UNIFIED DOSIMETRY SYSTEM: MANAGEMENT OF WORKERS' PERSONAL DOSES DURING JRC ISPRA NUCLEAR FACILITIES' DECOMMISSIONING PROCESS

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The Joint Research Centre of Ispra (JRC), the major of five research Sites belonging to the European Commission (Directorate General JRC), was created in the late '50s, in order to steer European research on nuclear industry.
It hosted numerous nuclear facilities, both for research and for the treatment, conditioning and storage of radioactive waste originating from the practices carried out in the JRC itself.
Some of JRC Ispra's nuclear facilities were shutdown in the past years, and are awaiting decommissioning, namely: two research nuclear reactors, hot cell facilities, radiochemical laboratories, melted fuel testing facilities, etc.
Other facilities and Laboratories are still maintained in operation, in the frame of the remaining JRC nuclear research activities, namely: Cyclotron, PERLA Laboratory, PUNITA Laboratory, etc.
Other nuclear facilities are also maintained in operation, as they are functional to the JRC nuclear decommissioning program, namely: liquid and solid waste storage facilities, waste conditioning facilities, etc.
Finally, some new nuclear facilities are being constructed, in the frame of the JRC Decommissioning & Waste Management Program, namely: a major new interim store for solid wastes, a characterization plant, a clearance laboratory, new facilities for the treatment and conditioning of solid waste, a new liquid waste treatment station, etc.
All these facilities are licensed and operated according to the Italian Law, following an agreement between the European Commission and the Italian Government.

The JRC therefore accounts, on its Ispra Site, in 2008, for **21 nuclear licences**, **14 Controlled Zones**[1] and **12 main Surveilled Zones**[2].

The JRC Ispra Directorate is committed, since the end of the '90s, to progressively reduce its nuclear liabilities in the Ispra Site, and has developed (and initiated) a global decommissioning strategy, which will span over almost three decades: its scope is to release from regulatory control all classified areas which were (and are) subject to nuclear activities, and eventually assign them to JRC conventional research activities, in the future.

In order to operate its existing nuclear facilities and to execute its decommissioning plan, the JRC makes use of internal Personnel and of a certain number of External Contractors.

On JRC classified zones, during the last 12 months, a considerable number of JRC exposed workers have been employed (**for a total of 178 JRC exposed workers**, as to May 2008), as well as **186 external companies' exposed workers**, belonging to around 30 different Companies.

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1 Controlled Zones are physically separated over the JRC Site, which covers an area of 160 hectares and has 36 km of roads and 6 km perimeter fencing.
[2] For the sake of simplicity, minor laboratories in which only radioactive calibration sources are being used (and in which a minor supervised zone is therefore designated) are not being accounted for in this grand total.

In the last 12 months, more than **50.000 passages** of Personnel have been registered inwards JRC Controlled Zones, among which almost **4.500 passages with non-zero dose** (i.e., associated with a registered "electronic" dose higher than zero, as explained in detail below).

The ***Nuclear Decommissioning and Facilities' Management Unit***'s specific mission is to safely operate existing nuclear facilities; and to manage and steer the decommissioning process of all JRC nuclear facilities. Within the Unit, the Radiation Protection Sector (RPS), is committed to assisting and supervising all work activities in which radiation risks may exist. Its functions and duties are mainly indicated by the Radiation Protection Qualified Expert of the JRC [1], and comprise the surveillance of work areas, daily operational assistance tasks to workers, routine dose and contamination monitoring, emergency response, technical reporting to Authorities and the License Holder, etc.

The RPS has developed and put in operation, in 2007, an informatics system aimed at the follow-up and control of radiation doses received either by JRC internal Personnel and, to a minor extent[3], by outside Workers intervening in present nuclear facilities' operation and during future decommissioning activities.

WORKERS' PERSONAL DOSE MANAGEMENT, ACCORDING TO THE ITALIAN LEGISLATION

The Italian Legislation ([1]), implementing relevant European Directives, requires that personal doses be evaluated, recorded and registered.
For some aspects, though, Italian Radiation Protection Legislation is stricter than the Directives from which it comes from, reflecting the peculiar attention granted to nuclear industry in Italy: the main role in the management of doses and of exposed workers risks is a responsibility assigned, by Law, to the Radiation Protection Qualified Expert (QE).
It is the QE's responsibility (among many others) to inform the Employer about radiation risks, to perform radiation measurements and samplings, and to suggest the prescription of PPEs, personal dosimeters and additional controls and verifications that may result necessary.
Moreover, the QE is the sole responsible for evaluating workers' effective doses, unlike what happens in other EU countries, in which an approved dosimetric service may assign and communicate *doses* to the Employer (and not only *dosimeters' readings*).

In the case of workers of Category B, the Italian legislation requests that the evaluation of external exposure may be based on ambient dosimeters, but, for workers of Category A, personal dosimeters must always be assigned to workers[4].

MANAGEMENT OF PERSONAL DOSES IN THE JRC IN THE PAST

In the JRC, the policy on personal dosimeters' assignment and management has always privileged safety aspects, and therefore it has always been current practice to assign official personal TLD dosimeters to all categories of workers (and to long-period visitors).

JRC workers' effective doses therefore resulted from the QE's evaluations and analyses of personal TLD dosimeters (either whole body, wrist and ring dosimeters), ambient TLD dosimeters, whole body count analyses, radio toxicology analyses.

These analyses were performed are recorded, either manually or electronically, on official registers, dosimetric sheets and other official documents, as requested: an enormous amount of work, to take account for all different "dose-related" data on Site.

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3 This is due because of the primary responsibility of the Outside Companies' Employers on Outside Workers. Dose evaluations, as will be explained later, are responsibility of the Outside Company's QE and not of the License Holder's.
4 For workers of category A, proper *in vivo* and *in vitro* methods must be employed for the evaluation of internal exposure.

