# THE ROLE OF DATA TREATMENT IN THE SAFEGUARDS APPROACH IN MELOX

M Boella, Ph. Dossogne, S. Kaiser, Y. Paternoster
CCE, DG XVII E (ESD),

**Abstract**

The handling of nuclear material is highly automated in the Melox fabrication plant. Consequently, the material follow-up system is based on computer technology. Euratom uses computerised plant operating data, along with independently generated computerised data in the safeguards scheme in place in Melox. The purpose of this paper is to explain in detail the data treatment performed by Euratom for safeguards purposes and to show how this treatment contributes to the attainment of the safeguards objectives.

The paper concludes with a proposals for a methodology aimed at evaluating the impact of data treatment on the attainment of safeguards goals.

## 1. Introduction

The Melox Safeguards Scheme has been explained in detail in the paper "Safeguarding the Melox fabrication plant" /1/ presented in this symposium. This Scheme relies extensively upon the generation, transmission and treatment of large amounts of computerised data, related to the storage, operations and movements of nuclear material in the installation.

This paper describes in detail the different categories of data, the way these data are generated and transmitted to the Euratom inspectors, the computer treatment performed on the data and the contribution of each category of data to the achievement of the Safeguards Scheme objectives.

## 2. Categories of data

The data used by Euratom for safeguards purposes can be classified in four categories:

- Operating data
- Independent unattended non-destructive analysis (NDA) measurement data
- Branching and logging of operator's equipment data
- Miscellaneous inspection data

The *operating data* are generated by the operator using his nuclear material follow-up system called SIGP ("Système d'Information et de Gestion de Production") and transmitted to the inspectors on a daily basis expect for the wastes in which case they are transmitted monthly basis. Each movement of nuclear material in the installation is authorised and recorded in real time on the SIGP computer system. The core of the SIGP system is a database containing all the process-relevant data including identification of items, locations, masses, dates and time of movements. The operating data transmitted to the inspectors are generated at the end of each working day from the SIGP database.

They consist of:

- the total masses of nuclear material per sector;
- the identification, masses of U and Pu, locations and last date of modification of all items in buffer stores. This part of the operating data is equivalent to a daily List of Inventory Items (LII);
- the flows of nuclear material between sectors (see below) in the last 24 hours, with a similar level of detail per item as in the daily LII;
- miscellaneous data such as isotopic composition per fabrication campaign, fuel rod active length and gross weights for selected categories of items.

The operating data transmitted to the inspectors represents 200 to 500 kbytes kbytes per day, according to the number of items.

The installation is divided into 8 sectors plus the laboratory. These sectors are the following:

1. $PuO_2$ and $UO_2$ input stores;
2. powder fabrication;
3. pellet fabrication;
4. rod fabrication;
5. assembly fabrication;
6. assembly store;
7. scrap handling and stores;
8. wastes.

Ref. 1 provides a detailed description of each individual sector.

The operating data cover the totality of the nuclear material present in the installation. The operating data cover also the totality of the flows of nuclear material, when they occur between sectors.

The operating data are transmitted to a Euratom dedicated computer application called MIDAS (Melox Inspection Data Analysis System). The treatment performed on the data by MIDAS is described below.

***The independent unattended measurement systems*** consist of a series of unattended Non Destructive Analysis (NDA)-in-line instruments connected to a centralised computer system collecting the measurement results in real time. The purpose of these unattended measurement systems is to measure the flow of nuclear material at strategic points within the installation.

The NDA stations consist of:

- a neutron and gamma station measuring all $PuO_2$ containers entering the process ("process entry");
- a neutron and gamma station measuring rod trays capturing the entire flow of nuclear material from the pellets sector into the rod sector ("rod tray counter");
- a neutron coincidence counter measuring all assemblies entering the assembly store ("neutron collar"), between sectors 5 and 6;
- a neutron coincidence counter measuring the shipment of scraps to other installations ("scrap counter").

In addition , a branching on the operator's gamma scanner measures the active length of each individual fuel rod ("gamma scanner");



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Each individual measurement station is duplicated for security reasons and connected to dedicated Data Acquisition System (DAS). The DAS are connected to a centralised computer system located in the Euratom office on site via a fibre optic network. This computer system is called NEGUS (NEutron and Gamma Unattended Station), and is described in more detail in /2/.

The ***branchings and logging of operator's equipment*** consist of:

- the weighing of all PuO2 boxes entering the process;
- the weighing and identification of all containers entering and exiting the homogenizer ;
- the weighing and identification of the containers recycling rejected pellets from the pellet sector to the powder sector (internal recycling flow);
- the weighing and identification of the containers transferring the accepted pellets from the pellets sector into the rod sector;
- the weighing and identification of scrap cans transferred to sector 7 (scraps sector).

