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Challenges in using RF link for intra-site communication at IMS waveform stations

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P4.3-558

POSTER

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ABSTRACT

Radio frequency (RF) systems are used at large number of IMS waveform stations for transmitting data and State-of-Health parameters from the array elements to the Central Recording facility.

Main operation and maintenance challenges experienced over time are related to equipment obsolescence, aging, material deterioration or harsh environmental conditions. RF equipment must receive regular preventive inspections and maintenance in order to ensure stable radio links and to achieve expected reliability over years of operation.

Unnecessary downtime can be avoided by implementing efficient technical solutions and by having regular maintenance of RF transmission equipment, by performing appropriate monitoring of critical parameters and by having recourse of qualified RF engineers for design, implementation and training of station operators.

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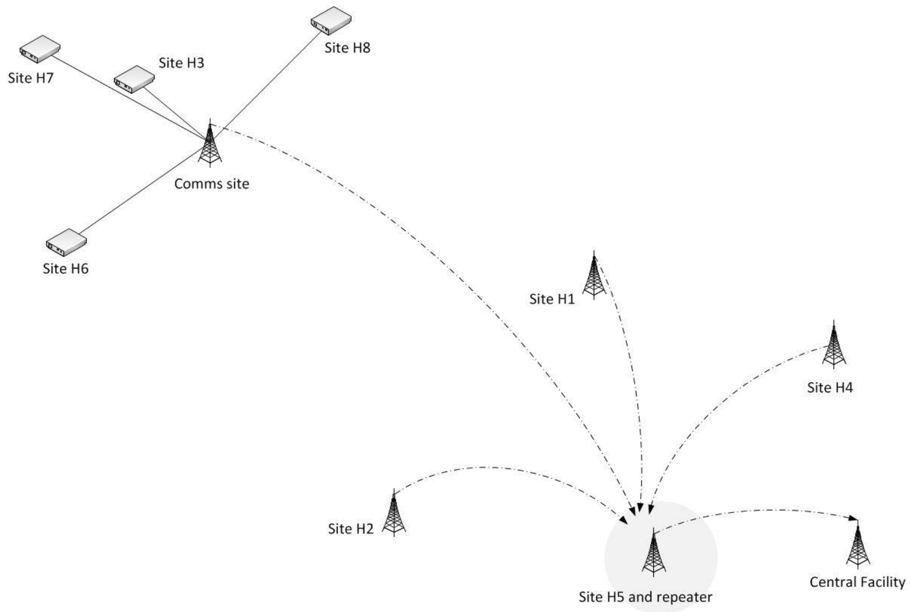
BACKGROUND

Standard IMS array stations consist of several sites of remote geophysical monitoring equipment recording and transmitting data to a Central Recording Facility (CRF). An IMS station can be comprised of 1 to 40 remote sites with distances between the sites and the CRF varying from a hundred meters to tens of kilometres.

Data transmission within the array is typically performed by wireless RF communication (400-5900 MHz), fibber optic communications or via copper wire communications. Communication equipment choices are made with respect of the environmental conditions, local licensing regulations, remote locations and the availability of power.

At several stations with RF link, a repeater is installed between the sites and the CRF, in order to overcome large distances or obstructed line-of-sight.

The figure shows an example of a station with 8 remote sites. Sites H3, H6, H7 and H8 are connected by copper cable to the RF modem located at a comms site. Data from this site and from sites H1, H2, H4 and H5 are transmitted to the CRF via repeater collocated with H5.



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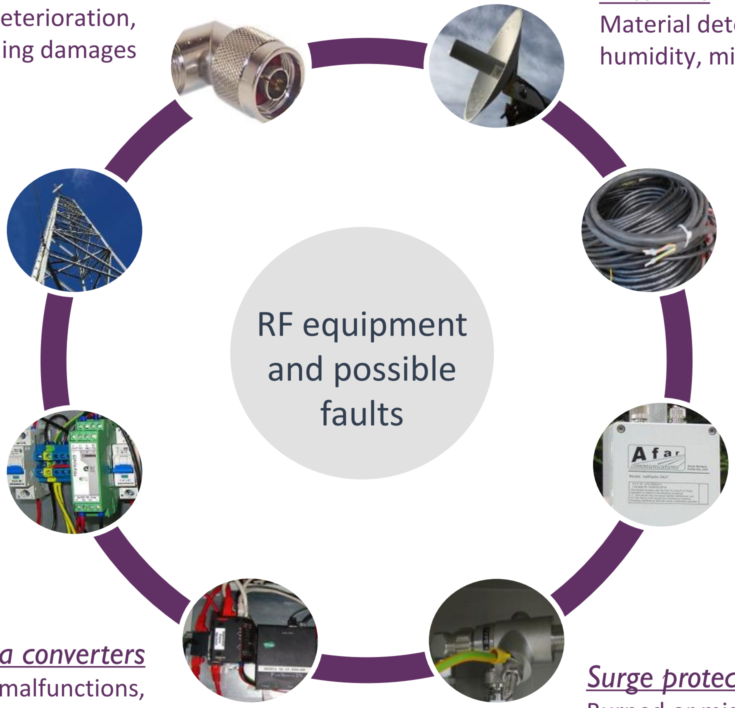
PROBLEMS



Connectors
Material deterioration, humidity, lightning damages

Antennas
Material deterioration, humidity, misalignment

Antenna towers
Material deterioration, instability

Cables
Material and insolation deterioration, mechanical damages, humidity and oxidation

Power supply
Technical malfunction, no input power

Radio modems
Technical malfunction, material deterioration – oxidation, humidity. Misconfiguration

Media converters
Technical malfunctions, misconfiguration

Surge protectors
Burned or missing SPD

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LIGHTNING PROTECTION

Lightning Protection

Damages by lightning are among the main causes of RF equipment failure, as the antennas on the radio towers and the coaxial cables are directly exposed to lightning strikes.