INTRODUCTION OF ELECTRONIC DOSIMETERS IN THE JRC ISPRA

In recent years, electronic personal dosimeters (EPDs) have gained much popularity in operational Radiation Protection, due to their enhanced ruggedness, portability, performance and additional in-line indication to workers (beeping, alarm light flash, dose and dose rate display, etc.), compared to other devices.

In the JRC, already in the early 2000's, a certain number of EPDs[5] were acquired and distributed to the Personnel, in order to evaluate the characteristics of the electronic system, and to assess its advantages, in addition to the official passive TLDs[6]. Since then, the number of EPDs on Site has not ceased to rise, and almost 400 EPDs (either gamma and gamma/neutronic) are now in use at the JRC Ispra.

Since the introduction of EPDs, external dose assessments are, therefore, composed of QE's evaluations and analyses of personal TLD dosimeters (either whole body, wrist and ring dosimeters), ambient TLD dosimeters and EPDs themselves. Their introduction, though, led to a major advantage in JRC operational dosimetric system, that is a very quick response of the dosimetric system, compared to TLDs, and the possibility to remotely access operational dosimetric data, and almost immediately.

The following diagram shows the complexity of information needed for a correct and global worker dose evaluation at the JRC: TLD official dosimetry service, medical service and WBC service are internal to the JRC, as well as the Operational Radiation Protection Service, to which the QE himself is attached.

The radiation protection archives store all the documentation, records and communications exchanged in this process and analogous QE's formal acts.

Doses resulting from EPDs have been treated manually, in the past, as well as all other data coming from JRC Services. Moreover, EPDs have long been used in "*manual*" mode, at the JRC, i.e. being turned on and off independently at the entrance of Controlled Zones by workers themselves, who were asked to communicate daily doses to the RPS. This process showed its limits, however, as dose collection and processing was sometimes incorrect or incomplete.

In the course of year 2007, a significant effort has been devoted by the RPS to promoting the integration of all EPDs records into a single automated informatics database, with the installation of a physical Ethernet network, linking EPDs and electronic readers (situated at the entrances of main JRC Controlled Zones) to the central database.
Thus, at 7 main entrances to the 12 main Controlled Zones of the JRC Site, electronic readers have been installed and connected to the informatics network, using the proprietary software (which interfaces with an ORACLE 10g database).

[5] EPDs in use at the JRC Ispra are manufactured by MGP International, and are of type type DMC 2000 S (for X and gamma, from 50 keV o 6 MeV), calibrated in Hp(10); and of type DMC 2000 GN (for gamma and neutrons).
[6] TLDs remain the basis of official dosimetry, but other dose information sources can be employed by the QE in the effective evaluation process.

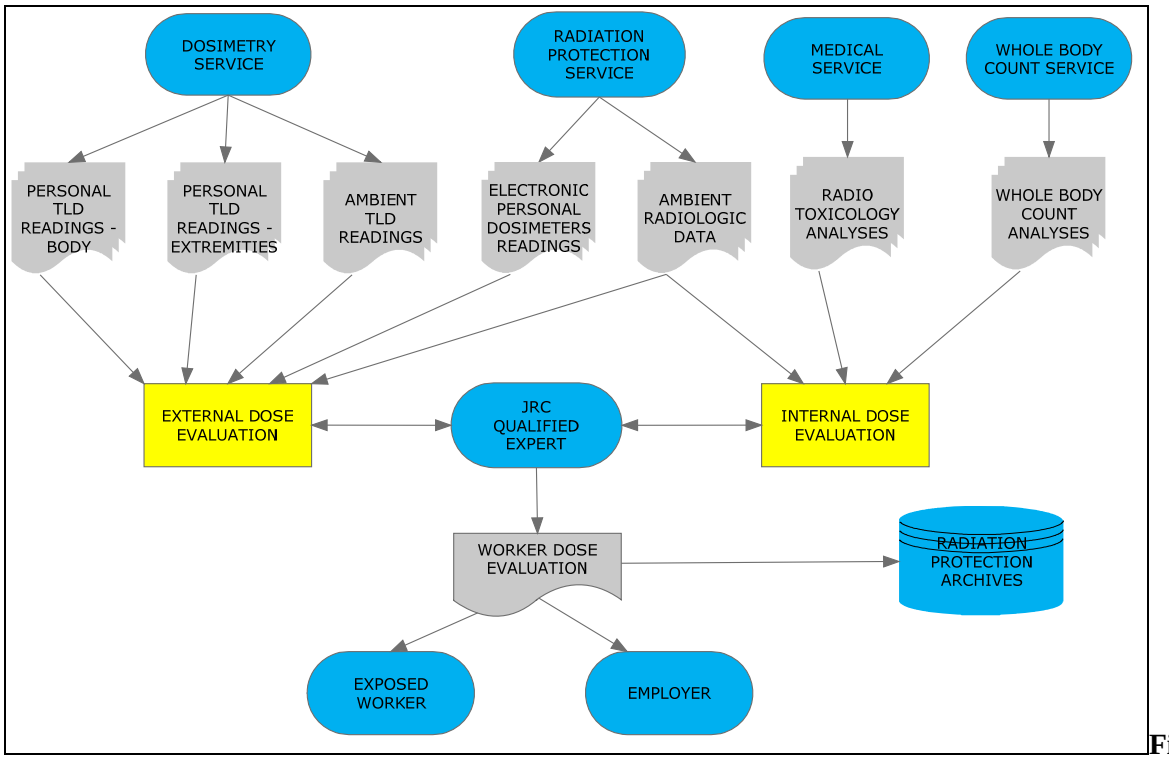

Fig. 1, Workers' personal dose evaluation at the JRC

The following picture shows the map of JRC Ispra, its Controlled Zones (circles in red), and electronic readers the network (green line).

