Current Status of Risk-Informed Fire Analysis in Taiwan

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Third TAEC-USNRC Technical Exchange Meeting
NRC, Washington D.C., USA
May 31, 2005

Outline

- Introduction
- Major Works of Chinshan RIFA Project
- Recent Activities of RIFA
- Conclusions

Introduction (1 of 6)

- Fire protection of Safe Shutdown Capability (SSDC) of Appendix R requirements
  - One train of systems necessary to achieve and maintain hot shutdown conditions from either the control room or emergency control station is free of fire damage
  - Systems necessary to achieve and maintain cold shutdown from either the control room or emergency control station can be repaired within 72 hours

Introduction (2 of 6)

- For cables and equipment of redundant trains of systems necessary to achieve and maintain hot shutdown conditions located within the same fire area
  - Separation by a horizontal distance of larger than 20 feet with no intervening combustible or fire hazards. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area.
  - Separation by a fire barrier with a 3-hour rating.
  - Enclosure of 1 redundant train in a fire barrier with a 1-hour rating. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area.

Introduction (3 of 6)

- SECY 99-182, ‘Assessment of the Impact of Appendix R Fire Protection Exemptions on Fire Risk’
  - More than 900 cases of Appendix R fire protection exemptions were requested and accepted.
  - Most of them were low risk significance, but some were high.
  - Risk-informed application based on RG 1.174 for Appendix R fire protection exemption was recommended.

Introduction (4 of 6)

- RG 1.189 (C) Regulation Position 1.8.2, ‘Exemptions to Appendix R of 10CFR50’
  - Based on GL 86-10.
  - An alternative approach provide a level of safety equivalent to the technical requirements of Appendix R.
  - Detailed fire hazards analysis, and/or in conjunction with proposed modifications is required.

Introduction (5 of 6)

- SECY 04-0050, 10CFR50.48, NEI 04-02, DG-1139
  - NFPA 805 can fit the requirements of RG 1.189.
  - NFPA 805 can be used as an option of risk-informed, performance-based fire protection program.
  - Implementation guidelines in NEI 04-02 is endorsed, with some exceptions and clarification by DG-1139 Released in September 2004.

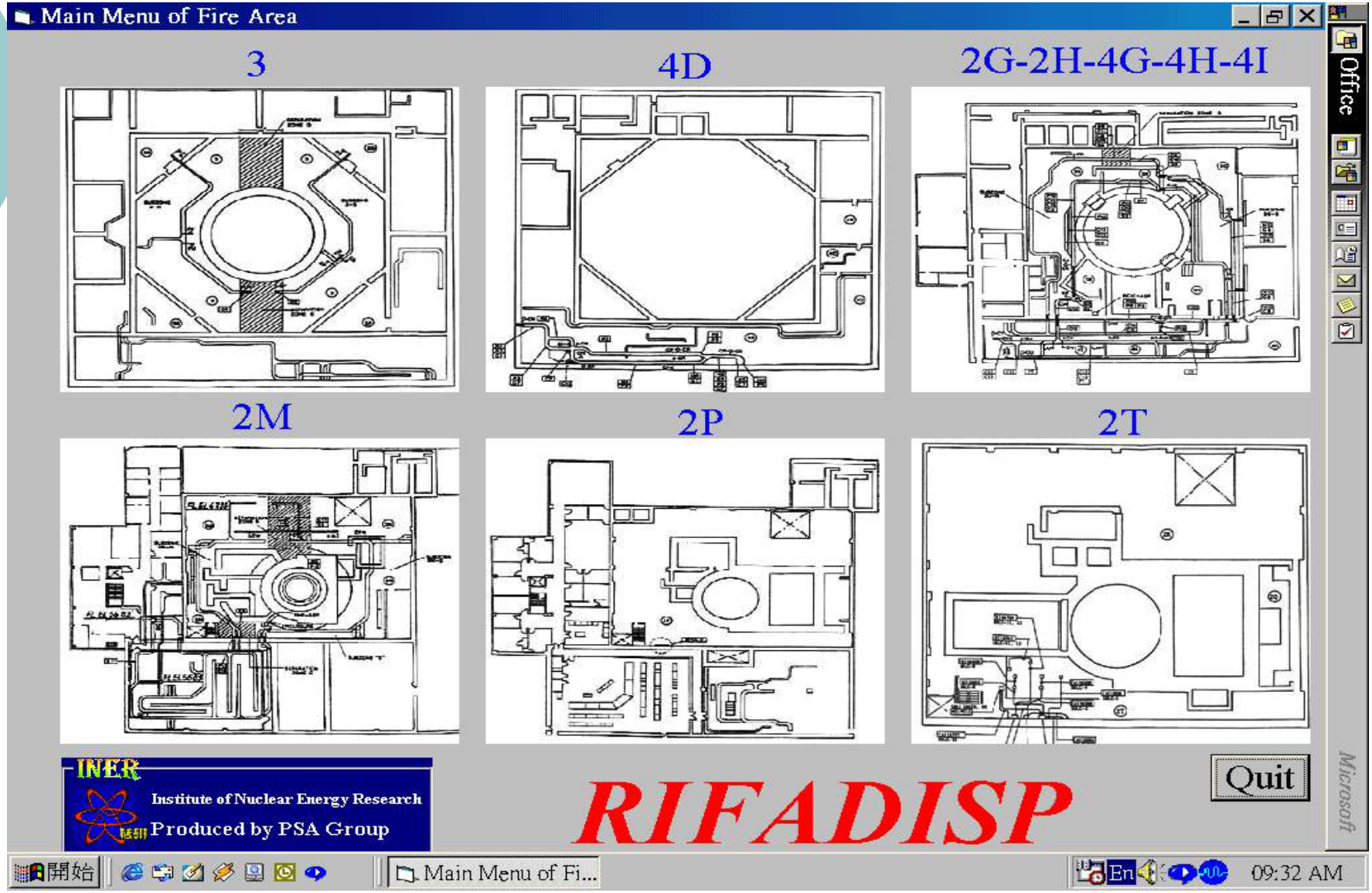
Introduction (6 of 6)

