fluidyn – Real time simulation

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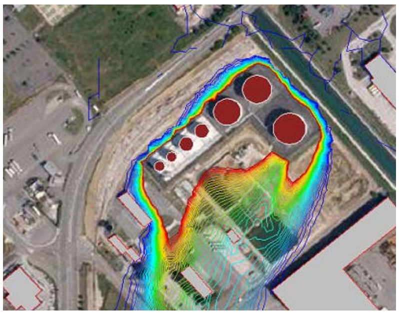
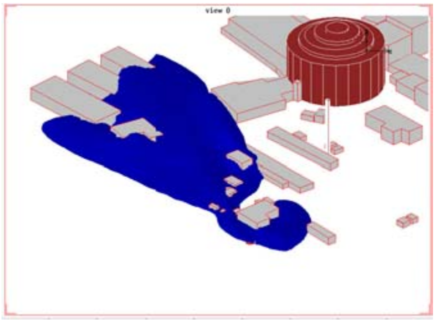
INDUSTRIAL HAZARDS REAL TIME MONITORING AND SIMULATION

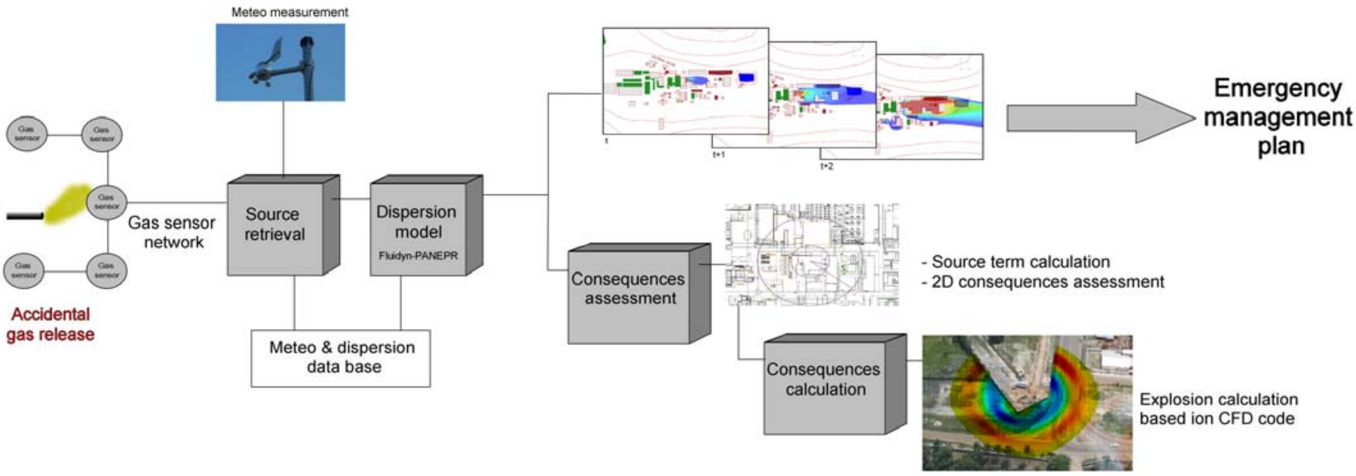




The emergency actions following an accidental release of hazardous substance (toxic or flammable) is strongly related to the best available knowledge of the accident and its short term evolution: the location of the source, the mass flow rate of the release, the velocity at which it is released and the duration of the release.

These parameters, along with the air flow on the site, will determine the spatial extent of the toxic cloud in time.

While the major part of the planning is based on risk assessment and training prior to accident, a real-time description, (indeed faster-than-real-time) and mapping of the pollutant spread would therefore be extremely valuable information for the management of emergency response both on site and around the site. The production of such pollutant concentration maps in time for decision-making requires capacity to perform fast simulations of the dispersion with reliable precision.



Precision is achieved by using computational fluid dynamics (CFD) simulations of the atmospheric flows on a complex topography with obstacles, which standard Gaussian or integral models cannot provide. The location and intensity of the source term is determined using a probabilistic approach exploiting both real time monitoring sensors and pre-calculated and validated dispersion results.

This approach has been successfully tried by using a limited number of sensors and sources on complex industrial sites. Dispersion of the hazardous gas by air flow around the equipments and buildings on the site is then calculated. The simulated results of 3D clouds movement can be therefore used for emergency plans or assessment of potential domino effects (ex. gas explosion).

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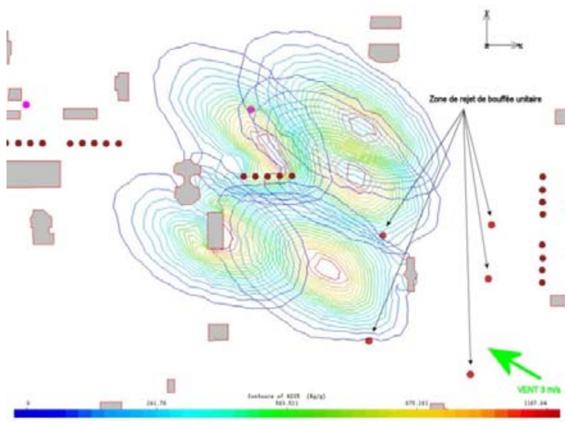
Real time constraint (for a typical industrial site)

An accident management tool can be useful only if constraints of time and objectives of an industrial plant, are integrated. Real time simulation of pollutants spread should provide its extent and concentration in short term (hours) and in range (several kilometres) within a few minutes after detection (order of 10min).
The operational tool relies on a detection network of gas sensors, usually few, and their monitoring uncertainties (detection threshold, sampling, response curve, noise.). It has to take into account the natural variability of local atmospheric conditions and terrain complexities.

