Marine Casualty Forecasting System of Korea

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Presentation Outline

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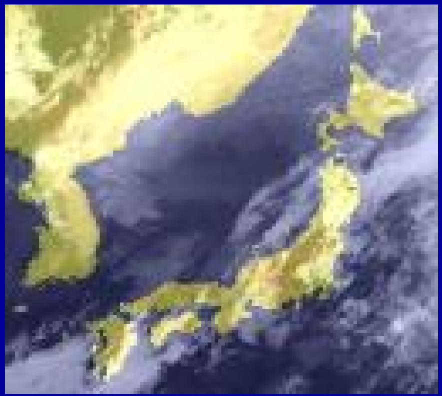
1. INTRODUCTION

Weather Forecasting V.S. Marine Casualty Forecasting

Weather Forecasting



- It can predict weather.
- It can predict come to risk by weather.

Is it possible ?

Marine Casualty Forecasting

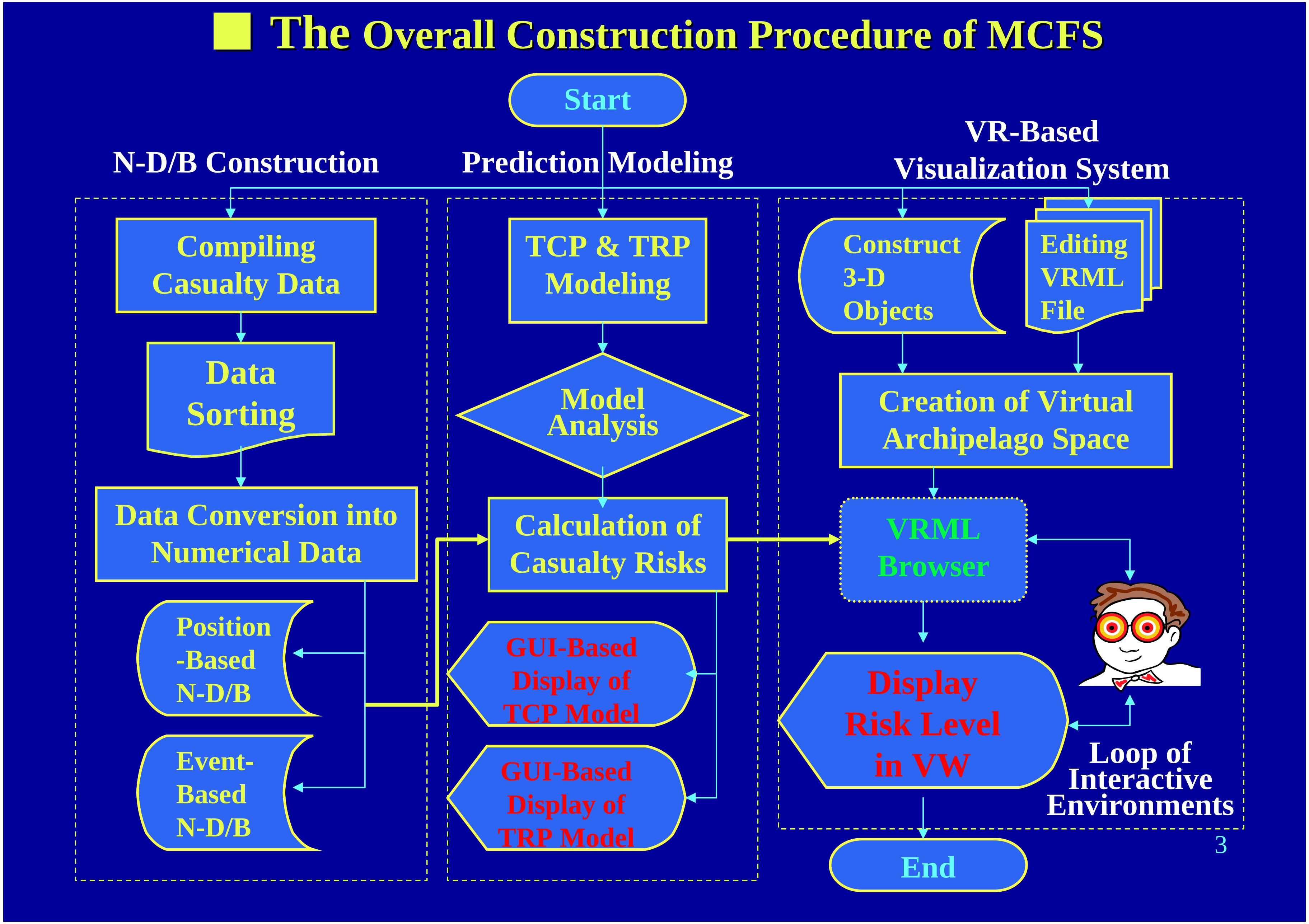
Purpose of the Study

- To develop VR-Based MCFS to broadcast precisely predicted risk levels of marine casualties as like daily weather forecasting system in a TV.