- In the Bulletin 92-01, failure of Thermo-Lag 330 was announced.
- Risk-Informed Fire Analysis (RIFA) projects were sponsored by TPC to assess the optimal alternative approaches for cable tray fire wrapping issues for three NPPs in Taiwan.
- Chinshan RIFA Project was finished in 2002; Kuosheng RIFA Project was finished in 2004; while Maanshan RIFA Project will be finished in the end of 2005.

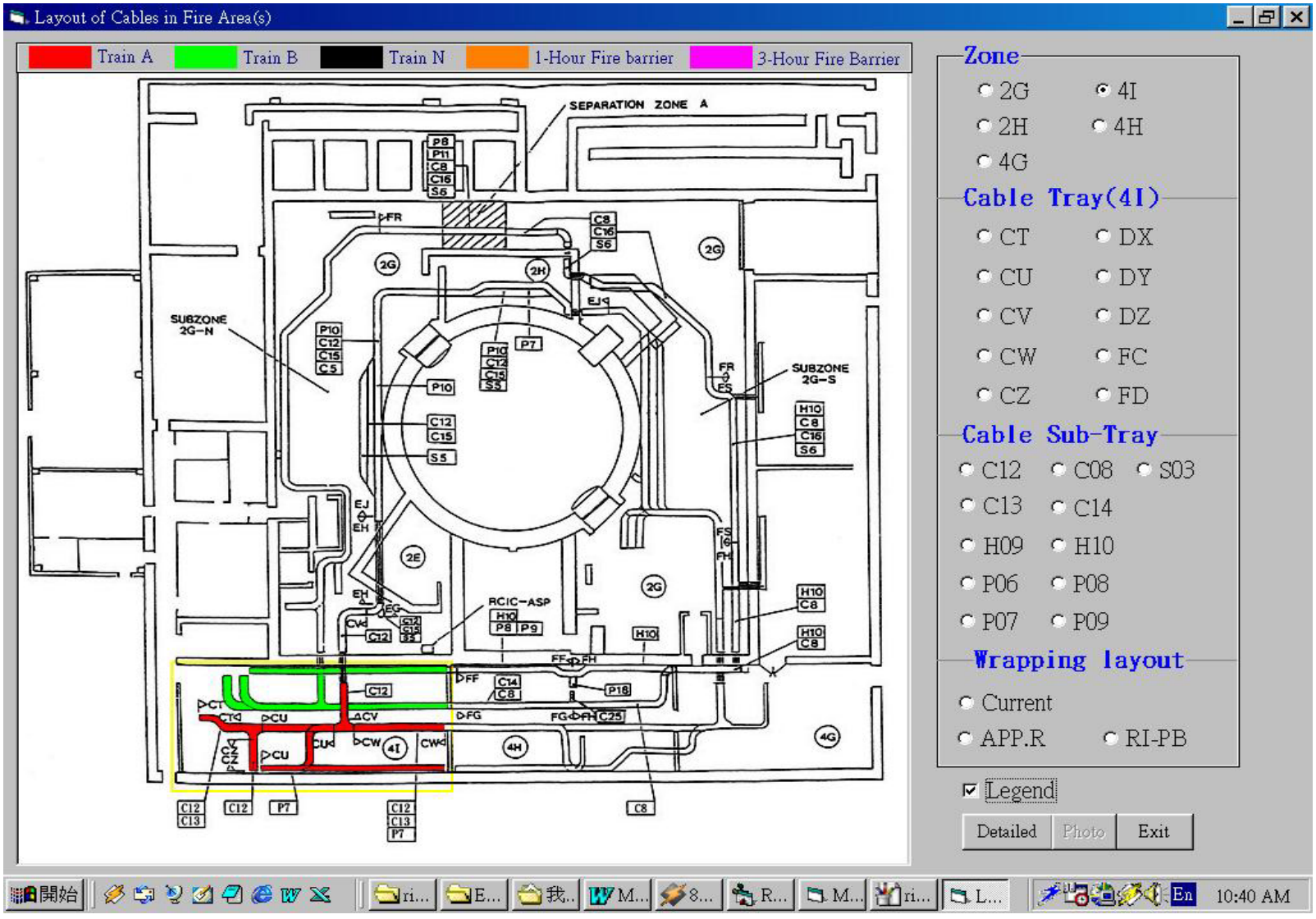
Major Works of Chinshan RIFA Project

- Display of Fire Zones
- Display of Train Differentiation
- Display of App. R Fire Barrier Requirements
- Display of Cable Details
- Display of Cable Tray Fire Consequences in CDF & LERF
- Display of Local Photos
- Display of Cable Layout with COMPBRN-IIIe Analysis
- Display of Wrapping Options from RIFA
- Display of Value-Impact Assessment

