PEGASE

PAN EUROPEAN GRID ADVANCED SIMULATION AND STATE ESTIMATION

D4.3: Feasibility of building and operating a European DTS

Grant Agreement Number: 211407 implemented as Large-scale Integrating Project
Coordinator: Tractebel Engineering S.A.
Project Website: http://fp7-pegase.eu/

Document Information

Document Name:	D4.3: Feasibility of building and operating a European DTS
ID:	**DEL_TE_WP47_D4 3-DTS ARCHITECTURE_V7**
WP:	4
Task:	7
Revision:	8
Revision Date:	29/06/2012
Author:	Promel F. / Villella F. / Bouchez F.X./ Warichet J. / Panciatici P.

Diffusion list

STB, SSB

Approvals

	Name	Company	Date	Visa
Author	Promel F.	TE	29/06/2012	
	Villella F.	TE	29/06/2012	
	Bouchez F.X.	TE	29/06/2012	
	Warichet J.	ELIA	29/06/2012	
	Panciatici P.	RTE	29/06/2012	
	Jansen J.M.	RTE	29/06/2012	
Task Leader	Bouchez F.X.	TE	29/06/2012	
WP Leader	Haut B.	TE	29/06/2012	

Documents history

Revision	Date	Modification	Author
1	14/06/2012	V1	TE
2	18/06/2012	V2	ELIA / RTE
3	20/06/2012	V3	TE
4	21/06/2012	V4	TE
5	22/06/2012	V5	TE
6	26/06/2012	V6 : update of appendix + comments on conclusions	TE
7	27/06/2012	V7: integration of conclusion on DTS test case with Elia	TE
8	29/06/2012	V8: feedback from STB	TE

Executive Summary

The continuous improvement of the security and of the reliability of the Electrical Power System (EPS) can be obtained on one hand with investments in new technologies, improvement in market design, adaptation to more complex protections and control systems. On the other hand, the role of the dispatchers is central in the operation of the power system and is one of the major components of the security of the overall EPS. Recent large disturbances on the European and USA EPS have shown that human factor can be critical during emergencies. Together with this, emerging technologies and the changes in paradigm of operation of the power system that is moving towards less predictable energy sources and power flows make the management of the dispatchers' skill a challenging task.

An improvement of the tools used by the dispatchers and a high quality, continuous training to normal and abnormal conditions and the impact of new equipments on the EPS are of paramount importance to assure the quality of energy supply in the future years.

The paradigm of system has changed and continues to change. On top of structural changes, the following internal evolutions impact the operation of the EPS:

- An already massive penetration of wind power and the growing installed capacity of distributed generation have a deep impact on the operating conditions of the entire system;
- Because it has become very difficult to build new Extra High Voltage transmission lines, more and more special control devices such as phase shifting transformers, as well as special protection schemes are being installed. These devices and schemes make the operation of the system increasingly complex;
- New power electronic technologies are increasingly used in interfaces between the network and new energy sources (HVDC VSC, micro-turbines, variable speed windmills, photovoltaic generation), which brings dramatic changes in the behaviour of the system and in its control;
- Higher power exchanges between countries and the future development of electricity highways to transfer bulk power over long distances across the continent make the national grids more interdependent and increase the need for coordinated operation as we move from the historically national operation of the power systems to a system-wide approach. This approach has to consider also the other main actors of the sector, i.e. the power producers and the distribution networks.

The increased uncertainty in predicting flows, together with the impossibility to keep sufficient preventive stability margins, brings the dispatchers to operate the system in a much more stressed state in which the fast dynamics plays an increasing role. These phenomena become even more important because of the presence of new technologies that have a strong impact on the behaviour of the EPS. Reproducing in a realistic way the system dynamics becomes every day more relevant to train dispatchers to respond correctly to unusual situations.

Because of the aforementioned structural changes in the behaviour of the EPS, the current training methodologies should be adapted. The training methodologies and processes defined by each TSO were efficient up to some extent on a national level, but their usage in the new context has several limitations:

- As operators from different TSO's are not trained together, they are likely not prepared to react correctly in a coordinated manner in case of large-scale incidents. This question is crucial and some first initiatives are already taking place between some TSO's;
- Standard Dispatcher Training Simulators (DTS) do not take into account the complete dynamics which become predominant when operating close to system limits, containing new technologies and/or showing a growing penetration of renewable energies. Consequently, operators may not understand the phenomena happening on the system and may fail to take the right decisions when facing critical situations.

A new generation of DTS is needed. It must be the cornerstone of the improvement of the operation of ETN. The authors believe that this tool should have the following features:

- **Dynamic**: in order to reproduce correctly the system behaviour for a wide range of operating conditions, the tool must be able to simulate the electromechanical model of the whole system. Robustness of this model is proven, and allows the simulation of severe incidents or unlikely situations like the ones met during emergency situations or restoration procedures.

- **Real-Time**: the DTS should react fast enough to the control actions taken by the dispatchers to represent realistically the response of the system.

- **Large scale**: the DTS should be able to handle large-scale systems to allow inter-TSO (or inter-regional) training

- **Advanced modelling:** the DTS should embed modelling facilities to allow easy and fast implementation of the new technologies that will be installed in the system.

- **Realistic and Modular**: the DTS should be open for SCADA/MMI connections, for local and/or remote training and for connection to power plant or distribution simulators. As a consequence:
    - The DTS should embed several generic communication protocols in order to communicate with any compatible tool (SCADA/MMI) through TCP/IP networks;
    - The DTS should run on data provided by the different TSOs that can be easily integrated.

Two main families of DTS architectures are envisaged for an ETN DTS:

- **Centralized architectures:** in these architectures, the power system model and DTS simulation engine are physically concentrated in one place, meaning that all data will be merged into a unique model. Instructor and operator consoles are connected locally or remotely using TCP/IP network.

- **Decentralized architectures:** these architectures are based on the principle that each TSO has formally its own DTS. All the DTS are connected together and exchange information so that the global simulation of the power system is consistent.

Each architecture has pros and cons. Detailed analysis reveals that centralized architecture can fully meet the identified training needs. A second important point is that decentralized architectures are still too speculative regarding nowadays technical barriers.

The DTS prototype developed in the framework of PEGASE project (WP4.5) covers and answer to several needs paving the way for a future European DTS.

In the field of the project, importance has been set to the algorithmic and modelling bottlenecks. As a result, the prototype contains a simulation engine which responds to the "**Dynamic**", "**Real-Time**", "**Large scale**" and "**Advanced Modelling**" requirements of a centralized DTS architecture and partly respond to the "**Modular**" requirement.

To get closer to a real European DTS and to validate the DTS infrastructure proposed, the next natural step is to build a demonstrator for the ETN DTS.

This demonstrator project should focus on:

- **Data issues**: static and dynamic data must be gathered from different TSOs in order to be merged in the simulator. The availability of models is driven in the TSOs by the needs of analysis by other applications addressing also the system dynamics (e.g. Dynamic

Security Assessment, offline simulations...). These data and models will be developed and aggregated to assess the overall security of the future ETN on dynamic tools and, of course, can be shared with the DTS application. In case real data are not available for some of the TSOs, generic data and/or models can be used instead. A common information model has to be agreed between all the involved parties. Next, ability of the architecture to connect proprietary black box models under the form of a compiled code (a Dynamic Link Library (DLL) for instance) or to connect altogether heterogeneous simulators, for instance transmission and generation simulators, for the training of power plant operators, must also be investigated.

- **Model validation issues:** the data gathered for the model are supposed to be duly validated by the different TSOs. Anyway, the merged model needs to be validated globally. Using a DTS for training operators on high end scenarios, checking common operational procedures, and testing advanced control tools will consolidate the quality of the model used in other applications such as static and dynamic security assessment or study tools.

- **Visualization:** Advanced Man-Machine Interfaces have to be designed to help operators to understand the state of the system and to have their attention drawn towards system-wide phenomena. These interfaces could also be added in control centres.

- **Legal issues**: data gathering will induce several confidentiality questions which have to be addressed. This would be the case if the information to gather should include data that are sensitive for the business, but basic technical data like inertia of generators or dynamic models of power plants designed for the purpose of a DTS shouldn't be critical.

- **Logistic issues**: training of operators is currently organised in TSO or in specialised companies. Decision is to be taken by all concerned parties to create a common training centre hosting the future European DTS.

Table of content

1. Introduction

The continuous improvement of the security and of the reliability of the Electrical Power System (EPS) can be obtained on one hand with investments in new technologies, improvement in market design, adaptation to more complex protections and control systems. On the other hand, the role of the dispatchers is central in the operation of the power system and is one of the major components of the security of the overall EPS. Recent large disturbances on the European and USA EPS have shown that human factor can be critical during emergencies. Together with this, emerging technologies and the changes in paradigm of operation of the power system are moving towards less predictable energy sources and power flows make the management of the dispatchers' skill a challenging task.

