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SELECTION OF APPROPRIATE SYSTEMS FOR TELETRANSMISSION OF HYDROLOGICAL DATA IN DEVELOPING COUNTRIES (*)

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INTRODUCTION

01. Within the framework of projects executed by WMO in developing countries in the field of operational hydrology, the question of whether satellite teletransmission of hydrological data should be used, has been considered since satellites became available for this purpose. However, although the prospects for satellite teletransmission appear very good from the technical point of view, because of its successful application in industrial countries, no major system for the collection of hydrological data has as yet been implemented in developing countries. The following review of a few relevant projects involving the establishment of telemetering systems should cast some light on the reasons for this, to date, unfavourable outcome for the use of satellites for data radio-transmission.

IMPROVEMENT OF FLOOD FORECASTING IN THE INDUS RIVER BASIN IN PAKISTAN

02. Large areas of Pakistan are prone to flooding because of particular natural and historical, social, and technical conditions. The flooding problems in Pakistan are extremely complex, and there is significant danger of major disasters due to flooding. Flood forecasting is successfully practiced in Pakistan and contributes towards a reduction in damage to property and particularly in loss of life due to flooding, but there is room for improvement of the flood-forecasting techniques in use.

03. Within the framework of a project for the improvement of the flood-forecasting and warning system in the Indus River Basin, a study was prepared by WMO in 1976, in order to examine the prevailing conditions of the flood-forecasting network in Pakistan, and to make recommendations for its improvement and modernization. Some of the basic difficulties and deficiencies found in the forecasting system are :

- Lack of meteorological and hydrological data from upper catchments of the Indus tributaries ;
- Heavy reliance on man-operated meteorological and hydrological stations ;
- Fragmentation of responsibility for data collection and transmission among several organizations.

04. It was therefore recommended that a system of automatic data transmission using data collection platforms (DCPs) should be implemented as soon as possible. The network was to comprise 24 stations in Pakistan. Most of these stations were already in operation, and the existing observers could have been used to guard the automatic equipment against vandalism. The automatic data-collection platforms would have transmitted data either via satellite, meteor-burst or conventional VHF relays. Among the significant advantages of the use of satellites for hydrological and meteorological data collection, the following were noted :

- Reliability ;
- High frequency of observations and of data transmission ;
- High efficiency in data reception and processing as the data are handled by computers ;
- Relatively low cost of installation, operation and maintenance ;
- Low power requirements.

05. It was, however, emphasized that, given the local conditions, and in order to be of any real use to the streamflow forecasting unit (SFU), the data collected by the data collection system (DCS) have to be conveyed directly to the SFU and not relayed through a central data-acquisition station in a distant foreign country.
The recommendations of this study gave a clear preference to a satellite DCS, preferably using a geostationary satellite, alternatively using the TIROS N polar-orbiting satellite.

06. In early 1979, a decision was taken to implement a conventional VHF automatic data-collection system. The reason given for not pursuing the installation of a satellite DCS, as had been recommended, was that the Government did not wish its flood-forecasting and warning system to rely on a satellite which was out of national control but would prefer to rely on its own resources. It is interesting to note some of the relevant questions which were raised during preliminary discussions :

- For how long would the satellite DCS be operated ? (The Government would apparently have expected a firm, long-term commitment by the satellite operator).
- What if the satellite failed ? Would there be a standby satellite ?
- What would be the charge for using the satellite ? Would there be a guarantee that charges would not be substantially increased in the future, once the flood-forecasting system had been designed to rely on a satellite DCS ? (The need for payment would probably have ruled out the use of the satelitte).

HYDROLOGY AND CLIMATOLOGY OF THE BRAZILIAN AMAZON RIVER BASIN

07. This project aims at obtaining a satisfactory level of hydrological and climatological knowledge of the Amazon River basin in Brazil, to provide a basis for rational development planning. Given the enormous size and extremely difficult environmental conditions prevailing in the area, the objectives of setting up a hydrological information system within the given constraints will require fundamental changes in the current system of network operation. The existing hydrometric network is insufficient by any standard. As the cost of operating a hydrological station in the Amazon River basin is excessively high ($ 25,000 - $ 40,000/station/year), it is not possible to expand the network significantly with the existing limited budget. Taking into consideration all aspects involved, it was recommended that the number of hydrometric stations should be increased by about 250 during the lifetime of the project.

08. A first set of 50 stations is being installed at present. Stations located on sites which are difficult of access or which are to be used for flood forecasting should be provided with data-collection platforms (DCPs) to make possible continuous observations and a rapid alert in case of non-operation. It was also found that the hydrometeorological network should be increased, emphasis being placed on the installation of recording raingauges with DCPs requiring infrequent attention.

09. On the basis of these recommendations, several data-telemetry systems were evaluated for possible use in the Amazon basin during a follow-up study. These were : meteorburst, GOES satellite, both interrogated and self-timed, and Tiros N/Argos-system. Conven-

tional radio telemetry was not considered because of several factors such as the large number of repeaters required, the lack of existing microwave repeaters and the large installation expense. The Landsat data-collection system was also not considered for the Amazon project because it is an experimental programme which could be terminated at any time. A further possibility, involving the use of Intelsat and the Canadian domestic communications satellite Anik, was not considered because of certain technical risks, potentially high costs, and possible operational problems. The transmission alternatives were evaluated under the assumption that data relayed by satellite must be received directly in Brazil, as it was considered unacceptable for hydrometeorological data from an operational Brazilian system to pass through the USA or France. The factors considered in selecting a hydrometeorological telemetry system for Amazonia were grouped in three main categories : technical suitability, cost, and management.