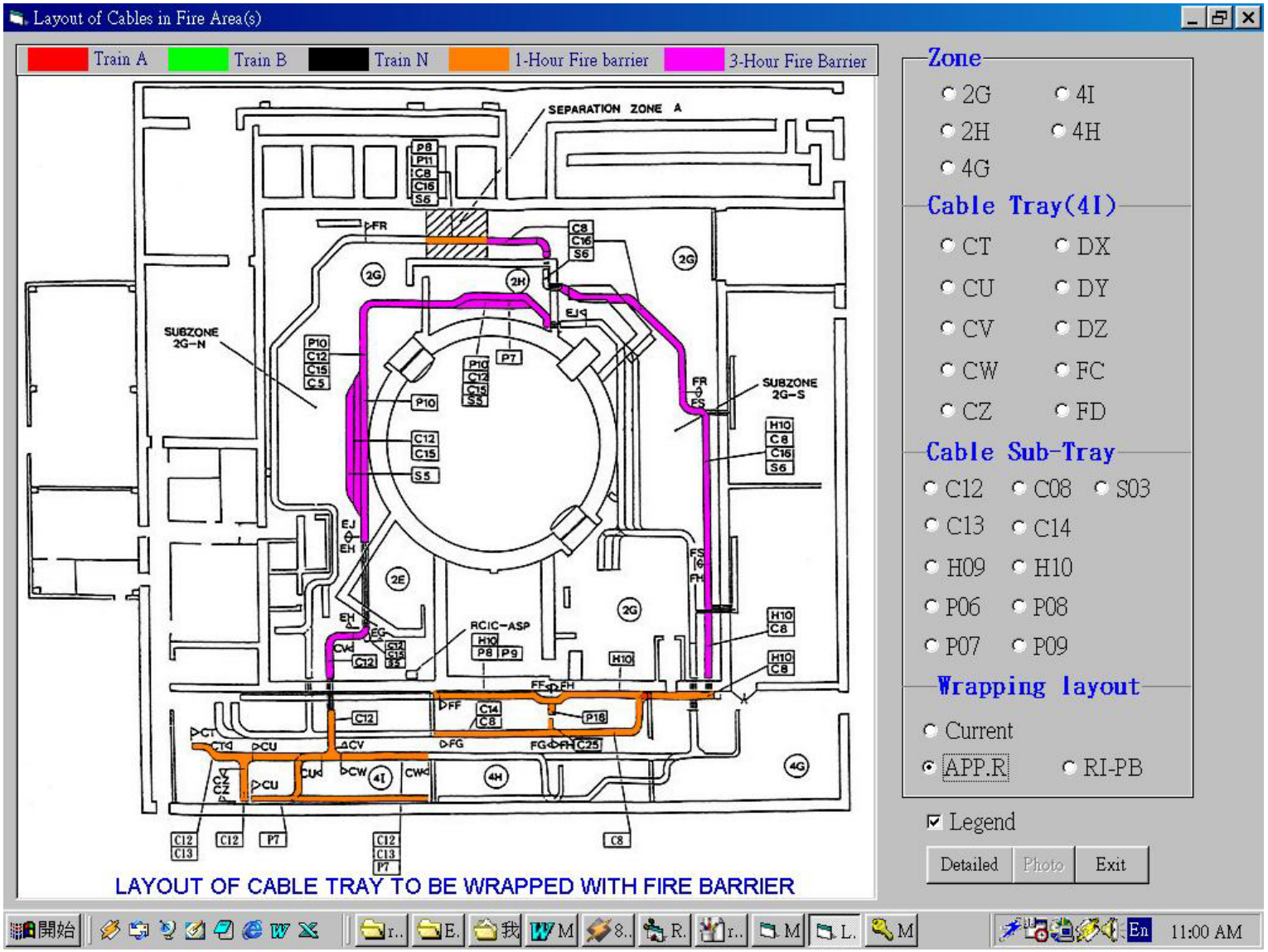
Display of Fire Zones



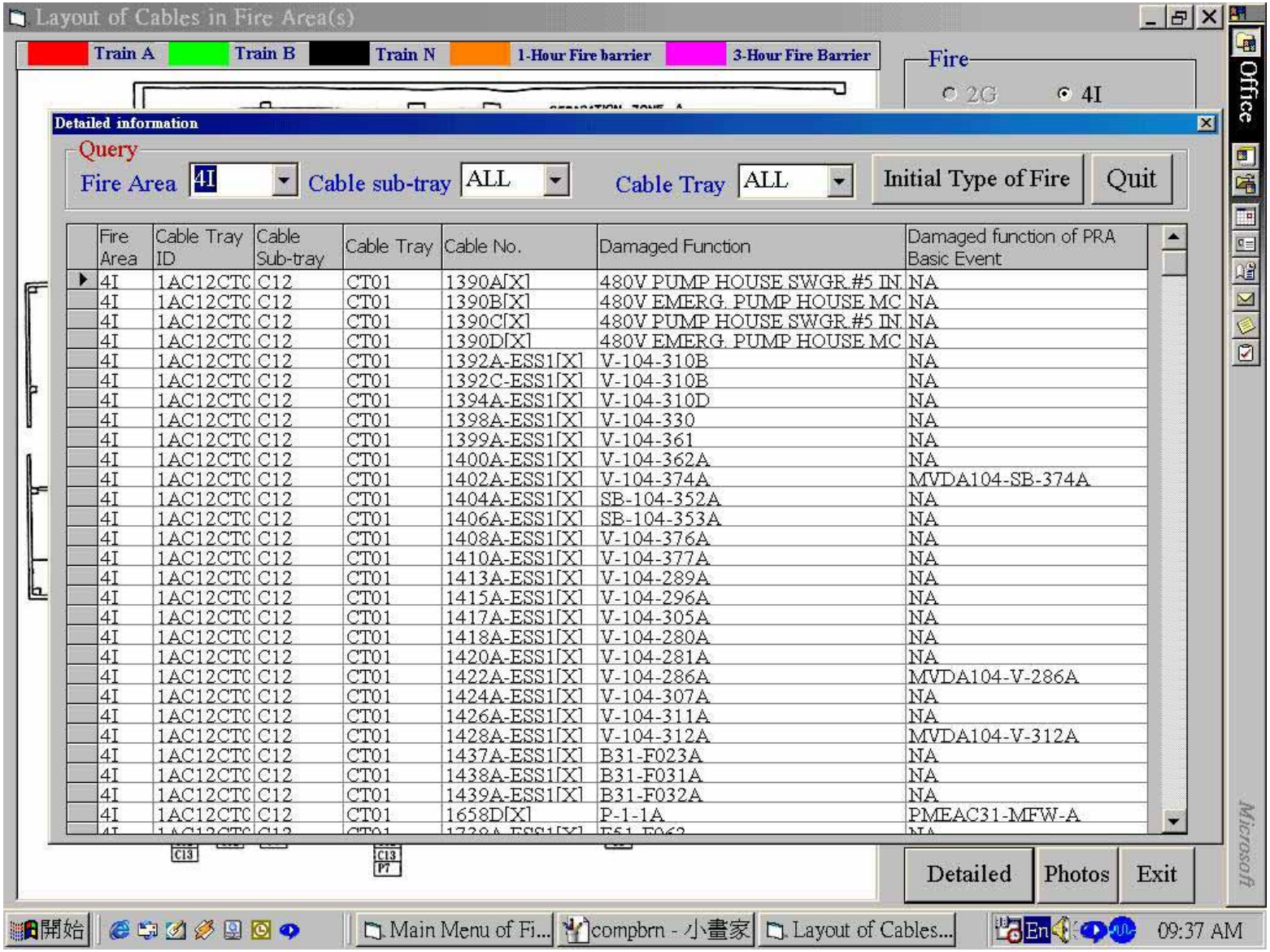
Display of Train Differentiation



Display of App. R Fire Barrier Requirements

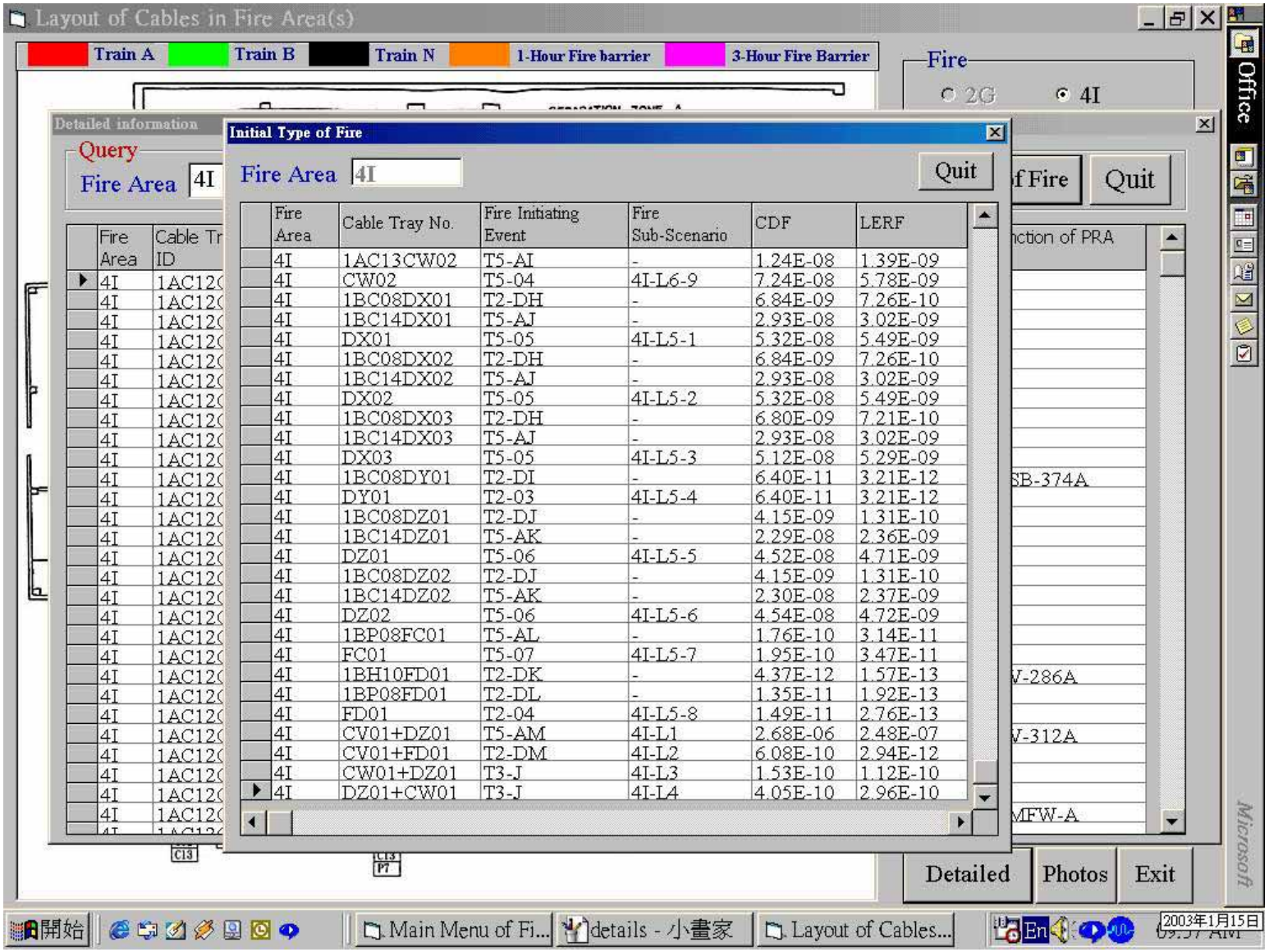


Display of Cable Details

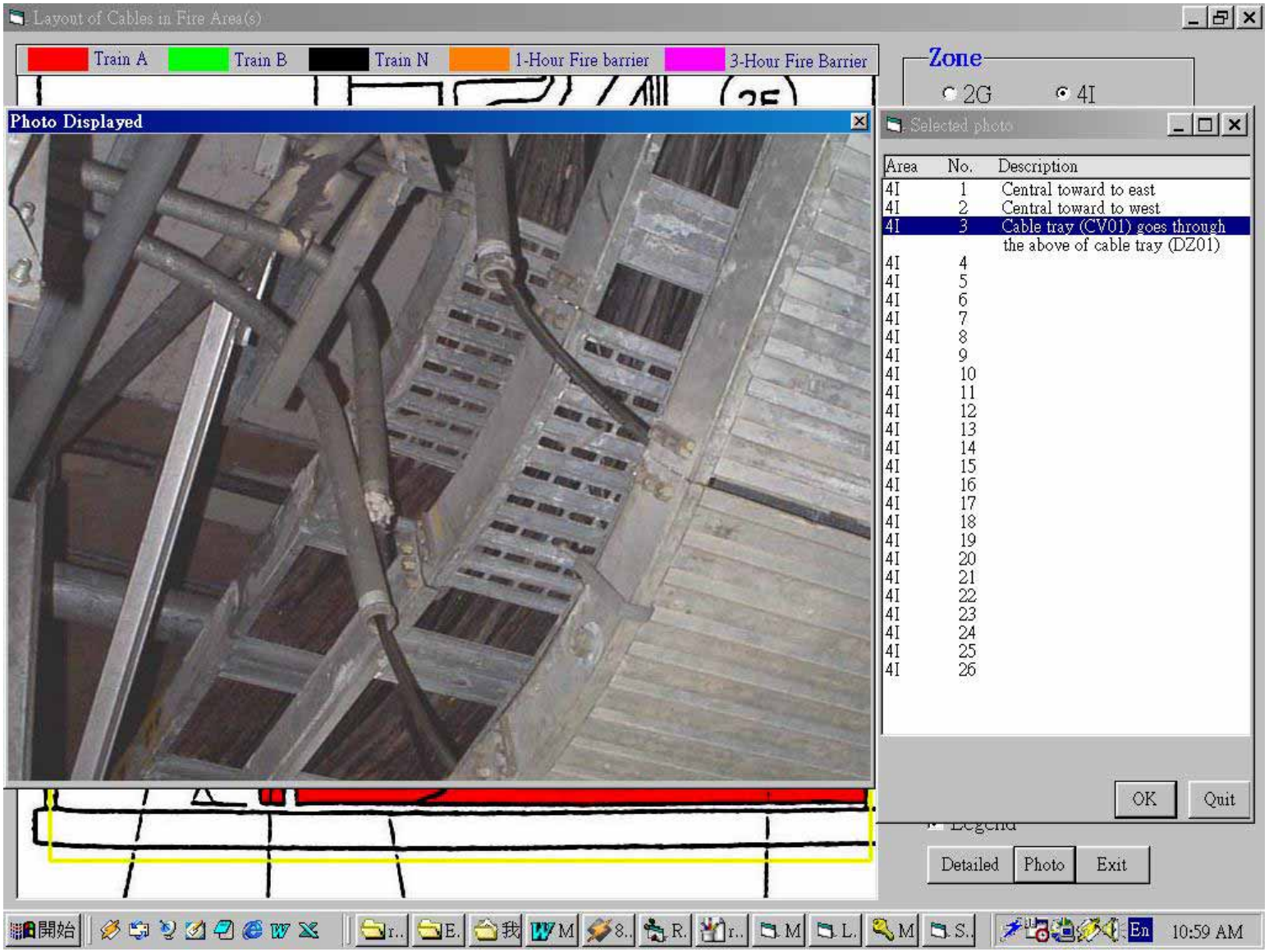


Fire Area	Cable Tray ID	Cable Sub-tray	Cable Tray	Cable No.	Damaged Function	Damaged function of PRA Basic Event
