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Hydrometry — Hydrometric data transmission systems — Specification of system requirements

Hydrométrie — Systèmes de transmission des données hydrométriques — Spécification des exigences des systèmes

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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 113, *Hydrometry*, Subcommittee SC 5, *Instruments, equipment and data management.*

This first edition of ISO 24155 cancels and replaces ISO/TS 24155:2007.

Introduction

Hydrometric data transmission systems provide data for the day-to-day management of water resources and for warning and forecasting of floods, droughts and conditions affecting water quality and public health. The systems transmit data measured at remote telemetry stations to a receiving centre for further processing.

This International Standard defines and standardizes the required specifications of hydrometric data transmission systems. It does not describe the specifications of the equipment and units constituting hydrometric data transmission systems, but does describe the functional performance that the hydrometric data transmission systems should provide.

Hydrometry — Hydrometric data transmission systems — Specification of system requirements

1 Scope

This International Standard specifies the technical requirements that should be considered in designing and operating hydrometric data transmission systems (HDTS) and also the necessary functions of those systems. The scope of HDTS is shown in Annex A.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 772, *Hydrometry — Vocabulary and symbols*

ISO 80000-1, *Quantities and units — Part 1: General*

ISO/IEC 2382, *Information technology — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 772 and ISO/IEC 2382 apply.

4 Basic requirements

4.1 General

This Clause specifies the general requirements for designing an HDTS.

An HDTS shall be designed to meet the basic requirements, defined hereinafter, taking into consideration functionality, geographical structures, time structures, installation conditions, reliability, safety, maintainability and economy. The final system specifications should be determined through the process of repetitive discussions among technological specialists in hydrological and telecommunications fields.

The conceptual configuration of an HDTS is shown in Annex A.

4.2 Objectives of use

An HDTS shall be designed with a full understanding of the necessity and importance of hydrometric services for appropriate water management in drainage basins, such as needed for early warning of high flood levels, or low flows in ecologically sensitive rivers, in which this system is to be used.

4.3 Functional requirements

The functional requirements for an HDTS are classified into the following:

a) **Mandatory requirements:** the minimum requirements that an HDTS designer shall comply with in designing the system. The mandatory requirements include legal requirements, for example, for the site where the system will be installed, and applicable specifications of various standards.

b) **Optional requirements:** the functions and methods of implementing them that an HDTS designer can select. The optional requirements include the requirements, such as the data collection sequence and selection of communication links as specified in 5.3.4.

An HDTS should be designed to fully achieve the mandatory functional requirements, and to meet the optional requirements in full consideration of the user's requirements and operational purposes of the system so as to demonstrate the required system functionality.

4.4 Geographical structures

The following geographical structures shall be determined as a fundamental element of HDTS:

a) location(s) of the remote telemetry station(s);

b) location(s) of the receiving centre(s);

c) location(s) of the relay station(s), if necessary.

A remote telemetry station is located at a selected hydrometric observation point. Therefore, remote telemetry stations are distributed over a geographically wide area, including a drainage basin. Remote telemetry stations cannot always be located at optimum hydrological sites, and may be relocated to alternate sites because of geographical problems and difficulties in data transmission.

A receiving centre consists of equipment that receives data from remote telemetry stations for data processing and display. It is located at a site where data and/or information are needed. Therefore, the receiving centre will usually be located within the facility of a user organization. In large drainage basins, receiving centres may be distributed at user organizations near a hydrometric-observation point.

According to the necessity of the communication medium, a relay station shall be provided in the system.

These geographical structures should be considered not only at the time of designing but also for the future plans.

4.5 Time structures

Usually, an HDTS is used on a real-time basis. An HDTS has two time domains: the first domain is the time used in the natural world; the other is the time series in system operation.

The basic property of time in system operation is the time when the hydrometric observation is made at a gauging point; the gauging intervals and the delay times that are required in data presentation.

Usually, sensors at remote telemetry stations continuously measure hydrological phenomena, but the data monitored at the receiving centre are sampled in a time series. Therefore, these time characteristics and their allowable error range should be determined for the purposes of operation. Details are shown in Annex E.

4.6 Installation conditions

The environmental conditions of the remote telemetry stations may be more severe than those of telecommunication equipment installed indoors. Therefore, the following conditions should be considered:

a) temperature range and rate of change;

b) relative humidity range with no condensation;

c) wind velocity;

d) lightning protection;

e) seismic resistance;

f) damage due to sea wind, dust, and/or corrosive gases;

g) available power supply conditions;

h) equipment damage and access during flooding.

The environmental conditions of the telecommunications and information processing system equipment to be installed at a receiving centre should also be considered for items a), b), d), e), and g) above. Details are shown in Annex C.

4.7 Considerations for designing

4.7.1 Reliability

An HDTS is basically designed for continuous operation for its original purpose of use, particularly in the case of heavy rains and floods. Designers shall consider the reliability of equipment and the entire system. For the important functions of the system, alternative means or a redundancy of the system should be provided.

For example, duplicate communication links can be installed to connect important remote telemetry stations in a gauging area to a receiving centre. A hot-standby system can also be used for the equipment having important functions. The hydrological data measured by important remote telemetry stations also can be input to a site recorder, and the storage term(s) and period should meet the user's requirements.

4.7.2 Safety

An HDTS shall be designed as a safe (fail-safe) system that can always secure safe system operation in the case of a malfunction of equipment, faulty operation by a user, or a system failure due to any external factor. The fail-safe should prevent such problems from spreading over the entire system.

If the malfunction or failure in part of the system or faulty operation by a user is non-critical, the principal functions of the system should continuously operate because of the importance of hydrometric observation.

4.7.3 Data permanence

The permanence of hydrometric data should be ensured, since these are stored and used for water resources management over a long period.

The permanence of data shall be ensured even if some component(s) of the system is replaced or changed. In addition, interface specifications shall be defined for the data transmission system, format and transfer timing between the sensors to be installed in the pre-stage of an HDTS and the information processing system to be installed in the post-stage of an HDTS. Data received at the receiving centre should be saved on reliable storage media.

4.7.4 Maintainability

The HDTS equipment shall be designed to have a composition that is easy to maintain and repair.

The HDTS equipment should be designed so that it is easy to check and replace parts, and so that inspections and adjustments can be conducted (easily or) conveniently.

Software shall be designed with future maintainability taken into consideration, i.e. for future modifications and/or future improvements. Documentation shall be provided in order to easily carry out necessary procedures for the cases when modifications are required.

The HDTS should also include the capability of performing line testing between receiving centre (Rc), via relay station (Rs), and remote telemetry station (Rts).

4.7.5 Operability

Each piece of the equipment shall be designed to allow for simple operation and to prevent unauthorized access, illegal operation, and unintentional shutoff of the power. An HDTS should be designed to enable the receiving centre to monitor the operational status of the entire system, identify problems and control necessary operations.

4.7.6 Economy

An HDTS should be designed to have a good cost performance in terms of required functions and reliability. The economy of the system should be evaluated considering the entire life cycle cost including the initial cost and operational cost. An HDTS should allow for future updating or expansion.

5 Functional requirements of system

5.1 General

The functional block diagram of an HDTS is shown in Annex B. The hydrometric data measured at remote telemetry stations are encoded into a format suitable for transmission at the remote telemetry stations. Communications are made between the remote telemetry stations and the receiving centre according to a prescribed collection sequence, transmitting the encoded data from the remote telemetry stations to the receiving centre. The receiving centre decodes the received data and performs data verification and processing to disseminate it to users as hydrometric information. An information processing system may be provided in the stage following this system.

5.2 Remote telemetry stations

5.2.1 General

The principal function of a remote telemetry station is to measure hydrometric data using sensors. This is a process for collecting data to be input to the system and for monitoring hydrological phenomena that change with time.

5.2.2 Locations

The locations of remote telemetry stations shall be determined in considering features of communication link(s) to be introduced as well as hydrological points of view. The possibility of using the sites, the availability of existing communication links and radio links, the radio propagation conditions (if radio links are chosen), the lead-in conditions from power sources, and the access roads should also be considered as important factors for determining the locations. The items that should be investigated in selecting the sites of remote telemetry stations from the viewpoint of data transmissions are shown in Annex C.

5.2.3 Data measurements

The measuring conditions for data to be acquired shall be specified based on operational purposes.

The items to be specified are:

a) data type and number of measuring points;

b) range of measurement, effective digits, data value, and units;

c) resolution and accuracy against full scale;

d) timing of measurement;

e) input interface (typical interfaces are shown in Annex D);

f) threshold values for detecting alarms; and

g) other necessary items.

Specifications of sensors and converters are outside the scope of this International Standard. However, the SI Units (International System of Units) specified in ISO 80000-1 shall be used for measurement.

5.2.4 Data processing

In general, the results of data measurements should be transmitted as momentary data without being processed. However, such input data may be processed for conversion into a form that can be transmitted at the interfaces with the sensors. For some data and under certain measuring conditions, it may be effective to calculate the moving average or maximum and minimum values of the data measured at successive time points at remote telemetry stations and transmit the calculated results. Abnormal data should be marked or highlighted for further inspection.

In recording and displaying the data measured at remote telemetry stations, the following items should be considered and decided:

a) storage of multiple data for batch transmission;

b) protection against data loss due to system troubles;

c) provision of displaying raw data, etc. for easy maintenance on site.

