Engineers Conclave - 2014

Oct 28 to Nov 1, 2014
IISc., Bangalore

PROCEEDINGS
&
RECOMMENDATIONS

Organized by:

Indian Space Research Organisation (ISRO), Bangalore

Indian National Academy of Engineering (INAE), New Delhi

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Engineer's Conclave 2014

Technical programme of the Engineer's conclave will include detailed deliberations on the following two themes:

Theme-1: Emerging Space Applications (organised by ISRO)

Theme 2 : Technologies for hill regions (organised by INAE)

Number of sessions: Both the themes will have five sessions each of two hours duration

Sessions under 'Theme 1' will cover the following major areas of applications :

1) Energy and Infrastructure
2) Weather and Climate
3) Natural Resources monitoring, management and E-governance
4) Early warning systems
5) Communication and Navigation

Co-ordinators for the above five sessions, in the same order are :

1) Shri Tapan Misra
2) Dr C.M.Kishtwal
3) Dr V.K.Dhadwal
4) Dr. Ajai
5) Shri Vilas Palsule

Members of theme-1 programme sub committee:

1) Dr V.K.Dadhwal
2) Dr Y V N Krishnamurty
3) Sri Tapan Misra
4) Sri Vilas Palsule
5) DR CBS Dutt
6) Sri N Prahlad rao
7) Dr C.M.Kishtwal
8) Dr. Ajai

Each session will have three presentations. Details on the topics to be covered in each of the above five sessions are as under:

1. ENERGY

As the country braces up for meeting the growing demands of energy to enable the sustained growth rate targeted for next few decades it is essential to address various inputs that can be provided by space based infra structure . This session also addresses the various space based inputs for harnessing the energy from the non conventional sources such as solar power, wind energy, Geo-thermal sources, wave and tide energy, bio-fuels etc. Session will also discuss use of space based inputs that are needed for a) planning and exploration including the selection of suitable sites b) operational use ,including assessment of energy out puts using near real time data, and c) improving efficiency etc.

Another important theme to be discussed in this session is the use of space based inputs in infrastructure planning and development.

Coordinator : Tapan Misra

Three presentations in this session are :

a) Conventional energy sector demands

b) Exploration of Unconventional sources of energy : Space based input requirement

c) Infrastructure planning and development (including energy infrastructure)

2. WEATHER AND CLIMATE

With the operationalisation of INSAT 3D and assured continuity of the programme a significant milestone has been achieved in providing space based inputs for country's weather monitoring, modelling and forecasting activities. However the demand on the weather monitoring and forecasting community to provide inputs for various short term, medium term and near real time requirements for various activities in the country is far from satisfactory. Thus demands from weather monitoring and forecasting community on space based inputs needs an intense thorough assessment. This session addresses these aspects

Climate change and its impact on human life has become an issue which cannot be ignored by any country especially India with a need to provide food security to its huge population. In addition, climate change also poses many challenges in providing information of various disasters and its mitigation approaches. This session addresses the current activities in space based information generation

including ECVs as well as the future requirements . Studies on the impact of climate change on the natural resources, environment and health will also be discussed.

Coordinator : Dr. C. M. Kishtwal

Three presentations:

a) Essential climate variables that can be monitored from space, current activities and future requirements. International and Indian scenario. Studies on impact of climate change

b) Activities demanding Weather monitoring and forecast current and future scenario

c) Need for addressing the specific issues of lower predictability over our region and identifying observation demands to improve predictability

3. NATURAL RESOURCE MANAGEMENT, MONITORING AND E-GOVERNANCE

During the past three decades, data from EO satellites has been extensively used in natural resource management and environment monitoring in our country . Some of the major sectors in which RS data have been extensively used include agriculture, forestry, water resources, landuse, urban and infrastructure planning, watershed development, marine resources, and snow and glaciers. Space based has also been used to address many of the environmental issues such as monitoring and conservation of wetlands, wastelands, desertification and land degradation, environmental impact assessment of developmental projects, implementation of CRZ notification in the country, inventory and monitoring of vital coastal habitats (coral reefs, mangroves, mudflats) and ecologically sensitive areas.

The large amount of spatial information generated from the analysis of the EO data on various natural resources/themes need to be achieved in standard formats which can serve to a variety of users and natural resources managers . Establishment of spatial data infrastructure for archival , processing , retrieval and dissemination of spatial information to the users is another important activity.

Space based inputs are also being used to support e-governance in many sectors in the country. However, there are many gaps and challenging areas in each of the above applications which need to be addressed. This session will deliberate on the present status, key issues and future challenges in the areas of natural resources management, and e-governance.

Coordinator: Dr V.K. Dadhwal
Three presentations (tentative) :

a) Space based inputs for management of natural resources: present scenario and future requirement

b) Monitoring of pollution (air, water and land)

c) E-governance

4. EARLY WARNING

A variety of adverse phenomena/events/hazards occur frequently which affects lives, property, infrastructures and economy of the country. These adverse events/hazards may pertain to meteorological, geological/geophysical, hydrological or biological processes/phenomena. Magnitude of losses from these adverse events/ hazards are often quite large. In addition, a large number of people , property and vital ecosystem are put to risk due to these events. In view of the above, establishment of early warning systems (EWS) are indispensible. Currently, a few early warning systems, based on inputs from space based infrastructure, are in place in the country. These include, EWS for Cyclone track and landfall, forest fire, drought, Sea state, Tsunami etc. However, there is a need to address and establish EWS for many other critical events . This session will discuss the present status of the EWS already in place, the possible improvement and identify the future activities toward the development and operationalization of the early warning systems for other important adverse events and hazards. Space based infrastructure towards establishing the integrated EWS will also be addressed in this session.

Coordinator: Dr. Ajai

Three presentations:

a) Early warning requirements of the country amenable to inputs from Space: An over view.

b) Early warning of hydro-meteorological events/ disasters including Oceanic and Coastal: present status and improvement required.

c) Early warning systems for geo- hazards

5. COMMUNICATION AND NAVIGATION

While the current space infrastructure has contributed significantly to the development in the country by providing broadcasting, telecommunication and data collection capabilities, the growth of competing terrestrial technologies has significantly changed the demand scenario. Similarly the operationalisation of

GAGAN and initiation of deploying regional navigation satellites has brought in a new dimension to location based services and safety of life activities. This session looks at the various aspects of emerging demands in these domains.

Coordinator: Sri Vilas Palsule

Three presentations:

a) Communication : Current scenario and emerging demands

b) Navigation : Current scenario and emerging demands

c) Data acquisition and disseminating requirements for enabling existing and emerging applications

Engineer's Conclave – 2014

Theme-II "Technologies for Hill Regions''

Convenor – Dr Ashwagosha Ganju, Director SASE

Apex Committee Chairperson – Dr K Radhakrishnan, Chairman ISRO

DAY – 1

Plenary Talk – Gen N C Vij/Er E Sreetharan/Dr R K Bhandari/Dr A.S. Arya

SESSION 1: (Mountain Weather) – 14:00 hrs – 16.00 hrs

Coordinator – Dr Swati Basu, Director, NCMRWF

Sr.No	Title of talk	Talk by	Institute	Mobile no	E-mail id	Status
1	Weather forecast in Hill regions	Dr G R Iyengar	NCMRWF	011-2419404	gopal@ncmrwf.gov.in	Confirmed
2	Avalanche forecast and advisories for same	Sh Amreek Singh	SASE	9417406958	amreek@sase.drdo.in	Confirmed
3	Response Mechanism for bad weather and avalanches	Sh K K Razdan, Chief Engineer	BRO	9412056699	kkrazdan@yahoo.com	Confirmed
4.	Rescue operations during Landslide and its mitigation through RCC cut and cover structure	Sh S S Porwal VSM Chief Engineer	BRO		ssporwal@yahoo.com	Mail to be sent

SESSION II: (Gravity Flows and Associated Hazards) – 16:30 hrs – 18.30 hrs

Coordinator – Dr Ashwagosha Ganju, Director, SASE

Sr.No	Title of talk	Talk by	Institute	Mobile no	E-mail id	Status
1	Technology for arresting Snow Avalanche causing Road Blockages	Maj Gen (Retd) S S Sharma, KC, VSM	IDST, Pune	9890062205	satyasharma@hotmail.com	Confirmed
2	Technologies for Channel Erosion	Prof Nayan Sharma	IIT, Roorkee	01332-285781	nayanfwt@gmail.com	Confirmed
3	Landslides in Mountain belt: Hazard Assessment and Mitigation	Dr Chandan Ghosh	NIDM	011-23724309	ghosh24@gmail.com	Confirmed
4	Tackling Glacier Lake outbursts, how to reduce its impact on humans habitat	Dr O P Mishra	GSI		mishraom2010@gmail.com	Confirmed

DAY - 2

SESSION III: (Earth Quake Hazards in Himalayan Region and its Mitigation) – 11:00 hrs – 13.00 hrs

Coordinator – Dr Dattatreyan, IMD (Seismology)/Prof C V R Murthy, Director IIT Jodhpur

Sr.No	Title of talk	Talk by	Institute	Mobile no	E-mail id	Status
1	Earth Quake Hazards in Hill regions	Dr Baldev Raj Arora, Former Director	WIHG, Dehradun	9871287209 9897391661	arorabr47@gmail.com	Confirmed
2	Civil Engineering codes and implementation	Dr. A S Arya	IIT Roorkee		anand.s.arya@undp.org	Mail to be Sent
3	Microzonation and safety issues for Hill regions	Dr Sumer Chopra	MoES Delhi	011-24611222	Sumer.chopra@gmail.com	Confirmed
4	Earth Quake resistance Buildings	Dr. C V R Murthy	IIT Jodhpur	0291 251 2141	director@iitj.ac.in	Confirmed

SESSION IV: (Glacier, Snow Cover, Water Management and Energy in Hill Regions) – 14:00 hrs – 16.00 hrs

Coordinator – Dr A V Kulkarni, IISc Bangalore

Sr.No	Title of talk	Talk by	Institute	Mobile no	E-mail id	Status
1	Role of Glaciers in Hill regions and water available in Rivers	Dr. Pramod C Nawani	Jindal Group, Former GSI	09560894337	drnawanipc@gmail.com	To be approached by Dr Arora
2	Snow cover mapping using satellites	Dr A V Kulkarni	IISc Bangalore	0948-294-1170	anilkulkarni@caos.iisc.ernet.in	Confirmed
3	Technologies for water management in the country by human interventions	Dr Sharad Jain	NIH, Roorkee	01332 249202	s_K_jain@yahoo.com	Confirmed
4	Micro wind-solar hybrid systems for off-grid applications in mountainous regions	Dr S Gomathiniyagam	C-WET, Chennai	044 - 2246 3981	ed@cwet.res.in	Confirmed