Goal of this Work

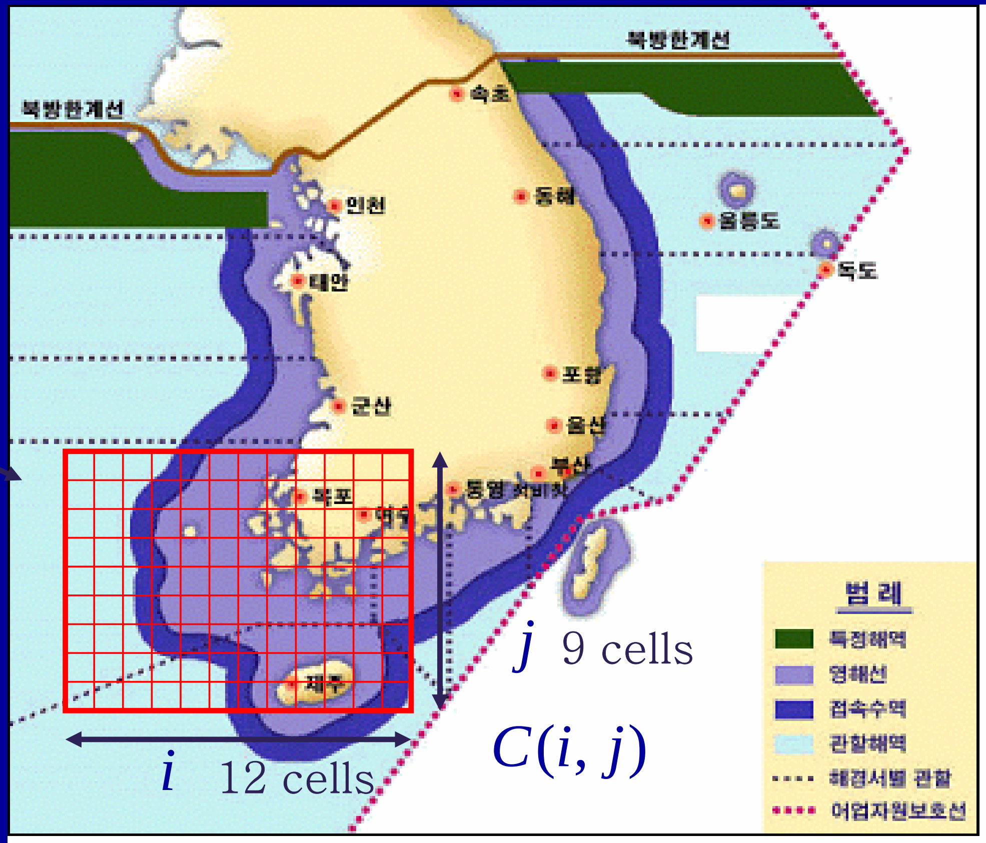
- To set-up the construction procedure of N-D/B from casualty history.
- To establish Time-based Casualty Prediction models to predict number of casualties and to predict risk level.
- To construct VR-based visualization system.

1. INTRODUCTION



2. NUMERICAL D/B CONSTRUCTION

2.1 Procedures of N-D/B Construction

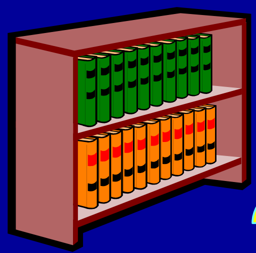


Geographical location of the target area

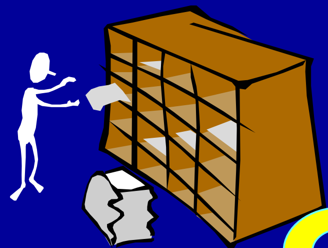
2. NUMERICAL D/B CONSTRUCTION

2.1 Procedures of N-D/B Construction

Decision Letters of KMST
(Korea Maritime Safety Tribunal)



Compiling 724 Ship Casualties in the Target Area

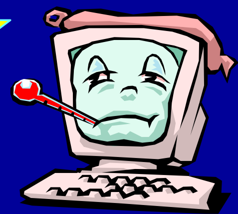


Classification Items

Classify Casualty Data into 14 Factors; Date, Position, etc.

Conversion Scales

Data Conversion into Quantitative Data with 14 Numeric Scales



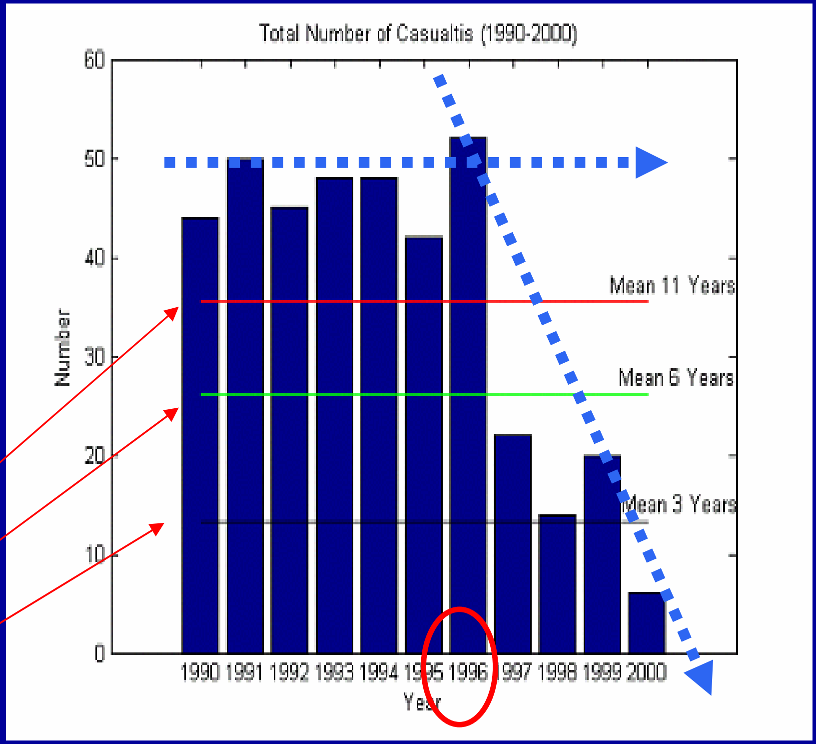
Numerical D/B

2. NUMERICAL D/B CONSTRUCTION

2.2 N-D/B Analysis

Analysis Results

- Overall trend of casualty figures keep almost uniform distribution during 1990~1996, and rapidly decrease after 1996.
- Mean values of number of ship casualties according to the year-band has great variances.
  11 years(1990-2000) = 37
  6 years (1995-2000) = 26
  3 years (1998-2000) = 13