Coaxial cables are subject to hazards from surge currents damaging to insulation between the inner and outer conductors and may destroy the cable and damage also the radio equipment connected to it. These damages might not be visually noticeable. At the same time, inspecting RF cables in a radio tower can be challenging due to height and safety constraints.

In order to minimize the risk of damaged radios, it is crucial to install RF and power/communication surge protection at all radio installations.

DEHN DGA AG N-type and DEHN DPA M CLE RJ45B48 surge arrestors are easily mounted inside the protection enclosure and are used to protect the radio modem both sides – RF and power/communication respectively. Another DEHN DPA M CLE RJ45B48 Ethernet surge arrestor is installed inside the equipment enclosure, at the entrance of the comms box, where power supply and Ethernet switch are installed.

It is also important to keep the radio masts grounded and install cables in metal conduits, tied closely to the radio masts.

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OBSERVED ISSUES

Maintenance of RF installations

Visual inspection of radios, cables and antennas are important to keep the radio links intact and operational over years of time. However, visual inspection can be challenging, both because much of the equipment is usually installed on radio towers, but also because not all failures can be detected visually.

Radios and surge protection should be installed so they can be easily replaced by the station operator. Configuration information of a radio for a specific site must be available at the CRF so the station operator can configure the spare radio correctly.

RF cables, connectors and antennas have shown to degrade when exposed to rain, humidity, temperature fluctuations and maybe lightning strikes or similar. As these degradations are seldom easily visually noticeable, monitoring the individual link performance over time is a necessary tool to identify transmission problems. This is easily monitored by checking the individual signal strengths (measured in dBm) directly on the root radio. If one or more links keeps loosing signal strength, troubleshooting and repair should be planned and conducted in due time with minimal effect on data availability.

When planning for repair, it is often necessary to plan for replacement of all components in the RF systems, including the RF cables, connectors and antennas in order to be sure to correct all failures. This will often require hiring a certified climber for the work in the radio towers as well as an RF engineer.

Since many stations have been operational for more than 15 years, it has also been seen that trees have grown to a size that is now affecting and disturbing the radio links. Careful planning must be taken to keep the link paths free or alternative routes or communication setup must be installed.

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SOLUTIONS

Roaming operation

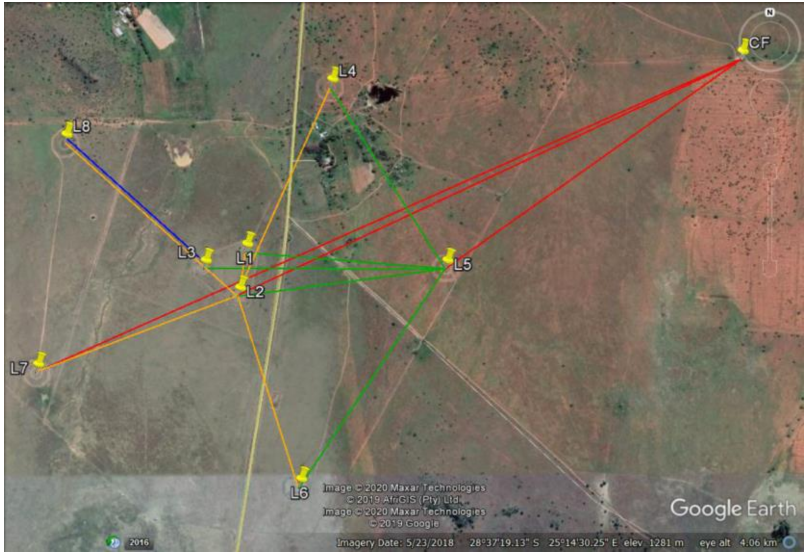
A new type radio modem, now widely used at the IMS network, has a roaming functionality, enabling the network of radios to use different paths and routes to send data from the sites to the CRF.

For each channel, as set in the configuration, the radio measures the RF signal strength from that parent, and the cumulative performance for reaching the CRF through several hops if necessary. Based on this assessment the radio chooses one specific path to reach the CRF.

While in operation the radio continues to scan and assess the performance of the alternate routes to the CRF. At any time that the current connection fails or becomes weak, the radio may change its channel to get a stronger route to the CRF.

This roaming functionality eliminates the risk of one repeater site being a single point of failure for multiple sites and hence makes the radio network more robust towards a failing radio.

For the example shown here, the figure shows the most likely links to be used based on radio location and directional antennas. The use of roaming mode mitigates the risk of single point of failure that represents the repeater at L5.



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CONCLUSIONS

Various communication systems are used at the IMS waveform stations. Equipment obsolescence, aging, material deterioration or harsh environmental conditions may cause drop of the transmission. Roaming operation of the radios allow to reduce the risk of having repeaters as single point of failure.

Regular preventive inspections and maintenance are essential in order to ensure stable radio links and to achieve expected reliability over years of operation.