The sampling interval of a data logger should be determined by the balance among the purpose of the logging data, the recordable time depending on the recording capacity and intervals of the logger, the intervals of log collecting and associated cost, and the risk of loss of data through natural causes or vandalism, etc.

5.3 Telemetry system

5.3.1 General

The telemetry system is the core of this HDTS, and its principal function is to transmit the data measured by sensors at remote telemetry stations to the data processing system at the receiving centre.

5.3.2 Amount and intervals of data transmission

The total amount and intervals of data transmission shall be provided for each data transmission link. The necessary capacity (speed) of a communication link is determined by the total amount of data, interval of data transmission, and allowable transmission delay time. The necessary capacity also depends on the selected data communication channel.

5.3.3 Data collection sequence

The data collection sequence that is the fundamental function of the telemetry system shall be determined. There are various data collection and transmission sequences, such as continuous data transmission with time, data transmission in certain intervals, and data transmission when the data reaches certain threshold values.

If the receiving centre polls remote telemetry stations one after another and receives the data measurement at each polling time, the actual time of measurement for each station may be different from each other as per polling order. On the other hand, if remote telemetry stations measure data with their own time schedule, the delay time in measurements can be minimized.

The typical methods are shown in Annex E.

5.3.4 Communication links

There are various types of communication links and communication methods such as wired lines, radio links, public telecommunication lines, mobile telephone network, Internet and satellite communication links. The type of communication link and communication method shall be decided by taking into consideration the communication environment and conditions of use including the amount of information to be transmitted, transmission speed, reliability of transmission, operating environment, feasibility and economy, and allowable delay time.

The communication links available for data transmission and their technical outlines are shown in Annex F. Communication links should be decided through comprehensive evaluation of the following items:

a) types and functions of communication lines that are provided by telecommunication company in the area where HDTS is to be installed;

b) possibility (including technical and legal restrictions) of constructing dedicated communication lines for the telemetry system other than those provided by telecommunication company;

c) required transmission speed calculated from the amount of data that the telemetry system transmits (amount of data transmissions), sampling intervals, and allowable delay time;

d) required reliability and economy of communication links. Reliability should be considered in event of disasters such as floods, and economy should be considered for the initial cost and life cycle cost.

Usually, exclusive radio communication links are used. In such cases, the frequencies and output powers are provided by international standards and national laws. Radio communications are usually available over distances of several tens of kilometres. Relay stations may be needed for longer distances and/or rugged terrain. Since the quality of radio communication depends on the peripheral conditions, propagation tests should be made after designing the communication links. A general process of designing simplex radio links is shown in Annex G.

5.3.5 Network architecture

Networks for interconnecting remote telemetry stations and receiving centres may be configured as various architectures depending on the locations of the remote telemetry stations and the receiving centres, the types of communication links to be used, presence of relay stations, etc. Appropriate network architecture shall be determined with a full understanding of the advantages and disadvantages of various architectures, such as economy, reliability, and adaptability. Some network architectures for the telemetry system are shown in Annex H. Data repeating methods at a relay station are shown in Annex I.

5.4 Receiving centre

5.4.1 General

The principal functions of the receiving centre are data collection through telemetry, data verification and processing, and dissemination of the results to users. Data processing may be conducted by providing a separate information processing system. In such a case, the details are outside the scope of this International Standard.

5.4.2 Data verification

Data shall be verified to ensure the quality of collected data.

The data verification can be classified into two processes. Both processes should be performed.

— The first is to detect errors in data transmission. This can be performed using parity bit, Cyclic Redundancy Check (CRC) error detection codes or other methods. These methods may be included in the communication control procedure.

— The other process is to examine the properties of hydrometric data, which can be performed using measured range of sensors, the upper and lower limits of data values, and the rate of change of measured data. Since most of the threshold values of these items vary depending on types of systems and/or application forms, the system should be designed to enable threshold values to be specified and set for individual parameters.

The system will generate a report that identifies potentially spurious data.

5.4.3 Data processing

Data processing in the HDTS are the procedures that generate meaningful hydrological information for users from the data measured at remote telemetry stations.

Users generally make their decisions based on operational information instead of basic hydrometric data. Therefore, necessary conversion functions, such as accumulation of rainfall or conversion from a stage observation to a discharge, should be incorporated in the real-time environment if the system is not provided with an information processing system in the post-stage of HDTS.

Parameters for processing, such as the stage-discharge relation, may be modified afterwards. Therefore, the real-time information that is necessary for decision-making and the information that is stored as hydrometric records for a long time should be separated within the HDTS.

5.4.4 Data storage

The HDTS shall have a function to store data and information in a memory media on the system.

The data storage in the HDTS should be intended for

— buffering measured data until it is transmitted to an information processing system after the HDTS

— real-time generation of information by combining data at multiple time points, and

— temporary storage of real-time information necessary for decision-making.

Information that will be stored for a long time and used as standards should be stored as a database in a separate information-processing system from the HDTS.

5.4.5 Data display and printing

The system shall have the functions of displaying and printing out data and information in tables and graphs. For these functions, there are methods for displaying and printing data immediately after each data collection and transmission cycle, and methods for outputting a batch of data collected at multiple sampling times (such as daily) and for outputting information for a specific time as requested by a user.

5.5 System monitoring

5.5.1 General

An HDTS shall be able to record its operational status, to provide a report of this record in order to check its operational status and to quickly notify users of problems, so that users can identify and remove the causes of problems, and quickly and appropriately restore the system.

5.5.2 Monitoring of operational status

The system should always be monitored to promptly detect any problems. Such events are usually transmitted through the HDTS.

The remote telemetry stations are to be installed geographically distributed and operated unmanned. Therefore, the operational status of the entire system including the remote telemetry stations should be monitored, and any problems should be detected remotely from the receiving centre.

The remote telemetry stations should be designed to report the status of telemetry equipment, sensors and power supplies to the receiving centre. The receiving centre should check the contents of status reports from remote telemetry stations, inspect for any equipment malfunctions in the receiving centre and provide notification of potential problems.

5.5.3 Alarming

The contents of status reports and the affected ranges shall be defined to record and report the extent of malfunctions and related problems. The necessity of troubleshooting should be ranked into two levels.

— “Warning” is used for an alarm that needs a countermeasure.

— “Caution” is used for an alarm that signals a warning level and/or a temporary problem that can automatically be recovered.

5.6 Power supply

Power supply shall be designed with thorough consideration for stable operation of the system. Especially, the power supply to remote telemetry stations shall be carefully designed because external power supply may not be available or stable depending on the installation environment. Typical concepts of power supply are given below.

a) During ordinary times, an external power supply such as a commercial power line is used to run the system. In case of external power failure, batteries and other backup power sources are used. Systems that need a high power capacity and important systems may be backed up with appropriate generators. The guaranteed backup hours should be determined based on the importance of the system (usually, several hours to several days).

b) Instead of using external power supply, photovoltaic and/or wind power generation is used. Backup batteries should also be used if there is a possibility that there may be periods during which power cannot be generated because the photovoltaic or wind power supply is affected by weather conditions. The guaranteed backup duration should be determined based on the prevailing weather conditions at the area where the system will be installed and the importance of the system (usually, one week to a month).

Details are given in Annex J.

The scale of backup power supply is determined by the electric power required at the load side and the guaranteed backup duration. The electric power load should be calculated by investigating the necessity of a backup power supply for each equipment and screening the equipment that needs backup. The guaranteed duration should be calculated by considering weather conditions, such as annual sunshine hours and wind conditions, the voltage and frequency fluctuation ranges of commercial power sources, estimated frequency of power failures, and other possible external factors as well as the importance and economy of the equipment.

6 Operational requirement

6.1 General

For stable operation of the HDTS, specialists in hydrology and telecommunication technology and other staff should be trained. The training should be programmed including both lectures and on-site training.

6.2 Operation and maintenance manual

The data management system should be determined for the whole system, including methods for long-term data storage and for recovery of data loss as well as ordinary operations. Methods for maintaining the system, hardware countermeasures against data errors and system failures, and the methods of keeping and handling consumables and spare parts in stock should also be determined.

6.3 Maintenance

For stable data acquisition over a long period, the system should have a preventive maintenance schedule.

Preventive maintenance consists of daily inspection, periodic inspection, and exchange of parts. Daily inspection is to check whether the entire system is normally operating by referring to the printouts or screen displays at the receiving centre. Periodic inspection consists of checking the system through visual checks and using testing instruments for preventive maintenance; inspection items differ depending on the inspection periods. If there are parts that have predefined life cycles, these parts are changed during periodic inspections.

Remote telemetry stations are usually operated unmanned. It is difficult to inspect such remote telemetry stations on a daily basis; these stations should be subjected to periodic inspection. Periodic inspection (and replacement of parts) is usually made within an interval of several months and/or before and after the flood season. Revalidation of measuring data should also be checked during the periodic inspection.

Annex A
(informative)

Configuration of hydrometric data transmission systems

Figure A.1 shows the concept of HDTS configuration.

The HDTS is configured with remote telemetry stations and a receiving centre. The remote telemetry stations are installed at hydrometric points and the receiving centre is installed at a point needing hydrometric data and information.