10. Under *technical suitability,* the following factors were evaluated :

(a) Timeliness, i.e. whether the system can provide data as often as required, and whether these data can be made available to all users ;

(b) Accuracy, i.e. whether the transmitted data are accurate, and whether there is a possibility to verify accuracy ;

(c) Reliability, i.e. what are the possibilities and consequences of failure in DCPs, satellites or ground stations ;

(d) Expandability, i.e. how easy is it to add additional remote stations to the network ;

(e) Technical risk, i.e. whether the system has proved itself under actual operating conditions, and whether there are possibilities of failure under exceptional circumstances ;

(f) Data distribution, i.e. how complex is the data reception and distribution centre, and whether the data links have been proven.

11. Under *cost,* the following factors were considered :

(a) Capital and operating costs for DCPs ;

(b) Capital and maintenance costs for ground stations ;

(c) Possibility for cost sharing, i.e. whether there are existing facilities which could be upgraded to handle hydrometeorological data telemetry ;

(d) Lifetime, i.e. how long would the equipment last before it becomes necessary to replace it.

12. Under *management,* factors related to planning, installation and operation of the system were considered :

(a) Implementation, i.e. administrative complexities which must be overcome in order to proceed with the system, such as the signing of user agreements, or obtaining operation licenses ;

(b) Scheduling, i.e. the time it would take to put the system into service, once administrative matters were settled ;

(c) Personnel, i.e. type of personnel required to operate the system.

13. The four possible methods for hydrometeorological teletransmission were compared by assigning points on the basis of a geometric progression. This tends to exaggerate

strengths and diminish weaknesses, which is fair because all systems could be used.
Also, in totalling the figures, technical suitability and cost were assumed to have equal weight, while management was assigned a weight of one-half. The meteor-burst system was arbitrarily assigned a uniform value and all others rated against that value. The results are shown in Table 1.
It can be seen that the GOES self-timed emerges as the most suitable system. As an alternative, the project is turning to a close examination of the only viable non-satellite alternative, i.e. the meteor-burst data-collection system.

Table 1. Comparison of telemetry systems for the brazilian Amazon River basin project

	Meteor burst	GOES Interrogate	GOES Self-Timed	Tiros - N Argos
I - TECHNICAL SUITABILITY (1)				
Timeliness	4	4	2	1
Accuracy	4	4	4	4
Reliability	4	4	8	4
Expandability	4	4	4	4
Technical risk	4	8	8	2
Data distribution	4	8	8	4
Total	24	32	34	19
II - COST (1)				
Capital/operating (DCPs)	4	2	8	8
Capital/operating (ground stations)	4	8	8	2
Cost sharing	4	8	8	8
Lifetime	4	4	8	8
Total	16	22	32	26
III - MANAGEMENT (0.5)				
Implementation	4	2	2	2
Scheduling	4	4	4	2
Personnel	4	4	4	4
Total	12	10	10	8
(0.5) (total)	6	5	5	4
IV - GRAND TOTAL POINTS	46	59	71	49

RIVER NIGER HYDROLOGICAL INFORMATION AND FORECASTING SYSTEM

14. The execution of this project will require a comprehensive real-time reporting network over the entire River Niger basin. A detailed study of the technology best suited to this purpose has not, as yet, been undertaken. At first sight, satellite data collection would appear to be a very convenient system for this purpose, as data from all over the basin could easily be concentrated at one ground station and transmitted to the basin-wide River Forecasting Center. However, there is already a preliminary indication that several countries object to having hydrological data from their territory relayed directly to an international center. In practice this would mean that several satellite-receiving ground stations would have to be installed. The costs involved in these additional stations would weigh against the selection of satellite data collection for this project.

CONCLUSIONS

15. All the above case studies have in common a situation in which the use of satellite teletransmission for hydrological data collection appeared to be convenient or was even strongly recommended because of its technical and economic advantages, yet did not lead to implementation. While it is most difficult to define clearly the final reasons why satellites are not being used, it may be surmised that these reasons are political and administrative, rather than technical. Among the questions which need further clarifications are the following :

(i) What is the lifetime of a satellite teletransmission system ? It can hardly be expected that developing countries should agree to invest scarce development funds in a system which may be discontinued in three, five or eight years or, even worse, be cut off for non-technical reasons.

(ii) What will be the cost of satellite data collection in the future ? Developing countries are reluctant to engage in the long-term use of a system which is at present free of charge, or available at nominal cost, but may start to charge considerable sums later on.

(iii) Some developing countries do not accept that the data collected from their territory be relayed directly to a foreign country. These countries want to «see» the data before passing them on. This point may be linked to the legal status of satellite-relayed information.

(iv) A few countries may expand the above argument by refusing to accept relays of hydrological data via a foreign satellite, because these data might then become available to third parties.

(v) In addition to the above reservations, some doubts have been expressed about the viability of a system which relays DCP data to one central receiving ground station far away, these data then being recovered at the user's site through telecommunication links.

16. It is our considered opinion that, before these administrative questions are fully clarified, there are limited prospects for the immediate implementation of large-scale

satellite systems for teletransmission of hydrological data. However, appropriate technical measures may, to some extent, alleviate the administrative problems, which at present are the main obstacle.