Starting from this consideration, even though this PEGASE task is devoted to the architecture of the DTS, it is interesting to consider the training of dispatchers as a whole, and not only from the point of view of the training simulators.

Training of dispatchers is a responsibility of the TSOs. In its Policy 8 [1], the RG CE[1] defines a standard framework for operational training in order to provide reasonable assurance that the dispatchers have and hold up the knowledge and skills to operate the power system in a safe and reliable manner under all conditions and at all time.

Policy 8 addresses four main topics: training programs, Inter-TSO training, training organization & dispatcher accreditation, and basic requirements for Dispatcher Training Simulators (DTS).

All European TSOs recognize the importance of dispatcher training for the security of the network. Therefore, they all have training programs. The purpose of the training programs is to prepare individuals and teams to perform their jobs and to maintain or improve their performance on the job. According to Policy 8, a training program should consist of an initial program for new dispatchers, and a continuous program for nominated dispatchers. Dispatchers in contact with neighbouring control areas should have sufficient knowledge of English to ease mutual understanding. If not, dedicated language training should be provided. The training programs include theoretical aspects, such as power system components, power system operation, and operational tools, on-the-job training, and simulator training. For experienced, nominated dispatchers, advanced theoretical aspects are treated and other competences such as stress management should be developed in the training program. The "Overview of Organisation of Training at TSOs" [2], compiled by ENTSO-E, shows that most of the TSOs have indeed a complete dispatcher training program. However, DTS sessions are not always a part of these trainings.

The aim of inter-TSO training is to focus on specific situations for the most critical boundaries in normal and abnormal conditions. These trainings also favour exchange of experience, and reinforce communication and coordination between neighbouring TSOs. The Policy 8 suggests cross visits between neighbouring TSOs dispatching, common training workshops, on-shift cross periods, and common DTS training sessions. From [2], it is clear that inter-TSO contact is considered as important, as all TSOs provide some form of inter-TSO contacts. However, many different viewpoints on inter-TSO contacts exist: for some TSOs, advanced inter-TSO training exists, while for others the program is very light. Bilateral inter-TSO trainings are quite common. Trainings including multiple TSOs are less common. There are no trainings involving TSOs from different regions in Europe.

Training organization and dispatcher accreditation distinguishes qualification and accreditation. Qualification comprises required knowledge and skills. Accreditation means a written endorsement of the proved qualifications of a person for the position of a dispatcher. Accreditation requires that the training program be organised by the TSO's management under the responsibility of a Training Management Committee (TMC) and trainers. Definition of the training program, criteria and validity duration of accreditation (first and renewal) are currently left to the

[1] Regional Group Continental Europe of ENTSO-e.

appreciation of TSOs; there are no European rules. This section addresses also the pedagogical training of the trainers, which can be provided by internal sessions or by outsourced training sessions.

A Dispatcher Training Simulator (DTS) is considered as a powerful tool to simulate the dynamic behaviour of the transmission system. A DTS can be integrated on the EMS in the dispatching centre or external, i.e. an independent simulator. An independent simulator is especially of interest for joint extended training including multiple areas. The general aim of DTS training is to learn solving situations, under normal or abnormal situations. Not all TSOs are providing simulator sessions to train their dispatchers, and if they do, dynamics of transmission systems and/or interaction between TSOs and other actors are not always taken into account.

Therefore, it can be argued that there is a lack of system-wide DTS trainings, and a lack of dynamic DTS trainings. One can ask the question if dispatchers are sufficiently prepared to react efficiently in case of cross border or system wide contingencies, or to manage correctly the increasing number of electronic devices causing fast phenomena or new behaviours in the system. Since operation of transmission system is not fully automated, the human factor is and will remain a key factor in system security. Dispatchers have to understand each situation, whatever the phenomena involved, be them slow or fast, local or global. Furthermore, they have to take adequate decisions in all circumstances, sometimes under the pressure of time or stress, and achieve operational results.

If we want to keep the current level of security of supply, training of transmission operators must follow the evolution of the power systems, i.e. a broader spectrum of phenomena must be covered, and a system-wide approach should be taken. These two important points should be reflected in the DTS as well.

2. Specification of the need

In this chapter the needs of the TSOs for a DTS will be analyzed in detail.

The input for this section comes from contacts with some of the TSO partners of PEGASE: ELIA, RTE and SO-UPS. The inputs have been collected via workshops, brainstorming sessions and bilateral contacts.

In the first part, the "Overview of organisation of training at TSOs" provided by ENTSO/e in the frame of the Policy 8 of the Operation Handbook (see reference [2]) is summarised, followed by the analysis of the current situation and the definition of the basic needs.

2.1. Current Situation

Most of the large European TSOs have some permanent staff dedicated to the training and knowledge management of the operators. This is true for RTE, ELIA and SO-UPS. Smaller European TSOs may have a limited number or no permanent staff dedicated to training and may use the services of external companies.

The training staff takes care of the organization of training session not only for the dispatchers but also for the different other profiles; the trainings involve theoretical and practical sessions with certification programs, mostly for which regards the ones about the working safety in the substations.

Among the different trainings given by the TSOs, the training of the dispatchers is one of the most important. ELIA, RTE and SO-UPS have dedicated trainings that include DTS exercises.

For ELIA, the static model, the dynamical model and the MMI displays are updated periodically. A dedicated team takes care of the model update and of the adaptation of the scenarios to the network topology that evolves continuously, while the static database and MMI is shared with the operation (EMS functions like the State Estimator, the Security Analysis, the Short-Circuit Calculation, etc.) and do not need to be specifically updated for the DTS.

The static model of ELIA includes a detailed representation of the Belgian network (up to low voltage levels – e.g. 11kV) and covers a broad representation of the European network outside

Belgium (almost the complete 380 kV transmission system of The Netherlands and France, and some buses in Germany and Switzerland). The dynamic model is an electromechanical model covering the generating units, the transmission system and the load dynamics. This model is adapted from the reference model of ELIA used for dynamic security assessment. The simulation engine is a full dynamical algorithm based on EUROSTAG (see [3]).

Trainings are organized for national, regional dispatchers and sometimes for external TSOs (e.g. RTE or CORESO). The ELIA DTS, being organized in several separate rooms, allows its use as a joint training centre in which regional and national dispatchers are trained together. This happens mostly in the case of black start (restoration after blackout) or a scenario on extreme situations during which the coordination of the different control centres is of fundamental importance. In addition, the use of specific utilities (e.g. the emergency procedure screens) can be hardly tested and used during the sessions.

RTE uses its SIDERAL DTS in dispatcher training sessions. This DTS is in-house software based on a quasi-steady state approximation. This means that slow dynamics are simulated, but fast phenomena are not considered.

The system has been developed from the late eighties and no major updates have been performed since then. The most important limitation of the system is of its limited flexibility. The data update is not a simple task as well as the models change and adaptation. Currently the investment to upgrade the DTS is not considered as a priority.

In the past, the RTE DTS was coupled to the nuclear training simulator to allow TSO-power plant dispatcher trainings, these kind of training ceased to exist after the unbundling. The trainings are organized for national and regional dispatchers separately. It is also possible to perform joint training sessions, but never with all the seven regional dispatching together.

For which regards the Inter-TSO trainings, few of them are at the moment organized.

The most advanced Inter-TSO training is given by DUTrain which is an independent DTS service provider. It is based in Duisburg and offers European-wide trainings. ELIA participates to the Inter-TSO trainings organized by DUTrain (approximately three times per year by teams of two National dispatchers). The network model used for these trainings is tuned by the various stakeholders, and dynamics are not taken into account. This affects the behaviour of the simulation. Nevertheless, the biggest added value of the DUTrain sessions is the fact of bringing together dispatchers from different countries.

Among the different European TSOs, ELIA and RTE are using procedure and advanced tools in the field of DTS tools and trainings. Their views may not be representative of all European TSOs even if they give a broad idea on the way trainings are organized.

In ANNEX1, a description of organization of the dispatcher trainings in SO UPS, JSC is presented. The transmission grid controlled by SO UPS, JSC is extremely large (it goes from Russia to Siberia), and dynamic phenomena affecting the system are addressed in their DTS.

2.2. Current and Future Needs

Even if the operational challenges encountered by the European TSOs may be different and are very various due to the size, the structure of the network, etc, the common Inter-TSO training needs can be summarized in four main topics discussed in the following paragraphs.

