NATIONAL REPORTING OF FAULTS AND INTERRUPTIONS USING CIM AND MADES/ECP

Jørn HEGGSET
Statnett – Norway
jorn.heggset@statnett.no

Ketil JOHANNESSEN
Statnett – Norway
ketil.johannessen@statnett.no

Arnt Ove EGGEN
SINTEF – Norway
arnt.o.eggen@sintef.no

Ketil SAGEN
Energy Norway – Norway
ks@energinorge.no

ABSTRACT

The Norwegian national reliability data collection system, denoted FASIT, has undergone a major renewal during the last few years, and a new version was put into operation from 2019. Improvements in data quality and reporting process efficiency are achieved by formalizing the information model by utilizing CIM and the MADES/ECP communication technology for connecting DNOs and TSO in the solution. All messages and reports in the new FASIT system are exchanged machine-to-machine, thus reducing manual work and securing data consistency between the different modules in the system.

INTRODUCTION

The FASIT (Fault And Supply Interruption information Tool) reliability data collection system has been in operation in Norway for more than 20 years [1]. In later years, new needs have appeared related to smart grids and new technologies, risk-based asset management, risk and vulnerability studies, quality of supply regulation and other purposes. Together with new possibilities and methods through digitalization of the data collection process and by utilizing links to other ICT tools, this has given rise to the development of a new FASIT version [2]. Although based on the former version when it comes to definitions and registration principles, the new version is based on modern methods for data exchange and control, among many other improvements.

The principles for registration of power system failures in FASIT are based on the bow-tie model (Figure 1), where internal and external strain (failure causes) on the left side may lead to a failure if the barriers indicated with vertical bars (B) do not prevent it. If a failure occurs, it may lead to different consequences indicated to the right in the figure, and again barriers (B) in the system may reduce the consequences.

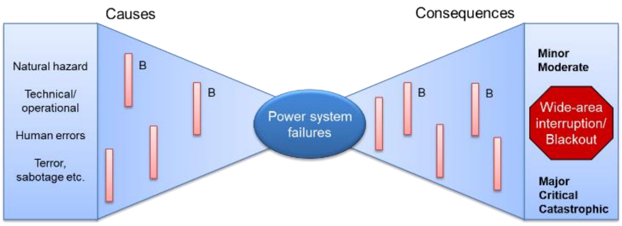

Figure 1 Bow-tie model for power system failures [3]

The system consists of five modules (Figure 2):

1. Local FASIT software – registration and reporting software for DNOs (Distribution Network Operators), including calculation of interruption consequences (ENS, CENS, etc.)
2. FASIT web – registration and reporting application for power producers and large end-users.
3. FASIT hub – the central recipient/database for reports and messages from concessionaires.
4. Control module – application where the TSO controls the FASIT reports and gives feedback to the concessionaires.
5. Statistics module – application where the stakeholders can get statistics and reports based on historic data from the national database, combined with other data sources.

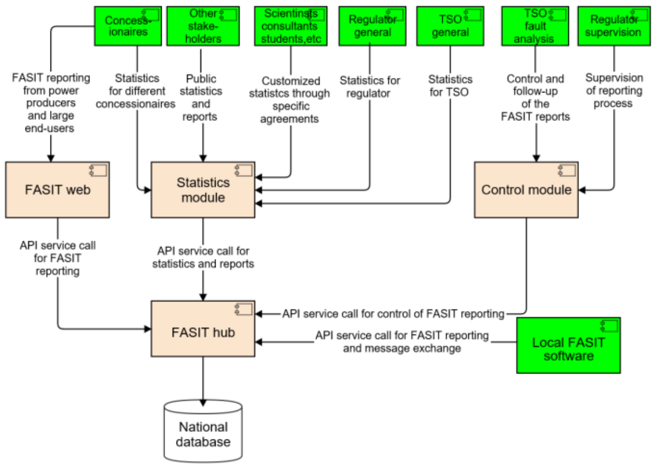

Figure 2 The FASIT modules and stakeholders

An important objective for the new system is to streamline the reporting process through digitalization. All concessionaires in Norway are obliged to report all disturbances and planned interruptions to Statnett (TSO) by using FASIT. In total, in the range of 30 000 FASIT reports are reported annually (all voltage levels). In the new FASIT system, the exchange of messages and reports are done by machine-to-machine (M2M) communication by utilizing MADES/ECP. The information in FASIT is based on the Common Information Model (CIM). This is outlined in the following sections.