Total number of casualties in 1990-2000

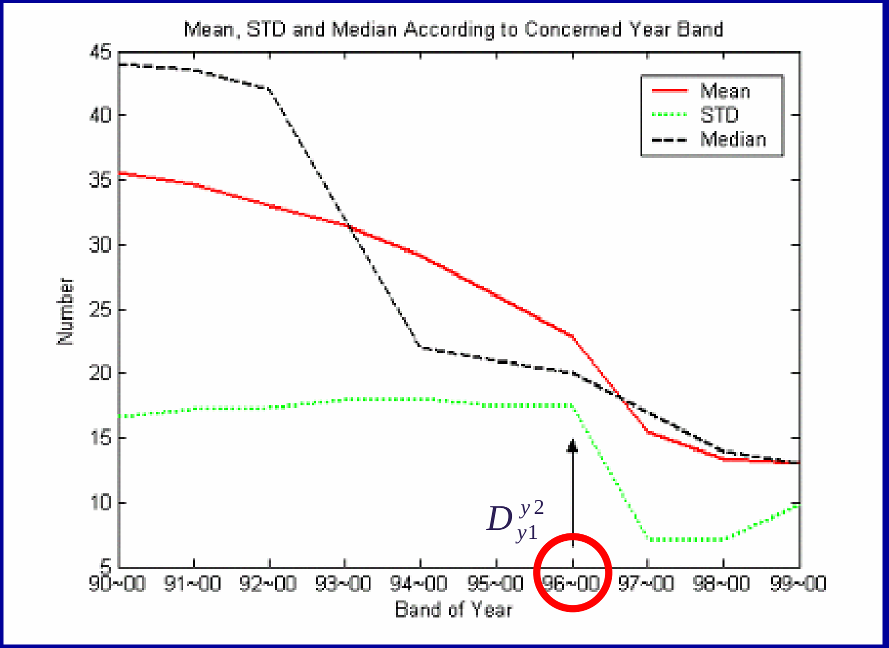
2. NUMERICAL D/B CONSTRUCTION

2.3 Optimum Year-band Selection

Considerations

- **Long year casualty statistics have certain disadvantages: if a safety analysis is based on long year statistics, this casualty data should include a great variety of different historical conditions.**
- **The drawbacks of long history statistics can be avoided by concentrating on the casualties of a limited historical year.**
- **The environmental conditions are uniform and the special features of the marine traffic are better known.**

$$D_{y1}^{y2} = \min[Mean(N_{y1}^{y2}) \sim STD(N_{y1}^{y2}) \sim MED(N_{y1}^{y2})]$$



Optimum year-band selection

3. MATHEMATICAL PREDICTION MODEL

3.1 Theoretical Background

The future distribution of marine accident can be expect by statistical model, which fit the past casualty data.

The casualty data can be modeled by a polynomial function as,

$$Y_p = \beta_0 + \beta_1 T + \beta_2 T^2 + \cdots + \beta_k T^k + \varepsilon$$

Where, $Y = [N_1, N_2, \ldots, N_m]$ **: number of casualty.** $T = [Y1, Y2, \cdots, Ym]$**: year,**
β_j **: regression coefficient** $(j = 0, 1, \cdots, k)$, ε **: error**

Consider the exponential function, known Linear-in-the-Parameter (LIP) as,

$$Y_{LIP} = \beta_0 + \beta_1 e^{-T} + \beta_2 T e^{-T} + \cdots + \beta_k T^{k-1} e^{-T} + \varepsilon$$

Consider casualty data in each cell position, (i, j)

$$Y_{CLIP}(i, j) = \beta_0(i, j) + \beta_1(i, j) e^{-T} + \beta_2(i, j) T e^{-T} + \cdots + \beta_k(i, j) T^{k-1} e^{-T} + \varepsilon(i, j)$$

3. MATHEMATICAL PREDICTION MODEL

3.2 Time-Base Casualty Prediction Model

Time-based Casualty Prediction (TCP) model is to predict number of casualty in the cell position (i, j) at every time in a year using time dependent weighting factor.

$$Y_{WCLIP}(i, j) = Y_{CLIP}(i, j)\underline{w_T(i, j, km, kd, kw, kt, ka, ks)}$$

Where,

$$w_T(i, j, km, kd, kw, kt, ka, ks) = 1/6[w(i, j, km) + w(i, j, kd) + w(i, j, kw) + w(i, j, kt) + w(i, j, ka) + w(i, j, ks)]$$

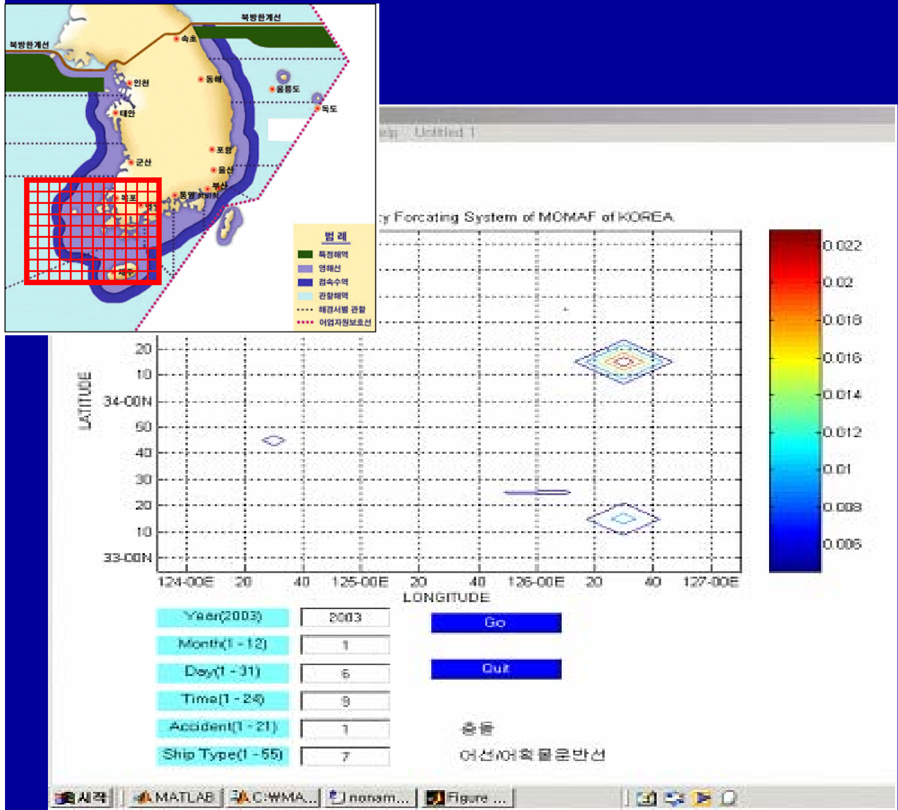
Time dependant factors (Month, Day, week, Time)