A remote telemetry station basically consists of telemetry equipment and communications equipment, to which power is supplied from power supply equipment. The telemetry equipment is connected to sensors that measure hydrometric data, and it communicates with the receiving centre in accordance with a preset data acquisition sequence. The communications equipment is available in types corresponding to line types and provides communication functions between the telemetry equipment and the monitoring equipment at the receiving centre.

The remote telemetry stations are connected to the receiving station via communication links, which are radio links in many cases, but may be wired lines. If radio links are used, relay stations are deployed as needed.

The receiving station basically consists of communications equipment and monitoring equipment to which an operating console and a printer are installed as peripheral equipment. The operating console is used for various operations to the monitoring equipment and may display data. The monitoring equipment collects the hydrometric data from remote telemetry stations in a preset collection sequence and performs data processing, online storage, data display and printing and recording. An information processing system may be installed in the stage after this system, but this system is out of the scope of the HDTS.

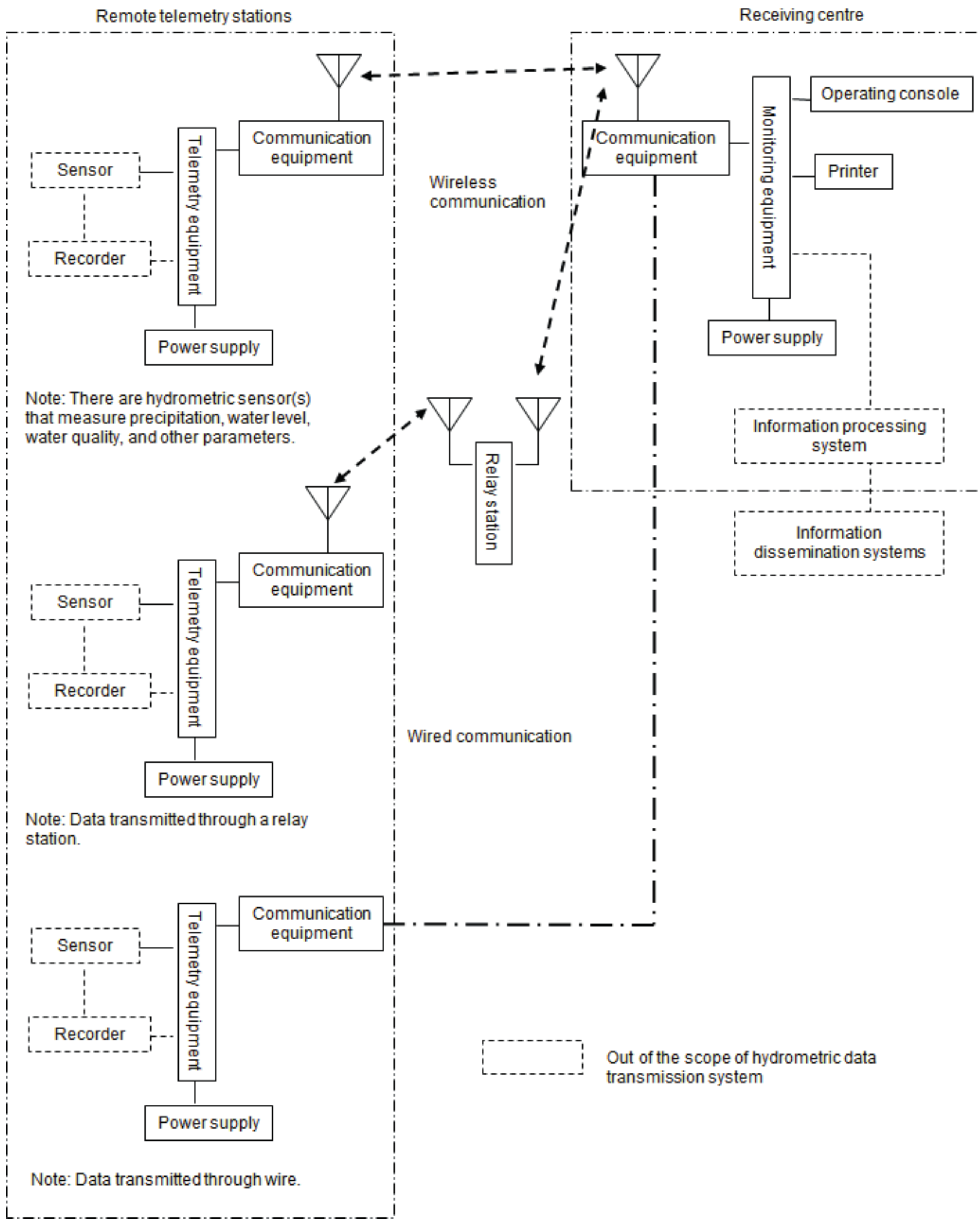


Figure A.1 — Configuration of hydrometric data transmission systems

Annex B
(informative)

Functional block diagram of hydrometric data transmission systems

Figure B.1 shows the functional block diagram of HDTS. The equipment configuration corresponding to that shown in Annex A is indicated on both sides of the figure.

A remote telemetry station measures the data via interfaces with sensors and encodes the data in accordance with control logic, and communicates with the sensors on a collection sequence under communication control. Control logic also performs data display, storage, and processing if they are required at the remote telemetry station.

The encoded data from each remote telemetry station is transmitted via a communication interface on a communication link to the receiving centre.

The data from remote telemetry stations is collected at the receiving centre via communication interface. The receiving centre performs communication on a collection sequence under communication control. The system control is the core function of HDTS, which performs centralized control of the system operations such as collection sequence. The received data are decoded and verified. Then, the data are displayed, stored or further processed.

There may be cases in which data are stored in cloud servers. In such cases, countermeasures against data security and other risks are to be carefully considered including provision of a standby system and/or a periodic data backup system.

When the data stored in the database is disclosed to a number of stakeholders, countermeasures should be taken against data manipulations by unauthorized or unscrupulous users.

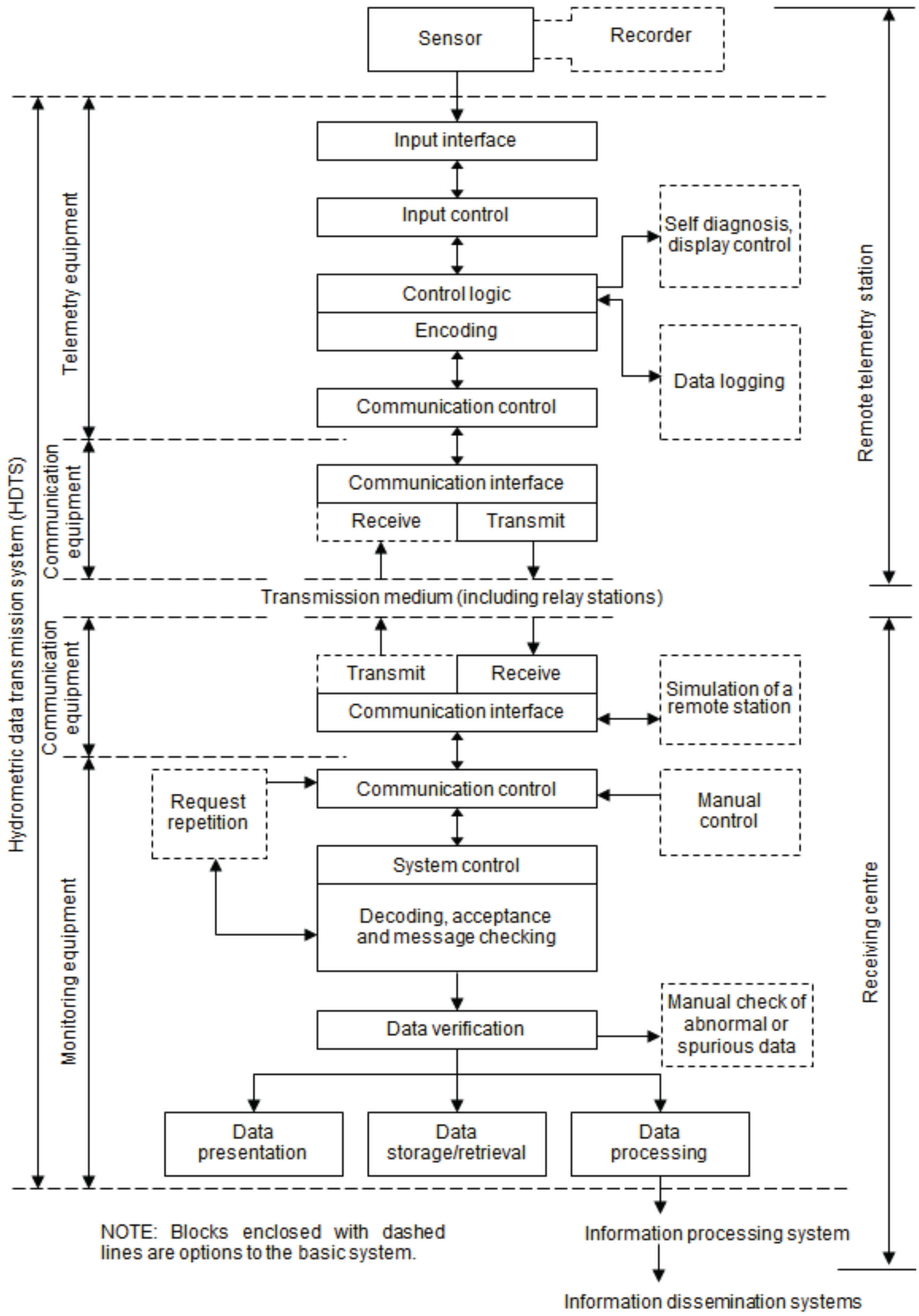


Figure B.1 — Functional block diagram of hydrometric data transmission systems

Annex C
(informative)

Locations of remote telemetry stations

C.1 Conditions for selecting locations of remote telemetry stations

Examples of the conditions for selecting the locations of remote telemetry stations are given below.

