APPLICATION OF 3D TERRAIN MODEL FOR INDUSTRY DISASTER 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 environmental description of the target area. There are different engineering models, according to type of disaster, to be used for industry disaster such as UVCE (Unconfined Vapour Cloud Explosion), BLEVE (Boiling Liquid Evaporation Vapour 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.

KEY WORDS: 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.

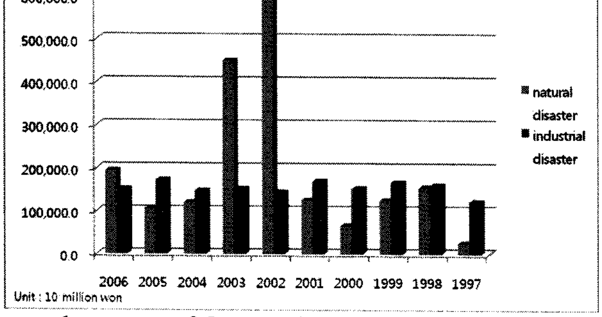

Figure 1 amount of damage in recent ten years

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, Phast Professional, 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.

Risk Assessment of disaster like explosion and prediction of damage proceeded as following steps, recognition and assessment of risk element, understanding of flammable sources and its scales, assessment of weakness about vessels of flammable sources and analysis of damage scale and range. The steps of disaster risk assessment are illustrated in Table 1.

The three elements, estimation of risk and construction of damage data and weakness of damage target, are necessary for these analyses. For example, As set up leak mass from the tank of flammable material and calculate mass of explosion in UVCE case, the model of explosion is established and it can be estimated the direction vector of explosion.

For these analyses, real terrain model is simulated by SEDRIS. It is standard of environmental data. It is a abbreviation of 'Synthetic Environment Data Representation & Interchange Specification'. The methodology of SEDRIS is composed of five technology element, Data Representation Model (DRM), Data Coding Specification (EDCS), Spatial Reference Model (SRM), SEDRIS Transmittal Format (STF). It is established by international standard throughout ISO/IEC JTC1/SC24.

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.

Table 1 Disaster Risk Assessment Steps

Element	Steps	Contents	
Risk Assessment	Risk Identification	Recognition of regional range of risk, consequence, frequency	Risk Element Modeling
	Risk Assessment	Estimation of damage when occurring risk event	
Vulnerability Assessment	Inventory Identification	Construction database of Inventory	Construction Database
	Vulnerability Assessment	Vulnerability assessment as typical inventory	Vulnerability Modeling
Analysis	Multi-Hazard Risk Assessment	Estimation of loss possibility, Money assessment of vulnerability, explanation of assessment way, effect estimation of inventory damage for regional society	Damage Estimation
	Assessing Vulnerability	Analysis of damage possibility and estimation of maximum damage by composition analysis of human resources and inventory – previous recognition of possible disaster	Decision Support

2. SIMULATION METHODOLOGY OF INDUSTRIAL DISASTER

UVCE mechanism

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

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

It is seldom whole or almost vapour cloud 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

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

where W = Equivalent mass of TNT[kg]
η = Empirical explosion yield[0.01~0.1]
M = Mass of flammable material released[kg]
E_c = Lower heating value of combustion of flammable gas[kJ/kg]
E_{cTNT} = Heat of combustion of TNT[4500kJ/kg]

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.

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

where R^* = Hopkinson-scaled distance[m/kg$^{1/3}$]
W_{TNT} = 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.

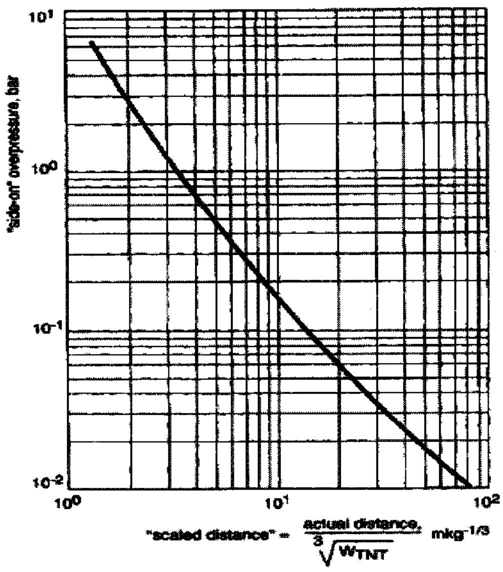

Figure 2 Overpressure due to explosions

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

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

where P^* = explosion overpressure[bar]
R^* = Hopkinson-scaled distance[m/kg$^{1/3}$]

