Terms of Reference & Cost Estimate

ICT INFRASTRUCTURE AND DATA MANAGEMENT CONSULTANT

(Contract Identification No. : PPCR/DHM/S/CQS-41)

June 2016

Kathmandu, Nepal

ABBREVIATIONS AND ACRONYMS

AMIS	Agriculture Management Information System
BRCH	Building Resilience to Climate Related Hazards
BUFR	Binary Universal Form for Representing Meteorological Data
DHM	Department of Hydrology and Meteorology
DNS	Domain Name System
DMS	Data Management System
EWS	Early Warning System
FMI	Finnish Meteorological Institute
FNEP1	Finnish Nepalese Project 1
FNEP2	Finnish Nepalese Project 2
GIDC	Government Integrated Data Center
GIS	Geographic Information System
GTS	WMO Global Telecommunication System
HPC	High Performance Computing
HQC	Human Quality Control
ICT	Information and Communication Technology
LAN	Local Area Network
LLS	Lightning Location System
MoAD	Ministry of Agricultural Development
NAS	Network Attached Storage
NARC	Nepal Agricultural Research Council
NITC	National Information Technology Center
NWP	Numerical Weather Prediction
NTP	network Time Protocol
QC	Quality Control
SAN	Storage Area Network
SI	System Integrator
SOP	Standard Operational Procedure
SMTP	Simple Mail Transfer Protocol
SSH	Secure SHell
TEMP	WMO message format
ToR	Terms of Reference
VHD	Virtual Hard Drive
VPN	Virtual Private Network
WLAN	Wireless Local Area Network
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization

1. Introduction

This Terms of reference is for a consulting firm (hereafter called – 'the Consultant')to provide the Department of Hydrology and Meteorology (DHM) with state-of-the-art Information and Communication Technology (ICT) infrastructure and Data Management System implementation with capacity capable of supporting DHM's mission critical activities and key development projects for years to come. Building upon hardware already acquired prior to this consultancy, the consultant will develop an operative ICT and data management system which is highly automated, equipped with advanced software tools to receive, store and process all external and locally produced hydro-meteorological data in support of enhanced delivery of DHM's services. The system characteristics include support to advanced R&D,large volumes of observation and Numerical Weather Prediction model data and automation of specialized customer products. Overall goal is to improve the quality and selection of DHM's service provision to all weather & climate dependent sectors in Nepal. Key customers that benefit from the enhanced services are, but not limited to, civil aviation, agricultural sector, tourism, energy sector, not to mention increased public safety by provision of enhanced early warnings services such as flood warnings and various alerts on severe weather.

The consultant will develop software to allow for smooth data input to the DHM file servers and data bases from international and local sources, transfer of data between DHM organization units, quality control of data, storage of data with easy access, post processing of data, automated generation of data products and readiness to deliver of data and products to various customers. The necessary hardware components, i.e. the physical ICT infrastructure will be acquired in different contract but synchronized with this ToR.Additional information on the system design of ICT infrastructure is found in the Appendix 1 provided as attachment; and additional documentation on Project- and system design will be provided by DHM in digital copy if required upon the request of the consultant.

After completion of the ICT infrastructure part of the assignment, the Consultant will continue working in parallel with the data management assignments– provide operational monitoring of system performance, system maintenance and support services until end of the contract period, i.e. up to 30 months from the date of the contract signing.

2. Background

2.1 The Building Resilience to Climate Related Hazards project (BRCH)

The objective of the BRCH project is to enhance government capacity to mitigate climate related hazards by improving accuracy and timeliness of weather and flood forecasts and warnings for climate vulnerable communities, as well as developing Agricultural Management Information System (AMIS) services, administered by the Ministry of

Agriculture Development (MoAD), to help farmers mitigate climate related production risks. The project comprises four components:

A. Institutional strengthening, capacity building and implementation support of DHM;

B. Modernization of observation networks and forecasting;

C. Enhancement of the service delivery system of DHM; and

D. Creation of an agriculture management information system (AMIS).

This consultancy assignment is of significant importance to the project as it contributes to all four components of the BRCH project. Component A aims to develop and/or strengthen DHM's legal and regulatory frameworks, improve institutional performance as the main provider of weather, climate and hydrological information for the nation, build capacity of personnel and management, ensure operability of the future networks, and support project implementation. Component B aims to modernize DHM observation networks, communication and ICT systems, improve hydro meteorological numerical prediction systems and refurbish DHM offices and facilities. Similarly, Component C aims to enhance the service delivery system of DHM by creating a public weather service that provides weather and forecasts impact, and information services for climate-vulnerable communities and the key weather dependent sectors. Component D will provide critical and timely agro-climate and weather information as well as agro-advisories to farmers in order to increase productivity and reduce losses from meteorological and hydrological hazards.

DHM maintains extensive hydrological and meteorological observation networks that will go through significant modernization in the BRCH project. This effort includes rehabilitation of the meteorological and hydrological stations, establishment of a sounding station, a weather radar and a lightning location system. The enhanced hydro-meteorological observation system and data management will allow for improved services provision, including an early warning system, numerical weather prediction system, delivery of observation data, numerical forecast and data products to the AMIS system and other downstream applications. 1

In order to fully exploit the possibilities provided by the significant observation network investment, the DHM ICT infrastructure and data management system will be extended with new features and totally new components.

2.2 Present status of ICT and Data Management at DHM

DHM is tasked to operate critical 24/7 weather services for civil aviation and the public sector, including dissemination of warnings on severe weather events and floods.

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[1] *Technical specifications of renewed DHM ICT infrastructure are presented in Appendix 1 attached to this document. Technical documentation such as the modernization/rehabilitation of the entire production system including observation networks, tools and methods for forecasting and services can be provided upon request.*

The current ICT systems are located in the DHM main office, airport office and at the National Information Technology Center (NITC)[2]. System quality and age of system components varies significantly. Most system administration work and software development tasks are done on an ad hoc basis. Connectivity between sites is done with basic ADSL-lines from local providers. DHM has presently very limited human resources for any ICT and software development to process data and products.

Prior to the BRCH project a full featured data management system has been implemented for DHM by the Finnish Meteorological Institute (FMI) and further tuned by the Real Time Solutions Ltd. (RTS) for storing and handling point observations during the FNEP project funded by the Government of Finland. Current features include web user interface, automated quality control, support for point-observations, lightning-detection and sounding data.

Before entering the database the data from meteorological observation stations is checked with real-time quality control software *kqc1* which is written with PHP-programming language. The user-interface for kqc1 is web-based using PHP, Ajax and HTML technologies. The kqc1 contains an automated Quality Control module (QC1) configuration and limited amount of station register configuration. These were developed by FMI by following the WMO guidelines on observation data Quality Control. It is recommended that these established features will be utilized as much as possible.

The current database for data management system is PostgreSQL with PostGIS-extension. It runs on CentOs Linux environment in computer room assigned by DHM. User interface is coded with PHP, Ajax and HTML and it is served by an Apache-web server. Data collection software is mainly created with PHP. System documentation will be made available before implementation of this activity.

2.3 General specifications of the ICT infrastructure

DHM's renewed production system is described through four functions illustrated in Fig. 1:

- **Data retrieval functions** including all data flows into DHM's production system such as observation data and GFS weather model data. All these functions will be implemented in the data management system.
- **Data warehousing and processing functions** that include for example all quality control, data upload to database and file sharing-like data warehouse, data processing such as format conversions and transfer to analytics and R&D functions. All these functions will be implemented in the data management system and further developed by DHM.

[2]Also called the Government Integrated Data Center

- **Data analytics and product generation** include functions where both hydrological and meteorological value is added to services and products for various customers are generated automatically. All these functions will be implemented in the data management system and further developed by DHM.
- **Services and end-users** include all distribution methods and channels such as web, FTP, email that are used to distribute services and products to customers. All the function will be implemented and further developed by DHM.

The four functions will be supported by the same shared ICT-infrastructure that is split into three layers: server virtualization, storage system and networking also illustrated in Fig 1. The core ICT infrastructure will be installed in the government data centre NITC in Singha Durbar, Kathmandu. Networking equipment as required by the design will be installed in DHM's main office and at the Airport office in Kathmandu. Outsourcing data centre operations will minimize DHM's burden on data center management and leverages the investment already made for both ICT processes and infrastructure at NITC.

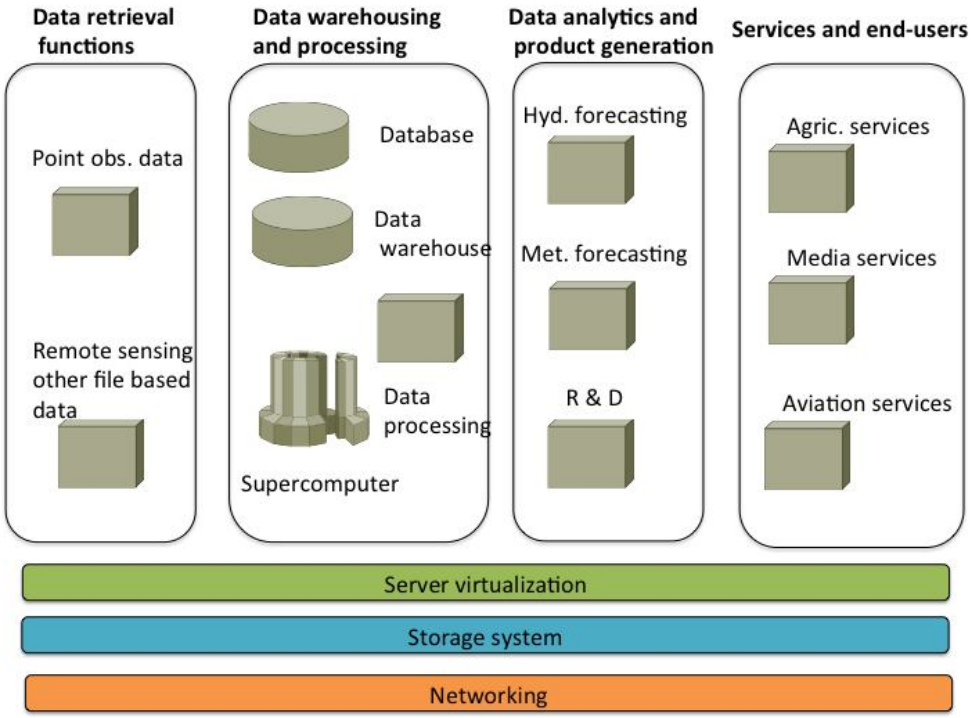

Figure 1: DHM's planned Production system functions and supporting ICT systemsServer virtualization

ICT systems will be based on proven technologies widely used in any modern weather service such as server virtualization, Linux based systems and PostgreSQL database. Server virtualization such as VMware, KVM or Hyper-V in high availability-cluster configuration will be used for all processing requirements, web services, data download services, project services etc. Separate physical servers should be installed only when absolutely necessary by

the computing requirements of a specific application. Server virtualization will provide not only more efficient use of resources but automatic failover capability and improved reliability.

Storage

The storage system will be a critical component as it will provide services to the server virtualization cluster, guest operating systems such as NFS/CIFS data share, web services and PostgreSQL-cluster. Controllers and other critical components must be duplicated to ensure high availability. Capacity and number of disks have been selected so that the system will meet both capacity and performance requirements in the coming 5-7 yrs. Estimated raw capacity will be 11TB for performance disks and 50TB for capacity disks. High number of spindles is needed not only for capacity but especially to ensure good performance for database and other high activity workload.