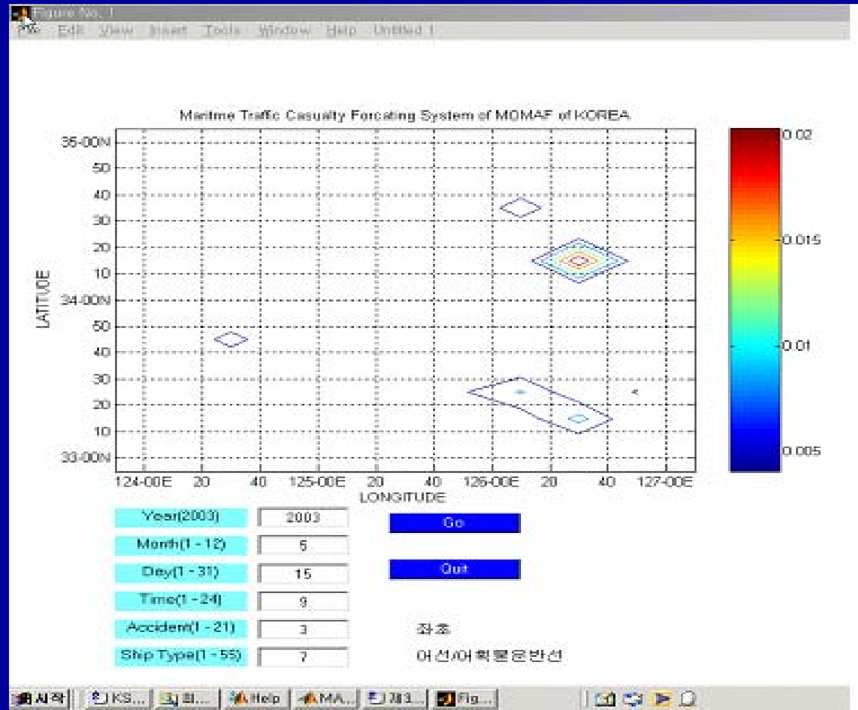
$$w(i, j, *) = \frac{N_{y1}^{y2}(i, j, *)}{N_{T\,y1}^{\;y2}} \;,\; 0.0 \le w(i, j, *) \le 1.0$$

$$N_{T\,y1}^{\;y2} = \sum_{k=1}^{nCLat} \sum_{l=1}^{nCLong} \sum_{m=y1}^{y2} N(k, l, m)$$

3. MATHEMATICAL PREDICTION MODEL

3.2 Time-Base Casualty Prediction Model





GUI-Based Display of prediction results by TCP model

**Year=2003, Month=1, Day=6, Time=0900,
Accident type='collision',
Ship's type='fishing/fishing barge'**

**Year=2003, Month=5, Day= 15, Time=0900,
Accident type=’grounding’,
Ship's type=’fishing/fishing barge’**

3. MATHEMATICAL PREDICTION MODEL

3.3 Time-Base Risk Prediction Model

Time-based Risk Prediction (TRP) model is to predict **normalized risk level in the whole target areas** at every time in a year using predicted casualty number from TCP model. TRP model is based on the TCP model

$$P_T(km, kd, kw, kt) = 1/4[\underline{P(km)} + \underline{P(kd)} + \underline{P(kw)} + \underline{P(kt)}]$$

Where,

$$P(*) = \frac{\sum_{k=1}^{nCLat} \sum_{l=1}^{nCLong} \tilde{N}^{yp}(k,l,*)}{\sum_{k=1}^{nCLat} \sum_{l=1}^{nCLong} \tilde{N}^{yp}(k,l)}, \quad 0.0 \le P(*) \le 1.0$$

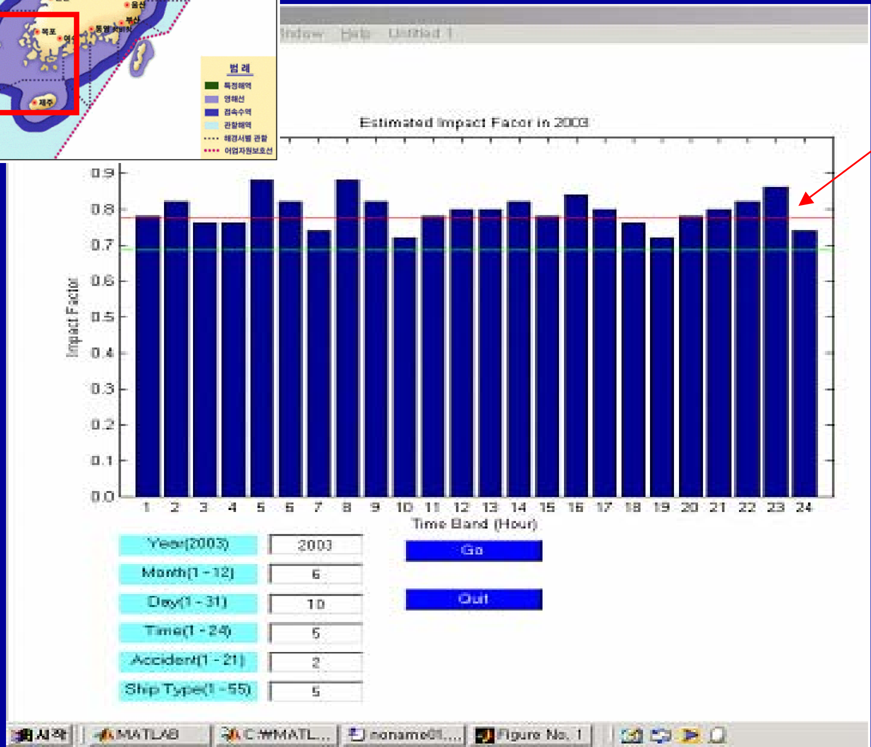
In addition, to provide guide line of risk level in TRP model, the risk criteria (RC) given as,