— The land area shall be sufficiently large.

— The permission of the landowner to use the land or to purchase the land shall be obtained.

— The weather conditions shall not be very different from those of the surrounding areas.

— The sites shall be safe against floods, landslides, vandalism, etc.

— If solar panels are used to charge batteries, the annual average sunshine duration shall be sufficient and the conditions of obstacles, such as trees, buildings and mountains, shall not cause the batteries to fail.

— If wind power generation is used, a sufficient wind velocity shall be available throughout a year.

— The access to the sites shall be adequate for installation and maintenance.

— If there are possible noise sources (such as factories, high-voltage transmission lines, and heavy traffic road sections) near the sites, they shall not affect data transmissions.

— There shall be no adverse effects of vibrations, dusts, corrosive gases, etc.

— The routes for transporting equipment shall be available.

— The sites shall be appropriate for the layout and installation of the equipment in terms of the dimensions and weight, and selected after investigation of those factors.

— The frequency of lightning should be investigated to take adequate countermeasures for prevention of equipment damage due to lightning surges appearing on the power line, signal lines, and antenna line, etc.

C.2 Locations for installing radio communications equipment

Examples of the conditions for selecting the locations for installing the radio communications equipment when very high frequency (VHF)/ultra high frequency (UHF) radio communication links are used are given below.

— The degree of interference between neighbouring stations shall be low enough for communications.

— If two or more antennas are installed in close proximity at the same site, the degree of mutual interference should be sufficiently low. If there is mutual interference, the degree of interference should be minimized by separating the antennas, inserting filters, etc.

— Radio communication stations for point-to-point communication should be located at elevations as low as possible through comprehensive evaluation of the radio paths, communication links, terrain profiles, and conditions of the locations, and should never be located at high points, such as the tops of mountains except for relay station.

— The equipment composition and radio link design should be appropriate in terms of frequency, transmission method, radio paths and terrain profiles.

— It shall be possible to set up an antenna mast having a height that is estimated from the results of radio propagation tests.

Annex D
(informative)

Interfaces of hydrometric sensors at remote telemetry stations

The interfaces between hydrometric sensors and data transmission systems (telemetry equipment) should be determined through comprehensive consideration of the properties of measured data, detection methods of sensors, distances between the sensors and the data transmission system, costs, affinity with the data transmission system, and market availability.

Usually, sensors are determined first, because of using existing sensors or the limited types of sensor that are physically restricted by the hydrometric data to be measured and the observation sites. In such cases, interfaces are chosen from the available interfaces for the sensors in considering the above factors.

General and typical interfaces are:

— Analogue: 0-1V, 1-5V, 4-20 mA, etc. ;

— Digital: bit parallel input such as Binary Coded Decimal (BCD), Gray code, etc.;

— Pulse: voltage pulse, no-voltage pulse, open collector output pulse, etc.;

— Serial: RS-232, RS-422, RS-485, SDI-12, HART®[1)], Ethernet®[2)], etc.

1) HART is the registered trademark of HART Communication Foundation and is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

2) Ethernet is the registered trademark of a family of computer networking technologies by Xerox Corporation and is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Annex E
(informative)

Data collection sequence

E.1 General

Typical data collection and transmission sequences are shown in this Annex. The data collection sequence can be divided into three categories: polling, self-reporting, and a combination of polling and self-reporting. The polling mode includes E.2, E.3 and E.6. The self-reporting mode includes E.4, E.5 and E.7. In the combination dmode, a system normally operates in the polling mode; it operates under both modes when a threshold value is exceeded or upon the demand of the receiving centre.

Generally, the operation mode can be divided broadly into the following four categories although it depends on selected data collection sequences.

a) Normal observation

In this mode, gauging data are collected automatically.

b) Gauging at event start

In this mode, observation is performed automatically when event data are input from sensors, etc. This mode can be performed in E.3, E.5 and E.6 collection sequences.

c) Manual calling

In this mode, data are collected from all stations or a selected remote station by manual operation at the time of maintenance, etc. Generally, the data collected by manual calling is not used for data processing. Manual calling can be performed in E.3 and E.6 collection sequences.

d) Recalling

When missing data are detected in normal observation or manual calling, the data are recalled automatically. Recalling can be performed in E.3 and E.6 collection sequences.

This mode can be applied for compensating the past data using logged data in remote stations in a lump for a specified period when the data missing continued for a long time.

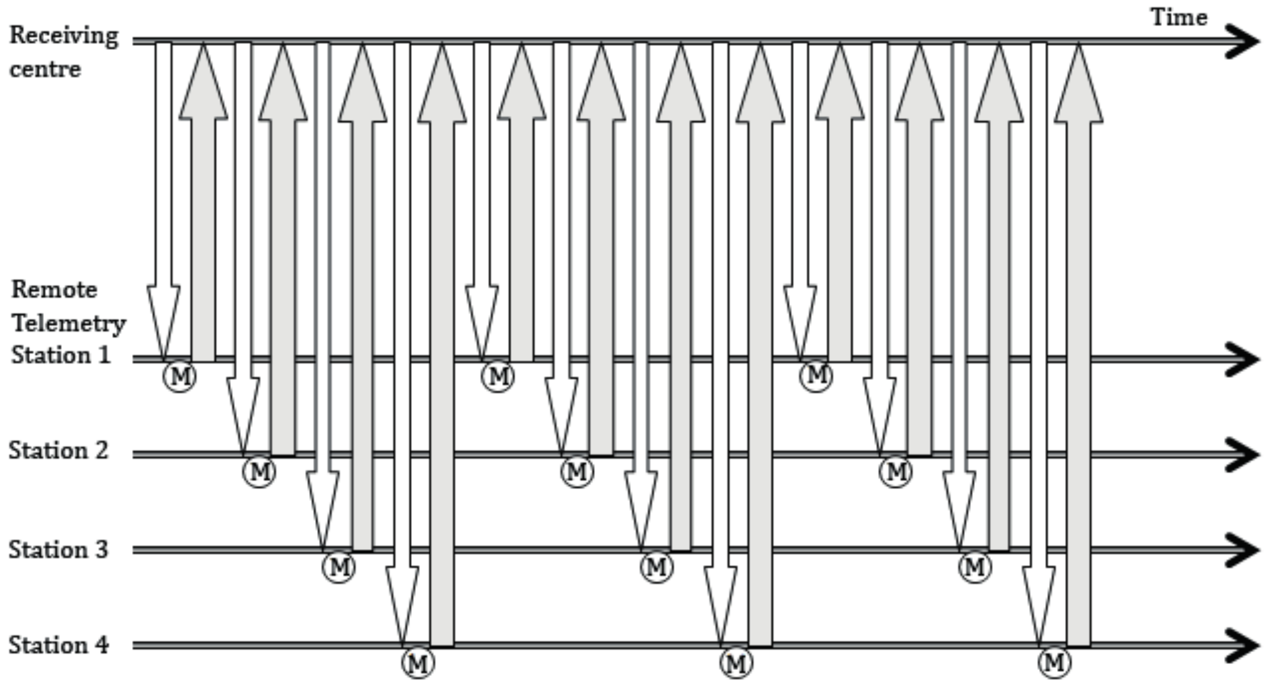
The power consumption and the communication cost may increase in proportion to the times of transmission from remote telemetry stations though it depends upon the communication links.

It also is advisable for remote telemetry stations to have the capability for field operators to enter supplemental data such as field-measured parameters (for example, dissolved oxygen or specific conductance).

E.2 Cyclic polling

Cyclic polling is used on the condition that various remote telemetry stations can jointly use a single communication link. Remote telemetry stations are polled one after another, and after polling of the last remote telemetry station, the first station is polled again, making a cyclic polling.

In general, the entire system should be polled at intervals based on the highest demand standard, but the system may be divided into several groups by the degree of demand for intervals, each of which is cyclically polled independently.