2.2.1. Importance of the dynamical representation in the future Electrical Power Systems

The paradigm of system has changed and continues to change. On top of structural changes, the following internal evolutions impact the operation of the EPS:

- An already massive penetration of wind power and the growing installed capacity of distributed generation have a deep impact on the operating conditions of the entire system;
- Because it has become very difficult to build new Extra High Voltage transmission lines, more and more special control devices such as phase shifting transformers, as well as special protection schemes are being installed. These devices and schemes make the operation of the system increasingly complex;

- New power electronic technologies are increasingly used in interfaces between the network and new energy sources (HVDC VSC, micro-turbines, variable speed windmills, Photovoltaic generation), which brings dramatic changes in the behaviour of the system and in its control;
- Higher power exchanges between countries and the future development of electricity highways to transfer bulk power over long distances across the continent make the national grids more interdependent and increase the need for coordinated operation as we move from the historically national operation of the power systems to a system-wide approach. This approach has to consider also the other main actors of the sector, i.e. the power producers and the distribution networks.

The increased uncertainty in predicting flows, together with the impossibility to keep sufficient preventive stability margins, brings the dispatchers to operate the system in a much more stressed state in which dispatchers have to react and take decisions rapidly. These phenomena become even more important because of the presence of new technologies that have a strong impact on the dynamics of the EPS. The correct simulation of fast dynamics becomes every day more relevant to correctly reproduce the situations that are faced regularly by dispatchers, to train them to respond correctly to unusual situations, and to illustrate the possible consequences of inadequate actions.

2.2.2. Exchange of experiences

Because dispatchers interact directly or indirectly on the system, they should exchange their experiences and get common trainings.

Having common trainings can bring as direct benefit the fact that the dispatchers meet and get to know each other, easing and improving the interactions (phone or mail...) in the daily job and better understanding of the reason behind the decisions taken in the neighbouring TSOs.

The work of a dispatcher is based on his experience that is build along the years and constitutes a real operational asset of the TSO. The operational philosophies are not the same throughout Europe and they changes depending on the structure of the network, on the evolution and on the TSOs history.

An additional benefit from common Inter-TSO trainings is that they can learn from each other and benefit from the different experiences and operation philosophies with the consequence of an overall improvement to the knowledge asset.

2.2.3. International trainings

ELIA and RTE agree that there is a need for large-scale international trainings involving multiple TSOs. These, together with correct training on local issues, are a fundamental tool to assure the security of the European interconnected power system of today and of tomorrow.

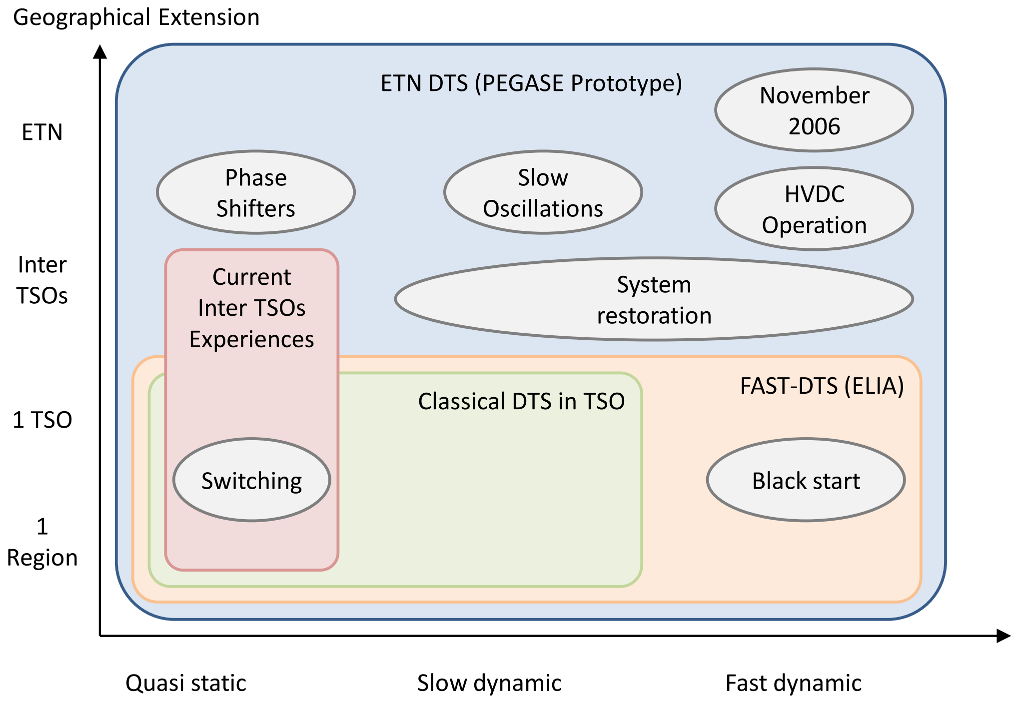
2.2.4. Training on realistic, international scenarios

The effectiveness of training is based on various factors, among which one of the most important is the realism of the scenario. The realism has a double importance: on the one hand, the dispatcher should recognize the behaviour of the DTS as close as possible to the reality and trust the DTS tool. On the other, the actions of the dispatcher should be correctly simulated because if the reaction of the model is too conservative or too exaggerated, there is the risk of inducing wrong reactions that will be then used in the everyday operation of the dispatcher with strong consequences for the network security.

The needs related to the realism of the DTS simulation are strongly related to the type of scenario and to the different dynamical aspects involved in it.

For scenarios involving slow phenomena and mostly static ones, such as controlling the cross-border flow using PST, the dynamical aspects are less relevant. For scenarios involving more dynamical aspects such as black start or scenarios in which the system is in an emergency state and far from the normal operation, an accurate and complete dynamical model and simulator is of utmost importance. An example of a realistic scenario would be relative to the incidents of November 2006 and the related restoration steps. In this case the incident and behaviour of the operators had an impact on the whole European synchronous area with the triggering a consistent amount of complex dynamical behaviour.

The figure below summarises the position of some typical scenarios according to the kind of phenomena they cause and the size of the model required for their adequate simulation. The square areas on the figure indicate the domain covered typically by some DTS.



2.2.5. Testing of operational procedures

A number of international procedures have been developed and are currently used in the operational practice. Among them, the emergency procedures and the emergency policies are valid examples of rules that have an inter-national effect that the dispatchers can apply at local level. The correct interpretation and application of these procedures is already a challenging task at a decision-making level of a single TSO and the task becomes even more difficult when the rules have to be explained and applied daily by the dispatchers and conjunctly by dispatcher from different TSOs at the same time. The DTS becomes a fundamental tool to give the possibility to the dispatchers to train about new procedures and rules that impact not only their control area.

The recent evolution of the European power system, with a growing number of flow control devices such as PST and of HVDC systems that strongly impact the classical way of operating the network, together with the massive integration of renewable, sees the increase in need of inter-TSO coordination. Indeed, an action of a dispatcher can have an impact on several other TSOs. It is expected that the number and the complexity of the international procedure will increase in the next years and multiple TSOs training will become a necessary tool to allow their correct application and improve their efficacy.

2.2.6. Case studies

The results of the analysis below are summarized in Table 1. Five different solutions for the DTS are compared. It is clear that a more complex solution may have also a higher cost that goes together with the benefits defined in the previous chapters. In addition some of the characteristics are interdependent. For example the architecture or the organizational structure could have an impact on the IT, and these links are strongly dependent on the chosen implementation. This has not been included here to keep a higher level of generality.

In the considered configurations, the first study case is a situation in which a TSO does not have a DTS for training. This is the case in Europe for some small TSOs and it is not suitable for the current needs and even less for the future needs. The realism of the training is very limited since the SCADA/MMI cannot be used actively. Nevertheless phenomena can be explained theoretically and using separate simulation tools.

Most TSOs use a DTS with the complete network model for the internal network and an equivalent for the external one. The dynamical model used is often simplified. Typical implementation covers the quasi-static phenomena (second study case) and the slow dynamics of the power plants (i.e. to model the ramp rates of the generators), but does not include an electromechanical model of the machines, which is necessary to simulate the fast dynamics. The dispatcher can thus be trained only on simple scenarios (like normal system operation, switching operations in substations, voltage control, flow control with phase-shifters, etc.) and the representation of the reality by the DTS is restricted to situations where fast dynamics is not predominant. On one hand, the algorithmic challenges, data and model are not really an issue (this kind of DTS does no require much more data than what the TSO have for their SACADA/EMS functions) and on the other, this approach it is strongly unsuitable for the future needs of the TSOs since the dynamical phenomena will have more and more importance in the future operations.