SESSION V: (Communication for Hazardous Conditions in Hilly Regions) – 16:30 hrs – 18.00 hrs

Coordinator – Prof Ashok Jhunjunwala, IIT Madras

Sr.No	Title of talk	Talk by	Institute	Mobile no	E-mail id	Status
1	Terrestrial wireless communication for Hill regions	Prof Ashok Jhunjunwala	IIT Madras	044-22574408	ashok@ee.iitm.ac.in	Confirmed
2	Role of Satellite Communication in Hill region and Connectivity to local Wireless communication	Mr Virendra Kumar	SAC Ahmedabad	079-26913683 09978976661	virender@sac.*isro.gov.in*	Confirmed
3	Satellite phone under emergency Perspective and Limitation for Hill regions	Shri N Prahlada Rao	SCNP, ISRO Bangalore	080-22172314	asi.sdmmt@leos.gov.in	Confirmed
4	Community-based Communication Systems for disaster mitigation-Community & Communication towards connectivity					The speaker to be identified by Prof Jhunjhunwala/ Shri Virender

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Table of Contents

1.0 INTRODUCTION

1.1 Engineers Conclave, a new initiative of the INAE is being organized every year, by one of the leading Science & Technology (S & T) organisations of India. The first Conclave, EC-2013 was organised by DRDO at Delhi and this, the second, EC-2014 was organised by Indian Space Research Organisation (ISRO) from Oct 30 to Nov 1, 2104 at JN Tata Auditorium, National Science Seminar Complex, Indian Institute of Science (IISc), Bangalore.

1.2 The two themes selected for EC-2014 are:

- Theme -1: Emerging Space Applications by ISRO
- Theme – 2: Technologies for Hilly regions by SASE

1.3 The focus of the two themes was on finding engineering solutions to the problems being faced by people and make specific recommendations for development / implementation. Eminent experts and senior functionaries from National and State Centres / Departments, Academia, Industry, ISRO, DRDO and INAE fellows participated in large numbers to deliberate on the above two themes of EC-2014.

2.0 ORGANIZATION OF EC – 2014

2.1 As per the INAE laid down norms for Engineers Conclave, Dr. K Radhakrishnan, Chairman, ISRO was the EC 2014 Chair and Dr. Baldev Raj, President INAE was the Co-Chair.

2.2 Dr. B N Suresh, Vikram Sarabhai Professor at ISRO and Vice President of INAE Chaired the Program Committee and Shri V Raghu Venkataraman of ISRO Hq Chaired the Local Organising Committee. Dr PS Goel, past President INAE, mentored the overall program.

2.3 The Theme #1 Technical Program was coordinated by Shri A S Kiran Kumar, Director, SAC, ISRO, Ahmedabad.

2.4 The Theme #2 Technical Program was coordinated by Dr. A Ganju, Director, SASE, DRDO, Chandigarh.

2.5 It may be noted that the two themes though apparently different, have a few common technology solutions. The space segment plays a very important role in technology solutions for hilly regions and finding applications of space in the hilly regions is a priority for space, particularly in the context of 2013 landslide/floods in Uttarkhand.

2.6 Three plenary talks were organized to focus on some of these issues as follows:

2.6.1 Dr Soumitra Chaudhuray, Former Member, Planning Commission on Impact of Technology on Economy.

2.6.2 Lt Gen AT Parnaik, Director General, Border Roads on Challenges in Maintaining Infrastructure in Himalayan Region.

2.6.3 Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences (MOES) on MOES initiatives to bring improvements in Weather and Ocean state Forecasts.

2.7 In addition, a brainstorming luncheon session on Climate Change was organized with participation of senior functionaries of the GOI and scientific community, requiring space based observations, soon after the inaugural session. Deliberations of this session are elaborated in Chapter-6.

3. DETAILED OUTCOMES OF TECHNICAL SESSIONS OF EC-2014

3.1 The detailed outcomes of the two Technical Sessions of Theme I and Theme II are given in the following sections.

3.2 **Theme -1: Emerging Space Applications :**

3.2.1 Under the theme 'Emerging Space Applications', deliberations were organized in the following five technical sessions (i) Energy & Infrastructure, (ii) Weather & Climate, (iii) Natural resources monitoring management & e-governance, (iv) Early warning systems and (v) Communications & Navigation.

3.2.2 There were three invited talks in each of the above five technical sessions. The presentations covered present scenario, gap areas, & future requirements in each of the above five emerging areas of space applications which are important in the context of the societal development of our country.

3.2.3 Session on **'Energy and Infrastructure'** had the following three presentations : (i) Conventional energy sector demands: Space based input requirement, (ii) Exploration of Unconventional sources of energy: Space based input requirement and (iii) Infrastructure planning and development including energy infrastructure. Based on the detailed discussions the following requirements /technological improvements have emerged :

- Satellite based Low frequency GPR (subsurface geological structures/ infrastructures mapping)

- Magnetometer to derive high resolution magnetic anomaly maps over land & ocean (for Hydrocarbon exploration)
- Very high resolution (< 1m) multispectral data
- High resolution winds over land and coastal regions

3.2.4 Technical session on **'Weather and Climate'** had detailed deliberations on the current scenario and future requirements for: (i) Essential climate variables that can be monitored from space as well as the studies on impact of climate change on natural resources and environment, (ii) Activities demanding weather monitoring and forecasts and (iii) Specific issues of lower predictability over our region and identifying observational demands to improve predictability. The following requirements /technological improvements have emerged from this session:

- Vertical profile of winds (Lidar/Radar) for improved weather forecast
- Surface Pressure (for improved weather forecasting)
- Cloud microphysical properties (for solar energy ; high resolution weather forecasting & Extreme events)
- Lightning sensors on geostationary platforms
- High spatial resolution surface winds over Ocean & Land (for wind energy; Ocean state forecast)

3.2.5 The present status on the use of space based inputs and the requirement to fill the gap areas for (i) natural resources management, (ii) monitoring of air, water and land pollution, and (iii) E-governance, were discussed under the third session. The requirements to fill the gap areas in the above areas of applications are:

- Very high resolution (< 1m) multispectral data
- Vertical profile of aerosol (for Pollution & insolation)
- Sensor for green house & Trace gases (Pollution)

3.2.6 Presentations and discussions in the technical session on **'Early Warning System'** covered : (i) overview on the early warning requirements of the country amenable to inputs from space, (ii) the present status and improvement required in the early warning of hydro-meteorological events/ disasters (including Oceanic and Coastal), and (iii) Early warning systems for geo- hazards. Future requirements are as under:

- Soil moisture at high spatial resolution (for Flash flood & drought)

- L-band SAR data (Land subsidence studies)
- High resolution rainfall (Landslide, Flash flood)
- High resolution weather forecast for 5-7 days (Flood, Landslide)
- High resolution near-shore bathymetry & DEM (storm surge)
- SAR interferometry with pair of satellites for generating very high accuracy DEM (for vulnerability assessment)
- Establishment of River gauges with satellite connectivity (for flood forecasting)

3.2.7 The fifth technical session dealt with current scenario and emerging demands in the field of spaced based **communication and navigation**. Data acquisition and dissemination requirement for enabling existing and emerging applications were also deliberated. Following technological improvements/ requirements have emerged from this session:

- LAAS (Local Area Augmentation System) for augmentation for GAGAN (for CAT I/II and possibly CAT III approach and landing) Development of HTS with >10GBPS for BB applications
- Development of MSS (S-band) satellite with multiple spot beams
- Development of low weight, compact satcom terminals for disaster management
- Electronic Beam Pointing (forming) system for multi-beam satellite
- Expansion/revamping of DMS network and integrating it with terrestrial network

3.2.8 An expert panel, comprising of Shri A S Kiran Kumar, Shri Pramod Kale, Dr V K Dadhwal, Dr V Jayaraman, Dr Tapan Misra, Dr P K Pal, had detailed discussions. Following points have been emphasized by the panelists:

- Investment in communication infrastructure in NE region,
- Continuity of space based services,
- Use of insitu/ ground data along with satellite based observations in modeling,
- Revisit of the remote sensing data policy in the context of availability of sub-meter data.

- Huge amount of satellite data is available; however present assimilation techniques are unable to utilize them. Improvements in the assimilation schemes are required to utilize maximum amount of available data to improve the predictions

3.3 Theme-II Technologies for Hilly Regions

3.3.1 The main aim of the Theme II "Technologies for Hilly Regions" was to come up with technological solutions for the development of hilly regions and mitigation of recurring disasters. The agenda of the theme was to suggest the engineering strategies for hilly regions to mitigate the effect of natural disasters and to propose solutions to reduce the impact and scale of disasters. Theme-II was further divided into following five sessions:

- Mountain Weather
- Gravity flows & Associated Hazards
- Communications for Hazards conditions in Hilly Regions
- Earthquake Hazards in Himalayan Regions & its Mitigation
- Glacier, Snow cover, Water Management & Energy in Hill Regions

3.3.2 There were three invited talks in each of the above five technical sessions. The presentations covered present scenario, gap areas, & future requirements in each of the above five emerging areas of space applications, which are important in the context of the societal development of our country. The recommendations of each session are summarized in the following paragraphs.

3.3.3 **Mountain Weather :** The Current System / practice / status for Mountain Weather Forecast are (i) Global Model by IMD with National Centre for Environmental Prediction (NCEP) based Global Forecast System (GFS T574/L64) for forecast up to 7 days and Meso-scale forecast system WRF (ARW) with 3DVAR data assimilation for forecast up to 3 days, (ii) Global Model by NCMRWF with NCMRWF Global Forecasting System (NGFS) and Global Ensemble Forecasting System (NGEFS) for forecast up to 10 days and (iii) Mesoscale model by SASE with WRF (ARW) with NCEP GFS and NCMRWF T574 global ICBC data and 3DVAR data assimilation for forecast up to 6 days. The gaps are (i) extent of mesoscale model limited to the interest of Army, observation system by SASE only for regions of Army interest and limitation of quantity and quality of data , (ii) area specific forecasts missing, (iii) extreme events warning missing, (iv) GIS visualization missing, (v) topography and land use in the model not truly representative, (vi) Physics in NWP models for hills not sufficient, (vii)

downscaling is dynamical and statistical and (viii) computational power. The recommendations that have emerged are given below.

