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# JRODOS FOR NUCLEAR EMERGENCIES: IMPLEMENTATION IN SWITZERLAND AND FURTHER DEVELOPMENTS

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**Abstract**: JRODOS stands for Java Real-time Online DecisiOn Support system and is a modular programme intended for use in radiological emergency protection. Switzerland has implemented this software as primary prognosis tool for the impact assessment of radiological emergencies in nuclear installations. As a result, Switzerland has become a major promoter of this system and has been instrumental in furthering its development.

***Key words:*** *JRODOS, decision support system, emergency protection, dose calculation, system development*

## INTRODUCTION

Providing prognostic assessment of the radiological situation in case of a nuclear accident and suggesting appropriate emergency protection measures to the decision makers is one of the key tasks of the Swiss Federal Nuclear Safety Inspectorate ENSI, as stipulated by law. From the year 2000 until 2015, the code ADPIC was used to achieve this goal. However, in 2010 a project was launched to find a suitable successor for the ageing program and from 2012 onwards JRodos was the preferred solution. As a consequence, ENSI has invested greatly in further developing the abilities and functions of JRODOS as well as increasing its stability.

## DEVELOPMENTS

To provide at least the same level of quality and detail as the previous system, advanced requirements for JRODOS were defined and the development of the software was fostered in these directions. The first among these was the use of meteorological data from the COSMO-2 model with its native time step of 10 minutes as provided by the Swiss Federal Office of Meteorology and Climatology MeteoSwiss. This in turn led to the possibility of calculating with a time resolution of 10 minutes (compared to the hourly resolution before).

Next came the request for a fivefold nested grid with selectable number of ‘rings’ and selectable innermost horizontal grid resolution. This grid is composed of approximately 30’000 grid cells per ring, totalling approximately 150’000 grid cells. The horizontal resolution is reduced by half from one ring to the next; combined with the fixed number of cells per ring and a selectable innermost grid resolution, this leads to a configuration where the downwind distance can be doubled by adding another ring. The values currently available for the innermost grid resolution are 50 m, 125 m, 250 m, 500 m, and 1 km.

A further development was the incorporation of approximately 140 nuclides (compared to the 25 nuclides available before) to cover regulatory requirements and the automatic inclusion of the most important mother or daughter nuclides if not already present in the source term nuclide list. As a consequence in the next release, the developers will include completely new dose conversion factors (according to ICRP119 and corresponding calculations performed by Public Health England) to provide a state-of-the-art dose calculation methodology.

Another new feature requested was a method for defining periodically recurrent jobs which run independently of any client GUI. This last request is intended, e.g., for hourly dispersion simulations for all nuclear installations of a certain country based on the most recent meteorological forecast.

Last but not least, we have been instrumental in the parallelisation and implementation of the Lagrangian dispersion model LASAT as a sub-module. LASAT (LAgrange Simulation of Aerosol Transport) is a dispersion model developed by Janicke consulting (Janicke, 2011) and incorporates state-of-the-art methods for the treatment of physical processes. It conforms to the VDI guideline 3945 part 3 and was the basis for the development of the German regulatory model AUSTAL2000, the official reference model of the Technical Instruction on Air Quality Control (*TA Luft*).

Parallelisation has been a major topic because speed is essential in case of a nuclear emergency. The requirements of ENSI's emergency organisation demand the availability of simulation results within 15 minutes at most, for a clearly defined benchmark configuration. This configuration mirrors a typical emergency calculation: a simulation domain of 24 km radius (approximate size of the UPZ in Switzerland), prognostic time span of 24 hrs, horizontal resolution of 250 m, time resolution of 10 min, and a source term consisting of approximately 100 nuclides. Thus, JRodos and LASAT had to be adapted to make sure multiple simulations started from one client run in parallel on the available sockets and cores. Research by the Ingolstadt University of Applied Sciences together with Janicke Consulting helped pave the way for a sufficient parallelisation of LASAT (Meyer *et al.*, 2012).

On a more general basis, ENSI has pushed for an increase in stability and reliability of the system. This includes a test suite designed by the developer and executed by himself before all releases, intended to ensure that no bugs are (re-)introduced into productive versions. All users are invited to provide test cases for this suite such that the range of possible applications of the system is eventually covered. Overall, JRODOS has matured significantly and became suitable for continuous operation as decision support tool in an emergency organisation environment.

**IMPLEMENTATION**

Since JRodos is intended as tool for the emergency organisation staff, it must be running on reliable and suitable hardware and of course be constantly available. The hardware layout chosen by ENSI is quite simple: two identical and parallel machines with JRodos server running on both, using completely independent databases. Thus, we have an operational system and a test system. The hardware chosen consists of two IBM X3850 X5 systems with four sockets of ten cores each, Xeon E7-8870 2.4 GHz processor cores, 256 GB RAM, and eight 280 GB SAS disks. Although this is very modest in comparison to the system required by ADPIC, JRodos runs suitably fast and provides results within a timespan acceptable for the emergency organisation.

The client runs on the workstations locally and connects primarily to the operational system but can be changed to address the test system. For training purposes, we provide the client as Windows 'Work Resource.' In this way, we set up the client on an in-house server and define which Windows users are permitted to access the program from their desktop or portable machines. A 'Work Resource' behaves similar to a Remote Desktop connection with only the program window being transmitted. This has the advantage of requiring only one centralised client instance to be updated and maintained.

At the National Emergency Operations Centre NEOC, another server-client combination is set up, with comparable configuration and hardware but a different operating system. Our aim is to connect these two systems in such a way that at login time the JRodos user can specify which of the three servers (in total) will be accessed. This will provide not only redundancy but also diversity to the two organisations.

**HANDLING OF METEOROLOGICAL FORECAST DATA**

Atmospheric dispersion simulations are based on numerical weather prediction (NWP) data. At ENSI (and NEOC), we use the forecast of COSMO-2, which is provided by MeteoSwiss every three hours for a prognosis time span of 24 hrs. To manage incoming data, we have set up two virtual SFTP servers and two virtual 'meteo' servers, connected as two parallel branches. The datasets are sent in parallel to both SFTP servers and stored on disks mounted from the 'meteo' servers. From there, the data sets are transferred to the operational and the test system, respectively. In addition, a daily backup of the forecast data is made. In case one of the SFTP or 'meteo' servers fails, the other transfer branch will provide both machines with data. This way, we have achieved redundancy in the delivery process to ENSI as well as within our data handling system. At NEOC, one train of SFTP and ‘meteo’ servers is set up to handle NWP data.

## OUTLOOK

All the software developments detailed above lead to a simulation time of about 15 minutes for a typical calculation and about 30 minutes for the benchmark configuration on our hardware. Whilst this is sufficient for application within our emergency organisation, we envision further developments to enable speedier and more versatile calculations. Paramount amongst these is the further parallelisation of JRodos, its modules, and sub-modules as well as the interaction between them to achieve an extended and architecture-independent use of the available processor power.

## REFERENCES

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Meyer, Facchi, and Pichler, 2012: Performance Analysis and Optimization of the LASAT Dispersion Model. Final Report to ENSI.