Some TSOs use a full scale dynamical DTS (third study case) that is suitable for the current and future needs of training the operators, reproducing phenomena like oscillations and instabilities on a local scale. Nevertheless, the extension of the model is limited to the TSO and to an equivalent simplified model for some of the buses of the neighbouring TSOs. As a consequence, scenarios are restricted to the local ones. The amount of data and parameters needed to collect and maintain is proportional to the complexity of the model, thus more complex than in the case of a quasi-static one. The best situation is the case where the simulation engine of the DTS shares its model with other dynamic applications in use inside the TSO, like Dynamic Security Assessment (DSA), Voltage Security Assessment (VSA), computation of critical clearing time, etc. In this case, basically only one model should be maintained for several purposes. Realism of simulations is also guaranteed by the implicit validation provided by all the other applications sharing the same model, and consequently, development of scenarios is greatly simplified. The achievements of PEGASE DTS for which regards the flexibility and the speed of simulation, together with the simplification of interconnection to external SCADA/MMI have considerably solved some of the challenges related to this solution. Indeed, thanks to the resolving power of its simulation engine, the PEGASE DTS is able to cope in real-time with highly sophisticated modelling like the ones used in advanced study tools. Sharing of a detailed dynamic model among several applications including the DTS is thus possible now.

As discussed in the previous paragraphs, there are some experiences with inter-TSO quasi static DTS (fourth study case). This approach is partly suitable for the current needs, since the realism of the results is limited, mostly for which regards scenarios where the dynamic plays an important role (e.g. November 2006 instabilities). This responds only to some of the needs of the TSOs but represent a first step in the implementation of a more complete INTER-TSO/ETN DTS.

The solution proposed in PEGASE (i.e. the fifth study case, INTER-TSO DYNAMIC) responds best to the different current and future needs of training. Most of the algorithmic challenges have been solved within PEGASE. The data collection and building of the model are more challenging here than in the case of a quasi-static simulator, but it has to be noted that the availability of models is driven in the TSOs by the needs of analysis by other applications addressing also the system dynamics (e.g. Dynamic Security Assessment, offline simulations...). These data and models will be developed and aggregated to assess the overall security of the future ETN on dynamic tools, and of course have to be shared with the DTS application. The challenges for the SCADA, IT and organization are very similar to the quasi-static case.

Table 1: Case studies

	NO DTS	1-TSO QUASI -STATIC	1-TSO DYNAMIC	INTER-TSO/ETN QUASI STATIC	INTER-TSO/ETN DYNAMIC
Suitable for Current Needs	--	-	+	+	++
Suitable for Future Needs	--	--	+	-	++
Algorithm Challenges PRE-PEGASE	--	--	+	--	++
Algorithm Challenges POST-PEGASE	--	--	--	--	-
Data Issue	NA	-	+	+	++
Model Issues	NA	-	+	-	+
IT Issues	NA	-	-	+	+
Scada/MMI Issues	NA	-	-	+	+
Organizational Issues	NA	-	-	+	+
Architecture	NA	-	-	+	+
Realism scenario	Not realistic	-	+	-	++
Remaining Challenges	NA	Scenarios range very limited	Possible to have only local scenarios	Limit Model + Organizational+Data	Organizational+Data
Future Works/Research	NA	/	/	Improve the data management	Data management issues

Legend

N/A	not applicable
--	very low
-	low
+	mid
++	high

3. Business model

This chapter gives some example of services that can be offered to the TSOs and additional benefits that can be obtained by the different TSOs.

3.1. Classical Services

The general services that a European DTS could offer are in general similar to what is already done at national level by a classical single-TSO DTS.

- An initial training for the young dispatchers before their accreditation;
- A continuous training followed at regular intervals by nominated dispatchers;
- Trainings for detailed or specific procedures;
- Specific trainings on new devices installed in the network;
- Development and training for national scenarios for TSOs which do not have a dedicated DTS or with too limited resources to develop it by themselves.

This would be in line with ENTSO-E Policy 8. A European DTS could also have a role to play in the accreditation process of dispatchers.

However, some TSOs have their own internal procedures and could be against their externalization. The evaluation process is a very sensitive issue and should be under the complete control of a TSO, moreover, there can be confidentiality limitations in the case that the information on the personal evaluation are stored in a location external to the TSO. In addition the evaluation may have a consequence also for which regards the human resource department and their processes should also be taken into account.

In any case the TSO would need to give first an accreditation to the European DTS (or the accreditation should be done by an external organism).

3.2. Additional Services

Due to the possibility to simulate part or the whole of the ETN, a European DTS would open the possibility to offer additional services for which a more complete model of the system would be needed.

3.2.1. Development of inter-TSO procedures and training on new devices/interconnections

The possibility of accurately simulate in real-time the behaviour of part or the whole European network gives the possibility to the experts and the dispatchers from different TSO to use a common platform to develop procedures involving actions of different TSOs.

Such procedures may be relative to extreme network conditions such as a black start of a unit with the support of an external network, the emergency feeding of a power plant auxiliaries supported by a different TSO...

In addition to this, specific procedure for the operation of new international connections such as HVDC or devices with a cross border impact such as PST, could be developed and tested using the DTS involving the full model of the different actors involved in the procedure.

The use of the DTS for this kind service requires having an adequate and correct modelling of the system and the flexibility to easily adapt it to include new devices not yet present in the system (e.g. new lines...).

3.2.2. Inter-TSO training with inter-TSO coupled market

An additional type of training that could be offered with an inter-TSO DTS is based to the need induced by inter-TSO market-coupling. A simulation based on inter-TSO DTS coupled with a simulator of the inter-TSO market models would give the possibility to model and analyze also the behaviour of the market and to include the market operators in the training.

3.3. Additional benefits

In addition to the benefits of promoting cooperation, sharing of experience, and testing of operational procedures, training on a different TSO network is very useful. The use of an unfamiliar environment stimulates the critical spirit of the dispatchers. Experienced dispatchers have a very good command of their tools, and are very familiar with the network. After years of experience, they could create automatic reactions by knowing what to do when incidents happen in the grid, almost without having to think about it. This may reduce the efficiency of handling unusual or unexpected incidents. In addition this situation somewhat lessens the effectiveness of the trainings. Having trainings on a grid that they do not know as well as their own one or with tools that they are less familiar with, forces them to think about the actions they take and challenge their experience based knowledge and automatic actions.

3.4. A European Training Centre

Inter TSO trainings could be organized by a dedicated instance, a "European training centre". An external entity could take the responsibility of collecting the various models, building the merged system, develop the scenario and update them continuously or periodically.

ELIA and RTE have a priori no objection against a third party organizing the trainings, as long as data confidentiality is assured. However, it seems unlikely that the third party would be totally independent from the TSOs. Most likely, an organization of TSOs is responsible, but a third party could deliver services.

In addition, the use of a dedicated European training centre would be most effective also from an economical point of view. In this case, the costs of the permanent staff can be shared among the stakeholders and would reduce the cost for each single session. Training is considered as a normal activity of the TSOs to improve the general security of the system and not a research project that could be founded by an external entity.

It should be noted that it would be possible to have more than one European Training centres for different zones of the European network.

4. Organization of Trainings

This chapter analyzes the organization of the training. Training that goes beyond what is already available is considered here. Beside the training services that are oriented to the dispatchers, a European training centre could also propose consultancy services oriented to the TSOs, for instance:

- Support to the TSOs' training management committee to structure and develop their internal training services, or to train their trainers;
- Provide facilities to test inter-TSO operational or emergency procedures.

In this paragraph, we will investigate mainly how training services could be organised for dispatchers and how this impacts the architecture of the DTS.

4.1. Training services

We have seen that operational training of transmission operators cover more topics than simulator sessions (like theoretical aspects of power systems and components). For that reason, the scope of services proposed to the dispatchers of TSOs could also cover:

- Theoretical trainings about system physics and dynamics, and power system components;
- Practical trainings on specific devices and protection systems;
- Training on new common functions of Energy Management Systems;
- Explanations on energy markets, and especially how they impact the system state and the cost in case some units need to be rescheduled;

- Trainings in close cooperation with producers, especially regarding units having black start capabilities, or auxiliary supply requirements;
- Trainings in close cooperation with distributors, especially in the perspective where distribution networks will connect more dispersed generation and controllable loads;
- Trainings to anticipate new situations, like new operational rules or new kind of equipment.

If we consider now more precisely trainings oriented to the transmission system, TSOs are interested in services that go beyond the functional capability of their current training simulators, in terms of:

- Ability to cope with cross-border and international scenarios;
- Accuracy to achieve the highest level of realism during the sessions.