- More detailed observation (data) plan for hilly regions.
    - More number of X and Ku band weather Radar network by IMD, IITM and SASE particularly regions of high density population, tourists places is required.
    - Densification of Automatic Weather Stations by IMD, NCMRWF and SASE.
    - More number of Radiometers by IMD, IITM and
    - SASE for vertical profiling of the atmosphere.
    - The details on instrument, participating agency, budget etc. are given in Appendix A. S-band DWR is not feasible in the mountainous region due to its size and range
- Research on site specific regional / global / mesoscale models, for vulnerable regions.
    - Coupling of Atmosphere, Cryosphere and Ocean systems.
    - High resolution and ensemble modelling.
    - Better and dynamic land use / land cover in the model.
    - The details on R&D activity, responsibility and budget are given in Appendix B
    - Involve more regional units for running regional / mesoscale models.
    - Mode I: Global and regional model could be run in a central place at IMD/NC in RUF. Model outputs could be collected and analysed at regional units and further downscaled could be done for more site specific mountain weather forecast by units like SASE, regional universities and other research laboratories.
    - Mode II: Regional units can run regional / mesoscale models for their specific site of interest and forecast can be drawn and disseminated, specific to following.

3.3.3.1 **Avalanches :** The Current System / practice / status are (i) All terrain study by SASE, (ii) Global model by IMD for rain and wind and (iii) Regional model run by SASE (being limited resource, computer and manpower), only for region of interest of Army. The gaps are (i) Limitations on data on ice cover and slope, (ii)

Limitation on SASE resource as limited manpower and (iii) No identified agency for all the hilly regions of the country. The recommendations are

- Recognize and expand SASE as National Agency for Avalanches forecast for the entire Hilly region, not just for interest of Army – Manpower, budget to commensurate with the additional responsibility.
- Deployment of a SAR formation Satellite by ISRO for precise DEM for all vulnerable regions continuous mapping of Himalayas and providing data to SASE in real time. ISRO, Approx. 1000 Crore
- The research from earlier recommended steps to be continuously available for better weather forecast.
- A task team by Army for preventing measure of Avalanches, in consultations with SASE.

3.3.3.2 **Surface & Aerial Connectivity: Road Response Mechanism:** The Current Scenario / Issues are (i) Road axis along rivers, river bank vulnerability and unprotected, (ii) Toe erosion and landslides common place, (iii) Unpredictable cloud bursts and (iv) Sinking of hill roads. The gaps are (i) No provision of alternate roads along with highways, (ii) Prediction of abrupt change in river course, (iii) Absence of Integrated Disaster Management Plan involving all stake holders and (iv) Awareness about river side habitation. The recommendations are:

- Pre plan preparatory actions for early warnings
- Alternate alignment of link roads along National Highways
- Integrated Disaster Management Plan
- Construction of Helipads at designated points in disaster prone hilly areas
- Capacity building Exercises: Capacity building by Govt and other agencies in terms of early warning systems, resource mobilisation including Earth moving equipment, bridging; formulation of village level civil defence organisation for disaster relief etc.
- Implementing agencies: BRO, State Authorities, NDMRF and the local authorities at village / town level.

3.3.4 Gravity Flows & Associated Hazards

3.3.4.1 **GLOF:** The Current Scenario / Issues are (i) About 16 dangerous glacial lakes exist in India, (ii) No dedicated Early Warning System in place and (iii) Regular and strict monitoring of glacial lakes has started only after recent disasters. The gaps are (i) Non availability of dedicated Information database on Glaciers and Glacial lakes, (ii) No dedicated agency for tacking GLOF and related hazards, (iii) Lack of comprehensive planning and preparedness, (iv) Lack of Knowledge sharing among the GLOF affected countries. The recommendations are :

- Formulate a plan for data collection and regular monitoring of glacial lakes. The task for study of GLOF could be given to Glaciological Centre, WIHG, Dehradun India.
- GLOF risk reduction plan should be prepared by the Institute
- Satellite data analysis and field verification plan of potentially damaging lakes can be taken up by SAC, Ahmadabad and NRSC Hyderabad in association with WIHG, Dehradun.
- The two implementation schemes could be :
    - Structural Measure

▪ Cut Channels through embankment to lower water level. This can be taken up by Indian Army in consultation with WIHG and IIT Roorkee.

- Non-structural

▪ Early warning and avoidance action. Sensors, Sirens etc. WIHG in association with NRSC, Hyderabad can take up this task.

▪ Preparation of dedicated data information base. This should be made available at NRSC, Hyderabad.

▪ Community Participation, Capacity Building. A comprehensive plan can be drawn by NDMA and NIDM and implemented on ground.

▪ Implementing Agencies: WIHG/GSI/IIRS/NRSC/ NDMA/SAC

3.3.4.2 **Channel Erosion & Flash Floods:** The Current System / practice / status are (i) No early warning system in place for flash floods and (ii) Road construction too close to river embankment. The gaps are (i) Limitations of data on flash flood in hilly rivers, (ii) Lack of robust & effective warning system, (iii) No identified agency for the construction of state-of-the-art roads in the hilly regions of the

country (on the line of BRO for Border roads), (iv) Mathematical Models for channel flow simulation and erosion not existing. The recommendations are :

- Development of mathematical models for simulation of river flow. This can be taken up by IIT Roorkee,
- Implementation of Piano key Weir type of structures by state governments to arrest excessive erosion of channels as well as use of water for irrigation purpose,
- Early warning systems by IMD supported by strong governance and organizational coordination mechanism with state governments,
- Control of erosion by application of Bio Engineering (Vetiver grass) and Hydro Seeding Techniques to be adopted by the state governments.
- A task team by BRO/ State Agency for preventive measures for flash flood, in consultations with NIH/ IITs to be established.

3.3.4.3 **Landslides:** The Current System / practice / status are (i) Landslide hazard mapping of a few affected sites available, (ii) Landslide monitoring & suitable early warning system available at a few locations only and (iii) Implementation of landslide control measures on ground at a few locations only. The gaps are (i) No comprehensive control plan exists for different terrain conditions, (ii) Identification of potential sites through remote sensing not existing. The recommendations are

- Slope monitoring for real time early warning system. (DST, NIDM, CSIO)
- Implementation of landslide measures on ground (BRO, State Agency)
- Treatment of vulnerable slopes by geo-textile, geo-grid, Rock bolting/ cable anchor & shot-crating with wire mesh of rocky strata
- Use of Jute geotextile & plantation for slope stabilization
- Continuous monitoring of whole slope by SSR (Slope Stability Radar)
- Placement of Micro-seismic Stations for monitoring of Landslide
- Alternate route planning along National Highways

3.3.5 **Communication for Hazardous Conditions in Hilly Regions**: The Current System / practice / status are (i) Portable and Mobile VSAT, (ii) MSS Terminals, (iii) Disaster Management Support System (DMS). The gaps are (i) Low Link Margins, (ii) Non Availability of Sufficient Bandwidth, (iv) High Cost, (v) Long

Response time of DMS teams and (v) Lack of Local Trained Manpower. The recommendations are :

- Network with advanced waveform & technologies (DVB-S2 with improved throughput network for IP communication) to be expedited.
- Integration of diverse technologies like GSM/CDMA/Wi-Fi /FM broadcast with satellite on-field VSAT nodes for wide area communication
- Provision for extending the reach of on-field VSATs by 5-10 km to extreme remote locations through simple low cost appliances
- Pre-Deployment of VSAT Nodes for DMS at identified locations connected to State Disaster Management Cells.
- Fuel Cell based power packs to be developed.
- Development of Lighter-than-Air vehicles especially small aerostats which serve as intermittent aerial stations of GSM /Microwave terrestrial links for disaster hit areas.
- Development of light weight hand Held Low Cost Satellite Phones.
- Training on such equipment's at grass root level i.e. village Panchayats, through NGO's working in these areas and State Rural Development Departments.
- Implementing Agencies: ISRO/IIT's/BSNL/ GSM Operators

3.3.6 **Earthquake Hazards in Himalayan Region & its Mitigation**: The Current System / practice / status are (i) No focus on Earthquake Resistant Construction, (ii) Improper planning for construction activity in Seismic Zones, (iii) Earth quake measurement system in the hilly regions by MoES is not adequate for want of logistic support in such areas. The gaps are (i) Dearth of trained manpower for seismic micro zonation, (ii) Acquisition of quality data from field missing, (iii) No focus on Earthquake precursor study and interdisciplinary research effort missing, (iv) No dedicated Earthquake Management Force in place. This should be in addition to national network by IMD/MoES, (v) Lack of Local Trained Manpower. The recommendations are :

- Development of Seismotectonics Model for detection potential threat zones by IMD
- Enhanced Seismological Network for earthquake monitoring by MoES and other organization in the Hilly regions.

- Master Plan for Earthquake Disaster Prevention by IMD
- Formulation of Plan Aimed at Earthquake Resistant City
- Promotion of Research on Earthquake-Resistant Buildings
- Micro zonation of vulnerable areas based on Peak Ground Acceleration measurements
- Placement of GPS for monitoring movement of Indian Plate Motion & Rate of Convergence
- Establish proper system to measure multi parametric geophysical parameters to understand earthquake
- Standardisation and zoning of Seismic Codes.
- Zoning for earthquake disaster prevention plans / measures & risk management.
- Master plan on earthquake disaster prevention should be prepared
- Implementing Agencies: GSI/NDMRF/NGRI and IMD. A lead agency should be identified by the GoI.

3.3.7 Glacier, Snow Cover, Water Management and Energy in Hilly Regions

3.3.7.1 **Glacier & Snow Cover:** The Current System / practice / status are (i) Glaciers mapping, inventory and mass balance model by GSI, WIHG, SAC, (ii) Glacier and snow hydrology modelling by IIT-Roorkee, NIH Roorkee, NRSC and SASE and (iii) Snow cover mapping and snow melt run off by NRSC, SAC , SASE. The gaps are (i) Limited study on Impact of future climate change on the cryosphere, (ii) Integrated approach with communication and collaboration among atmospheric scientists, glaciologists, geo-morphologists and geologists missing, (iii) Limited study on glacier discharge , (iv) Limitation of data: Snow cover with snow depth. This is required particularly in regions of high density population, tourists and where source of irrigation and drinking water is seasonal snows, (v) Limited use of RS and GIS based technologies for monitoring and management of ground as well as surface water, (vi) Limited data base on monitoring of key components of cryosphere, (vii) No identified agency for all the hilly regions of the country. The recommendations are:

- More detailed observation for Climatic scenarios produced by GCMs need to be refined to understand and better prediction of the behaviour of most components of the cryosphere and their impact.