This numerical tool should therefore have:

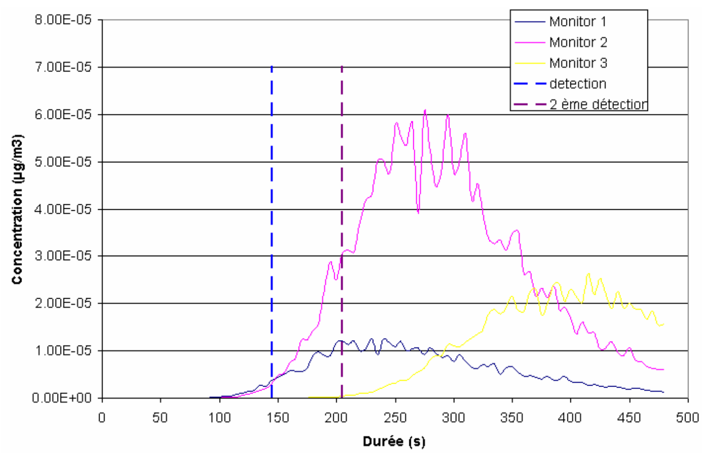
- Model to determine the source characteristics based on the on-site measurements; location, mass flow rate, emission time before 1st detection, duration.
- Precise simulation of atmospheric flow and toxic/flammable gas dispersion especially at short range (on site and in the neighbourhood) accounting for:
    - Topography, inhabited buildings, equipment, pipe networks, road
    - Variable wind conditions
- Simulation time should be several times faster than real time

Source (location and release) retrieval



The full range of source parameters (location, intensity, release time and duration) is sampled by a random convergence algorithm. Based on such sampling, a probability density function is produced for each parameter. The advantage of this approach is its robustness with respect to noisy and scarce sensors and its fast response. This overall approach is fully automatic i.e. the activation of the simulation platform is triggered by the detection.

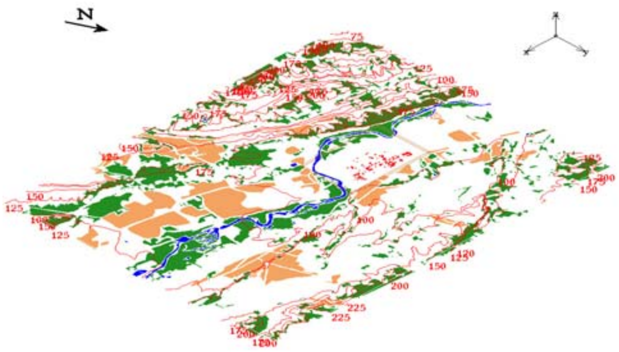
Inherent uncertainties (sensor noise, direct model errors) and natural variability (turbulence, mean flow variations) are some of the difficulties faced. A specific module has been developed for providing a most probable estimate of the location, intensity, and start-up time of the accidental release. It calculates the probability for each likely source & its release rate for observed concentration values and their evolution only above threshold concentrations at the sensors location.



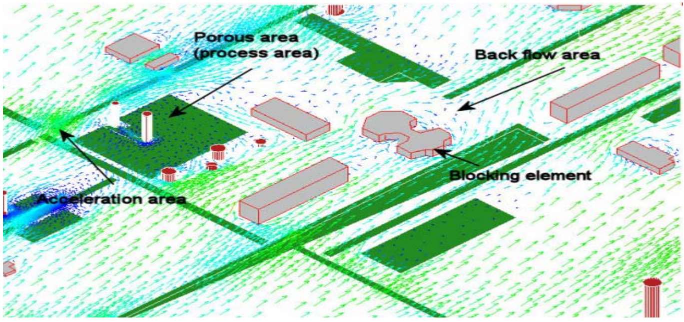
Dispersion model (CFD based)

fluidyn PANEPR

The estimated source term is integrated in the forward dispersion model in the well know CFD dispersion tool, Fluidyn-PANEPR. It prepares all likely wind flow conditions in 3D on and around the site in the preparatory phase. Thus at the time of the accident, both source term estimate and forward dispersion do not require real time wind field calculations but only ad hoc selection within a pre-calculated database. The computing time is exclusively devoted to the retrieval algorithm (with sampling) and to the pollutants dispersion. Both are fast and optimised (about 1/5 of the physical time).