Networking

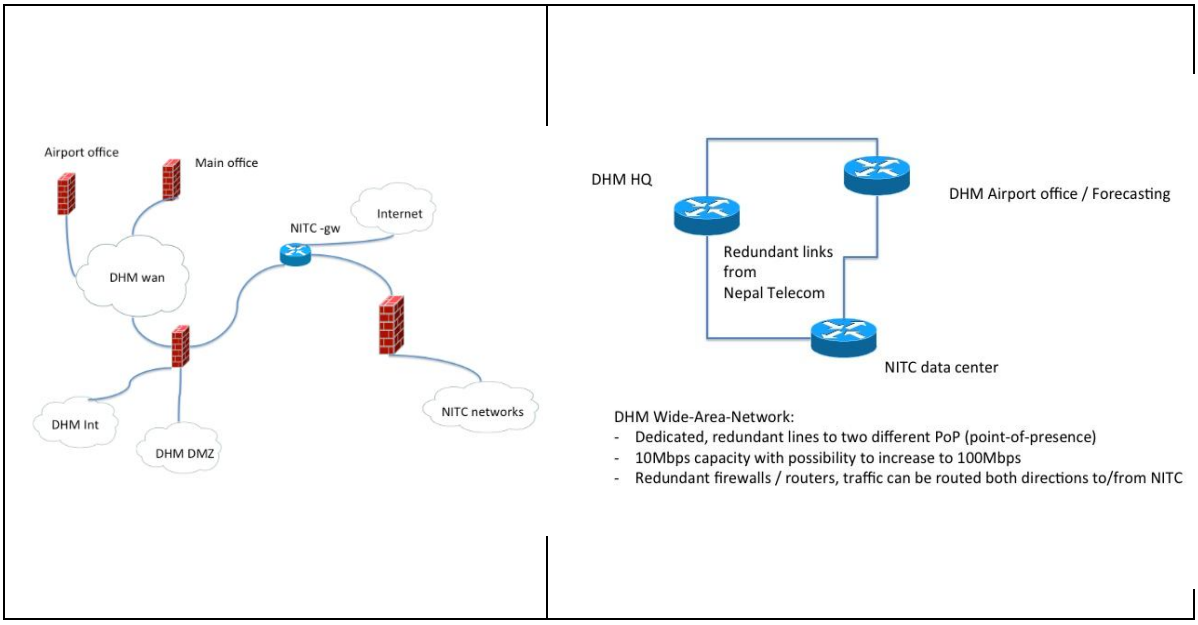

Figure 2: DHM networking plan

For networking, illustrated in Figure 2, high quality, cost-effective and scalable 1G and 10G Ethernet and other standard technologies will be used;10G Ethernet has been selected for iSCSI storage-area-network and for high speed connectivity for production systems including the HPC cluster. Multi-layer network security will be implemented in the firewalls. All critical systems will be consolidated to government data centre NITC in Kathmandu. Data transfers from data centre to forecasting department and DHM headquarters require reliable, high bandwidth network equipment and redundant lines. The option for Leased LAN provided by ISP should be evaluated for security and speed. A local area network could be established between NITC, Airport Office and DHM Office If found reliable. This network, and stations

inside this network would then be accessible only inside this network. Starting point will be 10Mbps redundant links that can be upgraded to 100Mbps in the future. For field and basin offices establishing suitable telecommunications can be challenging. Services should be designed so that data transfers between data centre and remote sites are kept to minimum. In any case a good starting point would be local router with redundant 1-2Mbit/s ADSL-links or single link with some other backup mechanism, even 3G could be considered. For sites with more data requirements a leased line with 1-10Mbit/s bandwidth should be considered. Running costs for leased lines are high, performance unknown and thus not recommended for all field and basin offices.

Detailed specifications of the ICT system design and hardware is found in Appendix 1.

2.4 General specifications of the Data management system

The data management system will be built upon the established ICT infrastructure described Chapter 4.1. Following the illustration of the ICT infrastructure components in Figure 1, the layout for data management workflow is presented in Figure 3.

Starting from the upper-left, observation data from hydro and met stations and is Quality Controlled (QC) before storage in the DHM relational database as 'point data'. Also lightning detection data and sounding data are stored in this data base. File based binary data such as Weather radar images, weather satellite data and Numerical Weather Prediction (NWP) grid data is processed separately and stored in a common file server. These data can go through various types of post-processing to bring the data in useable form. Extracts from file data can be generated and stored in the database as 'point' data representing surface station locations thus allowing for comparison with surface observations and to perform verification of NWP forecasts.

Selected data is further processed by calculation of derived variables (e.g. statistical values, potential evaporation, and drought index, etc.) and finally transformed into specialized data products according to user needs. Automated routines are developed to allow for dissemination of products via various media such as Internet, mobile networks and Wide Local Area Network (WLAN) and/or stored to user data bases such as AMIS and (WMO Information System (WIS). Workstations and corresponding user interfaces provide tools for the forecaster to visualise, analyse, control and edit data and to prepare specialized products such as weather warnings.

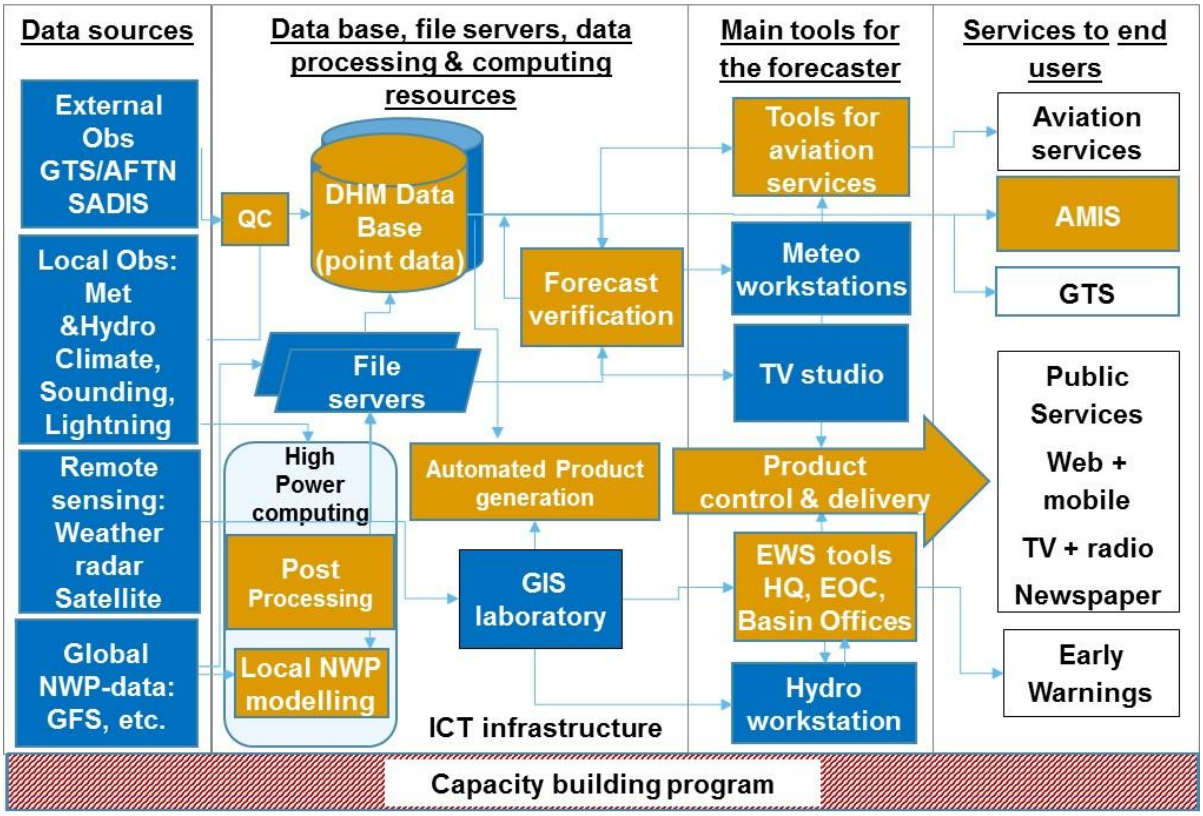

Figure 3:A simplified diagram of the planned DHM production process in which hydro-meteorological data, acquired from different local observation systems and international sources, flows through various data processing stages and is finally transformed and delivered as value added products to end-users. Blue boxes represent supply of data and information, hardware and off-the-shelf software. Orange boxes represent consulting works where new software and application are generated. The Boxes labelled as 'QC', 'DHM Data Base (point data)', 'Automated Product generation' and 'ICT Infrastructure 'are included in the Tasks of this ToR.

The data processing/ management modules to be developed through this consultancy are specified in the Tasks specified below. All modules must be able to handle both meteorological and hydrological observation data, NWP data and data generated by remote sensing methods.

All systems and interfaces specified in this ToR are located in the internal network of DHM, unless otherwise specified. By default, only users in DHM network will have access to the data management system. Data exchange to and from external parties may happen via public network.

3. Objective of the assignment

The main Objective of this consultancy is twofold:

First, to implement an operative ICT infrastructure, and

Second, to set up a data management system which is highly automated, equipped with advanced software tools to receive, capable of storing and processing all external and locally produced hydro-meteorological data in support of enhanced delivery of DHM's services. The assignment shall follow the overall design guidelines presented in Chapter 2and the Appendix of this document. The system shall support, but is not limited to, smooth data input from external sources, transfer of data between DHM organization units, quality control of data, storage of data allow for easy access, processing and delivery of data and products to various customer platforms.

The specific objectives for the development of an operative ICT infrastructure are:

- Implement scalable, high-availability ICT infrastructure to meet all performance and capacity needs for the coming years.
- Consolidate all ICT infrastructure into the government data center NITC
- Establish a resilient, high-performance and cost-efficient triangle topology network connecting the DHM main office, the DHM airport office and NITC
- Use of server virtualization wherever feasible for low-cost and enhanced resiliency
- Migrate existing services to the new infrastructure with minimum disruption to services
- Plan for cloud service integration for future development, especially with supporting services like DNS, SMTP and NTP.

As outlined above, all servers, storage and high-performance cluster will be installed at NITC, Singha Durbar data centre prior to this consultancy work. It is assumed that NITC will provide redundant power supply for DHM systems and public IPv4 addresses for DHM services. All ICT hardware will be procured in another tender. In principle no hardware components are procured through this consultancy.

Specific objectives of development of the Data Management system are:

- Implement data collection for all hydrological and meteorological observation data from various sources including potential 3rd party observation networks.
- Implement or improve automated and human quality control for both meteorological and hydrological surface observations.
- Store point-observations, lightning data and soundings in the DHM data management system. Store file-based data such as radar and satellite data in a high-availability file server.
- Implement data and selected product delivery to DHM workstations, media and customer data platforms (e.g. AMIS & GTS).
- Implement data visualization for different data types and selected products.
- Provide tools for observation network monitoring and management, and fault reporting.

All used software or technologies must be open source unless otherwise specified. Preferred

programming language is PHP as it builds up on previous work at DHM and is widely used, but consultant may propose alternative language for subtasks with justification. Interfaces of individual modules should reside in same portal, sharing same framework with common functions. Consultant may propose usage of external open source software for certain subtasks, such as Nagios for monitoring.

All intellectual properties and rights to deliverables, including source code will be given to DHM.

4. Scope of Work & Tasks

4.1 ICT Infrastructure

The scope of work on ICT Infrastructure consulting includes 11 tasks for which details are given below. A tentative timeline and list of deliverables are also given in the Table 4. SI and DHM will provide guidance for implementing each task.

Detailed implementation plan relevant to the Tasks have to be accepted by DHM and SI. DHM and SI will procure hardware for all tasks separately. DHM and SI will procure Hypervisors for Task ICT3 separately. Open source software is preferred for monitoring.

Task ICT 1 and 2. Wide Area Network and Local Area Network

In this Task the consultant will implement a Wide Area Network connecting DHM head office, NITC and Meteorological Forecast Division at Kathmandu airport as described in Figure 3 and Local Area Networks for DHM head office, NITC and forecasting at Kathmandu airport. The associated network hardware will be procured in another tender. The consultant shall provide a detailed low level network implementation plan including all aspects of functional network, address schemes, routing and L2 configuration. The L2 communication lines will be provided by the Nepal Telecom procured separately by DHM. The implementation phase must include the low level design and implementation. LAN and WAN at the three sites must include network segmentation and security schemas, as well as functionality testing for all three sites.