- Processes that are driven by interaction between the atmosphere and the cryosphere need to be understood better which will further allow the construction of more sophisticated and realistic climate sensitivity models.
- Monitoring of key components of cryosphere must continue. Database need to be further developed and maintained. They provide the bench mark for assessing future change and for model testing.
- Determining the spatio-temporal pattern of fluctuations of mountain glaciers from the last glacial cycle through the present.
- Identifying important but poorly understood processes controlling the motion and ablation of glaciers.
- Developing and expanding the application of numerical models of glaciers GSI, Wadia Institute of Himalayan Geology
- Conjunctive use of SAR & optical data from RISAT-1, AWiFS, LISS 3, 4, Cartosat, for snow and glacier studies (medium and high resolution). Use of INSAT-3D/GISAT data for snow and glacier studies (high temporal coverage).
- Development of Himalayan Glacier Information System (HGIS) and models for glacier health assessment.
- Energy balance approach for snow & glacier melt, glacier mass balance estimation using satellite derived AAR approach.
- Utilization of SAR Interferometry & Photogrammetry in glacier flow determination and glacier mass balance using DEM generated from these (differential DEM approach – geodetic)
- Explore hyperspectral and multispectral imaging for quantitative measurements of glacier and snow studies
- More and more RS and GIS based surface and ground water studies, hydrogeological data analysis for land and water management are recommended to be carried out in conjunction with field investigation to effectively exploit the expanding potential of RS and GIS technologies.
- Implementing Agencies: NRSC, SAC, SASE, NIH and IIT-Roorkee. A Lead agency to be identified by GoI.

3.3.7.2 **Water Management:** The Current System / practice / status are (i) The snow melt rate and glacial hydrology in Himalaya and their modelling are being conducted by NIH Roorkee, (ii) The promotion of integration and sustainable

development and management of India's water resources with different states by using state of the art technology is being done by CWC and (iii) Sustainable development and management of ground water resources are done by CGWB. The gaps are (i) Limited study on glacier discharge, (ii) Lack of Integrated approach with communication and collaboration among atmospherics scientists, glaciologists, geo-morphologists and geologists and state agencies, (iii) Insufficient local technological research on water management, (iv) Lack of integrated water management plan, (v) Lack of control over exploitation of ground water resources and (vi) Insufficient facilities for waste water management. The recommendations are:

3.3.7.3 **Renewable Energy for Hilly Regions: The** Current System / practice/ status are (i) Wind Energy and Solar Energy studies are being carried out by National Institute of Wind Energy (NIWE) Chennai and SSS National Institute of Renewable Energy, Kapurthala and (ii) Geothermal Energy study as a pilot project is carried out by SASE, DRDO in the Himalayan foothills in Manali, H.P. The gaps are (i) A sustainable energy future based on renewables is possible and technologies exist, however a comprehensive plan is missing, (ii) Despite the potential of technologies, progress is too slow at the moment and is missing in hills, (iii) A clean energy future requires systemic thinking and deployment of a variety of technologies, (iv) Lack of awareness about the use and management of renewable energy resources with local people. The recommendations are

- Create an investment climate of confidence in clean energy
- Unlock the incredible potential of energy efficiency – "the hidden fuel" of the future
- Accelerate innovation and public Research, Development and Demonstration (RD&D)
- Establish plans for policies and actions for energy efficiency and renewable energy sources
- Addressing all aspects of sustainability in energy production (environmental, economical, social)
- Promoting off-grid Wind Energy in Hilly Regions on the national levels
- Technological development in Smart Energy Management Technologies,
- Supporting development of energy saving technologies.

3.3.8 These recommendations were further discussed in the Panel discussion chaired by A. Ganju and consolidated the recommendations.

3.3.8.1 **Improvement in Weather and Avalanche forecast.**

- Weather observation System and forecast for the Himalayas.
  - IMD should upgrade the weather observation system by installing additional Radars and other equipment as per Appendix 'A'. Estimated Cost : INR 670 Crores
  - SASE (DRDO Lab) should be given extended mandate to be made responsible for generating detail weather model forecast, based on upgraded mesoscale model, running on operational basis for whole of the Himalayan region, including the area covered by the Civil population, in addition to the region of interest to the Army. This will require upgrading the computer system and enhanced manpower as per Appendix 'B'. This requires an approval at the GoI level and at the level of DRDO to accept to this expanded mandate and commit additional budget and manpower.
  - NCMRWF (Min. of Earth Sciences) should continue to support SASE in R&D activities for continuous up gradation of the Mesoscale model, applicable to each sub region of the Himalayas.
  - IMD should continue to do regular forecast of the Himalayas, as usual, on a broader scale. SASE shall focus more on issues related to special weather conditions, extreme events, Avalanches etc. The main difference is that while IMD will run overall global weather model, SASE will take that as input to generate weather data based on more detailed mesoscale model.
  - Monitoring of the slopes in the Himalayan region for snow and rocks along the roads through satellites has to be taken up for suggesting schemes for all weather road connectivity.
- It is reported that Europe has successfully demonstrated that a pair of SAR satellites in formation flying can generate DEM with high accuracy (within few centimetres).
  - EC 2014 recommends a formation of two such satellites to continuously monitor, at known intervals, for the whole Himalayan region.
  - This data should be received at SASE for preparing DEM, within 24 hrs, and classify vulnerability for Avalanches and landslides that are important to army and civil population.
  - Also SASE should design and implement avalanche protection schemes for different zones of avalanche on high resolution DEM. This DEM generated from satellite data will be a critical input, in addition to the weather data, which is otherwise being generated by SASE, in higher resolution.

- The estimated cost of the SAR satellites to be launched and maintained in formation by ISRO will be ~500 crore and that for upgrading facilities and manpower at SASE DRDO will be 150 crore.

3.3.8.2 **Gravity Flow, Earthquakes and Associated Hazards in Hilly Regions**

- It is an important area of concern and country has no mechanism to deal with such disasters. Like INCOIS (Min. of Earth Sciences) has been identified as agency for TSUNAMI warning and has a dedicated TSUNAMI warning centre.
- EC-2014 recommends creation of such a warning centre for Gravitational flow, landslides and associated Hazards (GLOF, Avalanches etc.) at NRSC (Dept. of Space) or any other institution like WIHG or Centre of Glaciology, Dehradun.
- This centre has to collect all the geotechnical data at all vulnerable regions, will have good tie-up for real-time weather data with IMD/SASE, plan additional observation sensors at vulnerable points etc.
- The WIHG may also be given the mandate of enhancement of seismological network for earthquake monitoring in partnership with NGRI.
- In addition the new Centre of Glaciology must focus on : (i) Regular Monitoring of Glacial Lakes (ii) GLOF risk reduction Plan in collaboration with NDRF, (iii) Take up the studies on structural & non-structural measures for risk reduction during such events in consultation with IIT's, (iv) Strategies to artificially break the steep bed gradient for curtailment of excessive stream power in consultation with IIT's, (v) Erosion prevention and holistic river restoration schemes in consultation with NIH and IIT's, (vi) Earthquake precursor study with WIHG.
- NGRI should take up monitoring of Indian Plate Motion and rate of convergence by placing GPS at designated points with the help of GSI and IMD.
- IMD may be given the task of development of Seismotectonics Model for detection of potential threat zones of earthquakes. Masterplan of earthquake disaster prevention has to be taken up by NIDM and IMD with the involvement of local bodies.
- Research in the field of earthquake resistant buildings should be taken up by CBRI, Roorkee to develop buildings for area which lie in the sensitive seismic zone.

- Stringent guidelines for town and country planning departments should be formulated to regulate construction in earthquake prone zones in a way so that the damage in event of an earthquake is minimised.

3.3.8.3 Communication for Hazards Conditions in Hilly Regions

Communication infrastructure is vulnerable to breakdown during any event of disaster. Restoration of communication links takes longer time due to tough terrains, inaccessibility and climatic conditions in Hilly regions. Govt and relief providing agencies increasingly rely on wireless mobile communication technology to provide effective command, control, and communication during emergencies and disaster response operations. Past events have shown that in the aftermath of an unexpected event, communication infrastructures play an important role in supporting critical services such as emergency recovery operations, infrastructure restoration, post-disaster surveillance, etc.

- EC-2014 recommends development of an exclusive S-band multi-beam satellite with frequency reuse technique and a 12 M Un-furlable Antenna. The multi-beam satellite will have large capacity and coverage as compared to the single beam satellites and will support compact terminals. ISRO should be asked to expedite the development of S-Band Satellite phones and man portable VSAT's for effective communication in the disaster hit areas, since such small portable devices are easy to transportable in inaccessible hilly regions. The approval from GoI should be sought to allocate a sufficient and dedicated bandwidth for disaster management and disaster warning systems.

- Last Mile Connectivity & Integration of Satellite and Terrestrial Communication Network: EC-2014 recommends GoI to consider the provision of rapidly deployable and resilient mobile networks which are compatible to the existing subscriber mobile units to provide broadband access in large coverage areas. Current mission critical systems and Disaster Relief Communication Systems are limited in terms of network capacity and coverage. They are not designed for or suitable to address large scale emergency communication needs in a disaster aftermath. The existing systems are also limited by interoperability barriers, the technological gap with commercial technologies and evolving standards. EC 2014 recommends a feasibility project to be taken up to provide mobile service coverage with a Lighter than Air (LTA) Platform which will integrate the terrestrial and satellite networks in hilly regions where network infrastructures have become inoperable. This will demonstrate the capability of LTA to restore GSM network with a mobile VSAT providing backhaul to base stations – PicoBTS, NanoBTS, and MacroBTS. The

proposed infrastructure will be composed of a Low Altitude Platform or a mobile modular tower mounted on a mini truck, based airborne communications segment combined with a Mobile Instant Network system coupled with satcom-enabled Portable Land Rapid Deployment Unit. The solution proposed to be developed within the framework of this project, attempts to demonstrate the high-capacity, low-latency and large coverage capabilities of existing mobile network components for the provision of broadband emergency communications. The subsystems of the proposed system at given at Appendix 'C'. Undertaking such a project will be multidisciplinary task with the involvement of ISRO, IIT Bombay, SASE and BSNL. The details of the work to be executed by the participating organisations are given at Appendix 'D'. The estimated budget for the execution of the proposed feasibility project would be about 9-10 Crores.

