

## GestInc – The Incidents Data Base

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**Abstract.** Nowadays, Quality of Service requirements, imposed to the electrical utilities, force them to develop efficient processes to register and organize incident data, which allow cross-referenced and fast access to the information and a greater reliability in data collection and in statistic indicators calculation.

REN – Rede Eléctrica Nacional, S.A., the Portuguese Transmission System Operator (TSO), developed an application to manage all incidents occurred in REN's grid. This application is called GestInc.

### Key words

Incident, interruption, quality of supply, energy not supplied.

### 1. Introduction

Electrical utilities are daily confronted with disturbances and anomalies in their grids. In consequence, it is extremely important to have an efficient registration and analysis system.

The development of information technologies and the present-day automation level of substations offer a large set of data to analyse, allowing a strict treatment, integration and data presentation, having access to more trusty results and interpretations.

The remote control effectiveness and efficiency is increased by the greater reliability of the available data. It is also used as a decision support tool for corrective and preventive maintenance. Quality of supply statistics and indicators calculation is based on the referenced data filled in and processed.

GestInc application, mentioned in this article, answers with effectiveness all these needs.

REN – Rede Eléctrica Nacional, S.A., as the National Transmission Grid (RNT) concessionaire, publishes every year the Quality of Service Report, where statistics and indicators obtained through GestInc are presented.

### 2. Incident Concept

An incident is an event that leads to disconnection (not planned) of one or more grid's elements (incident elements), which may lead to energy not supplied.

These elements are subdivided in: "Origin Elements" and "Affected Elements".

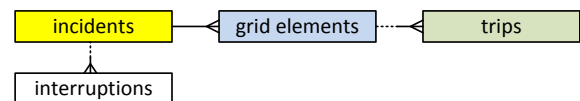


Fig. 1. Incident Structure

- Origin Element – grid's element where the fault occurs;
- Affected Element – grid's element, that hasn't any fault, but is removed from service in the sequence of a fault in the origin element. Affected Elements may exist when:

- incorrect functioning of a protection relay;
- overloads;
- busbar protection and breaker failure protection performances;
- zero voltage on a grid's area;

or exists a:

- breaker which is shared by two grid elements series connected (and one is, of course, the incident's origin element).

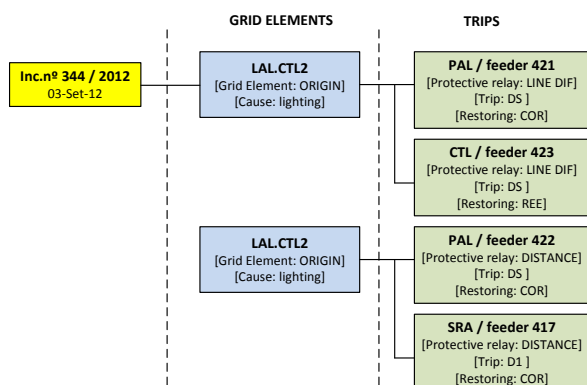


Fig. 2. Incident Example

### 3. GestInc – Incident Data Collecting and Treatment Application

#### A. Architecture

This application was developed in Access and Visual Basic for Applications, presenting Client-Server architecture. The executable file is placed on the user's personal computer, while the incident's data base resides on the server. New versions are automatically updated in the personal computers. This is a transparent process to the user.

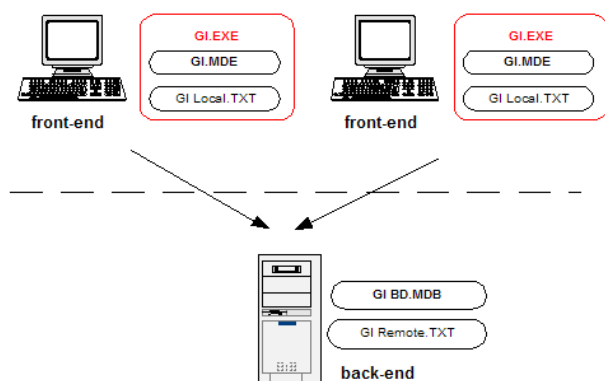


Fig. 3. Client – Server Architecture

#### B. Structure

The main purpose of this application is to organize and manage a large set of information, which is essential to future memory record production. The application's data base intends to be simple under a table structure organization.