All communications between stations and servers should use secured connection preferably SSH and VPN where possible.

Task ICT 3. Data center server virtualization and storage

Here, the Consultant must implement a resilient, high-capacity clustered server virtualization and storage including storage area network (SAN). All the equipment will be procured in another tender. The specification for network, server, storage hardware and virtualization software are given in Appendix 1. Virtualization cluster consists of two high power servers that will be configured in High-Availability mode but so that during normal operations load can be balanced between both systems. Storage system will be an enterprise level system with redundant controllers with suitable performance and capacity for weather service

usage. Storage area network (SAN) will use generic LAN switches with separate virtual LANs reserved for iSCSI use. The systems and storage must be deployed, and their functionality tested.

Task ICT 4.Network Services

Basic network services for LAN and WAN shall be installed for the data center, head office and forecasting at Kathmandu airport. These must include DNS, NTP, DHCP, SMTP and user authentication and authorization for servers and storage (NFS/CIFS). Especially uid, gid should be used consistently across the systems. These services must use the server virtualization implemented in Task ICT 3. The current DNS, DHCP, NTP services shall be consolidated and migrated to the new infrastructure. System and service deployment with functionality testing shall ensue.

Task ICT 5. Postgres-cluster

In this task, the Consultant shall design and implement a high availability PostgreSQL-cluster on Linux operating system. The cluster will consist of two high power servers with iSCSI access to common storage system described in Task ICT3. The cluster should be replicating data with only manual failover and failback. Functionality shall be tested.

Task ICT 6. NAS-system implementation

Here, the Consultant shall implement NAS-system[3] with Linux NFSv3/Samba services on a virtualization platform described on Task ICT3. The design and implementation shall include production of NFSv3 and Samba files hares for internal networks including airport and the main office. Write permissions should be limited to a minimum needed by the operational processes. The implementation should be flexible with possibility to provide NFS and Samba to multiple subnets, several network shares for different purposes and different access rights.

Task ICT 7. Database and web server migration from the current DHM systems

The Consultant shall migrate the existing FNEP-database to the new cluster platform. Similarly, the current DHM web server shall be migrated to the virtualization platform. Migration must be carried out with minimum interruption to operational workload. The current web server houses web sites mfd.gov.np, www.dhm.gov.np, 202.45.144.145 that shall be migrated to server virtualization platform. Migration must be carried out with minimum interruption to operational workload. All migration tasks are “as-is”, that is, no development work is required except for solving possible software library mismatches and other minor issues that may arise.

[3] *A Network Attached Storage (NAS) device is a storage device connected to a network that allows storage and retrieval of data from a centralised location for authorised network users and heterogeneous clients. NAS devices are flexible and scale-out, meaning that as you need additional storage, you can add on to what you have.*

Task ICT 8. High Performance Computing (HPC) system and hardware support

Here, the Consultant is tasked to provide system and hardware support to DHM's Linux HPC cluster to be procured in BRCH-project. Estimated size of the HPC is 300–500 cores. The HPC system management training will be provided as a separate HPC consultancy.

Task ICT 9. Automated production scheduling system

The Consultant will implement a batch scheduling and monitoring system with visual and intuitive user interface to launch and control automated production tasks. System should have features to launch jobs on predefined intervals, time schedule and triggered by other events such as receiving a new numerical data set. This controlled environment should provide tolerance for hardware and software failures with intuitive interface to restart jobs. Typically these tasks are small scripts for data manipulation, data transfer and product generation. Preferred system is the weather service industry standard ECFlow that is available as open-source from ECMWF, but also other commercial-off-the-shelf implementations are possible.

Task ICT 10. Documentation

The Consultant shall document all systems and services deployed. This document should include a complete system mapping and specification of hardware, software, connections between contracted partners and organizational units within DHM. Detailed roles and responsibilities of partner organizations should be highlighted, including staff qualifications, roles and tasks to operate and maintain the system. The documentation shall also include a 'user manual' in a form of Standard Operational Procedures to cover all operations such as, but not limited to operation of systems, monitoring system performance, maintenance and support services.

Task ICT 11. Systems monitoring

In this task, systems and services monitoring shall be implemented to oversee the ICT system performance, fix any malfunctions or in case further assistance is need, call for experts on duty to deal with any problems detected. One example of possible solution is open-source tool Nagios. The absolute minimum requirements for systems monitoring are:

- Capability to monitor and report status of servers, network devices and storage systems.
- Capability to monitor and report status of system usage including memory, disk, network and CPU usage with trending data.
- Capability to monitor system services such as web server and database server availability or generic TCP service availability.
- Capability to monitor directory and file level updates on NFS file shares.
- Script API for more advanced monitoring functions development

- Capability to send alerts based on all previous monitoring functions. Alerts should be able to send via email, text message or mobile app.
- Graphical, intuitive user interface with clear visual signals when monitoring functions detect a failure

4.2 Data Management system

The scope of work includes starts with an analysis of the existing data management system. Building upon the existing system, as applicable, the Consultant will develop several software modules with required functionalities, implementation, testing and commissioning. The technical documentation and training of selected DHM staff must cover all modules.

The specifications of the modules are executed as separate Tasks as listed and specified below. More detailed specifications will be formulated during the course of work in cooperation with the DHM and SI representatives.

All modules and tasks require some kind of a user interface. Unless otherwise agreed, they must be web-based and operate in Linux-environment. The interfaces should be compatible with latest browsers and should be responsive, that is to adapt automatically to different sized screens

All interfaces must support links to related modules/interfaces, e.g. if there is a fault notice (see Task DMS 5), it should also show up in the Observation network information management and visualization module, see Task DMS 4). The required linkages will be specified during the assignment.

Configurations and other needed information must be stored to the existing metadata - tables of the database. Consultant can propose new tables or modifications to existing tables as needed.

Database and systems should be configured to handle disasters of all nature. There should be provision for Automatic and Incremental Backups to be stored over LAN in separate and multiple locations with confirmation of each backup sent automatically over email.

After Systems are implemented VHD (or applicable File format) of servers should be generated and stored safely, so that incase of disaster the VHD can be deployed and systems can be running immediately with limited or no system down time at all.

Task DMS 1.Data collection module

In this task, the consultant shall develop a Data collection module. The Data collection module will operate in Linux-environment assigned by DHM. It handles the retrieval or receiving of all incoming data from several data sources. Data sources will be specified during the process and system must support adding new sources in the future. Preferred software/programming language is PHP but the consultant can propose alternative technologies. These technologies must fulfill general requirements, e.g. being open source.

The configuration for data collection must be stored to metadata-tables in the existing database.

The data collection module should support the following functionality:

- Support for various telecommunication technologies including, but not limited to, mobile networks (GPRS, CDMA)/satellite/xDSL used by DHM
- Support for various communication protocols including, but not limited to, HTTP, TCP (socket), FTP, SSH/SCP
- Support for 3rd party observation networks such as Agro-Met (AMIS), aviation systems and WMO Information System (WIS) and Global Telecommunication System (GTS).
- Support to configure the data collection module to handle any additional documented message formats
- Support to retrieve data from online sources with given intervals

The Data collection module development can further be divided into two/three parts:

- Collection of Hydrological and Meteorological Observation data from station sites including upper-air sounding and lightning detection data
- Data collection for satellites, NWP and weather radars
- The module should include an interface to enter observation data manually at the office. Examples of such data are observations from stations operated manually or not having telemetry for automated data transfer. These stations include e.g. manually operated climatological, precipitation, river gauge and river flow rate stations.

Task DMS 1a. Observation data collection

The observation data collection module includes all messages containing observations related to a location and time of occurrence, such as data from surface weather stations, hydrometric stations, upper-air soundings, lightning location system. Corresponding point information can be generated e.g. from NWP and remote sensing data, incidences of a hazard etc. This data is used e.g. to perform comparison of different methods and to validate or verify numerical forecasts.

The Data collection module will include decoders for each message type and store the decoded values into database as specified in technical description of the database. Depending on messages, some processing, such as - but not limited to - parameter mapping, unit conversions and station mapping may be required before storing to the database.

The Data collection module must be able to handle incoming data or files from different sources in real time and must have support for fetching data at given locations on certain intervals.

Technical details will vary depending on data sources and telecommunication methods utilized. The consultant must be ready to work with several different protocols and technologies.

Specific requirements regarding hydrological and meteorological observations

- Scalability for receiving and handling real-time data from 400 stations with 10-minute intervals with provision for extension of additional 200 stations reporting every hour.
- Support for a wide range of documented message formats from various vendors including ASCII, SYNOP and BUFR. Additional, future documented formats must be supported. For vendor specific binary formats it is assumed that the vendor will provide full documentation of format and suitable tool for decoding the message to generic form.
- The collection module must be extensible for receiving QC information from sensors or data loggers (QC0) and identify the sensor providing the measurement.

Specific requirements for lightning detection data

- The module must support retrieving/receiving data from the Lightning Location System (LLS) operated by DHM. This system will be procured as part of the BRCH-project.
- In this scope, lightning location is considered as observations with some specific differences compared to point observations.
- Data will be decoded and stored into the database.
- Scalability to more than 100 incoming messages or events per second from the LLS.
- The consultant can propose solutions to ensure reliable and real-time handling of large amount of incoming messages

Specific requirements for sounding data

- The module must support data from the sounding systems to be operated by DHM. One sounding system will be procured as part of BRCH-project and provisionally another sounding system will be procured during, or soon after, the BRCH project
- In this scope, sounding data is considered as observations with some specific differences compared to point observations
- Secure capacity for other sources such as from AMDAR and additional sounding stations
- Support for sounding data from the WMO GTS network.
- Support for BUFR and TEMP encoded messages.

Task DMS 1b. Data collection for satellites, NWP and weather radars

Radar, satellite and Numerical weather Prediction (NWP) data are produced in spatial data formats and/or images so they are stored in a separate file server (See Task DMS-6). The environment for this file server will be established in Task ICT-3. Main responsibility of this data collection module is to receive or retrieve files from given locations and to store them into the file servers. Implementation of this sub-module depends on selected solutions for satellites, NWP and weather radars, and thus, cannot be accurately specified at this point.

Specific requirements for radar data

- Support for weather radar data operated by DHM. Weather radar will be procured and installed as part of BRCH project.
- Radar data is typically transferred as files with standard protocols via dedicated connections to a file server.

Task DMS 2.Data quality control module

The consultant shall develop further the currently used data Quality Control (QC) module. The data quality control for meteorological and hydrological surface observations is a key part of the data flow chain. In this project the Nordic 4-level definition for quality control is used.

The FNEP-projects have already provided real-time quality control (QC1), for which the corresponding software currently installed at DHM is called 'kqc1' 4.

In addition, the consultant must evaluate the current situation of the WWW/PHP-based Human Quality Control (HQC)-software, currently in Beta-version, to decide on improvement and further development of the HQC[5],[6].

No quality control will be implemented for lightning data, soundings, radar or data from external sources (assuming that these data have been quality controlled by the external source).

Task DMS 3.Database module

For meteorological parameters, the real-time dataflow from several meteorological observation stations is currently established at DHM to a PostgreSQL-database, developed and installed in the FNEP-1 project.

This database was extended in the FNEP-2 project with features to include sounding data and lightning data.

In this task, the consultant shall:

- Provide inclusion of all hydrological parameters into the database, including the ones entered into the current hydrological database utilized by DHM. Existing table structure can handle hydrological data.