COMMON INFORMATION MODEL (CIM)

The Common Information Model (CIM) [4] is an international standard consisting of classes and attributes with information about an electrical network, and the relationship between these classes. The core standards of CIM are IEC 61970 and IEC 61968.

The CIM aims to allow application software to exchange data between different systems and data structures developed by multiple parties.

The FASIT Information Model is strongly based on CIM, including «primitive» datatypes (String, Integer, Float, DateTime, etc.), «CIMDataTypes» (Voltage, ActivePower, RealEnergy etc.), «Compound» datatypes, and some of the main classes (Outage, Interruption, Fault, etc.). One of the main reasons for using CIM as the backbone for the FASIT Information Model is that CIM is increasingly used by DNOs and TSOs, and hence also is well known by software vendors. Although CIM contains a large number of attributes, special requirements from the Norwegian Regulator (NVE) lead to the specification of many additional parameters not included in existing CIM classes. Hence there was a need to specify new classes to include the missing attributes. All FASIT-specific classes are stereotyped «FASIT».

On the other hand, there was also a need to simplify the CIM model to avoid unnecessary overhead. One example is a generic class containing basic component data that in CIM are distributed in several more specialized classes.

The CIM architecture is object-oriented, and inheritance allows specialization of common base classes. The FASIT Information Model utilizes existing CIM classes, with additional necessary classes incorporated together with the standard CIM classes. Some FASIT classes inherit from the CIM base class IdentifiedObject, see example in Figure 3.

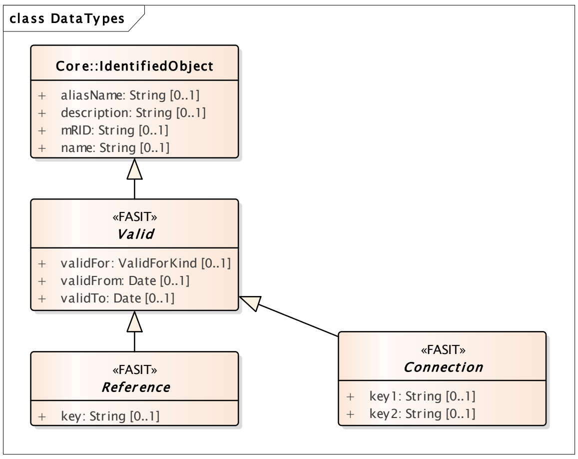

Figure 3 Example of inheritance in FASIT

The FASIT Information Model also utilizes the concept of double inheritance, where some of the existing CIM classes also inherit from special designed FASIT classes. One of the main reasons for this solution is that the new FASIT classes (attributes) can more easily be included in later versions of the standard.

Figure 4 shows that the CIM class Fault, in addition to IdentifiedObject, also inherit from the FASIT class Fault. The FASIT classes TemporaryFault and PermanentFault are specializations of CIM class Fault.

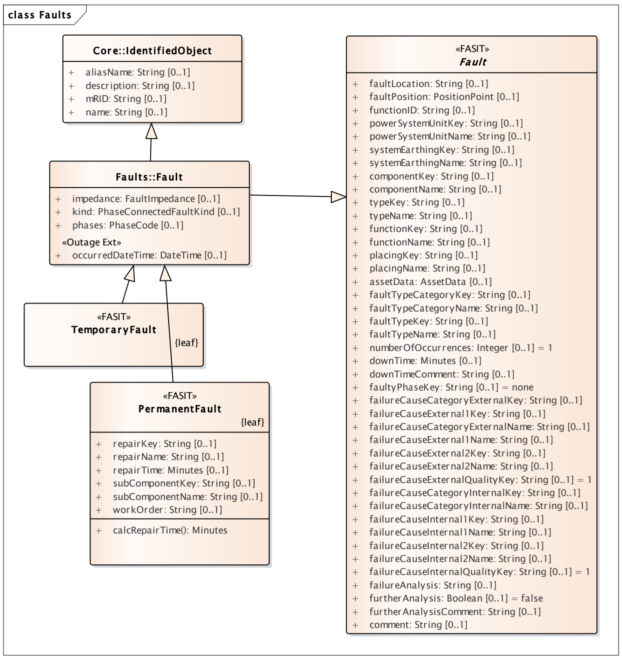

Figure 4 Combination of standard CIM classes and specialized FASIT classes

The FASIT Information Model is the basis for profiles specifying the information to be exchanged between concessionaires using predefined messages. These profiles constitute the payload element in these messages.