3.3.8.4 **Glacier, Snow cover, Water Management & Energy in Hill Regions**

EC-2014 recommends the following tasks to be taken up by a group of institutes/ organisations along-with the task as the task given below:

- Glaciers mapping, inventory and mass balance modelling to be taken by GSI and WIHG. ISRO and SAC should provide more products for snow cover and glacier monitoring. The conjunctive use of SAR & optical data from RISAT-1, AWiFS, LISS 3, 4, Cartosat, for snow and glacier studies (medium and high resolution) along with INSAT-3D/GISAT data for snow and glacier studies (high temporal coverage) to be taken up by GSI, WIHG and SASE collectively. The energy balance approach should be implemented for snow & glacier melt, glacier mass balance estimation using satellite derived AAR approach to arrive at the best results implementing the models to be developed by GSI and WIHG as suggested.

- The utilization of SAR Interferometry & Photogrammetry in glacier flow determination and glacier mass balance using DEM generated from these (differential DEM approach – geodetic) and snow hydrology modelling to be taken up by IIT-Roorkee, NIH Roorkee, NRSC and SASE.

- EC 2014 recommends a centre to be set up for cryospheric studies and water management in hilly regions or the task could be entrusted to the Centre of Glaciology, WIHG Dehradun. The centre would have the integrated approach with communication and collaboration among atmospherics scientists, glaciologists, geo-morphologists and geologists to take up studies on

  - Glacier Discharge

- Extensive snow cover and snow depth data for accessing the water sources for irrigation and drinking in hilly regions, impact of future climate change on cryosphere
- Expedite use of RS and GIS based technologies for monitoring and management of ground as well as surface water
- Determination of the spatial-temporal pattern of fluctuations of mountain glaciers from the last glacial cycle through the present
- Identification important but poorly understood processes controlling the motion and ablation of glaciers.
- Development of Himalayan Glacier Information System (HGIS) and models for glacier health assessment.

4. VALEDICTORY SESSION AND SUMMARY RECOMMENDATIONS

As elaborated in Chapter 3, the two panels of Theme 1 and Theme 2, Chaired by Shri A S Kiran Kumar and Dr A Ganju met separately and consolidated the recommendations of the technical sessions. The recommendations were further presented and discussed in the Valedictory Session Chaired by Dr K Kasturirangan. The Tables 1 and 2 given in Annexure 1 summarises the outcome in the form of an implementable recommendations.

4.1.1 Dr K Kasturirangan, during the valedictory session, emphasized the larger role of space technology in hill area development in the country. He stressed the need of a holistic approach for hill area development (including disaster management) which takes care of the ecological, environmental, social, cultural, and economic as well as policy issues. Sharing/dissemination of data/information, continuity of space based observations and services such as telemedicine and tele-education, creation of experts in computational intelligence, human resources development were some of the important issues discussed during the valedictory session. One of the mandates of INAE is to bring synergy among various technologies and stake holders and Engineer's Conclave is successful in doing that. Next step, in this direction will be to organize workshops on some of the important and selected topics.

4.1.2 Based on the deliberations during the conclave, the following recommendations have emerged for theme- I ;

- Continuity of space missions/services to be ensured. For weather forecasting, continuity of meteorological satellite INSAT-3D has been ensured with INSAT-3DR and INSAT-3DS. Similarly, to meet the other requirements

related to weather and ocean forecasting, continuity of the missions with microwave radiometer, scatterometeretc needs to be ensured.

- To improve the prediction capabilities, satellite based atmospheric wind profile measurements are indispensable. Efforts should be made to develop space based Lidar and microwave sounders for this purpose. A pilot experiment should be carried out, jointly by DOS and MoES, to develop airborne Lidar system and demonstrate its operational capabilities as well as the utility of wind profile in improvement of weather predictions.

- To design and develop the space based system for measurement of cloud microphysical properties. These observations are required for high resolution weather predictions, solar energy & prediction of extreme events.

- While collaboration with International agencies are happening for earth observation missions, there is a strong need for international collaboration to define the observational requirements to improve the weather predictability in tropical regions. Planned joint missions can become a part of global constellation. Additionally, a low inclination mission for better receptivity over tropical region may be planned for soil moisture and ocean salinity.

- Lightning information is useful for safety in aviation activities. This phenomenon is associated with specific atmospheric environment and its evolution. A joint team should study for exploring the feasibility of developing a satellite sensor for the detection of lightning phenomenon.

- Mission on SAR interferometry with pair of satellites for generating very high accuracy DEM

- In order to ensure the use of in-situ/ground based data in the models on near real time basis, efforts should be made to provide satellite connectivity to such network of in-situ/ground based instruments for their real time collection and dissemination. This may include river gauges, snow/glacier melt discharge measuring gauges, pollution measurement sensors, DCPs etc.

- For better utilization of space based data for natural resources management in the country, there is a need to involve more central/state departments and ministries through the existing mechanism under NNRMS. This may also require energizing the state NNRMS.

- Mechanism should be evolved for making the information/data available to users on operational and near real time basis. This may also require revisiting the national data policy (including Remote Sensing Data policy)

- LAAS (Local Area Augmentation System) for augmentation for GAGAN (for CAT I/II and possibly CAT III approach and landing).This needs to be taken up with Airport Authority of India.

4.3. The following key recommendations have emerged for theme-II;

- Forecast and mitigating disaster in the Hilly region requires continuous mapping of the slope for designated vulnerable spots all through the region. This can only be possible from a pair of SAR satellites interferometery, formation flying.

- Weather plays a very important role and ability to run memo scale model and now-casting requires intensification of IMDs observation system using X and Ku band DW Radars and AWS Network.

- SASE has done excellent work as DRDO laboratory to support army operations in terms of providing support with respect various operations in the Hilly region. However, the scope of this activity should be expanded to cover whole of Himalayas and SASE's mandate and resources should be expanded to cover whole of Himalayan region.

- A separate laboratory is being set up under DST to undertake studies of Glaciers in the Himalayan region. The mandate of this laboratory needs to be expanded beyond science of climate change, to disasters of various kinds, in cooperation and SASE and other laboratories of states and GoI.

- Water flow of Himalayan Rivers needs detailed modelling and studies with respect to terrain, interconnection of channels etc. IIT Roorkee could be tasked to take up comprehensive study.

- Water management of Himalayan rivers needs are holistic approach on the lines of Dastur plan of 70^{s} and options like linking rivers. Ministry of Water resources should come-up with a long term mega plan.

- Land slide prevention measures are immediate requirement and SASE and Border Roads organization should jointly come-up with a mega plan.

- Earth Quakes in Himalayan region are very important for safety of people and hence MoES and NGRI should be tasked to generate site specific earth quake mitigation plans using micro zonation for most of the populated places in the region.

- Glaciers play a very important role in the happening of disasters and we need to monitor with adequate data base to forecast incipient disasters, for

corrective measures. This could be done by the new unit at Dehradun (Under DST) in collaboration with SASE.

- Telecommunication is back bone any operations and it is important to maintain it under all disastrous conditions. A network supported by satellites and ground equipment with software Define Radio capability should be developed.

RECOMMENDATIONS OF THE INAE ENGINEERS CONCLAVE 2014 (EC-2014) Theme II TECHNOLOGIES FOR HILLY REGIONS

1. INTRODUCTION

This year's Engineers Conclave, EC-2014, was jointly organized by Indian National Academy of Engineers (INAE) and Indian Space Research Organisation (ISRO) from Oct 30 to Nov 1, 2014 at JN Tata Auditorium, National Science Seminar Complex, Indian Institute of Science (IISc), Bangalore. "Emerging Space applications" and "Technologies for Hilly regions" were the two themes for the EC-2014. The focus of the two themes was on cutting edge technological solutions and specific recommendations for development. Eminent experts and senior functionaries from National and State Centres/ Departments/ Units, Academia, Industry, ISRO, INAE and DRDO participated in large numbers to deliberate on the themes of the EC-2014.

i. EC-2014 Theme-II Technologies for Hilly Regions

The main aim of the Theme II "Technologies for Hilly Regions" was to come up with technological solutions for the development of hilly regions and mitigation of recurring disasters. The agenda of the theme was to suggest the engineering strategies for hilly regions to mitigate the effect of natural disasters and to propose solutions to reduce the impact and scale of disasters.

ii. Organisation of EC-2014, Theme-II

The Theme –II was organised in the following sessions with a plenary talk by Lt Gen A T Parnaik SM VSM, Director General, Border Roads and a panel on theme II was chaired by Shri Ashwagosha Ganju, Director SASE. The recommendations of both the panels were presented, discussed and approved in the valedictory session, chaired by Dr K Kasturirangan, Former Chairman ISRO and Former Member, Planning Commission.

Theme-II was further divided into following five sessions:

1. Mountain Weather

Chairperson: Dr. Swati Basu, Director, National Centre for Medium Range Weather Forecasting (NCMRWF)

Rapporteur: Dr. Jagadeesha, ISRO

2. Gravity flows & Associated Hazards

Chairman: Prof. Nayan Sharma, IIT, Roorkee

Rapporteur: Dr. J Krishnamurthy, ISRO

3. Communications for Hazards conditions in Hilly Regions

Chairman: Shri N Prahlad Rao, Director, Satellite Communication and Navigation Programme (SCNP), ISRO HQ

Rapporteur: Shri H Rayappa, ISRO

4. Earthquake Hazards in Himalayan Regions & its Mitigation

Chairman: Dr. Baldev Raj Arora, Former Director, Wadia Institute of Himalayan Geology (WIHG)

Rapporteur: Dr. K Ganesh Raj, ISRO

5. Glacier, Snow cover, Water Management & Energy in Hill Regions

Chairman: Dr. Pramod C Nawani Jindal Group, New Delhi

Rapporteur: Dr. S Bandopadhyay, ISRO

6. Valedictory Session: Technologies for Hill Regions

Chairman: Ashwagosha Ganju, Director, SASE

Panel Members:

i. Dr. Swati Basu, NCMRWF

ii. Prof Nayan Sharma, IIT Roorkee

iii. Shri N Prahlad Rao, ISRO HQ

iv. Dr. Baldev Raj Arora, Former Director, WIHG

v. Dr. Pramod C Nawani Jindal Group, New Delhi

	Key Problem Areas Identified	Agencies involved
1.	Avalanches	SASE
2.	Landslides	CBRI/DTRL/GSI
3.	GLOF	GSI/WIHG
4.	Channel Erosion	NIH/CWC
5.	Earthquakes	NGRI/IMD

6.	Water Management	NIH/CWC
7.	Forest Fire	NRSC/SAC
8.	Mountain Weather	SASE/IMD/NCMRWF
9.	Energy	CWET/SASE
10.	Surface and Aerial Connectivity	BRO/SASE/ISRO

The recommendations of each session are summarized below:

1. Mountain Weather

Mountain Weather Forecast

i. **Current System / practice / status.**

- Global Model by IMD
- National Centre for Environmental Prediction (NCEP) based Global Forecast System (GFS T574/L64) for forecast up to 7 days.
- Meso-scale forecast system WRF (ARW) with 3DVAR data assimilation for forecast up to 3 days.
- Global Model by NCMRWF
- NCMRWF Global Forecasting System (NGFS) and Global Ensemble Forecasting System (NGEFS) for forecast up to 10 days.
- Mesoscale model by SASE
- WRF (ARW) with NCEP GFS and NCMRWF T574 global ICBC data and 3DVAR data assimilation for forecast up to 6 days.

ii. **Gaps**

- The extent of mesoscale model limited to the interest of Army.
- Observation system by SASE only for regions of Army interest.
- Limitation of quantity and quality of data
- Area specific forecasts missing

- Extreme events warning missing
- GIS visualization missing
- Topography and land use in the model not truly representative
- Physics in NWP models for hills not sufficient
- Downscaling: dynamical and statistical
- Computational power

iii. **Recommendations**

1. More detailed observation (data) plan for hilly regions.

   - More number of X and Ku band weather Radar network by IMD, IITM and SASE particularly regions of high density population, Tourists places is required.
   - Densification of Automatic Weather Stations by IMD, NCMRWF and SASE.
   - More number of Radiometers by IMD, IITM and SASE for vertical profiling of the atmosphere.

