India Hydrology Project Phase II
Technical Assistance (Implementation Support) & Management Consultancy

Hydrological Instrumentation: Preliminary Review of GSM/GPRS-based Telemetry Systems for Real-time Data Acquisition

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3		HAHC			Final

Contents

Glossary

AMC	Annual maintenance contract
CDMA	Code Division Multiple Access
CGWB	Central Groundwater Board
CWC	Central Water Commission
GPS	Geographical Positioning System
DAS	Data Acquisition System
DSS-P	Decision Support System – Planning project
DSS-RT	Decision Support System – Real Time project
DWLR	Digital water level recorder (e.g. pressure transducer and logger)
EDGE	Enhanced Data rates for GSM Evolution
GPRS	General Packet Radio System
GSM	Global System for Mobile communications
HSPDA	High Speed Downlink Packet Access
IMD	India Meteorological Department
INSAT	Indian National Satellite System
LOE	Low Earth Orbit
M2M	Machine to Machine
PDS	Purpose Driven Studies
PSTN	Public Switched Telephone Network
SCADA	Supervisory Control and Data Acquisition
SMS	Short Message Service
TAMC	Technical Assistance (Implementation Support) and Management Consultancy project
TCP/IP	Transmission Control Protocol/Internet Protocol

1. Background

In HP-II, several State Implementing Agencies wish to make their hydrometeorological data more quickly available and accessible to users by transmitting them in near real-time from the measurement sites to the data centres, and uploading them to the State websites.

Telemetry-enabled loggers offer an affordable and easy to operate solution without the need for expensive telemetry IT infrastructure. The telemetry loggers at outstations transmit data by a variety of possible modem options:

- Public Switched Telephone Network (PSTN) i.e. land lines
- Global System for Mobile communications (GSM)
- General Packet Radio System (GPRS)
- Satellite LOE (Low Earth Orbit) Iridium network

After the field stations have sent their data via GSM/GPRS to the data server, the data will be transferred to other applications or databases for further processing. Figure 1.1 shows a possible configuration of a network provided by Isodaq (www.isodaq.co.uk) using GPRS telemetry loggers, and their bespoke web software (timeview) and database (Hydrolog4). Figure 1.2 shows a similar network configuration provided by Ott (www.ott.com/india) using their (HYDRAS3) software and database. The web software enables only the Implementing Agency to view and edit the data; to disseminate the data more widely they have to be loaded to the Agency's own website.