The training services needed are of course depending on the situation in each TSO:

- Does it use already a training simulator and what is its covered scope?
- What are the structural specificities and weaknesses of the system managed by the TSO?

For all those reasons, adequate design of scenarios is of great importance: on one hand, scenarios must be realistic, and on the other, they must bring unusual situations, pushing the dispatchers to analyse and take decisions. Training scenarios should be the output of the following competences:

- TSOs, which put on the table the objectives of the scenario;
- Power system experts, who design the steps of the simulation;
- If needed, simulation tools expert, who make the simulation effective.

Beside the training scenario itself, it is important to provide also good quality training material including:

- Briefing before the simulation, where the instructor will explain the objective of the training, its theoretical background, the possible limitations of the simulation or of the control means, etc.;
- Debriefing after the simulation, where the instructor will analyse the good and bad actions taken by the dispatchers, investigate the control strategies and explore the possible alternatives, have a closer look at the system dynamics, etc.

4.2. Training organisation

4.2.1. Instructors' position

One instructor will manage globally the training session. He will start the simulator, trigger the events that have been prepared within the scenario, check that the simulation runs smoothly, and take snapshots of the simulation at crucial moments of the scenario (to allow replaying some parts of the simulation during the debriefing of the session).

Dispatchers appreciate also to have an instructor physically present in the class room. This instructor can help them during the simulation to analyse the situation, to take decisions and to implement control actions. This is especially the case if dispatchers use remote consoles (they are thus not present in the training centre where the simulation is run), or when they use consoles that are not their usual ones (for instance if consoles are generic ones or if the dispatchers use consoles of another TSO).

Another important role of the instructor is to implement all the control actions that lie outside the areas of authority of the dispatchers present in the training session. For instance:

- Supervisory control of TSOs that is not present in the training sessions. This might be the role of the global instructor;
- Supervisory control of TSOs that is present in the training sessions, but in areas outside the authority of the dispatchers (for instance an action at the regional level when only national dispatchers are present). This might be the role of the local instructor physically present in the class room;

- Control actions in the power plants or in the distribution networks. This might be the role of the global instructor or the local instructors, depending on the location of the action to implement.

Because instructors are in strong interaction with the dispatchers during the training, it is important to choose adequate profile for this role. Instructors might be specialised trainers, system engineers or experienced operators.

4.2.2. Local or remote sessions

National dispatchers are open to international dimension of their job. For that reason, they are mostly ready to travel to a centralised training centre, to meet dispatchers from other countries, to share their experience, to speak English, to use generic consoles, etc.

Regional dispatchers might be more reluctant to travel. One reason is that they have generally a lower knowledge of English. In case they should be involved in an international scenario, they would appreciate the support of a local instructor speaking the national languages, and taking care of the contacts with the global instructor or the other TSOs present in the session.

In all cases, it is important that dispatchers cannot see or hear what other dispatchers do at the same time in the same training session. It is good to have separate rooms and communication by phone between the consoles, as it is in the reality. In all cases, they can share their experiences immediately when the training is terminated.

5. Architecture of ETN DTS

This section presents the architecture that could be set in place in order to build an ETN DTS. This architecture is driven by the analysis of the needs; the WP1 recommendations; the technical performance constraints identified in WP4.1-4.4 as well as the DTS prototype build in the framework of WP4.5.

5.1. WP1 recommendations

Three organization structures have been described in document “D4.1 – Recommended architectures for Pan-European state estimation and simulations functions”:

- **Centralised architecture**: DTS physically concentrated in one place;
- **Centralised architecture with remote connections**: centralised architecture allowing the connection of operator and instructor consoles remotely through a wide area network;
- **Decentralised architecture**: databases, simulations engines and operator consoles are distributed: each TSO must have its own DTS working on its data. Each simulation engine computes a part of the system and exchanges information with other simulations engines in order to create a consistent global simulation of the ETN.

Each of these architectures shows pros and cons. Before analyzing them, an assessment of the feasibility of these proposals is required. It has been partly done during the development of the DTS Engine prototype in the framework of WP4.5.

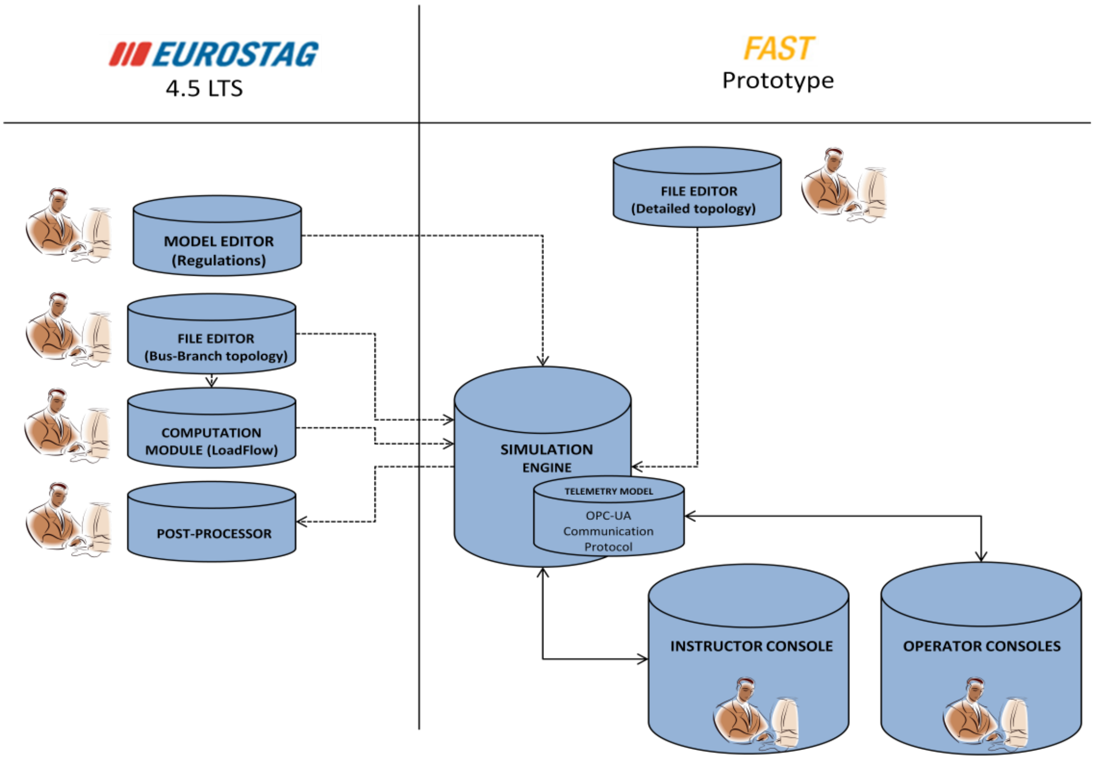
5.2. WP4.5 DTS Engine

In the framework of WP4.5 focusing on DTS simulation engine, a full DTS prototype has been developed. In order to reach real-time simulation on the whole ETN (mandatory prerequisite for a DTS engine), this prototype contains the best mix of the algorithms developed in WP4.1/WP4.2/WP4.3 and WP4.4. As a result, the prototype runs on a multi-processor system in a *shared memory* environment, meaning that DTS engine must be centralised on the same hardware.

The DTS prototype is based on product grade software named **FAST** which contains the real-time dynamic simulator, instructor and operator consoles. A second program which is used in parallel to

FAST is **EUROSTAG 4.5 LTS,** a special version of EUROSTAG software needed to design system Bus-branch topology, create initial load flow state and post-process simulation results. Moreover, it is possible to connect one or several external operator consoles using an up-to-date communication protocol name OPC-UA. FAST Prototype is thus able to be connected locally or remotely with advanced interfaces as well with some industrial SCADAs.