4I	1AC12CTC	C12	CT01	1390A[X]	480V PUMP HOUSE SWGR #5 IN	NA
4I	1AC12CTC	C12	CT01	1390B[X]	480V EMERG. PUMP HOUSE MC	NA
4I	1AC12CTC	C12	CT01	1390C[X]	480V PUMP HOUSE SWGR #5 IN	NA
4I	1AC12CTC	C12	CT01	1390D[X]	480V EMERG. PUMP HOUSE MC	NA
4I	1AC12CTC	C12	CT01	1392A-ESS1[X]	V-104-310B	NA
4I	1AC12CTC	C12	CT01	1392C-ESS1[X]	V-104-310B	NA
4I	1AC12CTC	C12	CT01	1394A-ESS1[X]	V-104-310D	NA
4I	1AC12CTC	C12	CT01	1398A-ESS1[X]	V-104-330	NA
4I	1AC12CTC	C12	CT01	1399A-ESS1[X]	V-104-361	NA
4I	1AC12CTC	C12	CT01	1400A-ESS1[X]	V-104-362A	NA
4I	1AC12CTC	C12	CT01	1402A-ESS1[X]	V-104-374A	MVDA104-SB-374A
4I	1AC12CTC	C12	CT01	1404A-ESS1[X]	SB-104-352A	NA
4I	1AC12CTC	C12	CT01	1406A-ESS1[X]	SB-104-353A	NA