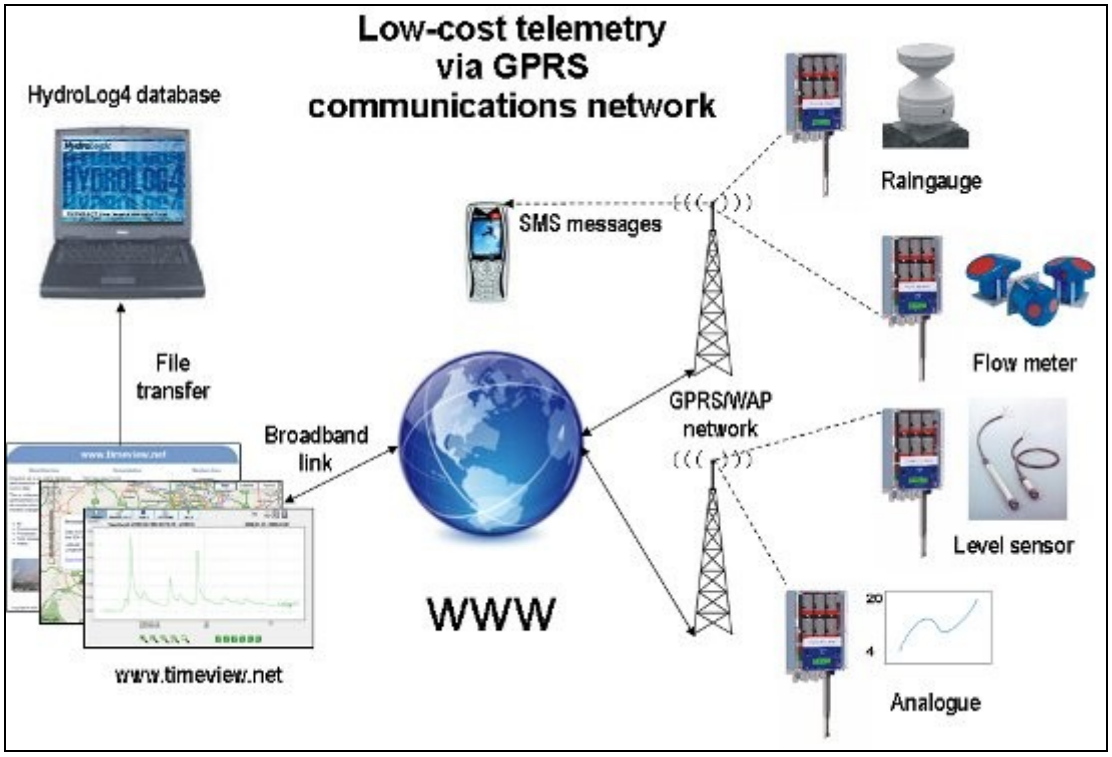

Figure 1.1: Example configuration of a GPRS-based data acquisition system (source: www.isodaq.co.uk)

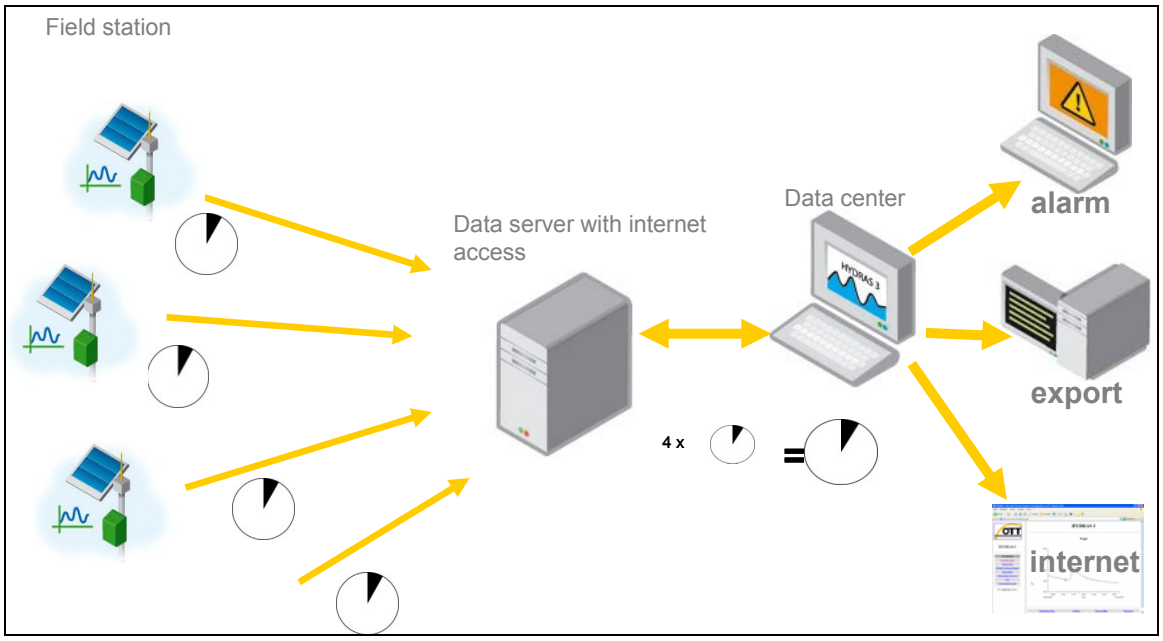

Figure 1.2: Example configuration of a GPRS-based data acquisition system (source: www.ott.com/india)

2. GSM/GPRS-based telemetry systems

GPRS utilises the same communications transmission network as GSM, but was designed for transmitting "data" rather than "voice" calls. It is widely used for applications such as mobile internet browsing and M2M (machine to machine) data communications. There are several benefits of GPRS connectivity over GSM:

- Lower service charges than GSM based on monthly data volumes
- Collecting data from outstations normally falls within the typical minimum 1Mb per month tariff
- International-standard communications protocol enables GPRS telemetry logger units to be installed almost anywhere in the world
- No SCADA (Supervisory Control and Data Acquisition) system or telemetry server or modems required to capture data
- Data collection via internet using industry standard TCP/IP protocols and appropriate software to access, visualise and store the data.

