 99.2% | 84.4% | 90.2% |
| 1:100 000 | 21.7% | 66.4% | 54.4% | 87.5% | 100% | 37.3% | 57.9% | 58.9% |
| 1:50 000 | 41.1% | 84% | 24.3% | 96.2% | 100% | 77.7% | 33% | 56.1% |
| 1:25 000 | 2.9% | 15.2% | 18.3% | 86.9% | 100% | 45.1% | 7% | 33.3% |

Fig. 1: Status of Topographic Mapping

Fig. 2 lists the update rates of the map coverages shown in fig. 1:

| Continent / Scale | Africa | Asia | Australia & Oceania | Europe | former USSR | North America | South America | World |
|---|---|---|---|---|---|---|---|---|
| 1:200 000 | 10.9% | 15.4% | 2.9% | 59.9% | - | 51.9% | 2.2% | 3.4% |
| 1:100 000 | 28.8% | 0.2% | 0.7% | 55.9% | - | 0.2% | 0% | 0.7% |
| 1:50 000 | 18.4% | 5.7% | 13.1% | 45.9% | - | 21.4% | 6.1% | 2.3% |
| 1:25 000 | 14.0% | 27.7% | 15.8% | 52.5% | - | 32.2% | 0% | 5.0% |

Fig. 2: Update Rates 1980-1987 of the Global Topographic Map Coverage

The summary states that about 100 % of the land area of the world is covered by maps 1:200 000 for global requirements, about 2/3 by maps 1:50 000 for local needs. Most of these maps are in the process of vector or at least raster digitisation. But the crucial truth is, that most of the map information is not up-to-date. The world coverage of up-to-dateness of maps is more than 20 years old. The current updating procedures by aerial photogrammetry are either too costly or too slow to permit an up-to-date coverage of digitised map information. With the exception of Europe and the developed countries of the world this constitutes a serious problem for the developing countries.

For this reason a new technology for mapping and especially for map updating is most welcome. Such a new technology is mapping from space. Ever since the launch of the Russian satellite Sputnik in 1957 there has been an interest in imaging the earth's surface from space. With the US-NASA-NOAA satellites, starting with Tiros in 1961 meteorological data were gathered around the globe with a few to 1 km ground resolution. They served global meteorological and climatological requirements, but could usefully also be employed to monitor the status of global vegetation at bi-weekly intervals at low resolution.

The thematic mapping of resources began with the medium resolution US-Landsat satellite program with Landsat MSS in 1972 at 80 m resolution. This was improved with Landsat TM in 1982 at 30 m resolution, useful for monitoring the status of agriculture, of land cover and of forests. The medium resolution of 30 m also proved useful in monitoring catastrophic events such as floods, fires, and earthquakes. Since NASA's Seasat in 1978 and ESA's ERS in 1991 all weather radar systems supplemented this informations. More detailed information required for topographic mapping was in the 1980's governed by military resolution restrictions. These higher resolution satellite missions were based on camera technology used from manned and unmanned space platforms and from digital optical sensors, which since the French SPOT in 1986 have been improved in ground resolution down to 0.6 m at present.

## 2. OPTICAL SATELLITE SENSORS

The history of medium to high resolution optical sensors is shown in fig. 3.

| | | | | |
|---|---|---|---|---|
| (1968) 1998 | Corona | 3 m | Film | Stereo |
| 1972 | Landsat MSS | 80 m | Digital | - |
| 1982 | Landsat TM | 30 m | Digital | - |
| 1983 | Metric Camera-SL | 10 m | Film | Stereo |
| 1984 | Large Format Camera | 5 m | Film | Stereo |
| 1986 | Spot P | 10 m | Digital | Stereo |
| 1987 | KFA 1000 | 7 m | Film | Stereo |
| 1991 | KVR 1000 | 2 m | Film | TK350(Stereo) |
| 1993 | MOMS 02 | 5 m | Digital | Stereo |
| 1996 | MOMS 02-P | 6 m | Digital | Stereo |
| 1996 | IRS 1C/D | 6 m | Digital | Stereo |
| 1999 | Ikonos 2 | 1 m | Digital | Stereo |
| 2000 | EROS A1 | 1.8m | Digital | Stereo |
| 2001 | Quickbird | 0.6m | Digital | Stereo |
| 2002 | SPOT 5 | 2.5m | Digital | Stereo |

Fig. 3: The High Resolution Optical System History (Optical Systems)

A systematic survey of high resolution imaging has been initiated by the US military Corona program in 1968. It was based on panoramic film cameras. In 1998 these images have been declassified. They are now available as inexpensive film products by the USGS. Overlapping images permitted stereo-restitution. The start of high resolution stereo-imaging was made by the German ESA Metric Camera experiment from Space Shuttle in 1983, in which about 10 % of the earth's surface was imaged in stereo with a ground resolution of 10 m. The US-NASA conducted another such experiment with the Large Format Camera LFG in 1984 reaching 5 m ground resolution in stereo. While Spot in 1986 with 10 m panchromatic resolution marked the beginning of Western digital high resolution sensor imagery, the Russian efforts of the 1980's and 1990's continued with optical film imaging system such as the KFA 1000 in 1987 with 7 m resolution and the KVR 1000 in 1991 with 2 m resolution.

In 1993 the first digital stereo sensor MOMS 02 was flown on US Space Shuttle with 5 m resolution. The missions were continued on the Russian MIR station from 1996 to 2000 with 6 m resolution. 1996 marked the year, when developing nations began to enter space imaging with the Indian IRS 1 C/D in 1996 with 6 m resolution. While digital stereo imaging at the highest achievable ground resolution is still carried out in the US military KH 11 and KH 12 programs the first U.S. commercial ventures have been launched by Space Imaging, with Ikonos 2 in 1999 at 1 m resolution. In 2000 Ofek of Israel launched EROS A1 as a 1.8 m satellite, and the U.S. Earth Watch with Quickbird surpassed the resolution up to 0.6m with a stereo possibility. Also the French launch of Spot 5 in 2002 with a 2.5 m resolution in an on-line stereo version is a step in this direction. Other efforts of high resolution imaging are planned by Japan with ALOS in 2004 with 2 m resolution, by China & Brazil with CBERS in 2004 with 2 m resolution, by India with Cartosat in 2003 with 2 m resolution. Earth Watch and Space Imaging have obtained licenses for 0.5 m resolution satellites for 2004/5.

## 3. RADAR SENSORS

The history of radar satellite sensors is shown in fig. 4.

| year | name | country | agency | pixel | elevation accuracy |
|---|---|---|---|---|---|
| 1978 | Seaset | USA | NASA | | |
| 1991 | ERS ½ | ESA | ESA | 12 m | 5 to 100 m |
| 1994 | JERS 1 | Japan | NASDA | | |
| 1995 | Radarset | Canada | Radarsat Int | 6 m | |
| 1995 | Almaz | Russia | | | |
| 2000 | SRTM-Cband | USA | NASA/NIMA | 15 m | 10 m |
| 2000 | SRTM-Xband | Germany | DLR | 15 m | 5 m |
| 2002 | Envisat | ESA | Astriun | 12 m | |
| Proposed after 2004 | | | | | |
| | High resolution System | Russia | | 1 m | |
| | Terrasar | Germany | | 4 m | |
| | Sar- Lupe | Germany | | 1 m | |

Fig. 4: Radar Satellite System History

Radar images have the advantage of an all day, all weather sensing system, but object reflections behave very different from those received by optical sensors. They can supplement, but not replace optical images.

Satellite radar systems, however, have the advantage of coherent radar pulses. Thus not only the distance to the object, but also the phase of the incoming backscattered signal may be utilized to achieve a high azimuthal resolution, and moreover signals received at two antennas separated by a base may be utilized by interferometric principles to determine height. Particularly the two ERS 1 and 2 satellites, flown in a tandem mission in nearly the same orbit a day apart have been used to obtain interferometric heights. After phase unwrapping and reference to control these agreed within 5 m in unvegetated flat areas, but showed discrepancies of up to 100 m in areas of radar foreshortening and radar shadows. The Shuttle Radar Topographic Mission SRTM flown in 10 days by NASA/NIMA and DLR with 2 radar interferometers, separated by a long mast of 60 m length provided a nearly global interferometric radar coverage. The construction of higher resolution radars and interferometric system (the CNES/DLR Interferometric Cartwheel in conjunction with Envisat) is in sight for the next few years.

## 4. SMALL SATELLITES

The monopoly of expensive large mass satellites and platforms launched by governmental organizations has been broken by private initiatives to launch small satellites. As early as 1993 the laboratories of Surrey University cooperated with Korea and Portugal to launch mini- or micro-satellites, which are able to carry small satellite sensors. In 1999 the DLR Tulsat launched from India was able to experimentally reach 6 m ground resolution by an optical sensor. This was later repeated with UoSat 12 launched by Surrey in Russia with a 10 m resolution. Other attempts launching small satellites have been successful, such as Kitsat (Korea), Tiungsat (Malaysia) in 1999, and Tsinghua 1 (China) in 2000. Surrey claims, that small satellites can reach 95 % of performance of the conventional satellite platforms at 5 % of the cost and 70 % of performance at 1 % of the cost. A great number of small satellites is in preparation for launch in the next years as shown in fig. 5.

| Mission | Agency | Launch | Resolution | Swath |
|---|---|---|---|---|
| Meisat | Korea | | 8.5 m | 47 km |
| Khrurnichev | Russia | | 8 m, 3-5 m radar | |
| S. Res.Inst. | Russia | | 1 m radar | 10 km |
| Rapideye | Germany | | 6.5 m | 4 satellites |
| Tubitac | Turkey | | | |
| Rocsat | Taiwan | | 8 m | 24 km |
| Hypseo | Italy | | 5 m pan | 20 km |
| Topsat | UK | | 2.5 m | |
| Sunsat | South Africa | | 5-10 m | 80 km |
| KAIST | Korea | | 2.5 m pan | 20 km |
| Interferom. | DLR/CNES | | 1-3 m | |
| Cartwheel | For Envisat | | radar interferometry | |

Fig. 5: Planned Small Satellite Missions

## 5. DIGITAL MAPPING TECHNOLOGIES

The recent transition of photogrammetric technology from analytical photogrammetry, using computers for the traditional manual mapping tasks to digital photogrammetry, in which raster scanned images are used in digital form, has opened new ways for semiautomatic and automatic operations in the restitution process. Due to the capabilities of digital image processing image matching has permitted automation in measurement of points and in creating digital elevation models (DEM's) via image correlation. Based on these DEM's orthophotos can be calculated via resampling techniques according to collinearity equations. These equations can be easily modified for different satellite sensor geometries, so that the photogrammetric restitution process is no more limited to aerial photography.

For the geocoding of orthophotos and their tone-matched mosaics new inflight determinations of the coordinates of the exposure stations and the sensor orientation have been made possible by inflight differential GPS and by inertial measuring units. These positioning and orientation data may be adjusted and analysed for large blocks of images guaranteeing a geocoding accuracy to the sensed pixel with high reliability due to statistical checks applied.

Recently P/C based digital photogrammetric restitution programs have internationally been made available. One of the examples is SIDIP (Simple Digital Photogrammetry) developed at the University of Hannover. It contains the following features:
- semiautomatic point measurement of fiducial marks, transfer and control points in the photos
- sensor models for aerial and satellite sensors
- orientation by bundle block aerial triangulation block adjustment up to 6000 images and 200 000 points, with the possibility of incorporating GPS exposure station and INS orientation data
- generation of elevation models via image matching with filtering capabilities
- geocoded orthophoto generation
- tone matched mosaicking
- interpolation of DEM contours in raster and vector form
- side views of DEM's by wire frame models with a possibility of draped image superposition.

With this program Ikonos 2 mono and stereo images have been restituted for the less expensive Carterra products offered by Space Imaging for a price of 29 $/km2 in Europe (apparently special offers in the USA went as low as 7 $/km2). The Carterra product constitutes an image projected onto a plane tangent to a local ellipsoid in the area imaged. The resultant discrepancies away from the image center line along the orbit reflect the height displacements with respect to that plane. In mountainous areas they can result in discrepancies of up to 200 m.

If, however, ground control and a digital elevation model is available, then the resulting geometric discrepancies may be reduced by an affine transformation and the application of collinearity equations to less than 4 m. A similar result in accuracy may be achieved by stereo restitution of stereo Ikonos images.

This proves, that the expensive Space Imaging high accuracy products (100 $/km 2 and more) can be obtained by own efforts with appropriate software programs. One should realize, however, that aerial photography at an image scale 1:40 000 with 50 cm pixels can yield a superior result in tone rendition and interpretability, as well as in geometric accuracy of ± 1 m for 1:10 000 mapping at prices of 23 $/km2 for the entire process of aerial flight to aerial triangulation, image matching to geocoded orthophoto generation, which is less than the Carterra product without restitution.

## 6. COST FACTORS

The digital photogrammetric mapping cost can be assessed at the following international standard rates:

aerial photography 4000 $ mobilization plus 10 $ per image
scanning of photos 15 $ per image
aerial triangulation 25 $ per image
digital elevation model 120 $ per image
digital orthophoto 30 $ per image
mosaicking 20 $ per image.

On screen digitising by stereo-workstations or in the orthophotos is labour intensive, and it may vary with the details available, e.g. for rural areas 10 hrs/image to urban areas 100 hrs/image. This is why companies of developed countries with labour rates of more than 50 $/hour have entered joint ventures with institutions in low labour cost countries of less than 20 $/hour to extract GIS information from the images.

It should be noted, that pricing for a product consists of costs plus overhead plus profit plus risk. These factors, additional to cost determine the bidding scene for international projects.

In aerial photography the costs relate to the neat portions of a photograph, which is scale dependent.
With the photo size a' x a' = 23 x 23 cm the area covered by a photo is a x a, with ' a=h/f *a
(f = focal length, h = flying height).

As the photos are usually flown with a longitudinal overlap of 60 % and a lateral overlap of 70 % the air base b becomes b = 0.4 a, and the distance from flight strip to flight strip q = 0.7 a. Thus the neat model area becomes b x q = 0.28 a2. For a photo scale 1:13 000 the neat model area is 2.5 km2 and for aphoto scale 1:40 000 is 23.7 km2. When these photos are scanned at 15 µm this results in a ground pixel of 20 cm for the 1:13 000 image scale and of 60 cm for the 1:40 000 image scale.

According to the above cost data for 1:13 000 photography 20 cm pixel orthophotos may be produced at 180 $/km2. For 1:40 000 photography scanned at 12.5 µm 50 cm pixels will result. These orthophotos may be produced at 23 $/km2.

Line mapping of 20 cm orthoimages is possible at the scale 1:2000 at 1200 $/km2, and line mapping of 50 m orthoimages at the scale 1:10 000 is possible at 150 $/km2.

One of the relatively high cost factors is the generation of digital elevation models. The advantage of DEM's is that they generally do not change except through construction of catastrophic events. In the States of Germany they have traditionally been generated either by terrestrial surveys with ± 1 dm accuracy in a very expensive time consuming way, or by stereo photogrammetry with ± 2 dm to ± 5 dm accuracy.

Nowadays laser scanning permits to derive digital surface models (DSM) with ± 1.5 dm accuracy at costs higher than aerial photography, but with the advantage to receive tops of trees or buildings and ground signals for DSM and DEM generation for areas (planted forests, cities), where this seems to be required. Another less expensive, but lower accuracy alternative is airborne radar interferometry with accuracies in the ± 1 m range or satellite radar interferometry in the ± 5 m range.

With DEM coverages available from these sources digital orthophoto production may be reduced in cost.

## 7. INTEGRATED APPROACHES

Mapping from satellites is not an either or proposition. Its advantage lies in its capability for value added data integration. This was demonstrated in a DLR project for the design of a disaster relief information system for the region of Kosovo. To obtain timely information on the crisis region the following data sources were integrated into an information system:

- the topographic maps 1:50 000 of NATO
- the European CORINE land cover maps 1:100 000
- the ERS ½ interferometric DEM
- the most recent satellite imagery from Landsat TM, IRS 1C/D, KVR 1000 and Ikonos 2 subjected to visual interpretation and change detection routines
- these were supplemented by local low accuracy GPS surveys determining the damages on roads, railways and bridges
- local digital camera images for multimedia use for the assessment of damages to buildings.

## 8. CONCLUSIONS

The review on the possibilities for mapping from space leads to the following conclus ions:

- Mapping from satellites to 0.6 m pixel is a reality. This corresponds to 2 to 4 m object recognition which is required for 1:5000 image mapping.
- 0.5 m resolution is in sight in the future.
- At present high resolution satellite images are more expensive than aerial photography with equal performance; they are thus geared for a military market in areas, where aerial photography is not easily possible.
- In the future there is strong competition between big agency satellite systems and small satellites.
- 1 m radar interferometric systems and 1 m radar imaging systems are in sight for the supplementation of optical images.
- Orthophoto mapping is far less costly than line mapping.
- Data integration from all sources is a must.

## REFERENCES

World Cartography, Vo. XX, New York 1990, ISBN 92-1-100432-2, United Nations, "Status of world topographic and cadastral mapping", pp 1-116, paper prepared by *A. Brandenberger* and *S.K. Ghosh*

*Gottfried Konecny*: "Geoinformation", ISBN 0415237947 & ISBN 0415237955, Taylor & Francis, London, 2002

*Karsten Jacobsen*: "Mapping with Ikonos Images", Proceedings, 22nd EARSeL Symposium, Prague, July 2002, earsel@meteo.fr

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

# DIGITAL ELEVATION MODELS: WHERE DO WE GO FROM HERE?

**Ian Dowman**
Department of Geomatic Engineering
University College London
Gower Street, London WC1E 6BT
United Kingdom
Tel: (44) 20 7679 7226  Fax: (44) 20 7380 0453E-mail: idowman@ge.ucl.ac.uk

**KEY WORDS:** DEM/DTM, Correlation, Fusion, Accuracy

**ABSTRACT**

This papers examines the current status of DEM generation and discusses current research which may lead to better quality DEMs. Data from so many different sensors can now be used for DEM generation that it is necessary to set out their advantages and disadvantages. There are also many applications of DEMs, and ways of processing and presenting them, and new research is constantly extending and improving these. Some of these methods are discussed and these include improved stereomatching, better representation of the surface and the use of data fusion.

## 1. INTRODUCTION

Digital elevation models (DEMs) have become a major product from different types of remotely sensed data in recent years for a number of reasons: production has become easier with the use of digital images and automatic stereo-matching; new techniques such as interferometric SAR (IfSAR) and LIDAR have provided an accurate alternative source to stereo images; and many new applications have been developed, ranging from orthoimages through 3D city models and visualisation. However, with this upsurge in the production and use of DEMs have come a number of problems. The main problem is the reliability of a DEM produced by automatic matching. It has been shown many times that given suitable acquisition dates, and suitable land cover, accurate elevation data can be produced. However it is also well known that blunders can easily creep in due to mismatching, and that this becomes more common at larger scales in built up areas and on vegetated steep slopes. As much time can be spent editing a DEM as generating it is the first place. Similar problems apply to IfSAR, although in this case the coherence image gives an indication of the quality expected. LIDAR data does not have these problems but is mainly suitable for large scale work and generally, at present, does not produce an image. A summary of the characteristics of optical data is shown in table 1.

| | Characteristics | Problems | Comments |
|---|---|---|---|
| **Aerial photographs** | 2 Vertical images | Occlusions | Well established theory and method |
| **Airborne 3 line scanners** | Forward, nadir and aft views; require GPS/INS for position and orientation; multispectral data can be collected simultaneously | Intensive computation required for correction | HRSC successfully used for true orthoimage production |
| **Medium resolution satellite images (SPOT, IRS, ASTER)** | Pushbroom (line scanner systems) with varying configurations; orbit stable, but not well known. | For SPOT and IRS problem of obtaining stereo pairs in short time. | Now widely used. Much data now available from these sensors |
| **High resolution satellite images (Ikonos, Quickbird)** | <1m pixel size; highly manoeuvrable; high positional accuracy. | Cost, availability of stereo and exterior orientation data. | Not yet much used for DEM generation. |
| **LIDAR** | Direct determination of X, Y, Z co-ords. | Small swath width, high cost. | Good for some applications |

Table 1. Characteristics of DEMs generated from optical data.

The availability of stereoscopic data from high resolution satellites such as Ikonos and Quickbird also has an impact on DEM generation. Images from these sensors may be acquired at very large incident angles: up to 45˚. Thus the degree of occlusion and correction needed is increased. Furthermore the accuracy of this data is dependent on the interior and exterior orientation data that may not be within the control of the user, being provided as rational polynomial co-efficients by the supplier.

As more data becomes available and techniques develop, there is a greater demand put on the DEMs. High quality is needed for terrain analysis in such areas as hydrology and terrain evolution for tectonic studies. It is therefore necessary that we examine the methods of generating DEMs and how we use them, asking a number of questions such as: is the matching method used the best for the application? Is the method of interpolation to a grid appropriate and is information lost in this process? Can we improve the DEM by using data fusion from two or more sources? This paper will discuss DEMs at medium to large scales and will consider DEMs generated from LIDAR only as supplementary data when high accuracy, over limited areas, is required. We will first review the methods of generating DEMs, not just the sensors used, but also the processes involved, and then look at ways in which the DEM might be improved and tailored to different applications.

## 2. GENERATION OF DIGITAL TERRAIN MODELS

### 2.1 Matching stereoimages

The principle method of generating DEMs from optical images is now automatic stereomatching. Software has been developed over many years and packages such as SOCET Set sold by Leica Geosystems and Match-T are now widely used. Editing software comes with the package and this has significant use, especially at large scales. The degree of automation in the editing routines in these packages is limited. Generally the software will handle aerial photographs and a range of satellite images, which is continually extending. This type of software is ideal for the generation of orthoimages, for which there is little editing required, limited to the removal of blunders. Surface features such as buildings and trees will be corrected only to the level of accuracy of the digital surface model (DSM) and at large scales this does not accurately model the surface features. 'True' orthoimages can be obtained from three line digital scanners using algorithms that use information from all three looks. Matching algorithms using only two images may be able to produce true orthoimages if breaklines can be utilised. This topic is discussed further below.

Automatic stereomatching produces a digital surface model (DSM) that is the first surface presented to the sensor, i.e. the tops of trees, buildings and other features. This is useful for some applications such as production of orthoimages and visualisations, and may be suitable for small scale applications, but at larger scales, a digital terrain model (DTM) will often be needed. This has let to the development of filtering algorithms to generate 'bare earth models'. These are more often used with LIDAR and IfSAR data.

### 2.2 Interferometric SAR

Interferometric SAR is used for generating DEMs from SAR images collected with a short base line from which phase differences can be determined and converted to elevation differences. The technique was proven with European ERS data and more recently used on the Shuttle Radar Topography Mission (SRTM) which collected data for the whole land surface of the Earth between 60˚ N and 54˚ S. ERS data is acquired with a time interval between images (repeat pass data) and has been used to create DEMs with regional coverage in countries such as Germany and UK. SRTM is single pass data and DEM data is now being released with 30m spacing in the USA and 100m spacing elsewhere. The vertical accuracy is generally around 8-10m. Airborne IfSAR systems are also in use now and are also used to collect regional DEMs with spacing typically 5m and with 1m vertical accuracy.

Prior to SRTM and airborne systems, which obtain 2 images simultaneously in a single pass mode, the major problem with IfSAR was lack of coherence between two images taken at different times. This led to gaps in the data that could be filled if multiple pass data was available. In the United Kingdom, for example, the Landmap project (Morley et al 2000) has created a DEM of the whole country using 4 near complete passes of ERS data. There is a very large archive of ERS data that can be used in this way.

Software for DEM generation from IfSAR is often developed for specific types of data nd is not generally available, although some vendors, such as PCI, sell software with image processing systems.

### 2.3 Discussion

We have shown that data is available to produce DEMs for most parts of the world with grid spacing of 30 metres or more using satellite data from sensors such as SPOT, IRS, ASTER and ERS. DEMs generated from SRTM IfSAR will shortly be available off the shelf. At higher resolutions airborne data is available from optical and radar sensors that can produce DEMs of small or large areas as required. High resolution optical sensors on satellites can also produce DEMs, but this data has not yet been much used for this purpose. Vertical accuracy is dependent on the sensor and the type of terrain and land cover, but also on the ability to obtain near simultaneous image pairs. The uses of this data are varied. A major use is to produce orthoimages and image maps. Sensors such as SPOT are particularly useful for this in areas where no up to date maps exist, and in remote areas where access is difficult and expensive. DEMs have also been extensively used in hydrological studies and for the prediction and management of disasters, such as flooding, landslides, volcanic eruptions and earthquakes. Differential interferometric SAR has been particularly useful in this latter application. In recent years DEMs have been in considerable demand for predicting flood prone areas for protection and insurance purposes. Airborne IfSAR has proved useful for large areas, supplemented by LIDAR for smaller areas.

## 3. IMPROVING THE QUALITY OF DEMs

### 3.1 Data acquisition

The main factors that affect the accuracy of a DEM that has been processed, edited and archived for use are:

- Accuracy of the source data and/or derived elevation;
- Terrain characteristics;
- Sampling method (grid [grid spacing], TIN]
- Interpolation method;
- Representation (raster, tessellation, contours…)

The relationship between accuracy and spacing is highly dependent on the nature of the terrain. The formula of Ackermann (1980) for optical data has widespread use:

$$\sigma_z^2 = (a \cdot d)^2 + b^2$$

where $\sigma_z^2$ variance of interpolated arbitrary points in the DEM
- $d$ mean (representative) point interval between measurements (grid spacing)
- $a$ proportionality factor depending on the type of terrain
- $b$ measurement error.

Apart from the terrain, all of these variables are dependent on the sensor. A higher resolution will result in the ability to have smaller grid spacing and smaller measurement error. Better sensors will therefore give better accuracy. The best sensors at present are the high resolution optical sensors such as Ikonos and Quickbird, but, as discussed above, the data is expensive and is therefore not used for DEMs over large areas. Stereo optical sensors such as ASTER are making the data available to more people but the accuracy of the DEMs generated is not as high as from existing data such as SPOT and IRS because of a larger pixel size. Better resolution will come from the Japanese ALOS mission and the PRISM sensor that has 3 line stereo data with a pixel size of 2.5m. One of the aims of this mission is to create regional DEMs and the specification for PRISM DEMs are 10m spacing with 5m vertical accuracy. The accuracy is related to the cost and Figure 1 gives comparison between the cost of data with the vertical accuracy.

In the area of IfSAR, SRTM will be a valuable data set because of its near global coverage, the accuracy however is no better than SPOT. ENVISAT, RADARSAT 2 and ALOS PALSAR are potentially useful sources of IfSAR DEMs. It has also been demonstrated that airborne IfSAR can produce regional DEMs economically. Complete coverage of England Scotland and Wales has recently been completed by Intermap with a 5m spacing and 1m vertical accuracy (0.5m in some places).

Table 2 summarises the characteristics of data acquisition and DEM generation.

**3.3 Improved representation of the terrain**

The size of feature that can be shown is ultimately limited by the pixel size of the imagery. However the size of the window used for matching, which can be changed, is also important. Strategies within matching software can be changed to influence the detail obtained. The method if interpolation, however, is often fixed.

Scientists from the Earth sciences have made their own investigation into methods of surface fitting and have proposed the use of techniques such as dynamic modelling, geostatistics and fuzzy classification, (Wilson et al, 2002). Use of these tools could lead to techniques for handling uncertainty, identification of scale dependent filters and handling of sub-grid scale variability. Hutchinson (2002) discusses a locally adaptive approach to the interpolation of DEMs and indicates the importance of not loosing information when interpolating from an irregular network to a grid representation.

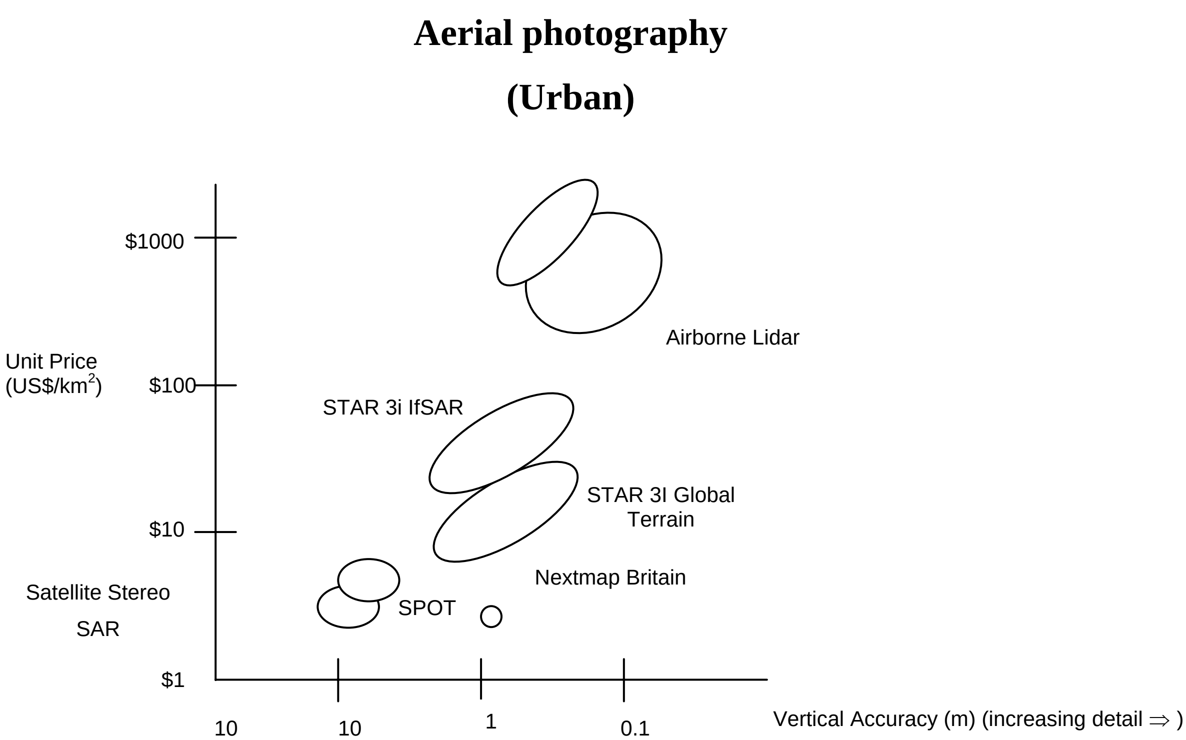



Figure 1. Relative costs of DEM production compared to vertical accuracy (after Mercer, Intermap)

| Platform/Sensor | Grid spacing | Vertical accuracy | Comment |
| --- | --- | --- | --- |
| Medium resolution satellite images (SPOT, IRS, ASTER) | **30m** | **10m** | **Reliable data and software. Subject to gaps due to cloud, occlusions and decorrelation.** |
| High resolution satellite images (Ikonos, Quickbird) | **5m** | **2m** | **High accuracy, narrow swath and high cost.** |
| SPOT 5 | | **<10m** | **Continuations of SPOT 1-4 with improved resolution and revisit capability, and along track stereo** |
| ALOS PRISM | **10m** | **5m** | **Good potential for regional DEMs** |
| ERS IfSAR | **30m** | **10m** | **Can produce good results if multiple passes, but can be problem due to decorrelation, occlusions and layover.** |
| SRTM | **30m** | **10m** | **Good global coverage. Only 100m data available outside USA** |
| Airborne IfSAR | **5m** | **0.5m** | **High quality data for regional cover.** |

Table 2. Summary of data acquisition

**3.2 Improving stereomatching**

Algorithms for stereomatching have been developed over many years and comprise highly complex code, there is therefore clearly an inertia to be overcome. New techniques such as the wavelet transform has been applied to image matching and suggestions have been made to use adaptive strategies, these are summarised in table 3. More use could also be made of breaklines, and to define these by automatic or iterative methods.

| **Technique** | **Examples** | **Comment** |
| --- | --- | --- |
| **Use of breaklines** | (Sohn and Dowman, 2001) concludes that the introduction of 3D breaklines improves the DEM which can be generated. Paparoditis et al (1998) and Cord and Declercq (1999) | Software available but not fully used. Methods developed for building extraction. Problem in defining breaklines by manual measurement or from maps |
| **Wavelets** | He-Ping Pan, (1996), Tsay (1998) | Not widely used |
| **New strategies** | Data fusion (Honikel, 2002) **Failure Warning Model (Fox and Gooch, 2001)** Adaptive strategies | Most promising approach, can be built on existing algorithms, but may require additional data. |
| **Multipoint matching** | Rosenholm, (1987) | Gives good results but also requires extra data. |

Table 3. Techniques for improving stereomatching.

**3.4 Data fusion**

The opportunities for data fusion are greatly increased as more sensors are launched and data becomes more easily available and often less costly. If more than one data set is available then solutions have been proposed for exploiting any synergy that is present. (Honikel, 2002, Hahn and Samadzadegan 1999). Fox and Gooch (2001) have proposed generating 2 DEMs from the same data to improve the result.

A useful discussion of the topic is given by Honikel (2002) who recommends three steps:

1. Data **alignment** during which all data is transformed to the same reference system in the same units.
2. Data **association** during which data is grouped and edited so that common points are merged and erroneous points are removed;
3. **Estimation** during which a final DEM is created which best fits to the multiple observations.