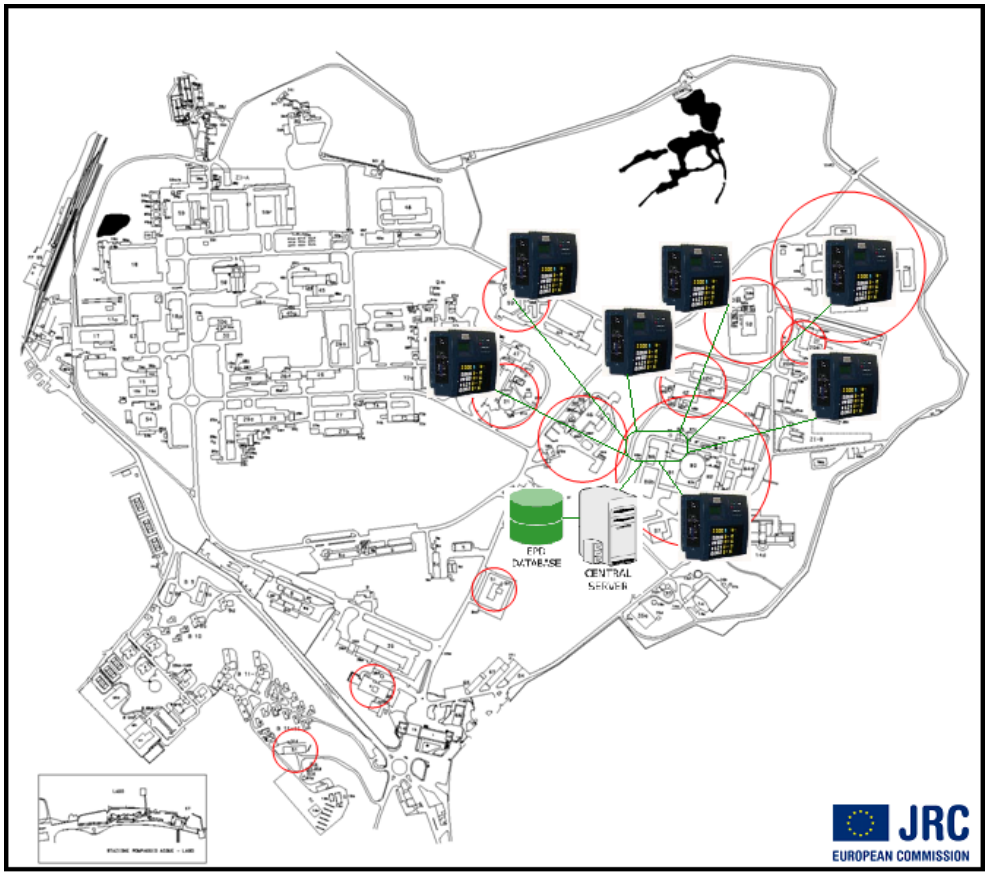

Fig. 2, Readers' and Controlled Zones positioning in the JRC Ispra

Each worker automatically turns on and off his/her EPD at the entrance/exit of the specific Controlled Zone, making dose collection automatic and quicker. Moreover, "*task codes*" have been identified for some specific work activities, which allow to separate and track doses pertaining to long-lasting projects or to planned repetitive operation and decommissioning activities on JRC nuclear facilities.

At present, active task codes are:

1. Radiation protection (for RP assistance activities all throughout the JRC)
2. Research activities at the JRC Cyclotron (IHCP Institute)
3. Radiopharmaceutical commercial production at the JRC Cyclotron (IHCP Institute)
4. Research activities concerning fissile material (IPSC Institute)
5. Decommissioning activities
6. Licensing and operation of JRC facilities
7. Maintenance activities on JRC facilities
8. Management of nuclear material
9. Visitors

It is therefore possible to identify passages and doses associated, and relate them to specific workplaces and work activities, accessing the ORACLE 10g database via DOSIVIEW®, the proprietary MGPi SOFTWARE. In the future, additional specific task codes will be employed to track more specific activities.