     The details on Instrument, participating agency, budget etc. are given in Appendix A. S-band DWR is not feasible in the mountainous region due to its size and range

2. Research on site specific regional / global / mesoscale models, for vulnerable regions.

   - Coupling of Atmosphere, Cryosphere and Ocean systems.
   - High resolution and ensemble modelling.
   - Better and dynamic land use / land cover in the model.

   The details on R&D activity, responsibility and budget are given in Appendix B

3. Involve more regional units for running regional / mesoscale models.

- **Mode I**: Global and regional model could be run in a central place at IMD/NC in RUF. Model outputs could be collected and analysed at regional units and further downscaled could be done for more site specific mountain weather forecast by units like SASE, regional universities and other research laboratories.

- **Mode II**: Regional units can run regional / mesoscale models for their specific site of interest and forecast can be drawn and disseminated, specific to following.

Avalanches

i. Current System / practice / status.

- All terrain study by SASE
- Global model by IMD for rain and wind
- Regional model run by SASE (being limited resource, computer and manpower), only for region of interest of Army.

ii. Gaps

- Limitations on data on ice cover and slope.
- Limitation on SASE resource as limited manpower.
- No identified agency for all the hilly regions of the country.

iii. Recommendations

- Recognize and expand SASE as National Agency for Avalanches forecast for the entire Hilly region, not just for interest of Army – Manpower, budget to commensurate with the additional responsibility.
- Deployment of a SAR formation Satellite by ISRO for precise DEM for all vulnerable regions continuous mapping of Himalayas and providing data to SASE in real time. ISRO, Approx. 1000 Crore
- The research from 1, to be continuously available for better weather forecast.

- A task team by Army for preventing measure of Avalanches, in consultations with SASE.

Surface & Aerial Connectivity: Road Response Mechanism

i. Current Scenario / Issues.

- Road axis along rivers, river bank vulnerability and unprotected
- Toe erosion and landslides common place
- Unpredictable cloud bursts
- Sinking of hill roads

ii. Gaps

- No provision of alternate roads along with highways.
- Prediction of abrupt change in river course.
- Absence of Integrated Disaster Management Plan involving all stake holders.
- Awareness about river side habitation

iii. Recommendations

- Pre plan preparatory actions for early warnings
- Alternate alignment of link roads along National Highways
- Integrated Disaster Management Plan
- Construction of Helipads at designated points in disaster prone hilly areas
- Capacity building Exercises: Capacity building by Govt and other agencies in terms of early warning systems, resource mobilisation including Earth moving equipment, bridging; formulation of village level civil defence organisation for disaster relief etc.
- Implementing agencies: BRO, State Authorities, NDMRF and the local authorities at village / town level.

2. Gravity Flows & Associated Hazards

GLOF

i. Current Scenario / Issues.

- About 16 dangerous glacial lakes exist in India
- No dedicated Early Warning System in place
- Regular and strict monitoring of glacial lakes has started only after recent disasters

ii. Gaps

- Non availability of dedicated Information database on Glaciers and Glacial lakes
- No dedicated agency for tacking GLOF and related hazards
- Lack of comprehensive planning and preparedness
- Lack of Knowledge sharing among the GLOF affected countries

iii. Recommendations

- Formulate a plan for data collection and regular monitoring of glacial lakes. The task for study of GLOF could be given to Glaciological Centre, WIHG, Dehradun India.
- GLOF risk reduction plan should be prepared by the Institute
- Satellite data analysis and field verification plan of potentially damaging lakes can be taken up by SAC, Ahmadabad and NRSC Hyderabad in association with WIHG, Dehradun.
- The two implementation schemes could be :
    1. Structural Measure
        a. Cut Channels through embankment to lower water level. This can be taken up by Indian Army in consultation with WIHG and IIT Roorkee.
    2. Non-structural
        a. Early warning and avoidance action. Sensors, Sirens etc. WIHG in association with NRSC, Hyderabad can take up this task.
        b. Preparation of dedicated data information base. This should be made available at NRSC, Hyderabad.

- Community Participation, Capacity Building. A comprehensive plan can be drawn by NDMA and NIDM and implemented on ground.

- Implementing Agencies: WIHG/GSI/IIRS/NRSC/NDMA/SAC

Channel Erosion & Flash Floods

i. **Current System / practice / status**

- No early warning system in place for flash floods
- Road construction too close to river embankment.

ii. **Gaps**

- Limitations of data on flash flood in hilly rivers
- Lack of robust & effective warning system,
- No identified agency for the construction of state-of-the-art roads in the hilly regions of the country. (onlines of BRO for Border roads)
- Mathematical Models for channel flow simulation and erosion not existing.

iii. **Recommendations**

- Development of mathematical models for simulation of river flow. This can be taken up by IIT Roorkee.
- Implementation of Piano key Weir type of structures by state governments to arrest excessive erosion of channels as well as use of water for irrigation purpose.
- Early warning systems by IMD supported by strong governance and organizational coordination mechanism with state governments
- Control of erosion by application of Bio Engineering (Vetiver grass) and Hydro Seeding Techniques to be adopted by the state governments.

- A task team by BRO/ State Agency for preventive measures for flash flood, in consultations with NIH/ IITs to be established

Landslides

i. **Current System / practice / status.**

- Landslide hazard mapping of a few affected sites available
- Landslide monitoring & suitable early warning system available at a few locations only.
- Implementation of landslide control measures on ground at a few locations only.

ii. **Gaps**

- No comprehensive control plan exists for different terrain conditions
- Identification of potential sites through remote sensing not existing

iii. **Recommendations**

- Slope monitoring for real time early warning system.
    - DST, NIDM, CSIO (Rough budget)
- Implementation of landslide measures on ground
    - BRO, State Agency
- Treatment of vulnerable slopes by geo-textile, geo-grid, Rock bolting/ cable anchor & shot-crating with wire mesh of rocky strata
- Use of Jute geotextile & plantation for slope stabilization
- Continuous monitoring of whole slope by SSR (Slope Stability Radar)
- Placement of Micro-seismic Stations for monitoring of Landslide
- Alternate route planning along National Highways

3. Communication for Hazardous Conditions in Hilly Regions

i. **Current System / practice / status.**

- Portable and Mobile VSAT.
- MSS Terminals.
- Disaster Management Support System (DMS)

ii. **Gaps**

- Low Link Margins.
- Non Availability of Sufficient Bandwidth.
- High Cost.
- Long Response time of DMS teams.
- Lack of Local Trained Manpower.

iii. **Recommendations**

- Network with advanced waveform & technologies (DVB-S2 with improved throughput network for IP communication) to be expedited.
- Integration of diverse technologies like GSM/CDMA/Wi-Fi /FM broadcast with satellite on-field VSAT nodes for wide area communication
- Provision for extending the reach of on-field VSATs by 5-10 km to extreme remote locations through simple low cost appliances
- Pre-Deployment of VSAT Nodes for DMS at identified locations connected to State Disaster Management Cells.
- Fuel Cell based power packs to be developed.
- Development of Lighter-than-Air vehicles especially small aerostats which serve as intermittent aerial stations of GSM /Microwave terrestrial links for disaster hit areas.
- Development of light weight hand Held Low Cost Satellite Phones.

- Training on such equipment's at grass root level i.e. village panchayats, through NGO's working in these areas and State Rural Development Departments.

- Implementing Agencies: ISRO/IIT's/BSNL/ GSM Operators

4. Earthquake Hazards in Himalayan Region & its Mitigation

i. Current System / practice / status.

- No focus on Earthquake Resistant Construction
- Improper planning for construction activity in Seismic Zones
- Earth quake measurement system in the hilly regions by MoES is not adequate for want of logistic support in such areas.

ii. Gaps

- Dearth of trained manpower for seismic micro zonation
- Acquisition of quality data from field missing
- No focus on Earthquake precursor study and interdisciplinary research effort missing
- No dedicated Earthquake Management Force in place. This should be in addition to national network by IMD/MoES.
- Lack of Local Trained Manpower.

iii. Recommendations

- Development of Seismotectonics Model for detection potential threat zones by IMD
- Enhanced Seismological Network for earthquake monitoring by MoES and other organization in the Hilly regions.
- Master Plan for Earthquake Disaster Prevention by IMD
- Formulation of Plan Aimed at Earthquake-Resistant City
- Promotion of Research on Earthquake-Resistant Buildings

- Micro zonation of vulnerable areas based on Peak Ground Acceleration measurements
- Placement of GPS for monitoring movement of Indian Plate Motion & Rate of Convergence
- Establish proper system to measure multi parametric geophysical parameters to understand earthquake
- Standardisation and zoning of Seismic Codes.
- Zoning for earthquake disaster prevention plans / measures & risk management.
- Master plan on earthquake disaster prevention should be prepared
- Implementing Agencies: GSI/NDMRF/NGRI and IMD. A lead agency should be identified by the GoI.

5. Glacier, Snow Cover, Water Management and Energy in Hilly Regions:

Glacier & Snow Cover

i. **Current System / practice / status.**

- Glaciers mapping, inventory and mass balance model by GSI, WIHG, SAC
- Glacier and snow hydrology modelling by IIT-Roorkee, NIH Roorkee, NRSC and SASE
- Snow cover mapping and snow melt run off by NRSC, SAC , SASE

ii. **Gaps**

- Limited study on Impact of future climate change on the cryosphere
- Integrated approach with communication and collaboration among atmospheric scientists, glaciologists, geo-morphologists and geologists missing.
- Limited study on glacier discharge

- Limitation of data: Snow cover with snow depth. This is required particularly in regions of high density population, tourists and where source of irrigation and drinking water is seasonal snows.

