# OPERRA Deliverable D5.29

# CAThyMARA report: Demonstration software, if relevant, for dose calculations in case of nuclear crisis


## DESCRIPTION

This report presents the main feature of a software for thyroid dose calculation in case of nuclear crisis. This software is directly accessible on the Web and consists of a professional tool and of a self-measurement reporting tool.

The professional tool enables direct dose calculation from measured thyroid activity for the radioiodine isotopes released during a reactor accident. It also enables calculation for different age groups.

The self-measurement tool includes all the basis for reporting measurement carried out by members of the public. It is currently devoted to measurement carried out with dose-rate meters, i.e. affordable device for non-professionals. Such a tool is intended as a demonstration tool and could serve as a basis for future development by national authorities.



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| **Nature** | **Report** |
|---|---|
| **Dissemination level** | **CO = Confidential, only for members of the consortium (including the Commission Services).** |
| **Lead beneficiary organisation** | **CTU (Czech Technical University in Prague)** |
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| **Approval** | **WP5 leader Lara Struelens: 16/05/2017**<br>**OPERRA coordinator Jean-René Jourdain: 19/05/2017** |

# CAThyMARA WP6

# Demonstration software, if relevant, for dose calculations in case of nuclear crisis

## 1. Rationale for the software

One part of the CAThyMARA project, namely WP6, was devoted to dose evaluation in a case nuclear crisis. Such situation requires specific consideration and treatment compare to dose evaluation used for individual monitoring of the professionals working with unsealed radionuclide sources. The difference is not only in monitored group age (adult workers vs. whole population including children), factors influencing intake (e.g. stable iodine administration) and measurement scope (few individuals vs. large number of subjects) but also in philosophy. Main purpose of worker's individual monitoring program is to prove if exposure is or not compliant with limits. Thus committed effective dose is appropriate quantity, since risk of deterministic effect (tissue reaction) is very limited at workplace, except in a few rare cases. Situation is rather different for serious accidents of nuclear facility, namely nuclear reactors. Large number of subjects may be exposed due to intake of radionuclides and the exposure in population may be highly heterogeneous. Thus main purpose of the dose evaluation is to categorize subjects to those who may, due to exposure, suffer from deterministic effects and need immediate medical care or follow-up and to those whose exposure does not require such attention. The discrimination should be made quickly with simple procedure, i.e. based on limited measurement data (typically one measurement). However dose evaluation had to be robust (with low sensitivity to input data uncertainty) and prudent in order to provide sufficient protection.

The evaluation system based on the primary goal described above was developed during the project. The dosimetric system stands on committed absorbed dose over 30 days in specific organ (thyroid) as recommended by IAEA for assessment of exposures which my produce tissue reactions. Such quantity is not implemented in any available software jet. Dose evaluation uses factors called dose per measurement quantity which link directly measured quantity (thyroidal activity) to committed absorbed dose over 30 days in thyroid, thus skip intake evaluation.

Existing software overview and analyses of nuclear crisis situation lead to findings which sketched key features and possible benefits of dedicated online evaluation system:

Benefits

- Unified dose evaluation
- Dose evaluation for children, including newborns and unborn (fetus)
- Automatized data integrity checks
- Data collection into database (not limited to one country or state)
- Mass data processing and post processing
- System maintenance
- Accessibility

Key feature

- Easy to use (simple interface allowing dose evaluation even for less skilled evaluators)
- Allow self-measurement reporting (done by general public, non-professions)
- Input data checks
- Exporting and importing data in simple format from central database

- Hierarchic users rights
- Multilingual interface
- Mobile optimized

Developed software was not intended as fully functional product since time frame of the project was limited. The proposed software tools has demonstrative functions and serves as a proof of concept, i.e. shows possible gain of online data evaluation.

## 2. Description of the main features

### Hardware and backend

The system used vitalized hardware powered by VMware ESXI 6. Such solution was used in order to allow High Availability feature of the system. In other words system is not limited to one physical computer and may be, in a case of power loss, connectivity loss or other hardware errors, migrated to another host in short time and thus allows nearly 24/7 accessibility.