If transmission through GPRS mode fails for some reason, the system should automatically switch over to the GSM mode.

Depending on the system and software installed there may be options for routine daily interval or more frequent event-activated data collection, independent of logging/measurement interval, for email alarm message forwarding with SMS (Short Message Service) message functions, and for remote logger set-up and sensor configuration. SMS messaging may also be feasible for groundwater data where there are only one or two readings per day, but for more frequently monitored river levels, SMS would not be appropriate.

Table 2.1: Mobile network operators in India using GSM/GPRS technology (source: www.gsmworld.com)

Operator	GSM 900 KHz	GSM 1800 KHz	GPRS	Website
Aircel*	Y	Y	N	www.aircel.com
Airtel	Y	Y	N	www.airtel.in
BSNL	Y	N	Y	www.bsnl.co.in
Datacom	N	Y	?	www.datacomsolutions.in
IDEA Cellular*	Y	Y	Y	www.ideacellular.com
Loop Mobile*	Y	Y	Y	www.loopmobile.in
MTNL*	Y	N	N	www.bol.net.in
Spice Telecom*	Y	N	N	www.ideacellular.com
Tata Teleservices	?	Y	?	www.tataindicom.com
Vodafone Essar*	Y	Y	N	www.vodafone.in

GPRS networks in populated areas provide very good coverage, but the approach may not be so feasible in remote areas where mobile phone coverage is poor. In these circumstances, satellites may still need to be relied upon.

Table 2.1 lists the mobile network operators in India using GSM/GPRS technology. Networks using other technologies (e.g. CDMA, EDGE, HSPDA) are omitted including Reliance and MTS, though these plan to start using GSM/GPRS technology in the future. Note that only three of the ten networks listed appear to use GPRS technology i.e. BSNL, Idea Cellular and Loop Mobile. However, technological advances are such that the situation is continually changing.

The operators indicated with a * in Table 2.1 were contacted by email to ask for a ballpark figure for a typical monthly tariff for transferring up to 1MB data. Only Idea Cellular acknowledged the query; none provided the requested information. However, one of the equipment suppliers estimated this to be 300-400 Rs per month.

3. Existing real-time data acquisition systems

CWC operate several flood warning sites in real-time, with gauge level data transmitted from the outstations via ground stations in Jaipur (Rajasthan) and Bhubaneshwar (Orissa) using INSAT. Staff at some river gauging sites also used wireless to transmit current level information to regional CWC offices during floods. A feasibility study using GPRS networks is being considered, but has not yet been initiated.

IMD operate 125 automatic weather stations in real-time, with data transmitted from the solar-powered outstations to the data centre via INSAT. The service is free of charge as IMD are a Central Government Agency; the same applies to CWC above, but the payment situation regarding the State Implementing Agencies is unclear (TAMC suspect that there would be a charge for use of INSAT). IMD have been investigating the use of GPRS networks, since the technology is already used in many States for the agencies to send SMS warning messages. For the 2010 Commonwealth Games in

Delhi, IMD are procuring 60 GSM/GPRS-based automatic weather stations, a detailed specification for which is available (IMD, 2009). The capability (at 10-minute time interval) of the system will be demonstrated for 2 years, after which it will become IMD's responsibility, should they wish to continue using it.

CGWB have a similar pilot study (running or about to start) operating 25 piezometer sites in Delhi in real-time, with data transmitted by GPRS and disseminated by website. More information about this study was not available at the time of writing. It is believed that the Groundwater Department in Andhra Pradesh already has some real-time groundwater monitoring capability, though the data are for internal use and not disseminated on-line.

A project to investigate and demonstrate the feasibility of using a GPRS network for real-time data acquisition by one or more of the HP-I states would make a useful PDS. Karnataka have expressed an interest, and CWC feel that Orissa would be a good test case, though neither of these States have been approached directly regarding a PDS. In fact, Karnataka Neeravari Nigam Limited have recently successfully concluded a pilot project monitoring part of the GLB canal system using Technolog's CELLO GSM/GPRS-enabled loggers, and plan to extend it to the whole canal network (pers. comm.). This may have stimulated the State's interest in this technology.