Honikel is concerned with fusing ERS IfSAR data with a DEM from SPOT and demonstrates how the synergy of these two data sets can be exploited to make use of the strengths of both sets of data to give a DEM that is better than either of the initial sets of data. In his case the SPOT DEM is used to improve the phase unwrapping and to remove systematic trends; associated data is used to remove blunders and get a better estimate for points to which more than one observation refer, and by working in the frequency domain the strengths of both data sets can be combined. From this we can propose some generic techniques:

- Fusion of data with different spacing (quasi or true grid) to get a better estimate of individual points.
  Examples: Hahn and Samadzadegan (1999) use wavelets to combine DEMs of different resolution and accuracy.
- Fusion of data that has different qualities.
  Examples: IfSAR can be very accurate where coherence is high and SPOT can be accurate where correlation is high, either can perform better on particular types of feature depending on aspect, time difference etc. Stereo SAR might be used with SPOT for similar reasons.
  LIDAR data might give an indication of where buildings or trees occur, which could control matching of optical data.
- Fusion in a coarse to fine strategy.
  Examples: A coarse DEM can be sufficient to give initial values to generate a fine DEM and to indicate areas where problems might occur.
  A coarse DEM can assist with phase unwrapping of IfSAR data and remove trends due to atmospheric effects or base line errors. (Honikel 2002)
- Fusion of different types of data.
  Examples: Use of rivers, spot heights, lakes, breaklines etc. within the matching process.

Two general questions remain to be answered in respect to data fusion:at what stage should fusion take place? And how to exploit the full information from an irregular network?

### 3.5 Interferometric processing

Research is ongoing in the area of processing IfSAR data. It has been shown recently that data fusion (Honikel 2002, see above), and multiple passes (Landmap, Morley et al, 2000) can be used. SRTM and airborne IfSAR have shown that intensive processing from single pass data can provide reliable and accurate data.

## 4. FUTURE DIRECTIONS

Better sensors should produce better DEMs and this has been demonstrated by SRTM, IKONOS and airborne IfSAR. In the future ALOS PRISM and PALSAR and ENVISAT may also produce widely available improved data. The use of data fusion techniques can also produce better DEMs, but at the expense of having more than one data sets and more processing. This may not be a major disadvantage in the future if data such as SRTM become widely available at low cost, and Data from ERS continues to be available. However we also need more efficient production, that is lower cost and more automation. This is the area where most research is needed: to make more use of breaklines and adaptive strategies for DEM production.

## REFERENCES


Ackermann F, 1980. The accuracy of digital height models. proceedings of 37th Photogrammetric Week. University of Stuttgart. 234 pages:113-143.

Cord M., Declercq M., 1999. Bayesian model identification: application to building reconstruction in aerial imagery. IEEE International Conference on Image Processing, Kobe, Japan,

Fox A, Gooch M, 2001. Automatic DEM generation for Antarctic Terrain. Photogrammetric Record, 17(98):275-290

Hahn M and Samadzadegan F, 1999. Integration of DEMs using wavelets. International Archives of Photogrammetry and remote Sensing, 32(7-4-3 W6)

He-Ping Pan, 1996. General Stereo Image Matching Using Symmetric Complex Wavelets. SPIE Proceedings vol. 2825. Anonymous ftp: ftp://ftp.cssip.edu.au/pub/projects/vision/pan/GSIMW_beta.ps.Z

Honikel M, 2002. Fusion of sapceborne stereo-optical and interferometric SAR data for digital terrain model generation. PhD thesis, ETH, Zürich.

Hutchinson M, 2002. Advances in locally adaptive interpolation of digital elevation models. DEMs and Geomorphology. Proceedings of the symposia on new concepts and modelling in geomorphology and geomophometry, DEMs and GIS, Tokyo, August 2001. Geographic Information Systems Association, Nihon University. (Also at http://www1.gsi.go.jp/gtopo30/papers/local.html)

Hutchinson M, Gallant J, (2000). Digital elevation models and representation of terrain shape. In Terrain Analysis, principles and applications, Ed Wilson J, Gallant J, Wiley, New York. Pages 29-50.

Morley J, Walker A, Muller J-P, Kitmitto K, Mitchell K, Chagani K, Smith A, Barnes J, Cross P, Dowman I, 2000. Landmap: Creating a DEM of the British Isles by SAR Interferometry. International Archives of Photogrammetry and Remote Sensing, 32(B4/2):686-693.

Paparoditis N, Cord M, Jordan M, Cocquerez J –P, (1998). Building detection and recognition from mid- and high resolution aerial imagery, Computer Vision and Computing, 7(2):83-94.

Rosenholm, D., 1987: Multi-point matching using Least-Squares technique for evaluation of three-dimensional models. Photogrammetric Engineering and Remote Sensing, 53(6): 621-626.

Sohn and Dowman, 2002. Feasibility study of stereo matching process in SocetSet.  ALFIE2 project document.

Tsay J-R, 1998. A new algorithm for surface determination based on wavelets and its practical application. Photogrammetric Engineering and Remote Sensing, 64(12):1179-1188.

Wilson J, Hutchinson M, Gallant J, (2000). Terrain Analysis, principles and applications, Wiley, New York. Pages 29-50.

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

**Prof. Dr. Martien Molenaar**

Rector
International Institute for Geo-information and Earth Observation (ITC)
The Netherlands

**Oral Presentation**

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

# Closing Remarks

**Ananta Raj Pandey**
Secretary
Ministry of Land Reform and Management

Prof. Shunji Murai,
Distinguished Participants,
The Organizing Committee Members,
Ladies and Gentlemen,

It is my great pleasure to chair this closing ceremony of the 23$^{rd}$ Asian Conference on Remote Sensing. As I understood, the conference activities did run smoothly. Therefore, I would like to thank and congratulate all the members of the organizing committee for their efforts to complete it successfully.

As, I know Prof. Shunji Murai has regularly monitored the progress and provided guidance to the organizing committee for the preparation of 23$^{rd}$ ACRS right from the very beginning, and he always expressed the satisfaction for it, and finally the committee conducted the conference successfully. So, I would like to express my thanks to Prof. Shunji Murai for his valuable contribution to conclude this conference in a grand manner.

I would also like to thank the eminent Keynote speakers and Prof. J.C.Trinder for their speeches in this conference due to which the horizon of this conference has broadened specially on the level of participation in the Global context.

I appreciate the overwhelming and active participation by the participants of national and international individuals, scholars, professionals and concern organizations in this conference, due to which the Nepalese participants have been able to update and widen their knowledge through sharing ideas with them, as well as from the technical papers presented during the conference. So, I am confident that with this newly gained information they will be able to make better use of the profesion for the betterment of the people.

I would like to inform you that, in Nepal, the application of Remote Sensing Technology is in a very childhood stage. So, I believe with this conference, it will grow a step further. Therefore, I request all the Nepalese professionals in this field to make use of the contacts you have created with the foreign professionals during this conference. I believe this long time association will help and cooperate in this context.

As Prof. Shunji Murai inform that the 24$^{th}$ ACRS will be held in Korea in the year 2003, so I request all the participants to prepare best technical papers and make the conference also a success. I would like to take this opportunity to wish the delegation of Korea for the success of the 24$^{th}$ ACRS.

Once again I would like to thank you all for your active participation and contributing to the success of the conference.

Thank you.

Nov. 29, 2002

**Prof. Shunji Murai**
General Secretary, AARS

Mr. Ananta Raj Pandey
Chairman and Secretary, Ministry of Land Reform and Management.
Mr Babu Ram Acharya,
Director General of Survey Department as well as Convenor of the 23rd ACRS.
Distinguished Delegates,
Ladies and Gentlemen

I am quite happy to conclude that the 23rd ACRS was successfully held in Kathmandu a rich cultural city.

I am pleased to report you that, since the ACRS has grown to an adult that is more than 20 years old, the organizing committee of the host country could almost more than 90% of organizing call for papers, selection of papers, publication of proceedings, preparation of exhibition and parties etc. At the beginning I was a little worrying about the confidence of Nepalese team but now I tell you that the Nepalese organizing committee under the leadership of Mr. Babu Ram Acharya did make this conference not only possible but also very successful.

During the conference, I convened two General Conferences, on Tuesday and Thursday. The general conference confirmed that 24th ACRS to be held in Pusan, Korea, 3-7 November 2003. It decided the 25th ACRS in 2004 be held in Chaing Mai, Thailand. We received a proposal from Malaysia for the 26th ACRS in 2005 and again from Australia for the 27th ACRS in 2006.

The General Conference has decided to support Digital Asia Network, GIS Software for education and the publication of a memorial book on successful applications of Remote Sensing and Gis in Asia in link with the 25th Anniversary of ACRS on 2004.

The outcome is needless to say but I want to add that the Nepalese media of newspaper and TV introduced this conference to the public.
Yesterday, we received an interview of TV, which will be on TV may be tomorrow or day after tomorrow.

Finally, I would like to extend my deep appreciation of main players.
First of all I thank three Keynote speakers and the Council of ISPRS.
From a token of my thanks I am pleased to present a gift to:

Mr. Babu Ram Acharya, Chairman of Organizing Committee,
Mr. Rabin K.Sharma, Conference Secretary
Mr. Durgendra M. Kayastha, Technical Director,
Mrs. Sushila Rajbhandari

I apologize that I cannot present gift to all members who worked for this conference but I want to request to share all participants to give big hands to those Nepalese who contributed to make this conference successfully.

I hope to meet you again in Pusan next year.

Thank You.

Nov. 29, 2002

**Mr. Babu Ram Acharya**
Convenor 23rd ACRS

Respectable Secretary Mr. Ananta Raj Pandey,
Ministry of Land Reform and Management
General Secretary of AARS Prof. Shunji Murai
Distinguished Delegates, Participants, Sponsors and Conference Officials,
Ladies and Gentlemen,

I am privileged to stand here before you once again, on the verge of closing, of this conference and speak a few words.

It goes without saying that, Programmes and venues for an event like this open up new avenues for all concerned; the Students, the Researchers, the users and the developers. It is very much encouraging in that this 23rd ACRS in Nepal received a satisfactory response from within Nepal and abroad.

After the 5th ACRS Conference in 1984, it is the only International Conference of this kind in the field of Geo-information in Nepal. Then was the time when many in Nepal in the profession itself did not even know about the conference being organized.

For various reasons, among them mainly financial, Nepalese scientists deprived of the opportunities to explore the benefits of such conferences abroad.

For this particular reason too, I very much appreciate the decision of AARS for choosing, to organize its 23rd annual international conference in Kathmandu. We shall remain co- operative for such occasions in future too.

Technological development has taken very fast and long strides in the last two decades, which developing countries like Nepal have not been able to exploit to the desired level.

Growing population and depleting resources have become the major source of conflicts globally. The present situation of endangered peace in the world warrants the attention of all resources managers to forecast and monitor any significant development in any part of the globe.

In this regard, this conference must have contributed to promote the awareness to and extend the application of RS and GIS through various personalities and deliberations. These will, I hope, be helpful in making the technology more useful and also affordable to many.

Myself from Survey Department had acknowledged the responsibility of the convenorship for this conference on behalf of AARS. In spite of, the efforts from myself and my team-mates within our capabilities, our doings might not be spread of several shortcomings and inconveniences for the participants, specially those from abroad. I humbly apologize for any such. We will try to be better next time.

I am very much indebted to the leading personalities Prof. J.C.Trinder, President ISPRS, Prof, Ian Dowman, Prof. Konecny and Prof. Molenaar as well as the participants, for kindly accepting our invitation and giving their valuable presence.

I would also like to sincerely appreciate the role of Prof. Shunji Murai for establishing this unique tradition of ACRS in consolidating Asian unity for the world cause. Let us look forward to the forthcoming 24th ACRS in Pusan South Korea, setting another milestone in the history of RS and GIS.

Participants from abroad,

You are going back to reunite with your families and friends after a weeklong stay in Nepal. I wish you safe and nice Journey back home in a Jubilant mood.

Thank You.

Nov. 29, 2002

# Brief Report on The 23rd Asian Conference on Remote Sensing

**Rabin K. Sharma**
Member Secretary, The 23rd ACRS Organizing Committee

**1 Introduction**

Asian Conference on Remote Sensing (ACRS) is an annual event of Asian Association on Remote Sensing (AARS). Each year this conference is organized in one of the countries of Asia. As per the tradition of ACRS, the venue of the Conference is decided two years in advance and the confirmation of date of the conference one year ahead. Accordingly, as per His Majesty's Government (HMG) decision, Survey Department, Nepal proposed to conduct the 23rd Asian Conference on Remote Sensing in Kathmandu on the 21st Asian Conference on Remote Sensing, which was held in China Taipei, Taiwan. One of the good reasons to propose to organize in Nepal was to commemorate "International Year of the Mountains 2002" which was declared by the United Nations, as Nepal is one of the mountainous countries having Mount Everest, the highest peak of the world. The 21st ACRS decided to hold 23rd ACRS in Kathmandu, Nepal. On 22nd ACRS, which was held in Singapore, the date of 23rd ACRS was confirmed for November 25-29, 2002. The Conference was held in Birendra International Convention Centre, New Baneswor, Kathmandu.

**2 Objectives**

The Objectives of the Conference were as follows:

- To discuss problems in Remote Sensing and GIS in Asia
- To exchange academic, technical information and applications
- To promote regional cooperation amongst member countries
- To promote operational applications of Remote Sensing and Space Technology

**3 ACRS Secretariat and Organizing Committee**

In order to perform preparatory work to conduct 23rd ACRS, HMG has decided to establish a Secretariat and an Organizing Committee. As per the decision, the 23rd Asian Conference on Remote Sensing Secretariat was established in the complex of Survey Department, and 23rd ACRS Organizing Committee with seven members under the Convenorship of Mr. Babu Ram Acharya, Director General, Survey Department was constituted.

**4 Technical Committee**

As the Conference has to deal with the Technical Papers to be presented on the Conference, a Technical Committee with nine members was constituted under the Chairmanship of Prof. Dr. Bishal Nath Upreti, Tribhuvan University (TU).

The scopes of the work of the Technical Committee were the following: -

- To formulate the topics for the Technical Papers
- To select the Technical Papers for oral or poster presentations or to reject the papers.
- To finalize the topics as per the available Technical Papers.
- To group the Technical Papers according to the topics

**5 Advisory Board**

As the application of Remote Sensing has wider spectrum, so in order to accommodate the number of users and to take advise from the experienced personnel from various field to run the conference, an Advisory Board was formed.

**6 Participants**

The Conference was participated by 232 national and 216 international participants. The participants were categorized into the following groups: -

- Organizers: Survey Department, Nepal and Asian Association on Remote Sensing jointly organized the 23rd ACRS.
- Secretarial staffs: 13 secretarial staffs were deputed for the preparatory works
- Sponsors: The sponsors of the conference were categorized into two groups as per the amount of sponsorship namely Principal Sponsor and Co-sponsor.
  The following organizations were categorized as Principal Sponsors:

1. European Space Agency (ESA)
2. Central National D'Etudes Spatial (CNES)

The following organizations were categorized as Co-sponsors:

1. ERDAS, India
2. FINNMAP OY
3. Hewlett Packard

- Exhibitors : Maximum of 3 persons from each exhibitors were participated for opening each booth
- Conference Staffs : 60 Officials were involved to assist in the different activities of the conference
- General Participants

**7 Programme**

The major highlights of the Conference Programme were as follows:.

- Opening Ceremony
- Exhibition
- Keynote Address
- Technical Information Session
- Technical Session and Poster Session
- National Delegates Meeting
- Cultural Programme and Conference Dinner
- Special Session
- Closing Ceremony

**7.1 Opening ceremony**

His Royal Highness Crown Prince Paras Bir Bikram Shah Dev inaugurated the opening ceremony by lighting the oil lamp with background chanting of *Veda* by the *Batuks* from Nepal Ved Vidya Shram. Upon arrival of His Royal Highness the *Panch Kanya* from Nepal Bal Sangathan offered garlands to the Crown Prince. Prior to commence the opening ceremony, National Anthem was played by a musical band from Royal Nepalese Army to honour the Crown Prince.

Mr. Babu Ram Acharya Director General, Survey Department as well as Convenor of the 23rd ACRS Organizing Committee welcomed all the dignitaries and the participants and in his address, he highlighted the programme and importance of this Conference. Rt. Hon. Lokendra Bahadur Chand, Prime Minister and Mr. Ananta Raj Pandey, Secretary, Ministry of Land Reform and Management delivered speeches. Prof. J.C.Trinder, President of ISPRS and Prof Shunji Murai, General Secretary, AARS also addressed in the ceremony. Mr. Rabin K. Sharma, Member Secretary of the 23rd ACRS Organizing Committee offered the vote of thanks.

**7.2 Exhibition**

One of the important events of the Conference is the exhibition in which the interested organizations exhibit/demonstrate their products and results of their research activities. His Royal Highness Crown Prince Paras Bir Bikram Shah Dev graciously opened the exhibition also by cutting the ribbon. In this Conference, 23 organizations participated in the exhibition. The exhibition was open not only to the participants but also to the general public and it was estimated that more than 800 individuals observed the exhibition.

**7.3 Keynote Speeches**

The following dignitaries delivered Keynote speech on the topics mentioned below: -

- Prof. Dr. Gottfried Konecny: "Mapping From space."
- Prof. Dr. Ian Dowman: " Digital Elevation Models: Where do we go from here?"
- Prof. Dr. Martien Molenaar :"Methodological Issues Related to Global Change Monitoring with Remote Sensing"

Prof. Konecny mentioned that mapping from satellite could bridge the existing gap in providing timely information to update small scale maps. He also expressed that the presently high-resolution satellite imagery are more expensive than aerial photography products. In future there will be competition to existing system by small satellite system.

Prof. Dowman presented the current status of DEM generation and discussed some of the improved methods of generation of DEM and its applications mainly in stereo-matching, better representation of the surface and the use of data fusion.

Prof. Molenaar discussed on the use of spatial information in global change studies using Remote Sensing technique. He further explained the use of mapping in monitoring, modeling and scenario building. He also emphasized on spatial unit identification at class relation aggregation level.

### 7.4 Technical Information Presentation

The following three organizations presented their technical information:
European Space Agency presented on "Envisat: the first results", Centre Nationale D'Etudes Spatiales on "Earth Observation Programme, SPOT 5", and ERDAS, India on "Capture It, Measure It, Map It: Geomatics for GIS".

### 7.5 Technical Session and Poster Session

In total 297 abstracts of technical papers were accepted for presentation and out of which, 247 papers were accepted for oral and 50 papers for poster presentation. The Technical committee rearranged and regrouped the topics of the presentation to accommodate the received abstracts. In total 38 technical sessions and 3 poster sessions were arranged for the oral and poster presentation respectively. In order to run the technical sessions, Chairpersons and Co-chairpersons were selected from the participants. Due to some unavoidable circumstances few cancellations and few no show were observed. The final statistics of the presentations were 161 oral and 25 posters.

### 7.6 General Conference of AARS National Delegates

The most important event of the conference was the General Conference of AARS delegates, which was held in the Blue Star Hotel. In order to cover up the items of the agenda two conferences were held under the Chairmanship of Mr. Babu Ram Acharya. The discussion covered the programme of the conference, international events in coming months, the achievements of ACRoRS, and finalizing the date and place for the next conference and proposal for the conference for the coming years from the member countries. Accordingly, the 24th ACRS has been confirmed to be held in Pusan, Korea 3-7 November 2003 and the 25th ACRS have been decided to be held in Chiang Mai, Thailand in 2004.

### 7.7 Special Sessions

The following two special sessions were conducted:

#### 7.7.1Student Session

The students from the Universities of 7 countries participated in the session. They discussed on the research activities, its results and future thoughts. The objective of the session was to facilitate, encourage and enhance the knowledge of the students so that they can schedule, perform and study as per the recent trends on the fields of their concern.

#### 7.7.2 Digital Asia Network

Digital Asia Network (DAN) session was one of the interesting sessions as other sessions of the conference. The session was sponsored and conducted by ACRoRS. Eight papers were presented in this session by different authors including introduction to DAN. The objective of the session is to disseminate the information on Digital Asia Network where people can extract different information from its site. Such site is very much helpful in stopping the duplication work and reinventing the wheel in this field of study. Further, the concept and prototype of the Digital Asia Network was demonstrated.

### 7.8 Cultural Programme and Conference Dinner

A cultural programme was organized for the participants in Hyatt Regency Hotel in which some glimpses of Nepalese Culture were presented by a professional cultural troupe. Then participants from different countries performed to entertain the audience. The programme culminated in the conference dinner hosted in honour of the participants with national and continental cuisine.

## 8. Closing Ceremony

The final activity of the Conference was Closing Ceremony, which was conducted under the Chairmanship of Mr. Ananta Raj Pandey, Secretary, Ministry of Land Reform and Management. In the ceremony, Mr. Durgendra M. Kayastha, Technical Director of 23$^{rd}$ ACRS Organizing Committee welcomed the dignitaries and the participants, and he presented the statistics of the Conference including technical presentation, exhibition etc. Prof Shunji Murai, General Secretary, AARS briefed the decisions of two days of National Delegates Conference. He also expressed his total satisfaction for the Conference organized in Kathmandu.

Associate Prof. Ryutaro Tateishi, Chairperson of the Evaluation Committee announced the name of the young authors for six best technical papers including poster paper presentations and Prof. Murai awarded them with JSPRS (Japanese Society of Photogrammetry and Remote Sensing) award in order to encourage the young scientists and to invite more in the field of Remote Sensing for the betterment of the Conference. Mr. Ananta Raj Pandey addressed the closing remarks. Finally, Mr. Rabin K. Sharma, Member Secretary offered the vote of thanks and the Conference was concluded with the refreshment.

**9. Achievements**

The following are the major achievements from the Conference:-

- The Organizing Committee members gained experiences to organize such a big conference.
- The capability of Nepalese professionals were positively evaluated and reckoned by national and international participants.
- Maximum number of Nepalese professionals got opportunity to participate in the Conference of international level and able to enhance their knowledge on the subjects concerned
- One, who presented a technical paper in the Conference, gained their confidence to face the audience comprising of recognized international professionals.
- Considerable amount of foreign currency entered into Nepal from such a small event of the country
- A positive message in the context of present scenario of Nepal conveyed to the foreign participants
- Number of organizations received opportunity to provide services to the Conference for their business promotion.
- There was a slight increment in the infrastructure development in Survey Department mainly in the context of computer facilities.

**10. Future Prospects**

After successful completion of the conference, it is now felt that Survey Department has the additional responsibility of widening the scope of work in the field of Remote Sensing. As, Survey Department has initiated the activity of Remote Sensing to produce satellite image map and in process to update the topographical base maps which were prepared few years back. The activity of Remote Sensing could be extended to make study in different application such as monitoring of natural resources, mapping etc. Since, Remote Sensing technology has a wider applications, therefore, number of disciplines could be more involved. Consequently, some organization should take a lead role to cooperate and coordinate with the other organizations. Survey Department could play a lead role as a coordinating body amongst the users group. However, a detailed proposal needs to be prepared and submitted to HMG.

Secondly, Survey Department should initiate to establish a satellite data receiving and distribution station. The support and assistance from Ministry of Science and Technology in this regard is inevitable as the organization related with Remote Sensing in most of the donor countries are affiliated with Science and Technology. The establishment of such station could have a great impact on mobilization of financial resources, which could be one of the major benefits to the country like Nepal.

Thirdly, Survey Department should organize regularly the conference in the level of national and international. This will motivate the staffs, enhance their work performance, and may assist to develop the modern technology for the betterment of Nepalese society.

**11. Conclusions**

Without hesitation, it can be expressed that the conference was conducted very successfully. It also proved that the Nepalese staffs could perform a big job like this as all the activities of the conference went off smoothly due to which all the national and foreign participants were highly impressed with all the programmes of the conference.

The conference provided the Survey Department a very good exposure in the international community, consequently, it will certainly help for professional development in the field of Remote Sensing, GPS and GIS, it will not be limited to Survey Department but also offer opportunity to made exposure of the other related national organizations.

After completion of this ACRS, Survey Department has now new additional challenge to extend its scope in the use of Remote Sensing technology. As the application is in a limited field it should extend to other wider fields and to do this the department should take cooperation from other related organization and the department should play a coordinating role to go ahead for the betterment of the society.

Regular organization of Conference like this 23$^{rd}$ ACRS will enhance the knowledge in the field of Remote Sensing of the Nepalese professionals and will promote tourist industries as well. The 24$^{th}$ ACRS will be held in Pusan, Korea from November 3-7, 2003 and the 25$^{th}$ ACRS will be held in Chiang Mai, Thailand.

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

# Managerial Aspects of the 23rd Asian Conference on Remote Sensing

**Mahendra Prasad Sigdel**
Chief Survey Officer
Survey Department

As per the decision of His Majesty's Government (State Minister Level) dated Chaitra 7, 2057, HMG Survey Department and Asian Association on Remote Sensing (AARS) organized the 23rd Asian conference on Remote Sensing (ACRS) from November 25-29, 2002 in Kathmandu, Nepal. At the same time HMG constituted a seven members local organizing committee on the Convenorship of Mr. Babu Ram Acharya, Director General, Survey Department. The other members of the organizing committee were Mr. Tirtha Bdr. Pradhananga, Deputy Convenor; Mr Mahendra Prasad Sigdel, Conference Manager; Mr. Durgendra Man Kayastha, Technical Director; Mr. Shiva Hari Upadhyay, Treasurer; Mr. Raja Ram Chhatkuli, Member and Mr. Rabin Kaji Sharma, Member Secretary. At the beginning of the fiscal year 2058/59, a well furnished Secretariat for the conference preparatory works having secretarial service facilities such as computers, Fax machine, Telephone lines, Internet facility etc. was established within the premises of Survey Department. Number of staffs required to run the Secretariat were also deputed.

The organizing committee met bi-monthly to identify the works and reviewed the work progress in each of its meetings. In order to conduct the conference smoothly, a final list of works was compiled after consultation with Prof. Shunji Murai (General Secretary AARS). A time schedule to perform this identified list of works was prepared with the help of Technical Director and Member Secretary of the Committee.

**A short description of the identified list of works were as follows :**

1. Birendra International Convention Centre (BICC) was chosen for the conference venue and was booked for the conference period. BICC has sufficient space and Halls for various activities of the conference such as Opening Ceremony, Exhibition, Registration and Parallel Sessions etc.

2. The Organizing Committee decided the following hotels to be listed as the official Hotels for the accommodation of the delegates and participants:

   i. Hotel Everest
   ii. Hotel Yak and Yeti
   iii. Hotel Blue Star
   iv. Hotel Himalaya
   v. Hotel Marsyangdi
   vi. Hotel Sita

   The organizing committee signed a Memorandum of Understanding with each of the hotels. The Hotel management agreed to subsidize the room rate for the 23rd ACRS participants and they also provided transportation from the Hotel to the conference venue and back to the Hotel.

3. First notice for the call for papers was distributed to the AARS member countries, other related International Organizations and some potential professionals in this field

4. Necessary stationeries were identified and procured.

5. Second notice for the call for papers was circulated once again to the concerns.

6. The technical committee finalized the list of abstracts of the papers. All the accepted abstracts including full text of the key note papers were printed in a book form.

7. The joint meeting of the Organizing Committee and Advisory Committee finalized the Programme of the 23rd ACRS and it was also printed in a book form.

8. The proceeding of the conference was prepared only in CD, as per the decision of AARS Delegates meeting in Singapore Conference.

9. A conference kit including conference bag, Token of Memory, Abstract Book, Programme Book, Tourist Map of Kathmandu Valley, CD proceeding, etc. were collected.

10. Advertisement for the participation in the conference was made through Nepalese newspapers and a few cloth banners were prepared and hanged in different places of the town.

11. Transportation facility was made available to the participants to attend the conference dinner in Hyatt Regency Hotel in Chabahil. The dinner was attended by about 600 persons.

12. Yeti Travels P. Ltd. opened a tourist information desk at the lobby of the convention hall. Quite a few participants joined the mountain flight and visited different places of the Kathmandu Valley through this desk. The ticketing reconfirmation service of their return flights was also provided.

13. The installation and management of Exhibition Stalls as well as all the backdrops and signage was arranged by the House of Rajkarnicar. The same group managed for the opening and closing ceremony.

14. A Nepalese Cultural Programme was showed by a group of professional artists. Following this Programme, eight participant Nations participated in the cultural event competition. In this event, Nepal became first, Japan second and China Taipei third.

15. AARS Meetings for the National Delegates of member countries were arranged at Hotel Blue Star on November 26 and 28, 2002. Transportation facility was provided to the participants

16. Pay Lunch facilities were arranged in BICC premises by Hotel Blue Star.

17. Hi-Tea facilities during Tea Break periods were sponsored by a few selected Organizations.

18. Necessary Computers, Multimedia Projectors and Over Head Projectors were installed in the rooms as per the requirements.

19. Still Photography and video filming was made available through a professional photographer.

20. Necessary formalities through Ministry of Land Reform and Management were fulfilled to request to inaugurate the conference by His Royal Highness Crown Prince Paras Bir Bikram Shah Dev. His Royal Highness kindly granted to inaugurate the conference.

Upon arrival of His Royal Highness Crown Prince Paras Bir Bikram Shah Dev on November 25th in BICC, Panchkannya offered flower garlands. Prime Minister Mr. Lokendra Bdr. Chand, Land Reform and Management Minister Mr. Badri Narayan Basnet, Secretary, Mr. A.R. Pandey, Director General and convenor of the 23$^{rd}$ ACRS Mr. B.R.Acharya, other organizing committee members, Prof. J.C.Trinder and Prof. Shunji Murai also offered bouquet of flowers to welcome the Crown Prince. The opening ceremony was started with the National Anthem and chanting of Vedas. His Royal Highness Crown Prince opened the conference by lighting the traditional oil lamp, Panas by Sukunda in a grand ceremony. His Royal Highness also inaugurated the exhibition and observed each stalls with great enthusiasm.

The conference continued for five days as per the programme and concluded on 29$^{th}$ November with a great success. Prof. Shunji Murai, General Secretary, AARS appreciated the management and thanked to all the local organizing committee members and staffs involved in the conference. The officials of Survey Department got opportunity to gain knowledge, ideas and experiences of such a conference and they build their confidence to conduct similar types of conferences in the days to come.

✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶ ✶

**Rates of Aerial Photo and Map Transparency**

| Product | Price per sheet |
|---|---|
| **Aerial Photograph** | |
| a) Contact Print (25cmx25cm) | Rs 150.00 |
| b) Dia-Positive Print (25cmx25cm) | Rs 500.00 |
| c) Enlargements (2X) | Rs 600.00 |
| d) Enlargements (3X) | Rs1200.00 |
| e) Enlargements (4X) | Rs 2000.00 |
| **Map Transparency** | |
| a) 25cm*25cm | Rs 310.00 |
| b) 50cm*50cm | Rs 550.00 |
| c) 75cm*75cm | Rs 800.00 |
| d) 100cm*100cm | Rs 1250.00 |
| **Diazo/Blue Prints** | Rs 40.00 |
| **Photo copy** | Rs 50.00 |
| **Photo lab facilities** | US$ 200/day |

<u>In case of the materials supplied by the clients, the office will charge only 40% of the marked price as service charge.</u>

# Looking Back at the 23rd ACRS

**Durgendra M. Kayastha**

## 1. DAY 1: The Conference Opening

The 23rd ACRS started with a grand opening on 25th November 2002, at the Birendra International Convention Centre, Kathmandu. The opening ceremony was highlighted by the inauguration of the conference by HRH the Crown Prince amidst the chanting of vedic hymns. The welcome speech by Prof. Dr. Shunji Murai, General Secretary, AARS and Mr. Babu Ram Acharya, Convenor, the inaugural speech by Rt. Hon. Prime Minister Lokendra Bahadur Chand, and the conference speech by Prof. Dr. J.C.Trinder, President, ISPRS were the highlights of the session.

The opening of the exhibition at the same venue concluded the opening ceremony.

The second session comprised of keynote addresses on relevant technological issues by three eminent academicians. Prof. Dr. Gottfried Konecny delivered his address on the theme "Mapping from Space", Prof. Dr. Ian Dowman deliberated on the topic "Digital Elevation Models: where do we go from here?" and finally Prof. Dr. Martien Molenaar provided thoughtful insights on the topic " Methodological Issues Related to Global Change Monitoring with Remote Sensing".

The Keynote addresses have helped immensely in setting up the right mood for the conference in the subsequent days.

The first day's deliberations concluded with the Technical Information Sessions where the principal sponsors have presented their products and deliberated on the opportunities and challenges ahead. There were three presentations in the session, viz.

Envisat: First Results by ESA
Earth Observation Program-SPOT 5 by CNES
Measure it, Map it, Geomatics for GIS by ERDAS.

## 2. DAY 2-5: The Technical Sessions

Considering the number of technical papers, the presentations were organized in thirty-two oral presentation sessions and three poster sessions. In addition two special sessions were also organized during the conference. Three to four parallel sessions were conducted in each time slot.


## 3. DAY 5: The Closing Ceremony

The conference ended with a closing session on the fifth day 29th Nov. 2002. The ceremony was chaired by the Secretary, Ministry of Land Reform and Management and presided over by the General Secretary, AARS; Convenor, 23rd ACRS; Member Secretary, 23rd ACRS; Chairman, JSPRS Award Committee, 23rd ACRS; and the Technical Director, 23rd ACRS.

The highlight of the ceremony was the presentation of JSPRS award to several young authors for best paper presentations. The Technical Director presented the facts and figures pertaining to the conference and also appreciated the efforts and support provided by the session chairs and co-chairs, the members of the Technical Committee and the Advisory Board and above all the Keynote Speakers to make the conference a big success. The ceremony concluded with the declaration of organizing the 24th ACRS in Korea and welcoming the participants to Korea.