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4 *Vejen, F. (ed), C. Jacobsson, U. Fredriksson, M. Moe, L. Andresen, E. hellsten, P. Rissanen, P. Palsdottir, P. Arason, 2002: Quality Control of Meteorological Observations, Automatic Methods Used in the Nordic Countries, met.no, KLIMA Report, 8/2002, 109 pp.* http://www.smhi.se/hfa_coord/nordklim/task1/quality_control.pdf

5 *Andresen, L (ed), H. Björnsson, U. Fredriksson, K. iden, C. Jaconsson, P. Plasdottir, O. Pettersson, P. Rissanen, A. Samuli, F. Vejen, 2003: Manual Quality Control of Meteorological Observations; Recommendations for a common Nordic HQC System., met.no, KLIMA Report 9/2003.* https://wiki.fmi.fi/download/attachments/24787599/KLIMA_HQC_2003.pdf?version=1&modificationDate=1424339633429&api=v2

6 *Rissanen, P.(ed), C. Jacobsson, H. Madsen, M. Moe, P. Palsdottir, F. Vejen, 2000: Nordic Methods for Quality Control of Climate Data, DNMI, KLIMA Report 10/2000, 50 pp* http://met.no/Forskning/Publikasjoner/Publikasjoner_1995_-_2013/Publikasjoner_2000/filestore/10_00.pdf

- Expand the current database structure to include station and instrument meta-data as specified in "Observation network information management and visualization module", see Task DSM 4.

Task DMS 4.Observation network information management and visualization module

The consultant shall develop a user interface to select and view data and metadata stored in the database and, concerning some data sets, also in the fileserver.

The observation network information management and visualization module must allow for handling all historical and real time observation (point) data available in the database. The module must consist of access (storing, editing & viewing) of site, station and instrument specific metadata which is necessary for network maintenance, performance monitoring and reporting.

Data and metadata visualization components are roughly divided in the following sub-tasks. The consultant shall provide an implementation plan with the following features:

Task DMS 4a. Metadata visualization and editing

The consultant shall evaluate the existing structure and content of metadata and observation data and provide a plan to augment the functionality according to needs expressed by DHM and as instructed by SI. Basic features of the module are (but are not limited to):

An interface to view, input and modify site, station and instrument metadata in a tabular form and other forms decided during the course of the DMS planning

The composition of metadata should follow WMO WIGOS recommendations as applicable, but also include local features as concluded necessary.

- Should provide map-based view on observation network. Observation stations shall include all measurement devices, such as observation stations, radars, sounding stations, lightning location sensors etc. Basic information of the station and latest measurements would be provided when clicking the symbol on the map. Information should be also available in list-mode.
- Should provide metadata-structures and interfaces for defining persons and their contact information, possibly combined to authentication. Structure and contents of these metadata shall be defined together with SI and DHM.

Task DMS 4b. Observation data visualization

The sub-task includes software development to visualize instantaneous observation data as received from the observation stations, corresponding statistic values over selected time periods, other derived data and station metadata.

The data products include (but are not limited to):

a. Station-wise time series of selected variables with a possibility to overlay parameters at least from four stations on a time plot;

b. Table(s) on measured and derived data and climatological statistic on selected stations and variables, if stored with observations; and

c. Spatial plots of measured data at station points overlaid on vector map data.

While viewing the products, the user must be able to select stations, time period and variables to be displayed as applicable depending on the data available and the mode of viewing. Data extracts in text format (csv) must be enabled.

In addition the consultant will be assisted to provide visualization of a few specialized products, such as - but not be limited to

a. Wind-rose plot images

b. Spatial and temporal visualization of lightning data with freely selectable samples of data.

c. Rating curve to estimate river discharge from stage measurements

d. Unit hydrographs to show the rate of flow versus time

e. Double mass curve for checking consistency of a hydrological record

f. Linkage to or contain a sub-module to create Fault notices to initiate a station maintenance process (see Task 5 below).

g. Linkage to or contain a tool to prepare periodic status and fault reports on observation station & instrument performance and success of maintenance operations (see Task 5 below).

This sub-module should visualize derived variables and Table(s) on measured and derived data and climatological statistics on selected stations and variables, if stored with observations.

Task DMS 4c Weather radar visualization

This sub-module should provide a map-based view of the radar network as with any other observing station network. Basic information of the station should be provided when clicking the radar symbol on the map. User should be able to view latest radar image animation (images are provided by the Radar data software installed within the Radar supply) for a user selectable period and time interval.

Further functionalities for these modules and tasks should be proposed by the consultant.

Task DMS 5.Fault notice and reporting module

In this task, the consultant shall develop a fault notice and reporting module. This module is an important part for general monitoring of the status of station networks. Main users of this module will be quality controllers and technicians. In addition, fault notices may be issued by any DHM personnel who notice a problem or deviation with expected performance of the network, individual sensor or appearance of a data value.

This module is basically a ticketing system[7] with a few specific features. Main feature is that the fault notices must be linked to an individual station or to a larger entity, such as data collection, region wide telecommunication problems etc. In this context, a "station" refers to a unique entity stored in the station table in the data management system with a unique station ID. Therefore, weather radars and lightning location sensors are considered as stations in this scope.

Detailed features of the desired ticketing system will be discussed during contract negotiations and fine-tuned during the course of the consultancy.

In addition, this module should provide tools to generate periodic fault reports based on issued fault notices including response information by the technicians. Contents of the fault reports shall be discussed in more detail during the course of consultancy.

Task DMS 6.Data warehousing for radar and other file based data

Radar, Satellite and weather model data are a poor fit for relational databases. Therefore this data is to be stored in a separate high quality file- based storage to support all file based data sets.

In this task, the consultant shall develop a file system hierarchy for storing cumulative file based datasets. File service is described in ICT task 6, "NAS-system implementation".

Task DMS 7.Data delivery module

The consultant shall design a module providing delivery of data from the observation database and data warehouses to develop products, applications and tailored to customers as follows.

The module should provide read and write access rights and file ownership to the file systems in support of for data accessibility and security.

Task DMS 7a.Data flow for observations

The module should provide data flow to the GTS network in BUFR format. The consultant shall provide a program which creates BUFR-coded messages from observations in the database. The program shall keep track of observations handled and BUFR-messages sent. It shall also be able to send correction messages as defined in the BUFR-specification. BUFR-messages are created from stations which are defined in station group-list in metadata.

The module should provide data flow to AMIS data management system at specific intervals. Message formats, intervals and transfer methods will be specified together with MoAD/NARC.

The module should provide observation data connectivity to DHM production systems,

[7] *Also called an issue tracking system, trouble ticket system, support ticket, request management or incident ticket system. It is a computer software package that manages and maintains lists of issues, as needed by an organization.*

including forecasting stations, GIS laboratory, Early Warning System and to any customer in need of data. It is assumed that some of internal applications can read data directly from the database. However, in some cases it is mandatory to provide specific data sets, formats and transfer methods as per required by the downstream application such as Meteorological or Hydrological workstation.

The module should have feature to provide data to requesting organization through API and Web services. Those Web services and API should have a management portal that can define data that is being provided to particular user, date when the particular web service will expire, authentication, limited pull and push requests. The web services built and implemented should follow tier architecture. The web service should in no condition directly run the query against the Database. This Module should be well tested against possible vulnerabilities including but not limited to Injection and Cross Scripting. The Module should have feature to generate and configure API based on requests. The Web services should implement open data exchange formats implementing RESTFUL Services. The data should be exchanged using XML, JSON, XLSX or CSV Format configurable in the API Management Portal.

Task DMS 7b.Data flow for soundings

The module should provide data flow to GTS network in BUFR format. This BUFR encoding feature may be provided by the sounding system, and will be specified later in the project.

The module should provide sounding data connectivity to DHM production systems including forecasting stations, GIS laboratory, Early Warning System and to any customer in need of data. It is assumed that some of internal applications can read data directly from database. However is some cases it is mandatory to provide specific data sets, formats and transfer methods as per required by the downstream application such as Meteorological or Hydrological workstation.

Task DMS 7c.Data flow for lightning data

The module should provide reliable dataflow from database to various downstream users and applications:

- To meteorological and, if needed, hydrological workstations. The format will be defined when workstation software has been selected.
- To GIS laboratory in case GIS laboratory cannot read data directly from the production database
- To early warning system (EWS) in data format to be specified in the EWS development phase
- To any other data customer or other DHM service

Task DMS 7d.Data flow for radar data

The Module should provide reliable dataflow from data warehouse to various downstream users and applications.

- To meteorological and, if needed, hydrological workstations. The format will be defined when workstation software has been selected.
- To GIS laboratory as a data copy. The format is to be defined.
- To Early Warning System (EWS) system. The format is to be defined.
- To any other data customer or other DHM service.

Task DMS 8.User training and documentation

The consultant is required to provide training related to data management; no training on ICT is needed as the operation and maintenance of ICT infrastructure is outsourced to DHM selected partner. The user training on Data Management should include basic and intermediate level hands-on training for each individual module described in Tasks DMS1-7. Basic training should be arranged before a module or a part of a module is put into production. Detailed training should be provided between 6-18 months after contract signing. The goal for training is to provide DHM staff with knowledge to use, maintain and configure the data management system. Tentative topics of training with length of training is indicated in Table 1.

The consultant shall prepare a detailed training plan including:

- Outline of training topics with list of target measures for the training
- Level of training with definition of the minimum qualification for participants
- Schedule of training sessions

Training material:

The consultant is required to provide all training material in an appropriate electronic format (.doc, .ppt, .xsls, .pdf, etc.) organized as per training topic.

The training sessions/presentations shall also be provided as a set of media files (Windows Media Player Compatible) as per topic of training. The media training is expected to have the complete perspective of actually attending training, including a live trainer providing the training and questions and answers. DHM shall have permission to make copies of the files on an unlimited basis.

Report on training:

- List of participant names, titles, and email address
- Evaluation of training using an inquiry template (to be provided)
- Training material(see above)

Table 1. Topics of training on data management

Topic of training	Length of training (days)
Observation network monitoring and reporting	6
Data collection	4
Data quality control	8
Database	4
Data warehouse	1
Data flow	6
Real-time visualization	2
Automated production scheduling system	8
Demonstration and instruction to prepare Standard Operational Procedures for maintenance and operation of the ICT and Data management systems	2

Task DMS 9 Continuous development of Data Management

After completing most of the basic development of the Data Management system (DMS Tasks 1-8), starting latest on the 17 month, Consultant shall allocate appropriate resource to continue development of the data management system until end of the contract. Examples of potential development needs/ services are (but not limited to):

- Augment the already established DMS components as agreed with DHM
- Upgrading data base structure due to availability of new data types (e.g. derived data variables)
- Inserting data that has become available due to progress of commissioning of new observation stations/ availability of new variables / establishing new observing systems.
- Completion of development of new data products to be inserted to the AMIS system delivery package or other customer platforms
- Providing support to other ongoing Consultancy Works

5. Implementation arrangements

5.1 Data management system development methodology and testing

Agile development

The approach in data management system software development is to follow a so called "agile development methodology"[8], which requires minimum of 3 iterations in understanding and identifying all requirements. The main idea here is that the consultant will carry work-in-progress and revise plans at least 3 times before submitting the final product. Processes, modules and tasks are linked closely together. Therefore it is assumed that iterations will be needed for defining processes and features of given task and separate iterations for user interface. Iterations allow for fine tuning requirements and to finally deliver the desired product. The approach will ensure accurate understanding of all functional enhancements and also help in identification of any additional requirements that may need to be incorporated during this process.

As part of the development process, rigorous testing should be carried out including system tests, functionality tests and user acceptance tests. Consultant should provide a detailed project plan with clearly defined tasks for each module together with detailed deliverables list and testing plan.

5.2 Roles of DHM and partner organizations

This assignment lead by the DHM will be carried out in mutual partnership between DHM and its partners NITC and the winning Consultant of this bid. MoU's between the partner organizations relevant to this consultancy will be established by the time of contract agreement of this bid. The roles of DHM and the partner organizations are briefly outlined in Table 2below.