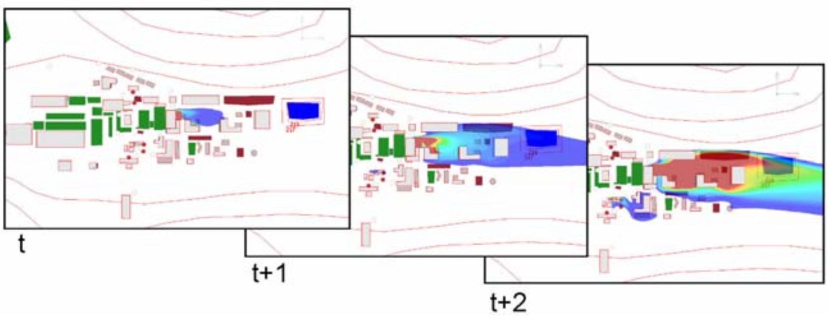
fluidyn-PANEPR a CFD model is used to simulate the 3D wind field pattern on the industrial site, taking into account the 3D topography of the plant layout. This model solves the Navier-Stokes equations for atmospheric flow in a RANS formalism. It includes mass, momentum and enthalpy conservation, state law and equations for advection-diffusion. A standard k-ε model is used for turbulence simulations and a micro meteorological model provides the initial and boundary conditions for atmospheric wind, turbulence and temperature profiles based on Monin Obukhov similarity theory.
This platform was developed for consequence modelling of toxic/flammable atmospheric dispersion in complex industrial site in a diagnostic risk assessment.



Precise description of 3D dispersion patterns is mandatory for the performance of the source retrieval module as flow paths are highly complex and important for the emergency and decision making on site.
This precision is reached by the model through the level of detail provided by the optimised use of nested domains and structured / unstructured meshes (automatic mesher included in the model).

Applications

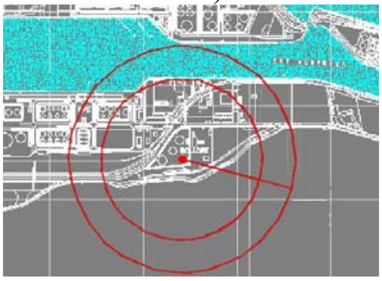
This methodology has been applied on an onshore gas extraction plant in collaboration with TOTAL E&P). Tools and implementation strategies can however be applied to various other industries and/or to urban/public safety issues (provided appropriate sensors network exist or can be quickly deployed on site. Examples are chemical sites, nuclear facilities, off shore platform (considering sensor with high level of response), sensitive urban areas (airports, rail stations, tourist or commercial areas).
This methodology for the real-time dispersion can also be used for chronicle emissions monitoring and is currently used for sewage treatment odour monitoring in France.



Consequences assessment (other tools for fast diagnostic)

Consequences of accidental gas releases are not limited to toxic effects but can also lead to other domino effects (UVCE, jet fire, boil over…). Results obtained from real time simulation can therefore be used for those consequences assessments by dedicated tools.

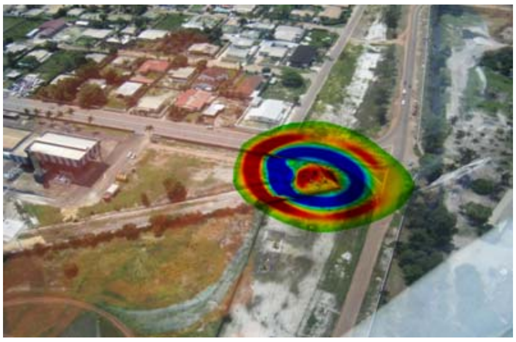
fluidyn-**ASSESS-RISK** is a software tool for the analysis of accident scenarios on industrial sites. The software uses the latest UFIP risk assessment methodology (Blue Book) for petrochemical refineries to analyse all possible accidental scenarios on petrochemical sites by analytical and empirical methods. This UFIP methodology has been validated by INERIS (French National Institute for Environment and Risks).



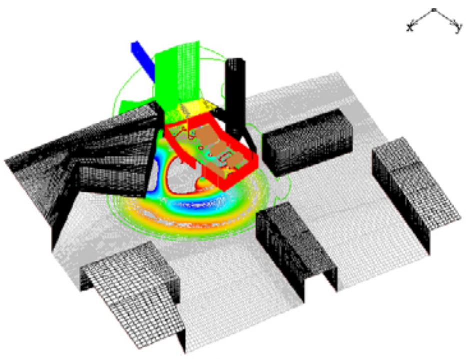
This tool provide Database of 13 Equipments: Atmospheric storage, Pressure vessel, Furnace, Boiler, Compressor, Pump, Pipes, Gasket, Branch connection, Valves, Loading/unloading arm, Rotating components etc.

Consequences calculation

Added to the last 2 items (real time dispersion simulation and fast consequences assessment), Fluidyn integrated software platform can also lead to complex consequences calculation such as explosion.



fluidyn-**VENTEX** is a module dedicated to the simulation of explosions in confined and semi-confined spaces. It simulates explosion of solids, gas clouds or particles-gas mixtures (dust clouds). The explosions may be multiple or simultaneous.



This tool also determines lethal and/or irreversible effects areas pressure waves on structures.

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