## 4. Participation

The presence of scientists and professionals from 23 countries apart from Nepal was one of the rewarding experiences for the organizing committee of the 23rd ACRS. The host nation naturally had the highest number of participants 228, which also reflects the interest and the on-going activities in the field of GIS and remote sensing in Nepal. There were 216 participants from other countries, majority of them from Asia.

| S.No. | Country | Participants |
|---|---|---|
| 1 | AUSTRALIA | 4 |
| 2 | CANADA | 4 |
| 3 | CHINA | 12 |
| 4 | CHINA TAIPEI | 31 |
| 5 | FINLAND | 2 |
| 6 | FRANCE | 3 |
| 7 | GERMANY | 2 |
| 8 | HONGKONG | 1 |
| 9 | INDIA | 23 |
| 10 | INDONESIA | 1 |
| 11 | IRAN | 1 |
| 12 | ITALY | 1 |
| 13 | JAPAN | 68 |
| 14 | KOREA | 10 |
| 15 | MALAYSIA | 11 |
| 16 | NEPAL | 228 |
| 17 | NETHERLANDS | 8 |
| 18 | PAKISTAN | 1 |
| 19 | SINGAPORE | 5 |
| 20 | SRILANKA | 4 |
| 21 | THAILAND | 20 |
| 22 | UK | 1 |
| 23 | USA | 2 |
| 24 | VIETNAM | 1 |
| | TOTAL | 444 |

Table 1: COUNTRYWISE REPRESENTATION

**5. Sponsors and Exhibitors**

Principal sponsors of the conference were European Space Agency (ESA) and Center National D'Etudes Spatiales (CNES), while ERDAS India, FINNMAP OY and Hewlett Packard cosponsored the event.

There were 23 exhibitors including both from Nepal and abroad and the exhibition covered the state-of-art technology and recent advances in the field of Remote Sensing, GPS, GIS.

**6. Special Sessions**

Two special sessions were also organized during the conference. The first was a Student Session; where information was delivered to the participants especially students regarding the prospects and possibilities of studies in various universities. Altogether 17 presentations were made in the session sharing the experience around.

The second special session was on Digital Asia where participants were deliberated on the scope of the geographic information sharing among the Asian countries and the plans and programmes of the Digital Asia project was presented.

**7. Technical Papers**

Altogether 297 papers on 19 different themes were selected for presentation during the conference. Among them only186 papers were actually presented. 32 papers were cancelled prior to the start of the conference whereas authors / presenters of the 79 papers did not show up during the conference (See Theme-wise Statistics Table).
Similarly, Table 3 shows the status of the papers from participating countries.

## 8. Remarks

The successful conclusion of the 23rd ACRS marks the end of a year long effort put up by the members of different committees. It was also an opportunity to provide ample exposure to the Nepalese Scientists, who for some reason could not go abroad for participation. For young scientist the event proved to be an eye opener and for not so young scientists and professionals it provided a forum at home for the scientific deliberations and exchanges. For Survey Department, it provided a testing experience.

Above all, the conference has provided ample exposition to the development of remote sensing science and technology in the country.

| Count of Paper | Status | | | |
|---|---|---|---|---|
| Theme | Cancelled | No Show | Presented | Grand Total |
| Data Processing Algorithm and Modelling (ADP) | 5 | 9 | 19 | 33 |
| Oceanography and Coastal Zone Monitoring (CZM) | | 5 | 2 | 7 |
| Education (EDU) | 1 | 2 | 8 | 11 |
| Ecology, Environment & Carbon Cycle (EEC) | | 4 | 3 | 7 |
| Mountain Environment and Mapping (ENV) | 2 | 2 | 8 | 12 |
| Earth Observation from Space (EOS) | 2 | 2 | 3 | 7 |
| Forestry (FOR) | | 5 | 7 | 12 |
| Geology / Geomorphology (GEO) | | 1 | 4 | 5 |
| GIS, GPS, & Data Integration (GPS/GIS) | 2 | 5 | 18 | 25 |
| Hyperspectral Data Acquisition & Systems (HAD) | 1 | 1 | 3 | 5 |
| Hazard Mitigation and Disaster Management (HDM) | 1 | 5 | 10 | 16 |
| Land Use / Land Cover (LUC) | 3 | 1 | 13 | 17 |
| Infrastructure Planning and Management (MGT) | | 5 | 3 | 8 |
| Photogrammetry (PHM) | | 2 | 6 | 8 |
| Poster (POS) | 9 | 16 | 25 | 50 |
| SAR / InSAR (SAR) | 2 | 4 | 8 | 14 |
| Soil and Agriculture (SOL/AGR) | 1 | 4 | 12 | 17 |
| Special Session (SPS) | | | 8 | 8 |
| Urban Mapping (URB) | 1 | 3 | 11 | 15 |
| Very High Resolution Mapping (VHR) | 1 | | 11 | 12 |
| Water Resources (WRS) | 1 | 3 | 4 | 8 |
| Grand Total | 32 | 79 | 186 | 297 |

Table 2: THEMEWISE STATISTICS

| Country | Cancelled | No Show | Presented | Grand Total |
|---|---|---|---|---|
| AUSTRALIA | 3 | | 4 | 7 |
| AUSTRIA | | 1 | | 1 |
| BANGLADESH | | 2 | | 2 |
| CANADA | | 1 | 1 | 2 |
| CHINA | 1 | 7 | 9 | 17 |
| CHINA TAIPEI | 6 | 1 | 23 | 30 |
| HONGKONG | | | 1 | 1 |
| INDIA | 1 | 8 | 12 | 21 |
| INDONESIA | | | 1 | 1 |
| IRAN | 1 | 10 | 1 | 12 |
| ITALY | | 1 | 1 | 2 |
| JAPAN | 7 | 15 | 53 | 75 |
| KOREA | 5 | 3 | 11 | 19 |
| LIBYA | | 1 | | 1 |
| MALAYSIA | | 3 | 4 | 7 |
| NEPAL | | 11 | 30 | 41 |
| NETHERLANDS | 2 | 1 | 5 | 8 |
| PHILIPPINES | | 3 | | 3 |
| QATAR | | 1 | | 1 |
| RUSSIA | | 1 | | 1 |
| SINGAPORE | 1 | | 8 | 9 |
| SRILANKA | | 1 | 6 | 7 |
| SWITZERLAND | 1 | | | 1 |
| THAILAND | 1 | 7 | 13 | 21 |
| UAE | 1 | | | 1 |
| USA | 2 | | 1 | 3 |
| VIETNAM | | | 2 | 2 |
| ZAMBIA | | 1 | | 1 |
| Grand Total | 32 | 79 | 186 | 297 |

Table 3: COUNTRYWISE STATISTICS

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

| Rate of Control Points | | |
|---|---|---|
| **Type** | **Control Points** | **Price per point** |
| Trig. point | First Order | Rs 2 000.00 |
| Trig. point | Second Order | Rs 1 500.00 |
| Trig. point | Third Order | Rs 800.00 |
| Trig. point | Fourth Order | Rs 100.00 |
| Bench Mark | High Precision | Rs 500.00 |
| Bench Mark | Third Order | Rs 100.00 |
| Gravity Point | High Precision | Rs 500.00 |
| Gravity Point | Lower Precision | Rs 100.00 |

# ACRS 2002 CD-ROM PROCEEDING

**Bhushan Narsingha Pradhan**
**Sushil Narsingh Rajbhandari**

Recently concluded ACRS2002 in Kathmandu on 25-29 November, organized by Survey Department, had participants from allover the world in a bid to share knowledge on geo-information. There were approximately 500 participants from different fields where science related to remote sensing and GIS could be of value in some or other way.

There were around 300 research papers sent by different experts in the field with an interest to present their research work or report of some kind in the related subjects. The compilation of such papers were published in CD-ROM as a proceeding with an aim to provide all the participants with the electronic versions aided by different features such as browsing the papers by authors, country, category etc. Technically, the CD-ROM contains files made in Macromedia Flash 5.0 and tagged in HTML4.0 (Hyper Text Markup Language), which are meant to be displayed in Internet Explorer, which has different features and facilities to view database of papers, which are in PDF format.

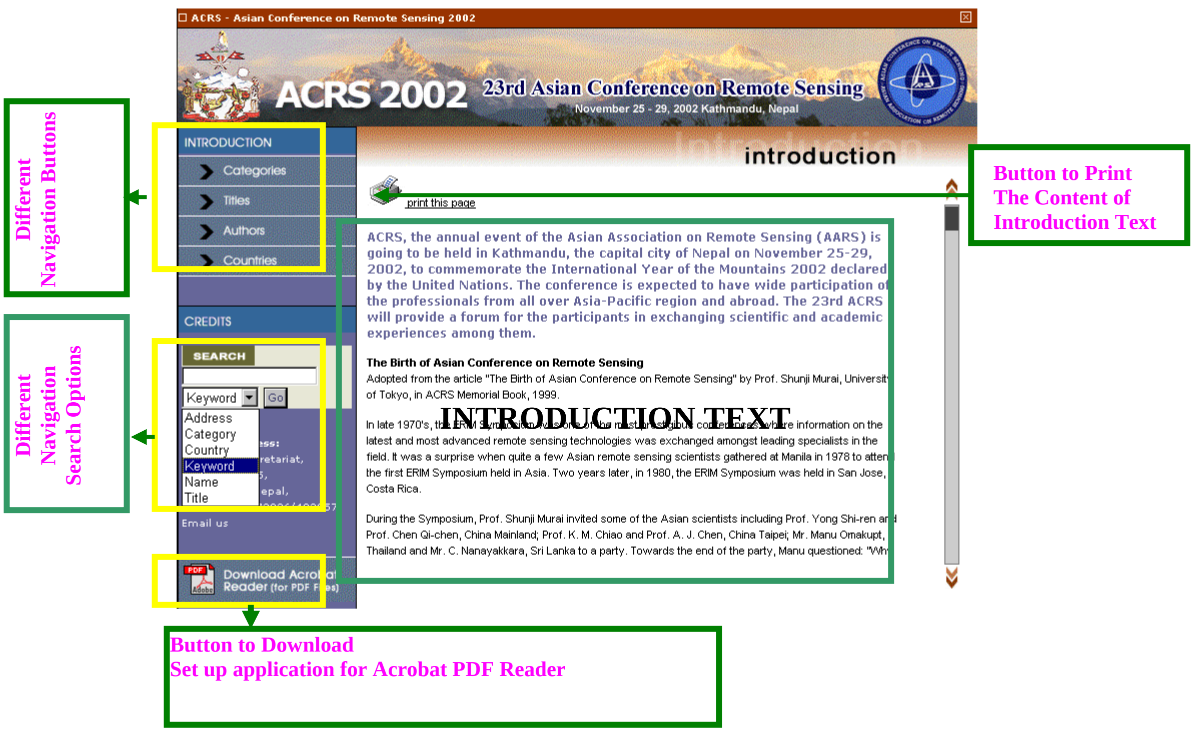



**Figure 1: Starting Interface**

The starting interface of CD-ROM is as shown in Figure 1, which is auto-loaded once the CD-ROM is inserted into CD Drive. The main functional components of the interface are:

- A group of Navigation buttons
- A Navigation Search options
- Button to Print The Content of Introduction Text
- Button to Download Setup application for Acrobat PDF Reader

The *Introduction text* contains brief information about ACRS2002 (The Asian Conference on Remote Sensing 2002) and AARS (Asian Association on Remote Sensing). Whole of this page cannot be seen at once. So one can read remaining texts using scroll bar at the right of the main interface. This introduction can be printed using a button having icon. 

The papers are arranged into different categories according to the sessions in which they were presented in the conference. In the preceding CD the papers can be viewed as Acrobat Portable Document Format (PDF). The interface is having a set of navigation buttons, which can be used to retrieve and view a paper according to a reader's wish. Different buttons are placed for different options viz. a reader can navigate through papers on the basis of *Categories, Titles, Authors, and Countries. Categories* are basically different scientific themes, special session and posters. On clicking *Categories*, the different categories are listed. The interface will be as shown in Figure 2. On selecting a particular category, titles of the papers under that category are listed in lower window on the same screen. To retrieve and view a paper, a reader has to select the title of desired paper then click the *Acrobat* button. On clicking this button, the paper will be opened in a different window (Acrobat Reader), provided that the computer has Acrobat Reader application.


**Figure 2: Navigation On the Basis of Category**

Similarly, the viewer can see the list of papers and related author(s) on the basis of *titles, authors and countries* on alphabetical order. The interfaces for these options will be as shown.

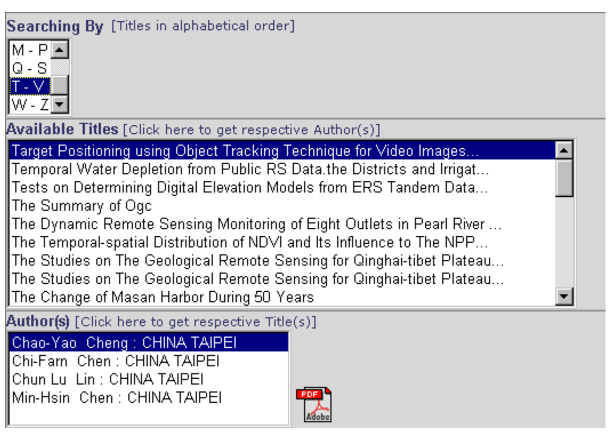



**Figure 3: Navigation On the Basis of Title**

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

# Participation in International Events by the Officials of Survey Department

**1. Aerial Photo Scanning for Orthphoto**
Mr. Suresh Man Shrestha, Survey Officer
Mrs. Roshani Sharma, Surveyor
12 Ashadh-2 Shrawan 2059 (26 June-18 July)
Helsinki, Finland

**2. Map Asia 2002**
Mr. Rabin Kaji Sharma, Chief Survey Officer
Mrs Sushila Rajbhandari, Surveyor
22-24 Shrawan 2059 (7-9 Auguest 2002), Thailand

**3. Training course on Toponymy & Eighth UN conference on the standardization of Geographical Names**
Mr. Suresh Man Shrestha, Survey officer
26 Shrawan to 22 Bhardra 2059 ( 11 August- 7 September 2002) The Netherlands and Germany

**4. Aerial Photo Scanning for Orthophoto**
Mr. Madan Bahadur Shakya, Survey Officer
Mr. Tika Ram Nepal, Surveyor
27 Shrawan-17 Bhadra, 2059 (12 August-2 September 2002) Helsinki, Finland.

**5. Survey Officials (SOM) Meeting**
**Nepal- India Boundary Survey**
**(2-4, Sept., 2002) Kathmandu 17-19 Bhadra, 2059**
**Mr. T.B. Pradhananga Leader**

| | |
|---|---|
| 1. Mr. T.B. Pradhananga, Deputy Director General, Topographical Survey, Kathmandu | Leader |
| 2. Mr. R.K. Nepal, Under Secretary, Ministry of Foreign Affairs | Member |
| 3. Mr. N.P. Adhikari, Chief Survey Officer, Survey Department | Member |
| 4. Mr. R. K. Sharma, Chief Survey Officer, Survey Department | Member |
| 5. Mr. T.N. Baral , Chief Survey Officer, Survey Department | Member |
| 6. Mr. M.P. Sigdel, Chief Survey Officer, Survey Department. | Member |
| 7. Mr. D.M. Kayastha, Chief Survey Officer, Survey Department | Member |
| 8. Mr. Purna Bahadur KC, Chief Survey Officer, Survey Department | Member |

**6. Finalization of the Maps of Panchswor Multiple Project.**
Mr. Tirtha Bahadur Pradhnanga, for Deputy Director General
Mr.Dharma Bahadur Poudel, Director
Mr.Mahendra Prasad Sigdel, Chief Survey Officer
Mr.Jagat Raj Poudel, ,, ,, ,,
Mr. Hari Man Tumbahangphe, Survey Officer
2-8 Bhadra, 2059 (18-24 August 2002)
Dehradun, India

**7. Job Training**
Mr. Kamal Nath Mishra, Survey Officer
Mr. Punya Prasad Paudel , Survey Officer
Mr. Deepak Sharma Dahal, Survey Officer
Mr. Mohan Chand Thakuri, Survey Officer
5-21 Bhadra 2059 (21 August-6September 2002) Helsinki, Finland

**8. G.S.D.I**
Mr. Durgendra Man Kayastha, Chief Survey Officer
22 Bhadra -13 Aswin 2059 (7-29 September 2002 ) U.S.A

**9. 25th Joint Technical Committe Meeting of Nepal-India Boundary Work led by**
Mr. Babu Ram Acharya Director General, Survey Department
Mr. Shri Prakash Mahara, Deputy Director General
Mr. Tirtha Bahadur Pradhanaga for Deputy Director General.
Mr. Narayan Prasad Adhikari, Chief Survey Officer
Mr. Raja Ram Chhatkuli, Chief Survey Officer
Mr. Mahendra Prasad Sigdel, Chief Survey Officer
Mr. Bhaskar Sharma, Survey Officer
2-8 Kartik 2059 (19-25 October, 2002) Delhi, India

**10. Workshop on Gender Sensitization in the World of Work.**
Twenty-one officials from the different offices under Ministry of Land Reform & Management Led by the Secretary of the Ministry of Land Reform & Management.
14-16 Falgun 2059 (26-28 February, 2003), Nagarkot.

**11. Midterm expenditure framework workshop**
Mr. Mahendra Prasad Sigdel, Chief Survey Officer
9-14 Chaitra 2059 (23-28 March 2003) Kathmandu

**12. Workshop on Gender Responsive Planning in the World of Work**
Mr. Rabin Kaji Sharma, for Deputy Director General (Including other five officials under the Ministry of Land Reform & Management)
2-5 Baishakh 2060 (15-18 April 2003) Dhulikhel.

**13. Eighth National Convention of Nepal Engineers' Association.**
Fifteen officers participated
Different activities of Survey department displayed in exhibition
22 Chaitra 2059 (3-5 April, 2003) Kathmandu.

**14. Visit Ortho-photo Production**
Mr. Raja Ram Chhatkuli, National Co-ordinator NGIIP
Mr. Dharma Bahadur Paudel, Director, Survey Department
6-12 Baishakh 2060 (19-25 April 2003), Thailand.

**15. Survey Department officials for higher education/ training**
Mr Sudarshan Karkee GFM-3, ITC, The Netherlands
31 Bhadra, 2059 – 19 Bhadra, 2060 (16 Sept, 2002 – 5 Sept, 2003)

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

| List of Exhibitors (23rd ACRS) | |
|---|---|
| **National Exhibitors** | |
| 1. | Community Forest Division, Department of Forest |
| 2. | Kathmandu Valley Mapping Programme |
| 3. | NITI P.Ltd and Synergy-one |
| 4. | Survey Department |
| 5. | World Distribution Nepal |
| 6. | World Wildlife Fund ( WWF ) |
| | |
| **International Exhibitors** | |
| 1. | AcoRS |
| 2. | Center National D'Etudes Spatials |
| 3. | ERDAS/Leica Geosystem India |
| 4. | European Space Agency |
| 5. | FINNMAP OY |
| 6. | GIS Development, India |
| 7. | Hewlett Packard |
| 8. | ICIMOD |
| 9. | ITC,The Netherlands |
| 10. | Kampsax India Private Limited |
| 11. | National Remote Sensing Agency, India |
| 12. | PCI Geomatics, Canada |
| 13. | Hitachi Software, Japan |
| 14. | Redlake MASD, Canada |
| 15. | Remote Sensing Technology Center ( RESTEC ), Japan |
| 16. | Space Imaging/ Auto Carto Consult |
| 17. | ViaSat Satellite Ground Systems |

# A Study on Digital Orthophoto Generation of Mount Everest Region

**Prof. Dr. Michael Hahn**
m.hahn.fbv@fht-stuttgart.de
www.fht-stuttgart.de
Vice-President
University of Applied Sciences, Stuttgart
Schellingstrasse 24, 70174 Stuttgart
Fax: +49 711 121 2666

**Toya Nath Baral**
tnbaral@ntc.net.np
Program Co-ordinator
Survey Department
Minbhawan-34, Kathmandu
Nepal

**Rabin Kaji Sharma**
planning@sd.htp.com.np
Chief Survey Officer
Survey Department
Minbhawan-34, Kathmandu
Nepal

## KEY WORDS:

Orthophoto, Digital Terrain Model, Mount Everest, Orthorectification, Aerial Triangulation, Automatic Matching.

## ABSTRACT

The basic objective of this paper is to present a system pertaining to the photogrammetric processing of high mountainous region, where the elevations difference are extremely high. Therefore, the paper will discuss on the issues of automatic orientation problems of images due to the lack of well-known features in the whole image, extreme height differences and its effect in aerial triangulation. It will also discuss the quality of automatic matching using images with large differences in scale and poor contrast. Furthermore, it will report on the results of orthorectification including tone balancing and mosaicking for a final orthophotomap where the image contains extremely bright and extremely dark parts due to snow and shadows. Assessment of the quality of DTM and an orthophotomap thus produced will be another part of the study.

A digital terrain model (DTM) of the Mount Everest and its surroundings and a set of orthorectified
aerial image data was created using photogrammetric workstation (ImageStation). This unique DTM and subsequently digital orthophotomap was created from the aerial image data using commercially available software. Scanning was performed from the transparent originals of second generation in 12 bit color-depth. Orientation procedures followed fully automatic and the densification of control points was performed using modem aerial triangulation procedure.

The study approach heralds a new age for aerial imaging and remote sensing whereby orthorectified image maps can be produced for anywhere without the need for any expensive and time-consuming Ground Control Point acquisition.

### 1. INTRODUCTION

Advancement in digital orthophoto acquisition techniques, lead to continuous growth of orthophoto production. So far none of the tests were performed using digital photogrammetry techniques in an area where the elevation varies (extremely) more than 45% of the flying height above ground level. This study was undertaken as a master thesis program in the university of applied sciences, Stuttgart in collaboration with Z/I imaging, GmbH, Germany. All hardware/software used for the investigation are from the family of Image Station (joint venture between Zeiss and Intergraph). Here we will, mainly discuss the problems associated with height differences and textures in the images as well as solutions and results. The study area lies on South Asian region and in an antique mountainous country Nepal.

Specific area under investigation is the Mount Everest region, well-known highest mountain in the globe, measured from MSL. Curiosity, whether it is possible to perform digital aerial triangulation, automatic extraction of DTM and orthorectify the images with extreme height differences created by high mountains in the study region, lead to formulate this program. We will address the automatic image matching problems arising from the poor textures in the images and big difference in radiometric resolution. Generation of tie points automatically will be the next issue to be discussed. The orthorectification process for the photographs from Mount Everest region requires not only identified ground control points, but also digital terrain models. Hence a DTM needed to be created as part of study project. This study project aims to demonstrate how automatic triangulation, extraction of DTM, orthorectification and mosaicking can be accomplished automatically. The editing of digital terrain model is of great importance, because the data is to be used for the production of orthoimages. To carry out this task efficiently, reference data is required (only map data is available) to ensure that the checks can be carried out on significant areas. The manual selection of checkpoints, is both time consuming and prone to error. This paper starts discussing the data available for the study, methods to be used, problems encountered during operation, solutions so far found out and the results.

## 2. DATA FOR THE STUDY:

Data available for this study are listed and described in table-1. Data available are panchromatic aerial images at a scale of 1:50000. The nature of terrain is highly irregular topography, from steep to very steep and most of the area is covered with snow. The variation of height within the project area is from 2500 meters to 8848 meters, creating extreme elevation differences of more than 45% of the relative flying height in individual models

| Project Name | Mount Everest | |
|---|---|---|
| Scene Content | Open, snow covered | |
| Scene topography | Steep to very Steep | Most rugged terrain |
| Image Scale | 1:50.000 | Large variation in Scale |
| Camera | Wild RC 30 | GPS onboard |
| Focal Length | 153.19 mm | Calibrated |
| Flight Date | Nov-Dec, 1992 | |
| Film Material | Panchromatic (B/W) | |
| Number of Images | 93=30*90 sq. km | 47 used |
| Overlap | l=80%, q= 40% | |
| Scanner used | Photo Scan 2001 | ZI Imaging's Product |
| Scanned pixel size | 14 um and 12 bits depth | Per image=728MB |
| Scanned Material | Positive Film | |
| Scanned Channel | Panchromatic | |
| Scan Date | August 2001 | |
| Source | Mount Everest, Nepal | Survey Department |

**Table 1, Characteristics of data sets available for Mount Everest-digital orthophoto project.**

## 3. PROCEDURES:

### 3.1 Aerial Triangulation:

First of all aerial images available in hard film copy were scanned using PhotoScan 2001.The results of scanning were 14um pixel size in resolution, 12 bits CCD data output and full set of overviews. The disk space occupied by one image data came to be 728 MB. These data were loaded to run automatic image matching process. A commercial software called ImageStation Automatic Aerial Triangulation (ISAT 2001 version 3.2-provided by Zeiss-Intergraph Imaging GmbH), was used to perform the automatic orientation of the input images for orthorectification. The final results of this is exterior orientation parameters of the images to be rectified.

### 3.2 Automatic DTM extraction:

Next step is the derivation of digital terrain model automatically. A surface model is needed for trueorthoimages.This step was performed automatically with ImageStation Automatic Elevation (ISAE). Inputs for the extraction of digital terrain model are the oriented images from.

### 3.3 Orthorectification:

Now we can use the oriented images for the generation of single orthoimage using the software called OrthoPro.This is rather straight forward and can be done automatically, but the surface model should be edited precisely to eliminate blunders and outliers.

### 3.4 Production of Orthomosaic:

Finally creation of orthomosaic, tone balancing and seam line hiding is performed in order to end up with a nice looking mosaic. Manual editing is very important to get the optimal position for seam lines in Mount Everest region.

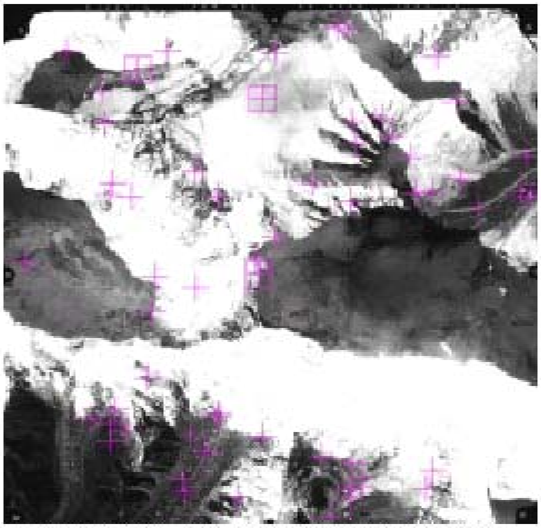
## 4. PROBLEMS ENCOUNTERED DURING AUTOMATIC AERIAL TRIANGULATION:

We encountered serious problems associated with extreme height and radiometric differences during the processing of automatic aerial triangulation. No tie points were generated in extreme bright (reflection of snow) and dark shadow area, because the automatic image matching algorithm could not resolve the problems associated with textures and contrasts in the images.

The other main problem with height difference was to create multi-ray tie points for the stability of the aerial triangulation block. There is almost no connection between the adjoining strips. Table-2 shows the height differences in the project area. We found much more difficulties in automatic matching, even in the single strip due to big differences in height between neighboring images. In strip 54, there is 3500 meters jump from photo no.09 to 08 (49% of relative flying height). In such situation, one more sub block was set up.

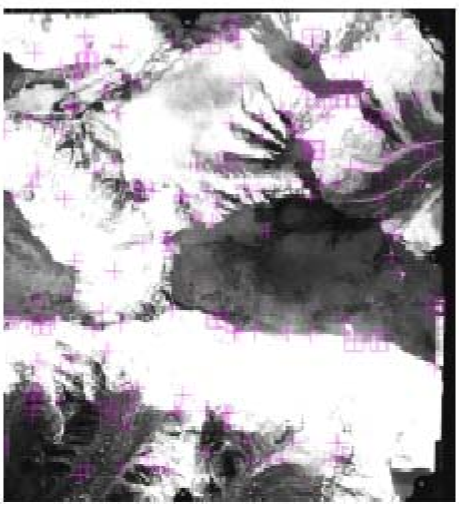
### 4.1 Problems In Matching:

Big problem was encountered in finding homologous patches for image matching due to the bright reflection of snow and dark shadows present in the images. No tie points were created in such an area.

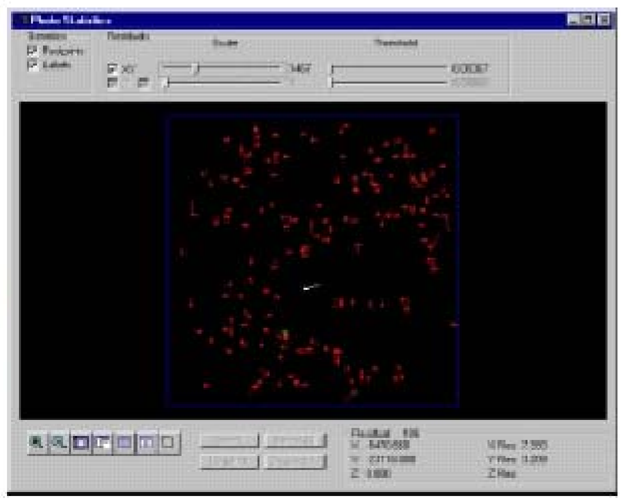


Model 5410-11, Automatic tie points created

Model 5410-11, Scanned image



Model 5410-11, after interactive measurement



Model 5410-11, Tie point distribution

**Figure 1, Tie points distribution after interactive measurements**

### 4.2 Problems With Height Differences

| Strip No. | Max.H(m) | Min.H(m) | dH.(m) | Av.Gr.El.(m) | Hg. (m) | %dH/Hg |
|---|---|---|---|---|---|---|
| 55 | 8383 | 5383 | 3000 | 6883 | 13500 | 45 |
| 54 | 8848 | 4848 | 4000 | 6848 | 13500 | 60 |
| 53 | 6700 | 4200 | 2500 | 5450 | 13500 | 31 |
| 52 | 7300 | 3200 | 4100 | 5250 | 13500 | 49 |
| 51 | 7100 | 2900 | 4200 | 5000 | 13500 | 49 |
| 50 | 5700 | 2500 | 3200 | 4100 | 12500 | 38 |
| 49 | 4200 | 2400 | 1800 | 3300 | 12500 | 20 |
| 48 | 4000 | 1500 | 2500 | 2750 | 12500 | 25 |
| 47 | 3500 | 2000 | 1500 | 2750 | 12500 | 15 |

**Table 2, Percentage of height differences in adjoining strips**

Average ground elevation for all strips above is found varying from 15% to 49% of relative flying height with an exception of 60% in strip 54. However an average ground height of 6000 meters was set up in the project and run the automatic image matching process. The algorithm of software was able to create the tie points from strip 55 down to strip 51, but from strip 50 to strip 47, no tie points were generated. When you change the average ground elevation from 6000 meters to 4000meters, the generation of tie points was reversed. But in both cases the block processing was not successful.

Then it was decided to split the block into 2 sub-blocks. The first sub-block was from strip 55 to strip 51, where the average ground height was taken as 6000 meters. The second sub-block was from strip 50 down to strip 47, where the average elevation was taken as 4000 meters. In both the cases, generation of tie points was noticed but the solution was failed.

A number of tests were performed and finally it was decided to process every single strip as one sub block and connect interactively.

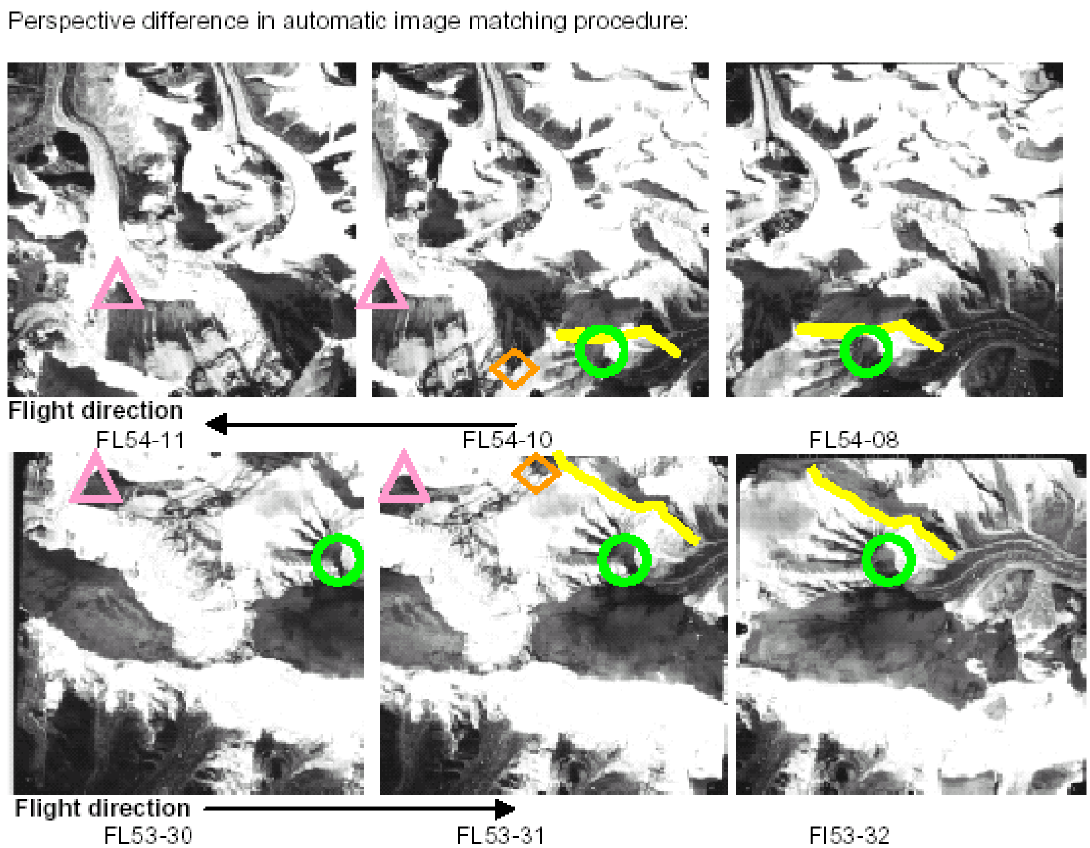



**Figure 2, Perspective difference in automatic image matching procedure.**

| Vendor | System | AV. Correct TP.Per image | Elim. Blunders | | Number of multi ray points in object space | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. | % | Total | 2 ray | 3ray | 4ray | 5ray | 6ray | 7ray |
| ZI imaging | ISAT 2001 | 45 | 71 | 3.2 | 2165 | 1132 | 685 | 325 | 15 | 3 | 5 |

**Table 3, Generation of multi ray Tie Points**

### 5. SUMMARIZING THE SPECIFIC PROBLEMS WE GET:

•Large scale variation due to extreme height differences, created big matching problem and ended with high residuals.
•Variable overlap created problems with the tie points of the start and end of the strips.
•Erroneous correspondence was established due to bright reflection of snow and dark shadow.
•Measurement of natural control points was found difficult where no signalized points exist.