The functional structure of the DTS prototype is described in document "D4.2-part1: DTS engine", it can be summarized by the following scheme:



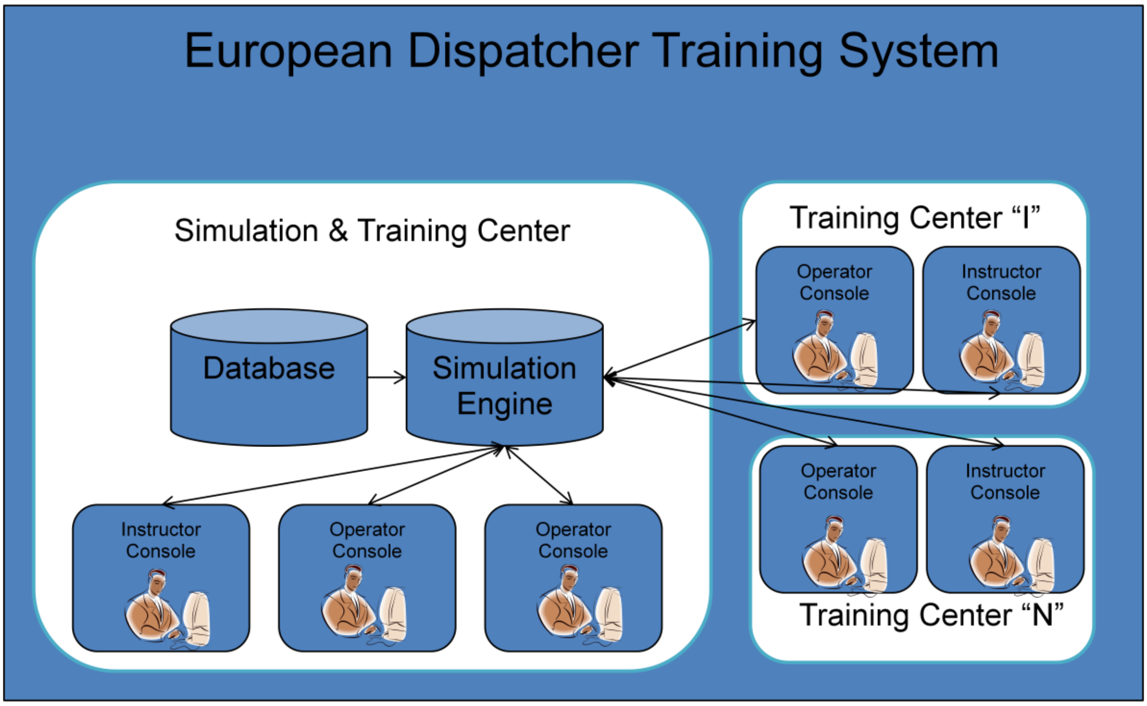
On basis of the prototype, it can be concluded that a decentralised architecture containing decentralised simulation engines exchanging data during simulation is currently still too prospective. The main bottleneck is thus algorithmic: the best distributed method does not permit to reach real-time dynamic simulation with a sufficient accuracy.

However, regarding the prototype, building a centralised ETN DTS able to accept remote connections from operator and instructor consoles is feasible.

5.3. Proposed architecture

As an output of the analysis of the needs, the WP1 recommendations as well as the DTS prototype, the architecture for the ETN DTS computation engine should ideally be centralised and must permit the connection of remote operator and instructor consoles.

Structure of this solution is presented in following picture.



Elements of this architecture are:

- **Database:** The database contains the static and dynamic model of the whole EHV ETN. The static model must include the detailed topology of the substations (so that switching operations can be performed). The dynamic model must be adequate for all the phenomena of interest and all the training scenarios. The model must be suitable for phasor-domain simulation. It must be homogeneous in terms of level of detail and accuracy. The dynamic model covers the network equipment dynamics (including SVCs, FACTs, HVDCs, PSTs, ULTCs, etc.), the generating unit dynamics (alternator, voltage regulation and prime mover), the load dynamics and the protective devices (unitary protections but also system protections).
This DB must be accessible by the simulation engine during the initialization phase in order to feed the internal structure of the engine. The simplest and most robust way is to use a central DB but a distributed DB could also be considered.

- **Simulation Engine:** The central simulation engine is able to perform real-time dynamic simulation on data issued from the database. A DTS engine prototype is available from PEGASE WP4.5. Performance and quality have been validated in the framework of WP6.

- **Instructor Console(s):** The console allows the instructor to control the course of the simulation (start, pause, resume, accelerate, stop, etc.), to select a scenario (list of events), to select an initial state, to monitor the system state, to monitor the actions of the trainees, to trigger interactively events that are not in the selected scenario, to disable devices like breakers, protective devices or communication links, to take actions that the operators cannot do (like actions inside a power plant or in an external network), to review the training session, to play the role of operators that are not involved in the training exercise (operators of neighbouring systems, power plants or distribution systems). This role is very versatile and for demanding scenario, several instructors must be able to interact with the same simulation engine.

- **Operator Consoles:** Different types of operator consoles can be connected to the simulation engine. The most natural way would be each TSO has its console allowing him to interact with its system. The coordination and interactions between TSOs are taken into account during training sessions since all consoles are connected to the same simulation engine. Other type of operator consoles can also be considered like the representation of a coordination centre or a global view of the ETN status. Operator consoles can be either generic (same functionalities for each console) or replica (copy of the Energy Management System (EMS) that is in use in the real dispatching). Operator consoles can be either local (in the same training centre as the simulation engine) or remote (using an existing private network between TSOs or using a VPN through Internet).

- Information that is received from the simulation engine is the analogue points ("measurements") and digital points ("indications"). Information sent to the simulation engine includes control actions and device settings. In fact, this is the information that is normally exchanged between the control centre and the RTUs, or between control centres. In the case of a DTS, the communication process has to be simulated by a telemetry model that runs in the simulation engine.

5.4. Feedbacks from TSOs

Architecture has been presented to TSOs member of the project during workshops, and they agree that it covers the needs for an ETN DTS.

Regarding operator consoles, two important points are to be mentioned:

- Generic and replica consoles show both interests. Generic consoles should be simple to use, contains basic SCADA functions and will force the operators to think more about the solutions since they are not familiar with these kinds of consoles. Replica console, at the opposite will permit the operators to use a well-known environment, allowing them to be trained on their daily tools;

- Regarding the architecture, it seems optimal to use generic consoles inside the “Computation & Training Centre” and replica console remotely.

6. Data management

A centralized DTS architecture is mandatory in order to reach real-time with good accuracy on the ETN. This is due to the performance limitations of actual available algorithms and IT systems. It implies that the data related to the DTS must, when the simulation starts, be centralized on a single computer.

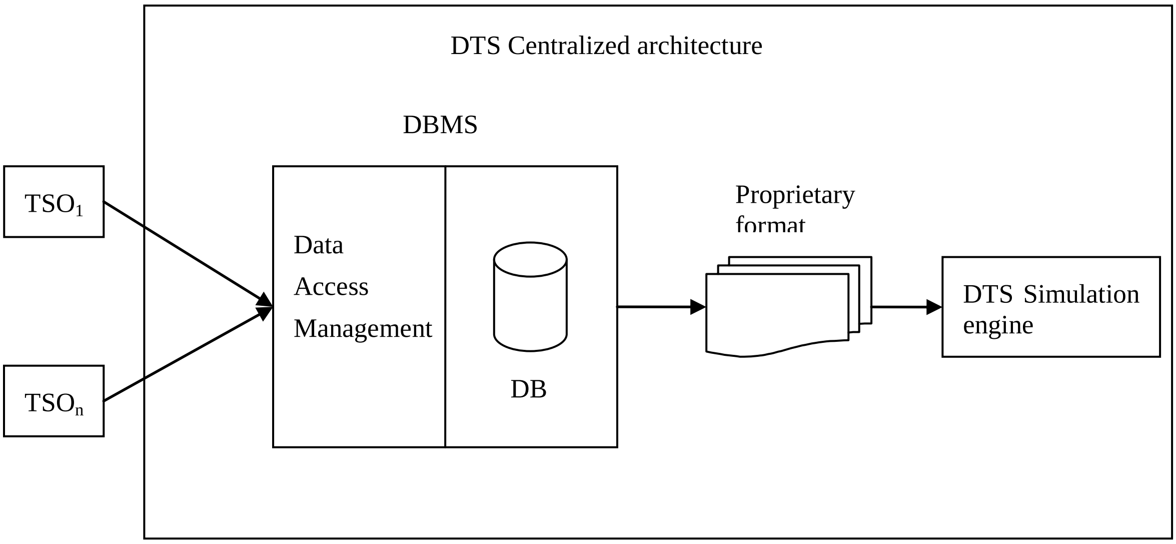
This constraint leads to many questions about data management: confidentiality, updating rules, format exchange, missing data…

This section addresses most of these issues and proposes adequate solutions.

6.1. Data storing

The data used by the DTS simulation engine are usually directly stored in files using proprietary formats. These formats are not dedicated to exchange of data and favour efficiency (flat files) on clarity (XML structure). Direct use of these files is not suitable to cope with European DTS requirements.

The approach suggested is to introduce an additional database which will store the model(s) and which can be addressed by the various TSO’s. When a simulation is started, an extract from this database will be performed and converted to the proprietary format used by the simulation engine. Since this extract contains the aggregated model of the complete system, it will not be accessible to the users whether they are final users (operators & instructors) or TSO’s data manager.