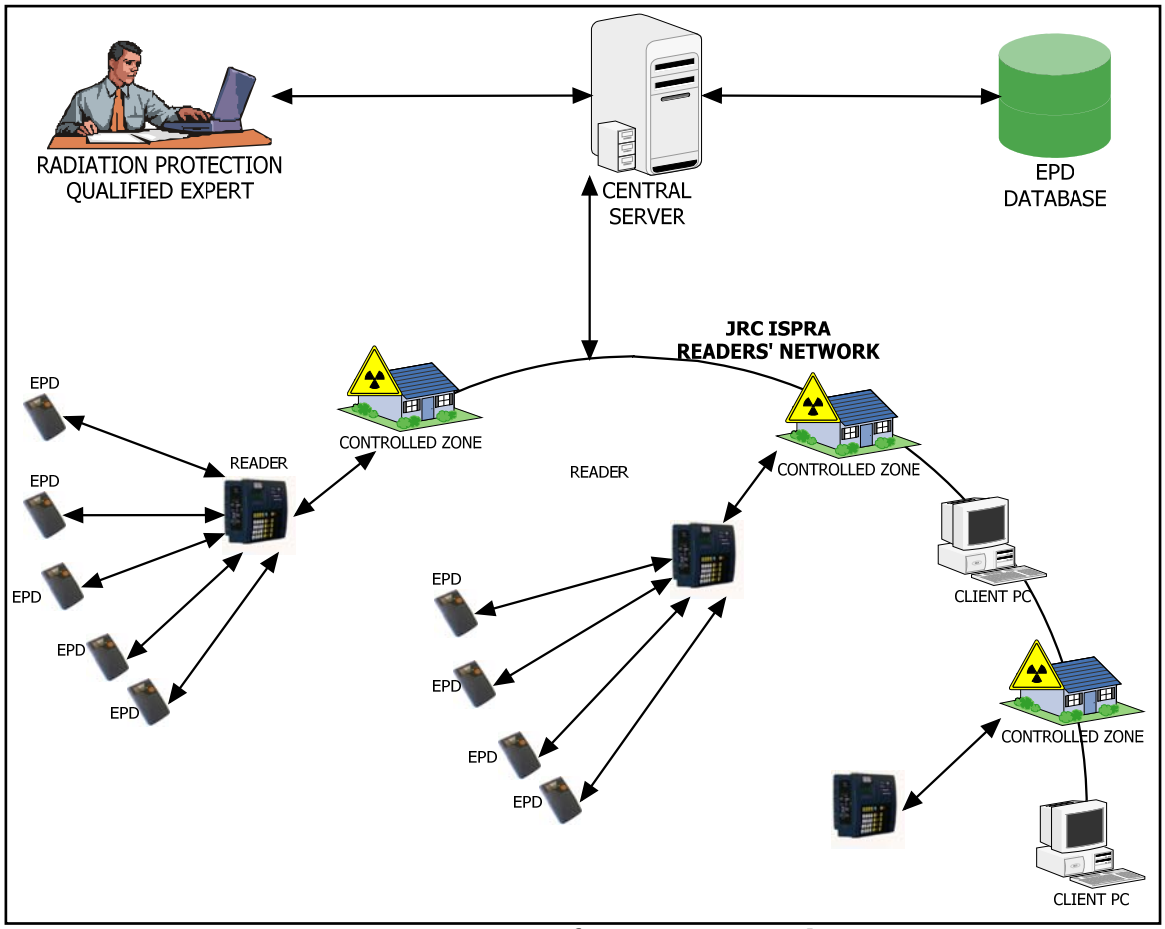

Fig. 3, View of JRC EPD network

UNIFIED DOSIMETRY SYSTEM

The ORACLE EPD database stores itself a huge number of data, namely:

- Personal workers' data (name, birth date, address, company, category, last medical visit, medical aptitude, previous doses, etc.)
- Access data (identification of controlled zone reader, date and hour of entry, date and hour of exit, errors in communication with the reader, etc.)
- Data related to doses (integrated dose (either gamma and neutron) between entry and exit, average dose (either gamma and neutron), dose or dose rate threshold exceeded, dose and dose rate alarm, integrated dose alarm (on a time period basis), etc.)
- Data related to "task codes" (task code typed in during entrance)
- Various informatics data

It was therefore developed a specialized tool to extract single data of interest and make them available in-line and simplified form to the Qualified Expert and to Radiation Protection technicians, in order to monitor workers' doses on JRC almost immediately[7].

Moreover, to overcome the need for the Qualified Expert to collect and manually treat all other data relating to internal and external dosimetry (some of which are normally made available with some weeks of delay) and radiation protection archives data (medical aptitude, previous dose records, training, passports, missions, etc.), the need for an even more complex database has been felt.

This informatics tool, aimed at operational purposes, has been developed by the JRC, with SERCO and IBERDROLA and is called "**Unified Dosimetry System**" (UDS): it integrates different archives:

- The **Workers' personal data archive**, recording personal ID, arrival date to the JRC, category of exposure, medical visits and aptitude, doses received in previous activities (if present), working location, appointed QE, training information, emission of certificates and radiation passport, etc.
- The **Worker's calendar**, presenting milestones in the worker's personal history (general RP training date, specific RP training date, medical aptitude date, *in vivo* and *in vitro* examinations dates, incidents and contamination dates and references, etc.)
- The **dosimetric archive**, either for TLD personal dosimeters, for EPDs and for TLD ambient dosimeters, importing and regrouping raw dose data coming from the Dosimetric Service and the RP Sector
- The **radio-toxicological *in vitro* archive**, importing and regrouping data from Medical Service examinations
- The **WBC *in vivo* archive**, importing and regrouping data from Whole Body Count examinations
- The **Qualified Expert evaluations archive**, regrouping evaluations of internal[8] and external doses and other QE's official acts
- The **dose communications' archive**, regrouping the official dose communications from the Employer to workers and the communications of dosimeters' readings to Outside Companies

The complexity of the UDS is very indicated in its tables' relationships, as shown in the next picture.

The functionalities of this system include the possibility to issue personal radiation sheets, signalling doses and intakes from the last months/years, and additional information on medical aptitude and RP training.

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[7] It must be noted that, due to the architecture of the system, raw dose data are recorded into (and displayed by) the server's database immediately after the worker's exit from the controller zone, but are made available on the network with an average delay of one hour.

8 IMBA Professional Plus® software is also used in conjunction to the UDS for the evaluation of internal doses

Finally, as dose evaluations are regularly communicated to the Employer and the Workers, as requested by Law [1]: all the data for the communications are easily regrouped in a single view by the UDS.