The concurrent DSS-RT and DSS-P also have some requirements for real-time data acquisition and it is important to maintain close links with these projects to ensure synergies and avoid unnecessary duplication.

4. Issues

There are several issues that need to be considered when adopting a GSM/GPRS-based telemetry system for data acquisitions and a semi-automatic web-based dissemination system, not least the implications for data validation. It is possible for most systems to have some form of automatic preliminary data validation which identifies major transmission errors and anomalous data, and it would be possible to make these "raw" data available to some users at this stage, albeit with a qualification. Preliminary data validation will alert the Agency to any problems with instruments, enabling them to better distribute resources and prioritise site visits for routine maintenance teams. However, it is imperative that further validation is carried out, and quality controlled dataset made available, as soon as possible.

To display river flow or reservoir volume data automatically, the water level data would have to be converted using a rating equation or rating table (stage-discharge of stage-volume relationship). Therefore, it is important that Implementing Agencies develop these ratings and, for rivers, periodically check them through regular discharge measurements using current meters, ADCPs or other methods. There seems to be a reluctance by some of the States to do this.

CWC note that constraints over data accessibility may prevent data being disseminated directly via the web, though perhaps gauge level data (but not final discharge data) might be possible in the future. Issues such as this are beyond the scope of the current report but clearly need to be clarified and resolved.

Another key issue is the design and content of any public website disseminating data. In is important to be aware who the main and/or intended audience is and what they would like to see on the website i.e. the data coverage, periodicity and timeliness, the data integrity, the data quality, and the suitability of the data for the audience. Different levels of data may be accessible to different levels of user via user names and passwords, with the highest level users being able to download data. There are readily available tools for registering the number of visitors to the website and the pages most visited, and these statistics should be collected. TAMC recommend that existing websites showing near real-time data are reviewed to help specify the design and content e.g. the USGS WaterWatch website at http://waterwatch.usgs.gov/ which shows maps, graphs and data at about 3000 sites in the US and Puerto Rico (Hirsh & Costa, 2004).

Since several, if not all, Implementing Agencies may wish to disseminate their data via the internet, it would seem sensible for them to minimise the specification and design work by adopting common webpages reproduced on each State's website, or even a common website, rather than developing them in isolation. This would improve the audience's access to the information and services, strengthen the quality of the content, and provide cost and efficiency savings to the Agencies. The Agencies must also make a commitment to maintain and update their websites as often as required, and fund the technical and staff resources needed to do this.

5. Specifications, conditions and requirements

IMD appear to be the most advanced of the Central Implementing Agencies in terms of their investigations of the feasibility of using GSM/GPRS-based telemetry systems for real-time data acquisition and their procurement for such systems for the 2010 Commonwealth Games. TAMC would encourage close links with IMD during this procurement and implementation exercise, and recommend that this and any other IMD and CGWB feasibility studies are successfully concluded, as are any new PDS feasibility studies in one or more States, before any large-scale implementation of such an approach is initiated. This will enable any problems to have been identified and solutions to have been found.

Should any of the States feel that this functionality would be useful in the future at any of their monitoring sites, they may wish to ensure that any data loggers they procure under HP-II are GSM/GPRS-enabled. However, given that the limited life-time of data loggers i.e. 5-10 years, by which time the above mentioned feasibility studies will be concluded, this is probably an issue that, in many cases, can be postponed until any loggers are replaced. Hence, GSM/GPRS supporting capability should remain optional in the data logger specification, depending on the particular schedule of requirements.

The IMD 2010 Commonwealth Games procurement document (IMD, 2009) will be useful to refer to for any other GSM/GPRS-based telemetry system specification. The IMD automatic weather stations are collecting many more parameters than any of the State Implementing agencies will require, so many of the specifications concerning the layout of the site and the measurement sensors are not relevant. However, the

specifications relating to the GSM/GPRS network and data server are of interest, though the detail (communications requirements, modems, antenna, GPS, optional display unit, server specification) will depend on the system and equipment installed.