The system stands on open source software, particularly Ubuntu server 16.04.2 LTS. Web pages are powered by Apache 2 server 2.4.18 and backend uses Miranda database (fork of MySQL) and php version 7.0.15. Used software is general, open source, and with long term support.

### Framework and its feature

Application part, front end, was custom developed and has many feature which are not fully implemented. One of those is geolocation mapping which allows drawing of the stored results above map.

### Application part

The publically available tool, intended for testing and demonstration, has two sections. The first one is focused on radiation protection experts in internal dosimetry and the second allows reporting of public self-measurement. These two tools are presented below.

## 3. Tools for professional

This section contains two independent calculators. The first one is trivial and calculates the committed absorbed dose over 30 days in thyroid for any population member and any considered radionuclide mixture ($^{131}$I, $^{132}$I, $^{133}$I, $^{134}$I, $^{135}$I and $^{132}$Te). This calculator requires as an input the measured activity of a particular radionuclide and the time between intake and measurement. Default settings will provide result for all public members (i.e. taking into account the age of the subject), however this may be changed by a user. Interface is shown in **Figure 1**. Available tabulated data has limited range however the calculator allows extrapolation beyond the range. Administrator may easily import new data from CSV file if needed, as shown in **Figure 2**, and thus the system is not limited to actually available data set.

The second calculator allows dose evaluation based on the methodology described in chapter 4 of the technical guidelines of the CAThyMARA project. This means that the user may obtain dose evaluation for a realistic nuclide composition and the evaluation takes into account the possible influence of stable iodine administration. The main benefit of the calculator is avoiding lookup for tabulated values which may be for complicated cases rather demanding and may be a source of error. Additionally this data may be stored in database and processed (exported, analyzed, re-evaluated) lately.