The purpose of the branchings and logging is to capture in real time events related to flow of nuclear material at strategic points within the installation.

The branchings are connected to a dedicated computer system located in the Euratom office on site, via a fibre optic network. The name of the computer system is BRANCH.

***The miscellaneous inspection data*** consists of:

- interim verification results;
- high precision NDA on small sample results;
- video review data;
- accountancy data.

### 3.Data flows

The operating data, transferred by diskette are directly transmitted to the MIDAS system.. The miscellaneous inspection data are entered in the MIDAS system by keyboard entry, except the high precision NDA measurement results which are transferred by diskettes. The high precision NDA results are transmitted to the MIDAS system by diskettes.

The NEGUS computer system performs a series of treatment routines consisting primarily of defining and storing significative *measurement objects* from the raw data transmitted by the DAS systems on a continuous basis. A *measurement object* can be defined as a subsequent set of data pertaining to *one* significative event such as the measurement of a container in the process entry. The software process involved in the *definition* of one measurement object consists of recognising, extracting and storing the data pertaining to each event from the raw data sent on a continuous basis by the DAS systems. Each item of measurement object data is associated with its time and date. These measurement object data are then transferred to the MIDAS system via the Local Area Network (LAN) located in the Euratom office.

The BRANCH computer system performs an association of the weighing and identification signals relevant to the same event and stores them along with the time and date of the event. The BRANCH data is then transferred to the MIDAS system via the LAN.

The data flows are shown in figure 1.

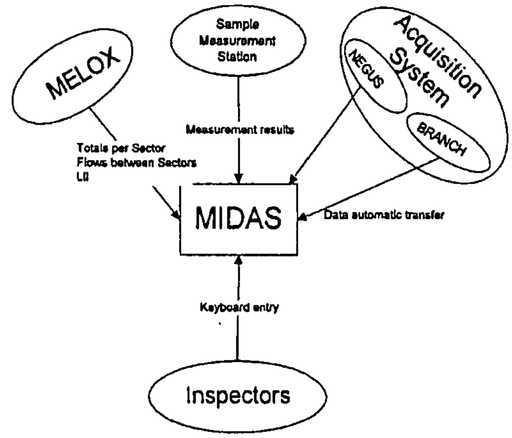


Figure 1: Data flows

### 4. MIDAS data treatment

As explained in the previous section, all the data are finally transmitted to the MIDAS system. The MIDAS treatment on the different data set consists of:

- the integrity verification of the operating data;
- the flow consistency verification of the operating data;
- the time consistency verification of the operating data;

These three first steps result in the demonstration that the operating data set transmitted by the operator is *consistent* and *logical*.

The data of the NEGUS and BRANCH systems are then transferred onto MIDAS which performs the verification of:

- the consistency between the operating data and measurement data recorded on the NEGUS system;
- the consistency between the operating data and the events recorded on the BRANCH system.
- the consistency between the operating data and the miscellaneous inspection data

MIDAS ***integrity verifications*** are aimed at detecting syntax errors in the operating data (such as bad format or requested record or fields missing). If MIDAS detects errors in this step, they are simply communicated to the operator who corrects them and generates a new operating data set.

MIDAS ***flow consistency verifications*** are aimed at detecting nuclear material balance errors in the operating data, such as the total amount of nuclear material in a sector lower than the sums of the masses of nuclear material in each individual item in this sector, or the total amount of nuclear material in a sector inconsistent with the flows of nuclear material for this sector. These verifications are performed at the installation and at each individual sector level.

MIDAS ***time-consistency verification*** is aimed at detecting *impossible* modifications in the operating data set, when compared to the operating data set transmitted on the previous day. These verifications are performed for each individual item.

Among the list of impossible modification in the operating set, the most important are:

- the *creation* of an item in a sector not associated with a flow or a transformation;
- the *disappearance* of an item not associated with a flow or a transformation;
- the modification of the nuclear material content of an item, not justified by a valid transformation;
- the flow of an individual item into a sector and not subsequently present in the receiving sector, without possibility of transformation.

The result of these three steps is the demonstration that the operating data are not only self consistent, but are also consistent *in time*. This fact plays an important role in the overall Safeguards evaluation, as explained in the following section.

MIDAS keeps an historical record of all operating data declared in the past. MIDAS is therefore the prime tool used to perform Safeguards relevant statistical analysis.