The remainder of this section includes some general conditions and requirements. Any GSM/GPRS-based telemetry system for real-time data acquisition should be supplied, ideally, as a complete system or turn-key solution which:

- Includes all the hardware, software, installations, manuals, guidelines and training
- Has a projected lifetime of 5 years (or 10 years if feasible)
- Makes clear the reliability of the system and the availability of individual components spares
- Makes clear all costs required to fully implement the telemetry system, including monthly tariffs from the identified GSM/GPRS service provider
- States all costs for any licence fees and annual maintenance contracts

At each of the identified field stations, a Data Acquisition System (DAS) collects the hydrological data (rainfall, water level). The DAS comprises a data acquisition component (the measurement sensor) and a data storage and communication component (the GSM/GPRS-enabled data logger or data logger and GSM/GPRS modem). The collected data are transmitted by GSM/GPRS to a data server (which must also be GSM/GPRS-enabled or have a GSM/GPRS modem, though this can service more than one outstation) at the system supplier or at the State Agency. All stations together comprise an integrated data acquisition and telemetry network.

Two types of data transfer should be supported: latest data (i.e. since last retrieval) from the logger at a scheduled time or times each day, and "on-demand" data requested by the data server (i.e. the user) for a specific date and time. The first is a standard data transmission for normal use, and can be programmed to be, say, hourly or 6-hourly during the monsoon, otherwise daily at the lowest tariff times. The second allows for retrieval for specific event data or missing data (e.g. due to a communications failure). The telemetry message should contain:

- The station/data logger identification code
- The retrieved sensor data i.e. rainfall, water level, etc
- The date and time stamps associated with the date and time of acquisition of the retrieved sensor data

Ideally, the telemetry messages from the outstations should also contain housekeeping information, such as the clock reading at the time of transmission and the status of battery charging if relevant. However, it should also be possible to retrieve the latter by a separate command and at a longer interval than retrieval of hydrometeorological data.

It should also be possible to retrieve data from the logger manually using a palmtop or laptop computer. It should be possible to set-up and control the logger by at least one method: directly using a keypad and screen on the logger, directly through a palmtop or laptop computer attached to the logger, and/or indirectly via the telemetry system. All cables, interfaces, software and other accessories required for effective operation should be included.

The arrival of the retrieved data at the data server may be affected by communications delays or failures and error recovery protocols. At the data server there should be some form of automatic preliminary data validation which identifies major transmission errors and anomalous data. The system should be reliable during bad weather events (e.g. intense rainfall, heavy wind load, flood flows, concentrated lightning), when the acquisition and delivery of rainfall and water level data may be particularly important. During the monsoon, the availability and performance of the complete system, including data delivery within a specified maximum duration, should be 99% (if proved feasible).

All outstation equipment may make use of the same power supply which might be provided by a solar panel, or by non-rechargeable batteries (or not rechargeable in the field). It is unlikely that mains power will be available, particularly in remote locations, and even then back-up batteries would be required. If power is by solar panel, a charge controller must protect the rechargeable batteries against damage due to overcharging and full depletion. The fully charged batteries should maintain the fully functional system for at least 7 days, and the recharge time should be less than 2 days, while the system is in full operation during the monsoon.

If the power supply is by other batteries, these will require periodic replacement, in which case they should be standard size batteries readily available in India and easily replaceable in the field by trained staff from the Implementing Agency. Technolog's (www.technolog.com) CELLO range of GSM/GPRS data loggers, which have an internal GSM modem, use non-rechargeable batteries which have a typical life in excess of five years based on sampling two level sensors at 30-minute logging intervals, with daily data transmission by SMS.

All outstation telemetry equipment should be protected against ingress of dust, moisture and/or insects and similar in compliance with IP65; measurement sensors will have their own specifications. Where some form of enclosure or housing is required to shelter the electronic components, this should be is should be included and any space and ventilation requirements specified. All equipment should fully meet the operational and accuracy specifications over the temperature range of -20 to 60ºC and humidity range of 0 to 100%, though the temperature values may be location-dependent.

Proper measures to protect the outstations against vandalism and theft are required. This could be provided by a fence, though at some sites a guard may be needed.

6. Equipment suppliers and indicative costings

In order to explore the products available to implement a GSM/GPRS-based telemetry system a number of suppliers were approached for information and rough costings (see Appendix). This is certainly neither a definitive nor a recommended list of suppliers, but those TAMC already have contacts with. The costings provided, excluding any measurement sensors, are shown in Table 6.1.