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

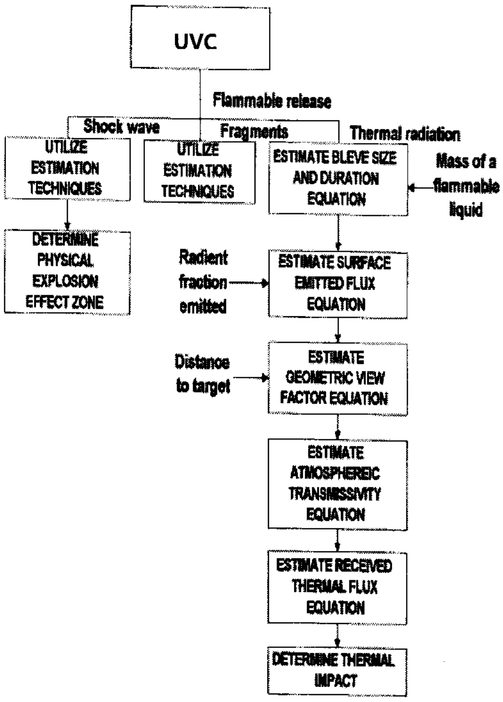

Figure 3 Logic diagram for UVCE

3. CONSTRUCTION MODEL AND APPLICATION OF TERRIAN 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 modelled 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.

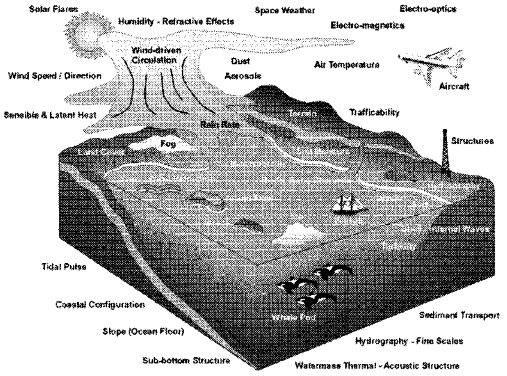

Figure 4 SEDRIS Environment Domains

SEDRIS is fundamentally about: (a) representation of environmental data, and (b) the interchange of environmental data sets.

To achieve its representation and interchange objectives, 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.

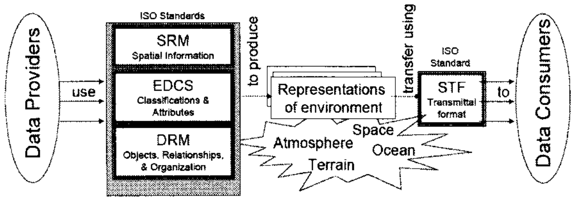

Figure 5 Technical Components & Process

In October 1999, SEDRIS began the process of establishing international standards through ISO/IEC JTC1/SC24. SEDRIS technologies have been assembled into the following specification and language binding standards through the ISO/IEC.

ISO/IEC Ref.	Title	FCD	FDIS	IS
18023-1	SEDRIS Functional Specification	05/04	01/06	05/06
18023-2	SEDRIS Transmittal Format	03/04	02/06	06/06
18023-3	SEDRIS Transmittal Format – Binary Encoding	03/04	02/06	06/06
18024-4	SEDRIS Language Binding Part 4 : C	06/04	01/06	05/06
18025	Environmental Data Coding Specification (EDCS)	12/02	10/04	05/05
18026	Spatial Reference Model (SRM)	06/04	01/06	06/06
18041-1	EDCS Language Bindings, Part 4: C	02/03	11/04	07/05
18042-4	SRM Language Bindings, Part 4: C	07/04	12/05	06/06
24788	Templates for the SEDRIS DRM	08/07	2008	2008

Figure 6 ISO/IEC SEDRIS Standards