DHM is committed to provide basic organizational support to the consultant. At the request of the Consultant, DHM will provide following documents

- Information and data related to the project including information on status of observation networks, monitoring/lab equipment, communication, computing resources, and data processing tools;
- Detailed Information on hydrological and meteorological monitoring networks; type of monitoring systems; frequency of sampling and reporting; parameters measured; meteorological systems in place; and data available to central and decentralized levels of government as well as reporting requirements for different governmental institutions and the public;
- All hydrological and meteorological data and station meta data available in digital form;

8 https://en.wikipedia.org/wiki/Agile_software_development

- Project Appraisal Document (PAD), reports of missions and other relevant publications;
- Consultant may be granted access to relevant DHM facilities and NITC

Table 2. Organizations and their roles in developing DHM's ICT infrastructure and Data Management system

Organization	Role
DHM	- Acquiring services from partners - Contract management - User of ICT & data management to provide Data Services and to practice R&D - Specify further development of services with partners
NITC (partner)	- Outsourcing partner - Host IT hardware
DHM named ICT and Data management partner	- Outsourcing partner - ICT system development, maintenance, support & monitoring - Data management & system development, maintenance and support

5.3 Guidance, Supervision and Quality Assurance

The BRCH project has several components that involve demands on both ICT infrastructure and data management affecting the design of systems and the desired schedule of development. The DHM and the Consultant should work in close cooperation in order to plan and schedule implementation of ICT infrastructure and the data management in an efficient way taking into account overall design of the services production system and the schedule of implementation of its components. The consultant should adapt to the development process and planning accordingly.

Project Management Units (PMUs) have been established in each of the two implementing agencies (DHM and MoAD), and include technical, financial, procurement, environment, social, monitoring and evaluation specialists.

General consultant/system integrator (SI) is hired for four years to provide service to DHM. The main objective of SI is the development of technical documentation for the

implementation of each of the project component and effective technical support for project activities in order to achieve project goals.

All key outputs/deliverables including designs and reports will be subjected to review at various levels. On technical matters, the consulting firm will work in close consultation with DHM, PMU, SI and Project stakeholders.

The Consultant can get technical support and guidance from SI as and when required during the period of implementation. In addition the Consultant will hold:

- Regular (monthly) consultations with DHM
- Kick off meeting with key stakeholders
- Time to time updates with key stakeholders

6. Time line, reporting requirements and deliverables

6.1 Time line of Tasks

The overall contract period is 30 months from signing of contract divided into four phases as follows:

The 1st phase concentrates on development of the ICT Infrastructure and lasts 9 months from contract signing consisting of completion of Tasks ICT 1-10.

The 2nd phase concentrates on Data Management System development (Tasks DMS 1-8) and can start earliest after two months from start of contract and last until 16 months. It must be noted that timing of the DMS Tasks is highly dependent on the progress of other project components; pending for periodic upgrading of the schedule in cooperation with DHM and the Consultant.

The 3rd phase contains monitoring, support and maintenance services by the Consultant (Task ICT 11) focusing on the established operative part of the ICT & Data Management system starting on 5th month and continuing until end of the contract period.

The 4th phase (Task DMS 9) contains continuous development of the Data Management System starting after completion of most of the Tasks DMS 1-8 until end of the contract period.

Table 3 provides an approximate time-line of Phases, Tasks and Reporting for the purpose of assessing the human resources needed. A more detailed schedule can be agreed upon contract negotiations. It must be noted that start time of Tasks DMS 1-8 depends on the progress of commissioning of the observation systems.

Table 3. Preliminary timeline of completion of Tasks and Reporting. Months are running calendar months after signing the contract. 'Effective months' indicate estimated work time needed for completion of each Task by assuming a fixed proportion from the calendar months.

Task/ Month		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Calendar months	Effective months
ICT	1	Inception report		Phase 1.							1st mid-term report							2nd Mid-term Report						3rd Mid Term Report							Final Report	4	1,5
ICT	2																															4	1,5
ICT	3																															4	1,5
ICT	4																															4	1,5
ICT	5																															4	1,5
ICT	6																															4	1,5
ICT	7																															6	2,3
ICT	8																															6	2,3
ICT	9																															6	2,3
ICT	10																															9	3,5
ICT	11					Phase 3.																										26	10,0
DMS	1			Phase 2.															- Start time of these Tasks depends on progress of other project components - Earliest possible execution period for Tasks is indicated															14	5,4
DMS	2																															4	1,5
DMS	3																															4	1,5
DMS	4																															14	5,4
DMS	5																															7	2,7
DMS	6																															14	5,4
DMS	7																															15	5,8
DMS	8																															11	4,2
DMS	9																		Phase 4.													13	5,0
																															Total (months)	173	66,7
																															Total (days)		1400

6.2 Reporting requirements

All the reports must be submitted in 3 hardcopies along with e-copies.

<u>Inception report</u> (due 1 month from contract signing)

The report will be based on elaborated discussions with DHM, SI, Project Management Unit (PMU), Ministry of Population and Environment (MoPE) and Ministry of Agriculture Development (MoAD. The Consultant shall propose a clear discussion on carrying out of all tasks (ICT 1-11, DMS 1-9), including methodologies required, deliverables and timeline. The Consultant shall review the existing information, identify gaps and make specifications of the surveys necessary for filling information gaps. The Consultant will also elaborate on: (i) additional tasks, (ii) work and staffing plans, and (iii) reporting modalities. The report must also clearly specify all risks and issues, which may negatively affect project deadlines and effective execution of project activities.

1st Mid-term report (due 10 months from contract signing)

This report must include detailed description of the commissioned ICT Infrastructure (Tasks ICT 1-10), as well as preliminary results on operations, support and maintenance operations including the corresponding SOPs (ICT 11).The report must also highlight the results of completed DMS Tasks so far and discuss progress of Data Management development for the ongoing Tasks.

2nd Mid-term report (due 17 months from contract signing)

This report must include detailed description completed Data Management components so far including preliminary SOPs for using the completed data management tools. For the uncompleted Task the progress and deviations from original plan must be highlighted. The report shall contain a performance report on operations, support and maintenance procedures for the operative ICT infrastructure & data management system established so far (Task ICT 11). The report must also present a detailed work plan for the continued Data management development (Task DMS 9) based on expressed needs and as agreed with DHM.

3rd Mid-Term Report (due in 23 months from contract signing)

This report is an update of 2nd mid-term report: This report must include detailed description of completed Data Management components (Tasks DMS 1-8) including preliminary SOPs for using the completed data management tools. For the uncompleted Task the progress and deviations from original plan must be highlighted. The report shall contain a performance report on operations, support and maintenance procedures for the operative ICT infrastructure & data management system. The report must also present a detailed work plan for the continued Data management development (Task DMS 9) based on expressed needs and as agreed with DHM.

Final report (due 30 months from contract signing)

The report must provide a concise description of the ICT Infrastructure and Data Management system developed with list of completed results. The details of each components and SOPs in the form of a 'User Manual' shall be attached in Appendices.

6.3 Summary of ICT tasks with deliverable and time line

Table 4 lists the ICT tasks with deliverables and time lines indicating the start and completion month of assignment from signing the contract period.

Table 4. List of Tasks, deliverables and preliminary time line for completion of the ICT Infrastructure development.

Task No.	Description	Deliverable (systems fully completed, tested and commissioned)	Start–Ready in months from contract signing
ICT 1	Wide area network connecting DHM head office, NITC and forecasting at Kathmandu airport.	- Design and implementation plan - System deployment	1-4
ICT 2	Local area network for data center at NITC, DHM head office and forecasting department at Kathmandu airport	- Design plan and specifications - System deployment	1-4
ICT 3	Data center server virtualization and storage	- Design plan and specifications - System deployment	1-4
ICT 4	Basic network services for data center, head office and forecasting at Kathmandu airport	- Design and implementation plan - System and service deployment and migration	1-4
ICT 5	Postgres-cluster	- Design and implementation plan - System and service deployment	1-4
ICT 6	NAS-system implementation with Linux NFSv3/Samba services on virtualization platform	- Design and implementation plan - System and service deployment	1-6
ICT 7	Database and web server migration from current DHM systems	- Migration plan - System and service deployment	1-6
ICT 8	HPC system and hardware support	- Participation in user training - Service provided during last six 6 months of the contract	1-6
ICT 9	Automated production scheduling system	- Implementation plan - System deployment - Training	1-6
ICT 10	System and service documentation as specified	System specifications SOPs Performance reports Progress reports	1-9
ICT 11	Systems monitoring, support and maintenance	- On call system monitoring - Support on workdays Regular and on-demand Maintenance	5-30

6.4 Summary of Data Management tasks and timelines

Table 5 lists the Data Management tasks with deliverables and time lines indicating the start and completion month of assignment from signing the contract period. Note that the start time of Tasks is tentative and the earliest possible execution period is indicated. Actual start depends on progress of other project components.

Table 5. Tasks, deliverables and preliminary time line for completion of the Data Management development.

Task No.	Description	Deliverable (modules fully completed, tested and commissioned)	Start - Ready in months from contract signing
DMS 1	Data collection module	- Software - List of data sources collected - Summary of activities completed leading to satisfactory completion of the task	2-16
DMS 1a	Observation data collection		
DMS 1b	Data collection for satellites, NWP and weather radars		
DMS 2	Data quality control module	- Software - List of data sources under QC - Summary of activities completed leading to satisfactory completion of the task	2-6
DMS 3	Database module	- Software - Description of data base structure - Summary of activities completed leading to satisfactory completion of the task	2-6

Task No.	Description	Deliverable (modules fully completed, tested and commissioned)	Start - Ready in months from contract signing
DMS 4	Observation network information management and visualization module	- Software - User interface - Demonstration of data visualized - Summary of activities completed leading to satisfactory completion of the task	2-16
DMS 4a	Metadata visualization and editing		
DMS 4b	Observation data visualization		
DMS 4c	Weather radar visualization		
DMS 5	Fault notice and reporting module	- Software - User interface - Demo on fault notices - Demo on fault reporting - Summary of activities completed leading to satisfactory completion of the task	5-12
DMS 6	Data warehousing for radar and other file based data	- Software - List of data stored - Summary of activities completed leading to satisfactory completion of the task	2-16
DMS 7	Data delivery module	- Software - List of data delivered - Summary of activities completed leading to satisfactory completion of the task	1-16
DMS 7a	Data flow for observations		
DMS 7b	Data flow for soundings		
DMS 7c	Data flow for lightning data		
DMS 7c	Data flow for radar data		

Task No.	Description	Deliverable (modules fully completed, tested and commissioned)	Start - Ready in months from contract signing
DMS 8	Training to DHM staff	- List of participants - Training material - Evaluation reports - Summary of activities completed leading to satisfactory completion of the task	5-18
DMS 9	Continuing DMS development	- Inclusion of new data - Upgrading data base structure (e.g. new data tables) - Upgrading data products - Developing new data products - Support to AMIS and other customer platforms	17-30

7. Consultant's qualification and Experience

The ICT and data management consultant's role will be crucial in implementing the new, modern ICT infrastructure and data management to support DHM mission critical actives. Special emphasis will be put on the prospective consultant's experience and references on implementing and supporting similar systems.

7.1 Company requirements

The following are mandatory requirements from the consultant firm (company), minimum criteria are underlined and/or shown in (brackets):

- Company standing for at least five years in ICT infrastructure consulting(≥ 3 refs[9]).
- Company standing for at least five years in Data Management consulting(≥ 3 refs).
- Company financial statement providing information on company turnover and payments background.
- All prospective consultants should be national or showing >50% of their personally allocated work time in Nepal.