##### 1) Application support tables. Each incident record is supported by a set of tables, of which stand out:

- Grid elements – RNT and border elements record that are subdivided in: power lines, busbar, transformers, capacitors, shunt reactance and power generators;

- Delivery points – all the delivery points where the electric energy is delivered either to clients or other grids;
- Electrical facilities – all REN's substations, power plants, EHV Clients and Spanish Electrical Transmission Grid border substations;
- Incident causes – all causes and their types used on incident classification, in accordance with Quality of Service Regulation;
- Restoring agents – all agents (entities and automatic devices) that close the breakers, manually or automatically, after a trip or a non-expected opening, putting the element back into service;
- Fault types – fault characterization (phase identification);
- Protections relay and trip types – all existent relays that may act in case of incident and associated trips.

##### 2) Application support tables. Main tables store incidents data.

Fig. 4. Main Incident's Register Display

Fig. 4 presents the display where incident's data are filled in. This display is divided into three embedded windows, being the higher level window related to the incident's common data. The grid elements related to the incident are in a second level. This level can contain several records, depending on the number of grid elements involved in the occurrence. Associated to each one of these is linked a third level window, which has its trip information.

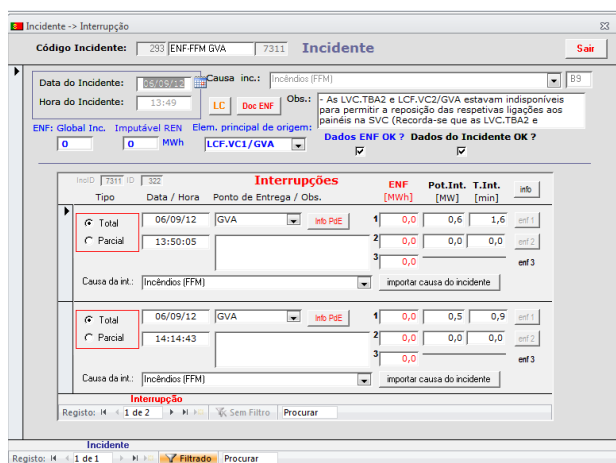


Fig.5 refers to interruptions record display, which consists of two embedded windows, being the higher level one similar to the incident's one, which contains the grid element responsible for the fault and overall of energy not supplied.

The second level window refers to energy not supplied by delivery point.

The previous displays are reached through the following one:



Fig. 6. Incident selection display

Here it is possible to filter incidents one by one or grouping them by periods (monthly, quarterly, annually) or even per grid element.

### C. Information Gathering

To perform incident analysis and populate the application data base, the following information is necessary:

- SCADA (Supervisory, Control and Data Acquisition) records;
- Chronological data logging of involved substations;
- Involved feeder fault records;
- Incident cause identification.

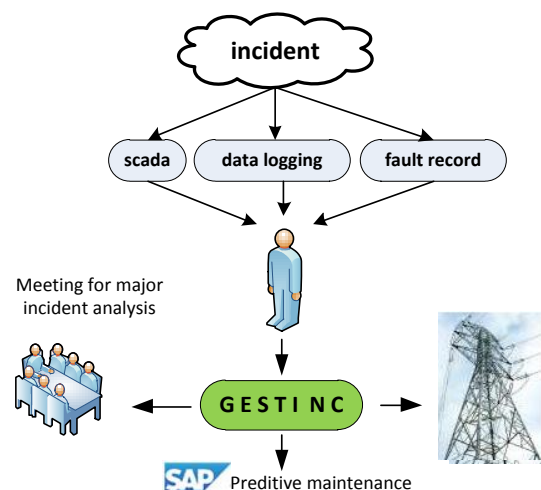


Fig. 7. Incident analysis organization

- 1) *Chronological data logging.* These records are downloaded from each substation local control system and its process, which isn't mentioned in this article, runs from a specific application capable to establish communication with different manufacturer's systems (via modem or via data network). Through these records it is possible to identify which protection relays have acted, the fault phases, trip type and if they are in agreement with SCADA records.
- 2) *Fault recording.* The fault records are imported through manufacturer's specific applications which allow incident's current and voltage curves analysis. It is also possible to identify the protection relays involved, the fault elimination time, the maximum short-circuit current value and the distance to the fault.

#### D. Fill In

Grid's operation and supervision centralization associated with local register import capacity speed up the data gathering process and the incident analysis activity, allowing a prompt data base population.



Incidents records converge in the Grid Operation Centre. Through these it is feasible to analyse correctly and fill

the application's data base. Incident information stays available to all interested users, in a systematic way, i.e.: Quality of Service, Protection and Control Systems, Substations Maintenance and Lines Maintenance Departments.