Key

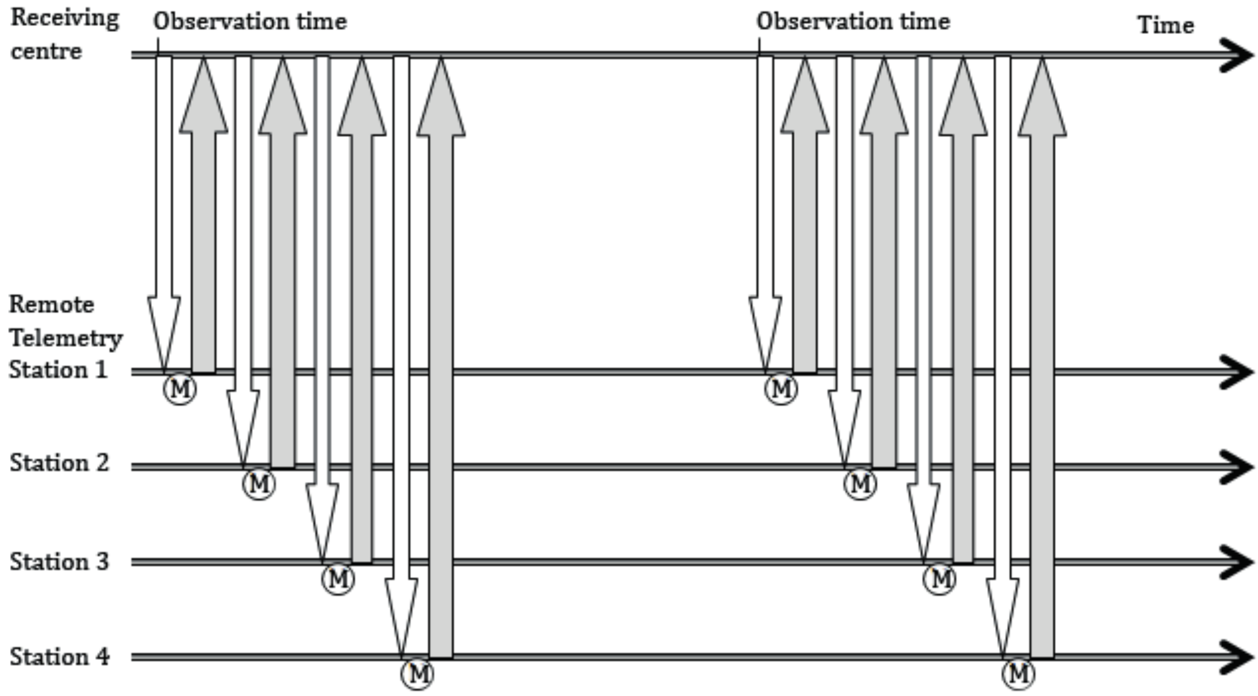
Ⓜ measuring

Figure E.1 — Cyclic polling

E.3 On-demand polling

On-demand polling is a cycling polling, from the first to the last remote telemetry stations, that is made at a minimum necessary timing interval, such as every hour. This method is appropriate for systems that use communication links based on communication time-dependent charging. It is also effective for those remote telemetry stations that need to minimize power consumption, such as those that use solar panels to charge batteries.

The method has a disadvantage that the measuring timing differs among remote telemetry stations if the measurement at each station takes a long time, or if there are many remote telemetry stations to be polled.



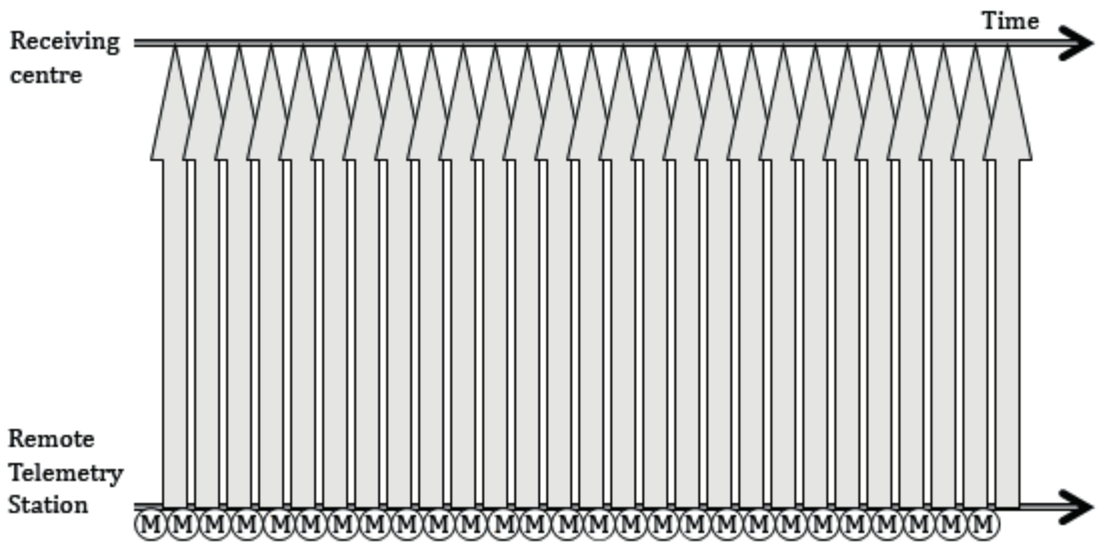
Key

(M) measuring

Figure E.2 — On-demand polling

E.4 Continuous transmission

Continuous transmission is used on the condition that a remote telemetry station can make exclusive use of a communication link between the station and the receiving centre. This method allows the remote telemetry station to continuously and sequentially transmit the measured data to the receiving centre. The receiving centre can arbitrarily sample data at necessary intervals and has a high degree of freedom.



Key

Ⓜ measuring

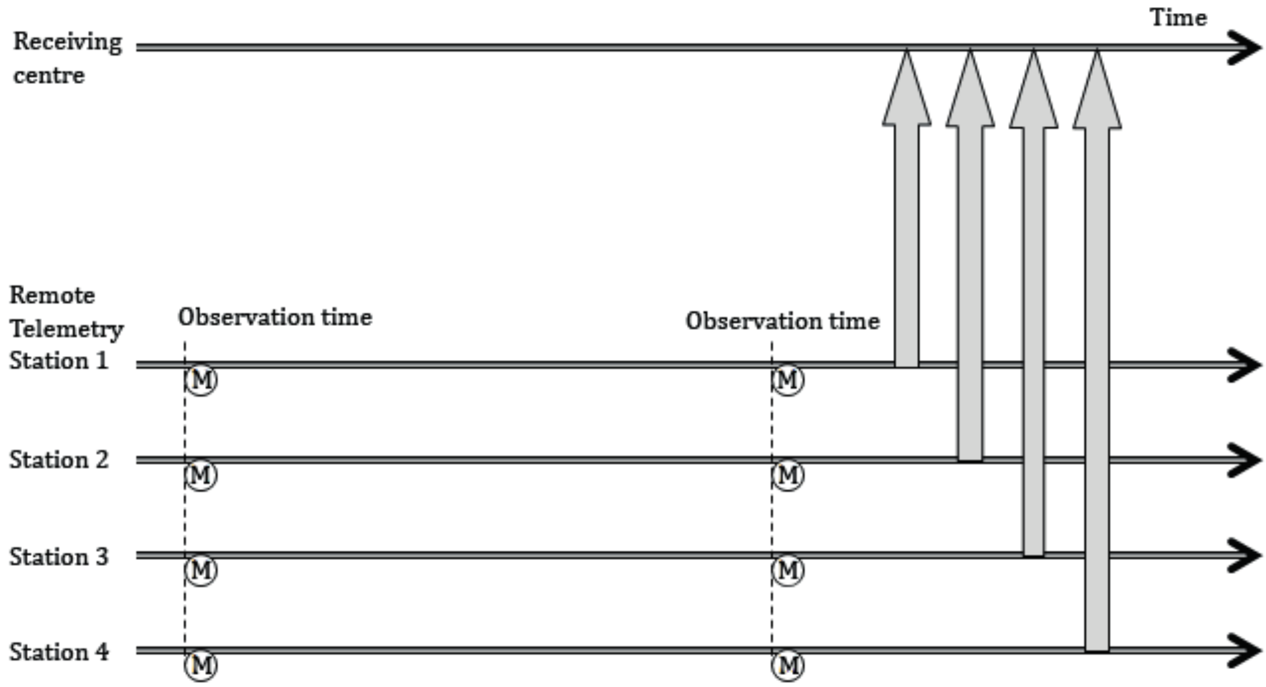
Figure E.3 — Continuous transmission

E.5 Batch report

A batch report is a method by which the data for a certain period of time (several sampling data sets) are stored at a remote telemetry station to transmit a batch of data to the receiving centre as the result of polling, or by the automatic reporting function of the remote telemetry station.

This method is effective for the telemetry systems that cannot maintain communications during certain hours, such as via polar-orbit satellites.

Since the method conducts measurements independently at each remote telemetry station, a highly precise clock is needed at each station to conduct punctual measurements. Each station should also be equipped with a device to temporarily store the measured data.