4I	1AC12CTC	C12	CT01	1408A-ESS1[X]	V-104-376A	NA
4I	1AC12CTC	C12	CT01	1410A-ESS1[X]	V-104-377A	NA
4I	1AC12CTC	C12	CT01	1413A-ESS1[X]	V-104-289A	NA
4I	1AC12CTC	C12	CT01	1415A-ESS1[X]	V-104-296A	NA
4I	1AC12CTC	C12	CT01	1417A-ESS1[X]	V-104-305A	NA
4I	1AC12CTC	C12	CT01	1418A-ESS1[X]	V-104-280A	NA
4I	1AC12CTC	C12	CT01	1420A-ESS1[X]	V-104-281A	NA
4I	1AC12CTC	C12	CT01	1422A-ESS1[X]	V-104-286A	MVDA104-V-286A
4I	1AC12CTC	C12	CT01	1424A-ESS1[X]	V-104-307A	NA
4I	1AC12CTC	C12	CT01	1426A-ESS1[X]	V-104-311A	NA
4I	1AC12CTC	C12	CT01	1428A-ESS1[X]	V-104-312A	MVDA104-V-312A
4I	1AC12CTC	C12	CT01	1437A-ESS1[X]	B31-F023A	NA
4I	1AC12CTC	C12	CT01	1438A-ESS1[X]	B31-F031A	NA
4I	1AC12CTC	C12	CT01	1439A-ESS1[X]	B31-F032A	NA
4I	1AC12CTC	C12	CT01	1658D[X]	P-1-1A	PMEAC31-MFW-A