- Limited use of RS and GIS based technologies for monitoring and management of ground as well as surface water

- Limited data base on monitoring of key components of cryosphere

- No identified agency for all the hilly regions of the country.

iii. **Recommendations**

More detailed observation for

- Climatic scenarios produced by GCMs need to be refined to understand and better prediction of the behaviour of most components of the cryosphere and their impact.

- Processes that are driven by interaction between the atmosphere and the cryosphere need to be understood better which will further allow the construction of more sophisticated and realistic climate sensitivity models.

- Monitoring of key components of cryosphere must continue. Database need to be further developed and maintained. They provide the bench mark for assessing future change and for model testing.

- Determining the spatio-temporal pattern of fluctuations of mountain glaciers from the last glacial cycle through the present

- Identifying important but poorly understood processes controlling the motion and ablation of glaciers

- Developing and expanding the application of numerical models of glaciers GSI, Wadia Institute of Himalayan Geology

- Conjunctive use of SAR & optical data from RISAT-1, AWiFS, LISS 3, 4, Cartosat, for snow and glacier studies (medium and high resolution). Use of INSAT-3D/GISAT data for snow and glacier studies (high temporal coverage).

- Development of Himalayan Glacier Information System (HGIS) and models for glacier health assessment.

- Energy balance approach for snow & glacier melt, glacier mass balance estimation using satellite derived AAR approach.

- Utilization of SAR Interferometry & Photogrammetry in glacier flow determination and glacier mass balance using DEM generated from these (differential DEM approach – geodetic)

- Explore hyperspectral and multispectral imaging for quantitative measurements of glacier and snow studies.

More and more RS and GIS based surface and ground water studies, hydrogeological data analysis for land and water management are recommended to be carried out in conjunction with field investigation to effectively exploit the expanding potential of RS and GIS technologies.

Implementing Agencies: NRSC, SAC, SASE, NIH and IIT-Roorkee.

A Lead agency to be identified by GoI.

Water Management

i. **Current System / practice / status.**

- The snow melt rate and glacial hydrology in Himalaya and their modelling are being conducted by NIH Roorkee.

- The promotion of integration and sustainable development and management of India's water resources with different states by using state of the art technology is being done by CWC

- Sustainable development and management of ground water resources are done by CGWB

ii. **Gaps**

- Limited study on glacier discharge

- Lack of Integrated approach with communication and collaboration among atmospherics scientists, glaciologists, geo-morphologists and geologists and state agencies'

- Insufficient local technological research on water management

- Lack of integrated water management plan
- Lack of control over exploitation of ground water resources
- Insufficient facilities for waste water management

iii. **Recommendations**

- Awareness on efficient water management strategies and techniques (conservation, reuse and recycle)
- Renovation and restoration of water bodies
- National Aquifer management programme through community participation
- Use of latest technology for modernisation of water resources
- Modernizing irrigation and drainage departments to integrate the participations of farmers and other agencies for efficient use of water resources.
- Awareness on better water management practices
- Conservation of ground water ,rain water harvesting and recharge of ground water
- River flow by Space based methods for mountainous regions
- Robust telemetry for collection of hydro meteorological observation data
- Small weirs on run-of-the-river for Hydropower Generation
- Development of robust hydrological modelling suiting Indian Himalaya
- Establishing of more discharge observation sites
- Networking of river gauging stations
- Preparation of high resolution DEMs for better modelling
- Implementing Agencies: NIH,CWC,CGWB.
- A Lead agency to be identified by GoI.

Renewable Energy for Hilly Regions

i. **Current System / practice / status.**

- Wind Energy and Solar Energy studies are being carried out by National Institute of Wind Energy (NIWE) Chennai and SSS National Institute of Renewable Energy, Kapurthala.
- Geothermal Energy study as a pilot project is carried out by SASE, DRDO in the Himalayan foothills in Manali, H.P.

ii. **Gaps**

- A sustainable energy future based on renewables is possible and technologies exist, however a comprehensive plan is missing.
- Despite the potential of technologies, progress is too slow at the moment and is missing in hills.
- A clean energy future requires systemic thinking and deployment of a variety of technologies
- Lack of awareness about the use and management of renewable energy resources with local people

iii. **Recommendations**

- Create an investment climate of confidence in clean energy
- Unlock the incredible potential of energy efficiency – "the hidden fuel" of the future
- Accelerate innovation and public Research, Development and Demonstration (RD&D)
- Establish plans for policies and actions for energy efficiency and renewable energy sources
- Adressing all aspects of sustainability in energy production (environmental, economical, social)
- Promoting off-grid Wind Energy in Hilly Regions on the national levels

- Technological development in Smart Energy Management Technologies,

- Supporting development of energy saving technologies.

These recommendations were further discussed in the valedictory session chaired by Dr. K. Kasturirangan, Ex Chairman ISRO and Ex member Planning Commission. EC 2014 finally makes the following recommendations.

1. Improvement in Weather and Avalanche forecast.

R.1. Weather observation System and forecast for the Himalayas.

IMD should upgrade the weather observation system by installing additional Radars and other equipment as per Appendix 'A'.

Estimated Cost : INR 670 Crores

R.2. SASE (DRDO Lab) should be given extended mandate to be made responsible for generating detail weather model forecast, based on upgraded mesoscale model, running on operational basis for whole of the Himalayan region, including the area covered by the Civil population, in addition to the region of interest to the Army. This will require upgrading the computer system and enhanced manpower as per Appendix 'B'.

This requires an approval at the GoI level and at the level of DRDO to accept to this expanded mandate and commit additional budget and manpower.

NCMRWF (Min. of Earth Sciences) should continue to support SASE in R&D activities for continuous up gradation of the Mesoscale model, applicable to each sub region of the Himalayas.

IMD should continue to do regular forecast of the Himalayas, as usual, on a broader scale. SASE shall focus more on issues related to special weather conditions, extreme events, Avalanches etc. The main difference is that while IMD will run overall global weather model, SASE will take that as input to generate weather data based on more detailed mesoscale model.

Monitoring of the slopes in the Himalayan region for snow and rocks along the roads through satellites has to be taken up for suggesting schemes for all weather road connectivity.

R.3. It is reported that Europe has successfully demonstrated that a pair of SAR satellites in formation flying can generate DEM with high accuracy (within few centimetres). EC 2014 recommends a formation of two such satellites to continuously monitor, at known intervals, for the whole Himalayan region.

This data should be received at SASE for preparing DEM, within 24 hrs, and classify vulnerability for Avalanches and landslides that are important to army and civil population. Also SASE should design and implement avalanche protection schemes for different zones of avalanche on high resolution DEM. This DEM generated from satellite data will be a critical input, in addition to the weather data, which is otherwise being generated by SASE, in higher resolution.

The estimated cost of the SAR satellites to be launched and maintained in formation by ISRO will be ~500 crore and that for upgrading facilities and manpower at SASE DRDO will be 150 crore.

2. Gravity Flow, Earthquakes and Associated Hazards in Hilly Regions

It is an important area of concern and country has no mechanism to deal with such disasters. Like INCOIS (Min. of Earth Sciences) has been identified as agency for TSUNAMI warning and has a dedicated TSUNAMI warning centre.

R.4. EC-2014 recommends creation of such a warning centre for Gravitational flow, landslides and associated Hazards (GLOF, Avalanches etc.) at NRSC (Dept. of Space) or any other institution like WIHG or Centre of Glaciology, Dehradun. This centre has to collect all the geotechnical data at all vulnerable regions, will have good tie-up for real-time weather data with IMD/SASE, plan additional observation sensors at vulnerable points etc. The WIHG may also be given the mandate of enhancement of seismological network for earthquake monitoring in partnership with NGRI. In addition the new Centre of Glaciology must focus on

- Regular Monitoring of Glacial Lakes
- GLOF risk reduction Plan in collaboration with NDRF
- Take up the studies on structural & non-structural measures for risk reduction during such events in consultation with IIT's
- Strategies to artificially break the steep bed gradient for curtailment of excessive stream power in consultation with IIT's

- Erosion prevention and holistic river restoration schemes in consultation with NIH and IIT's
- Earthquake precursor study with WIHG

NGRI should take up monitoring of Indian Plate Motion and rate of convergence by placing GPS at designated points with the help of GSI and IMD. IMD may be given the task of development of Seismotectonics Model for detection of potential threat zones of earthquakes. Masterplan of earthquake disaster prevention has to be taken up by NIDM and IMD with the involvement of local bodies. Research in the field of earthquake resistant buildings should be taken up by CBRI, Roorkee to develop buildings for area which lie in the sensitive seismic zone. Stringent guidelines for town and country planning departments should be formulated to regulate construction in earthquake prone zones in a way so that the damage in event of an earthquake is minimised.

3. Communication for Hazards Conditions in Hilly Regions

Communication infrastructure is vulnerable to breakdown during any event of disaster. Restoration of communication links takes longer time due to tough terrains, inaccessibility and climatic conditions in Hilly regions. Govt and relief providing agencies increasingly rely on wireless mobile communication technology to provide effective command, control, and communication during emergencies and disaster response operations. Past events have shown that in the aftermath of an unexpected event, communication infrastructures play an important role in supporting critical services such as emergency recovery operations, infrastructure restoration, post-disaster surveillance, etc.

R.5. EC-2014 recommends development of an exclusive S-band multi-beam satellite with frequency reuse technique and a 12M Un-furlable Antenna. The multi-beam satellite will have large capacity and coverage as compared to the single beam satellites and will support compact terminals. ISRO should be asked to expedite the development of S-Band Satellite phones and man portable VSAT's for effective communication in the disaster hit areas, since such small portable devices are easy to transportable in inaccessible hilly regions. The approval from GoI should be sought to allocate a sufficient and dedicated bandwidth for disaster management and disaster warning systems.