## 6. HOW THE PROBLEMS WERE SOLVED:

Matching problems are assigned to that the image can be relatively rotated, images can have different scale, occluded objects, and large variations on radiometric resolution.
Difference in scale means different resolutions and this gives a sharp image in one and the blurred in the other. Rotated image means that one has to resolve the geometrical relationship between images and if automatic procedures failed then the system allows us to measure interactively. Blurred texture present in the image make the correlation almost impossible even in the manual measurement mode.
The matching problem was solved after necessary interactive measurements were carried out and using a robust matching technique i.e FBM which use the technique of describing features to establish correspondence between two images within ISAT.
Matching quality was found much better within ISAT, after exterior orientation parameters were imported, but that did not helped much in adjustment to provide a stable block automatically. However, interactive measurement was necessary for the stability of the block.
System finds erroneous correspondence between images with cloud patches, bright reflection of snow and dark shadow. There is robust estimation algorithm to detect the blunders and eliminate within ISAT, still in this extreme condition of poor textures and big height differences, manual editing is found very effective.

**Summarizing the solution, we have**

•Interactive measurements of additional tie points and robust matching within ISAT.
•Alternative to that is to import the exterior orientation.
•Measurements of redundant ground control points.

## 7. DISCUSSION OF THE RESULTS:

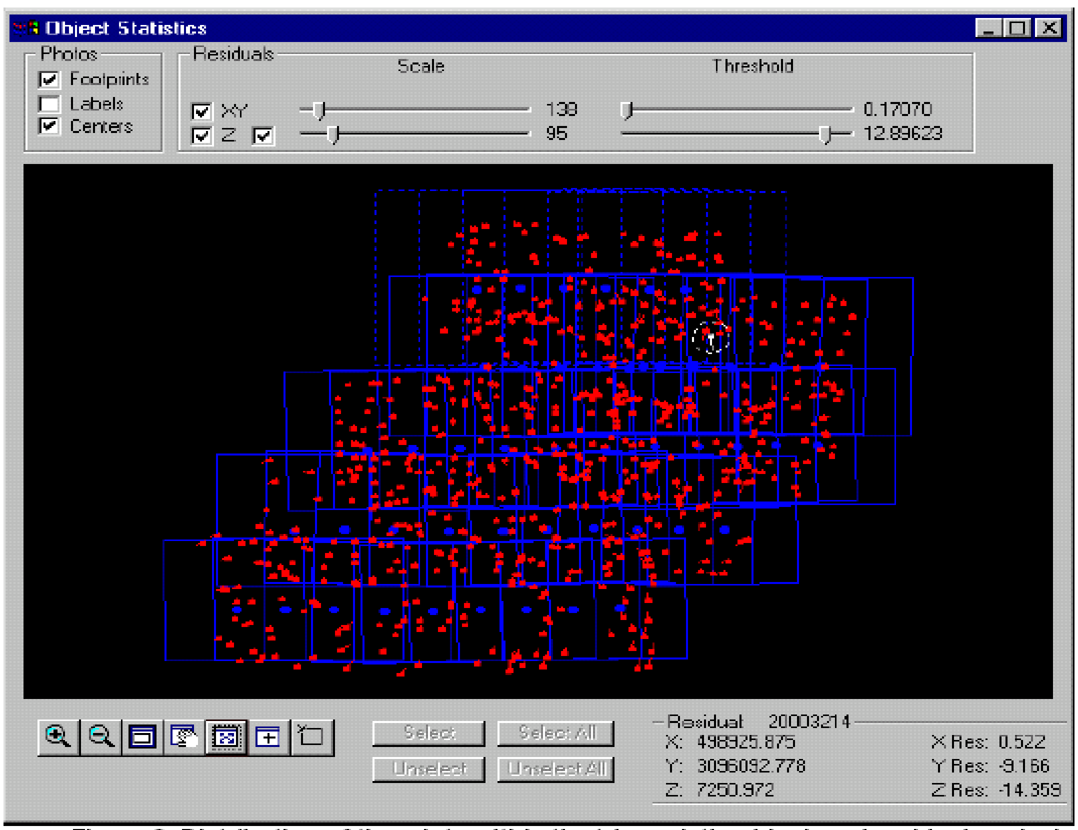



Figure 3, Distribution of tie points within the triangulation block and residual analysis

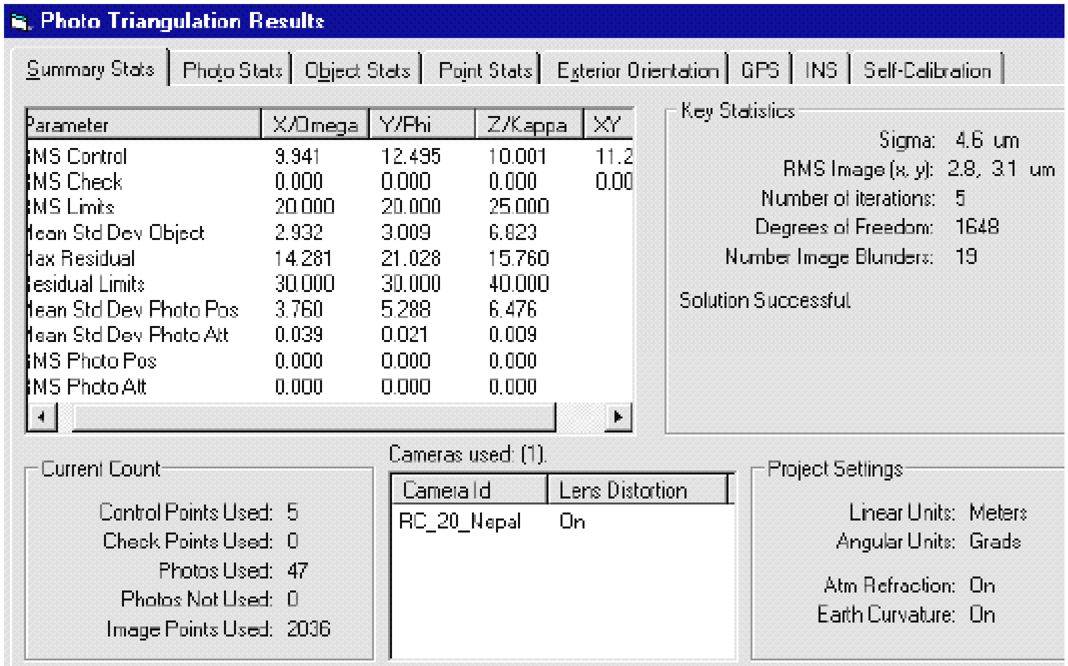



**Figure 4, Result of bundle block adjustment**

The above result is from an aerial triangulation block adjustment of Everest region. This block initially was prepared using available exterior orientation parameters of all photos of the block. Automatic thinning of the image point was enabled which resulted in less number of image points in the block adjustment. Manual measurements of tie points need experience in Mount Everest region. Experience play very important role to get the block adjustment successful. High residuals in the results are the residuals from ground control point measurements. No control points are signalized and measurements are performed in stereo mode still there is problem to locate exactly the position of natural points.Ground control points are extracted from the existing analogue maps of Everest region. A total of 5 control points were used in the final adjustment (4 in each corners of the block and one at the center of the block) and the adjustment was successful. This was due to the exterior orientation parameters were already used in the adjustment.

## 8. DIGITAL TERRAIN MODEL:

Mass points in a digital elevation model are points on the earth's surface having known elevation, as well as known positional coordinates. They are used in recitification of aerial image into orthophotos, and in adjusting other data to account for distortions due to terrain slope.

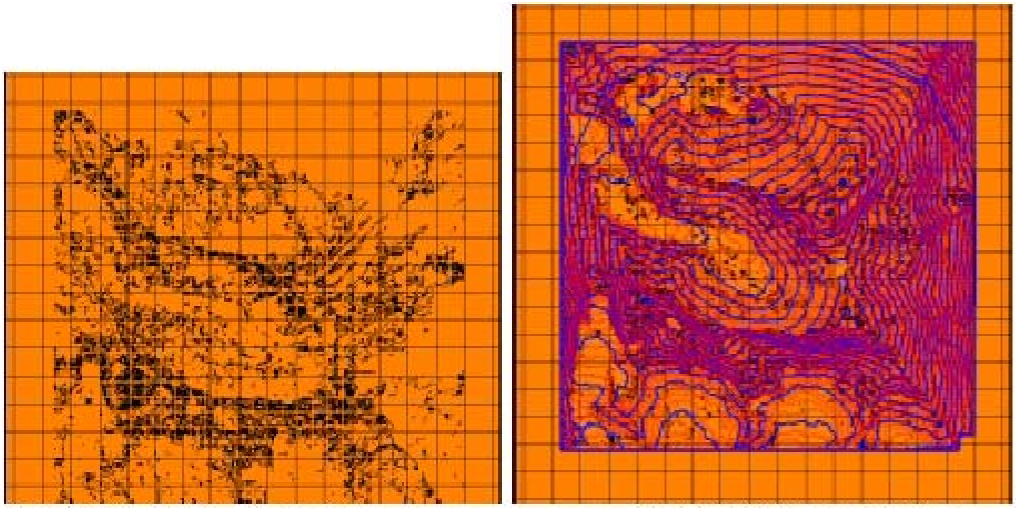
During automatic DTM extraction, the following parameters were considered.

**Terrain type and matching, surface reconstruction, feature pyramid parameters, resampling of matching window, correlation coefficient, threshold for correlation coefficient and threshold for weight.**

### 8.1 Accuracy Of Extracted *DTM:*

The accuracy of DTM depends on many factors, so it would be different in various parts of the model. So the single root mean square error may not suffice for the whole area. This would cause many tiles on the rectified images. Manufacturers could take up, is to include in the software some methods of telling the user what to expect in a particular area that is to have a spreadsheet with the terrain slope, flying height and other parameters like the land cover. This could help give an idea of what accuracy to expect in a particular area, thus pointing the way towards resolving the problems of checking DTM quality control. Most of the extreme dark and extreme bright areas due to snow and shadow have no control/tie points/check points which lead to interpolation of DTM data in such an area. Checking during post-processing is a visual check and for this one must find the places where editing is necessary and this takes a lot of time. It took one hour for visualizing the wrong DTM points in one normal model and where there are occluded areas as well as extreme bright and dark areas, it takes even more time. Of course it depends to some extend on the experience and speed of the operators how fast it could be done. It was not necessary to edit all the models, but was important to find out which model has wrong DTM, so it could be edited before importing it for the image rectification purposes. A few models of DTMs generated with different parameters are shown here under for references.

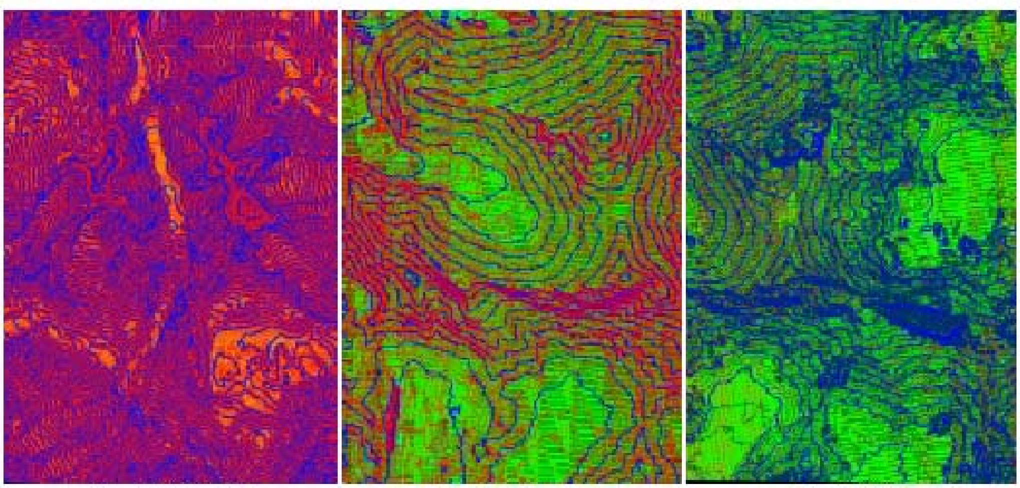
**8.2 Discussion Of The Results:**



Model 5411-12 (Elevation points) Model 5411-12 (Contour line )

**Figure 5, Elevation points and contour from 8 bits image**

Note: Contours generated using elevation points of the same model. 8 bits/14um pixel size was used for the extraction of DTM in this model. Extraction of DTM started from the center of the model and ended halfway without completing the model.



Model 5246-47 Model 5411-12 Model 5409-10

**Figure 6, Comparison of DTM extracted from 14 micron and 28 micron pixel from 12 bits image**

**8.3 Analysis:**

Model 5246-5247 was extracted with 14um pixel size and 12bits color depth, where there was no snow area, but the height difference was extremely high. Contour interval is fixed and same for all and is 50 meters. Model 5411-5412 is full of snow and shadow where the scale variation is extremely high. 28um resolution was selected for DTM generation in this model. Model 5409-10 is full of snow and shadow where the scale variation is extremely high. 14um resolution was selected for DTM generation in this model.

Model 5246-47 has no snow area and the DTM extracted there is found comparatively very good even there is extreme height difference (49% of the flying height above ground). Outliers are limited and notsignificant editing is necessary. Mountains and valleys are distinctly visible in stereo display when contours are overlaid on the image. But in model 5409-10, the DTM was extracted from 14um pixel size and 12 bits CCD data out put, the terrain model there was found very noisy and having much more outliers, which need extensive editing before importing this DTM for rectification. So the neighboring model 5411-12 was again tested to compare the results in the overlapping area, which resulted providing a fairly good DTM. In snow area where we are not much worried about centimeters accuracy and would like to make recommendation to use 2nd level of pyramids. 8 bits images are not recommended and also 14 um pixel size need not to be used for such an area. Long time processing is another draw back of 14um images. About 5 times more time is required for processing 14 um images than 28 um images in DTM extraction. It took about 30 minutes if you use 2nd level of pyramids for DTM extraction, but 2hours and 48 minutes was taken when processed with 1st level of pyramids.

### 8.4 Editing DTM:

•Editing is found important mostly towards corners and edges of the models caused by extreme height difference and presence of outliers mostly in snow and shadow region. In the corners and edges of the models the perspective is highly distorted and overlap region has different quality of elevation points in different models. So it is most important to have extensive editing in Everest region.
•Method developed practically in editing, was to delete the outliers and wrong elevation points and fill up the gap area by interpolation.
•Experience showed that it took 2 hour to edit one model in average.
•Measurements of control points were carried out to assess the accuracy of the elevation points.
•Contours could be viewed in stereo display over the models to assess the shape of mountains and glaciers.

## 9. ORTHORECTIFICATION:

Digital orthophoto production provided – compared to analogue production techniques – a larger flexibility taking mainly advantage of digital image processing techniques. Furthermore, the digital output opened a larger variety of applications, e.g. in a GIS environment. Both aspects influenced the production workflow changing from analogue to digital, and thus, allowing to take advantage of the inherent capabilities for automation. Looking at the workflow of orthophoto production starting from aerial survey, scanning, aerial triangulation, DTM capturing to orthophoto computation and mosaicking, the orthophoto computation itself is an easy and straightforward task compared to the others.

**Parameters considered for the rectification are:**

Interpolation method
The pixel spacing.
Transformation type
Clipping inside fiducial marks
Pixel intensity adjustment
File format
Ground resolution.

## 10. MOSAIC:

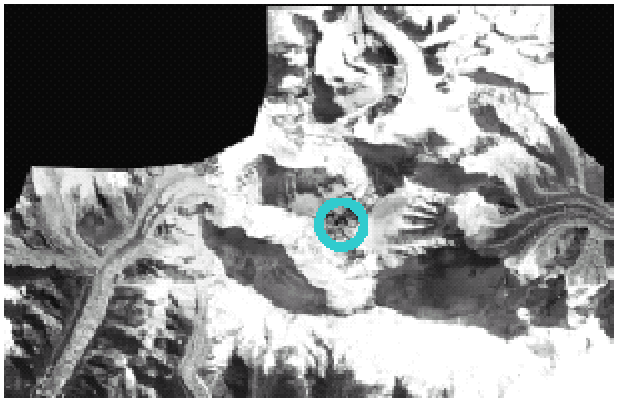


**Figure 7, Sample of mosaic from Mount Everest**

### 10.1 Analysis:

Now all the photos in the project area are rectified and ready for mosaicking to create a seamless image over the whole project area. For mosaicking, first of all seam lines are generated automatically and edited manually. Editing is possible wherever necessary. After placing seamlines satisfactorily on the mountains and valleys and glaciers, they are saved in OrthoPro database.
Next task is to assign mosaic polygons, where it is possible to select which image will fill that area during mosaic processing. Once all the mosaic polygons are assigned and they are saved. Then it is possible to start mosaicking. Here first option is to decide whether tone balancing is necessary, if the sourse for the mosaic is same then it is not necessary. Now the project is selected for mosaic. On completion of the mosaicking process, return to the compatible softwares to view and analyses the final product of the whole process.

## 11. CONCLUSION:

With 12 bits image AAT finds enough and fairly distributed tie points in the overlapping areas in MountEverest region, but automation fails if the height difference exceeds 30% of the relative flying height.The integration of direct exterior orientation measurements in the photogrammetric reconstructionprocess using GPS/inertial systems might become a standard tool for airborne image orientation in high mountainous region. Nevertheless, in future "true" integrated processing software approaches might beavailable directly based on the GPS phase measurements and inertial angular and linear accelerationto overcome the problem associated with extreme height and radiometric differences in photogrammetric processing.

## REFERENCES

Madani, M. and North, S., 1998. MATCH-AT: Some Fundamental Workflow Issues,
Automated Digital Photogrammetric Production Environment
Thomas kersten, Willie O'Sullivan, Nathalic Chuat
Swissphoto Vermessung AG
Dorfstr. 53, CH-8105 Regensdorf-Wart, Switzerland
http://www.swissphoto.ch.
Proceedings of the OEEPE Workshop on Application of Digital Photogrammetric Workstations, EPF Lausanne, 4-6
Kersten, Th., O' Sullivan, W., 1996b. Project SWISSPHOTO: Digital orthophotos for the entire area of Switzerland
International Archives of Photogrammetry and Remote Sensing, Vol. 31, Part B2, pp. 186-191
Kersten, Th., Haering, A., 1997b. Efficient Automated Digital Aerial Triangulation Through Customisation of a Commercial Photogrammetric System. International Archives of Photogrammetry and Remote Sensing. Vol. 32, Part 3-2W3, pp.72-79
Schenk T., 1997: Towards automatic aerial triangulation, ISPRS Journal of Photogrammetry & Remote Sensing (52) 3, 110-121
Dorstel, C. and P. Willkomm (1994): Automating Photogrammetric Operations and Workstation Design, International Archives of Photogrammetry and Remote Sensing, Vol. 30, Part 3/1, pp. 188-193
Faust, H. (1989): Digitization of Photogrammetric Images, Proceedings of the 42nd Photogrammetric
Week, Stuttgart, pp. 69-78
F. Ackermann, W. Schneider (1986), High Precision Point Transfer by Digital Image Correlation, Int.
Archives of Photogrammetry, Vol. 26-III, p. 18, Rovaniememi 1986.
Gulch, E. (1994): Using Feature Extraction to Prepare the Automated Meassurement of Control Points in Digital Aerial Triangulation, International Archives of Photogrammetry and Remote Sensing, Vol. 30, Part 3/1, pp. 333-340
Procededings of ACSM 28th annual meeting, Washington, D.C., March 10-15, pp 253-264.
Integration, Automation and Intelligence in Photogrammetry, Remote Sensing and GIS, pp. 49-58.
Willkomm, P. and C. D^rstel (1994)
Kersten, th., S., O'Sullivan, W., 1998. Digital Aerial Triangulation in Alpine Regions – A Challenge. Inter-national Archives of Photogrammetry and Remote Sensing. Vol. 32, Part 2, pp. 149-156.

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

## CONGRATULATIONS!

In the fiscal year 2058-59, His Majesty's the King Gyanendra Bir Bikram Shah Dev awarded **Mr. Babu Ram Acharya,** Director General and **Mr. Krishna Raj Neupane,** Survey Officer of the Survey Department with ***Tri Sakti Patta Class IV*** and ***Gorkha Dachhin Bahu Class IV*** respectively. Therefore, all the staffs of the Survey Department expressed their **HEARTY CONGRATULATIONS** to both of them for getting such an auspicious medal.

## Call for papers

The Editorial Board of Nepalese Journal on Geoinformatics announced to call for articles related with Geoinformatics for the publication on third issue of the journal. Last date for the submission of the article is March 31, 2004.

For more information, please contact
Mr Jagat Raj Paudel, Chief Survey Officer
or
Mr Deepak Sharma Dahal, Survey Officer
Topographical Survey Branch
Survey Department
P.O.Box 9435, Kathmandu, Nepal
Tel: +977-1-44 78 723, +977-1-44 66 463
Fax: +977-1-44 82 957, +977-1- 44 96 216
Email: topo@mos.com.np
Website: www.dos.gov.np

# LAND MANAGEMENT AND HUMAN RESOURCE DEVELOPMENT POLICIES IN NEPAL

**Hari Prasad**
Principal
School of Geomatics, Kathmandu

**Mahendra Prasad Sigdel**
Chief Survey Officer
Survey Department, HMG/N, Kathmandu

## ABSTRACT

Nepali life is closely dependent on land resources. Though small in size, Nepal is endowed with multiple land resources more than enough to provide good livelihood to the whole population if they are properly harnessed and utilized. Spatial diversity in terms of climate, topography and associated bio-domains is enough to illustrate Nepal's richness in resources. In order to utilize those resources, first thing for Nepal to do is to have a sustainable vision and mission based on reliable, disaggregated and organized information for harnessing of the resources towards sustainable livelihood. Such system can not be put into place in the absence of human resources capable of doing in-depth survey of lands in relation with human beings and understand inherent resources therein. Nepal has, however, not yet oriented its HRD policies towards this direction. Focus is still either on general education or engineering trades other than surveying. Whether it relates to land reform, natural resource management or agricultural development, the course of Nepal's development cannot be directed towards sustainable livelihood unless the HRD policies place due emphasis on developing quality land surveyors and land managers. This paper tries to analyse the present HRD policies of the country in the context of surveying and land management.

## INTRODUCTION

Nepal is well known for diversity in resources such as climate, topography, land types, wild lives, water, forest, culture and ethnic composition within its small land area expanded in the east-west direction. Eight out of the 14 peaks that rise above 8000 meters from the mean sea level lie here. The country is gifted with diverse climates found in the world. It is the habitat of about 850 species of birds which constitute some 10 per cent of world's bird species and about two per cent of the world flowering plants. About five per cent (246 species) of the total flora is reported endemic to the country. Water resource-wise, it is one of the countries in the world with highest hydro-power potential. Amidst this bio-physical diversity, 60 caste and ethnic groups speaking 70 different languages and dialects live.

Despite the land offering rich alternative resources, land is still a prime resource of livelihood in Nepal. Until Nepal was opened to interact with outside world in 1950s, over 95% of the people depended on land for their subsistence. Even after about 50 years of planned development efforts, land is still a primary source of subsistence for over 80% of the people and working field for over 77% of economically active work force. Agriculture sector still holds 40% share in GDP.

In the course, land resource of Nepal has experienced an unscrupulous change. The agricultural productivity of the country has gone down to one of the lowest in South Asian countries which used to be highest until 40 years ago. Similar is the case with forested land. The coverage of land under forest has been reduced to around 37% from 45% in 1964. With the changes brought in the socio-economic patterns by the wave of modernization, many of the rural settlements have been shifted to urban settlements demanding innovative methods and strategies of land management and administration. Much of the agricultural land in and around urban centres has already been changed to urban residential and industrial use, mostly in an unplanned manner. The resultants of the process are congestion in the urban areas, increasing land related conflicts, squatter settlements, increasing number of people with less subsistence resources and disfigure of the beautiful landscapes.

Given the complex nature of the land and its close affiliation with life of the people, land has been a major factor in shaping the state polity of the country, too. Most of the political parties in Nepal, including the autocratic party-less Panchayat regime of pre-1990, have had constantly been according "land reform" a priority agenda in their political campaigning. Accordingly, all elected and non-elected governments in the past have made efforts, at least at the policy level, to posit land resource in the perspective. The efforts have, however, not been successful to achieve desired results. This paper tries to examine the land sector in the context of land policies, institutions and HRD policies. The paper is primarily based on published information and personal observations of the authors.

The authors have organized the paper in four sections. First section reviews the land policies followed by institutional arrangement in the second section. The third section discusses about HRD policies and fourth section sums up the findings and suggested course of actions for improvement.

## LAND POLICIES

Land is a complex resource to manage and regulate as different forces keep interplaying on it. In the absence of keen understanding of interrelationship among the different natural features operating on the land and human life, sound and effective land policies can not evolve. The context of policy making becomes more complex when the demand for land increases requiring innovative strategies and methods to address the issues.

Looking at the history, Nepal has tried to address the land management issues through different policy measures at different periods. In the early periods, the governing bodies did not require strong regulatory policies to manage the land since the unavailability of land was not a problem and the land was basically a resource to produce subsistence. It has, however, been a primary source of subsistence to both the people and the state and basic element of establishing relationship between people and the state throughout the history of Nepal and has always received attention of the state. Although not in a comprehensive form, state land policies began to emerge in Nepal as early as 300 AD during Lichhabi era when a law for recording of land ownership records was introduced. Since then the state powers had introduced land policies to mostly regulate the agricultural and residential land use and raise land tax. Land administration in Nepal used to be very complex with different categories and sub-categories of ownership until modern system emerged. Now, there are only two forms of ownership namely Raikar (private ownership) and Guthi (Trust Land; normally owned by public institutions of religious groups). It should, however, be noted that the state is the de-facto owner of the land.

Drawing upon the experiences from the past, changing socio-economic and political context of the country, and increasing accessibility to the technologies, the first organized and more scientific policy relating to land management issue was promulgated in 1963. The Land (Measurement) Act 1963, first time defined land data and designated Survey Office as a responsible agency to collect data about the land parcels with ownership status, quality, measurement and prepare ownership records and provide to the Land Revenue Office. One major achievement of this Act is that the Survey Department has now cadastral data for whole country.

Following Land (Measurement) Acts, Land Acts (1964) was enforced to modernize the use of land resources. First time it recognized the necessity of transferring the inactive land capital into other sectors of national economy and tried to bring land resource in a perspective. It abolished Zamindari system, established and protected tenancy rights, fixed the upper ceiling of land holdings and set limit to the land a tenant household could rent for cultivation. At present, over 66 Acts and bylaws guide land management and administration in Nepal. They basically stipulate certain procedures, terms and conditions related with land ownership, tenancy, land registration, inheritance, land transfer, land revenue, mortgage agreements, leasing and renting of land. The Acts and bylaws have yet not conceptualized land management as engine of socio-economic transformation of the country. Many times they do not speak each other.

Apart from these laws and bylaws, the five year periodic plans and other development master plans set policies on land management. Development of appropriate land use system and promotion of land consolidation to control increasing fragmentation envisioned in the Ninth Plan can be cited here as examples.

## INSTITUTIONS:

To implement the policies, a number of organizations have been set up and mechanism developed. The Parliament and Cabinet are the apex bodies responsible for making policy choices and decisions related to land reform, management and implementation. The National Planning Commission (NPC) acts as an advisory body. It provides philosophical and professional inputs, integrative perspective on land policies and framework for implementation. The Ministry of Land Reform and Management acts as sectoral in-charge. Its main responsibilities are to develop policy proposals, design strategies and make arrangements for implementation of the policies and provide subsequent/updated information to Parliament, Cabinet and the NPC as and when required and land related information to other Ministries and agencies. The Ministry has three Departments and one Land Management Training Centre, and Guthi Corporation under it to implement the policies, programs and projects related to land management and reform. They are Department of Survey (DoS), Department of Land Information and Archives (DoLIA) and Department of Land Reform and Management (DoLRM). Department of Survey is sole agency responsible for surveying and mapping activities, and support all Departments of the Ministry in their decision making process related to implementation of the land policies, programs and projects assigned to them by providing land information. Guthi Corporation is responsible for implementing government policies and programs related to Guthi land. All the Departments in turn operate through a network of regional and district offices.

All these institutions are staffed with technical and administrative personnel. Altogether 6240 positions have been created under MLRM and out of them 339 positions are fallen vacant. Out of the total vacancies 28 are officers and rest are non-officers and unclassified (Info 1999). The share of technical personnel accounts for 1878 all placed in Department of Survey excluding three persons placed at the Ministry. Out of the 1878, 138 are senior professionals and rest are junior and basic technicians (Survey Department 2002).

## HUMAN RESOURCE DEVELOPMENT AND MANAGEMENT POLICIES

Translation of policies and programmes into reality is primarily a function of human power. In the absence of motivated and innovative human power, no policy and program can be materialized. Although there is no well articulated policy on HRD development for land sector management, Nepal has endeavoured to develop human resource through training programs and sending graduates to international universities under different scholarship programs. The training policies are mainly focussed on producing technical human resources in surveying rather than the whole sector. The Survey Training Centre, recently renamed as Land Management Training Centre (LMTC), was established in 1968, primarily to produce technical human resources required for implementation of provisions and policies set by Land (Measurement) Act (1963). The decision was a milestone since without having people capable of extracting land information; it was not possible even to imagine implementation of land sector policies. All of the subsequent periodic plans have also emphasised on the production of land surveyors and none of them have set HRD policies specifically for land sector.
The main objective of the Centre is to produce survey technicians in the field of Surveying and Mapping. The Centre primarily runs three courses: Basic, Junior and Senior Surveying. The entry qualification for the courses is SLC, I. Sc. and B.Sc./MA Geography for Basic, Junior and Senior courses respectively. Apart from these courses, the Centre also conducts special courses in different trades of surveying such as Cartography, Geodesy and Photogrammetry. None of these courses have incorporated aspects, such as land dynamics, land economics and sociology, spatial analysis of different human and natural features, of land management other than surveying and mapping technologies, and related laws. The focus is on the land data acquisition, processing and management rather than land management. Since its establishment, the centre has produced 347 senior surveyors, 1308 junior surveyors and 2423 basic surveyors.

The liberal policies adopted by the government after 1990s have encouraged also the private sector to invest in land sector education. Now, there are four private institutions imparting basic surveying training courses. One of them has also started intermediate level academic course in the field. These courses have tried also to incorporate socio-economic aspects in the courses. Both courses include community and environment skills, land valuation, land management concepts and communication skills as parts of the course.

The graduates of these training/education courses are mostly employed by Survey Department. About 25% of the professionals in the senior post have also undergone foreign training. There is, however, not yet a single person with PhD degree in land surveying and management. This points to less academic attention to the sector. Most of those who got opportunity to get advanced study in the foreign universities have been consumed mostly by the respective countries.

Professionals in the Ministry and other Departments are from general education background having experience mostly either in personnel management or other sectors. At the same time there is no articulated policy and regular mechanism to develop their skills and knowledge about the dynamics of land management. A comprehensive HRD policy for the sector is yet to be developed.

HRD is also a function of human resource management policies. The Human Resource Management approach adopted in the government offices is basically based on the concepts of hierarchical order. The facilities and incentives provisioned by the Civil Services Acts and Rules apply invariably to all the personnel. Since the incentives and rewards are largely not provided based on performance, personnel normally are not motivated for innovation in their assignments. The motivation to work and innovation also depends on the degree of professional exposure to the subject. Land is a spatial concept. Various different forces operate on it in continuum showing a complex pattern of relationship. In the absence of such knowledge, the actors normally tend to meet the formal rituals. Professionals in the land sectors are not exception in this regard. As revealed majority of the personnel, excluding the technical professionals in Survey Department, in the land sector are from general education background and can be transferred to any other ministry, they generally take this field as a platform to other promising ministries and departments. This apparently does not match with the land reform and management policies.