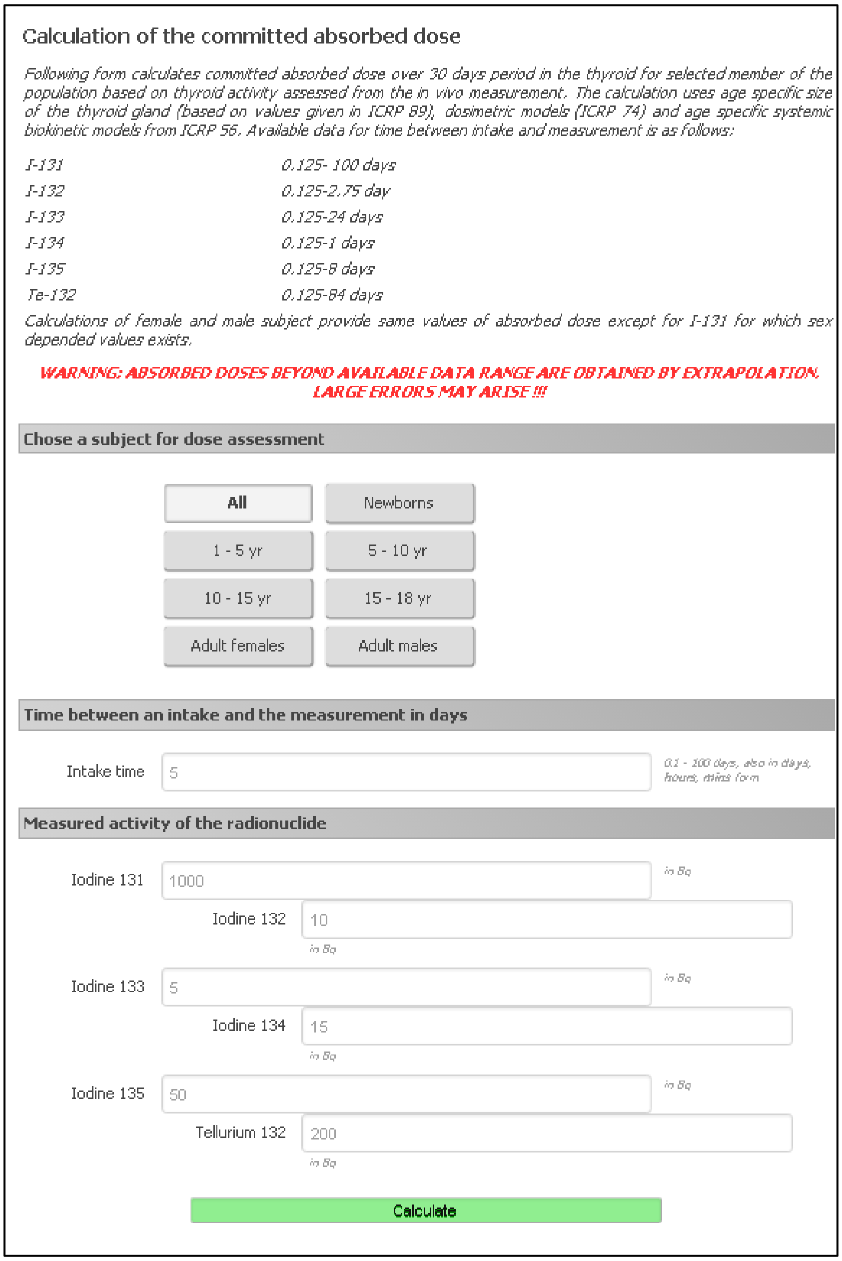



Figure 1: Easy calculator for professionals. The dose is calculated for all age categories or a selected one. The user inputs the time of measurement after intake and the measured thyroid activity of the radionuclides.

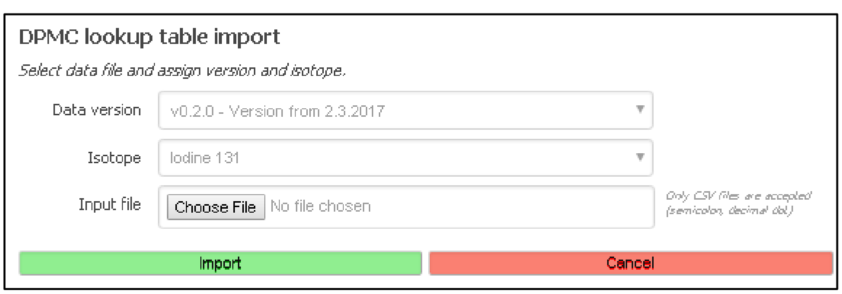



Figure 2: Administration interface for data upload

## 4. Self-measurement evaluation tool

One of the generally discussed topics after the Fukushima accident was how to handle measurements performed by non-professional equipment and/or by members of the public, i.e. non-specialists. The main weakness of otherwise valuable source of information on exposure is uneven quality and thus the difficulty in interpretion. The measurement part of the issue was address in WP4 of the CAThyMARA project. An attempt to interpretation self-measurement data was done in WP6. Both parts were integrated into a separate calculator which tries to provide “how to” guide to non-professional, verify input data and gives reasonable and consistent interpretation. Calculated results are not of numerical nature but categorizes measured subjects to three exposure categories: safe (green color), potentially high (yellow) and significantly high (red).

The input form is divided into sections. The first requires date and time of the measurement and the location. Location may be indicated by Address bar or by simple clicking on map area (**Figure 3**).