Table 6.1: Indicative costing for GSM/GPRS-based telemetry system

Item	Technolog	In-Situ	Ott
Power supply (solar panel)	3000 USD	Complete In-Situ TROLL Link system: 2500 USD Also sell indigenous system with some In-Situ TROLL Link components: 0.5-0.6 Lakh Rs	300 Euro
4-channel GPRS-enabled data logger			1000-2000 Euro
Equipment housing			500 Euro
GPRS modem	850 USD		400-1000 Euro
Software (database/web)	1000 USD		500 Euro
Total	**4850 USD**	**2500 USD**	**3300-4000 Euro**
Total	**2.4 Lakh Rs**	**1.3 Lakh Rs**	**2.3-2.8 Lakh Rs**

Isodaq Technology www.isodaq.co.uk
Isodaq are a division of Hydro-Logic Ltd (www.hydro-logic.co.uk), UK. They specialise in the development and supply of monitoring systems for the water and environmental protection industries, and supply most UK environmental regulators, water supply and drainage bodies plus an expanding client-base around the world. They promote low-cost data acquisition systems and advanced data management tools to help clients transform data collected from remote monitoring networks into vital management information. Products include measurement sensors, the FROG and HAWK GSM/GPRS data loggers, and server and web software.

Technolog www.technolog.com
Technolog, UK specialises in the design and manufacture of battery-powered data logging, meter reading and pressure control products for the water, gas and electricity utilities. Technolog is one of the largest industrial users of GSM/GPRS technology in the UK with over 300,000 monitoring devices installed through a broad customer base which includes many of the utility supply companies seeking to facilitate efficient management of their networks. Products include measurement sensors, the CELLO4 and CELLO-DTX ranges of GSM/GPRS data loggers (which come recommended by the Department of Water Affairs and Forestry in South Africa), and web software.
Indian agent: EMS Technologies, Kuala Lumpur, Malaysia www.ems-tech.com.my

In-Situ Inc www.in-situ.com
In-Situ, USA specialises in in-situ (on-site) monitoring instruments with an emphasis on rugged, reliable and accurate instruments for field measurements, whether spot sampling or long-term, unattended deployments in remote locations. In-Situ provided what proved to be the most reliable DWLRs in HP-I, and claim to have made various improvements to their instruments as a direct result of their experiences in HP-I.. Products include measurement sensors, GSM/GPRS data loggers and other telemetry systems, and software. As well as providing a complete In-Situ telemetry system, they have also developed an indigenous system that uses some In-Situ components.
Indian agent: Swan Environmental Pvt Ltd, Hyderabad, India www.swanenviron.com

Ott MessTechnik www.ott-hydrometry.de
Ott, Germany is Europe's largest manufacturer of complete hydrometric systems, working in more than 90 countries worldwide to supply efficient solutions in the

fields of hydrometry, meteorology and environmental technology. Whilst the Ott Universal Current Meter is continues to be widely used in many countries to gauge flow in rivers, recent advances have been in the field of electronic water level monitoring, data collection and transmission. Products include measurement sensors, GSM/GPRS data loggers and web software.
Indian agent: Ott Hydromet, New Delhi, India www.ott.com/india

There may be discounts for multiple purchases. There would be additional costs for initial training and for AMCs, as well as the small monthly tariff. If the power supply is by battery, rather than solar panel, these will require periodic replacement, in which case they should be standard size batteries readily available in India and easily replaceable in the field by trained staff from the Implementing Agency. It is also probable that there will be some import duties or tax liabilities, which may differ from State to State.

A procurement issue the Indian agent for Ott mentioned is that any items of equipment procured through them directly would be payable in foreign currency. However, any items procured through their own distributors in the States would be payable in local currency. The States may wish to take this into consideration.

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Indian Meteorological Department (IMD). 2009. *Request for proposal (RFP) document for procurement of 60 GSM/GPRS based automatic weather stations (AWS) for Commonwealth Games 2010.* IMD, Pune, 30pp.

Telecom Regulatory Authority of India (TRAI). 2009. *Press Release No 11/2009*. 5pp.

Appendix: Contact details

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