Key

Ⓜ measuring

Figure E.4 — Batch report

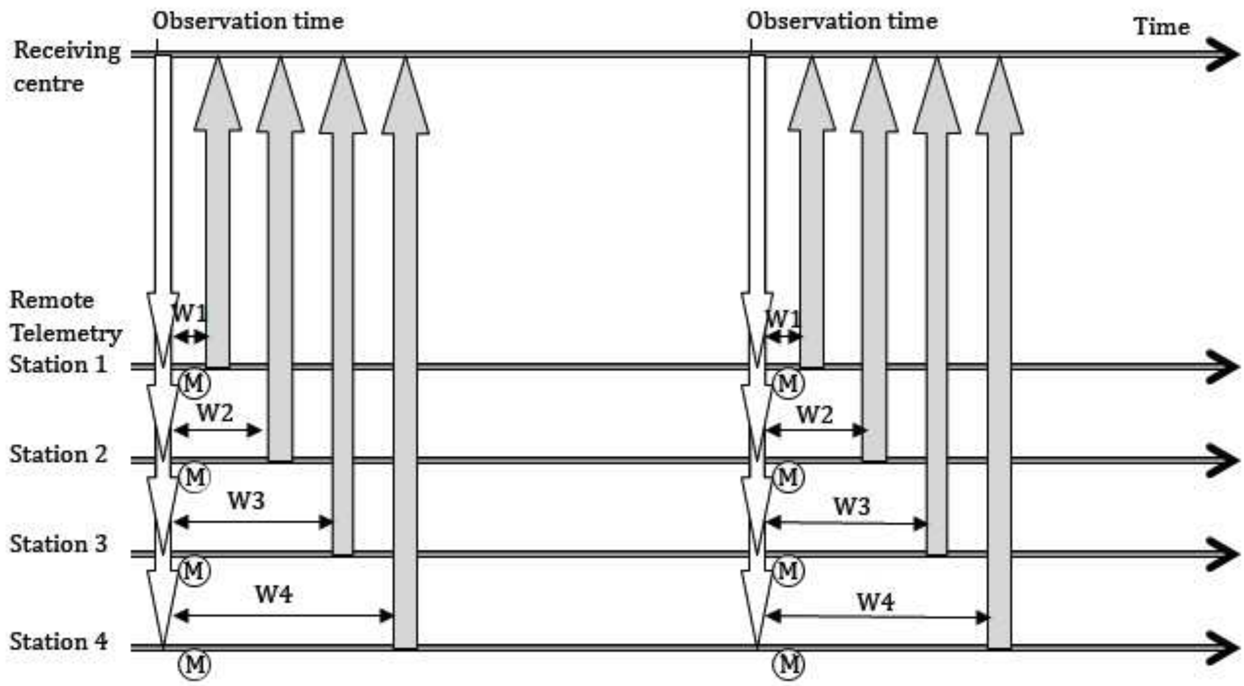
E.6 Batch polling and sequential reporting

Batch polling and sequential reporting is an improved method that combines E.3 and E.5. The sequence is shown below.

a) The receiving centre polls all remote telemetry stations at each time of measurement;

b) Each remote telemetry station conducts measurement when it is polled, and stores the data in its local memory;

c) Each remote telemetry station transmits the measured data to the receiving centre after a specified waiting time (W*n*). The W*n* should be specified as a different time constant for each station to prevent jamming.



Key

Ⓜ measuring

W1/W4 waiting time

Figure E.5 — Batch polling and sequential reporting

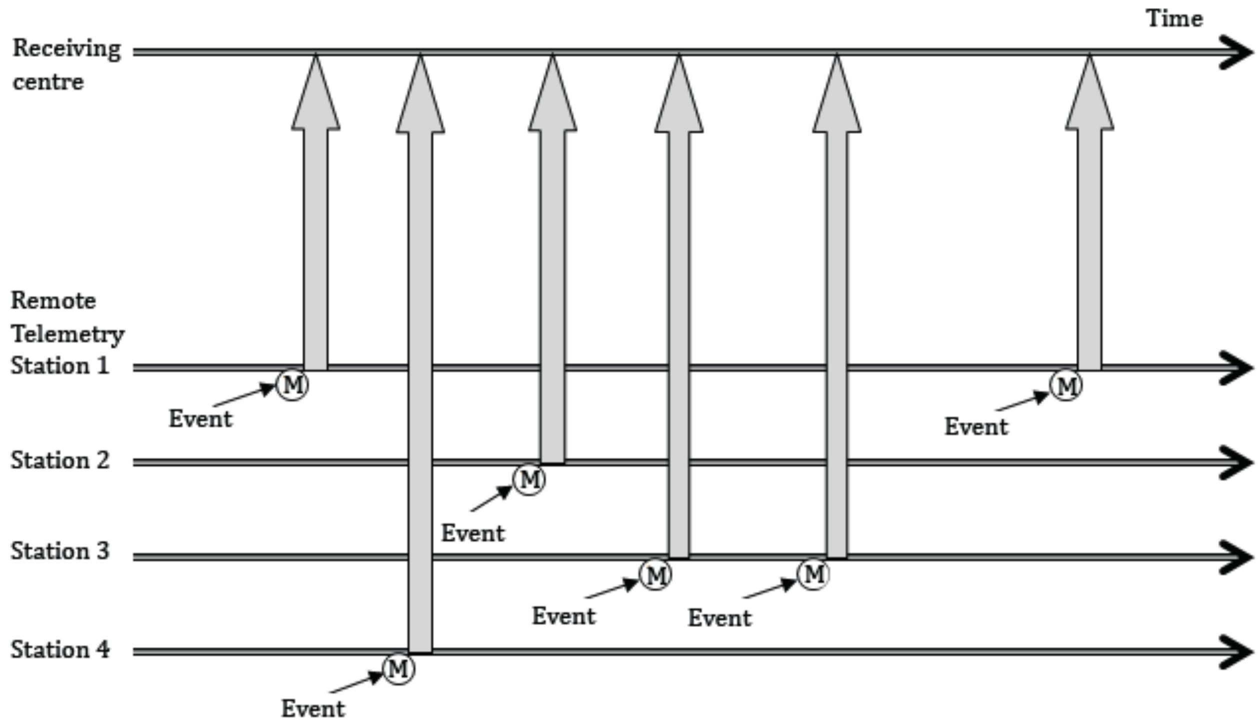
On-demand polling (E.3) has the disadvantage that it has different measuring timing among remote telemetry stations. The batch reporting method (E.5) needs a highly precise clock at each station. On the other hand, this method (E.6) conducts measurements at all stations at the times when the receiving centre makes synchronous polling to all the remote telemetry stations. Therefore, the measuring timing is the same at all stations, and there is no need of a precise clock at each station.

E.7 Event reporting

In event reporting, remote telemetry stations automatically transmit data to the receiving centre in the event that a sensor detects a precipitation value or a water level value exceeding the preset upper (or lower) limit. This method is effective for the receiving centre to immediately detect events. The method can also be used to collect periodic data by processing the data at the receiving centre at certain intervals.

When data are not transmitted to the receiving centre for a long time, it is difficult to identify whether there is no event or whether there is a system problem. Therefore, this method should be combined with the method of automatically transmitting data at scheduled times in order to configure a reliable telemetry system.

If a large number of remote telemetry stations jointly use a communication link, transmissions from various remote telemetry stations may overlap, resulting in data losses depending upon the number of remote telemetry stations and the frequency of events. Therefore, measures against data convergence (such as repetitive transmission of a data set and transmission of integrated data) are needed to improve reliability.



Key

M measuring

Figure E.6 — Event reporting

Annex F
(informative)

Communication links for data transmission

F.1 General

Communication media and technologies that are available for telemetry systems are outlined in this Annex. Telemetry systems should meet the standards of the communication medium.

F.2 Telephone lines

Telephone lines provide a switched telephone network with dial pulse or multi-frequency signalling.

The cost is usually communication time-dependent, though in some areas, such as within a city, the cost is fixed.

There are analogue and digital lines. Usually, their transmission performances are conforming to international or domestic standards, and the communication quality is guaranteed.

The transmission speed on an analogue line using communication modems is over 50 kbps (kilobits per second) if the line has a good quality.

The transmission speed on a digital line using communication modems is usually over 100 kbps.

The traffic on the lines may drastically increase in the event of disaster, and it may be impossible to use the line due to convergence.

F.3 Mobile phone links

Mobile phone links provide a switched mobile telephone network with multi-frequency signalling.

The cost for voice traffic is usually dependent on communication time. For data communication, the cost may not be dependent on the communication time, but on the amount of data (number of packets). There are cases of fixed charging but with limitation to data communications.

There are analogue and digital systems. Usually, their transmission performances conform to international or domestic standards, and the communication quality is guaranteed.

The analogue system is classified as the first generation, and is usually inappropriate for data communications.

The digital system of the second generation allows data communications at 9 600 bps (bits per second) or more. The 2,5th, third, fourth and later generations of mobile communication allow high speed data communications at several hundreds of kbps and in Mbps (megabits per second).

Besides mobile phone services that use wireless base stations on land, there are mobile phone services that use satellites.

These mobile phone services use a switching system, including those in the packet cost or fixed cost system. The traffic on the links may drastically increase in the event of disaster, and it may be impossible to use the links due to convergence.

The communication also can adopt Short Message Service in mobile phone links. Short Message Service is a words/characters transmission and receiving business between point to point or Short Message

Entity to Short Message Entity and message centre covers message information storage and re-transmission.

F.4 Common carrier leased lines

Common carrier leased lines provide dedicated line service to a specific user or group of users

The cost is usually fixed.

There are analogue and digital lines. Usually, their transmission performances conform to international or domestic standards, and the communication quality is guaranteed.

The transmission speed on an analogue line using communication modems is over 50 kbps if the line has a good quality.

The transmission speed on a digital line is 50 kbps or over depending on the class of service, and there are high-speed services at several to several hundreds of Mbps.

Since the line is for exclusive use, there is no convergence by increase in traffic.

F.5 Internet connection

A constantly connected high-speed line service is available for exclusive use of data communication through the Internet.

Depending on the transmission routes to be used, there are optical fibre cables, Digital Subscriber Line (DSL), and Cable Television (CATV).

The lines are constantly connected and the cost is usually fixed.

The available communication protocol is limited to Internet Protocol (IP).

In the Internet, the quality of service is on best-effort basis. There is a possibility of convergence when the traffic increases.

F.6 Privately-owned lines

The lines are installed and operated by users themselves. The initial investment is necessary, but there is no cost during operation.