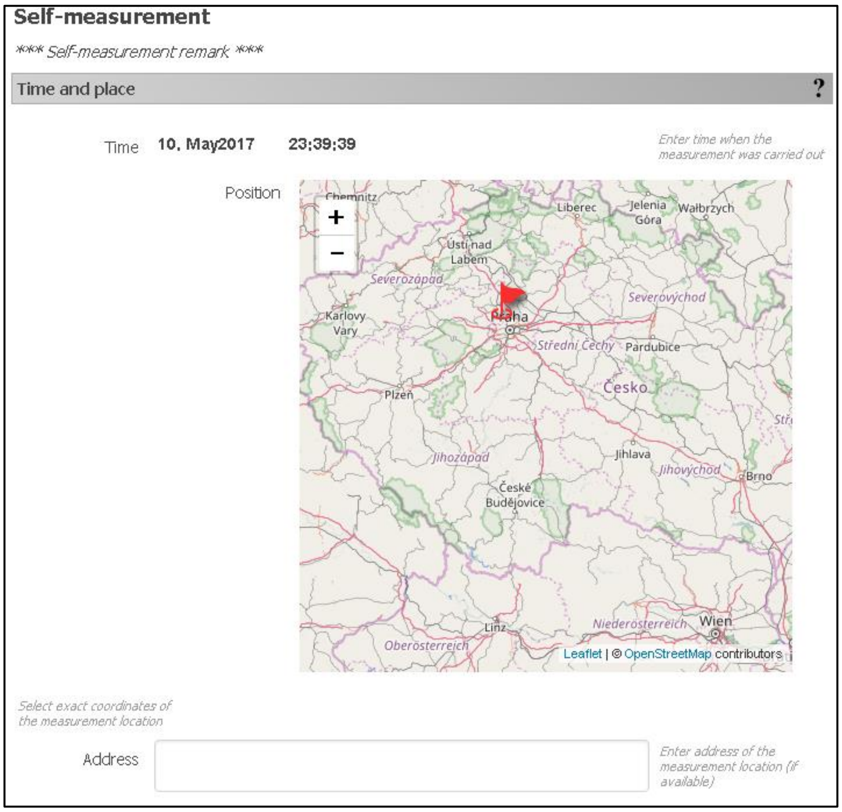



**Figure 3: Time and location part the of self-measurement form**

The second section collects data on measured subjects, which is needed for evaluation and contact information. Email and phone number may allow a professional operator to contact the subject if the evaluated value indicates a possible high dose (**Figure 2**).

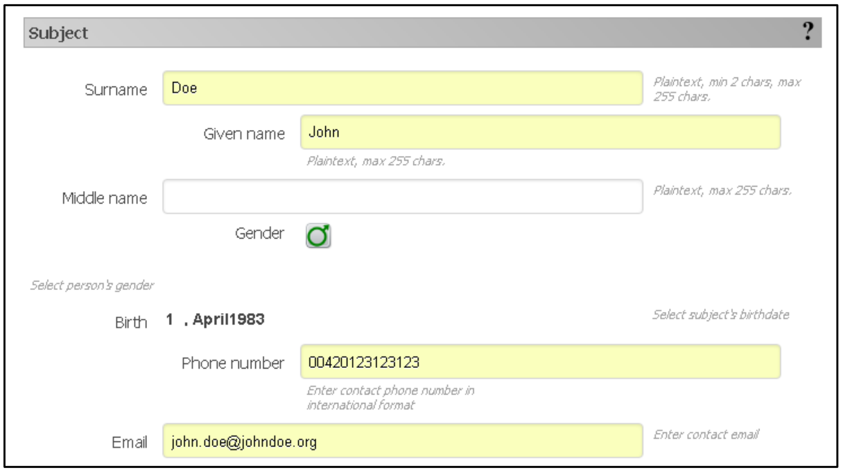



Figure 4: Subject information section of the self-measurement form

The subsequent parts collect information on stable iodine administration, visited places since start of the accident and on used measurement device which may be selected from drop down menu (Figure 5).

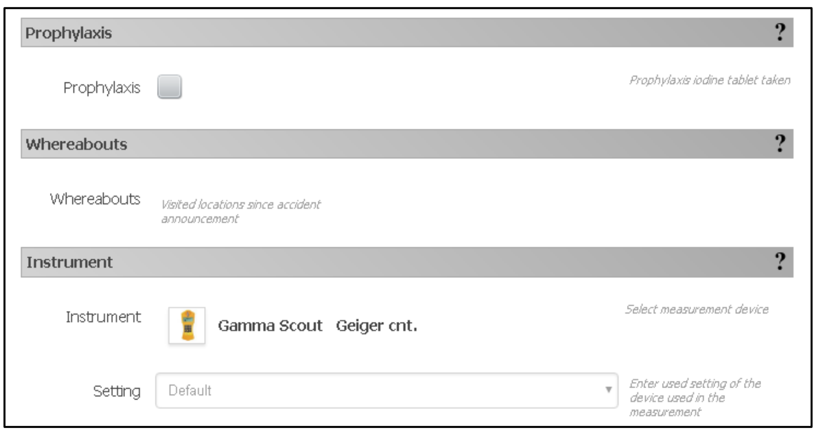
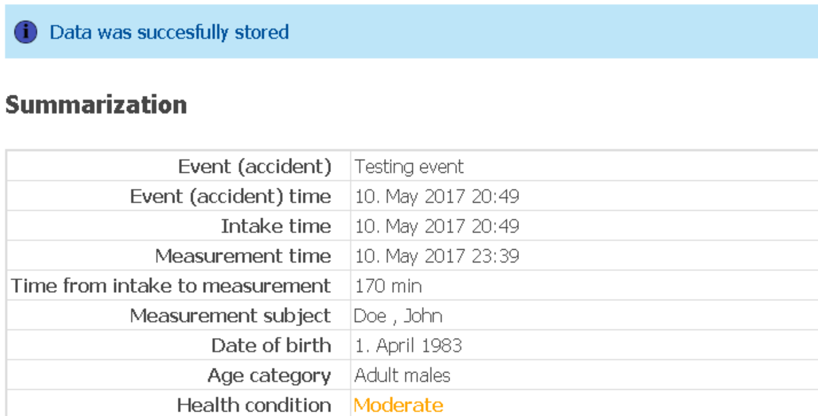