[9] *(≥ 3 refs) stands for: 'at least 3 relevant references'*

- The company must show proven track record of at least three referenced ICT projects and two referenced Data Management projects during the last five years with similar network, server and storage technologies.
- Proven track record (≥ 3 refs) of working with international projects, preferably with the World Bank. Prospective consultant must provide reference information on at least one such project in Nepal.
- Proven track record (≥ 3 refs) with wide-area-networking implementations and local area network implementations with associated services (DNS, SMTP, NTP, DHCP) and routing.
- Proven track record with Linux servers, enterprise virtualization and PostgreSQL clustering, (≥ 3 refs).
- Proven track record with software development with agile methods using open source technologies such as Linux, PostgreSQL and PHP, preferably for hydro-meteorological environments, (≥ 3 refs).
- Proven track record with implementing monitoring for operational systems preferably with open source tools (such as Nagios, Ganglia, etc.), (≥ 3 refs).
- Consultant must provide certified local employees for network, server virtualization, Linux operating system, storage system design and development. Consultant must provide the CVs of at least three employees with such certifications each with at least three years of working experience.
- Consultant must provide detailed information on reference implementations listed above. Reference contact information must be provided so that DHM and SI can validate references if deemed necessary. Reference implementations for consultant's own use are not valid.

7.2 Staff requirements

The consulting firm may consist (but will not be limited to) combination of the following posts: Project Manager, Systems Engineer/Specialist, Systems Analyst/Developer, Technician, Technical writer/Documentation Specialist and Administrator. Consultant must provide the CV(s) of the prospective Project manager, Systems Engineer/Specialist(s) and Systems Analyst/Developer(s). All staff shall be national. Qualification requirements of the employees are as follows:

Project manager (300 days, 1 employee)

The Project Manager (PM) will play a key role as a coordinator and has major responsibility in the designing &implementation state-of-the-art ICT and Data Management system for use by DHM. PM is responsible for an overall management of the assignment including quality assurance, completeness, timely delivery of outputs and reports and documentation of the systems. S/he will transfer the knowledge on international best practices in ICT Infrastructure and data management to DHM personnel through training workshops and hands-on training. The team leader should spend all allocated days in Nepal.

Qualification

- Bachelor or Vocational degree in engineering or any related discipline. Higher degree would be an advantage.
- Minimum 5 years' experience in designing state-of-the-art ICT and Data Management projects. References of at least three (3) successful projects in developing countries, particularly in south –Asian region. Proven experience in successful design, development, and management of projects (including financial management) ensuring alignment with requirements of concerned institutions and development partners.
- Proven Working knowledge in appropriate technologies on ICT infrastructure and data management mentioned in the company requirements.
- Strong command in computer application and communication.

Systems Engineer/Specialist (450 days; 1 or more employees)

Systems Engineer/Specialists will be responsible for the technical architecture implementation and low level design of ICT systems and various components in the data management system. Demanding system configuration, system migration and software development tasks carried out together with system analysts and developers. Participation in agile development iterations and development process.

Qualification

- Bachelor or Vocational degree (or higher) would be an advantage
- Expert(s) must have proven experience in data communications and networking, Linux operating system, network design, network service design, network security design, storage systems, agile development methodology, server virtualization, software design, PHP-programming, user interfaces and relational databases (preferably PostgreSQL). Consultant must provide the CVs of the employee(s) with such experience each with at least five (5) years of working experience.
- Minimum of three (3) years of experience in working in Nepal or in the nearby countries with appropriate technologies on ICT infrastructure and/or data management mentioned in the company requirements.

Systems Analyst/Developer (200days, 1 or more employees)

Systems Analysts/Developers will be responsible for all system configuration tasks, system migration tasks and software and database development tasks. Participate in agile development iterations and development process.

Qualification

- Bachelor or Vocational degree (or higher) would be an advantage
- Expert(s) must have proven expertise in managing state-of-the-art ICT infrastructure and/or Data Management projects in Nepal or nearby countries. They must have shown experience for experience for data communications and networking, Linux

operating system, network design and maintenance, network service design and maintenance, system security design, storage systems, server virtualization, agile design methodology, software design, PHP-programming, user interfaces and relational databases (preferably PostgreSQL). Consultant must provide the CVs of employee(s) with such experience each with at least three (3) years of working experience.

- Minimum of three (3) years of relevant experience in working in Nepal or in the nearby countries with appropriate technologies on ICT infrastructure and/or data management mentioned in the company requirements.

Technician/ Documentation specialist / Administrator (450 days; 1 or more employees)

The employee will assist System Project Manager, System Engineers/Specialists and Analysts/Developers in any tasks assigned to them. They perform System monitoring, maintenance operations and support DHM staff on issues related to ICT and data management.

Qualification

- The employee(s) will have working knowledge on their assigned tasks.
- At least three (3) years of working experience with appropriate technologies on ICT infrastructure and/or data management mentioned in the company requirements.

8. Payment schedule

- 10 percent of contract value on signing of contract as advance against a bank guarantee.
- 10 percent of contract value after approval by DHM on the Inception Report.
- 30 percent after approval by DHM of the 1st Mid-Term report and commissioning of the ICT infrastructure (Tasks ICT 1-10)
- 30 percent of contract value after Tasks DMS 1-8 have been successfully completed.
- 20 percent of contract value after Tasks ICT 11& DMS 9 have been completed and the Final report accepted by DHM and SI.

9. Selection procedure and form of contract

The selection procedure follows the selection based on consultant qualification (CQS).

10. Input of the Client

The staff of DHM/PMU will provide basic organizational support to the Consultant.
At the request of the Consultant, DHM will provide:

- Information and data related to the project, including information on status of DHM observation networks and internet;
- Project Appraisal Document (PAD), technical reports on rehabilitation of DHM's operative systems and other relevant DHM publications;
- Other project related documents in support of activities;
- Consultant will be provided working space with limited furniture within DHM office.

Appendix 1

Technical Specification
for
Communication Equipment for ICT Infrastructure and Management System (DHM Networks and Offices)

1. Introduction

This chapter specifies the hardware for new ICT infrastructure for Department of Hydrology and Meteorology, Nepal as part of the BRCH project.

New ICT infrastructure will be the foundation for all operational work carried out at DHM. BRCH project includes significant investment in observation equipment, data management and downstream applications. It is essential to design and implement scalable, high-availability ICT-infrastructure to meet all capacity needs for the coming at least for the next 7 years to come.

All servers, storage and high performance cluster will be installed at NITC, Singha Durbar data center. It is assumed that NITC will provide only mains power for DHM systems and public IPv4 addresses for DHM services.

Systems design

Overall goal of this system design is to provide DHM with state-of-the-art ICT infrastructure capable of supporting their mission critical activities and key projects for years to come. In order to provide world-class services to key customers such as civil aviation and agricultural sector, and to further enhance DHM's position as a national focal point of any weather, climate and hydrology related activities, not only the observation systems but also the supporting ICT systems will be designed and built from ground up to provide reliable and high performance service.

Same high quality requirements will be extended to ICT management supporting processes and development of resources. Procurement, installation and implementation of ICT infrastructure in the PPCR/BRCH-project with the help of SI to provide valuable learning experience and knowledge to DHM and so improve DHM's capacity to maintain and develop these systems in the future. In order to guarantee sustainability of the ICT infrastructure and it's capability to provide high quality services, DHM will focus not only on hardware and software but also management, processes and key resources as illustrated in Figure 1.

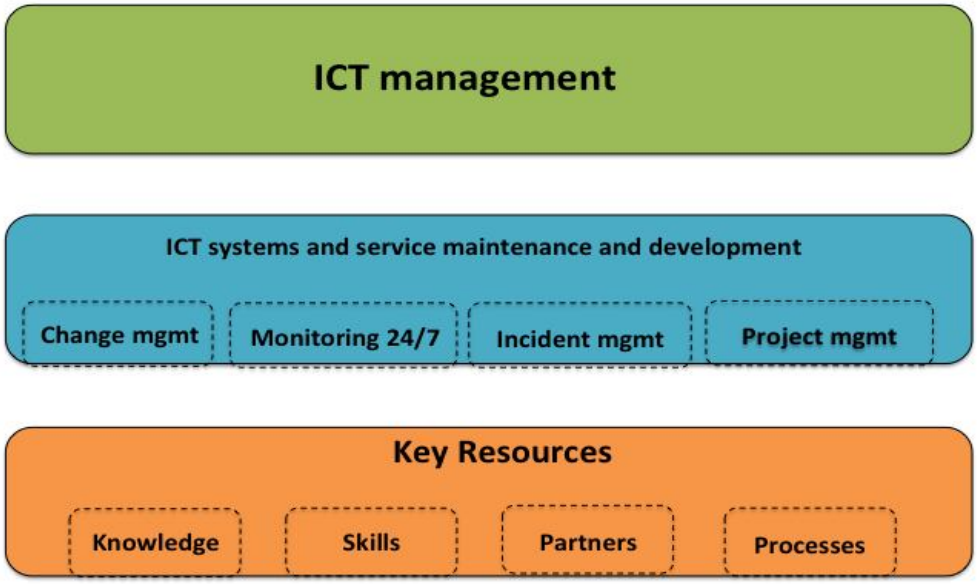


Figure 1 Required focus areas of ICT Infrastructure management

Responsibilities and practices of operational ICT management should be clear and preferably should be duty of a single person reporting to DHM top management. Key processes such as change management, system monitoring 24/7 and incident management should support ICT system and service management. Development practices can be guided with project management practices. Several key resources can be identified that should be developed: knowledge in the broadest sense of the word, skills required, partners as DHM's own resources are limited and processes as described above.

DHM' s new production system can be described through four functions illustrated in fig1:

- Data retrieval functions including all data flows into DHM's production system such as observation data and GFS weather model data. All these functions will be implemented in the data management system.
- Data warehousing and processing functions that include for example all quality control, data upload to database and file sharing-like data warehouse, data processing such as format conversions and transfer to analytics and R&D functions. All these functions will be implemented in the data management system and further developed by DHM.
- Data analytics and product generation include functions where both hydrological and meteorological value is added to services and products for various customers are generated automatically. All these functions will be implemented in the data management system and further developed by DHM.
- Services and end-users include all distribution methods and channels such as web, FTP, email that are used to distribute services and products to customers. All the function will be implemented and further developed by DHM.

All these four functions will supported by the same shared ICT-infrastructure that is split into three layers: server virtualization, storage system and networking also illustrated in fig 1. The core ICT infrastructure will be installed in the government data center NITC in Singha Durbar, Kathmandu. Networking equipment as required by the design will be installed in DHM's main office and airport office. Outsourcing data centre operations will minimize DHM's burden for data centre management and cleverly leverages the investment already made for both processes and infrastructure at NITC.