In addition to exchange of data between concessionaires and between a concessionaire and the Regulator, a local FASIT application may also exchange data with other local systems like NIS, CCBS, GIS, AMS, DMS and SCADA. One additional benefit of the FASIT Information Model is that vendors may use it as a basis for the specification of profiles for data exchange between such systems. This also ensures an open system discouraging "lock-in" by vendors.

The FASIT system has existed for more than 20 years and has continuously been extended due to new regulations and user needs. Static enumerations are not ideal in such situations. Thus, in the new FASIT version we have specified special classes that act as "extended enumerations" that among other things include a validFrom and validTo attribute specifying a time interval, usually a number of years, each enumerator is valid. Hence the FASIT system can add and/or remove enumerators and generate "enumerations" valid for any given year. It is also possible to create logical connections between such enumerations, e.g. a subset of failure causes valid for each component.

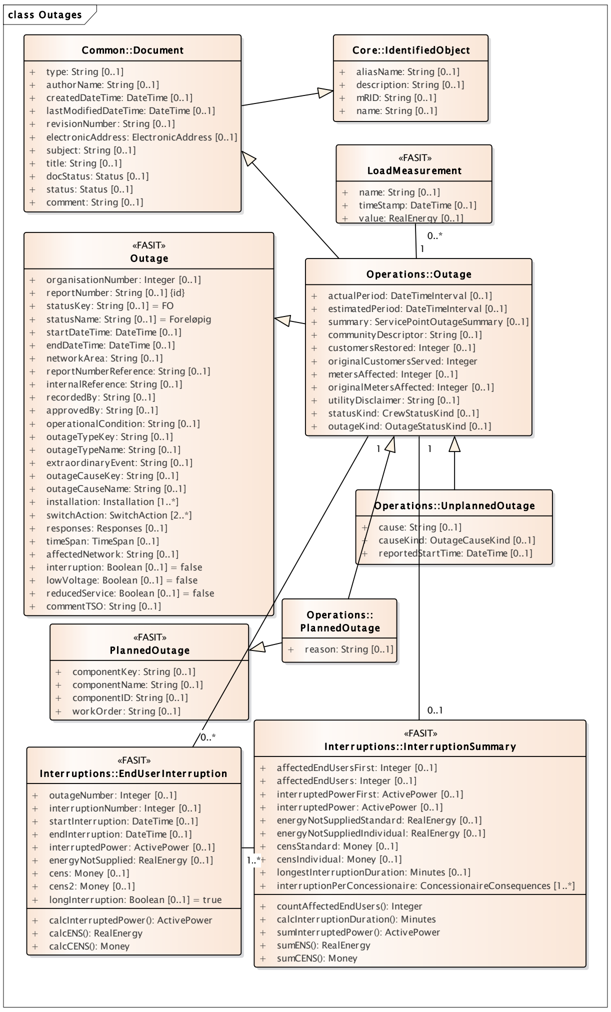

Figure 5 Part of the outage model in FASIT

MADES/ECP

Drivers for change

The application of a certain technology should always be justified by the business needs that drives the change, and the new FASIT reporting process is no different from this. The key business requirements driving technological changes for FASIT were:

- Outage and Interruption reports include information considered confidential according to current Norwegian regulation
  - Strong encryption as well as authentication schemes must be used for all communication between parties. This necessitates the need for maintaining client-side certificates used for both authentication, signing as well as encryption.
- The FASIT reporting in Norway has economic impacts for the involved DNOs due to the incentive arrangement built into the process. DNOs that are responsible for fewer faults and thus less consequences, are rewarded by a higher income cap the following years.
  - Information contained in the Outage messages as well as the Interruption messages represent financial responsibilities for the involved DNOs and this information must therefore be considered legal documents and therefore requiring "non-repudiation" and digital signatures by the respective parties.
- Reduce workload and increase quality of the reporting process through automated interfaces between the DNO parties, the TSO and the Regulator.
  - The solution must incorporate features that make manual processes unnecessary, such as exchanging attachments by email or decide on responsibility matters via informal channels (phone, email, msn, skype, etc.)
- Decentralized reporting originating from approximately 120 DNOs in Norway requires a robust solution resilient from failures caused by imminent communication network disconnects from one or more parties.
  - The system must guarantee at-least-once delivery of messages.
  - The system must be idempotent in terms of replay of previously received messages.