There are various transmission media, such as copper twisted pair cables, coaxial cables, and optical fibre cables.

There are various types of line terminal equipment available from simple communication modems to multiplex terminal equipment.

It is possible to select a wide range of communication speeds from several tens of bps (bits per second) to several Gbps (gigabits per second) by combining the above communication media and line terminal equipment.

The communication quality on private links should be checked by the users themselves.

F.7 VHF/UHF radio communication links

The effective use of frequencies is available worldwide under the control of ITU (International Telecommunication Union).

Frequency ranges are globally specified as follows:

— VHF (very high frequency): 30 MHz to 300 MHz;

— UHF (ultra high frequency): 300 MHz to 3 000 MHz.

The allotted frequency ranges are different from country to country.

The number of central frequencies (the number of channels) that can be used in a region or country is usually limited. Usually, one central frequency (one channel) is jointly used by a number of remote telemetry stations. To avoid interference, neighbouring systems cannot adopt the same frequency group. The frequency for communication should follow the local regulations and laws. For event reporting, collision from the same frequency is not avoidable; reasonable allocation of frequencies can reduce this interference.

There are analogue and digital systems.

Radio communication equipment controls transmitting and receiving of radio signals so that link connection is established.

The transmission speed is usually 200 bps to 1 200 bps on an analogue system used for voice communication by frequency shift keying (FSK). The transmission speed on a digital system or analogue system by minimum shift keying (MSK) or Gaussian MSK (GMSK) is usually 1 200 bps to 9 600 bps.

F.8 Multiplex radio communication links

The effective use of frequencies is available worldwide under the control of ITU (International Telecommunication Union).

The available frequency range extends from UHF to SHF[3)] (300 MHz to 30 GHz).

The allotted frequency range is different from country to country.

These links are used for multi-channel telephone communications and high-speed data communications.

There are analogue and digital links. The links that do not pass through exchanges are always connected.

F.9 Satellite communication links

Very Small Aperture Terminal (VSAT) and International Maritime Satellite Organization (INMARSAT®[4)]) are typical satellite communication links for data transmission. There are other satellite communications available internationally or locally.

Since satellites are used as relay stations, international communications as well as domestic communications are available.

The digital circuits via VSAT can also provide voice conversation.

The transmission speed via VSAT varies depending on the class of service, but it is up to 64 kbps.

The transmission speed on INMARSAT® varies depending on the class of service, but is over 64 kbps.

Transmission signals may attenuate during heavy rains and communications may not be available.

3) SHF is super-high frequency.

4) INMARSAT is the registered trademark of Inmarsat (Plc) and is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

F.10 Optical fibre communication

The optical fibre communication system uses optical fibre cables as transmission lines, and the system has the following features.

In comparison with metal cables, the optical fibre cables have the following advantages.

— Since the transmission rate from several hundred Mbps to a few Gbps or more is available, large-capacity data such as closed-circuit television surveillance footage and radar images can be transmitted.

— Long distance communication is possible because of little loss of data.

— The optical fibre system is not affected by lightning induction and ground loop, ensuring highly reliable communications.

Meanwhile, the optical fibre system has the following disadvantages.

— The optical fibre cable is difficult to handle because of its fragility.

— The optical fibre is difficult to repair when it is broken and disconnected.

Annex G
(normative)

Design of VHF/UHF radio link

G.1 General

This Annex specifies the methods of designing VHF/UHF radio links and the points to be considered.

G.2 Prerequisites

The radio frequencies in the VHF/UHF bands are the most widely used. In general, radio frequencies are assigned by making an application to the authority controlling the radio frequencies. When the emission and receiving points are on a line of sight, the communication distances are generally decreased from the VHF band to the UHF band.

G.3 Radio circuit design

G.3.1 Determining quality standards

The signal-to-noise ratio (S/N) values shall be determined in advance. These values are used to judge whether the quality of the radio circuit can satisfy the required quality standards. If the measured S/N values are lower than the designed S/N value, measures (such as relocating the station or setting up a relay station) should be taken.

G.3.2 Radio path study

G.3.2.1 General

In general, the following procedure is used for a desk study of radio path.

G.3.2.2 Preparing terrain profiles

Prepare the terrain profiles by analysing the route topography on scale maps (normally, the scale is 1:50 000) or using the digital map database.

G.3.2.3 Calculating propagation losses

Calculate the propagation losses by considering each of the following losses:

a) free-space loss, which is determined by the distance and frequency used;

b) diffraction loss, which is determined by the depth of maximum diffraction along the line between two points of emission and receiving, and the distances from the diffraction point to the emission point and the distance to the receiving point;

c) other losses, which are plane-earth and spherical-earth losses.

G.3.2.4 Determining specifications of equipment

Determine the transmission output and the type, direction and necessary height of an antenna to satisfy the designed S/N value, taking into consideration the characteristics of the receiver (such as the receiver noise power and the S/N improvement factor), the antenna angle loss and the antenna system loss.

The points that should be considered in designing radio circuits are described below.

— When a lot of interference is anticipated, the loss at a rejection filter should be considered.

— When remote telemetry stations are distributed over a wide area, antennas that have wide beam-widths should be selected and oriented to the site with the worst designed S/N.

— The higher the output power of the transmitter, the better is the quality of transmission, and the smaller are the effects from other systems. However, such a transmitter may cause interference to other systems. The minimum necessary output power should be implemented.

G.3.3 Radio propagation tests

The actual radio propagation may differ from the radio path study due to buildings, trees and environmental noises that cannot be determined in the radio path studying. Radio propagation tests should be conducted at candidate sites of emission, receiving and relay stations.

The survey should include S/N measurements, field strength (received power) measurements and external noise field strength measurements. If necessary, the horizontal and vertical antenna patterns should be investigated. Interferences on the scheduled frequencies should also be monitored.

These survey results are fed back to correct the desk design values and determine the types of antenna and the output power of the transmitter.

Finally, a test report of radio link should be presented.

Annex H
(informative)

Network architecture

H.1 General

Telemetry systems are available in various configurations, and generally follow X:M:N architectures which are described in this Annex.

H.2 1:0:1 architecture

This type of system is a point-to-point system consisting of one remote telemetry station for one receiving centre. Since the system can entirely occupy the said link, continuous transmission is also possible.

Key

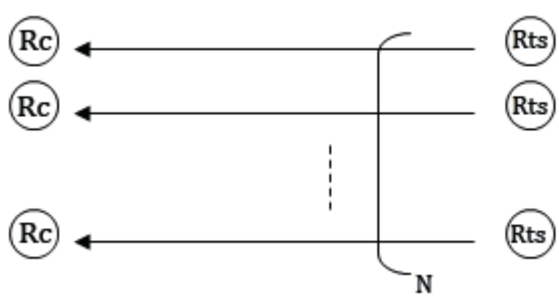
Rts remote telemetry station

Rc receiving centre

Figure H.1 — 1:0:1 architecture

H.3 (1:0:1)x N architecture

This type has a number (N) of point-to-point systems, each of which consists of one receiving centre and one remote telemetry station. This architecture is widely used for systems that are to be expanded every year or those that are used for individual classes of service.



Key

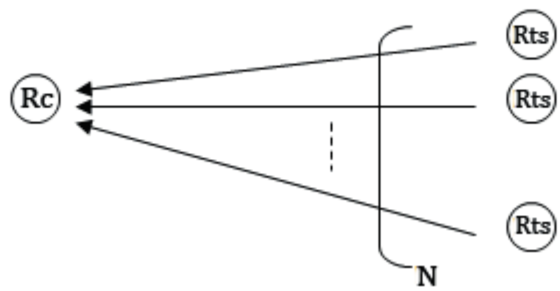
Rts remote telemetry station

Rc receiving centre

Figure H.2 — (1:0:1)x N architecture

H.4 1:0:N architecture

This type has various remote telemetry stations (N) connected to one receiving centre. It needs only one master station and ensures the downsizing of equipment and energy saving. Since various stations jointly use a link to communicate with the master station, this configuration is inappropriate for those systems that need continuous monitoring, but is appropriate for systems that should monitor at relatively long intervals the operational status of equipment and collect measured data from points that are scattered over a wide area.



Key

Rts remote telemetry station

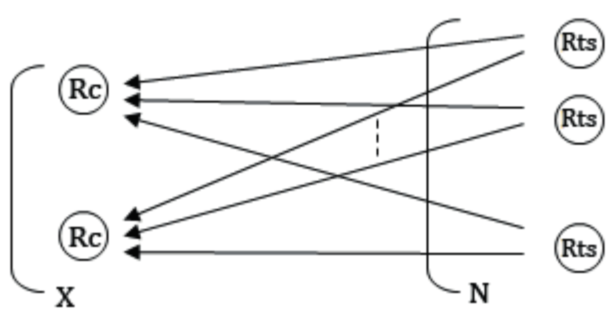
Rc receiving centre

Figure H.3 — 1:0:N architecture

H.5 X:0:N architecture

This type has X receiving centres connected to N remote telemetry stations. It has the advantages of both architectures (1:0:1) x N and 1:0:N.

Multi-receiving centres may also be used to reduce the time necessary for collecting data. In such a case, the remote telemetry stations are divided into multiple groups from which data are collected at the different receiving centres. In both cases, the receiving centres may be designed for multiple receiving to minimize the system-down effect.