The ***consistency verifications between the operating data and measurement data recorded on the NEGUS system*** serves as the first independent *validation* step of the operating data. All measured events recorded on the NEGUS system can be *directly* related to the operating data. In particular, the measurements performed at the neutron-gamma counter located at the process entry correspond to the flow between sector 1 and sector 2, the measurements performed at the rod tray neutron-gamma counter correspond to the flow between sector 3 and 4, and the measurements performed at the neutron collar counter correspond to the flow between sector 5 and 6. For each of this flows, there is a detailed declaration existing in the operating data. MIDAS verifies the consistency between the operating data and each of the measurement results.

The ***consistency verifications between the operating data and the events recorded on the BRANCH system*** serve as the second *validation* step of the operating data. Similarly to the measurement events recorded on the NEGUS computer, each event recorded in the BRANCH system corresponds to detailed declarations in the operating data. MIDAS verifies the consistency between the operating data and each of the events recorded by BRANCH in the same manner as for the NEGUS measurements results.

MIDAS also proposes sampling plans for interim verifications, based on the daily operating data. These interim verifications are performed by the inspectors in the installation, on a daily, weekly or monthly basis. They consist of verifying the location and identification of a selection of items in the process and performing a gross or partial defect verification on these items. Samples for partial defect verifications are done as a subset of the interim verifications. The results of the interim verification serve as the third and final *validition* step of the operating data.

Finally, MIDAS is also used to produce other analyses such as D-Statistics and the correlation between accountancy and the operating data.

## 5. Evaluation of the impact of the data treatment on the attainment of the Safeguards Goals

As the operating data defined in the case of Melox cover the totality of the nuclear material present in the installation at all time, any anomaly in the nuclear material accountancy or any nuclear material diversion scenario would result in a departure between the actual physical situation and the situation reflected by the operating data.

The large amount of verifications performed on the operatıng data every day, are able *by themselves* to catch a departure which would violate any of the internal or time consistency rules which are checked for. Consequently, the remaining number of *possible* diversion scenarios or anomalies, on the basis of the operating data verifications alone, is already limited.

The other verification steps (NEGUS consistency, BRANCH consistency and interim verifications), aimed at the *validation* of the operating data set, should be therefore devised and dimensioned in such a way as to catch the *remaining possible* diversion scenarios.

In any case a diversion scenario of nuclear material or anomaly would result in the introduction of an *alteration* of the operating data. In order to maintain consistency *in time*, the operator would have to perpetuate or modify this alteration in a *consistent* manner. This to avoid detection of the alteration by comparison of two subsequent sets of data. Due to the periodic verifications performed by means of the NEGUS system, the BRANCH system and the interim verifications, the probability to discover the anomaly or the diversion increases with time.

The consequences are that the access and treatment of the operating data contributes significantly to the attainment of the Safeguards goals and could be used to minimise the need for further in-process verification.

## 6. Conclusions and future prospects

It has been demonstrated in this paper how the use of extensive data treatment on a set of operator's data transmitted to Euratom, bring about a significative contribution to the attainment of the Safeguards goals in Melox.

It should be stressed, however, that in the design and the calculation of the independent in-process verifications performed in the framework of the routine inspection activities in Melox (interim verifications, NEGUS and BRANCH), no benefit has been taken from this contribution.

This decision not to take into account the possible benefits of the data treatment into the dimensioning of the in-process verification activities has been taken because, at this time, there is no well-established theoretical way of quantifying these benefits in terms of impact on the overall level of confidence.

For the time being, one can say that the overall confidence level derived from the Safeguards Scheme applied in Melox contributes significantly from the data treatment, in a *non-quantifiable* manner.

If it were wished to take this further, we believe that possibilities exist to enable a quantificationn to be made. A path that might be followed is by means of *simulation models*. The principle would be to build a simulation model of the nuclear installation, including the generation of operating data, the Safeguards independent measurement systems, the in-process verifications and the treatment of the data. Diversion scenarios or anomalies would be modelled in a large number of simulation runs. The model could determine which diversion scenario has been detected, after what amount of time, with what minimum quantity of diverted nuclear material and with what overall probability. The model could also be used to define the best set of in-process verification scenarios and to improve the operating data set transmitted to the inspectorate.

## 7. References


/1/ Safeguarding the Melox fabrication plant.
ESARDA symposium 95
Arenz, Dossogne, Kaiser, Paternoster, Schenkel, Beaudoin, Molinarin Petit

/2/ "Unattended monitoring and measurement for Safeguards", ESARDA symposium 93
Franklin, Mercier, Huckins, Zalokar, Zukosky, Smith, Swinhoe, Butez