1) *Incident display (1<sup>st</sup> level)*. The data entry begins with first level window (incident common data) fields, i.e., numbering the new record and introducing the exact date and time. Incident's origin, repercussion, cause, name of operator and relevant comments are also introduced at this level. The first three mentioned fields are chosen from a lookup table. These fields purpose is to classify the incidents in order to get the intended results.

Origin field has the following options:

- MAT-SP – National Transmission Grid Primary System in EHV;
- MAT-SA - National Transmission Grid Ancillary Services;
- AT-SP - National Transmission Grid Primary System in HV;
- AT-SA - Ancillary Services for HV (border with the Distribution Grid);
- SE – External Electrical Systems to REN where can occur incidents that open breakers on REN's substations (Producers, EHV Clients and Distribution Grid).

Repercussion field has the following options:

- ENF – the incident has caused Energy Not Supplied which REN is responsible;
- MAT – the incident has removed from service EHV elements, whether is origin or not;
- ROEMR – the incident has affected other or others elements of the same grid;
- AT - the incident has removed from service HV elements, whether is origin or not.

All repercussion options can be matched between themselves, in order to have all possibilities to combine with origin options.

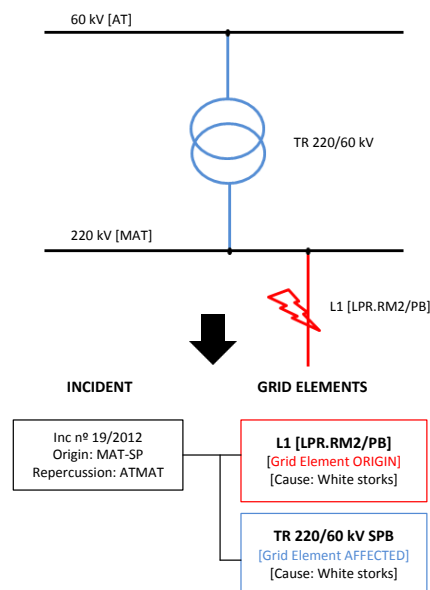


Fig. 9. Classification example

2) *Grid element window (2<sup>nd</sup> level)*. In elements grid window it is selected the grid element and ORIGIN / AFFECTED classification. It is also filled in the date and time of removing and restoring of service, the fault type and nature.

3) *Trip window (3<sup>rd</sup> level)*. In trips window is filled in all data related with affected feeders. At this level the fields which are filled in are the following: trip date and time, restoration date and time, substation, feeder number, protection relay, type of trip, restoring agents, short-circuit current ( $I_{CC}$ ), fault elimination time (TED) and distance to fault. A flag will be selected if the grid element is in by-pass.

4) *Incident grouping*. Incident grouping consists in joining several grid elements or several occurrences affecting the same grid element in one record which means a single incident with more than one origin element, according to the following rule:

- Incidents due to same cause (cause must be either forest fires or fog) and time interval between trips minor than 10 minutes, that could involve one or more grid elements located nearby.

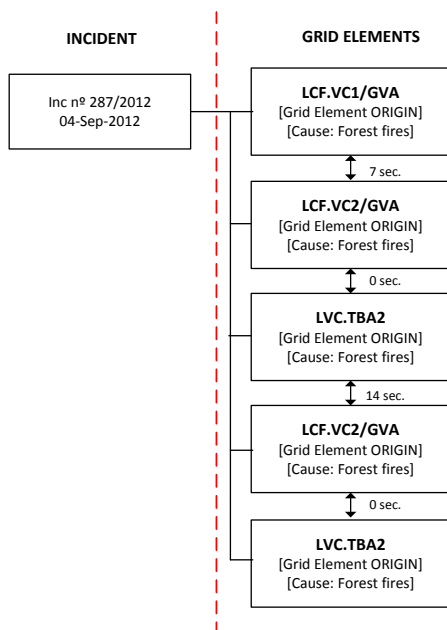


Fig. 10. Aggregation example

5) *Interruption window.* In case of supply interruption at least in one delivery point it is necessary to fill in the data in the interruption window. The date, time and incident cause are automatically stamped in this window from the incident one.

In the second level of this window, to all interrupted delivery point it is fulfilled:

- a flag indicating whether the interruption has affected the whole delivery point or part of it;
- the interruption date, time, energy not supplied, interrupted power and interruption period;
- The interruption cause if it is different from the incident one.

The energy not supplied calculation follows established rules, which are beyond the scope of this article.