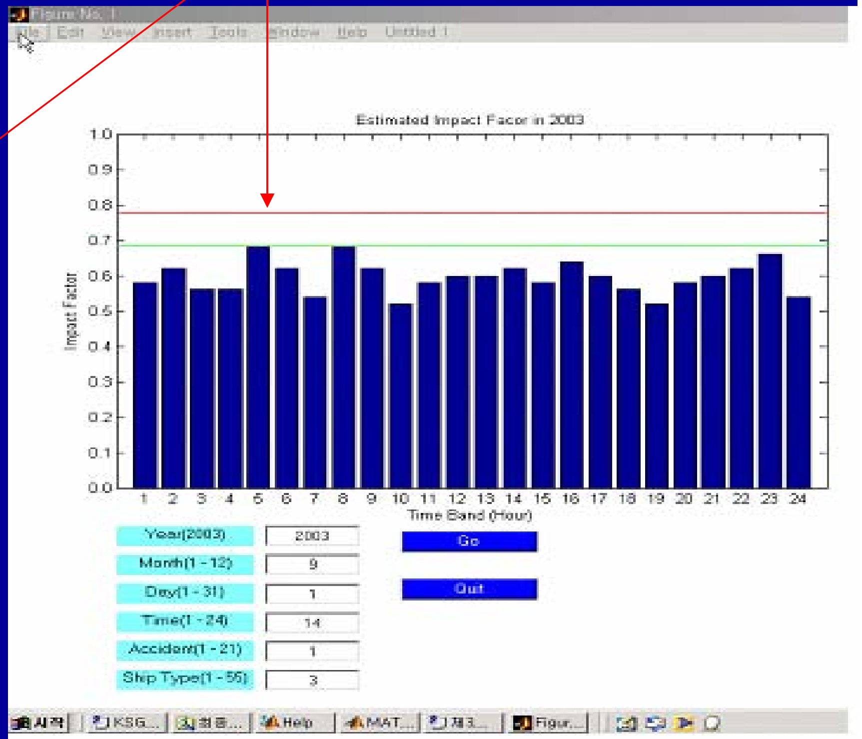
$$RC = Mean(P_T) + STD(P_T)$$

3. MATHEMATICAL PREDICTION MODEL

3.3 Time-Base Risk Prediction Model

$$RC = Mean(P_T) + STD(P_T)$$





GUI-Based prediction results by TRP model

year=2003, month=6, day=10 (June 10, 2003)

year=2003, month=9, day=1 (September 1, 2003)

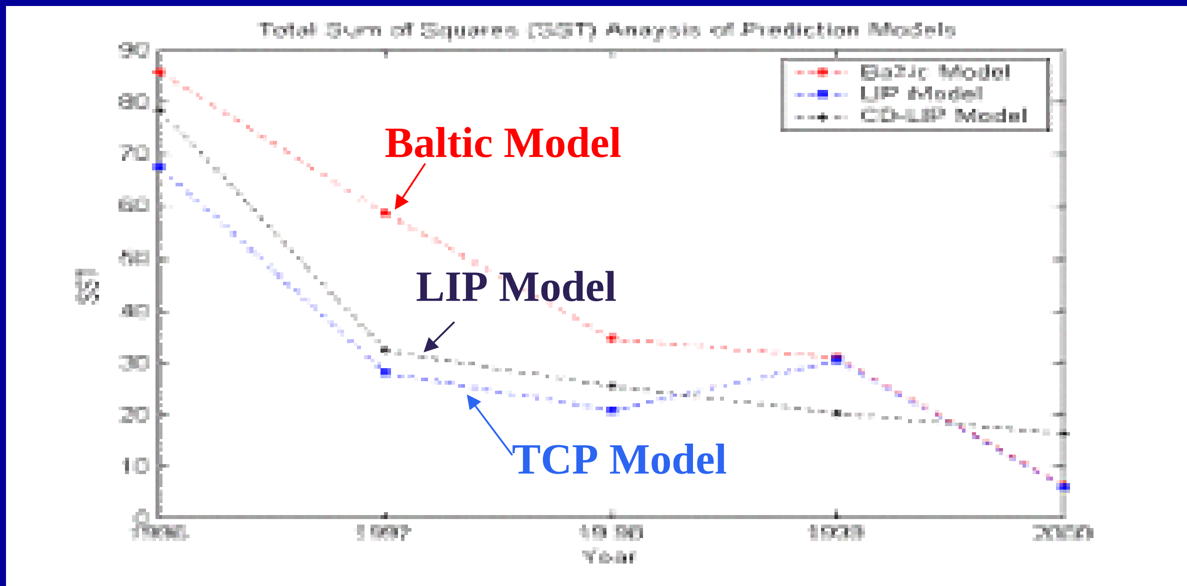
3. MATHEMATICAL PREDICTION MODEL

3.4 Error Analysis of Prediction Models

Compared Model (Baltic Model) : $P(N=k)=\dfrac{m^k e^{-m}}{k!}$

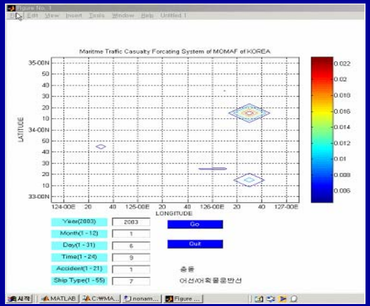
Model Error Analysis Method

$$\underbrace{\sum(N_{year(i)}-\overline{N}_{year(i)})^2}_{\text{Total Sum of Squares(SST)}}=\underbrace{\sum(\hat{N}_{year(i)}-\overline{N}_{year(i)})^2}_{\text{Regression Sum of Squares(SSR)}}+\underbrace{\sum(N_{year(i)}-\hat{N}_{year(i)})^2}_{\text{Error Sum of Squares(SSE)}}$$