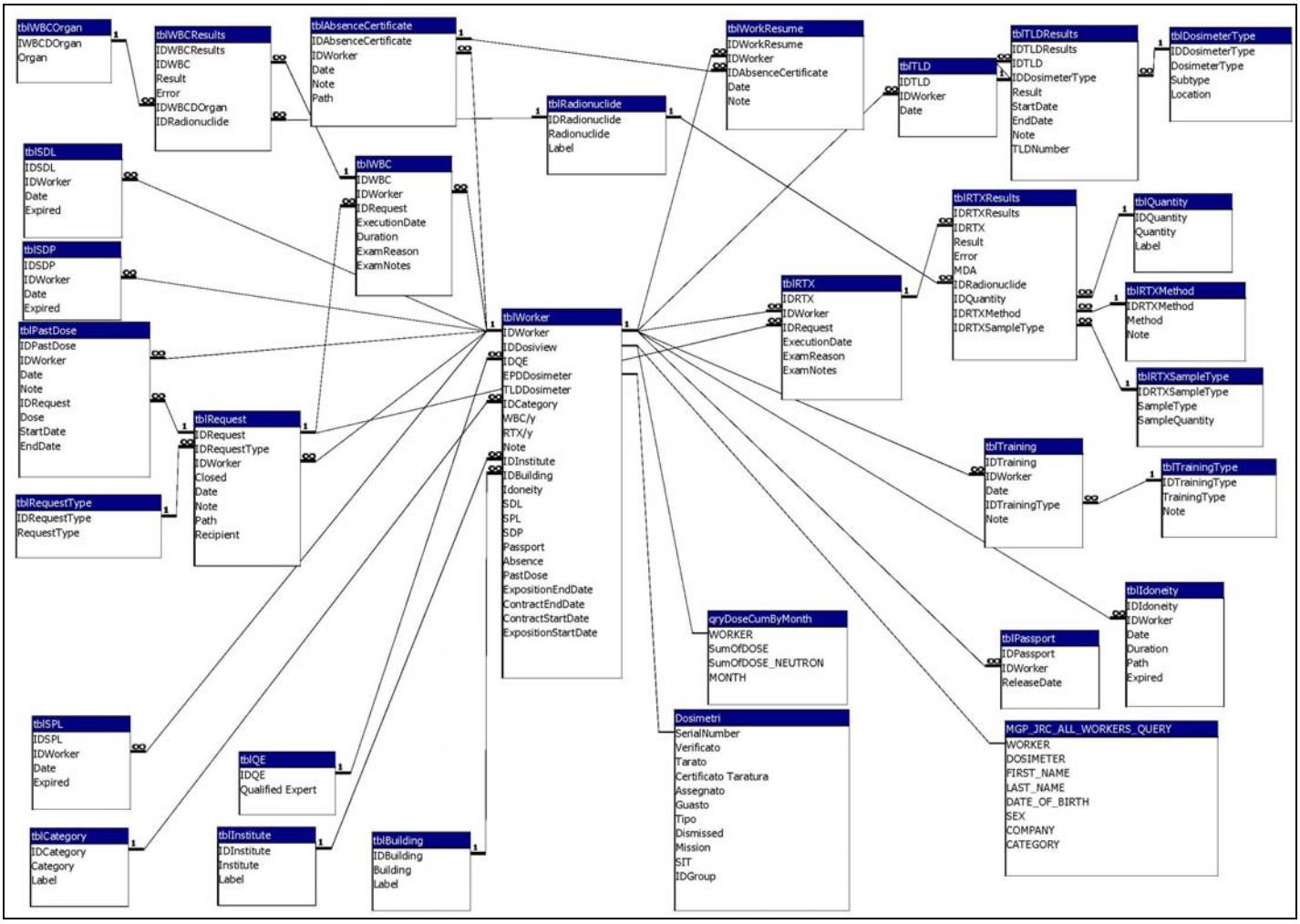


Fig. 4, Structure of the UDS

In the future, the UDS will incorporate the possibility to issue the document itself, inserting in the standard format letter, which is used for JRC dose communications, workers' dose evaluations and other data.

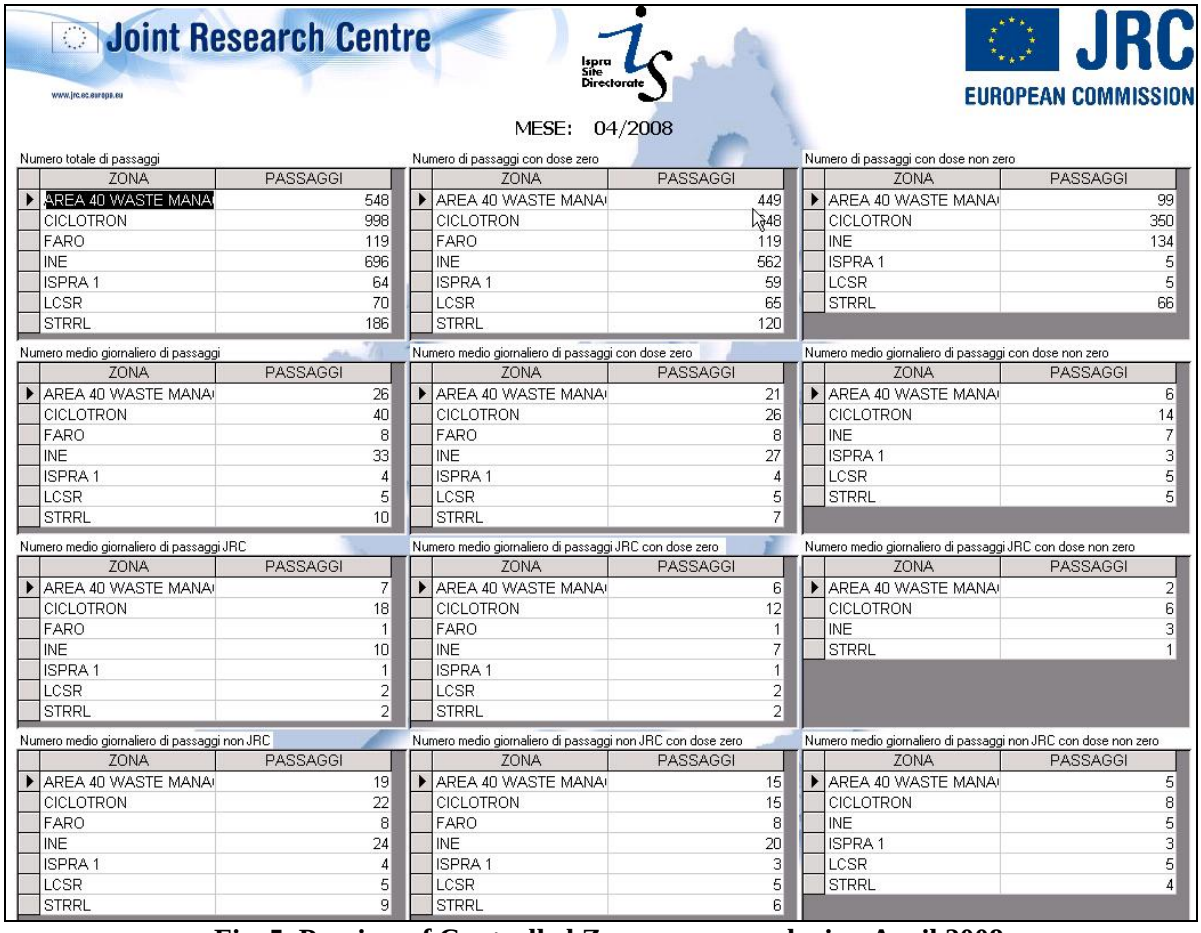
STATISTICS ON RADIATION DOSES

The UDS also allows authorised users to check and follow-up external personal doses, integrated doses over periods of time, over a Controlled Zone (or group of Controlled Zones), and over specific JRC activities (via "*task codes*").
It allows also the same follow-up of total doses, over monthly and yearly basis.