Figure 5: Additional information collected in the self-measurement form

The pre-ultimate section requires check of the device functionality, if the measured person was decontaminated, measurement of the background levels and the thyroid measurement value of the subject.


Figure 6: Measurement information in self-reporting form. The dose rate at the thyroid location is requested as well as a measurement of the background.

The last part allows the user to upload photo or any other file relevant to the measurement. Validity of the values are check, thus is not possible to input unrealistic date. Calculator checks if measured value is significant when compared to background values at the place of the measurement. Result is provided if input data meets all check as displayed on Figure 7.


Data was succesfully stored

**Summarization**

| | |
|---|---|
| Event (accident) | Testing event |
| Event (accident) time | 10. May 2017 20:49 |
| Intake time | 10. May 2017 20:49 |
| Measurement time | 10. May 2017 23:39 |
| Time from intake to measurement | 170 min |
| Measurement subject | Doe , John |
| Date of birth | 1. April 1983 |
| Age category | Adult males |
| Health condition | Moderate |

Figure 7: Output of the self-reporting form

## 5. Conclusion and prospects

The professional part of this calculator is based on carefully benchmarked data. Provided that the measurement data are validated the calculated doses are correct. The main radio-iodine isotopes expected to be released following a nuclear accident have been considered for dose evaluation. Thyroid dose is directly calculated from measured values and for different age categories.

Currently the calculated quantity is the thyroid dose integrated over 30 days which is recommended by the IAEA to evaluate possible severe effects. It must be noticed that for radio-iodine isotopes the numerical value of this dose is to an excellent approximation equals to the committed equivalent thyroid dose. Furthermore multiplication of this dose by the thyroid weighting factor also provides very good approximation of the committed effective dose (except in the case of iodine prophylaxis).

The professional calculator will include by the end of the project:

- The fetus case
- Inclusion of default correction parameters to take into account non-measured short-lived radioisotopes

Prospective features

- Inclusion of other radionuclides measured in other parts of the body ($^{137}$Cs measured by whole body counting)
- Implementation of generally used spectrometry devices
- Graphical display of available data

The self-measurement calculator includes the entire feature for collecting useful data reported by members of the public: date and location of the measurement, kind of instruments, an interface for reporting measurement values, an interface for uploading additional information. It is possible to enter personal details so that professional can contact the self-reporting subject. To provide fully reliable data such a tool should contain a database of calibration factors for all possible instruments (mainly dose-rate meters and count-rate meters). Creating and maintaining such a database is one of the features of the software, but its actual realization is beyond the scope of the current project. Currently one commonly used, low-cost but reliable dose-rate meter is supported.  Such a tool could serve as a basis for future development that could be undertaken by national authorities.

## 6. How it can be accessed

All mentioned calculators may be freely accessed at the following addresses

| | |
|---|---|
| Professional simple dose evaluator | https://cathymara.fjfi.cvut.cz/cdata |
| Professional complex dose calculator | https://cathymara.fjfi.cvut.cz/cdata/profi |
| Self-measurement calculator | https://cathymara.fjfi.cvut.cz/cdata/self |

Accessibility will be maintained at least until May 30th, 2019.