Different type of database can be considered. Each type is characterized by different functionalities, performances or constraints on the data model to be used. The choice for the database type used in the European DTS must be guided by the following consideration:

- The performance is not the key factor. The amount of data used to build a sufficient model for the European system (24.000 busbars, 3800 generators, 12 500 lines,…) is still small with respect to size arising in other domains;
- The data model used to send information from TSOs to the DTS must be compatible with the database restriction without complex manipulation;
- Sufficient functionalities must be provided to satisfy the requirements described in this section (including the access and security management, isolation between users, automatic backup, and default values handling…).

The traditional relational database with SQL support is well suited to these requirements. The implicit constraints brought by this database type such as attributing a unique key to each element are not binding since these constraints are already present in most of the data models used to transfer information between TSOs.

6.2. Access rights and confidentiality

The data used by the DTS can be classified in two distinct groups:

- Boundary data: these data are related to all elements which are related to the interconnections between TSO's. It includes the interconnection lines and the substations to which are connected these lines;
- Internal data: all the data which are located strictly inside a TSO network.

The data relative to the first group (the boundary data) will be fixed and visible from all the TSO. In order to prevent uncoordinated data update, this information cannot be changed directly by a TSO. If these data need to be modified, on request from one of the TSO the *DTS data manager* will updated it after validation with the other involved TSOs.

The second set of data (the internal data) will be managed directly by the TSOs. A *TSO data manager* will have access only to its data. No TSO will have direct access (not even reading rights) to internal data of other TSOs.

This policy is set-up to ensure strict confidentiality of the data. It should be highlighted that this rule **does not** prevent a TSO from seeing the impact of a simulation on a neighbouring system. Indeed, the simulation results will be exported directly from the DTS engine to the various SCADA and not through the database. For example, the database could contains a detailed model for a particular generator with the correct parameters while the DTS engine exports only the power injected by the generator on the network.

Such access rights restrictions can be configured in all majors database (MySQL, PostgreSQL, Oracle Database,…). If internal data relative to different TSO are stored in different tables, it will be easy to limit the access rights so that one TSO will not be able to access data of the others TSOs. The authentication of the *TSO data managers* will be ensured by a classical username/password process over an SSL connection validated through certificates.

With this configuration, the only entity having full access to the confidential information will be the *DTS data manager* which will administrate the database. A special non-disclosure agreement has to be sign by this person.

6.3. Upgrade policy

Once the initial model has been set-up, this model must be regularly updated in order to follow, as close as possible, the real system. However, there is a trade-off to be done on the update frequency:

- Each time the system is updated, in addition to the time needed to perform the update (new data, new screens, mapping of the new elements,…), there is a risk that some of the scenarios previously developed no more act as supposed and that some dynamic effects highlighted by the scenario disappeared (even if this risk is reduced when the dynamic model has been validated previously). The instructors will have therefore to adapt their scenario to the new system configuration;
- If the system is not updated often enough, then the simulated dynamic will diverge from the real dynamic and the risk of inappropriate reflexes learned by operators on the simulator will increase. Moreover the "realistic aspect" of a DTS is an important feature to motivate the trainee's investment. Keeping the simulator as close as possible to the real system is therefore important for the training efficiency.

Taking into account the advantages and drawbacks of an update, it is recommended to update the data with a frequency of:

- Once per year for global database: this frequency is currently used by various European TSOs for updating their own DTS;
- Every time needed for local updates: when a major change in power system impacting inter-TSO training appears, it should be taken into account as soon as possible.

The update of a European DTS will need coordination between the various partners involved. The following procedure will limit the risks of incoherent simultaneous updates:

1. A copy of the current database is made and is used as basis for the new version;
2. The update of the boundary data will be carried out by the *DTS data managers* under the supervision of all TSOs directly impacted by the modified data;
3. A new copy of the modified database is made for each *TSO data managers*;
4. Each *TSO data manager* will update his own data using his private copy:
    - The DTS simulator will be able to be run on this private copy. It allows the *TSO data manager* to test his modifications;
    - The values exported by the simulation engine will be automatically updated according to the new data. It allows the TSO to also update his own SCADA screens.
5. Once all independent modifications have been validated, they are merged inside a same database. This merging is trivial since all tables will have been modified by at most a single *TSO data manager*;
6. The global data coherency is verified by the *DTS data manager* though automatic testing (global oscillation detection, system stability checking, data range checked,…);
7. The behaviour of the existing scenarios are validated by DTS instructor and, if needed, adapted to the new system.

The total elapsed time of this procedure is estimated around 3 months with 1.5 month for data update/merging/data check and 1.5 month for validation and update of the scenarios.

In case a TSO is unable to provide his updated and validated data on schedule, the last validated version of his data will be used. Six months later, a minor update of the DTS data will be performed to update data which were not included in the last major update.

6.4. Data model exchange

The TSO's will exchange their data through direct access to the DTS database and not through files exchange on a FTP server. This approach allows to benefit from the advanced functionalities directly provided by databases (access right control, isolation between users,…) but does not spare the task of defining a common data model on which the database structure will be based.

The current trend for European TSOs is to exchange data according to the CIM data model. An ENTSO-E profile has already been set-up for the bus-branch model. This profile will be used as frequently as possible.

For the dynamic elements, there is currently no existing common format. This issue will be part of project iTESLA.

One possibility for dynamic data is that the model used would be limited to the "CIM Dynamic – standard models". The choice for the "CIM Dynamic – standard models" with respect to the "CIM Dynamics – user defined models" is guided by the following considerations:

- The definition of the standard model profile is much more advanced than the user-defined model profile. The user-defined model is not expected to be available in all the TSO's tools before some years;
- The level of accuracy for the dynamic model required by a DTS can be satisfied using standards models.

Some elements needed by the DTS are not included in the profiles listed here above such as the detailed topology of the substations and the related protection systems. For these missing elements, the minimal subpart from the general IEC 61970-301 standard will be used.

6.5. Data availability

As per the consulted TSOs, one of the main bottlenecks for the set-up of a dynamic European DTS is the availability of the data (even at the TSO level).

The recommended approach is to set up a European DTS with the already available data and to complete them with generic data where needed. This model will be updated when real data will be available. It is a way to avoid the "chicken or egg" problem: no tool is set-up since no good data are available but no data are available since there is no tool using them. The use of generic data allows thus not delaying the process as long as real data are missing.

A second important orientation to take is to rely on model and data used by another application. In the dynamic DTS case, the model used is a full electromechanical model which is also used by DSA application. As soon as data will be available for DSA, they can be reused for DTS purposes.

7. Proof of concept connection of the ELIA operational model and MMI

A proof of concept has been implemented to further demonstrate the feasibility of an inter-TSO dynamical DTS.

The PEGASE test case has been merged with the real static and dynamical operational data from ELIA network.

A hypothetical scenario of large power flow through the Belgian network has been created by the dispatchers and network experts of ELIA on the large test case obtained. The scenario involves a large north-south flow due to a large renewable production and a wrong renewable prevision that brings disequilibrium in the whole European system with saturation of the secondary active power reserve. This scenario is particularly suitable for inter-TSO simulations since it involves European-wide phenomena that must be solved by different TSO in a coordinated manner.

A copy of the ELIA SCADA and MMI has been connected to the PEGASE DTS prototype and the scenario developed has been tested by the ELIA dispatchers.

The dispatchers have appreciated the powerfulness and the fluidity of the simulation algorithm together to the large scope of the scenario. They were able to be correctly trained on their own MMI system on a dynamical inter-TSO scenario[2].

In addition during the development of the scenario, the modelling flexibility of the DTS prototype has revealed fundamental for the implementation of detailed ad-hoc control systems (i.e. secondary power-frequency control at European level for different zones).

8. Conclusion

PEGASE project brings a major breakthrough in real-time dynamic simulation. At the end of the project, a fully validated prototype able to simulate in real-time the entire ETN system is operational. It has been connected to a copy of the ELIA SCADA/MMI system and uses the static and dynamical data of the Belgian TSO together with a very complex large scale model of the rest of the European interconnected system.

ETN DTS architecture has been designed. Both the prototype and the architecture allow large scale demonstration of the solution and its added value.

To get closer to a real European DTS and to validate the DTS infrastructure proposed in this document, the next natural step is to build a demonstrator for the ETN DTS.

This demonstrator project should focus on:

- **Data issues**: static and dynamic data must be gathered from different TSOs in order to be merged in the simulator. The availability of models is driven in the TSOs by the needs of analysis by other applications addressing also the system dynamics (e.g. Dynamic Security Assessment, offline simulations...). These data and models will be developed and aggregated to assess the overall security of the future ETN on dynamic tools and, of course, can be shared with the DTS application. In case real data are not available for some of the TSOs, generic data and/or models can be used instead. A common information model has to be agreed between all the involved parties.