R.6. **Last Mile Connectivity & Integration of Satellite and Terrestrial Communication Network:** EC-2014 recommends GoI to consider the provision of rapidly deployable and resilient mobile networks which are

compatible to the existing subscriber mobile units to provide broadband access in large coverage areas. Current mission critical systems and Disaster Relief Communication Systems, are limited in terms of network capacity and coverage. They are not designed for or suitable to address large scale emergency communication needs in a disaster aftermath. The existing systems are also limited by interoperability barriers, the technological gap with commercial technologies and evolving standards. EC 2014 recommends a feasibility project to be taken up to provide mobile service coverage with a Lighter than Air (LTA) Platform which will integrate the terrestrial and satellite networks in hilly regions where network infrastructures have become inoperable. This will demonstrate the capability of LTA to restore GSM network with a mobile VSAT providing backhaul to base stations – PicoBTS, NanoBTS, and MacroBTS. The proposed infrastructure will be composed of a Low Altitude Platform or a mobile modular tower mounted on a mini truck, based airborne communications segment combined with a Mobile Instant Network system coupled with satcom-enabled Portable Land Rapid Deployment Unit. The solution proposed to be developed within the framework of this project, attempts to demonstrate the high-capacity, low-latency and large coverage capabilities of existing mobile network components for the provision of broadband emergency communications. The subsystems of the proposed system at given at Appendix 'C'.

Undertaking such a project will be multidisciplinary task with the involvement of ISRO, IIT Bombay, SASE and BSNL. The details of the work to be executed by the participating organisations are given at Appendix 'D'. The estimated budget for the execution of the proposed feasibility project would be about 9-10 Crores.

4. Glacier, Snow cover, Water Management & Energy in Hill Regions

R.7. EC-2014 recommends the following tasks to be taken up by a group of institutes/ organisations along-with the task as the task given below Glaciers mapping, inventory and mass balance modelling to be taken by GSI and WIHG. ISRO and SAC should provide more products for snow cover and glacier monitoring. The conjunctive use of SAR & optical data from RISAT-1, AWiFS, LISS 3, 4, Cartosat, for snow and glacier studies (medium and high resolution) along with INSAT-3D/GISAT data for snow and glacier studies (high temporal coverage) to be taken up by GSI, WIHG and SASE collectively. The energy balance approach should be implemented for snow & glacier melt, glacier mass balance estimation using satellite derived AAR approach to arrive at the best results

implementing the models to be developed by GSI and WIHG as suggested.

The utilization of SAR Interferometry & Photogrammetry in glacier flow determination and glacier mass balance using DEM generated from these (differential DEM approach – geodetic) and snow hydrology modelling to be taken up by IIT-Roorkee, NIH Roorkee, NRSC and SASE.

R.8. EC 2014 recommends a centre to be set up for cryospheric studies and water management in hilly regions or the task could be entrusted to the Centre of Glaciology, WIHG Dehradun. The centre would have the integrated approach with communication and collaboration among atmospherics scientists, glaciologists, geo-morphologists and geologists to take up studies on

- Glacier Discharge
- Extensive snow cover and snow depth data for accessing the water sources for irrigation and drinking in hilly regions, impact of future climate change on cryosphere
- Expedite use of RS and GIS based technologies for monitoring and management of ground as well as surface water
- Determination of the spatial-temporal pattern of fluctuations of mountain glaciers from the last glacial cycle through the present
- Identification important but poorly understood processes controlling the motion and ablation of glaciers.
- Development of Himalayan Glacier Information System (HGIS) and models for glacier health assessment.

Appendix 'A'

S No	Instruments	Participating agency	Quantity	Unit price (Lac)	Budget (Lac)	Remarks
1	C-band DWR	IMD	20	1600 (Rate as per BEL)	32000	Covers whole of Indian Himalayas
2	X-band DWR	IMD	25	600	15000	Covers valleys
3	Ka-band radar	IMD	100	100	10000	Mobile radars to be distributed to institutions
4	AWS	IMD / SASE / NCMRWF	100	10	1000	Every 50km spatial resolution
5	Radiometer	SASE/IITM	50	180	9000	Vertical profiling of atmosphere in place of traditional balloons
Total					**67000**	

Appendix 'B'

S No	R&D activity	Responsibility	Unit price (Lacs)	Budget (Lac)	Remarks
1	Coupled Atmosphere Cryosphere ocean model	IMD / IITM (MoES)	04 x 40000 = 160000 pm HPC@ 1000 lac	1001.6	JRF / SRF / project staffs and HPC system
2	Better and dynamic land use and land cover in models	SASE / NRSC (ISRO)	02 x 40000 = 80000	0.8	JRF / SRF / project staffs
3	High resolution modelling	IMD / NCMRWF	04 x 40000 = 160000	1.6	JRF / SRF / project staffs and HPC system
4	Ensemble prediction system	IMD / NCMRWF			JRF / SRF / project staffs and HPC system
5	Solid-liquid partitioning in the model	SASE / NCMRWF	02 x 40000 = 80000	0.8	JRF / SRF / project staffs
6	GIS visualization	IMD / NCMRWF			
7	Regional Climate Modelling	SASE / IITM			JRF / SRF / project staffs and HPC system
Total				**1004.8**	

* Average rate of JRF / SRF / project staffs has been taken.
* Rates are per year for staffs.
* Centralized new / upgraded HPC will solve the purpose of all the agencies.
* Requirement of staffs is as follows:

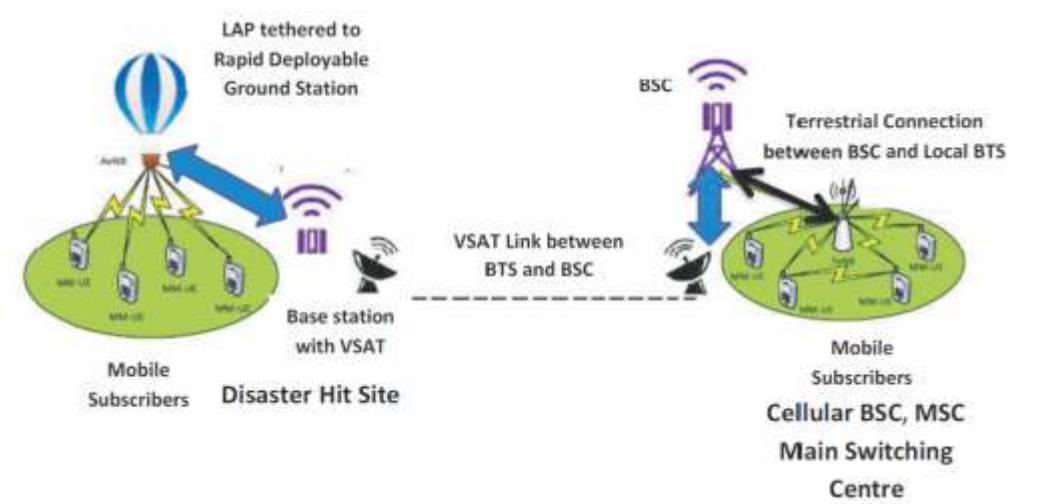
IMD:	04
NCMRWF:	02
IITM:	02
NRSC:	02
SASE:	02

Subsystems for Last Mile Connectivity & Integration of Satellite and Terrestrial Communication Network:

(a) Low Altitude Platform (LAP) or Modular Vehicle Mounted Tower: Airborne System capable of lifting communication equipment preferable antenna off the ground to heights between 300m to 4km. This subsystem provides the fastest way to deploy the system antennas at a height in practically very less time. The LAP are commercially available e.g. Helikite which can lift a load of about 10kg upto a height of 2km. A modular vehicle mounted tower structure can be designed which can be easily transported to the disaster hit area on a mini truck and can be assembled to a desired height at the spot, taking the antenna up to a height of about 50m for a shorter range communication.

(b) Portable Land Rapid Deployment Unit / Instant Network System / Cell on Wheels (COW): One of the fastest methods of restoring networks is the rapid deployment of temporary and portable cell sites. These portable cells are Base Transceiver Stations (BTS) that enable mobile communications to take place. These subsystems are termed Instant Network System or Cell on Wheels. Commercially available systems are below 50 kg in four module boxes less than 10 kg each. This makes them easily transportable. The system can be deployed by trained personnel in less than 40 minutes and is able to provide GSM and 2G data services for a radius of up to 10 km - 30km on both 1800 and 900 spectrum bands. The deployment of additional BTS can either reduce local network congestion or plug gaps in a damaged

(c) Satcom VSAT Subsystem: The Satcom subsystem will consist of a VSAT with IP-TDMA. Instead of using a standard terrestrial fiber or microwave link between the BTS and BSC, a VSAT network provides connectivity. VSAT technology enables the A.bis/Iub/Iuh interface to span any distance at a fixed cost. It also provides a solution unaffected by terrain restrictions or line-of-sight requirements and is quick and easy to deploy. For disaster hit inaccessible hilly regions, this provides a solution for deploying a BTS/(e)Node B to remote areas where service is defunked due to the devastation.



Appendix 'D'

Sr No.	Agency / Organisation	Responsibility
1.	ISRO	Satellite BW Allocation, Providing IP-TDMA network based VSAT, Approval for Regulatory VSAT Licences , Integration of VSAT with Mobile BTS, Instant Mobile Network System
2.	Mobile Operator (BSNL)	Approval for regulatory Cellular Frequency Allocation and Usage, Provision of connecting BSC with VSAT Satellite Link. Omni Directional Antenna for Mounting on LAP
3.	IIT, Mumbai	Design and approvals for suitable LTA, Identification of the best available LTA with factors relating to launching, maintenance and deployablility.
4.	SASE	Implementation for project for Hilly Regions, Identification of sites for max coverage, Project Formulation, Prototype Development and integration of Complete System, Training on System, SASE personnel can take the lead for final deployment of system.

INDIAN NATIONAL ACADEMY OF ENGINEERING

The Indian National Academy of Engineering (INAE), founded in 1987, comprises India's most distinguished engineers, engineer-scientists and technologists covering the entire spectrum of engineering disciplines. The aims and objects of the Academy are to promote and advance the practice of engineering and technology, related sciences and disciplines and their applications to problems of national importance. INAE also encourages inventions, investigations, and research in pursuit of excellence in the field of "Engineering".

INAE had taken an initiative of organizing an annual mega event of engineers as "Engineers Conclave" starting from year 2013, essentially to provide a platform for all engineers/scientists to deliberate and address major engineering challenges and opportunities of vital concern and relevance to the country and society. The "Engineers Conclave" is organized by INAE jointly with one of the premier engineering organizations/institutions of the country each year. There are two themes for the Conclave, both focusing on the issues relevant to the Country. While the theme-1 will be decided by the host department, the theme-2 specific to some social problem where engineering intervention is desired, will be decided by INAE. The discussions in the two themes will be focused in finding engineering solutions to the challenges with specific recommendations which would be forwarded to the concerned Departments/Industry for consideration.

For more details, please visit INAE website www.inae.in

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