Experience of Mr. Shambu Prasad Shrestha who spent over 33 years in the Ministry of Land Reform and Management in different positions and retired from the post of Joint Secretary would best illustrate the situation. He believes that land sector in Nepal is governed largely by the people who do not even know the "L" of land. The concept of land management in real sense is beyond their purview. There is, in fact, a dearth of quality human resource at all levels - data acquisition, processing, analysis, policy and decision making - of land sector management. The variables operating on the land are fast changing. They need to be monitored and studied on a regular basis and stock of knowledge and skills in the tools and technologies updated, some times innovated to address the upcoming issues. The present HRD/M policies have neither taken account of this aspect nor have they reflected the spirit of land sector management policies. Migration of 12 highly qualified surveying and mapping professionals including PhDs to other countries also substantiates the fact that the present HRM policy is incapable of attracting quality professionals. All these indicate that there is little innovation for better management of such a critical and important sector. This aspect of HRM has, however, received less attention from the concerned. He also believes that there is an acute need for mainstreaming all Acts and bylaws and institutions if land sector is to be managed for sustainable development of the country.

## CONCLUSION AND SUGGESTIONS FOR IMPROVEMENT

Land sector is an important engine for socio-economic transformation of Nepal. Though a number of Acts and bylaws have been put in place, they have not been effective to develop land sector as basis to the development of the country. The problems partly lie in mismatching land sector management policies and HRD/M policies. Unless land is understood in its entirety and sound matching policies for HRD/M emerge, the issues of land management will continue to be on the backdrop. In order to get on to a more sustainable management of the sector, following activities are suggested.

- Assessment of present Acts and bylaws guiding land sector in the context of their usefulness and effectiveness in guiding land resource management and development of consolidated land Acts and bylaws;
- Assessment of present institutional mechanism and reforming them to match the context created by the consolidated land Acts and bylaws;
- Assessment of present concepts and theories of land as a resource, establishment of its components and preparation of comprehensive land management course for HRD required to meet the objectives of consolidated land Acts and bylaws;
- Assessment of present HRM approaches and policies and reform in the context of consolidated Acts and bylaws.

### REFERENCES


1. Info Assembly Pvt. Ltd. (1999), Study on Land Consolidation in Nepal, Cadastral Survey Branch, Department of Survey, Kathmandu, Nepal

2. Survey Department (2002), National Mapping (Issues and Strategies), Kathmandu, Nepal

3. Bhumichitra Company Pvt. Ltd. and others (1996), Detailed Study Report on Developing Developing Land Information System in Nepal, Integrated Land Information System Project, Ministry of Land Reform and Management, Kathmandu

4. Nepal Law Campus- Legal Research and Advisory Committee (2055), Collection of Laws Related to Land

5. Central Department of Geography (1999), The Study of Land Use Plan, Department of Land Reform, Kupondol, Kathmandu

6. National Planning Commission, 8th and 9th Periodic Plans

# TOPOGRAPHICAL SURVEY BRANCH WITH REMOTE SENSING

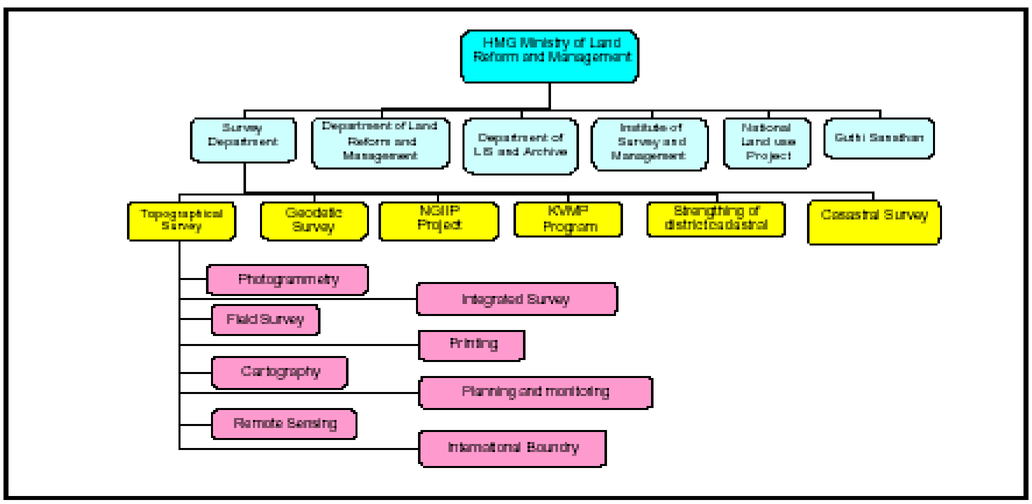
**T.B. PRADHANANGA**
**SURVEY DEPARTMENT**
Tel: 4482338/ 4420182
E-mail: topo@mos.com.np, Website: www.dos.gov.np

## ABSTRACT

This paper is made for institutional development and it is oriented towards the study of past, present and future of Topographical Survey Branch. All existing (Topographical, Land Resource, Thematic, Derived etc) maps of HMG Topographical Survey Branch prepared on different dates by different donor agencies, has become outdated, so regular and systematic updating of these maps are very important. This has become a big problem because of constraints of finance and human resources. When we adopt modern technology, like Remote Sensing with GIS, there are problems in lack of specialists and finance. If we adopt conventional method we have financial constraints and it is very time consuming also. Remote Sensing with GIS is the only optimal methodology for updating all these maps. Other than that, the Satellite Space image data used for updating of existing maps can be further used for various other programs, projects, studies and research of other users also.

## 1. BACK-GROUND OF THE BRANCH

Topographical Survey Branch, under the Survey Department, Ministry of Land Reform and Management, His Majesty's Government of Nepal is the Central Organization to provide topographical mapping services, land resource mapping, derived mapping and other mapping services to all concerned. Our organization structure as its names stand is given below.




With the following responsibilities and aims, this branch was established in 1972, since its birth the branch is struggling to develop its activities in the field of Surveying and Mapping.

- To produce topographic, administrative, political and thematic maps.
- To produce large scale topographical maps for urban and rural areas as required.
- To provide Land Resources maps and information.
- To publish National Atlas, reports and data relating to the topography and land resources of Nepal.
- To provide aerial photographic services for various mapping projects.
- To participate in regional and international mapping programs

## 2. PAST AND PRESENT PROJECTS OF SURVEYING AND MAPPING IN THE BRANCH

Before and after the establishment of the Branch a number of projects and programmes has been launched and completed. Some of the major projects are as follows:

### a) Survey of India

The first topographical base map of the country was 1" = 1 mile. It was completed during 1950-60 with the co-operation of the Government of India. A total of 266 maps sheets covering the whole country were prepared. These maps are now outdated and too small in scale. Moreover, the units of measurements were not metric, and the projection systems and parameters used are different from the present system. However these first topographical maps have been support for a long period of time in all development and administrative activities of Nepal. In many cases demand for more detailed, up-dated and larger scale maps were seeking.

**b) UNDP**

In the initial stages, with the UNDP assistance, infrastructure of the branch was established. This branch was able to procure major surveying and mapping instruments and equipments. It also assists on manpower development through training at home and abroad as well as technical assistance by different types of technical exports. Today this branch has more than 150 employees working in various posts in different technical sections. Under the head of the Deputy Director General, there are photogrammetry, remote sensing, field, cartography and GIS, map reproduction, integrated survey and border sections. This project was started from January 1979 and ended on June 1982. During this period various programs were launched and completed, for example numerous derived maps, thematic maps were prepared under the supervision of foreign experts and volunteers.

### c) Government of Canada

In 1977, with the assistance of Canadian Government, Land Resource Mapping Project was launched from this project we got land capability maps, land System maps, Land Utility maps, Geological map, Climatological maps of Nepal based on existing 1"= 1 mile maps and aerial photographs taken in 1978. They prepared these maps in the scale of 1:50 000 in regions below15000feet altitude.

### d) JICA

In 1989, with the assistance of Japanese Government Topographical base maps of Lumbini Zone was prepared and it was 81 map sheets in the scale of 1:25 000 and was completed in 1992.

### e) Government of Finland

Topographical mapping of other zones was also necessary and due to financial constrain branch could not prepare the new series of topographical maps, so proposal was sent to donor agencies, ultimately thanks goes to the Government of Finland that the Finnish Government has accepted the proposal. With this grant assistance, Topographical mapping of two development regions of Nepal viz. Eastern and Central Development Regions was started in 1991. Accordingly a new series of topographical base maps at 1:25 000 scale for Terai plains and mid- mountain regions and 1:50 000 for the rest area was completed in 2002.

In the first phase of the project a total of 294 map sheets was completed in 1996 and in the second phase of the project a total of 255 sheets at a scale of 1:25 000 was completed in 1999 and in the third phase a total of 76 map sheets in the scale of 1:50 000 was completed in 2001. Including 81 maps sheets of Lumbini zone, a total of 706 topographical map sheets are available and in use and sale.

### f) Census Mapping

With the assistance of Finland, Denmark and European Commission, Census Mapping Project was started from 1999. This project's main aim was to prepare a digital data of all hard copy made so far. Within given time period most of topographical maps sheets of the whole country except mountain regions where population is very low, digitization and preparation of census mapping are completed. At present the mountain area maps also digitizing and secondly ortho photomaps of the urban area are preparing. Third program of this project is at presently known as National Geographic Information Infrastructure Project is preparing derived maps of different scales and preparing national date base.

### g) Other activities

Before establishment of this Survey Branch, there were only cadastral maps, 1:1 mile topographic maps and geographical maps of the country prepared by foreign countries only. With the help of existing 1"= 1 mile topographical maps first Nepal map, Development Region maps, Zonal maps, District maps were prepared in different scales by HMG resources only. Different types of maps prepared under this program were revised and reprinted whenever necessary. Apart from these different derived maps, there are some municipality maps and engineering or other project maps prepared on the users request. There are Village Development Committee maps prepared by HMG resources for census purposes in 1990 and they are a total of 3997 map sheets in different sector.

The branch has prepared wall maps in the scale of 1: 75 0000 and School Atlas prepared for schools and general users. There are other small-scale maps prepared, printed and published by HMG resources. Apart from these maps there are some reports, Land resources, manuals of technical works. The branch also provides topographical mapping services to government and non-government agencies. One of the main activities of the branch is to maintain the record of administrative boundaries and International boundaries. In international boundaries, all works like delineation of boundaries Surveying and mapping of boundaries, pillar construction & maintenance, boundary delineation, boundary maintenance, periodic inspection etc is also responsibilities of this branch.

## 3. EXISTING MAPS AND DATA OF THE BRANCH

Since, main objective of Topographical Survey Branch is to provide services concerning facts and figures of land by means of maps, data, photographs images etc. Within its thirty years of period the branch is providing following products for the users:

**Derived Maps**

| Administrative Maps | Scale | No. of sheets | Remarks |
|---|---|---|---|
| Nepal | 1: 1,000,000 | 1 | Various version |
| Nepal | 1: 2,000,000 | 1 | Various version |
| Regional Maps | 1: 500,000 | 5 | Nepali version |
| Regional Maps | 1: 500,000 | 3 | English version |
| Zonal Maps | 1: 250,000 | 15 | Nepali version |
| District Maps | 1: 125,000 | 76 | Nepali version |
| Municipality Maps | 1: 10,000- 50,000 | 39 | Map manuscript 1990 |
| VDC Maps | 1: 10,000- 50,000 | 3997 | Map manuscript 1990 |

**Thematic Maps**

| Map | Scale | No. of sheets | Remarks |
|---|---|---|---|
| Land Utilization Map | 1:50,000 | 266 | |
| Land System Map | 1:50,000 | 266 | |
| Land Capability Map | 1:50,000 | 266 | |
| Climatological Map | 1: 250,000 | 7 ( Western Nepal ) | |
| Climatological Map | 1:1,000,000 | 1 | |
| Geological Map | 1:125,000 | 82 | |

**Topographic Maps**

| Name | Scale | No. of sheets |
|---|---|---|
| **Lumbini Zone** | 1:25,000 | 81 |
| Eastern Nepal Topographic Project | 1:25,000 | 255 |
| Eastern Nepal Topographic Project | 1:50,000 | 37 |
| Western Nepal Topographic Project | 1:25,000 | 254 |
| Western Nepal Topographic Project | 1:50,000 | 79 |
| Total | | **706** |

## Aerial Photographs

i. Aerial Photographs of the country below 15,000 feet taken in 1978-79 at the scale of 1:50,000.
ii. Aerial Photograph of Lumbini zone taken in 1990 at the scale of 1:50 000
iii. Aerial Photograph of Eastern Nepal (Eastern and Central Development region) taken in 1992 at the scale of 1:50,000.
iv. Aerial Photograph of western Nepal (Western, Mid Western, Far Eastern Development region) except Lumbini zone taken in 1995-96 at the scale of 1:50,000.
v. Aerial Photograph taken for different projects in different dates in different scales. .
vi. Aerial Photographs of metro political area taken by Census Mapping Projects in 1998 at the scale of 1:15,000.

## Digital Data of topographical maps

All above Topographical maps of scale 1:25 000 and 1:50 000 (total 706sheets) has been digitized and are published for users, but some map sheets are common on above projects, so digital sheet data of total 678 sheets are available.

## 4. REALIZATION OF REMOTE SENSING IN THE BRANCH

Since, establishment of Survey Department, Topographical Survey Branch is the Central organization under the Government of Nepal responsible for National Surveying and mapping activities within the country, it is therefore responsible for the accomplishment of Land Surveys, mapping production and distributions. Thus, the responsibility is to give the updated geo-information in the country to support multi-sector development activities by publishing the data/information in the format as per the demand of the users communities, modern and efficient geo information can be obtain from the data/remote sensing technology.

Updating geo-information is very important because reproduction is not a problem but correct, accurate and
up-to-date as well as in the users' required format is important. After perceiving these activities the branch is looking forward to the appropriate opportunity to formulate a procedure or a project for the updating of database of topography or land resource or any other types of geo-information. For this purpose we select the Remote Sensing technology. Satellite image data will be efficient and good geo - information requires for multi sector development activities and can be achieved by scientific spatial information technology called Remote Sensing. There are very good range of Remote Sensing applications, but one of the main applications of Remote Sensing is mapping or geo-information collection of data required for geo-information.

Since, information is power and remote sensing is spatial information, therefore spatial information is also a power. This power plays a vital role in the national building but also use as monitoring and evaluation of any scientific and technical studies. At present its main field of applications are topographical, forestry, agriculture, geological and mining, meteorological, land resources system, soil and water resources management, environment and pollution, wetland mapping, vegetation classification and plantation, oceanography, land use and land classification, soil erosion etc.

Geographical information system today is one of the major decision making tools in the areas of resources planning and management. Integration of Remote Sensing technology with GIS technology has widened the potential of both technologies so another major benefit of this technology is that they can be integrated and a number of national level or local level projects of natural resources or other studies can be implemented successfully. Some beneficial points on Topographical Survey Branch with Remote Sensing are as follows:

- Digitization of whole topographical maps series is completed.
- GIS and RS can be integrated.
- As centre for satellite images, data can be used for other purposes and projects.
- Low cost compared to aerial photographs.
- Remote Sensing with aerial photographs can create digital photogrammetry for large-scale mapping.
- Mapping with point by point digitization is not required.
- It does not require stereo viewing or measurement.

Space Imaging as a visual information and visible resource has numerous application viz. Environment, Utilities, Exploration and Mining, Media, Entertainment and consumer, Transportation, Agriculture, Property insurance and Crisis management, Real estate and Development, Forestry, Telecommunication etc. Thus selection of technique of remote sensing for topographical survey branch is feasible.

## 5. STATUS OF REMOTE SENSING IN THE BRANCH

Present status of Remote Sensing in Topographical survey Branch is in initial stage only. At present we realize that remote sensing technology is important, necessary and appropriate for our mapping activities. There are many things to be done for full operation of remote sensing in the branch. At present following works has been done by the branch.

- The branch established remote sensing lab with few computers and procured ERDAS Imagine Professional software version 8.4 and 8.5, high resolution IKONOS image (1 meter resolution, the product of merging of 1m black & white e and 4 m multi-spectral image) of Kathmandu Valley and IRS data of Lumbini zone.

- The branch prepared project proposal and sent it to different donor agencies.

- After establishment of Remote Sensing Lab and some local training with the IKONOS image of Kathmandu Metropolitan area, our staff has prepared a image map.

  The following steps have been taken for the image map preparation.

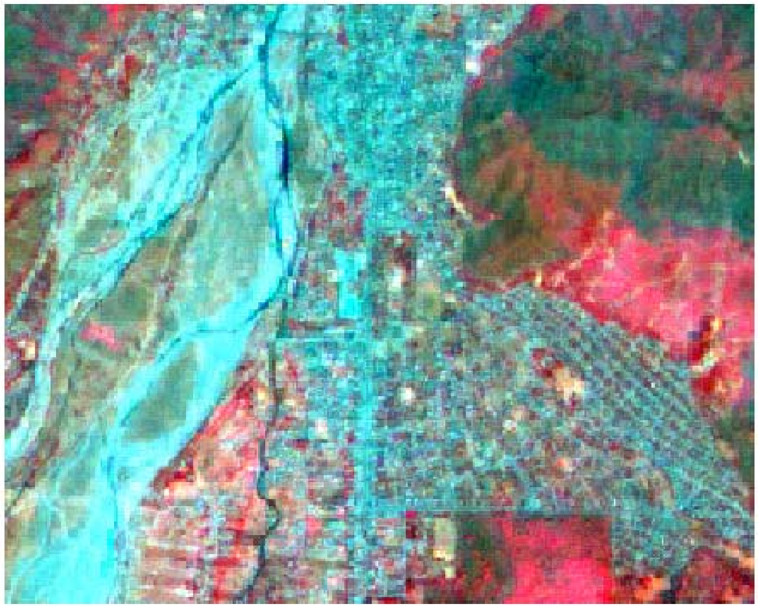
- The image was procured in two parts; therefore they were geo-corrected with the help of toposheets and mosaics.

- Enhancement - To improve the sharpness of the image enhancement was done.

- There was a problem in enhancement of image only in the core area due to fogs, which we suppose to be due to air pollution. Therefore the images were enhanced for atmospheric correction, which reduced the effect of atmospheric pollution and gave sharp image to some extent. The sample of this product is given below.

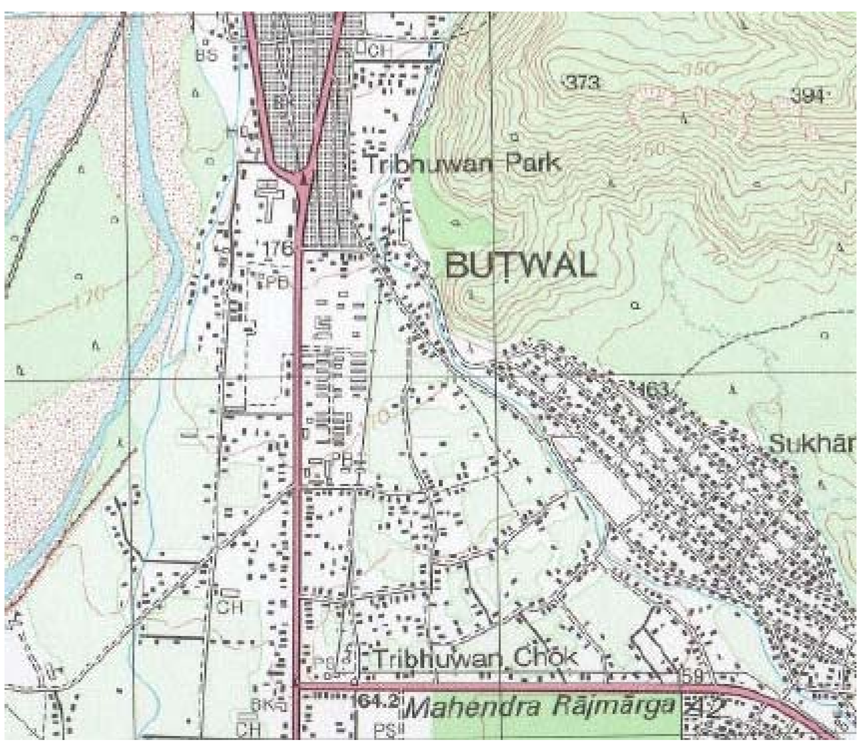
IKONOS Image of a part of Kathmandu Valley in scale of 1 : 4000

- These enhanced images were cut and composed in our mapping layout system in 1:5000 scale. Secondly, the branch has worked for up-dating topographical maps and following steps has been taken for up-dating in brief.
- Topographical map of Lumbini Zone of scale 1:25,000 was selected for updating.
- For this purpose IRS data, which we procured in two parts (1C/1D LISS-24 m and 1C/1D PAN-6 m) were geo-referenced separately with the help of existing toposheets.
- These geo-referenced images were mosaiced and merged together. We got the image map after some enhancement.

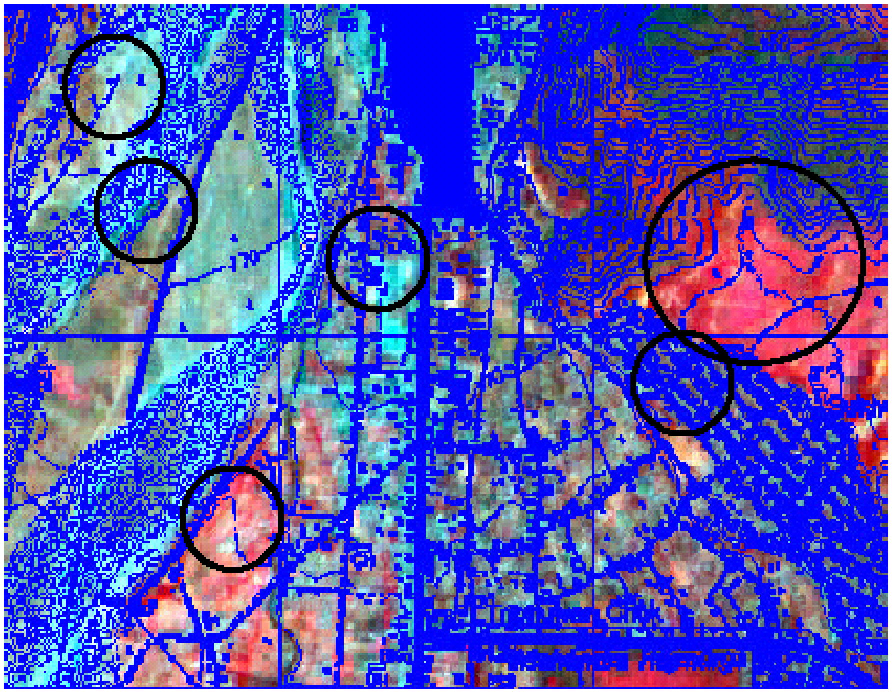


IRS Rectified Merged 24 m/6 m Image (1:25000)

- Recent rectified IRS multi-spectral Image (24-m) of 2002 and Topographical map of 1991 of Lumbini, JICA were compared and many changes were noted within these two image and toposheets.
- These changes were updated accordingly in the digitized vector layer.
- This new vector database will be used for printing of topographical maps after completion of symbolization and color separation. Sample of satellite image map prepared base on IRS data is given below.
- Changes in features are indicated by circles.




Scanned Topo 1:25000



Overlay of Toposheet on top of image for the comparison (1:25000)

## 6. PROBLEM OF REMOTE SENSING FOR IMPLEMENTATION IN THE BRANCH.

The main problems in the implementation of remote sensing technology are as follows.

- It is the new technology in context of Survey Department.
- Our branch has limited budget and no skilled human resources.
- There are some institutions, which give GIS training but there is no opportunity to get Remote sensing training/courses in Nepal.
- Since this is research and cost oriented technology, this problem is more in developing countries compared to developed countries.
- Government and some non-government organization have already realized the usefulness of these technologies but due to lack of specialists, development in this field are very low
- Some other problem is about satellite image data and proper software itself because we do not acquire any satellite and we have to order it and to buy it from concerned agencies it takes time.

## 7. CONCLUSION

In this paper there are explanations of Topographical Survey Branch and its necessities of Remote Sensing Technology. The branch has selected this technology for their further programs, but this is not all for them they should implement this program for resource mapping and updating of the new series of topographical maps with the help of aerial photographs and GIS data. It will be worth to prepare new land resource maps rather than updating of old land resource maps. In the second phase while updating new series of topographical maps they should prepare all topographical maps of the country in one scale (1:25000) in one system with same accuracy.

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

**List of Secretariat Staff for the 23rd ACRS**

| | | |
|---|---|---|
| 1. | Survey Officer | Mr. Niraj Manandhar |
| 2. | Survey Officer | Mr. Govind Baral |
| 3. | Survey Officer | Mr. Sushil Narshingh Rajbhandari |
| 4. | Survey Officer | Mr. Kamal Nath Mishra |
| 5. | Survey Officer | Mr. Nara Hari Lakhe |
| 6. | Computer Officer | Mr. Bhushan Narshingha Pradhan |
| 7. | Office Secretary | Ms. Sushila Rajbhandari |
| 8. | Office Secretary | Ms. Nirja Prasai |
| 9. | Store Keeper | Ms. Lalita Shrestha |
| 10. | Account Assistant | Ms. Beena Bhattarai |
| 11. | Computer Operator | Miss Sabina Sapkota |
| 12. | Peon | Ms. Sangita Giri |
| 13. | Peon | Mr. Ram Krishna Dhakal |

# AN OVERVIEW ON TIME SERIES OF GEODETIC AND GPS NETWORK OF NEPAL

**Niraj Manandhar**
Geodetic Survey Branch,
New Baneshwor, Kathmandu, Nepal.
Tel 4482547
E-mail: manandhar_niraj@hotmail.com

**Maheshwor P. Bhattarai**
Geodetic Survey Branch,
New Baneshwor, Kathmandu, Nepal.
Tel 4482547

**KEYWORDS:** Geodetic, GPS, Networks

**ABSTRACT:**

This paper makes an overview of different geodetic and GPS networks of Nepal established in different time, with different accuracies and with different objective. Before 1945 the importance of surveying and its application was poorly understood in Nepal, therefore the surveys were limited to the measurement of land parcel covering a small area, considering it as a plane. After launching the land reform policy HMG/ Nepal 1963 and also because of the various development project, the importance and the requirement of establishing the geodetic control, defining the ellipsoidal shape of the earth as the reference surface is felt necessary in the country for the surveying and mapping activi ties. Interestingly various countries has been involved in establishing the high precision geodetic networks in the time series of evolution of scientific mapping in the country. Different networks being established by different institutions but very little interest had been given in integrating them. As a result problem persists in understanding and integrating spatial measurements in the geodetic field of survey department. This literature tries to identifythe existing problems in defining the relationships between the networks and demonstrates the status of existing geodetic and GPS network of Nepal.

## 1. INTRODUCTION:

All national and regional surveying and mapping works are based on one single framework of Geodetic control which is considered as the primary network of the country conventionally called the first order network subsequently the control points of different orders are fixed by densifying within the primary network based on their relative precesion and categorically depending on the distance between two points. The primary or the first order network is defined by means of well defined three-dimensional reference system of co-ordinates related to the earth fixed reference system. Such a reference system is defined by the dimension of the reference ellipsoid in terms of five parameters such as semi-major axis 'a' and flattening 'f' and its position represented by regional X, Y, Z or ö,ë, h system specifying the orientation with respect to the global system, hence with respect to earth or geoid.

Usually the centre of the ellipsoid does not coincide with the earth's centre of mass but that axes are made parallel to the earth's axis of rotation with a pre assumption that global Xg, Yg, Zg rectangular co-ordinate system, has the origin which lies on the earth's centre of mass and a Z axis coinciding with the mean rotating axis of the earth, a X- axis passing through the mean of the Greenwich meridian. The Y- axis as defined by the plane which is perpendicular to X and Z-axis (
Torge, 1991, p138).

Determination of the parameters of such a reference datum defined by shape, size, and orientation of ellipsoid of revolution in other words the three dimensional co-ordinate system requires the high precision spatial measurements. This work requires highly trained and skilled manpower.
Survey Department of Nepal (SDN) adopted Everest Spheroid (1830) parameter as the reference datum to fulfil immediate need of controlled mapping in the country.

## 2. INDIAN DATUM:

The Indian datum is defined by the following parameters

Reference Spheroid : Everest (1830)
a = 20922931.80 ft
f = 1/ 300.8017
Indian datum origin : Kalianpur

Latitude (ö) = 24° 07 ' 11''.25
Longitude (ë) = 77° 39 ' 17''.57

Deflection of vertical in the
meridian (î) = - 0''.29
prime vertical (ç) = 2''.87
Geoid height (N) = 0 meters.

Survey of India (SOI) established control points in Nepal for the topographical mapping in the scale 1" = 1mile. The co-ordinates of these control points were derived by using Everest Spheroid (1830) parameters. The coordinates of these controls were provided to Survey Department/Geodetic Survey Branch (GSB) by Survey of India.

Geodetic Survey Branch (GSB) established second, third and fourth order network of control points in the districts where cadastral survey has to be done. The computation and the adjustments was done based on co-ordinates of points made available from SOI converted into

UTM rectangular system modified for Nepal large scale mapping (Triangulation Instruction book p30). As these coordinates were not from rigorous primary geodetic network it is called the
provisional co-ordinates but as referred by late Z. M. Wiedner former director of GSB in his final report these coordinates are basically used for the cadastral purpose should be named as cadastral co-ordinates.

## 3. PROBLEMS IDENTIFIED IN ADOPTING SOI CO-ORDINATES:

### 3.1 Difference in semi-major axis:

Geodetic Survey Branch (GSB) established second and lower order networks calculated in plane rectangular UTM (modified) system with the same value of the Everest Spheroid. As the Govt. of Nepal decided to adopt metric system in the country it was necessary to use the factor of conversion from foot to meter ( This factor of conversion was taken from TM5 – 241 – 7, Department of Army Technical Manual: Universal Transverse Mercator Grid Table 0 – 45)

The conversion factor and the value of semi- major axis was
1 Indian foot = 0. 30479841 m
a = 6 377 276.345 m

Adopting the Everest Spheroid (1830) with the value of semi-major axis stated above using SOI controls GSB started to establish new control points. Subsequently latter it was found that the conversion factor adopted in India was

1 Indian foot = 0.3047996 m
Therefore the value of semi-major axis comes to be
a = 6 377 301. 243 m

Since these values are used in Survey of India and apply to all SOI co-ordinates made available and used in GSB, the major axis is incorrect by 24.898 m (phuyal et.al 1992). Because of the difference of the semi-major axis, there will be a different values of co-ordinates of the SOI points converted to the rectangular UTM system, also in the coordinates of the points established by GSB and the difference have to be verified.

### 3.2 Correction in Longitude:

The survey of India (SOI) established a series of control point in Nepal and these points are based on the India datum. The Indian datum origin is based on the astronomically determined values at Kalianpur. Because the published value of geodetic longitude ($\lambda$) on the Indian datum require a correction of –3.16 seconds of arc to agree with accepted definition of datum origin therefore the prime vertical component in [$\lambda$a –($\lambda$g – 3".16)] . cos$\varphi$ and similarly , the Laplace azimuth condition is Aa-Ag = [$\lambda$a -3".16)] . sin$\varphi$ ( Report and Results of Geodetic Survey of Nepal 1981-84) or ( Bomford 3rd Ed.,pp117) therefore the values of longitude of points established by SOI in Nepal and the other values derived from these values require correction of –3.16" seconds of arc.

### 3.3 Features of Survey of India (SOI) Triangulation Network (1946-63):

In report made available to Geodetic Survey Branch such as co-ordinates, statement of the results and triangulation chart of control points survey made during 1964-63, following features were identified. Nine different series of triangulation chains were established to make a framework of control for the topographical mapping (1" = 1 mile) of Nepal. The average and maximum triangular errors in nine different series are given below.

Table – 1( Triangular error table)

| Series | Instrument used | AverageTriangular error(arc seconds) | MaximumTriangular error (arcseconds) | Closing error On Base | Remarks |
|---|---|---|---|---|---|
| A | 1arc sec Theodolite | 3 | 8 | 1/42000 | Adjusted series |
| B | do | 5 | 17 | 1/15000 | do |
| C | do | 4 | 12 | 1/5000 | do |
| D | do | 4 | 13 | 1/12000 | do |
| F(main) | do | 3 | 10 | 1/14000 | Unadjusted (closing error not adjusted) |
| E(a) | do | 4 | 10 | - | do |
| E(b) | do | 4 | 10 | 1/10000 | do |
| E(c) | do | 5 | 10 | - | Unadjusted Series |
| F(sub) | do | 3 | 16 | - | do |

The remaining triangulation network inside Nepal was based on stations of the above series with average triangular error 5 seconds and maximum triangular error 30 seconds. (Source: SOI Report, 27 June 1977)

The table-1 shows the triangulation series do not form a single network and are not homogeneous. The triangulation series named F (main), E (a) and E (b); the closing error in these chain were not adjusted where as E(c) and F (sub) the chains are left unadjusted. The reason behind this could be perhaps the starting and closing of the triangulation chain was not done in higher order stations or may be misclosure were exceeding this tolerance or the accuracy obtained was enough for the topographical mapping project.

## 4. National Geodetic Network (Nepal Datum) :

Geodetic Survey Branch (GSB) was aware of the requirement of National Geodetic datum defined by the network of points of first order controls. With the agreement between the government of Nepal and the United Kingdom's Directorate of Military Survey, Ministry of Defense (MODUK) established the first order geodetic control net consisting of 68 stations covering the east-west extent of Nepal leaving the far north area because of the rugged and difficult terrain. The task was completed in 1986.

### 4.1 Datum defined :

References spheroid: Everest (1830)
a = 6 377 276.345m
f = 1/300.8017 and ($e^2$ = 0.00663784663)
With the Geodetic Origin Station 12/57 Nagarkot defined as
Latitude ($\varphi$g) = 27° 41' 31''.04 N
Longitude ($\lambda$g) = 85° 31' 20''.23 E
meridian ($\xi$) = -37''.03
Prime Vertical = -21''.57
and assuming the geoid height
(N) = 0 meter

The deflections quoted are derived from an astronomic position observed by Czechoslovak Geodetic Institute.