4. IMPLEMENTATION OF MCFS

4.1 Discussion of Visualization Methods



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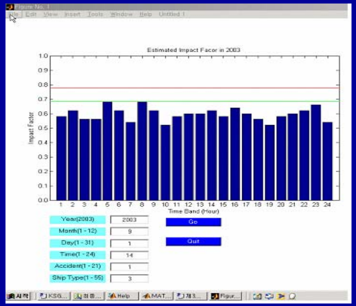

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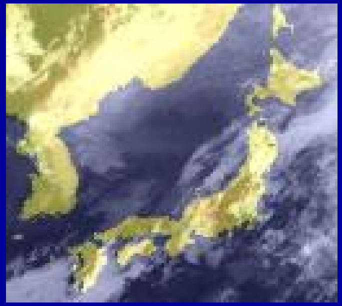

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How?

The answer is using Virtual Realty technology.

■ Merits of VR-Based System

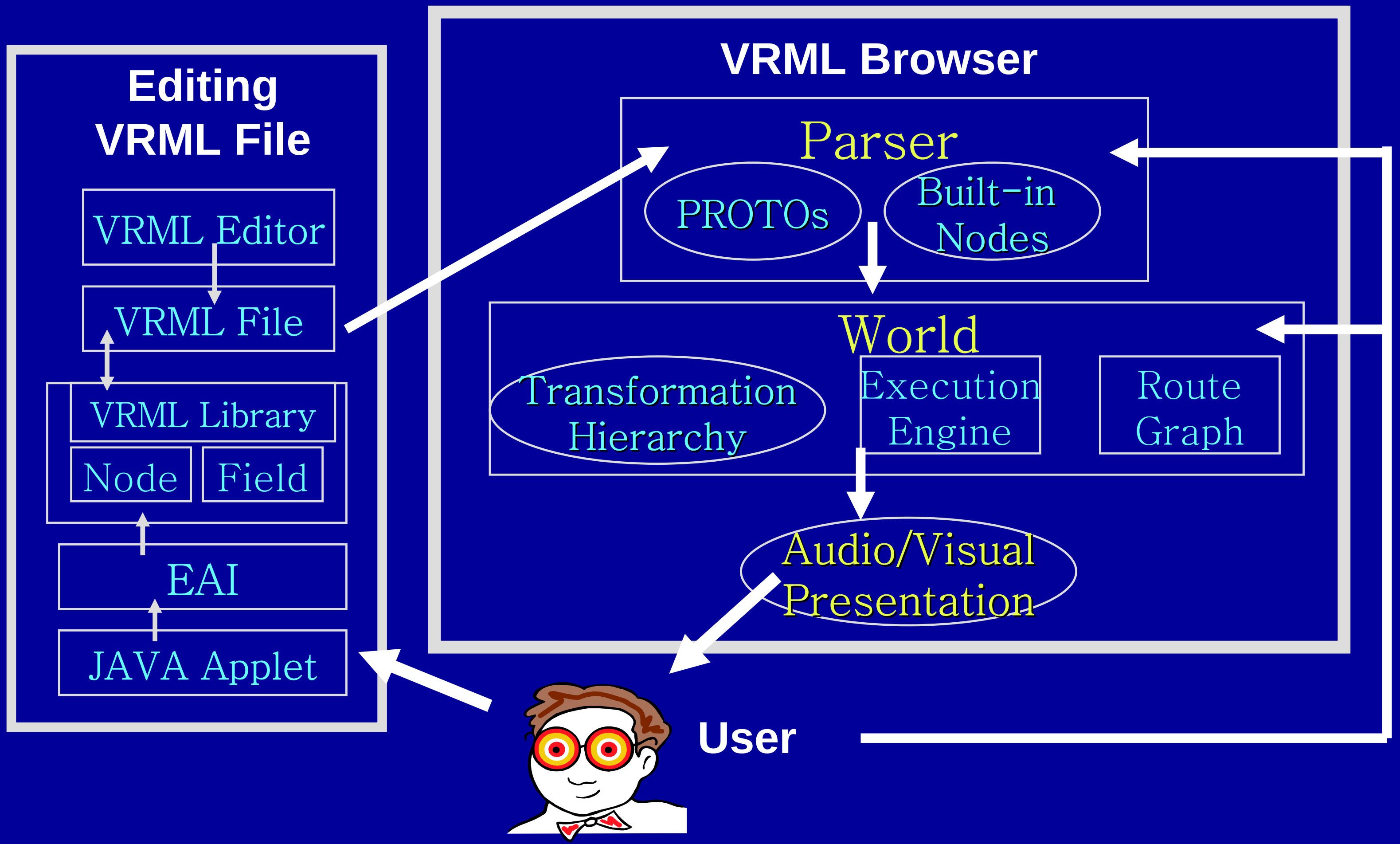
- **Suitable for the low-cost, readily available system.**
- **Ease of system up-grade as environment needs change.**
- **Enhances user's ability to understand with real-like experiences.**

The VR world

4. IMPLEMENTATION OF MCFS

4.1 Discussion of Visualization Methods

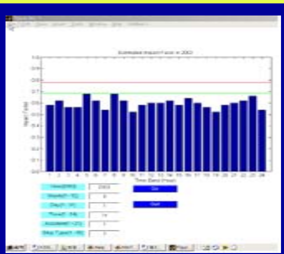
Interactive virtual world creation by VRML file & VRML Browser