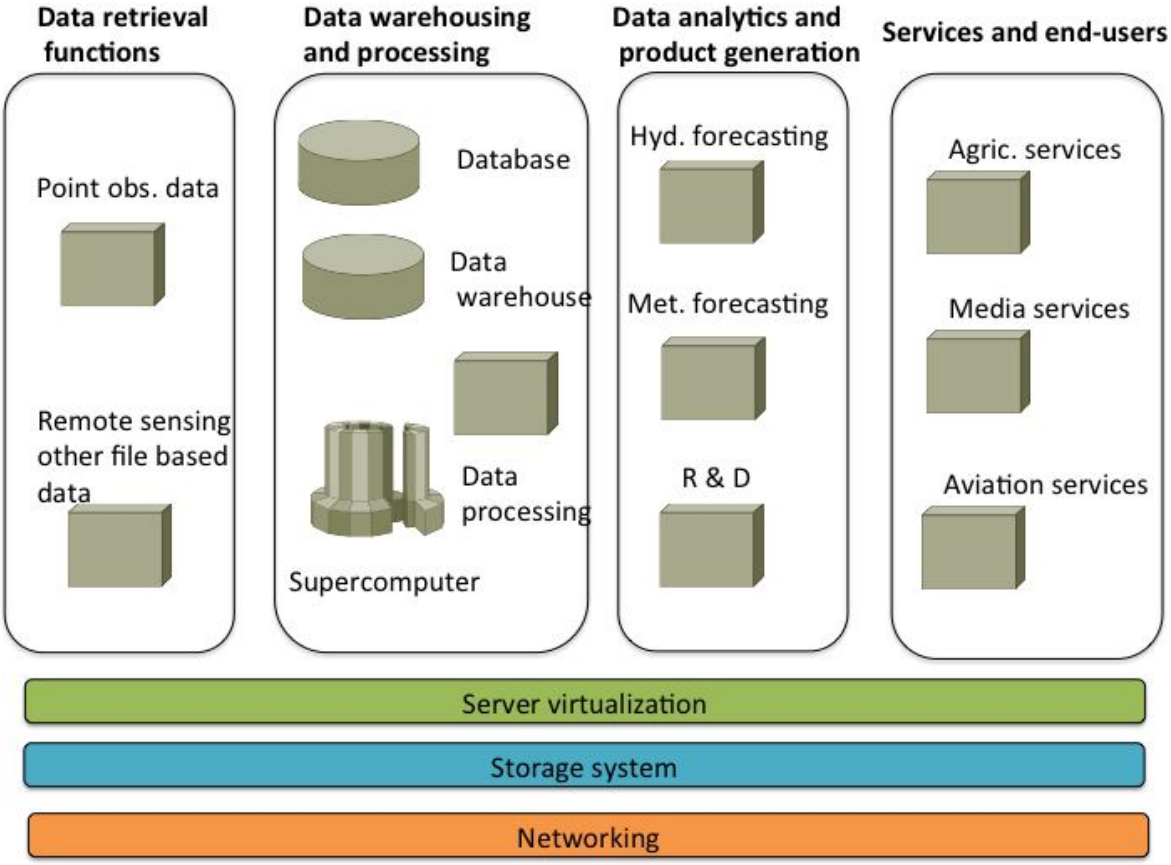


Figure 2. Production system functions and supporting ICT systems

Server virtualization

ICT systems will be based on proven technologies widely used in any modern weather service such as server virtualization, Linux based systems and PostgreSQL database Server virtualization such as VMware, KVM or Hyper-V in high availability-cluster configuration will be used for all processing requirements, web services, data download services, project services etc. Separate physical servers should be installed only when absolutely necessary by the computing requirements of a specific application. Server virtualization will provide not only more efficient use of resources but automatic failover capability and improved reliability.

Storage

The storage system will be a critical component as it will provide services to the server virtualization cluster, guest operating systems such as NFS/CIFS data share, web services and PostgreSQL-cluster. Controllers and other critical components will be duplicated to ensure high availability. Capacity and number of disks have been selected so that the system will meet both capacity and performance requirements in the coming 5-7 yrs. Estimated raw capacity will be 11TB for performance disks and 50TB for capacity disks. High number of spindles is needed not only for capacity but especially to ensure good performance for database and other high activity systems.

Networking

For networking high quality, cost-effective and scalable 1G and 10G Ethernet and other standard technologies will be used. 10G Ethernet has been selected for iSCSI storage-area-network and high speed connectivity for production systems including the HPC cluster. Multi-layer network security will be implemented in the firewalls. All critical systems will be consolidated to government data center NITC in Kathmandu. Data transfers from data centre to forecasting department and DHM headquarters require reliable, high bandwidth network equipment and redundant lines. Starting point will be 10Mbps redundant links that can be upgraded to 100Mbps in the future. For field and basin offices establishing suitable telecommunications can be challenging. Services should be designed so that data transfers between data centre and remote sites are kept to minimum. In any case a good starting point would be local router with redundant 1-2Mbit/s ADSL-links or single link with some other backup mechanism, even 3G could be considered. For sites with more data requirements a leased line with 1-10Mbit/s bandwidth should be considered. Running costs for leased lines are high, performance unknown and thus not recommended for all field and basin offices.

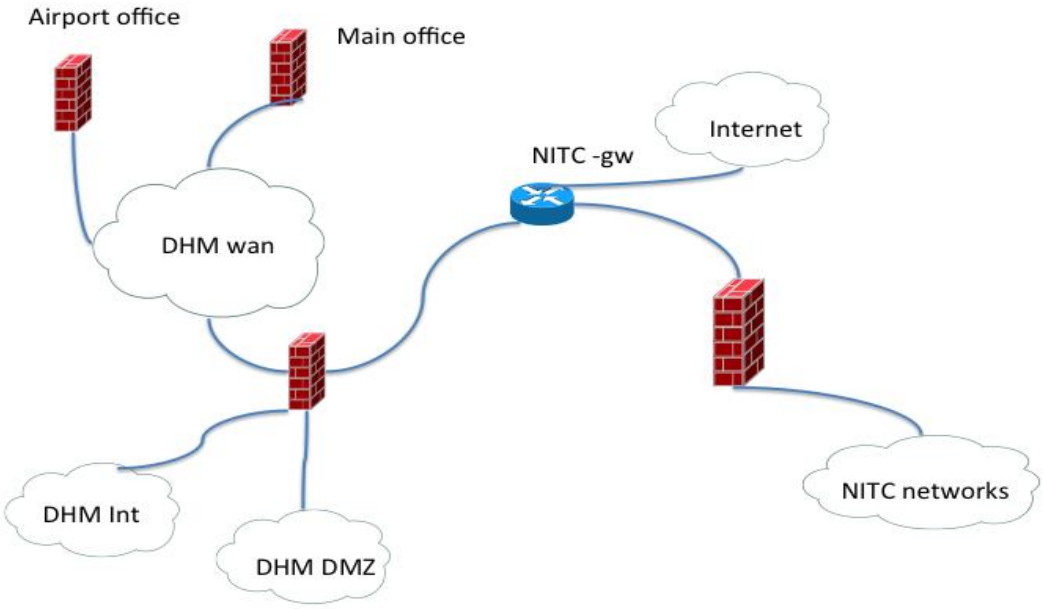
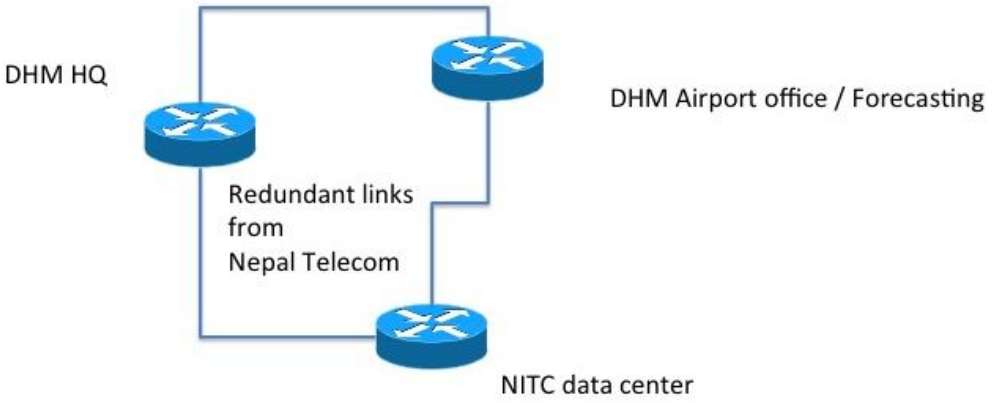


Figure 3 DHM networking

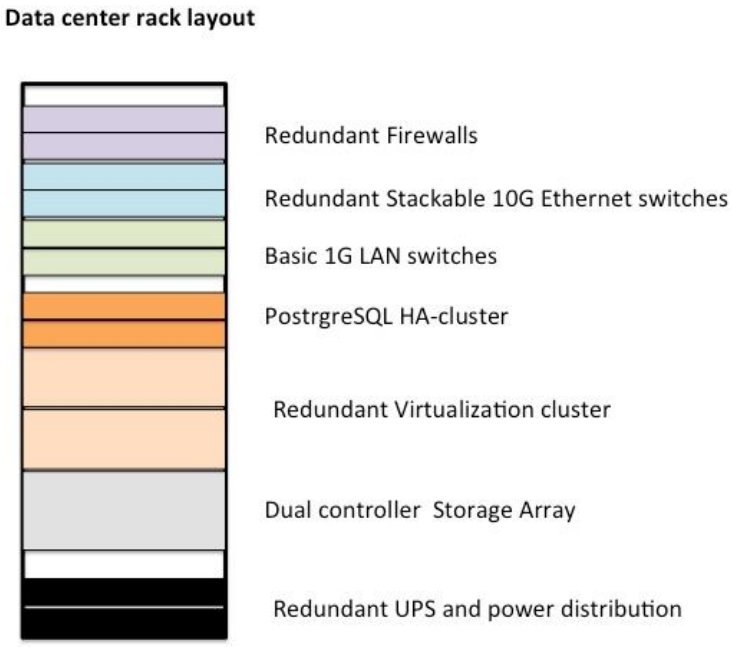


DHM Wide-Area-Network:
- Dedicated, redundant lines to two different PoP (point-of-presence)
- 10Mbps capacity with possibility to increase to 100Mbps
- Redundant firewalls / routers, traffic can be routed both directions to/from NITC

Figure 4 Wide-area-networking

Physical layout

ICT hardware forms a compact system that will install into single rack with appropriate UPS and power distribution systems. The layout has been illustrated in figure 4.



Data flow volumes

Estimated data flow volumes based on FMI's current operational data flows or extrapolated from current DHM data.

Type	Path	Typical data package size	(Minimum) Transmit interval
Sounding data from 1 sounding station	From stations to database, from database to analysis and production systems	Kilobytes	12h
Met and Hydro observations. By the end of BRCH project DHM will have 94 real-time hydrological stations, 56 manual hydrological stations 100 real-time AWSs, 112 manual climatological stations and 306 manual precipitation stations.	From stations to database, from database to analysis workstations and production systems	All data in the range of kilobytes to hundreds of kilobytes	10min -

Type	Path	Typical data package size	(Minimum) Transmit interval
Met observations from GTS covering South Asia	From GTS to database, from database to analysis workstations and production systems	1-2 megabytes	30min -
Radar data from 1 radar installed in BRCH.	From radar to data warehouse and further to analysis workstations and production systems	Raw data 100s kilobytes to few megabytes, radar products 100s kilobytes.	10min -
Satellite data	From internet to data warehouse and further to analysis workstations and production	Satellite products 100s kilobytes to few megabytes	Daily
WRF NWP data Double nested, 9km/2km resolution,72h forecast with 1h output interval	From supercomputer to data warehouse and further to analysis workstations and production	NWP output data approx. 16 gigabytes NWP data to workstations 1-2 GB	6h
GFS data, example data set with various parameters. 120h forecast, 3h time step. 50N,125E; 10S,50E	From internet to data warehouse and further to analysis workstations and production	200MB in 0.5 degree resolution 800MB in 0.25 degree resolution	6h

Cumulative total for 14 day period: approx. 0.9 terabytes. Transmission time for GFS data from with 1Mbps bandwidth is approx. 1h 40min. Transmission time for GFS data from NITC to airport forecasting with 6Mbps (60% of 10Mbps) bandwidth is approx. 17 minutes, 2GB WRF data transmission time 44 minutes respectively.

Data warehousing policy

Mid-term and long-term data policy should keep all observation data and selected remote sensing data online. Current database size is 15GB. Estimated volume for raw data is 0,5GB

per year with additional data from value added fields and lightning detection data. Global lightning detection data is 150GB per year. For weather model data, only max. 14 days of data should be kept after which only weather model data required for verification purposes should be kept online. In any case estimated data volumes are very low compared to the 14 day operational requirement.

Future development

Numerical Weather Prediction model data dominate the data flow volumes. Future development will not change the picture dramatically. Main drivers are possible WRF resolution increase to 1,5km that would increase the data from 16GB to 25GB per run. As a longer term (5-10 years) goal ensemble forecasting implementation would increase the data volume dramatically, for example 10 members WRF ensemble would provide 10 times more data. A multi-model PEPS approach is probably more feasible alternative with more useful data processing characteristics and requirements. Possible extension of radar data network could mean installation of five radars all together which would increase the data flow fivefold. Still the cumulative radar data volume is small compared to NWP data. Any optimizations in radar usage, say limiting measurement interval during dry period decreases data volumes.