The chosen solution

MADES/ECP was chosen as the communication technology for connecting DNOs and TSO. Both MADES and ECP originate from initiatives under ENTSO-E [5]. MADES is a standard for market data exchange between market participants and the standard is defined by ENTSO-E. MADES is an acronym for "Market Data Exchange Standard" and is intended for facilitation of communication between TSOs and European electricity market participants.

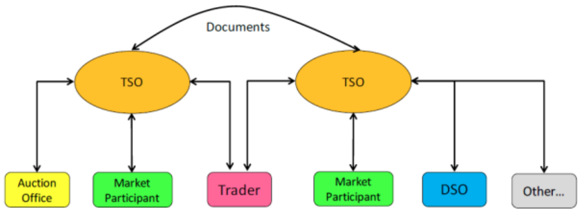

Figure 7 MADES overall view [5]

MADES specifies how message transmission and reception should be implemented in a "MADES network", including the need for the following features:

- Directory services, authentication, encryption, signing, message tracking.
- Message acknowledgement and delivery status.
- Hiding the complexity related to recipient localization, message routing as well as authentication and encryption from the business applications. The business applications can focus on solving the business domain instead of the need for implementing non-functional requirements.

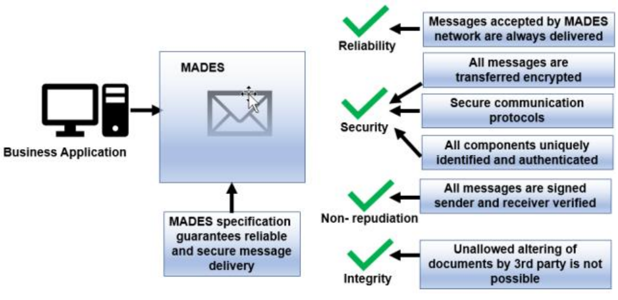

Figure 8 MADES security and reliability [5]

ECP is an acronym for "Energy Communication Platform" and is a software implementation of the MADES standard. Development of ECP is funded by ENTSO-E and is available to all ENTSO-E members and their market partners as a free licensed product. The ECP implementation consist of the following major application components:

Component directory: Application responsible for

- "on boarding" new participants in the "MADES network".
- client certificate lifecycle and distribution of authentication keys.
- directory service for routing information needed when communicating.

Broker: Application responsible for

- "store and forward" by message queueing between messaging participants.
- load-distribution of messages (optional setup).

ECP-endpoint: The Business application "mailbox" in the "MADES network". Responsible for address lookup, encryption and signing of transmitted messages, and local queuing of received and transmitted messages in transit.

Service Catalogue: Directory service of business services defined on top of the MADES network layer, services such as fault reporting, asset management or market related services.

EDX-toolbox: Application installed locally at each DNO and cooperating with the local ECP endpoint. It adds higher level services on top of the ECP such as

- plugin for directory-based file transmission between parties in the "MADES network".
- ability to transfer large files between parties.

Figure 9 shows a simple overview of an example "MADES network" and connected business applications. Although the diagram only describes a TSO and one DNO ("DNO A"), expanding this example to multiple DNOs will only require replicating the left side of the diagram for each DNO. In the diagram the DNO part shows the necessary ECP components located in the DNO internal network, and it also shows how multiple business applications shares the ECP instance for communicating in the "MADES network", the local FASIT business application (blue) being one of these. In the right part of the diagram, the necessary ECP components related to the TSO are presented. These ECP components also include the common ECP infrastructure components, such as the central Broker, the Component Directory, the Service Catalogue. The ECP endpoint and the EDX toolbox are present also for the TSO, due to the need for integrating TSO business applications with the "MADES network".