The Nepal datum represents a rigorous reference system. The net in properly oriented to the conventional origin (CIO) and the scale of the net is consistent with the international standards of length defined by the Doppler satellite observation.
As stated in the Report submitted by MODUK , the geographical co-ordinates of first order points are of high standard and hence fulfill the requirement of a rigorous Geodetic datum in Nepal.

## 5. GPS OBSERVATION IN NEPAL:

In co-operation with HMG/Nepal , University of Colorado and Massachusetts Institute of technology established the precise Global Positioning System(GPS) Geodetic network throughout the country.

The objective of establishing precise GPS geodetic network was

i) to provide a precise control gird for the geodetic survey throughout the country and
ii) to establish large scale strain grid to measure the north-south shortening, east-west extension and quantifying the uplift of the terrain across the Himalayan collision zone (Bilham & Jackson,1991)

### 5.1 Datum defined :

References spheroid: World Geodetic System (WGS) 84
a = 6 378 137.00m
f = 1/298.2572235
With the Geodetic Origin Nagarkot tracking station defined as
Latitude ($\varphi$g) = 27° 41' 33''.778 N
Longitude ($\lambda$g) = 85° 31' 16''.384E

The observation took place from March 25, 1991 and ended on April 12, 1991. The instruments used for the observation were Trimble 4000 SSI and ASTECH XII GPS receivers. Three stations were held fixed during the campaign. Nagarkot (NAGA), the central station of GPS network. Jomsom (JOMO) located in the high Himalayas of the central Nepal. Simikot (SIMI), located in the high Himalayas of Western Nepal. The station Nagarkot was fixed because this station is the central station of Fist-order conventional national network. Each site was occupied with minimum of five days with each data measurement session exceeding 8 hours per day.
The best co-ordinate values in WGS 84 reference system for station related to Nagarkot were determined from a network solution of all stations. The network consist of 28 precise GPS controls.

## 6. ENTMP AND WNTMP GPS OBSERVATION:

The Eastern Nepal Topographical Mapping Project ENTMP & Western Nepal Topographic Mapping Project WNTMP was launched in order to produce new topographical map series of the country.

Geodetic controls over the project area was established by using the static relative GPS survey. In ENTMP a total of 101 stations were established and observed, the network consisting of 29 primary stations and 72 Secondary stations. Instruments used for this field survey were Astech LD-XII GPS receivers. These instruments are 12 channel and dual frequency receivers.

#### 6.1 Observations:

One session per day was observed using four to eight GPS satellites. The length of the observation session was 180 minutes in the primary network. Carrier phase observation of GPS satellites were processed using L2 corrected L1 phase measurements and double differences phase observations. Astech Inc's Geodetic post-processing software (GPPS), version 4.4.01 was used for the data processing. The adjustment of the network was done by using in FLLNET (version 3.0.00.) adjustment program. One sigma accuracy of the baselines in the Network are all better than 1-5 ppm .

### 6.2 Datum defied:

The datum is defined by the following parameters.

Reference Spheroid: Everest (1830)
a = 6 377 276.345
1/f = 300.8017

Initial Station Nagarkot :
Latitude ($\varphi$g) = 27° 41' 32".956 N
Longitude ($\lambda$g) = 85° 31' 24".991 E

Defection of vertical in the
meridian ($\xi$) = -37".03
Prime Vertical ($\eta$)= -21".57

(See Yrjola and Jarvina 1993)

As compared the parameters of Nepal datum in section 4 it showed the difference in geodetic latitude and longitude. The observed difference is

$\varphi$E - $\varphi$N = 1".916
$\lambda$E - $\lambda$N = 4".311

The elevation difference between IMSL height and ellipsoidal height from GPS in found as 13.531 meters.

The apparent differences observed is because the initial station Nagarkot is close to the fundamental station 12/157 Nagarkot but not to it.

The table below shows the different datums.
Table –2 Comparison of datums of Nepal

| Datum | India | MODUK | ENTMP | WGS84 |
|---|---|---|---|---|
| Source | Sources of India | MODUK | ENTMP project report | SDN & University of Colorado |
| Ref. Spheroid | Everest 1830 | Everest 1830 | Everest 1830 | WGS84 |
| a(semi-major axis) | 20922931.80ft | 6 377 276.345m | 6 377 276.345m | 6 378 137.00m |
| 1/f (flattening) | 300.8017 | 300.8017 | 300.8017 | 298.2572235 |
| origin Latitude ($\theta$) | 24° 07' 11".26 N | 24° 41' 31".04 N | 24° 41' 32".956 N | 27° 41' 33".778 N |
| Origin Longitude ($\lambda$) | 77° 39' 17".576 E | 85° 31' 20".23E | 85°31' 24".941 E | 85° 31' 16".384 E |
| Defection of ($\xi$ ) in meridian | -0".29 | -37".03 | -37".03 | - |
| Defection in P.vertical | 2".28 | -21".57 | -21".57 | |
| Separation (N) | 0 | 0 | 0 | |

From the Table-2-1 it is obvious that there exists four different sets of co-ordinates on four different datum. The transformation between these 4 datum has to be established.

### 7. Discussion in rebuilding of co-ordinates in National Geodetic System:

It has been felt essential that in the integration of the positions of GSB established second and lower order triangulation control points and GPS control points in National Geodetic datum to setup the homogeneity in co-ordinate system.

7.1 As the reduction of the observation and computation of GSB established points has been done on Everest Spheroid using the parameter given in section 2 with the a value of semi-major axis ‘a’ = 6 377 276.345m using SOI control point of the uncorrelated SOI triangulation series the second and lower order networks of Geodetic Survey Branch will have large discrepancies; more than the tolerance therefore it will be difficult to tie them into one single system. In that case the
second and lower order network is required to be recomputed using the first order controls established by MODUK. Once this is done we can abolish the coordinates based on Indian datum. Then the new set of co-ordinates can be considered as national coordinates.

7.2 The relationship between Nepal datum and GPS co-ordinates based on WGS84 reference datum is of immense need in GSB at present. Without the use of co-ordinates derived from rigorously adjusted first order controls GPS measurement cannot be introduced properly. In order to bring the uniformity and consistency it is very important to determine reliable transformation parameters. It can be determined only by making GPS observation in all first order points based on Nepal Datum.
7.3 It has been found less attention has been given by the Institution involved with SDN/GSB in integrating the conventional system with WGS84 reference datum.

7.4 Support of International organization is required to accomplish the above task..

7.5 The ENTMP GPS network is integrated with the national co-ordinates based on Nepal datum. In order to determine the relationship between the WGS84 and Nepal datum co-ordinates total of 11 primary GPS network station which are common to stations of primary geodetic network of Nepal was considered. Three Transformation parameters (ie block Shift ) were determined using latitude and longitude of primary geodetic network of Nepal and WGS84 co-ordinates of the same stations considering the ellipsoidal height of

Nagarkot as fixed however block shifts determined is not a reliable transformation parameter of geodetic standard. Therefore 7-parameter transformation has to be computed to define the orientation of two reference systems.

7.6 The GPS controls established in collaboration with University of Colorado and Massachusetts Institute of technology being the high precision co-ordinate value in WGS84 reference system; it is very important to integrate the conventional first order network of Nepal with this GPS network. This can be accomplished by conducting GPS observation considering the control points of two different networks in common in the observation session.

## 8. References


Acharya P., Adiga G., Phuyal B.P (1992) Geodetic Datum of Nepal, Nepal Surveyors Society Journal.

Bomford, G. (1977), Geodesy, 3rd ed., Oxford University Press.

Billham R. and Jackson, M 1992, Nepal 1991 GPS Measurements, Progress Report to HMG/Nepal

Manandhar N. (1997), Geoid Studies for Nepal, M.sc Thesis, University of New South Wales, Sydney, Australia.

Reports and Results of a Geodetic Survey of Nepal, 1981-84, Technical Report, submitted to Nepal Survey Department.

The Defence Mapping Agency (1987), DMA Technical Report (Supplement to Department of Defense World Geodetic System 1984 Technical Report) Part1: Methods, Techniques, and data used in WGS84 Development. DMA TR 8350.2 2-A Washington D.C.1 December 1987. Torge, W. (1991). Geodesy. 2nd Edition. Walter de Gruyter: Berlin, 1991

Triangulation Instruction Book, Geodetic Survey Branch.

Yrijola, J and Jarvine, T. 1993, Reports on GPS Survey of Nepal, Technical Report, Nepal Survey Department.


✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

## Japanese Society of Photogrammetry and Remote Sensing (JSPRS) Award

*(for Best Presentation from Young Authors.)*

1. Mr. Yongcheol Suh, University of Tokyo, Japan
   "Development of a Simulation System for Assessing the Layout of Pseudolite"
2. Ms. Zhihua Wang, China Aero-Geophysical Survey & RS Center for Land Resources, China
   "Satellite Monitoring of the Yigong Landslide in Tibet, China"
3. Mr. Sendo Wang, China Taipei,
   Image Orientation by Fitting Line Segments to Edge Pixels"
4. Mr. Tika Ram Adhikari, Kathmandu Valley Mapping Programme, Nepal
   "An Appropriate Urban Management Decision with a Remote Sensing and GIS Technology Integration Approach"
5. Ms. Atiek Widayati, ICRAF SEAC Indonesia
   "An Application of Combined Spectral-Based and Spatial-Based Approaches for Improved Mixed-Vegetation Classification using IKONOS"
6. Ms. Sangita Kharel, Kathmandu University, Nepal
   "Wildlife Corridor Mapping between Royal Bardia National Park, Nepal and Katarniyaghat Wildlife Reserves India by using GIS.

## Technical Committee Members for the 23rd ACRS

| | | | |
|---|---|---|---|
| 1. | Prof. Dr. Vishal Nath Uprety, | Geology Department, T.U., Nepal | : Chairperson |
| 2. | Dr. Nanda Gopal Ranjitkar, | Geography Department, T.U., Nepal | : Member |
| 3. | Dr. Pushkar Pradhan, | Geography Department, T.U., Nepal | : Member |
| 4. | Mr. Pramod Pradhan, | NITI, Nepal | : Member |
| 5. | Mr. Pradip Mool, | ICIMOD, Nepal | : Member |
| 6. | Dr. Krishna Pahari, | University of Tokyo, Japan | : Member |
| 7. | Dr. Dhruba Pikha Shrestha, | ITC, The Netherlands | : Member |
| 8. | Dr. Dinesh Manandhar, | University of Tokyo, Japan | : Member |
| 9. | Mr. Durgendra M. Kayastha, | Survey Department, Nepal | : Member Secretary |

# GLOBAL POSITIONING SYSTEM ON CADASTRAL SURVEY OF NEPAL

**Krishna Raj Adhikary**
Chief Survey Officer
Geodetic Survey Branch, Survey Department
Minbhawan Kathmandu Nepal
Email : astrogeo@htp.com.np, krishna_adhikary@hotmail.com

**KEY WORDS:** Cadastral survey, global positioning system, geodetic control, and adjustment

**ABSTRACT**

Preparation of a series of cadastral maps and distribution of the land ownership certificates to each landowner of the whole kingdom of Nepal has been completed recently. However, half of the cadastral mapping of the country was carried out without the national coordinate system references and attention has given to map the private cultivated land, public land and government land with settlements during the cadastral surveying and mapping of the country. During the cadastral mapping of the country, it was realized that a national system of geodetic network of different order of ground control is required to prepare the large-scale map of the whole of the kingdom of Nepal. Everest spheroid 1830 and UTM
(modified with three degree zone) projection system was selected for the geodetic reference and the higher order and lower order geodetic control networks was established with the traditional geodetic survey equipment i.e., theodolite and distance meter.

This paper describes the observation procedure and the adjustment results with the accuracy standard of the geodetic control network of Nepal established in different time using different types of equipment and techniques. Attempt has been made to give some idea on the use of Global Positioning System GPS control network extension for the production of large-scale cadastral plan of the country. A pilot project was selected to evaluate the results of the GPS techniques with that of the traditional theodolite and distance meter techniques for the control points extension of the large scale cadastral mapping of the densely populated area of the country.

## 1. INTRODUCTION

### 1.1 Land in Nepal

Kingdom of Nepal has an area of 147181 sq. km. and a population of over 23million (2001 census). Population density of the country is 157.73 per square kilometer. Himalayan region, north of Nepal, is difficult for accessibility and cultivated land / population is very small. The mountain region, middle part of the country and terai (flat ground) region, southern part of the country, has its cultivated lands and most of the people live on this part of the country. Land in Nepal is categorized into government, public, trust and private lands. The government and public land consist of all that land defined by the Land (survey and measurement) act 1963. Government land includes the land occupied by the roads, railways, forest, rivers, ponds and other lands in its possession. Similarly public land constitutes the land of public importance as defined by the Land (survey and measurement) act 1963.Nepal is a country of temples. It has got its own religious and cultural importance. People and the government has donated the land/trust land, so that the income of the land will support to preserve its cultural heritage and maintain the religious activities of the temple.

### 1.2 Geodetic control

In Nepal, Survey of India has established Triangulation survey frameworks during 1954-60 under the Colombo plan agreement for the surveying and mapping activities in Nepal. These controls are mainly used for the preparation of topographic base map at 1" to 1 mile. Survey of India did the fieldwork and subsequent computation and adjustment with the following reference system.

Reference spheroid: Everest1830 a=20922931.8ft f=1/300.8017 $e^2$= 0.00663784663

Origin: Kalianpur h.s Latitude 24° 07' 11.26"N

Longitude: 77° 39' 17.57"E

Meridian: -0.29"

Prime vertical: +2.28"

The survey department with the collaboration of the government of United Kingdom has established the geodetic Triangulation survey network of Nepal during 1981-1984 and the subsequent mathematical adjustment with final result was completed on 1986. Eastern and western Nepal topographic mapping project (1991 &1997) has also established Geodetic Control Net of Nepal for the preparation of topographic base map of Nepal with the following geodetic reference system which is different from the survey of India geodetic reference system.

Reference spheroid: Everest (1830) a=6377276.345m f=1/300.8017 $e^2$ = 0.00663784663

Origin: 12/157 NAGARKOT

Latitude= 27° 41' 31.04"N

Longitude = 85° 31' 20.23"E

Meridian = -37.03"

Prime vertical =-21.57"

Vertical Datum of leveling network of Nepal is based on Birjung and Bhairahawa fundamental benchmarks of Survey of India values relative to the mean sea level.

### Use of Global positioning System

The Global Positioning System (GPS) is a satellite based navigation system and is designed to operate 24 hours in all weather for Global coverage. The system has three segments. A space segment including 24 GPS satellites in 6 orbital planes. They transmit the data of ephimeride, almanac line, satellite health, ranging signal and atmospheric conditions. A control segment includes the ground monitor command and control function. It performs the tracking, orbital determination, time synchronization function. A user segment includes GPS receiver, which tracks the satellites and identifies the individual satellites. The receiver decodes the satellite signals and computes the position such as latitude, longitude and altitude. GPS is used for the position determination on the earth surface with the following reference system.

Reference system: World Geodetic System 1984 (WGS84) origin at the earth's center.

Semi major axis (a): 6378137.00m

1/f 298.2572235

Origin latitude 27° 41' 33.778''N

Longitude 85° 31' 16.384''E

Global positioning system (GPS) was introduced in Nepal by the Japanese consultant in 1988 for the establishment of control points for photogrammetric triangulation in Lumbini zone mapping project (JICA). Latter on Survey department with the collaboration of University of Colorado (USA), Eastern and Western topographical mapping project has established the GPS Higher order control points in Nepal. As a result of these experiences, in 1994 Survey Department has introduced the GPS technology for the extension of geodetic network of Nepal. Now a day's GPS is the main techniques for the extension of higher order controls in Nepal.

The University of Colorado and Massachusetts Institute of Technology established the precise Global Positioning system (GPS) geodetic Net during 1991. The instruments used for the observation were Tremble 4000SST and ASTECH SLLGPS receiver. Three stations at Nagarkot, JomSom and Simikot were held fixed during the observation and each station was occupied with minimum of five days of at least 8 hours per day with each data measurement. The raw data file of the Ashtech and Tremble were converted to RINEX format using Berness V.3.3 GPS software.

The Eastern Nepal Topographical Mapping Project 1994.established some of the first order Geodetic Control in Nepal covering eastern and central development region of Nepal. The existing first order Geodetic Control Net 1981-84 were checked and utilized during the observation and adjustment of Geodetic Control Net of eastern Nepal Topographical Mapping Project. The methodology for the observation of first order geodetic control net of 1981-84 was according to the traditional theodolite and distance meter. However the eastern Nepal topographical mapping project utilizes the method of Global Positioning System (GPS) for the observation and subsequent adjustment thereof. The project has established 13 new geodetic primary stations with the help of existing 16 geodetic first order points.

Geodetic Control over the ENTMP project area was established by using the static relative GPS Survey. Altogether 29 primary stations (13 new and 16 old) were established and observed by using Astech LD_SLL GPS receivers. One season per day was observed with four to eight satellite in 180 minutes. Astech Inc's Geodetic Post Processing Software version 4.4.01 with fillnet version 3.0.00 adjustment program was used for the processing and adjustment of data transformation of WGS4 coordinates to UTM (Nepal System) was done by affine transformation.

The Western Nepal Topographical Mapping Project (WNTMP) consists of western, mid western and Far Western regions of Nepal. The project is implemented in co-operation with HMG survey Department Nepal and FM International OY (FINNMAP). The ground control Survey was based on GPS (Global Positioning System) measurement. Altogether 51 primary GPS stations were established and computed as free network using one existing point of ENTMP as initial stations. WGS-84 co-ordinates were transformed to Nepal reference datum by affine transformation and orthometric heights were computed by geoid model. The survey of ground control points was based on the use of global positioning System (GPS). ASHTECH GPS receiver made observations with four dual frequencies using station relative positioning. Observation time for all seasons was planned to 180 minutes were down loaded in micro computer and field computation were carried out using astech Inc's Geodetic post processing software (GPPS) version 4.4.01.First order network consist of 121 base lines and 51 stations. The adjustment was done as " free network adjustment" using only one first order point as fixed point using Ashtech Inc.'s FILLMAP software version 3.0.00. The accuracy was controlled over 1-sigma accuracy of the base line. These varied mainly between 0.9 to 2.2 ppm.

### 1.3 Nepalese Cadastral survey

Cadastre has existed, in some form, in Nepal since 300 AD. The role of cadastre for tax assessing was commenced in about 1300AD. Land registration process was introduced during 1923 AD in order to give the assurance of the transacted amount of money during land transaction. With the introduction of the land survey (survey and measurement) act 1963,the the cadastral map become the legal documents defining the boundaries of all land properties and provide the basic data for land administration including land taxation and become an integral part of the land registration process.

Preparation of a series of nationwide cadastral maps of kingdom of Nepal was initiated during 1964. Cadastral survey was designed to serve the tenancy reform of 1964 to combine the twin objectives of tenancy as well as revenue survey with less emphasis on the usual cadastral objectives. National geodetic network was not available on those days to prepare large scale cadastral map of the country. Out of 75 district of Nepal, Cadastral maps of 38 district were prepared without the national geodetic control points forming the island map sheets of cultivated land The areas of land parcels quoted in the land register as well as the ownership certificate are at the variances with the true physical areas This causes problems at the time of land subdivision for sale or transfer.

Surveying of remaining 37 districts was carried out with national geodetic control and emphasis is given to meet the cadastral surveying objectives. Cadastral survey office was established in each district after the completion of the cadastral surveying of the district. Updating the cadastral maps and documents should be done by this survey office at the time of land subdivision for sale or transfer in theprocess of land administration. Nine survey offices are engaged on different district to update those cadastral maps and documents which does not serve the cadastral surveying objectives. All these maps are based on the controls provided by the GPS technology.

## 2. GEODETIC SURVEY NETWORK OF NEPAL

### 2.1 Laplace stations for azimuth

In 1976-77 astronomic observation for position and azimuth at 7 stations in Nepal was carried out in collaboration with the Czechoslovak Geodetic Institute. The following points were taken into account while establishing the laplace stations.

- The astronomic positions were observed by the Latitude and Longitude methods of time transits of pairs of stars at equal altitude using T4 thedolites. Times were recorded by impersonal micrometer operation of quartz crystal clocks.
- Standard error value is of the order of ± 0.10 to ± 0.20 seconds arc in both latitude and longitude.
- In 1981-84 geodetic Survey astronomic positions were observed by the position line method of timed altitude of balanced sets of stars using T3 thedolites.
- Hand switch operation quartz crystal clock and mechanical chronometer recorded times.
- Azimuth observations reduced by black's method, which provide deflection component values, were observed at some station using the same equipment as the position line observations.

Geodetic Network was established at 68 different places distributed all over the country. The high Himalayan part of Nepal was not included on the net as it is not accessible for the ground observation.

The control net includes 13 of the 14 Doppler Station established in 1984, existing stations of Survey of India survey framework of 1954-60 and newly monumented survey stations. The control net also includes microwave communication control with an associated ground station sites in the terai region of Nepal. All the Laplace station (Astronomic Observation during 1976-77) together with some of the additional astronomic observations were included in the observation of Geodetic net of 1981-84.

### 2.2 Horizontal angle and length measurement of the geodetic network

Wild T3 Theodolites (occasionally wild T2 Theodolites) are used for the horizontal angle observation of the geodetic network (1981-84). A set of observations consisted of 8 rounds and two sets of observations of an angle during a single period and further two sets or another occasion by different observer were observed (i.e. 4 sets in 32 rounds). Additional sets were observed if 4 individual sets exceeded 2 seconds arc or misclosure of 3 angles of a triangle exceed 3 seconds arc. For verticality of the theodolite the inclination greater than 10 30' readings of horizontal plate level were recorded.

EDM microwave equipment operating on a carrier frequency of 10 GHZ, instruments are used for length measurement. Tellumat model MRA5, Tellumat Model CMW6 and Microfix model 100c instruments were also used for length measurement. For air temperature reading a mercury thermometer tested in a psychrometer in agreement to within 0.5 degree Celsius and dry bulb temperature was correct to one degree. For air pressure reading aneroid barometer of digital reading type and altimeter instrument were used.

### 2.3 Vertical angle observation and computation:

The vertical angle observation was carried out during geodetic survey network observation (1981-1984). The computation of vertical angle observation and subsequent height determination was carried out and results were found as follows.

- Values of the combined curvature and refraction correction factor were derived in seconds of arc per kilometers of line length.
- Standard derivation of an observed value of the combined curvature and refraction correction is ± 0.2 sec/km.
- The variation in refraction on lines between "hill stations" is very small and does not differ much by time of observation.
- The variation in refraction on lines between hill station and plain station is a marked difference and it was taken account in selecting the most probable value.
- Misclosure value i.e. mean value of the height differences observed on each line, range from a minimum of less than 0.1m to 4.1m with an average value of 1.1m.
- The typical standard error uncertainly in an observed height difference was of the order of ±1.0m for a line of 40km in length.
- Net consists of 261 observed height differences on 138 lines.
- At some Micro Communication Centre sites there is a discrepancy between elevation value from the level net.

### 2.4 Adjustment of plan control and its analysis

A number of trial adjustment were made using different types of data available in the Survey Department of Nepal (i.e. Doppler observation 1980-81, ground survey Laplace azimuth, astro azimuth observation 1981-84 and Geodetic Survey net observation 1981-84 etc).

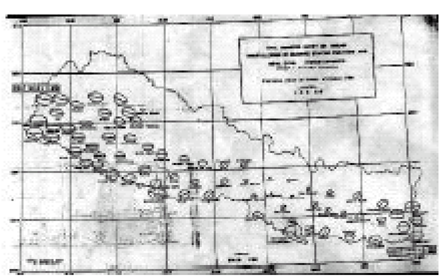
The bias Parameters was introduced in the adjustment to allow for systematic bias in some classes of observation. Care was taken that the standardization of the instruments for length measurement to be used was made by the manufacturer and with proper atmospheric correction formulation principle. Thus the effect of scale bias in the length is removed in the adjustment.

The adjustment of the net was made by the least square method of variation of geographic coordinates on the reference spheroid and "Nagarkot Station" was held fixed to its defined position. All the observational data was expressed in terms of the reference spheroid.

The Standard error of unit weight determined in the solution was 1.15 and standard error uncertainly of each azimuth value was based on the estimated positional accuracy of ±0.5 metre over the length of the line concerned.

Standard error (se) uncertain in the adjusted–Positions of the stations relation to the fixed origin station (i.e. Nagarkot) vary from zero up to ±0.30m in latitude and ± 0.45m in longitude at the east and west extremes.

A plot of the obsolute error ellipses of the adjusted stations shows that the direction of the major axes tends to be radial from the fixed origin**.**



## 3. GPS GROUND CONTROLS IN CADASTRAL SURVEYING

Cadastral surveys are the surveys carried out to support registration of interest in land. They usually result in the preparation of the cadastral maps and land registration documents. Cadastral survey in Nepal is carried out in three different scale i.e, 1:2500 scale maps for the agriculture land,1:1250 scale maps for the semi urban land and 1:500 scale maps for the urban land of the country. At least six ground controls are provided on each sheet of the cadastral map. Since 1994AD,Geodetic survey branch initiated to use the GPS technology to provide the ground control network. They are placed at about 5km apart on the basis of existing geodetic net of higher precision. GPS control survey is completed on 8 districts out of 38 uncontrolled cadastral mapping districts of Nepal and 11 district are in progress.

In order to see the results of the GPS techniques with that of the traditional theodolite traverse existing lower order ground controls are selected and GPS observations on those points were made and the results are evaluated and found that the accuracy is well within the cadastral standard. Sample result of the coordinates and the differences are shown below.

| Station No | Traverse coordinates | | GPS coordinates | | Difference | |
|---|---|---|---|---|---|---|
| | Y | X | Y | X | Y | X |
| G3 | 626920.422 | 3066671.838 | 626920.413 | 3066671.819 | -0.009 | -0.019 |
| G2 | 626847.403 | 3066574.53 | 626847.414 | 3066574.514 | 0.011 | -0.018 |
| T1 | 626855.43 | 3066541.045 | 626855.438 | 3066541.003 | 0.008 | -0.042 |
| T2 | 626882.053 | 3066444.362 | 626882.046 | 3066444.297 | -0.007 | -0.065 |
| T3 | 626794.519 | 3066350.082 | 626794.5 | 3066350.055 | -0.019 | -0.027 |
| T4 | 626925.418 | 3066395.973 | 626925.408 | 3066395.962 | -0.01 | -0.011 |
| T5 | 627053.106 | 3066305.452 | 627053.061 | 3066305.41 | -0.045 | -0.042 |
| T6 | 627151.535 | 3066321.927 | 627151.481 | 3066321.848 | -0.054 | -0.079 |
| T7 | 627088.925 | 3066366.578 | 627088.902 | 3066366.528 | -0.023 | -0.05 |
| T8 | 627124.475 | 3066457.04 | 627124.471 | 3066456.99 | -0.004 | -0.052 |
| 14121 | 626948.366 | 3066547.753 | 626948.379 | 3066547.747 | 0.013 | -0.006 |
| G1 | 627002.66 | 3066529.41 | 627002.665 | 3066529.392 | 0.005 | -0.01 |

## 4. CONCLUSION

Survey department of Nepal has been using GPS technology for the extension of ground control to provide control for large-scale mapping. At the moment though, there is not much GPS activity in the area of cadastral surveying, attempt should be done to go further to use the potentiality of GPS technology e .g, Real time Kinematics' Systems for the rapid point layout of the individual parcel. The use of GPS technology into this area of data collection in cadastral surveying is a change that will therefore have to necessitate certain changes in the institutional and technical framework of the survey department.

## REFERENCES


1. K. R. Adhikary: Data collection for aerial triangulation with real time quality control, M. Sc. thesis 1982 ITC The Netherlands.
2. K. R. Adhikary Triplet and quadruplet in online photogrammetric triangulation ITC Journal 1982-4 The Netherlands.
3. K. R. Adhikary Surveying and mapping accuracy test: An user approach Iind National conference on science and technology RONAST Nepal 1994.
4. K. R. Adhikary Test on mapping applications of metric camera (space lab) fifth Asian conference on remote sensing Nov 15-18 ,1984 kathmandu.
5. K. R. Adhikary Survey Department today and tomorrow 21st Asian conference on remote sensing Taiwan 2001.
6. K. R. Adhikary Introduction to global positioning system and an investigation to utilize in Nepal: sixth seminar of survey officers, survey department 1990.
7. K. R. Adhikary A photogrammetrist view of remote sensing: NRSC conference Kathmandu Nepal1983.
8. Survey Department Unpublished report on first order geodetic network of Nepal 1981-1984
9. Survey Department Unpublished report on GPS survey of eastern and western Nepal topographical survey mapping project 1994,1997.
10. Gordon o. wayumba et. al. GPS in cadastres: A case study of Kenya ACSM-ASPRS 2002 annual conferences.
11. Pro. Ian P. Williamson Cadastral tool box: a frame work for reform FIG XXII International congress Washington DC USA2002
12. Jurg Kaufmann Bench marking cadastral system result of the working group 7.1 FIGXXII International congress Washington DC USA2002.

# ORTHOPHOTO MAPPING: A FUNDAMENTAL DATA LAYER FOR URBAN GIS IN NGII IN NEPAL

**R.R. CHHATKULI**
***National Geographic Information Infrastructure Programme***
Survey Department, Kathmandu, Nepal
Phone: +977.1482.903, Fax: +977.1.482.957, Email: ngiip@ccsl.com.np

**KEYWORDS:** Urban GIS, High-resolution imagery, Orthophotography, National Geographic Information Infrastructure

## ABSTRACT:

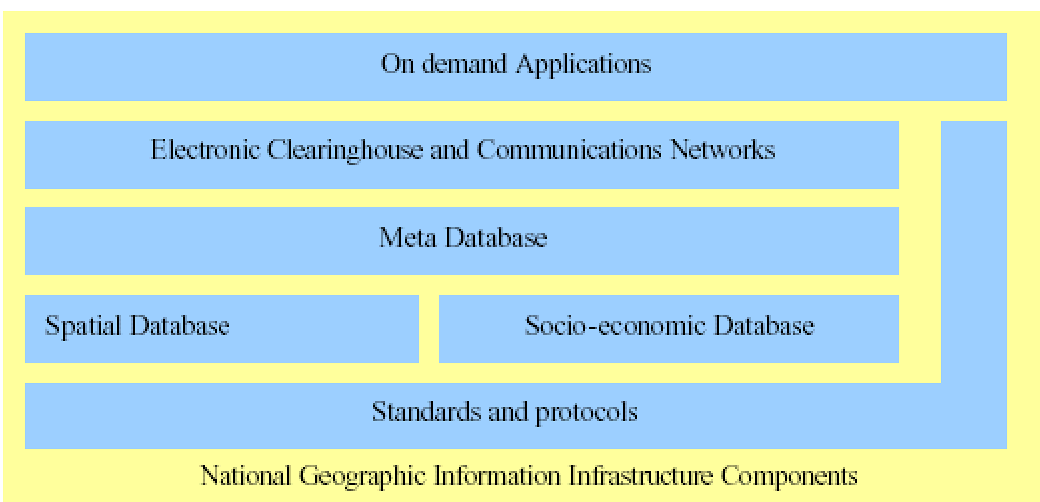
More recently, a national geographic information infrastructure programme to support spatial data need of different users has been initiated in Nepal. Quite often, urban planners need very detailed topographic details for their applications and more often they need a temporal coverage of data. Line map data layer having a clean topological vector database have very easy applications in a GIS, but they cannot fulfill many of the urban planning needs. To cater for these needs, an orthophoto map layer in the Nepalese NGII is under progress. The rationale and the coverage of the current orthophoto-mapping programme have been explained. A suggestion for a temporal coverage of orthorectified high resolution remote sensing imagery has been suggested.

## 1. NATIONAL GEOGRAPHIC INFORMATION INFRASTRUCTURE IN NEPAL

Geographic Information System (GIS) and Remote-sensing (RS) are very effective tools for the study, monitoring and management of spatial decision-making. GIS and RS become versatile, efficient and cost-effective due to the possibility for multifarious applications and usages of general framework spatial and attribute data. In Nepal, due to unavailability of such digital data, each GI Systems had to spend a lot of resources in its development as part of the GIS project. That meant a lot of duplication and loss of resources, which would eventually affect the time, budget and the efficiency of the system. The current national geographic information infrastructure (NGII) initiative undertaken by the Survey Department of His Majesty's Government of Nepal will help in the sharing of data in the country and thereby on the efficiency and cost/ time effectiveness of individual GI systems.

The National Geographic Information Infrastructure (NGII) in Nepal has a broader objective of strengthening planning and resource management through availing geo-spatial and thematic information to decision makers at all levels. This is proposed as a national spatial data infrastructure (NSDI) consisting of fundamental datasets, electronic clearinghouse, communication networks and on-demand applications. A schematic representation of the various components of the Nepalese NGII is shown in Fig 1.