Infrastructure renewal and associated investment should be planned well beforehand. ICT equipment lifecycle is estimated as follows:

- Network equipment 7-10 yrs
- Storage systems 5-7 yrs
- Servers 5-7 yrs

In the coming 5-10yrs time improvements in energy supply and data connectivity may allow for transformation towards more cloud based technologies, which provide enhanced flexibility and cost-efficiency in ICT infrastructure management.

2. Components to be procured

The following hardware and software components will be procured:

- 2 x servers for enterprise class virtualization to be installed in NITC
- 1 x server for virtualization management to be installed in NITC
- 2 x servers for Postgres-cluster to be installed in NITC
- 1 x storage system that will be used for all servers to be installed in NITC
- 4 x 1G Ethernet switches that will be used for generic connectivity, 2 installed in NITC, 1 installed in airport office and 1 in main office.
- 2 x 10G Ethernet switches that will be used for connectivity for servers and with iSCSI to the storage system, installed in NITC

- 3 x Firewalls/routers with redundant units that will be used for connectivity between DHM head office, NITC data center and DHM airport office. One device with redundant unit will be installed at each site.
- 1 x 42U standard rack with power distribution units and cable organizers installed in NITC
- 2 x 2.2KVA UPS installed in rack in NITC
- 2 x 1.5 KVA UPS installed in main office and airport office to protect network equipment
- 2 x hypervisors and virtualization management software for enterprise virtualization
- 3 x Linux server operating system for Postgres-servers and management server, CentOS or other free OS version preferred.

All hardware components will include full vendor on-site support for replacement devices and parts and access to new firmware releases on NBD (Next business day) basis. Examples of such support schemes are: HP CarePack, Dell ProSupport. A support scheme based on bidder resources only will not be accepted.

In order to ensure full compatibility, the 10G and 1G Ethernet switches will come from the same vendor.

All proposals will include detailed information or vendor documentation that clearly states that the proposed configuration meets the requirements. Any missing documentation or missing part of the configuration will deem the proposal not valid.

ICT-infrastructure implementation work and systems support will be procured in another tender.

3. Delivery and completion

The hardware will be delivered, installed into rack and hardware tested within 6 months after the contract has been signed. Mandatory hardware tests will include the following:

For Network devices:

- Will be booted up,
- Management interface functionality verified with “shconfig” or similar
- Hardware configuration verified via management cli
- Self test launched with visual check on all led’s

Servers

- Will be booted up
- Management connection set up
- Hardware configuration verified from BIOS

Storage

- Will follow vendor's instructions on installation process and system tests
- Present LUN to single Linux server via iSCSI
- Verify both read and write operations with umount/mount to verify that data is actually written to the file system.

4. Specifications for Communication Equipment for ICT Infrastructure and Management System

4.1 Virtualization servers

Processors	2 sockets, 2 CPUS, minimum 10 cores per CPU, 2,5GHz, Intel E5-2600v3 **or similar**
RAM	256GB DDR4with ECC minimum
Chassis	Rack-mountable, 2U with at least 4 PCIe slots
Power supply	Redundant, hot-swappable, 230AC 50Hz
Local disk	Local Raid1 controller with 2x146GB SAS (or bigger), hot-swappable disks DVD-ROM, internal or external
Network connectivity	4x1GbE iSCSI HBA: 1x Dual port 10GbE with SFP+
Remote management	Full lights-out-management via Ethernet: power cycle, remote console, virtual DVD etc.
Rack mount kit	Rack-mount kit included
Vendor hardware support	Full NBD on-site hardware support for 5 years covering spare parts and access to firmware releases. Suitable spare part set for local maintenance as per vendor best practice.

4.2 Postgres-database servers

Processors	2 sockets, minimum 8core CPU per CPU, 2,4GHz, Intel E5-2600v3 **or similar**
RAM	32GB DDR4 ECC minimum
Chassis	Rack-mountable 2U with at least 4 PCIe slots
Power supply	Redundant, hot-swappable, 230AC, 50Hz
Local disk	Local Raid1 controller with 2x300GB SAS (or bigger), hot-swappable disks
Network connectivity	4x1GbE iSCSI HBA: 1xDual port 10GbE with SFP+
Remote management	Full lights-out-management via Ethernet: power cycle, remote console, virtual DVD etc.
Rack mount kit	Rack-mount kit included
Vendor hardware support	Full NBD on-site hardware support for 5 years covering spare parts and access to firmware releases. Suitable spare part set for local maintenance as per vendor best practice.

4.3 Management server

Processors	2 sockets, minimum 8core CPU per CPU, 2,4GHz, Intel E5-2600v3 **or similar**
RAM	64GB DDR4 RAM with ECC minimum
Chassis	Rack-mountable 1U or 2U
Power supply	Redundant, hot-swappable, 230AC, 50Hz
Local disk	Local Raid1 controller with 2x300GB SAS (or bigger), hot-swappable disks
Network connectivity	4x1GbE iSCSI HBA: 1xDual port 10GbE with SFP+
Remote management	Full lights-out-management via Ethernet: power cycle, remote console, virtual DVD etc.
Rack mount kit	Rack-mount kit included
Vendor hardware support	Full NBD on-site hardware support for 5 years covering spare parts and access to firmware releases. Suitable spare part set for local maintenance as per vendor best practice.

5. Network equipment

5.1 10G Ethernet switches

Management	Remote management via SSHv2 command-line interface (CLI), SNMPv1-3, NTP
Rack-mountable	Rack-mount kit included
Power supplies	Redundant, hot-swappable, 230AC, 50Hz
Connectivity	24 x 10GbE ports, SFP+, stacking with 10Gbps minimum, 12 pcs SFP+ devices included per switch.
Advanced features	Stackable, several switches can be managed as one, multi-switch/chassis link-aggregation (HP IRF, MC-LAG or similar).
L2 features	Standard spanning-tree support: STP, RSTP, MSTP, STP Root Guard Link-aggregation IEEE 802.3ad
L3 features	IPv4: VRRP, static routing, policy routing, OSPFv3, full support for IPv6
Security	ACLs, IP source guard, Port isolation
Vendor hardware support	Full NBD on-site hardware support for 5 years covering spare parts and access to firmware releases. Suitable spare part set for local maintenance as per vendor best practice.

5.2 1G Ethernet switches

Management	Remote management via SSHv2 command-line interface (CLI), SNMPv1-3, NTP
Rack-mountable	Rack-mount kit included
Power supplies	Redundant, hot-swappable, 230AC, 50Hz
Connectivity	24 x 1GbE ports, 2 x 10GbE ports with SFP+, 2 pcs SFP+ devices included per switch.
L2 features	Standard spanning-tree support: STP, RSTP, MSTP, STP Root Guard Link-aggregation IEEE 802.3ad
Security	ACLs, IP source guard, Port isolation
Vendor hardware support	Full NBD on-site hardware support for 5 years covering spare parts and access to firmware releases. Suitable spare part set for local maintenance as per vendor best practice.

Both the 10G and the 1G Ethernet switches will come from same vendor.

5.3 Firewalls

Management	Advanced GUI, Command line interface (CLI) via SSH2 for L3 features, configuration rollback
Connectivity	Minimum 4x1GbE SFP +interfaces, 4 SFP+ devices included per firewall. Minimum 12x1GbE
L3 features	IPv4 and IPv6: VRRP, static routing, OSPFv3, DNAT, SNAT, site-to-site VPN tunnelling
Security	Stateful firewall with clustering to HA unit.
Advanced security	Cloud based anti-virus, application security, anti-spam, web filtering
High availability	Redundant unit with automatic failover and failback, active-passive and active-active configuration support, session mirroring between devices
Stateful firewall inspection throughput	Minimum 1.8Gbps
IPS throughput	Minimum 230Mbps
VPN throughput	Minimum300Mbps
Concurrent sessions	Minimum 200k
Licenses	Full 5 year licensing for all above mentioned features.
Vendor hardware support	Full NBD on-site hardware support for 5 years covering spare parts and access to firmware releases. Suitable spare part set for local maintenance as per vendor best practice..

5.4 Storage system

3.7.1 The mandatory requirements for the storage system

Controllers	Two controllers in redundant mode, mirrored cache between controllers, cache persistency provided by battery or other technology. Minimum 16GB cache. Failure of single controller will have no affect on system or client operations. Connectivity: at least 2x10GbE for iSCSI, support for link-aggregation and multi-chassis link-aggregation. All SFP+ devices included that are needed for redundant data path connectivity.
Features	Raid levels: RAID1, RAID5, RAID6 Thin provisioning
Virtualization	Support for virtualization technologies such as Vmware, Hyper-V, RHEV, Xen
Operating system support	RedHat Linux, SuSE Linux, Ubuntu Linux, MS Windows Server
Multipath	Support for native Linux dm-multipath
Power supply	Redundant, hot-swappable power supplies 230V 50Hz
Data path redundancy	Redundant data paths from storage shelves to controllers, from controller to controller and to possible IO units.
Management	System management GUI
Disk capacity	24x600GB 15k SAS, 24x3TB NL 7,2kSAS, should include hot-spare configuration as per vendor best-practice
Licenses	Full 5 year licensing for all above mentioned features.
Vendor hardware support	Full NBD on-site hardware support for 5 years covering spare parts and access to firmware releases. Suitable spare part set for local maintenance as per vendor best practice.

5.5 Rack, power distribution units, uninterruptible power supplies, cabling and SFPs

Standard data center rack	Enterprise quality 42U rack, external width 600mm, 19" wide enclosure, cable organizers
4 x Power distribution units (PDUs)for rack	Enterprise quality PDUs, vertically mountable within 42U rack, input 230V 16A 50Hz, output 230V 16A 50Hz, single phase, 1 x input IEC-320 C20 -type connector, 10 x outputIEC-320 C13-type connector, max 10A per outlet,
2 x 3KVA Uninterruptible power supply (UPS)	Enterprise quality UPSs, rack mountable, 2U size, management via USB, input 230V 50Hz, output 230V 50Hz sine wave, 1x IEC-320-C20 input connector, 6 x output IEC-320-C13 connectors, >90% AC-AC efficiency in online mode, maintenance free battery with intelligent battery management, automatic and manual bypass capability, surge protection, overload capability, input circuit breaker, minimum 4 minutes battery capacity at full load
2 x 1KVA Uninterruptible power supply (UPS)	Enterprise quality UPSs, tower model, management via USB, input 230V 50Hz, output 230V 50Hz sine wave, 1x IEC-320-C20 input connector, 6 x output IEC-320-C13 connectors, >90% AC-AC efficiency in online mode, maintenance free battery with intelligent battery management, automatic and manual bypass capability, surge protection, overload capability, input circuit breaker, minimum 4 minutes battery capacity at full load
Stack cable pair for 10G switches	Redundant cabling with SFP+
20 x Cat6 RJ-45 cables for connecting servers, storage and network equipment management interfaces	Suitable length for single rack installation
10 x multimode optic cables with SFP+ for iSCSI connectivity	Suitable length for single rack installation,
All power cords	Suitable length for single rack installation, compatible with PDUs.

5.6 Virtualization software; hypervisors

Enterprise grade virtualization	Vsphere, RHEV, Hyper-V or similar
Management suite	Advanced management suite: vCenter, SC operations manager or similar
High availability	Two or more hypervisors can be configured in a HA- cluster
Live migration	Guest operating systems can be migrated from one hypervisor to another transparently
Live VM snapshots	Guest operating system snapshots that can be used for example to rollback from operating system update.
Physical resource pooling : "Resource Pool" or similar	Resource pools are used to manage physical hardware resources
VM template	Creating templates of virtual machines that share same configuration, network settings, applications
VM clone	Cloning virtual machine from template so that the settings are inherited from the original
Virtual network / bridging	Support for virtual network interfaces, bridging, virtual LANs
Linux guests supported licensed	Full support for Linux operating system as guest.
Windows guests supported and licensed	Full support for Windows server operating system as guest.
Software subscription for 5 years	Full basic subscription for all features above will be included.