# 3D Terrain Model Application for Explosion Assessment

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**Abstract.** An increase in oil and gas plants caused by development of process industry have brought into the increase in use of flammable and toxic materials in the complex process under high temperature and pressure. There is always possibility of fire and explosion of dangerous chemicals, which exist as raw materials, intermediates, and finished goods whether used or stored in the industrial plants. Since there is the need of efforts on disaster damage reduction or mitigation process, we have been conducting a research to relate explosion model on the background of real 3D terrain model. By predicting the extent of damage caused by recent disasters, we will be able to improve efficiency of recovery and, sure, to take preventive measure and emergency counterplan in response to unprepared disaster. For disaster damage prediction, it is general to conduct quantitative risk assessment, using engineering model for environmentaldescription of the target area. There are different engineering models, according to type of disaster, to be used for industry disaster such as UVCE (Unconfined Vapor Cloud Explosion), BLEVE (Boiling Liquid Evaporation Vapor Explosion), Fireball and so on, among them;we estimate explosion damage through UVCE model which is used in the event of explosion of high frequency and severe damage. When flammable gas in a tank is released to the air, firing it brings about explosion, then we can assess the effect of explosion. As 3D terrain information data is utilized to predict and estimate the extent of damage for each human and material. 3D terrain data with synthetic environment (SEDRIS) gives us more accurate damage prediction for industrial disaster and this research will show appropriate prediction results.

**Keywords:** Quantitative risk assessment, Disaster, Fire, UVCE, SEDRIS

## 1 Introduction

An increase in oil and gas plants caused by development of process industry have brought into the increase in use of flammable and toxic materials in the complex process under high temperature and pressure. There is always possibility of fire and explosion of dangerous chemicals, which exist as raw materials, intermediates, and finished goods whether used or stored in the industrial plants. The scales of industrial and natural disasters in recent ten years are illustrated in Figure. 1.

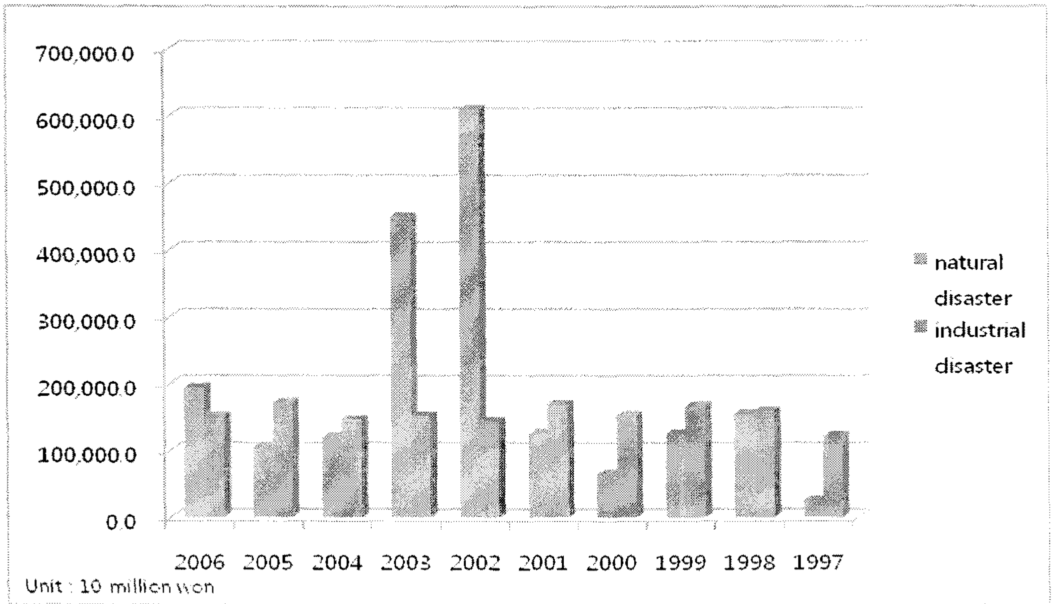


Figure 1 amount of damage in recent ten years

It shows industrial disaster was growing and its scale is as much as big. So, corresponding disaster prevention policy is needed. There are many cases of human cause and its damage range is predictable. So it is able to establish corresponding plan by prediction of accurate scale. Because past prevention policy of disaster was established without systematic analysis and survey, engineering simulations only performed. For simulation of industrial disaster, PhaseProfessional, commercial software, or CAMEO, EPA and NOAA made, has used in general condition. And the researches are active about relate part. But it is simple application of plain ground condition without considering Korean terrain environment. There are the necessities of simulation in real terrain condition.

For Quantitative Risk analyses, real terrain data is simulated by SEDRIS. To construct the target area's terrain model with SEDRIS, we have to combine DEM (Digital Elevation Model) of high resolution satellite image and aerial photograph and SEDRIS with geographic data. And apply industrial disaster model with that result. This approach will show more accurate prediction of damage than past one.