Key

Rts remote telemetry station

Rc receiving centre

Figure H.4 — X:0:N architecture

H.6 1:1:1 architecture

This architecture has a relay station between a receiving centre and a remote telemetry station. The features of this network are selective output of information from the remote telemetry station, transmission of edited information from the remote and relay stations, and discrimination of control instructions.

This type of network has many advantages over the conventional networks connecting two sets of the 1:0:1 system because it has reduced input and output circuits at the relay station, ensuring reduced equipment size, improved accuracy, and energy saving.

Key

Rts remote telemetry station

Rc receiving centre

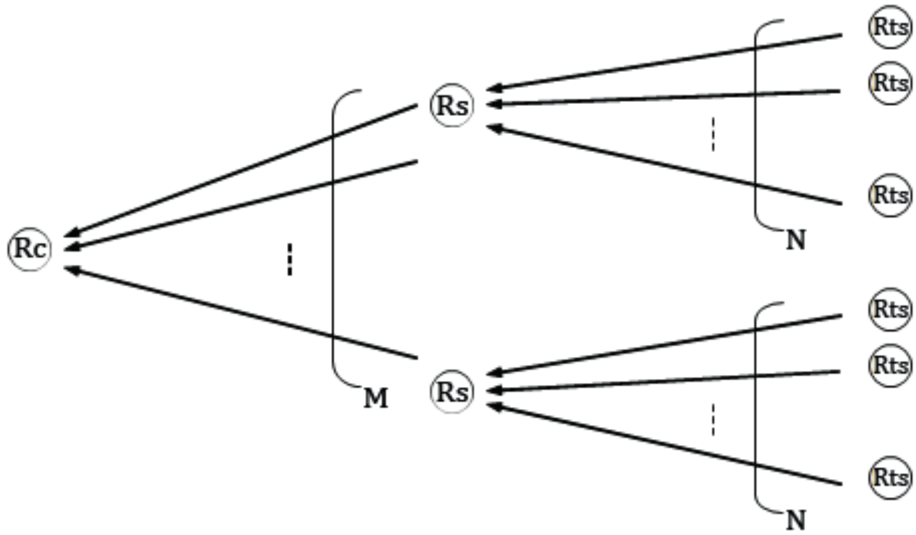
Rs relay station

Figure H.5 — 1:1:1 architecture

H.7 1:M:N architecture

A number of remote telemetry stations (N) are connected to several relay stations (M) and to one receiving centre. This network is widely used in large-scale centralized monitoring and control systems for use in wide areas. In many cases, subsystems having the 1:0:N architecture may be configured with a remote telemetry station and M number of relay stations. As the number of remote and relay stations increases, it is usual to duplicate the receiving centre in order to enhance the system reliability (H8 X:M:N).

Data collecting time may be reduced by dividing remote telemetry stations into a number of groups.



Key

Rts remote telemetry station

Rc receiving centre

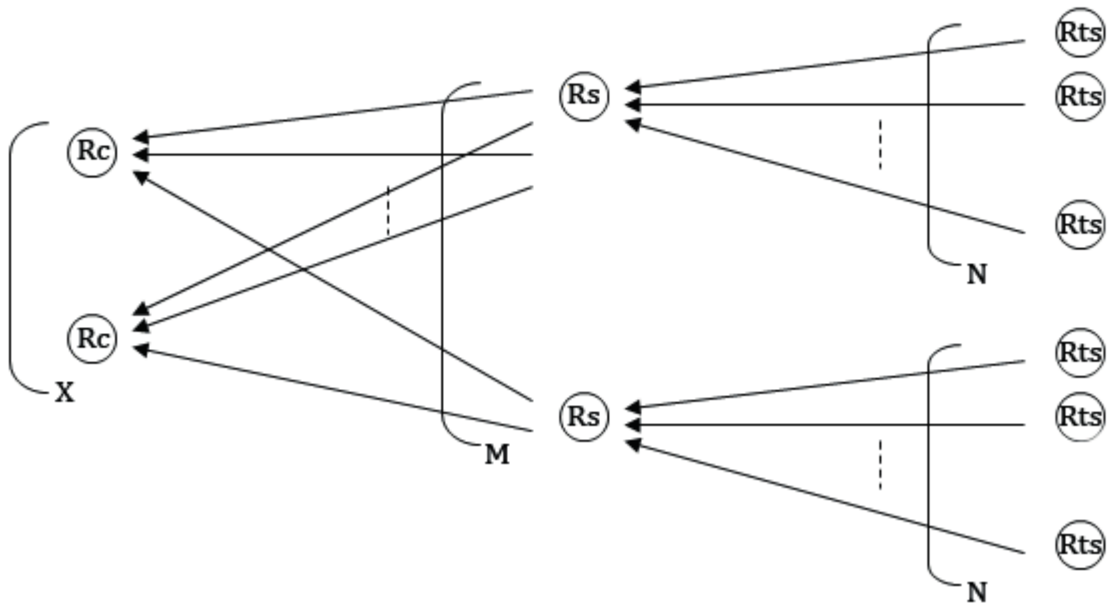
Rs relay station

Figure H.6 — 1:M:N architecture

H.8 X:M:N architecture

Receiving centre can be designed for multiple receiving, if necessary. Figure H.7 shows the architecture with multiple redundant receiving centres.

Data collecting time may be reduced by dividing remote telemetry stations into the number of relay stations, in addition to improvement of reliability.



Key

Rts remote telemetry station

Rc receiving centre

Rs relay station

Figure H.7 — X:M:N architecture

Annex I
(informative)

Data repeating methods at a relay station

I.1 General

The data repeating method can be classified as either real-time or store-and-retransmit methods.

I.2 Real-time data repeating method

This is the method of transmitting data in real time, i.e. at the same time a signal is received.

In using a radio link, the receiving frequency is generally different from the transmitting frequency in order to avoid interference. The analogue transmission system may be inadequate for multi-stage repeating because of noise pile-up. However, the real-time data repeating circuit is simple. In addition, the equipment with a voice communication function at both points has an advantage in that maintenance, using voice communications, is available.

I.3 Store-and-retransmit data repeating method

In this method, a signal is stored after it is received, then is transmitted a certain time later.

As the reception time is different from the transmission time, it is possible to use the same frequency for both receiving and transmitting. Generally, since the data are processed as digital values, the deteriorated data will not pile up. Therefore, this method is suitable for multi-stage repeating. The store-and-retransmit data repeating method takes longer than the transmission time and it increases frequency interferences, so it should be designed with caution. Furthermore, this method does not allow maintenance with voice communications or an alternative means of communication for maintenance, for example when text exchange is needed.

Annex J
(informative)

General power supply for remote telemetry stations

J.1 Where a commercial power line is available

J.1.1 General

When a commercial power line is available or can be installed, the existing power source is usually used unless there are special reasons.

J.1.2 DC power supply

DC power supply provides uninterruptible power supply that is widely used when DC voltage is required by loads.

The equipment obtains the necessary DC power by inputting AC power. It is equipped with batteries or a battery-charging function to supply DC power.

In selecting a DC power supply, it may be necessary to ensure that the units have the charging capacities to satisfy the average power consumption and charge batteries.

J.1.3 AVR

Automatic voltage regulators (AVR) may be needed if the fluctuation of power exceeds the allowable range. Since the regulators are not equipped with backup functions, another unit with a backup function should also be used if the backup is necessary.

J.1.4 UPS

The uninterruptible power supply system (UPS) is widely used when an alternative current voltage is required by a load.

However, long uninterruptible time systems need large, costly, built-in batteries. When the need for a long uninterruptible time is anticipated, an engine generator for backup is jointly used to ensure the start-up function.

If the power is also supplied to a personal computer, UPS is widely used to ensure the time until the computer can shut down.

J.1.5 Backup engine generator

Backup engine generators are sometimes used together with UPS and other systems for especially important observation points where long and frequent power failures are likely to occur. There are generator systems that are equipped with optional functions that automatically detect power interruption and start the generator.

J.1.6 Lightning protectors

When using commercial power lines in areas where lightning occurs frequently, it is strongly recommended to use lightning protectors such as lightning transformers.

J.2 Where no commercial power line is available

J.2.1 General

Power supply systems should be selected by considering the conditions of each remote telemetry station, the maintainability of the supply system, the harmony with the peripheral environment, costs, etc.

The installation of solar panels and wind turbines may require permission according to local regulations.

J.2.2 Photovoltaic power generation

Photovoltaic power generation is most widely used since it can supply a relatively stable output power. To generate a high output power, the site must be able to accommodate a large solar panel.

Solar panel should be combined with storage battery to supply necessary power during no-sunshine duration. A charge controller and blocking diode are suggested.

J.2.3 Wind turbine generation

In places where winds of certain speeds are available, wind turbine generators or combinations of wind turbine generators with photovoltaic power generators are used. It is better to introduce wind turbine generators after making wind surveys for one to two years. Since power generation is proportional to the cube of wind speed, care should be taken to determine the capacity.

A wind turbine should be combined with a storage battery to supply necessary power during periods with no winds. A charge controller is suggested. Hybrid power system combining with photovoltaic power generation is also suggested.

J.2.4 Batteries only

For remote telemetry stations where it is difficult to acquire a power supply, telemetry systems are operated with batteries with relatively large capacities. In these cases, the telemetry systems should be designed for power saving and batteries should be periodically exchanged.

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