Moreover, additional statistical data are available for the Qualified Expert and the License Holder, on a monthly basis. These include the total number of passages of workers inwards a specific Controlled Zone (total, with and without significant doses[9]); average number of passages per day over Controlled Zones.

As an example, the following picture shows the preview of the *number of passages* information for the month of April 2008, indicating, passages inwards Controlled Zones associated with "zero dose" and "non zero dose" either for JRC staff and "non JRC" staff.
It must be stressed that in the JRC Ispra, given the early state of its Decommissioning Program, which just started a few years ago, and the reduced research activities, radiation doses are not yet relevant, and most dose readings associated with passages in Controlled Zones are in fact of value zero.

As reference values, during the last 12 months, the integrated dose over the JRC has been 25,9 mSv (of which 9,9 mSv to 135 JRC Staff and 16 mSv to 301 External Staff) and average annual doses are: **0.07 mSv/y for JRC Staff** and **0.05 mSv/y for External Staff**, with a global average of **0.04 mSv/y for all Staff**, , taking into account also 159 Visitors to JRC Controlled Zones.


Joint Research Centre

www.jrc.ec.europa.eu

Ispra Site Directorate

JRC EUROPEAN COMMISSION

MESE: 04/2008

Numero totale di passaggi

ZONA	PASSAGGI
AREA 40 WASTE MANA	548
CICLOTRON	998
FARO	119
INE	696
ISPRA 1	64
LCSR	70
STRRL	186

Numero di passaggi con dose zero

ZONA	PASSAGGI
AREA 40 WASTE MANA	449
CICLOTRON	648
FARO	119
INE	562
ISPRA 1	59
LCSR	65
STRRL	120

Numero di passaggi con dose non zero

ZONA	PASSAGGI
AREA 40 WASTE MANA	99
CICLOTRON	350
INE	134
ISPRA 1	5
LCSR	5
STRRL	66

Numero medio giornaliero di passaggi

ZONA	PASSAGGI
AREA 40 WASTE MANA	26
CICLOTRON	40
FARO	8
INE	33
ISPRA 1	4
LCSR	5
STRRL	10

Numero medio giornaliero di passaggi con dose zero

ZONA	PASSAGGI
AREA 40 WASTE MANA	21
CICLOTRON	26
FARO	8
INE	27
ISPRA 1	4
LCSR	5
STRRL	7

Numero medio giornaliero di passaggi con dose non zero

ZONA	PASSAGGI
AREA 40 WASTE MANA	6
CICLOTRON	14
INE	7
ISPRA 1	3
LCSR	5
STRRL	5

Numero medio giornaliero di passaggi JRC

ZONA	PASSAGGI
AREA 40 WASTE MANA	7
CICLOTRON	18
FARO	1
INE	10
ISPRA 1	1
LCSR	2
STRRL	2

Numero medio giornaliero di passaggi JRC con dose zero

ZONA	PASSAGGI
AREA 40 WASTE MANA	6
CICLOTRON	12
FARO	1
INE	7
ISPRA 1	1
LCSR	2
STRRL	2

Numero medio giornaliero di passaggi JRC con dose non zero

ZONA	PASSAGGI
AREA 40 WASTE MANA	2
CICLOTRON	6
INE	3
STRRL	1

Numero medio giornaliero di passaggi non JRC

ZONA	PASSAGGI
AREA 40 WASTE MANA	19
CICLOTRON	22
FARO	8
INE	24
ISPRA 1	4
LCSR	5
STRRL	9

Numero medio giornaliero di passaggi non JRC con dose zero

ZONA	PASSAGGI
AREA 40 WASTE MANA	15
CICLOTRON	15
FARO	8
INE	20
ISPRA 1	3
LCSR	5
STRRL	6

Numero medio giornaliero di passaggi non JRC con dose non zero

ZONA	PASSAGGI
AREA 40 WASTE MANA	5
CICLOTRON	8
INE	5
ISPRA 1	3
LCSR	5
STRRL	4

Fig. 5, Preview of Controlled Zones passages during April 2008

[9] Here, with the term "significant dose" we designate integrated doses which exceed the "trivial dose" threshold.

In the next picture, a preview of "Area" dose information for the same month (April 2008), showing, as examples, that:

1. the most significant integrated doses relate to the Cyclotron, during this specific month, and integrated monthly doses are almost equally shared between JRC and non JRC Staff;
2. in Area 40, JRC waste storage area, doses received by "non JRC" Staff exceed by almost an order of magnitude those received by JRC Staff, a condition easily explained on the basis of JRC major outsourcing policy for operational works;
3. in INE, the old reactor still in custody, doses received by JRC Staff exceed by almost 30% those received by "non JRC" Staff. This condition is also easily explained, as "safe conservation" activities performed at the reactor (mainly an obligation coming from the Law) are executed mostly by JRC Internal Staff.