## 2 Simulation Methodology of Industrial Disaster

UVCE(Unconfined Vapor Cloud Explosion) is occurred through following 4 steps.

1. Leaking out flammable vapor or gas
2. Forming flammable vapor cloud by mixing leaked material and air
3. Igniting flammable vapor cloud compound
4. Propagating flame through vapor cloud in flammable concentration

It is seldom whole or almost vapor clouds explode. Flames propagate with chain detonation in many cases. Gas react rapidly seems to explode at a time.

There are two cases Which One Flash Fire, flame propagate slowly Another UVCE, flame propagate rapidly, so it takes place a lot of over pressure.

If UVCE occurred, it companies big over pressure in conditions of turbulence flow and partial confinement or objection and explosion.

In real UVCE, explosion over pressure can be 15 psi in stagnant area but 1.5 psi in not confinement condition.

Using following equation 1, approximates the mass of TNT.

$$W = \frac{\eta M E_c}{E_{cTNT}} \qquad (1)$$

where W = Equivalent mass of TNT[kg]

η = Empirical explosion yield[0.01~0.1]

M = Mass of flammable material released[kg]

Ec = Lower heating value of combustion of flammable gas[kJ/kg]

EcTNT = Heat of combustion of TNT[4500kJ/kg]

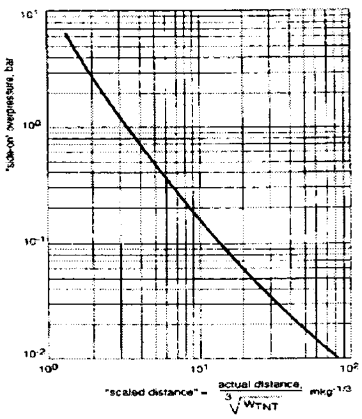


Figure 2 Overpressure due to explosions

The side-on blast overpressure at some real distance(R) of charge of mass of TNT, result of equation 1, is found by following equation.

$$R^{*} = \frac{R}{W_{TNT}^{1/3}} \qquad (2)$$

where R* = Hopkinson-scaled distance[m/kg1/3]
WTNT = charge of weight of TNT[kg]
R = real distance from charge [m]

If the scaled distance is R* known, the corresponding side-on blast peak overpressure can be read from the chart in Figure 2.

But Figure 2 about scalded distance vs. overpressure graph is non-linear. So regression equation is fitted as equation 3.

$$\log_{10} P^{*} = 1.052 - 2.158\log_{10}(R^{*}) + 0.3009\log_{10}(R^{*})^{2} \qquad (3)$$

where P* = explosion overpressure[bar]
R* = Hopkinson-scaled distance[m/kg1/3]

Damage amount of explosion area is estimated with above equations and chart. Whole flow chart for calculating explosion quantity is following.

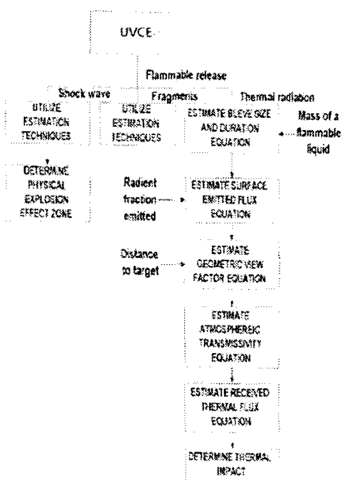


Figure 3 Logic Diagram for UVCE

## 3 Construction Model and Application of terrain model

Accurate and unambiguous representation of environmental data is an important part of many information technology applications. SEDRIS(Synthetic Environment Data Representation and Interchange Specification) permits representations of environmental data that can be described accurately, unambiguously, and precisely.

Authoritative representations of the environment are expected to be internally consistent and conform to physics-based principles. Furthermore, representations of environmental data shall contain an appropriate integration of terrain, ocean, atmosphere, and space domain data about a region of interest. SEDRIS supports the representation of the physical as well as the abstract aspects of each environmental domain. In addition, the actual reference objects being modeled or described can be either natural (e.g., some region of the Earth) or some constructed object. This latter capability is important in applications that evaluate the characteristics and performance of constructed objects with respect to environmental effects and impacts, prior to production (e.g., testing and evaluating land, water, air, and space vehicles).

SEDRIS also supports the representation of 3D models, including various articulations required to convey general system design characteristics, as well as data representation in the environmental domains of: Terrain, Ocean, Atmosphere, and Space.

A representation of the terrain domain includes data on the location and characteristics of a planetary surface, natural and permanent or semi-permanent constructed features, and related processes including seasonal and diurnal variation.