4. IMPLEMENTATION OF MCFS

4.2 Implementation Method

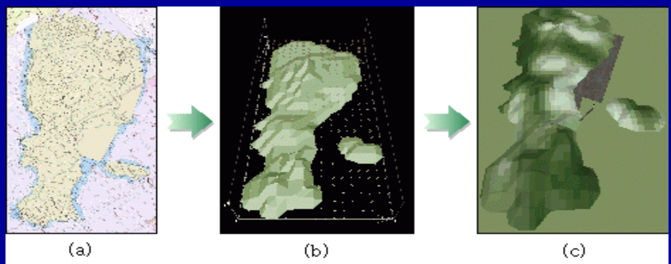
Apply TRP model at each cell (i, j), and scaling risk value to 6 steps

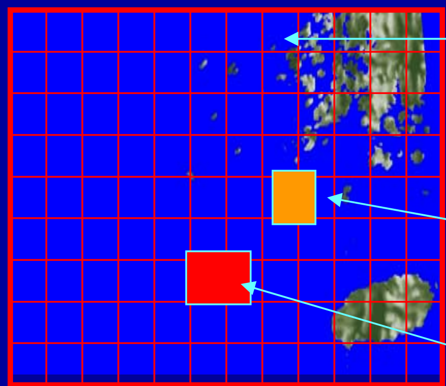


$P_T(km, kd, kw, kt) \longrightarrow P_T(i, j, km, kd, kw, kt, ka, ks)$

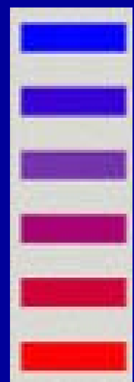
$0.0 \le P_T \le 1.0 \longrightarrow P_T = \{1,2,3,4,5,6\}$

Create VR world. and divide background space, then display 6 steps risk value as a related color





12 by 9 cells (108)