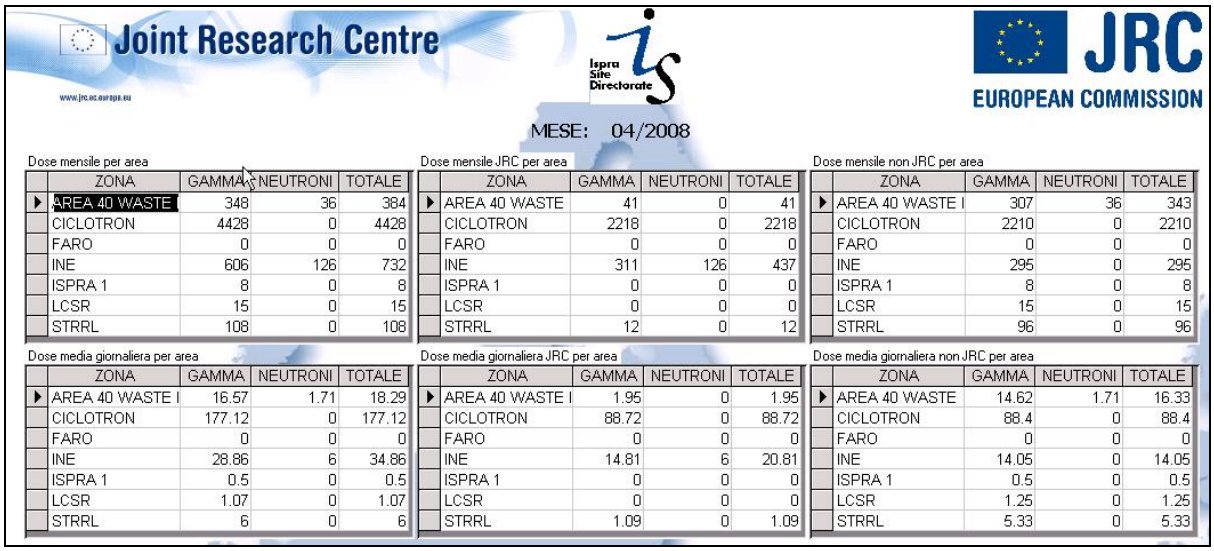


Fig. 6, Preview of integrated monthly doses and average daily doses per JRC Controlled Zones and per JRC and "non JRC" staff during April 2008 (values in microSv)

The next picture shows the use of *task codes*, indicating how doses associated with work activities are spread in the JRC among the different fields (April 2008):

1. "Maintenance" activities integrated doses are predominant, during this specific month, and this reflects the state of work in the JRC, where custody is one the main work activities
2. "Commercial production" of radiopharmaceutical (FDG Production[10]) is the second most significant integrated dose source term
3. "RP assistance" is a significant exposure practice, even more than "Decommissioning", in this specific month (but it must be stressed that RP assistance is being given to all work activities, including research and commercial FDG production)
4. "Decommissioning" and "Research" account for, in this month, similar integrated doses
5. Figures are different if split between JRC and External Staff, as shown in central and right tables
6. JRC "Visitors' doses" are not insignificant, accounting for 0.3 mSv, in this specific month.

[10] FDG production is an external (competitive) action, executed at the JRC by an external Company (General Electric HealthCare), assisted by JRC Staff.

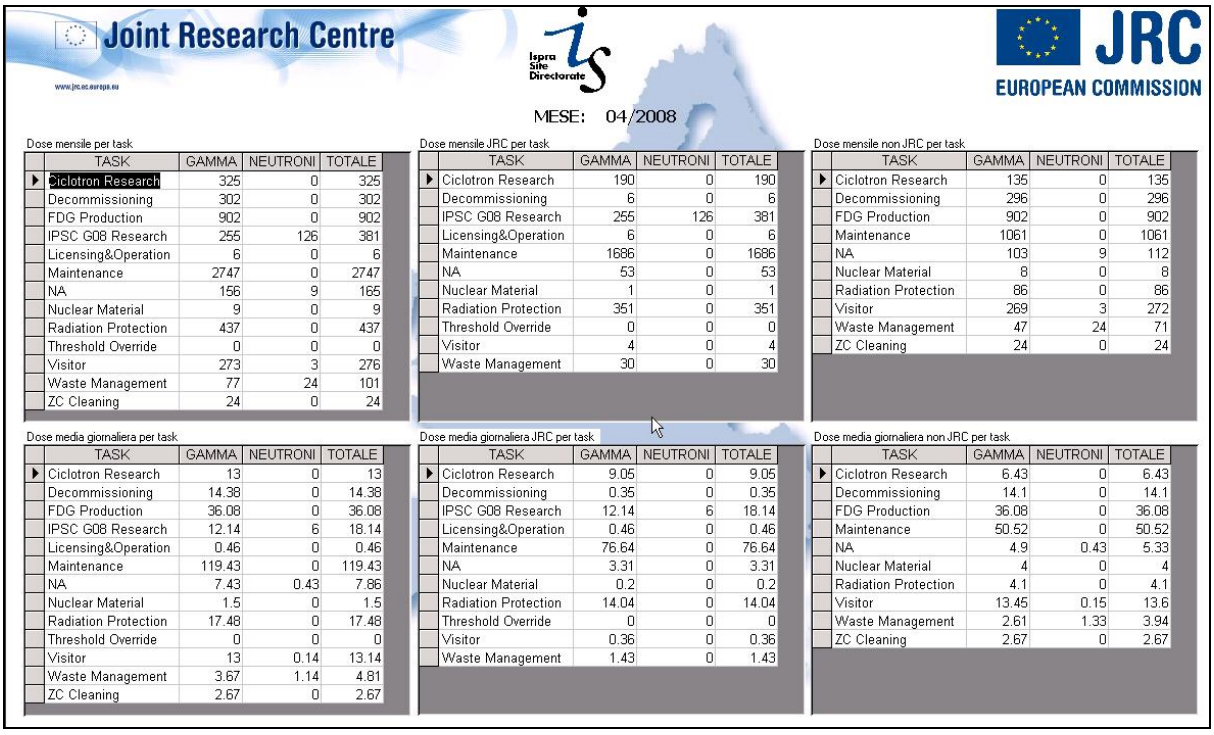


Fig. 7, Preview of integrated monthly doses and average daily doses per "*task codes*" during April 2008 (values in microSv)

The following picture shows the view of integrated monthly doses (made anonymous) for reporting purposes: a similar view, showing Workers' names (instead of codes) is available to the Internal Services.