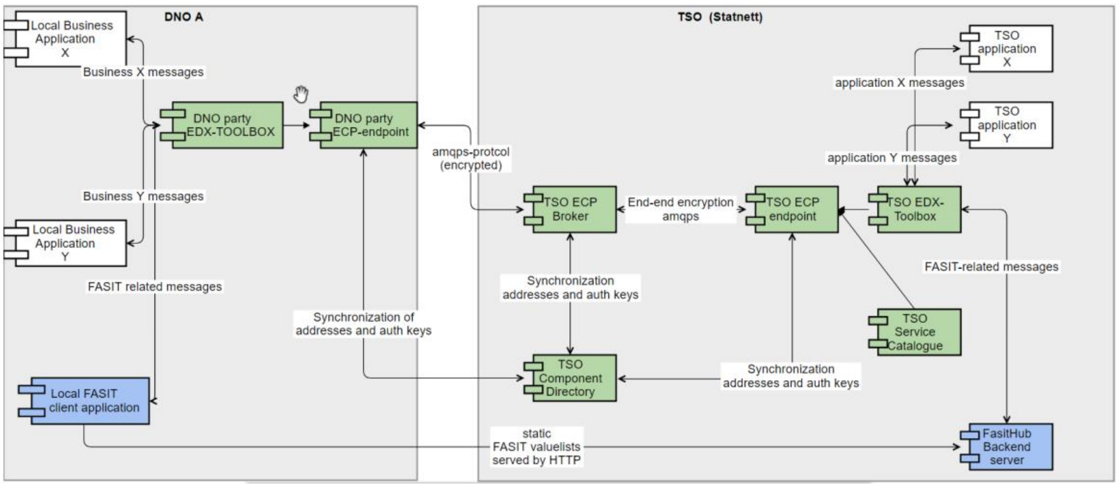

Figure 9 Example of MADES network and connected business applications

EXPERIENCES

The new version of FASIT was put into operation on 1 January 2019, and so far the experiences have been satisfying. Not many FASIT reports have been sent in yet due to a deadline of maximum four weeks after the incident, but the process has been agile for the few reports received in the FASIT hub.

ECP is currently being used as integration technology for more than 100 DNOs nationwide. The experience gained indicates that the process of rollout to all DNOs was less complicated than expected. The large variety of size among DNO organizations as well as their IT capabilities were a potential challenge in implementing the system. An important factor in reducing the complexity and thus risk in network enablement, was that the DNOs could choose between different options for network enablement. The options span from (1) doing all IT activities in-house, (2) using consultancy companies, to (3) procuring the solution as a service from a software vendor.

EXPECTED BENEFITS

The expected benefits of the new system are improved principles and guidelines for data collection leading to increased data quality, better integration/interaction between FASIT and other ICT systems, a more efficient reporting process, and more flexible report and statistics generation. All in all, a considerable improvement of quality and efficiency in asset management.

Increased data quality is to be expected by the use of a dynamic user interface, guiding the FASIT user to enter correct data consistently by relevant dropdown lists on each level. The dropdown lists are downloaded from FASIT hub and managed by the TSO. In addition, automatic quality checks both in the local FASIT software and in the FASIT hub are implemented. Finally, the FASIT user is obliged to specify failure causes together with a degree of certainty. This will reduce the amount of unknown failure causes both in the DNO's own statistics and in aggregated national statistics.

Improved efficiency is to be expected by facilitating integration between FASIT and other ICT tools, such as the Head End Systems for the Automatic Meters, handheld applications used by field staff, climatic data from third parties, SCADA, NIS, CCBS. Automatic messaging and reporting between actors involved and the FASIT hub are also expected to improve the efficiency of the reporting process.

Acknowledgments

The "Next generation FASIT" project, that has developed the new requirement specification [2], was coordinated by Energy Norway (the power industry organization) in cooperation with a number of network companies, the transmission system operator (Statnett), the Regulator (NVE), FASIT software vendors and the R&D partner (SINTEF Energy Research).

REFERENCES

[1] G. H. Kjølle, H. M. Vefsnmo, J. Heggset, 2015, "Reliability data management by means of the standardised FASIT system for data collection and reporting", *Proceedings CIRED conference*

[2] A. O. Eggen, H. M. Vefsnmo, 2018,
FASIT requirement specification – version 2019,
Publication number 434-2018,
Energy Norway, Oslo, Norway (in Norwegian)

[3] G. H. Kjølle, O. Gjerde, 2015, "Vulnerability Analysis related to Extraordinary Events in Power Systems", *Proceedings IEEE Powertech conference*

[4] Common Information Model (CIM)
https://www.entsoe.eu/digital/cim/

[5] MADES Communication Standard, version 1.1,
ENTSO-E, 20 June 2014
https://www.entsoe.eu/fileadmin/user_upload/edi/library/mades/mades-v1r1.pdf