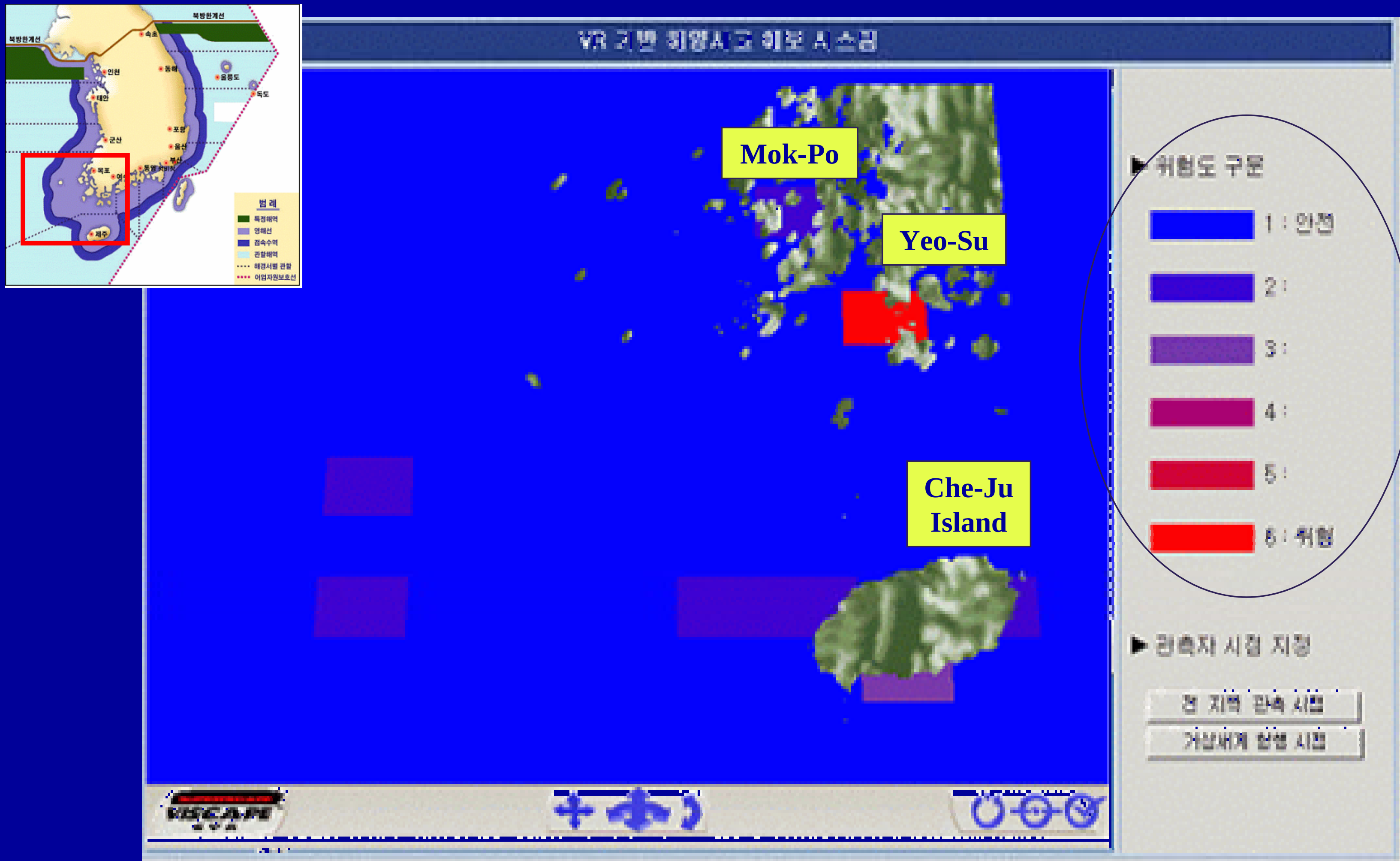


Safety if $P_T = 1$

Very danger if $P_T = 6$

4. IMPLEMENATION OF MCFS

4.3 Visualization Results



Operating result of MCFS - a plane view -

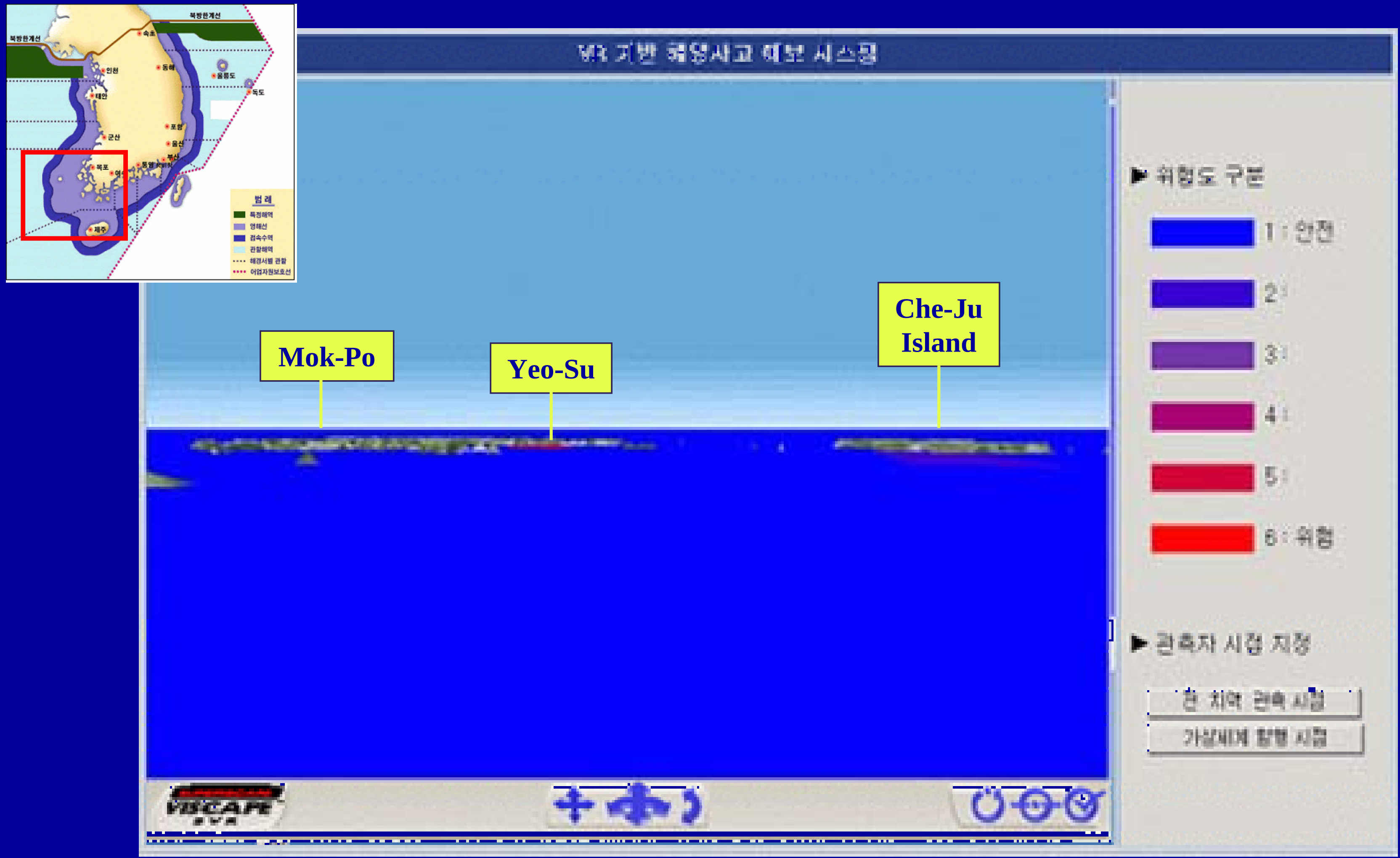
4. IMPLEMENATION OF MCFS

4.3 Visualization Results

Operating result of MCFS - a slant view -

4. IMPLEMENATION OF MCFS

4.3 Visualization Results



Operating result of MCFS - a far field view -

5. CONCLUSIONS

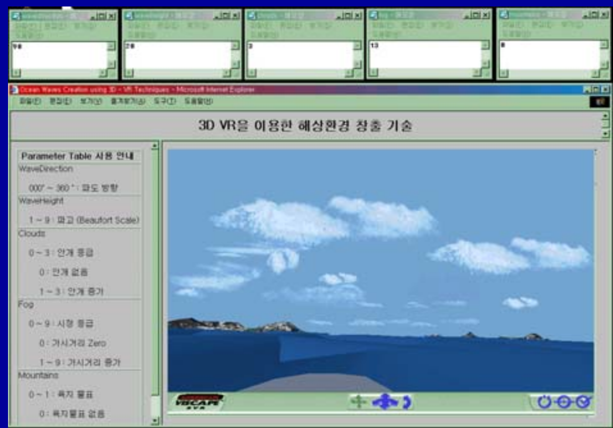
Through the study, the following conclusions are made:

- **Established the construction procedure of Numerical D/B from text-type casualty data.**
- **Developed optimum year-band selection method to provide correct N-D/B analysis and precise model prediction.**
- **Newly developed TCP and TRP models are fit to predict marine risk levels in any occasion.**
- **Complex prediction data can be display on the background scene of a virtual archipelago space as a simple color.**
- **Thus, it is clearly known that the MCFS can provide intuitively understandable risk meaning to a person who engaged in an ocean industry to ensure marine safety.**

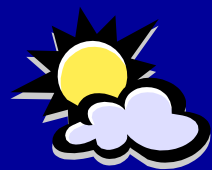
FURTHER WORK

- **To increase the accuracy of prediction models, some crucial factors, such as human errors and social factors which can be influence the degree of accuracy, are to be consider.**
- **To provide flexible and smart predictions, advanced prediction methods are also to be consider.**
- **The construction of a real-time prediction system, which has casualty risks and weather information from Internet, is under proceeding.**

Create sea state scene with 3D objects, and show the related scenes



Weather Forecasting



Casualty Risk Forecasting

Thank you for your attention !