An overview of the Companies' integrated doses in the month is also shown in this view.

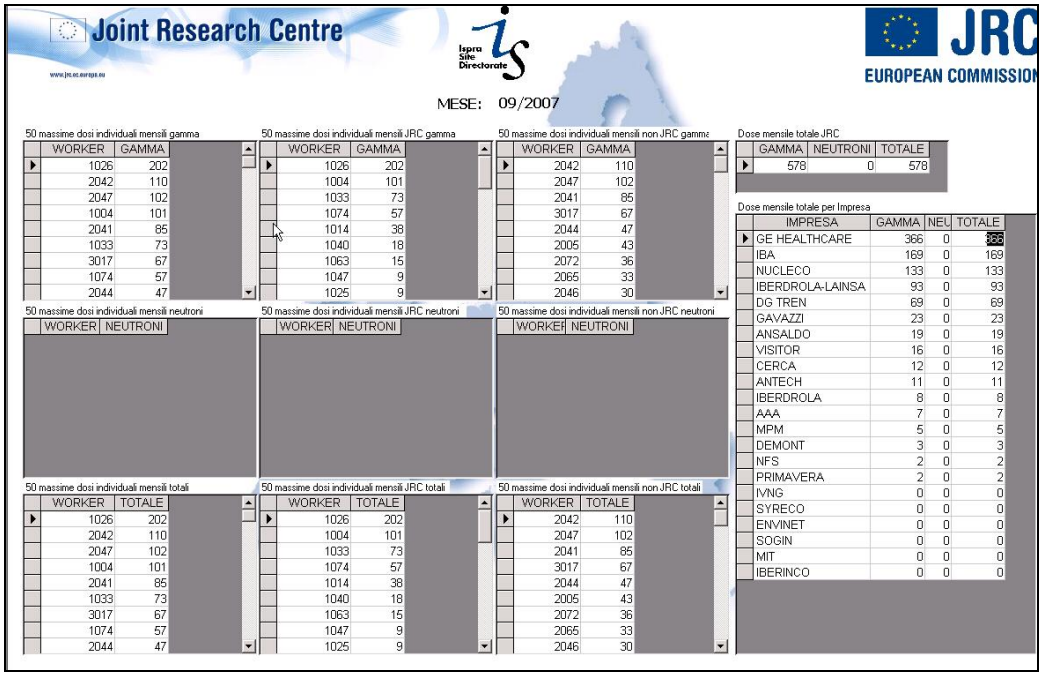


Fig. 8, Preview of integrated monthly doses and average daily doses per JRC and "non JRC" (anonymous) staff during April 2008 (values in microSv)

The following picture shows the same data, again in anonymous form, integrated over the year: a similar view, showing Workers' names is always available to the Internal Services.

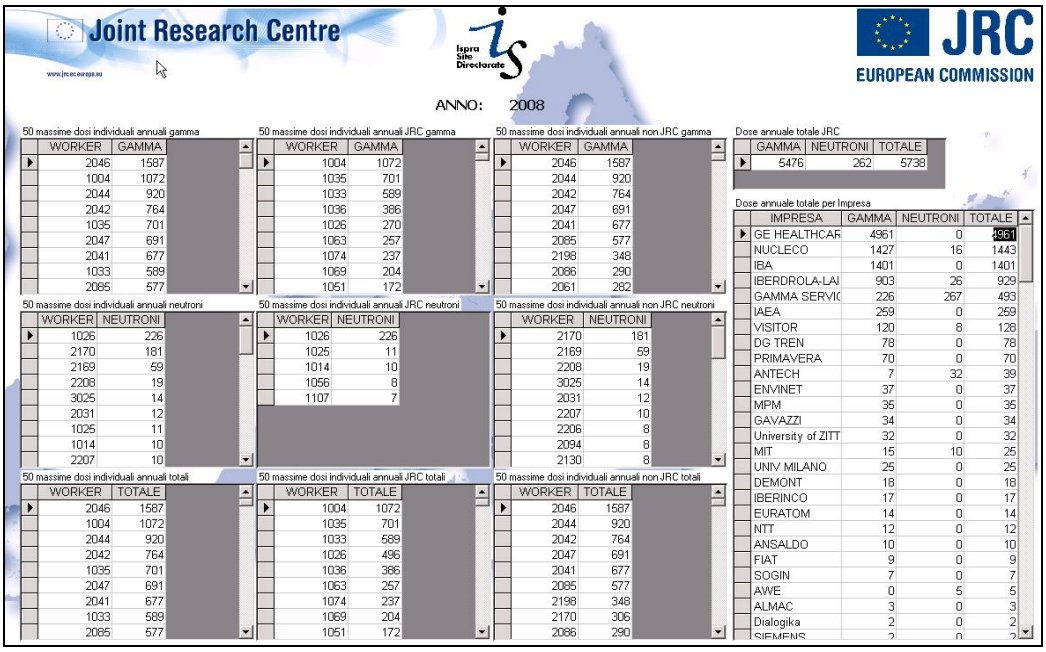


Fig. 9, Preview of integrated annual doses per JRC and "non JRC" (anonymous) staff during April 2008 (values in microSv)

FINAL REMARKS

The “Unified Dosimetry System”, is a wide and flexible informatics tool, which allows a thorough follow-up of regulatory personal dosimetric data, as well as statistical analyses over dosimetric data.

The UDS is based on the integration of dosimetric data of different origin: either the use of both regulatory TLD passive dosimeters (either personal and area monitoring TLDs) and operational active electronic dosimeters (EPDs); and also data of internal dosimetric evaluations, both direct and indirect.

The UDS allows the printout of official communications of doses, and the build-up, in the future, of electronic Dosimetric Sheets to replace the paper ones, according to Italian Legislation.

The UDS is a strong system to respect the ALARA principle, and will be of paramount relevance during future JRC decommissioning works, for which a much higher collective dosimetry is expected.

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