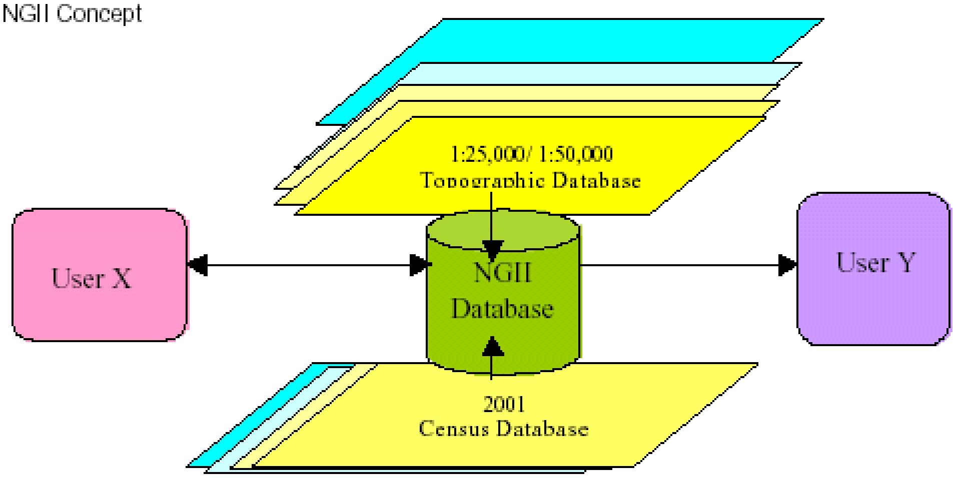
Figure 1; Schematic Representation of NGII Components




The fundamental spatial dataset in the NGII in Nepal are the National Topographic Database (NTDB) and the fundamental socio-economic dataset are the National Census Database (NCDB). The NTDB will have a horizontal coverage covering the whole country and vertical coverage at the scales of 1:25,000/ 1:50,000; 1:100,000; 1:250,000; 1:500,000 and 1:1M. The primary data input in the NTDB is the digitalization of the 1:25,000/ 1:50,000 topographic base maps produced by the Survey Department between 1992- 2001. The base data are generalized for the reduced resolutions and separate data layers are archived in the database.

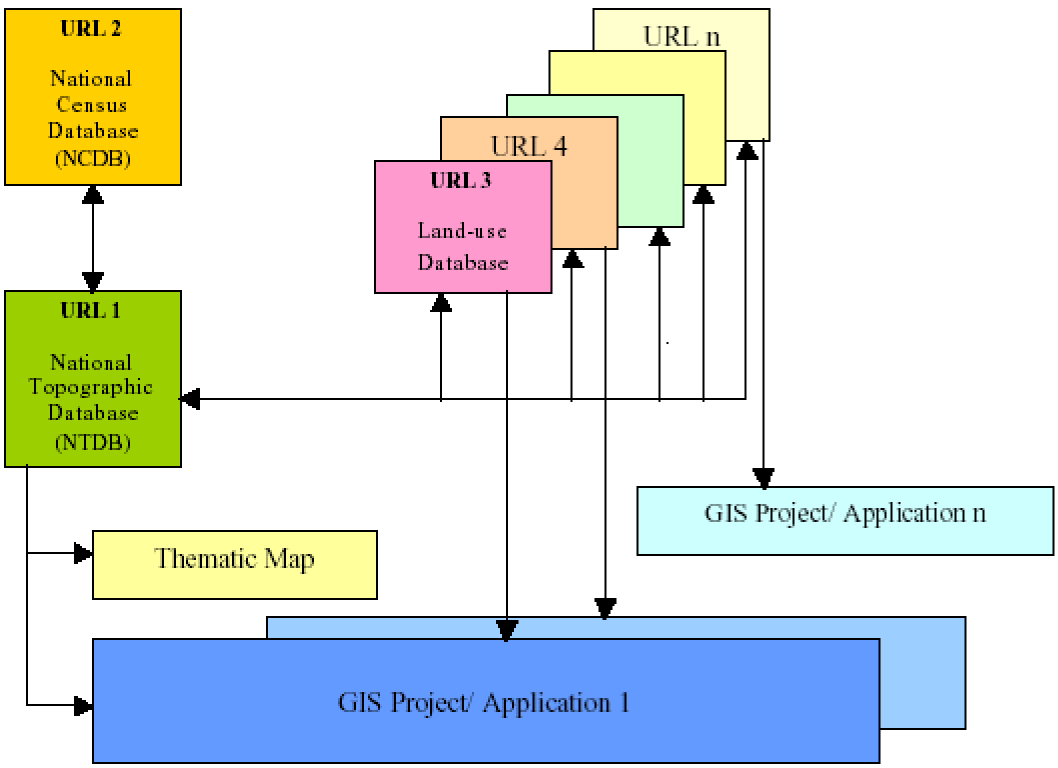
The NCDB is based on the results of the decennial national population and housing census. Therefore the NCDB will have a temporal coverage of decennial interval.

Figure 2: NGII Concept




The NTDB database maintained at the Survey Department (SD) and the NCDB database maintained at the Central Bureau of Statistics (CBS). They will be fully integrated and available as fundamental NGII dataset for different applications.

Figure 3: Generalized Schema of NGII




**2. FUNDAMENTAL SPATIAL DATA LAYERS IN THE NEPALESE NGII**

The spatial database of NGII has the following major fundamental datasets:

- Control points,
- Administrative Boundary,
- Designated Areas,
- Transportation network,
- Buildings,
- Landcovers,
- Hydrography,
- Topography,
- Utilities,
- Toponymy.

The above become essential framework data for all GIS applications, but they become insufficient for many applications. The urban growth in Nepal has been very rapid and in most of the cases unplanned and haphazard. Therefore for monitoring of urban phenomena and carrying out rational urban planning activities, it is felt that topologically clean vector database alone will not be enough to give a very clear picture of the existing situation. The urban planners at one time or
other find it useful to have a pictorial view of the situation as an additional data layer.

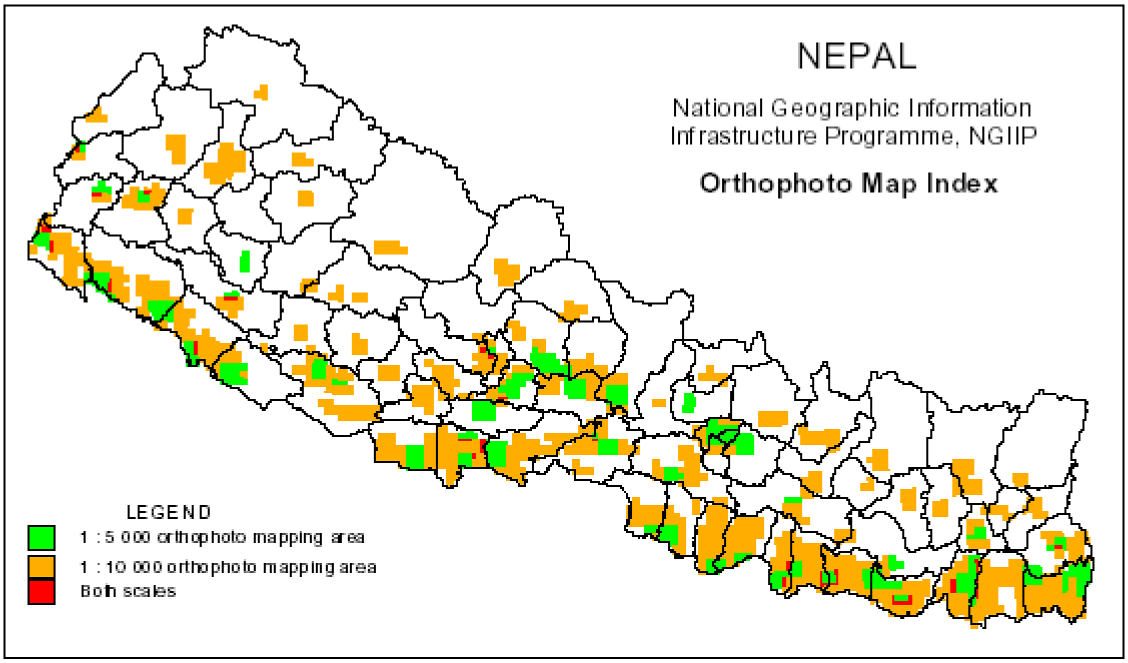
Orthorectified image layer of necessary resolution is proposed as the answer to this demand. This should form one of the important data layers in urban GIS.

## 3. ORTHOPHOTO- MAPPING STATUS IN NEPAL TO SUPPORT URBAN GIS

Traditionally, Nepal had an experience of photomapping to cater for specific needs of the users. Quite often semi-controlled photo-mosaics or rectified photo mapping were conducted in the last 25 years to support specific user applications. With the advent of digital techniques, it has now become possible to digitally ortho-rectify photo imagery with more ease and accuracy. Survey Department recently launched an ortho-photo mapping project under its NGII programme to support general applications among which the urban planners and managers are the major target group.

Nepal has 58 municipalities the so assumed densely populated urban areas and many other areas, which are semi-densely populated. The densely populated urban areas are estimated at 7500 km2 and the semi-densely populated urban areas are estimated about 25000 km2. The orthophoto-mapping for the densely populated urban areas are based on 1:15,000 scale aerial photography of 1998-99 and that of semi-densely populated urban areas is based on the 1:40,000 - 1:50,000 aerial photography of 1996. The area of ortho-photo mapping is shown in figure 4.

Figure 4: Index of Orthophoto- mapping in Nepal




The orthophoto-mapping are conducted under the following procedure. The original film negatives or diapositives as appropriate are scanned using precise photogrammetric scanner with scanning resolution of 20 microns. Digital ortho-rectification is carried out using the GCP data and further control data derived from aerial triangulation. Digital Elevation Models are derived using the method of autocorrelation. Additional support is taken from the existing digital database based on 1:25000 scale/ 20m interval contour map digitization, where necessary. The accuracy of orthorectification for dense areas and semi-dense areas are expected as 2m and 5m respectively. Based on the resolution of imagery and the accuracy, the assumed mapping scale of the ortho-photo mapping are assumed as 1:5,000 and 1:10,000 respectively.

## 4. PROBLEMS OF ORTHO-PHOTO MAPPING IN NGII

- The orthophoto-mapping based on aerial photography being a complex process involves various expensive and sensitive hardware and software. It is felt that a non-commercial organization will severely under-utilize them, and is considered un-economic to install the full orthophoto-mapping system. Therefore, not all hardware and software are available in-house.

- There is a large time-lag between aerial photography and the orthophoto image production.

- It will not be too easy and economic to have temporal data layers of orthophoto- images in the database.

- Suitable data dissemination policy needs to be in place to correspond with the aerial photo distribution policy of the country.

## 5. CONCLUSIONS AND RECOMMENDATIONS

The ortho-photo mapping project is in the progressing phases and the results are not yet ready for dissemination. The conclusion from the experience so far is that it is expensive and high-tech project. The full conclusion on the economy and suitability of the project can be adjudged after the results have been tested by the users. The Urban Planning and Building Construction Department has already been looking forward to them for their forthcoming urban mapping and urban GIS application.

It is felt that the use of high-resolution satellite imagery could be more economic and efficient in many respects compared to ortho-photo mapping from based on traditional aerial photography. It is expected that most of the problems outlined in section 4 could be overcome using such highresolution satellite imagery for ortho-photo mapping.

However, this conclusion is based on theory alone. We do not have the experience of using highresolution imagery for ortho-photo mapping for a project of similar size. A pilot project is recommended for being undertaken.

## References:

Aronoff S. (1991), Geographic Information Systems: A Management Perspective, WDL Publications, Canada

Brinker, Russel C. & Minnick, Roy; Edt (1997) The Surveying Handbook, CBS Publishers and Distributors, New Delhi

Chhatkuli, R.R. (1996); Geoinformatics: A New Challenge to Surveying and Mapping Professionals in Nepal, Nepal Surveyor Vol 1996.

Chhatkuli, R.R. (2002); Concepts and challenges of National Geographic Information Infrastructure Programme in Nepal, Valedictory Lecture, 5th ESRI India Users Conference, New Delhi, 23 January 2002.

Harvey, Francis (2001); US National Spatial Data Infrastructure (NSDI), GIM Volume 3, March 2001.

Korte, George B. (1994), GIS Book, OnWard Press, USA

Maser, Ian (2001); The Indian National Geospatial Data Infrastructure, GIM Volume 15, August 2001.

Roger, Gilles and Lopez, Salvador (2001), Nepal Population and Housing Census 2001: Mapping Component, EC Nepal, July 2001 (Unpublished Revised Draft Report).

Star, Jeffery & Estes, John (1990), Geographic Information Systems: An Introduction, Prentice Hall Inc, USA

✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

# TOWARDS STRATEGIC PLANNING FOR BUILDING LAND INFORMATION SYSTEM (LIS) IN NEPAL


**Arbind Man Tuladhar**
International Institute for Geo-Information Science and Earth Observation (ITC), Enschede
Tel: 31 (0) 53 4874312, Fax: 31 (0)53 4874335
Email: tuladhar@itc.nl
THE NETHERLANDS

**Krishna Raj BC**
Department of Survey, Min Bhawan
Tel: 977-1-4482713, Fax: 977-1-4482957
Email: krishnabc@hotmail.com
Kathmandu NEPAL

**Nama Raj Budhathoki**
Department of Land Information and Archives (DoLIA),
Tel: 977-1-4477615,
Fax: 977-1-4477613
Email: namaraj@dolia.gov.np
Kathmandu NEPAL



**KEY WORDS:** GIS, Geo-ICT, LIS, Land administration, Strategic plan, SWOT analysis


## ABSTRACT


The interaction of human societies with land is becoming crucial for the economic, social, political and environmental development. In Nepal, the main causes for the increased scarcity of land and destruction of natural resources (deforestation & degradation of agricultural land) and increasing uncontrolled urbanization are mainly due to the rapid population growth and high migration from rural to the urban and terai (i.e. flat/ plains). For managing and controlling the use of land and resources, a reliable land information system (LIS) is a prerequisite. Recently HMG Ministry of Land Reform and Management (MLRM) has established “Department of Land Information and Archive (DoLIA)” as a new dedicated department. The main tasks are to build and maintain a nation-wide LIS for timely supply of reliable land information to all its users at an affordable cost. Since such tasks are complex in nature, time consuming and costly, it requires the realistic strategies to carry out its tasks.

This paper overviews the effort that has been put for the last nine years to build LIS in Nepal. It then provides an approach to continue the effort by formulating a strategic plan for the DoLIA within internal and external environmental constraints. To support such formulation, the situation analysis with respect to strengths, weakness, opportunities and threats are performed. The paper then presents a broad LIS vision and various strategies to meet in a planned time with the effective utilization of resources.


## 1. INTRODUCTION

Land is the means of life on which our continued existence and progress depend. It is, in one way or another, the basic source of most of the material wealth. Because land is fixed and the world population is growing, the land-to-people ratio is decreasing. Since land is becoming increasingly valuable asset in the society, there is a growing demand for the better security of land right. Therefore the transparent and efficient land administration services, the higher revenue collection and proper utilization of land have drawn national focus in most of the countries. Since land plays central role in preserving the environment and optimum utilization of its resources, it has become a subject of constant international concern in recent years. These have triggered the need for more effective land management and therefore land administration organizations are in tremendous pressure for the timely supply of reliable and accurate land information. In such context, a land information system (LIS) plays crucial role as an efficient and effective instrument for land management.

Introduction of geographical information and communication technology (Geo-ICT) for various components of LIS such as capturing, storing, processing, managing, analyzing and disseminating the land information have tremendous impacts on functioning the tasks of organizations. These impacts relate to institutional, legal, financial and technical issues, and need to be carefully planned and managed to build and maintain a LIS. Hence the tasks of building, operating and maintaining LIS require clear strategies that need to be formulated and strictly adopted by the organizations.

## 2. EMERGING TRENDS AND ISSUES

The international initiatives such as the Bathurst Declaration (FIG, 1999) and various workshops on land administration (Groot and Molen, 2000) suggest that cadastre and land registration systems are currently undergoing major changes worldwide. On such changes, the emerging trends are to focus on easy access to land, security of land tenure, establishment and operation of efficient land markets, re-engineering of land administrations, development of land information systems (LIS) particularly cadastral and land registration systems, etc. These initiatives have encouraged nations, international organizations, policy makers, administrators and other interested parties to promote the cadastral future vision, which is to develop a modern cadastral infrastructure that facilitates efficient land and property markets, protect the land rights of all, and support the long-term sustainable development and land management.

In support of these above initiatives, Williamson and Ting (2001) provided a global framework for reengineering land administration systems whereby the system is developed and continuously refined with the vision of a new humankind-land relationship in the light of the existing land administration system. Under this conceptual framework, a process of change would be dominant issue within the context of institutional, social, culture, legal, financial and technical changes within a country, as it has to transform the existing situation to the desired new situation.

## 3. MANAGEMENT FRAMEWORK AND STRATEGIC PLANNING

Modernizing land administration organisations in the developing countries (or countries on transition) posses many management challenges for the responsible organization. The challenges concern external and internal driving factors, which need to be managed properly. It is generally known and recognized that resistance to change is high and attempts are needed through an assessment of cultural readiness and to apply change management framework. Environmental factors (such as land policy, user requirements, etc.), strategic planning, business process, geo-information technology, data models, organizational aspects including people and finally products, service and performance are the key elements in management framework. The following figure no.1 provides such general framework for the development or reengineering of cadastre and land registration system (Tuladhar, 2002).

The essence of this framework is that it allows us to apply the modern technology of business reengineering concepts and tools in order to implement, operate and maintain the LIS system successfully. Here strategic planning is a key management tool, which manages the changes in an organisation.

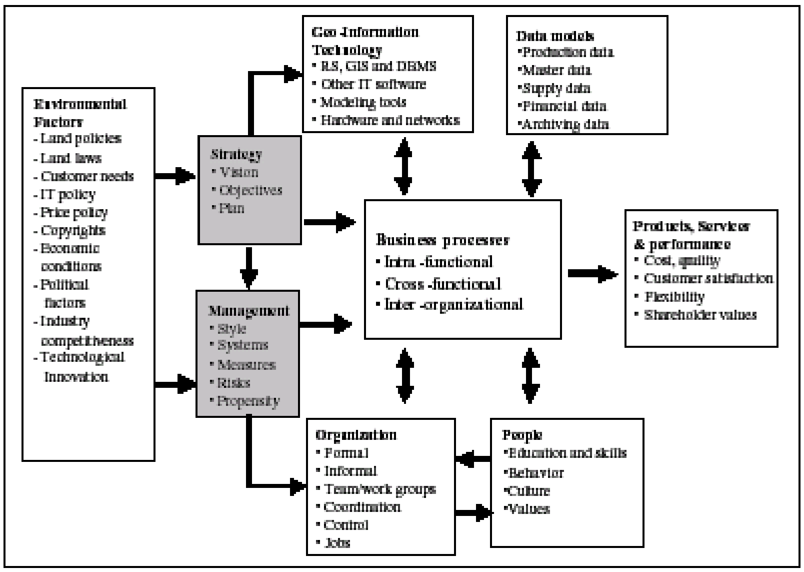



Figure no. 1: Management framework for building nationwide LIS (source: Tuladhar 2002)

Strategic planning is visionary, yet realistic; it anticipates a future for an organization that is both desirable and achievable. It involves a disciplined effort to produce fundamental decisions and actions that shape and guide organizations for reengineering with a focus on the future (Hunger and Wheelen, 1997). There are many positive and significant reasons to engage an organization in strategic planning. Some of them are given below:

- *It is a planning for change in complex environments* such as increasing demands for services, shrinking resources, greater expectations for better services.
- *It is a result-oriented management*. It involves analysis of the existing situation to set the objectives and develop strategies. While doing so, it carefully assesses an organization's capacities and environment, and therefore leads to the realistic resource calculations and informed decisions. This all leads to the result-oriented management.
- *It is an essential managerial tool*: Organization is asked to focus on achieving end results and improving outcomes each year. Therefore strategic planning enables organization to develop a system to institute continuous improvement at all levels.
- *It is future-oriented:* It involves a disciplined effort to produce fundamental decisions and actions that shape and guide what an organization is, what it does, and why it does it, with a focus on the future.
- *It is adaptable*: Although planning focuses on a long-range approach, regular reviews, up-dates to determine progress and reassess the validity of plan that keeps planning flexible. The plan then can be up-dated to make necessary adjustments necessary to respond to changing circumstances and take advantage of emerging opportunities.
- *It is customer oriented*: Strategic planning process determines the ways to address the customer's expectations and their needs.
- *It promotes communication*: It facilitates communication and participation, accommodates divergent interests and values, and fosters orderly decision-making and successful implementation of goals and objectives.

A successful strategic planning normally asks and answers the following: ***Where the organization is now***? ***Where the organization wants to reach in the near future? How the organization is going to achieve the desired future state? And how to stay there?*** The following sections provide the analysis of these questions and answers in the Nepalese context.

## 4. NEPALESE EFFORTS IN BUILDING LIS AND INSTITUTIONAL TRANSFORMATION

During the mid 1990s, the computers were quite new tools to our Nepalese society and there was severe shortage of the skills required to operate these technologies. The computers were considered as the sufficient tool to solve the problems, and there were very few private companies engaged in the field of computer science.

In 1993, His Majesty's Government started putting her resources to introduce the information and communication technology (ICT) in land administration in Nepal. A unit called "Central Integrated Land Information System" was established within the Department of Land Revenue under the Ministry of land reform and Management (MLRM). The focus was to computerize the alphanumeric data about the cadastral parcels, which were and is being managed by the district land revenue offices. It continued till 1995 until the council of ministers formed a new project as Integrated Land Information System (ILIS) directly under the MLRM. The intention of the change was to incorporate the spatial aspects of land administration data, which was and is being managed by district survey sections. In 2000, the council of ministers decided to establish a new dedicated department called Department of Land Information and Archive (DoLIA). The figure no. 1 shows the current organizational structure of MLRM.

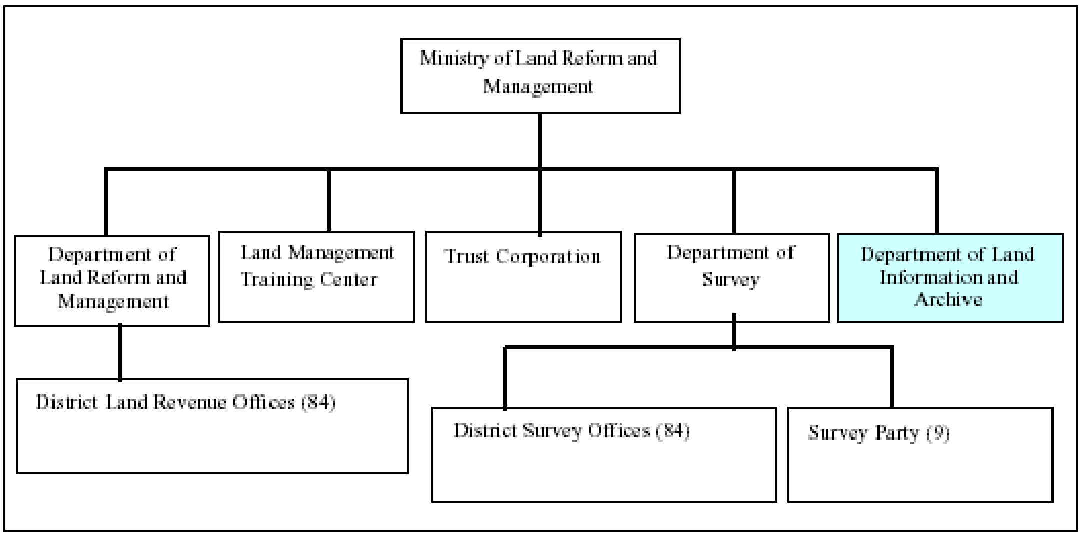



Figure no.1: Current organizational structure of MLRM

During the last decade effort, MLRM has undertaken a number of initiative/activities to modernize land administration according to the needs of the Nepalese society. In a broad sense, the current progress of LIS project based on ICT in Nepal may be seen in three consecutive periods on the basis of our national plans. These periods are initial period (1993-1995), intermediate period (1996-2000) and current period (2001 to date) after establishing DoLIA. The following table no. 1 compares eleven elements, which can be considered to be the important factors in building LIS (DoLIA 2001, NPC 2000 and Swedesurvey 2002).

Currently, DoLIA is heavily involved in piloting the LIS in two districts: Bhaktapur and Kaski. Bhaktapur is the small district that share boarder with Kathmandu whereas Kaski is 200 km away from the capital. In both of these districts, its effort has been focused on the non-spatial part of the cadastral parcels i.e. land revenue offices. In both of the offices, a private company is being used for data conversion. It is expected that the attributes of all the parcels in these two offices will get digitalized within next four months. The three other offices in the Kathmandu Valley have also got small set up established with few computers and other accessories.

| | Initial period (1993-1995) | Intermediate period (1996-2000) | Current period after establishment of DoLIA(2001 to date) |
|---|---|---|---|
| Government policy | Eighth national plan (1992-1997) envisioned to introduce computerization of land records. | Ninth national plan (1997-2002) has emphasized on the computerization of land records and map, and simplification of land administration procedure. | Tenth national plan (2002-2007) has given priority in the accessibility services through computer based system, and centrally developed archives of land records and cadastral maps with modern technology. |
| Scope of the task | To computerize non spatial aspects of cadastral parcels. | To computerize both non spatial and spatial aspects of cadastral parcels. | To build LIS by incorporating both non-spatial and spatial aspects of cadastral parcels. In addition develop the central archives of land records. |
| Implementing agency | The then Department of Land Revenue of MLRM | Land Information System project (LISP), within MLRM | DOLIA |
| Structured coordinating mechanism | None | None | Council of ministers (Cabinet) decision for steering committee with MLRM Minister's chairmanship. |
| Human resource recruitment and development | 40 technical positions were created and recruited. | No recruitment but trainings were organized for developing the skills and creating awareness at different levels. | Department was established with 21 technical and 17 non-technical positions including the Director General. |
| Budget | ? | 0.565 Million (US dollar) | 0.535 Million (US dollar) |
| Foreign assistance | None | SIDA's (1999-202) support basically for the transfer of technology and experience | SIDA's support continued till 2002 march |
| Research and studies | Computerization of land Recording | Detail study report in developing an integrated | Studies have been carried out by short term Swedish consultants in |
| | system in Nepal by spice info Tech | Land information system in Nepal by Bhumichitra company.<br>Design and Development of District land information system (DLIS) APROSC | Certain aspects of LIS. A few studies have also been carried by DOLIA staff together with the local consultants. |
| Software development | Although LIS was quit new technology, an application software was developed by NCC with an aim of handing the non spatial data. | Developed District land Information System (DLIS) software | Refined the DLIS software and developed customized application to handle the spatial aspects of LIS |
| Data capture | Started in few districts with government staff | just continued | Use of private companies |
| Concept of data sharing | None | Discussion started | Exists; developed an understanding with Kathmandu Metropolitan city |
| Awareness and understanding | Not that high as it was just the beginning | Increased Level of awareness | Significant understanding about the complexities in building and operating LIS. |

Table No. 1: Overview of efforts in building LIS during three different periods

In the survey offices of Survey department, the moderate resources have been deployed for the staff's hands-on practice to develop their skills. The task of data conversion has not really started mainly due to lack of required human resources. There is also an activity to scan and store the cadastral maps for the archiving purpose.

Thus, the efforts of building LIS have not been as successful as was expected. During the period of about 10 years, there has however been certain encouraging developments and understanding regarding the underlying issues and complexities. Time has now come for an extensive review of the way the department has been managing the resources to build and operate LIS. It is realized that the past effort has been adhoc and has seriously lacked the structured planning and clear strategies.

## 5. SWOT ANALYSIS

SWOT is an acronym, which stands for Strengths, Weaknesses, Opportunities and Threats. The SWOT analysis is a management tool designed to be used in the preliminary stages of decision-making, often as a precursor to strategic planning. The results of the SWOT analysis can be summarized in the SWOT Matrix. Strategic planning may use the matrix to identify how external opportunities and threats facing a particular organization can be matched with the internal strengths and weaknesses, to arrive at possible strategic alternatives. The SWOT analysis provides the idea to formulate good strategy to ensure a fit between the external environment (threats and opportunities) and the internal qualities (strengths and weaknesses) of the organization. Its results will then be used to formulate the realistic strategies. As a part of study, the following section 5.1 and 5.2 refer to environmental scanning for external and internal assessments for Department of Land information and Archiving (DoLIA) for a nationwide LIS in Nepal (BC, 2002).

### 5.1 External Assessment

The external environment covers major driving forces like political/legal, economic, technological, socio/cultural and demographic forces. Useful **opportunities** can come from changes in technology, changes in market, changes in users expectation, changes in government policy etc. and Where as **threats** are the external factors like require high investment, lack of legal support for LIS, increasing land disputes and so on. These factors are in fact externally outside DoLIA and MLRM, but they have significant impacts on the organization and its mission.

| Opportunities | Threats |
|---|---|
| Approval of IT policy 2000 in October | Insecurity in the continuity of funding, commitment, and project team. |
| Capitalize the demand of land information in multi facet use and growing land market. | The legislative framework has not yet been developed regarding the various activities of DoLIA. |
| With the increasing trend of LCT. There is an increased demand of digital land information. | Building of LIS to cover the entire country involves high initial investment. |
| Privet sectors have started focusing on the GLS and therefore the skills are available in private sectors. | The over expectation of the stakeholders in terms of time and functionalities of LIS |
| Contribution to the good governance. environment management and sustainable development. | A computerization attempt without analyzing the current land administration system (specially data and processes). |
| The tenth five-year plan has given priority to modernize land administration | Lack of a comprehensive land policy at the national level. |
| Once LIS is fully operational. It will minimize the operating cost in land administration. | DoLIA has been established without a clear definition of its mandate. |
| Link to geospatial data infrastructure (GDI) at national level for meeting the demand from a wide variety of its users. | The traditional mechanisms of producing and delivering the information/product/services are unsatisfactory. |
| Creates increased awareness to policy/decision marks. | Lack of local capacity building. |

Table No. 2: Assessing the external factors of DoLIA

### 5.2 Internal Assessm ent

The various internal factors like organization structure, culture, management, leadership, financial issues, operation issues and human resources of DoLIA have been analyzed to identify its **strengths** and **weakness** and some of them are explained as follows:

| Strengths | Weakness |
|---|---|
| New department attracts all the stakeholders | Lack of both managerial as well as technical experience at all the levels. |
| Continuous budget since its establishment. | Lack of efficient and effective organization including knowledge field and ICT support. |
| Increased awareness about the LIS at all levels within DOLIA, sister Departments and MLRM. | Frequent change of leadership |
| Availability of knowledgeable, skilled and committed staffs with MLRM. | Resistance to change in the way the organization needs to provide service and products |
| Extensive pilot experience regarding the underlying complexities in developing and operating LIS. | Lack of rigorous planning to build, operate and maintain LIS. |
| The study that has commenced recently to review and propose a more effective organizational structure to build, operate and maintain LIS. | Poor quality of the data sources (both the MOTH and the maps). |
| The system to handle the non-spatial aspects of LIS has been built and is on operational in pilot offices. The preliminary design of the system for spatial aspects of LIS is complete | Sever shortage of human resource capacity. |
| Government has decided in the use of private sector for data conversion. Currently, private houses are being used in two districts. | Poor communication, coordination, participation of sister departments and stakeholders. |

Table 3: Assessing the internal factors of DoLIA

## 6. PROPOSED VISION AND STRATEGIES OF LIS

The ideal situation for a nationwide LIS and dissemination of reliable and up-to-date land information could be through the integration of both land revenue and surveying offices. However, in the context of the organizational set up within the ministry, the DoLIA as a permanent Department can play the leading role for building and maintaining a nationwide LIS. After the system is built and placed on operation, DoLIA would have responsibility to managing information system in terms of database security, data protection and archiving all related documents, while land revenue and survey offices uses the system in order to update data in the LIS and delivers the quality services.

In the following figure no.2, the proposed vision consists of two sets of users for LIS (BC, 2002). Internal users are responsible to provide efficient land administration services delivery and maintain data in the system. For the external users, DoLIA would be responsible for the timely supply of land information at affordable cost to all users. This is very important to generate the income and sustain the system economically.