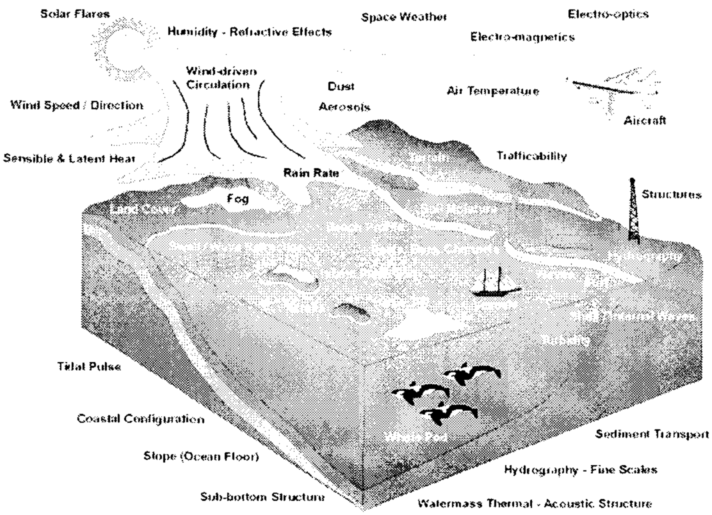


Figure 4 SEDRIS Environment domains

SEDRIS relies on its five core technology components. These are the SEDRIS Data Representation Model (DRM), the Environmental Data Coding Specification (EDCS), the Spatial Reference Model (SRM), the SEDRIS interface specification (API), and the SEDRIS Transmittal Format (STF).

Three of these (DRM, EDCS, and SRM) are used to achieve the unambiguous representation of environmental data. The combination of these three core components provides the mechanism for description of environmental data. In some respect, this capability within SEDRIS can be viewed as analogous to a language for describing data about the environment. The DRM, the EDCS, and the SRM enable us to capture and communicate meaning and semantics about environmental data. The SEDRIS API and the STF allow the efficient sharing and interchange of the environmental data represented by the other three components. In the following, each of these five components is briefly described.

## 4 Simulation Result

For performing simulation, explosion conditions are following.

| |
|---|
| Explosion in the LPG replenishment station case, |
| Explosion Type : UVCE |
| Explosion Material : LPG(Butane:$C_4H_{10}$) |
| Released Mass : 10kg |
| Empirical explosion yield : 0.4(4%) |

Condition is illustrated in Figure 5. It shows explosion effect range is drawn by concentric circle. This result is obtained by not reflecting the geographical information in UVCE model. In 2D case, a concentric circle indicating the pressure becomes a concentric circle.

If the explosion is simulated with three-dimensional model and non-existence of objection condition and reflecting the geographical information from DEM in UVCE model, simulation result is represented by ellipsoidal shape according to the geography of the area. It is illustrated in Figure 7. This is the more correct result then 2D's one and this can be used in planning for emergency fire escape.

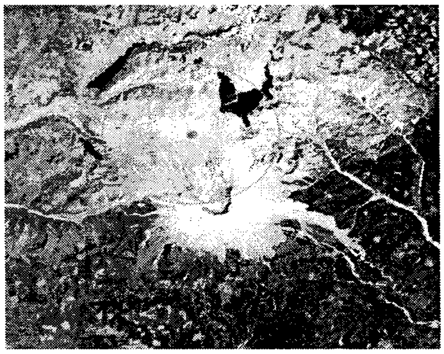

Figure 5 Explosion effect for 2D model

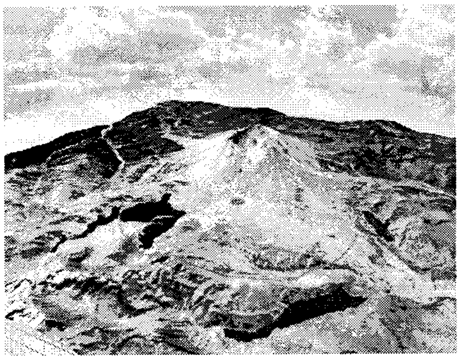

**Figure 6 Explosion effect for 3D model**

## 4 Conclusion

Today, not only the frequency of industry disaster has increased but also the scales of the disaster have enlarged and broaden due to the recent industrial development and constantly occurring accidents. Yet there is no disaster prediction system at present which is pointed out as the limitation to cope with disasters in scientific measures. Therefore, it is suggested to develop a disaster prediction system suitable for domestic terrain condition to establish a scientific disaster management system and an effective driving force in disaster prevention strategy and a disaster measure system. As a mean of status analysis study to predict disaster, this paper focuses on the application of the 3D terrain model.

The result of the risk prediction made the two-dimensional damage prediction into a three-dimensional one. In other words, it can be used to predict possible damages more accurately and to make it possible to establish strategies for emergency evacuation. But on the other hand, due to the diversity of data on various subjects and in many different types, it is pointed out that standardization of the data types is highly required along with the articulated cooperation system for proper application for the sake of future damage prediction.

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