After the fulfilment, the total energy not supplied is automatically calculated, adding the energy not supplied at each delivery point.

Fig. 11. Interruption fulfilling example

6) *External documents links.* One of the application's features is to create a link between incident records and external documents. The following links are already available:

- a link from incident record to its data logging records;
- a link from the incident to the corresponding report, issued when a major occurrence happens.

After data entering it is possible to print simple or detailed reports for each incident.

### E. Automatic Calculation of Indicators

The RNT security of supply is characterized by the system performance indicators, according to the Quality of Service regulation, which are automatically calculated by GestInc. In the system performance indicators, the calculation of short ( $\leq 3$  minutes) and long ( $> 3$  minutes) interruptions are distinguished.

The user's access to system performance indicators results from the following display:

Fig. 12. Indicators selection display

The individual indicators are:

- Interruption Duration (ID): total duration of the interruptions verified in a delivery point, during a period of time, in minutes;
- Interruption Frequency (IF): number of interruptions on a delivery point, during a period of time.

The general indicators are:

- Energy Not Supplied (ENS): the ENS for a certain period of time is the sum of the estimated ENS, in megawatts hour, originated by supply interruptions on each delivery point;
- Average Interruption Time (AIT): measures the total number of minutes that power supply is interrupted during the year:

$$AIT = \frac{ENS}{ENS + ES} \times T \quad (1)$$



where  $ES$  is the energy supplied in megawatts hour, and  $T$  is the considered period in minutes;

- System Average Interruption Frequency Index (SAIFI): represents the annual average frequency of the interruptions on the total delivery points, during a period of time;
- System Average Interruption Duration Index (SAIDI): measures the interruption average duration on the delivery points, during a period of time, in minutes;
- System Average Restoration Time Index (SARI): is the interruptions average restoration time on the delivery points, during a period of time, in minutes.

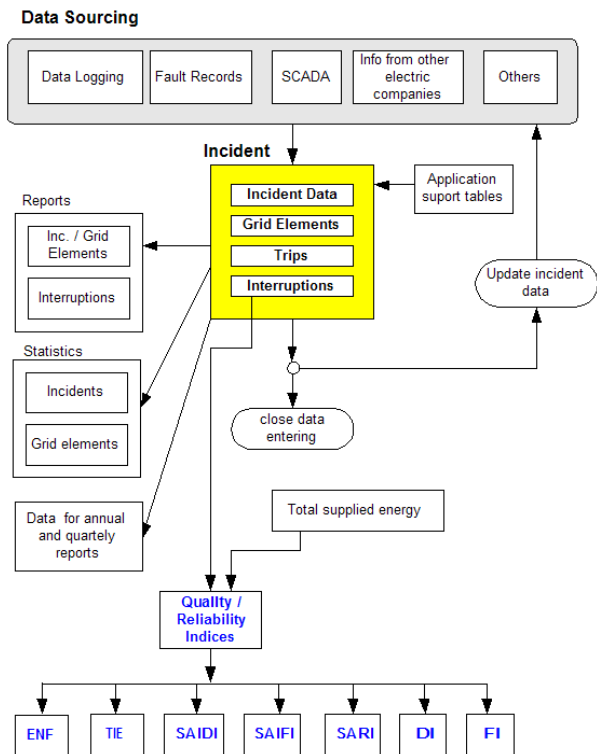


Fig. 13. Indicators organization

## 4. Conclusions

GestInc was developed by REN's internal staff. Due to this, it becomes easier to adapt and improve the application, depending on the identified needs.

Through the use of this application, we were able to identify added value to the company, namely:

- increased effectiveness on data entering and treatment;
- more accurate occurrence analysis;
- faster detection of anomalies in Protection and Control Systems;
- quick and easy access to the Incidents and Interruptions data through the company intranet;
- better Quality of Service indicators calculation;
- immediate imported records location with access through the application;
- substation maintenance support (e.g. number of switching operations and interrupted current).

From this paper it is easy to conclude how much user-friendly GestInc is. It is easy to navigate and to populate and spreads its information to several departments.

GestInc is being used since the beginning of 2001, containing all incident records until now.

It is also important to refer that this application is an auditable data source for the Portuguese Electricity Regulator (ERSE) in security of supply and indices calculation components.

## References

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- [2] J. Lobo and S. Almeida, "GestInc – The incidents data base: purposes, contents, management and automatic indicators calculation. Future developments", ERIAC – Encontro Ibero-Americano do Cigré, 2004.