- **Model validation issues:** the data gathered for the model are supposed to be duly validated by the different TSOs. Anyway, the merged model needs to be globally validated. Using a DTS for training operators on high end scenarios, checking common operational procedures, and testing advanced control tools will consolidate the quality of the model used in other applications such as static and dynamic security assessment or study tools.

- **Visualization:** Advanced Man-Machine Interfaces have to be designed to help operators to understand the state of the system and to have their attention drawn towards system-wide phenomena. These interfaces should be developed also for daily operation, the DTS can be used to develop and validate them.

- **Legal issues**: data gathering will induce several confidentiality questions which have to be addressed. This would be the case if the information to gather should include data that are sensitive for the business, but basic technical data like inertia of generators or dynamic models of power plants designed for the purpose of a DTS shouldn't be critical.

- **Logistic issues**: training of operators is currently organised in TSO or in specialised companies. Decision is to be taken by all concerned parties to create a common training centre hosting the future European DTS.

[2] In this case the role of the external TSOs was played by the instructor.

9. References

[1] ENTSO-E Operation Handbook, P8 Operational Training, v1.0 – March 2008 (https://www.entsoe.eu/fileadmin/user_upload/_library/publications/entsoe/Operation_Handbook/Policy_8_final.pdf or www.entsoe.eu > resources > Publications > System operations > Operation Handbook)

[2] ENTSO-E Overview of organisation of training at TSOs, January 2010 (https://www.entsoe.eu/fileadmin/user_upload/_library/publications/ce/otherreports/100326_COR_2009_Annex1.pdf or www.entsoe.eu > resources > Publications > System operations > Continental Europe)

[3] www.eurostag.be

ANNEX1: Organization of the Dispatcher Trainings in SO UPS, JSC

In SO UPS, JSC the training of personnel is based on the requirements of the "Staff Regulations in the Organizations of Power Industry in the Russian Federation" approved by the order of the Ministry of Energy of Russia dated February 19, 2000, and the standard of SO UPS "Staff Training and Professional Development".

<u>Certification of the dispatch personnel</u>

Certification of the dispatchers in SO UPS is carried out in accordance with the order of the Russian Ministry of Industry dated July 20, 2006 "On Certification of Persons Engaged in Professional Activities Related to the Dispatching in Power Industry."

The order defines unified certification requirements for determining the level of professional education of a person, his experience and knowledge on technological conditions of the dispatch center and dispatch units management aspects, as well as the procedure for certification itself.

Certification is proceeded by Certification Commission, created by the authorized federal body of executive power. Knowledge test of each person is carried out individually in the form of an examination by an oral interview and testing (written survey) using automated control program in the PC. After the successful completion of testing a person is given a certificate valid for five years. Persons in respect of which the Commission considers as non-qualified should be re-certified after additional training. Prior to expiration of the certificate the person subject to certification must pass the certification.

Pre-certification training of personnel is carried out in the training centers (points) situated in the branch offices of the Company.

<u>Dispatch personnel training</u>

The concept of corporate training system of dispatchers provides organization of the centers or points of simulator training in all branches of the Company.

Simulator training centers were developed as separate departments (Service of simulator training of personnel) in the main office of SO UPS, JSC and in each of its the seven branches - United dispatching offices (UDO).

Points of simulator training are equipped and operated as part of operational and dispatching services in each of the 59 branches - Regional dispatch offices (RDO).

Simulator training centers are larger and more equipped, compared with points. In these centers besides the training of UDO's dispatch personnel and technical staff, the 1 - 2-week special program training courses for the staff of the

RDOs in the control area are carried out, as well as professional skills competitions.

In the points of simulator training in RDOs, as a rule, only the RDO's dispatch personnel is training.

Prepare for a new position

Preparing for a new position in dispatch personnel is made according to approved individual training programs, developed on the basis of standard training programs for the position and includes the following:

- Pre-examination training (the study of normative and technical documents, and local regulations);

- Training at the workplace (practical mastery of the working skills);

- Checking of knowledge (the prescribed amount of documents, requirements and regulations) is carried out using a PC software "Expert-Dispatcher";

- Educational trainings and knowledge-check trainings (implementing actions to address the specific tasks in the emergency mode training, that aims to develop appropriate skills in the relevant field of activity). Trainings are carried out using a dispatcher simulator "Finist";

- Duplication of work (dispatch operation of power system mode at the workplace under the supervision of a qualified person responsible for preparing a substitute);

- Certification of a dispatcher;

- Access to independent work (solution that allows independent work on the position).

Basic training of RDO's and UDO's dispatchers is organized in the simulator training centers as group learning: it includes lectures, practical exercises and simulator training. At the same time training course in the simulator training center can pass a group of dispatchers (up to 12 people). After the completion of training courses the dispatchers receive certificates.

All the new RDU dispatchers must undergo training courses in the UDO Urals simulator training center (for control area of the Urals, Siberia and the East) or UDO South simulator training center (for other control areas). Then at least every three years RDU dispatchers must be trained in their UDO's training center. All the new dispatchers of the UDOs and central dispatch office, except special training in their own training centers must pass training in the central dispatch office main simulator training center. Then, every three years they should study at UDOs and central office dispatchers' national training courses, which are conducted by the UDO South training center.

Skill maintenance and personal development

Skill maintenance of dispatch personnel is performed to ensure continued compliance with qualification requirements. The forms of skill maintenance include:

- Pre-examination and pre-certification training;

- Periodic knowledge checking (exam) on technical operation, labor protection and fire safety (at least once a year) and re-certification (every five years);

- Educational and knowledge-check trainings. Educational trainings are conducted on a monthly basis during the preparation period, knowledge-check trainings - every three months; they are designed to assess the readiness of staff to the elimination of technical disturbances.

- Briefings (making employees aware of the production features and labor protection in specific types of work);

- Special training (to study the changes in the schemes and serviced equipment, the study of new documents and the results of the disturbances investigations);

- Competition of professional skills within the branch office, and among the best dispatching teams of branches (every three years).

RDU and UDO dispatchers are trained in the simulator training center of their UDO, the dispatchers of the central dispatch office are trained in the central simulator training center. The training programs are not fundamentally different from each other because they are organized and conducted according to the requirements of common standards, regulatory, organizational and administrative documents of the company.

In the training process not only the simulator training center specialists and dispatching services experts are involved, but also the heads and experienced technological services specialists of the corresponding UDO (regime control service, relay protection and automation, operational planning, etc.).

Simulator training

Simulator training of dispatch personnel takes place in the points and centers of simulator training with dispatch simulator "Finist." The simulator allows to simulate the static and dynamic modes of power system and to display all the parameters of the regime. In fact, the simulator is a software-hardware complex, it implies mathematical model of the power system and includes the operational information complex (OIC) of the appropriate dispatch center. Thus it can show absolutely similar schemes, tables, forms, sets of telesignalling and telemeasuring as a real OIC in the dispatch center, that the dispatch personnel is working with.

The simulator uses a single mathematical model of the UPS of Russia displaying the scheme fragment of the corresponding dispatch center and its control area. The model on equivalent circuit parameters is broadly consistent with the calculation model used in the UPS of Russia operational planning, and is updated constantly by simulator training center experts, as usual every month or *more often if there is a significant change in the state and network scheme of the control area (substation input, power plant input, etc.) under the jurisdiction of the control center. As a baseline data of the power system regime the profile of telesignalling and telemeasuring values from the real OIC (SCADA) can be taken.*

Training scenarios development and update are conducted on a regular basis (monthly) by the heads and experienced specialists of the Simulator training center and dispatch control service of the corresponding dispatch center. The scenarios are made on the simulation of the most relevant scheme-mode situations for each dispatch center, including those based on analysis of real-world events and technological disturbances that occurred in the control area or in the UPS of Russia (most important events and disturbances).

The annual training process of each dispatcher numbers 12 educational emergency trainings which are held monthly by the instructor of corresponding simulator training center or point, and 4 knowledge-check emergency trainings which are held once a quarter by the head of Dispatching Control Service using the simulator "FINIST."

Twice a year each simulator training center conducts cross-system training with the involvement, according to the training scenario, of the RDU dispatchers of the several (2-3) dispatch centers of the UDO control area, as well as the trainings for several (2-3) UDO dispatchers from different control areas.

In addition twice a year in the central dispatch office Simulator training center the inter-state trainings, involving dispatchers from national grids operating synchronously with the UPS of Russia, are conducted.

Anastasia Zorina

Specialist, Scientific&Technical Cooperation Unit

System Operator of UPS of Russia