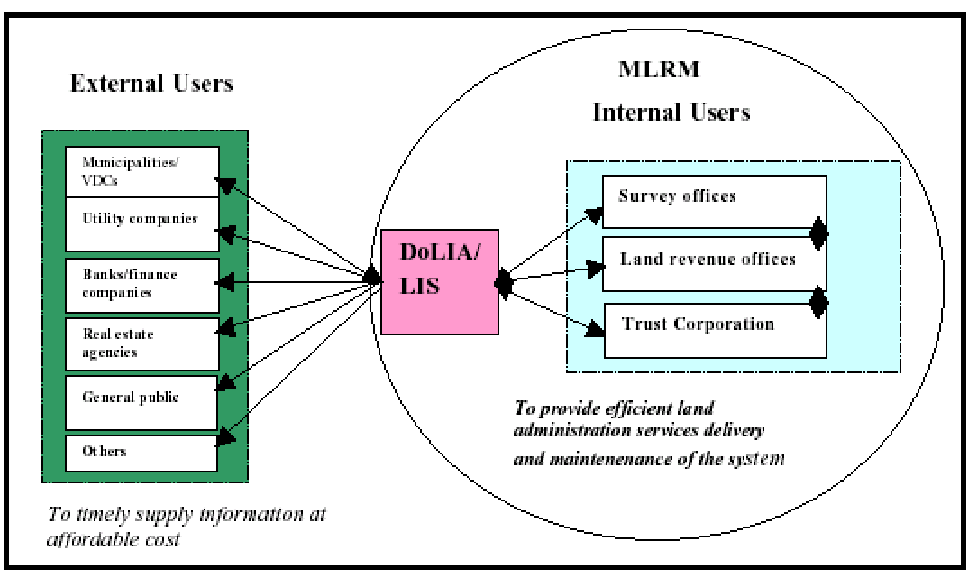



Figure no. 2: proposed vision of Land Information system in Nepal (adopted from BC, 2002)

### 6.1 Proposed major strategies

After assessment of external and internal environment within DoLIA and MLRM, the table below lists the major strategies, which have been developed by taking advantage of the opportunities, to make use of the strengths to minimize weaknesses and threats.

| | Opportunities | Threats |
|---|---|---|
| STRENGTHS | √ Accelerate LIS activities to support growing land markets, improve the land administration service, and meet the diverse land information demands.<br>√ Develop the effective and fully supportive organizational structure and get it implemented.<br>√ Design & develop an effective central archiving system.<br>√ Develop realistic government-private partnership model to encourage the involvement of the private sectors.<br>√ Further develop the system with centralized database concept y using new developments in ICT.<br>√ Actively participate in the development of NGDI to fully utilize it in and information sharing, dissemination and marketing | √ Work towards greater organizational autonomy and management flexibility<br>√ Define a clear mandate and arrange the LIS legislation<br>√ Seek for foreign assistance to solve the funding and technical complexities of LIS<br>√ Formulate and implement the comprehensive land policy.<br>√ Accelerate continuously more awareness rising program.<br>√ Develop training program to improve the efficiency/quality of staffs in various levels<br>√ Carry research and development activities in cooperation with the expert GeoInformation Institutions. |
| W | √ Develop dynamic and committed leadership | √ Develop technical & management training |
| EAKNESSES | √ Develop capacity building programs and implement with focus to the LIS vision<br>√ Focus on new business opportunities<br>√ Introduce cost recovery principle to sustain and maintain the system for long run<br>√ Introduce quality management system -at all the stages of LIS development<br>√ Renovate the data sources | √ Program to improve skills/capability of senior/middle managers.<br>√ Re-engineering of land administration to respond to the shrinking budget and satisfy the users<br>√ Develop deeper inter-departmental relationships to develop common -interest and cooperation for LIS.<br>√ Restructure and activate existing LIS committees |

Table 4: SWOT Matrix for DoLIA

## 7. CONCLUSIONS

Good governance, poverty reduction, social justice, environmental protection and sustainable development are some of the key national agenda as well as priority areas of donors, and a good and reliable land information system (LIS) is a prerequisite for their effective and efficient decision making. HMG of Nepal has put considerable efforts towards building a LIS during last decades; immediate attentions are necessary to develop a structured strategic planning and analysis of user requirements. DoLIA requires involvement of major stakeholders, and needs to take immediate actions in creating awareness to its stakeholders including policy-makers. Active participation and commitments from the other departments should play a determining role in the successful building of LIS. Since building nationwide LIS is a huge task and based on Geo-ICT, modern management techniques and tools are required to improve coordination, cooperation and communication among the various department of the MLRM. This would act one of key node within National Geo-spatial Data Infrastructure (NGDI).

## ACKNOWLEDGMENTS

The authors would like to express sincere thanks to Mr Babu Ram Acharya, Director General of Survey Department and Mr Tirtha Prasad Ligal, Director General of Department of Land Information and Archives for their kind supports.

## REFERENCES


- BC, K. R., (2002), *Formulation of a strategic plan for land Information systems in Nepal.* Final Project for the degree of Professional Master in Geoinformation management, ITC, Enschede, The Netherlands.
- Dale, P. & McLaughlin, J. (1999), *Land Administration*. Oxford University Press.
- DoLIA (2001), *DoLIA: Objectives, Vision and Challenges.* Department of land information and archive, Kathmandu, Nepal.
- *FIG (1999), The Bathurst Declaration on Land Administration for Sustainable Development*, FIG Publication No. 21, Bathurst, Australia, 1999.
- Groot, R., and McLaughlin, J. (2000), *Geospatial Data Infrastructure Concepts, Cases and Good Practice* (First ed.): Oxford University Press, U.K.
- Groot, R., and Molen, P., (2000), *Workshop on Capacity Building in Land Administration for Developing countries,* ITC, Enschede, The Netherlands.
- Hunger, D. J., and Wheelen, T. L. (1997), *Essentials of Strategic Management*: Addsion-wesley, Boston, U.S.A.
- Molen, P. v. d. (1999). *IT Re-engineering and land Legislation with a Focus on Automated Registration of Deeds.* Available: http://www.oicrf.org/ (accessed on Aug 2002).
- NPC (2000), *Information and Technology Policy*. National Planning Commission, Kathmandu, Nepal. Available: http://npc.gov.np:8080/it/it_policy.pdf (accessed on July 2002).
- Swedesurvey. (2002). *Final Report on Implementation of LIS in Nepal*: Swedesurvey, LISP, HMG/Nepal,.
- Tuladhar, A. M. (2002), *Developing a Framework for Cadastre and Land Registration Systems in Land Administration Organizations.* Paper presented at the FIG XXII International Congress, Washington, D.C.,U.S.A,
- Williamson, I., Ting, L. (2001). *Land administration and cadastral trend – a framework for reengineering.* Computer Environment and Urban systems, an International journal, Theme Issue: Cadastral systems, edited by C. Lemmen & P. van Oosterome. Elsevier Science Ltd.


✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶✶

### Rates of Digital Data Layers

| LAYER | Class (A) NRs | Class (B) NRs | Class (C) US$ |
|---|---|---|---|
| ADMINISTRATIVE | 500 | 1 000 | 30 |
| TRANSPORTATION | 1 000 | 2 000 | 60 |
| BUILDING | 300 | 600 | 20 |
| LANDCOVER | 1 500 | 3 000 | 100 |
| HYDROGRAPHIC | 1 200 | 2 400 | 80 |
| CONTOUR | 1 200 | 2 400 | 80 |
| UTILITY | 100 | 200 | 10 |
| DESIGNATED AREA | 100 | 200 | 10 |
| ***FULL SHEET*** | ***5 000*** | ***10 000*** | ***300*** |

(A) Napalese Researchers, Students, HMG Organizations, Non-Government Organization (Non-profit), HMG Affiliated institutions.

(B) Nepalese Private Company (Consultant, Contractors)

(C) Foreign Organizations, Consultants, Contractors.

### Rates of some publications of Survey Department

1. List of Geographical Names volume I to IV – NRs 300 | - for each volume.
2. Nepalese Journal on Geoinformatics – NRs. 100 | -

# UPDATING GEOGRAPHIC INFORMATION USING HIGH RESOLUTION REMOTE SENSING OPTICAL IMAGERY

**Nab Raj Subedi**
***Survey officer***
**National Geographic Information Infrastructure Project**
Survey Department
Tel: 00977-1-482903 Fax: 00977-1-482957
E-mail: shreesnabu@mail.com.np, Min Bhawan Kathmandu, Nepal

**KEY WORDS:** Classification, DEM, Resampling, Geo-referencing, GIS, Optimum Index Factor, Remote sensing, Spectral Resolution, Spatial Resolution, Topology, Updating

**ABSTRACT:** Remote sensing may be broadly defined as acquiring and then interpreting information about objects, which are away from the sensor. Geographic Information System (GIS) is a tool for integrating and analyzing spatially referenced geo-spati al data. The integration of remote sensing and GIS technology provides an opportunity for characterizing and analyzing dynamic environments so that any change of objects in terms of geometry, class and topology can be identified. Updating of the vector data of scale 1:25000 of Enschede Municipality, the Netherlands by using remotely sensed Ikonos imagery was performed by simultaneous viewing them using GIS tool. It is found that remote sensing high optical imagery are of promising characteristics in terms of capturing feature so that updating of vector is possible and database can be maintained easily and comparatively in less time than by using the field surveying techniques.

## OBJECTIVES

i) To Apply of different techniques like image enhancement, image fusion (if necessary), etc. for proper discrimination of different classes and enhancement of interpretability of the image.

ii) To coincide the Remote-Sensing Image data with the GIS data of the same area (integration) and visualize on screen to detect change.

iii) To update the change detected, and add it to the parent data (replacing the old data).

## PRE-PROCESSING

The first part of the image processing is usually known as pre-processing, since it must precede most other image processing operations. The amount of pre-processing required varies with the sensor type and the quality of the digital data. The following are the type of correction that is applied on the image to make them understandable. They are, System Correction, Radiometric correction, Geometric correction.

Here System correction and the corrections like error due to the satellite positions, the earth rotation correction is not applied as these corrections were expected to be applied by the provider of the imagery (by the distributor).

It has been commonly known that the Spectral reflection of an object is image specific. That is to say, it is dependent on the viewing angle of the satellite at the moment the image is taken, the location of the sun, weather conditions (like Haze) that are not same in the entire image. It is therefore these possible sources of errors are accounted for and corrections are applied on the multi -spectral image on all bands.

The mathematical relationship existing between the different parts of the radiometric correction is give by the equation below.
(i) Reflection detected by the sensor (O) (ii) Sun angle (S) (iii) Skylight (D) (iv) Sensor indicator (I) (v) The irradiance incident by the sun (T) and (vi) Reflection form the object/surface (R) and the relationship is

$O = (T*S + T*D*I)\ R*I + H*I$ ……………………………………………………………………………….…...(1)

## HAZE CORRECTION

Observing the function above reveals the fact that the haze effect (H) is contributing additively whereas the sun angle is supplying errors multiplicatively. It is due to this reason that the image has lower DN values than it should be. By applying correction, the haze value is approximated and the same value is deducted from each Pixel of the given image. The lower the value in the given image is estimated, the higher will be the correction of the image. The formula for the application of the haze correction used was

$DN = Vw + Vh$
i.e. Input DN Value(DN) = estimated lower value( if there were no atmosphere, Vw) + Haze contribution (Vh).
Therefore,
Haze contribution = Input DN Value minus estimated lower value (if there were no atmosphere)
………………………………………………………………………………………………………………………(2)

It is reminded that haze correction value 18 for band 1, has been obtained by estimating the value of the DN (here 2) as if there was no atmosphere present and using eq(2). The correction value is subtracted from all of pixels in band 1. The same procedure is applied for band 2. The lowest values in band 3 and Band 4 values were already near to zero so they did not need correction.

## SUN ANGLE CORRECTION

Since an image of the same period is used for the entire study work the relative approach of sun angle correction is not applied in the sun angle correction but the "absolute" one. Using absolute approach, the sun angle correction is applied by the original DN values divided by the sine value of the Sun elevation angle provided by the distributor in the header files. Thus, DN′ = DN / sin ($\delta$) i.e.
Output Pixel = input pixel / Sin (sun angle)
…………………………………………………………………………….(3)
Where sun angle i s measured in degrees.

The following list shows the data for the application of sun angle correction.

| Image | Sun angle | Sin value |
|---|---|---|
| Band1 | 41.34205 | 0.66055 |

All of the haze corrected images are undergone through the sun angle correction by using the function eq (3).

It is noted that the resulting image after the haze correction is in image domain whereas the image after the sun angle correction is Value domain. (The necessary division converts this value domain image into image domain again carefully. Technically, the image domain is given emphasis since it is the only domain through which we can view color composite)

## SKYLIGHT CORRECTION

The incoming radiance from a ground pixel to the sensor is affected by the two types of components. They are:

(i) The irradiance from surrounding pixels, which is more severe in the case of lower resolution images, but for higher resolution images, it is neglected. Hence for the images that are under used at present there was no correction applied and,

(ii) The path irradiance from the sky which is caused by scatter presents in the atmosphere by the dust, cloud etc. As the image under use is cloud free, the error possibly present by dust particles is neglected.

## GEOMETRIC CORRECTION

Out of the two methods of the geometric correction, the method that involves the identification of ground control points (GCP) on the image was applied. Numerical values (Ground coordinates) were fed to these GCPs on the image. The accuracy achieved by geo - referencing the image was 0.73 of a pixel of 1- meter resolution (in case of the IKONOS Panchromatic Image). After geo-referencing (following the transformation), resampling was performed to move each digital value in the slave image to the new position of the new corrected image. In the case of the study work, bilinear interpolation was used which has better effect than nearest neighborhood and has less modification than cubic convolution.

## SECOND STAGE IMAGE PROCESSING AND CLASSIFICATION

A range of techniques were applied to improve the appearance and interpretability of digital imagery directing particularly at final product, which was going to be subject to visual interpretation. Namely, image enhancement (either contrast stretching or color composite), filtering, Ratio images, principal components analysis as well as image fusion are prevalent for this purpose. These all activities were carried out to make the image better understandable.

## IMAGE ENHANCEMENT

IKONOS images are provided with the dynamic range of 11 bit per pixel (2048 gray levels), where as the Image processing software facilitates the work using a dynamic range of 8 bits per pixel (256 gray levels) ranging from black = 0 to white = 255. Hence when image is imported, it seems to be readily black. To avoid this low contrast and low DN values the image is rescaled to the range of 0 to 255 immediately after the image is imported.

## CONTRAST STRETCHING

Satellite images, particularly those at the optical range, often make use of a limited part of the dynamic range , especially when the sun illumination is low.(Reference no 3) For better interpretability, the image is transformed to occupy the full dynamic range. This is called contrast stretching(fig. 2). This expands the digital values to fill the dynamic range of the display system, producing an image of better contrast.

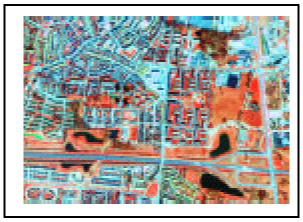
Fig 1, Band 1, IKONOS as provided

Fig 2, Contrast stretched image (IKONOS band 2)

When stretching the histogram as a whole, there are two techniques to enhance the contrast of an image (except piecewise-contrast stretch), linear stretching techniques and histogram equalization. Out of these two, histogram equalization was performed since the distribution of output gray levels is proportional to the frequency of the occurrence of the original DN values.

### COLOR COMPOSITE OF THE STRETCHED IMAGES

Color images, when displayed on a monitor are normally composed of three bands, usually three different bands of an image taken at the same time (co-registered images). Each band is assigned to one of the color guns (red, green or blue). Apart from these composites, is also seen through the conversion of RGB to IHS.



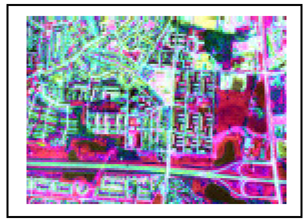


Fig 3, False Color Composite 4,3,1 Fig 4, False Color Composite 4,3,1through
HSI *system*

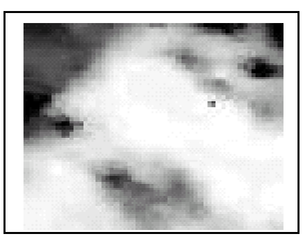
### CHOICE OF BANDS FOR THE COLOR COMPOSITE

It is not by the random decision that three bands for a color composite were chosen. Allowable input bands for the color composite can be identified by statistical procedure. One such method is based on the selection of data, which have the highest variance. This method was propounded by Chavez et al (1982) called, Optimum Index Factor (Reference no 3). The higher the covariance the better the composite. Before introducing images to the monitor, Optimum Index Factor of the different combinations (in each combination there are three images) was calculated through the covariance matrix, which has been enlisted below.
OIF Index Highest Ranking was like 1: Band1 Band 3 Band 4 (129.22)
2: Band 1 Band 2 Band 4 (125.20) 3: Band 2 Band 3 Band 4 (111.95)
4: Band 1 Band 2 Band 3 (75.62)

As the image consists of mostly built up area, there are many linear structures like road lines. This linear structure could not be differentiated with the building or other details in the resulting color composite. Since many details cold not be visualized as clear as they could be result was not felt so satisfactory. Hence the processing was forwarded to the application of high pass filters (Edge enhancement).

### APPLICATION OF MAJORITY FILTERS

When a close look was made on the image at bigger scale, noise was felt on some parts of the image where the distribution of details was more heterogeneous. It was due to mixing of pixel of values. Hence the majority filter was felt to be applied before edge enhancing filters.



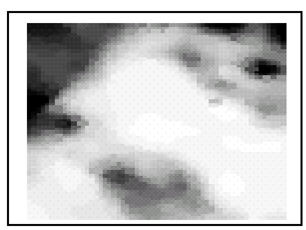


Fig 5, Image before majority filter applying Fig 6, Image after majority
filter applying

### CLASSIFICATION

Principally, Classification techniques use a selection of spectral characteristics of objects in order to subdivide the imagery into meaningful classes of different land-cover types. By classification, the enhanced images are modified into different thematic classes. The choice of class depends on the objective of analysis, the spectral and the spatial resolution of the images under consideration. It was thought here that the objective of the study was to update a dataset to a scale of 1:25000. The following classes were pre -defined fo r the classification:
Built up area, Tree area, Open area, Water area, Road lines

It is here noted that by open area we mean the barren area, area of cultivation and grassland in a combined class. In the same way the industrial, sports grounds, residenti al and other constructions are comprised under built up area class.

### SELECTION OF THE CLASSIFICATION TYPES

Since an updating of GIS data process is going to be undertaken after the classification of the image, Supervised classification procedure was selected for the classification purpose. It was also felt confident to classify by supervised method.

## COLLECTION OF TRAINING SAMPLES

Considering the spatial resolution of the image, it was regarded that many more classes could be differentiated on the multi-spectra. A field visit was made for the collection of different training samples with the number of class more than just mentioned above. e.g. class like cultivation land with no crops, cultivation land with smaller crop, grass land, wetland etc. More than 30 f training samples were collected in the field for the purpose of classification.

## FORMATION OF MAP LISTS

For classification using multi -spectral image, one need to define which combination of the bands are used for feature extraction. As the OIF of the given images showed the best combination for 3,4 and 1 band, these three bands were used to define the map list undergoing classification. (Noted that this is the first classification among many others that was performed during the analysis in which other combinations were also made).

## DEFINING THE SAMPLE SET

As there are three scatter plots for this image because all three dimensions cannot be viewed simultaneously in the two dimensional monitor. When defining some sample sets, features of same class have different pixel values and they scattered very widely in the feature space. Because of this overlap, it was difficult to assign it to limited classes. Hence the number of classes was increased keeping in mind that after classification these features would be merged to a more general category again in the GIS analysis. Road features were divided as highway and road, bicycle track. Open area was divided to grassland, cultivated land etc. In the places where the building and road lines were seen to be mixed they were given name as X (unknown)

## SELECTION OF THE CLASSIFICATION ALGORITHM

Out of different types of algorithms available for Classification and in spite of its simplicity, the box classifier was rejected because not all values pertaining to a certain class are arranged in a compact form so that they nicely fall inside a crisp boundary of an estimated rectangular box. When forcing such partition in the feature, low accuracy results. Similarly, the minimum Euclidian distance to mean classifier is also not chosen in the classification of the image because there is a danger of assigning a class to a pixel, which is far away from the mean. This can be avoided by assigning a distance but it is a value, which seems to be a biased and user sensitive.
The third, Maximum Likelihood Classifier, is more independent one, since it works on the statistical probability principle. The parameters like the cluster mean and covariance are taken into consideration in assigning a class to a pixel. This Algorithm was applied for the classification.

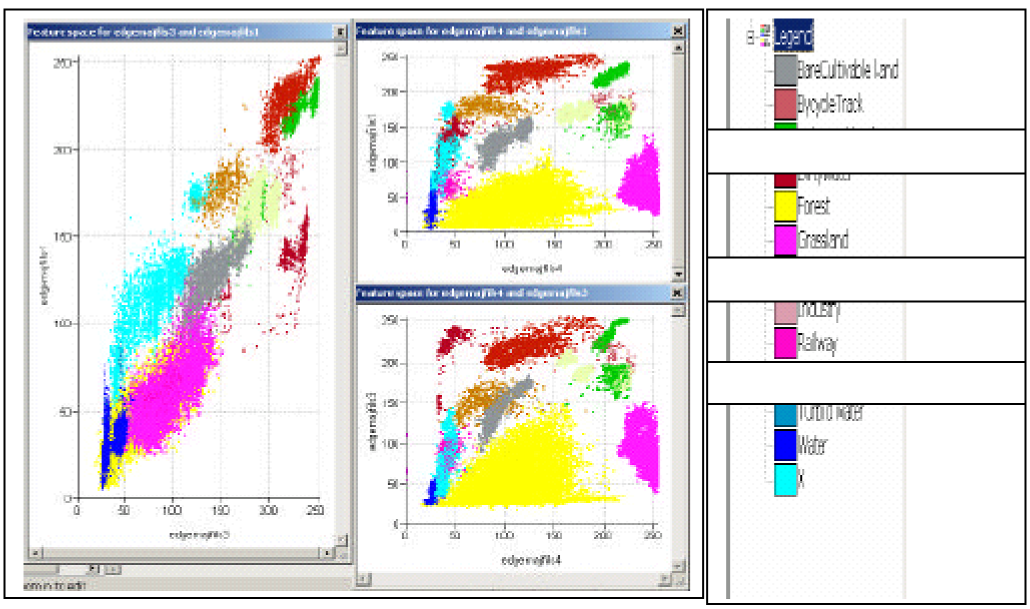



Fig 7, Three-Scatter plot using bands 4,3 and 1

## PERFORMING THE CLASSIFICATION

After completing above steps for the classification, classification of the multi -spectral bands (using the map-list constructed already) was performed by using the sample set already defined, and using the algorithm as mentioned above.
The outcome of the classification was apparently very poor. Most of the buildings were seen to be classified as roads (highway). Some of the buildings (black roofed) have the same reflection as water in the image. Some tree areas are classified as water as well. The result of the first classification gave the impression that classification using the original bands of the image as they are could not procure a good result(fig. 8). That is why the image processing was forwarded to the application of arithmetic and other techniques to see whether the result would be better. The resulting image after these processing was found to provide good interpretability therefore better classification was expected.

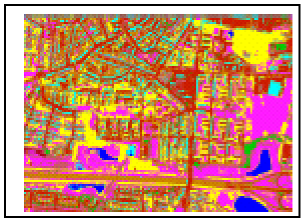


Fig 8, Classified image

## APPLYING OTHER TECHNIQUES OF IMAGE PROCESSING

As the result of classification was not obtained satisfactory, other techniques of image processing were applied to see whether a better result would be obtained for the classification. For this different techniques were tested namely, Image arithmetic, Image Fusion and principal component analysis.

## IMAGE ARITHMETIC

To solve the problem of spectral confusion, such as built up area and road networks, which got the same class in the previous classification, an effort was made to make them separate using band 4 because it consists of information more about vegetation. For this, piecewise contrast stretch was performed and the resulting image was inverted. But the result came up with the mingling of road feature and built up area. Hence the idea of inversion and piecewise stretching was abandoned.

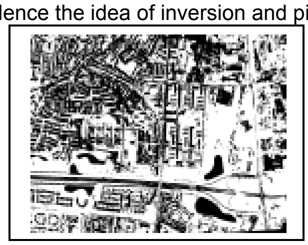


Fig 9, Piecewise stretched image of IONOS band 4 (65– 78)

Fig 10, Inverted image of fig 9.

## IMAGE FUSION

Image fusion is defined as the combination of two or more different images to form a new image by using a certain algorithm (Genderan and Pohl 1994). The principles behind the image lie on the fact that it should increase accuracy as well as reliability thus reduce ambiguity. Three different approaches of image fusion were performed to peruse the best interpretable image. These are,
(i) Addition of the individual bands with the Panchromatic
(ii) Averaging of three bands and replacing the individual component by the panchromatic
(iii) RGB–IHS-RGB transformation

## ADDITION OF THE INDIVIDUAL BANDS WITH THE PANCHROMATIC

Another effort made to rectify the image was the addition of the multi-spectral band with panchromatic one. For this the process involved is as below:
Let x, y and z are the three multi -spectral bands (Particularly 1,3,4 respectively)
Then Resulting Image after adding panchromatic band is given by,
Xnew = (x + panchromatic band)/2, Ynew = (y + panchromatic band)/2, Znew = (z + panchromatic band)/2
The color composite result is a promising one but the image processing is forward towards the image fusion by averaging techniques as described in the succeeding chapter to make a comparison to see which of the image will give the better result.

## AVERAGING THREE BANDS AND REPLACING THE INDIVIDUAL COMPONENT BY THE PANCHROMATIC

This method was performed to see if the out coming fused image would be a better result. In this approach, three bands 1,3,4 were averaged. The average was divided by the each component separately and each time mul tiplied by the panchromatic one.
The formula used were ,
Int = (iko1 + iko3 + iko4)/3, I1 = (int / iko1) * pan, I 3 = (int / iko3) * pan, I4 = (int / iko4) * pan
There I1, I3, I4 are three resulting images. Finally the color composite of these images was prepared. The result was found to be better than the previous fusion. This combination was used to classify with the same parameter as mentioned in the first classification. But the result of the classification was poorer than the outcome that would come with the visual interpretation. Hence this classification result(fig. 11) is also rejected.

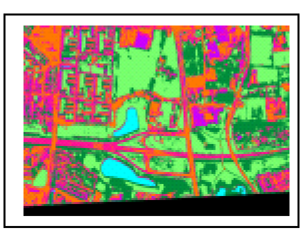


Fig 11, Showing classification using the fused image

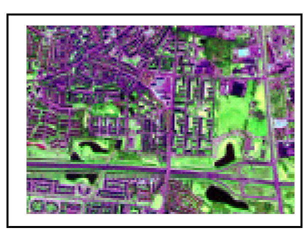


Fig 12, The image after RGB – IHS Transformation

## RGB–IHS TRANSFORMATION

In this method, from colour composite (i.e. band 3,4 and 1) intensity, saturation and hue were extracted separately, each time resulting in new images. Out of these three Images, the image containing hue and saturation were again combined with the panchromatic image leaving the intensity image behind. In general, the idea to replace the intensity is to generate colour information at a higher resolution The HIS colour transformation effectively separates spatial and spectral information from a standard RGB image.
These three images are combined this time and visualized through the HSI channel(fig.12). But the visual impression was found to be even worse than the result achieved before. Hence this fused image is also rejected. No effort for automated classification was made with this fused image.

## PRINCIPAL COMPONENT ANALYSIS

In this analysis, series of four bands of original data were converted to 4 new components, where the first components contains information least of the correlation between all the original bands, second components contain next lower correlation and so on in decreasing order. Statistically, the first principal component contains the main variance and is equivalent to topographical features and the information goes in the decreasing order. The first three components were combined and visualized as a color composite. The result seemed worse than the result obtained by the averaging. So this composite was rejected for classification.

## REASONS FOR REJECTION OF THE RESULTS OF DIFFERENT ENHANCEMENT AND FUSION METHODS

In fact, the image under consideration consists of mostly built up area and less natural area of trees, open land or land of cultivation. In areas, where there is more landuse detail than land cover detail, the topographic features render complexity. In our case for example, shadows behind almost all the buildings. Moreover, in some case, water reservoir or ponds or lake in the urban area was more turbid than in other area. The roofs of most of the buildings have the same intensity levels as of roads. They look alike. Similarly, water areas absorb more radiation and therefore they have very low DN values, where as shadowy areas do not receive any radiation and send no response toward the sensor. Some of the industrial area, which has nearly black roofs, has almost the same DN values as those of water.

The classification results, in this case, are all rejected. Therefore, the option of automated feature extraction by classification was abandoned (taking time into consideration). Instead, manual feature extraction using visual interpretation was done. This is since human mind takes account of other factors like texture, pattern, form and more importantly association, which are not found in the automated system. The visual interpretation was made and accordingly changes in feature were picked up from the fused images obtained on averaging and addition method.

## INTEGRATION OF VECTOR DATA WITH THE IMAGE RASTER AND UPDATING

The processed image was already co-registered with the un-updated original vector data, with the allowable error value (1 pixel). Updating was done overlaying features of one class on to the image and comparing these data with the image by visual interpretation. Interpretation elements like tone, texture, shape, size, pattern, site and association were taken into account. Simultaneous uses of the elements and by applying logical inference, many features were identified. A more detailed is like this: First, one of the classes of the generalized vector data was displayed in GIS. The image was already present in the same view. Any change in the feature is digitized and feature attributes assigned accordingly. If there is reduction in the feature area of a class then it means that, this changed area falls on the area of new feature. This changed part is also digitized and assigned a new attribute relevant to it. The process is continued on till all the features of all different classes are updated.

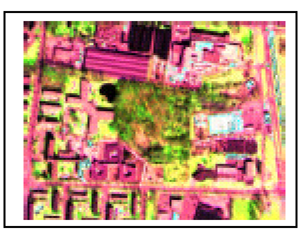
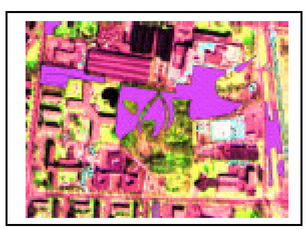
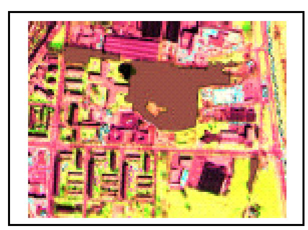




Fig 13 New Image    Fig 14, Old vector data showing partly forest    Fig 15,Forest updated

## CONCLUSION

- Remote Sensing imagery of higher spectral and spatial resolution has been a promising source for information extraction.

- Remotely sensed data are seemingly more effective in terms of time and cost in updating GIS data. Feature extraction from RS data depend on the nature of geographic feature class e.g. from urban area in the image, it is difficult to extract information by classification because of low variance of spectral values (not statistically). But visual interpretation method is more efficient, less time consuming.

- It needs to be focused on the error analysis on the result of the integration of the vector and raster data.

- For a feature of highly undulated area or mountainous area, the integration of data must be associated with DEM. It is due to the flat geographic area, DEM was not considered in the work. In mountainous area, tilt and relief distortion makes the data displaced from their true position, so for hilly or elevated area, DEM must be accounted.

## REFERENCES


- Lilesand, T.M. and Kiefer, R.W. (1994), Remote sensing and image interpretation. 3rd. Wiley and Sons, New York
- Feingersh, T. (2000), Synergy of multi -temporal SAR and Optical imagery for crop mapping. The International Institute for Aerospace and the Earth Sciences (ITC), Enschede, The Netherlands
- Dr. Christine Pohl, Proceedings of Geoinformatics'95 Hong Kong, Sustainable Development and Environmental Monitoring (Hands Out given during the lectures on image fusion) by Supplied by, The International Institute for Aerospace and the Earth Sciences (ITC), Enschede, The Netherlands, 2001
- Lucas L.F. Janssen, Principle of Remote Sensing, An introductory textbook, The International Institute for Aerospace and the Earth Sciences (ITC), Enschede, The Netherlands
- Feingersh, T, Exercise Principle of Remote Sensing (October 2000), Geoinformatics (GFM) Program, Geoinformation management (GIM-c) Program, (ITC), Enschede, The Netherlands
- Jeffrey L. Star, Proceedings: The Integration of Remote sensing and Geographic Information Systems, Proceedings of a special session held at the Baltimore 1991 ACSM-ASPRS Annual Convention, Published by American Society for Photogrammetry and Remote sensing
- Rhristopher Legg, Remote Sensing and Geographic information System: Geological mapping, mineral exploration and mining, John Wiley and Sons, 1994
- Rolf A. de By, Principle of Geographic Information System, An introductory textbook, The International Institute for Aerospace and the Earth Sciences (ITC), Enschede, The Netherlands
- Feingersh, T. (April, 2001), Radiometric correction on optical imagery, (Hands Out given during the lectures on image fusion) The International Institute for Aerospace and the Earth Sciences (ITC), Enschede, The Netherlands
- The International Institute for Aerospace and the Earth Sciences (ITC), Enschede, The Netherlands ILWIS 2.1 for Windows, The INTEGRATED LAND AND WATER INFORMATION SYSTEM, User's Guide, Ilwis Department, (ITC)

Menno-Jan Kraak and Ferjan Ormeling, Cartography: Visualization of Spatial Data, Longma


## Rate of Maps

| S.No | Description | Coverage | No. of shees | Price per sheet (NRs) |
|---|---|---|---|---|
| 1 | 1:25 000 Topo Maps | Terai and mid mountain region of Nepal | 590 | 150.00 |
| 2 | 1:50 000 Topo maps | High mountain and Himalayan region of Nepal | 116 | 150.00 |
| 3 | 1:50 000 Land Utilization maps | Whole Nepal | 266 | 40.00 |
| 4 | 1:50 000 Land Capability Maps | Whole Nepal | 266 | 40.00 |
| 5 | 1:50 000 Land System maps | Whole Nepal | 266 | 40.00 |
| 6 | 1:125 000 Geological Maps | Whole Nepal | 82 | 40.00 |
| 7 | 1:250 000 Climatological Maps | Western Nepal | 7 | 40.00 |
| 8 | 1:125 000 Districts Maps (Nepali) | Whole Nepal | 76 | 20.00 |
| 9 | 1:250 000 Zonal Maps (Nepali) | Whole Nepal | 14 | 20.00 |
| 10 | 1:500 000 Regional Maps (Nepali) | Whole Nepal | 5 | 20.00 |
| 11 | 1:500 000 Regional Maps (English) | Whole Nepal | 5 | 20.00 |
| 12 | 1:500 000 Maps (English) | Whole Nepal | 3 | 20.00 |
| 13 | 1:1 million Nepal Map | Nepal | 1 | 30.00 |
| 14 | 1:2 million Nepal Map | Nepal | 1 | 15.00 |
| 15 | Wall map (mounted with wooden stick) | Nepal | 1 | 400.00 |
| 16 | Photo map | | 1 | 150.00 |
| 17 | Wall map (loose sheet) | Nepal | 1 | 50.00 |
| 18 | VDC/Municipality Maps | Whole Nepal | 4181 | 40.00 |