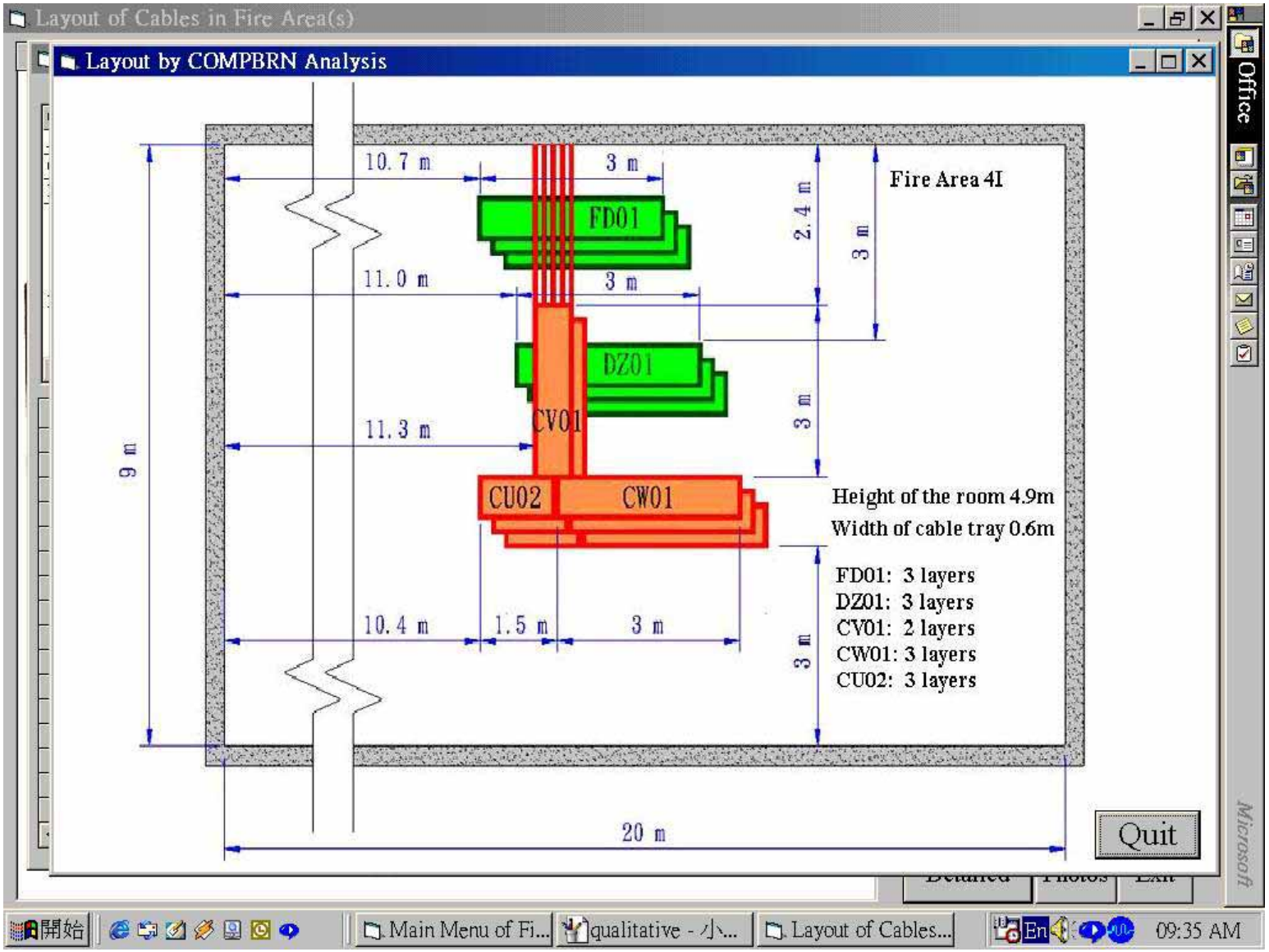
Display of Cable Tray Fire Consequences in CDF & LERF



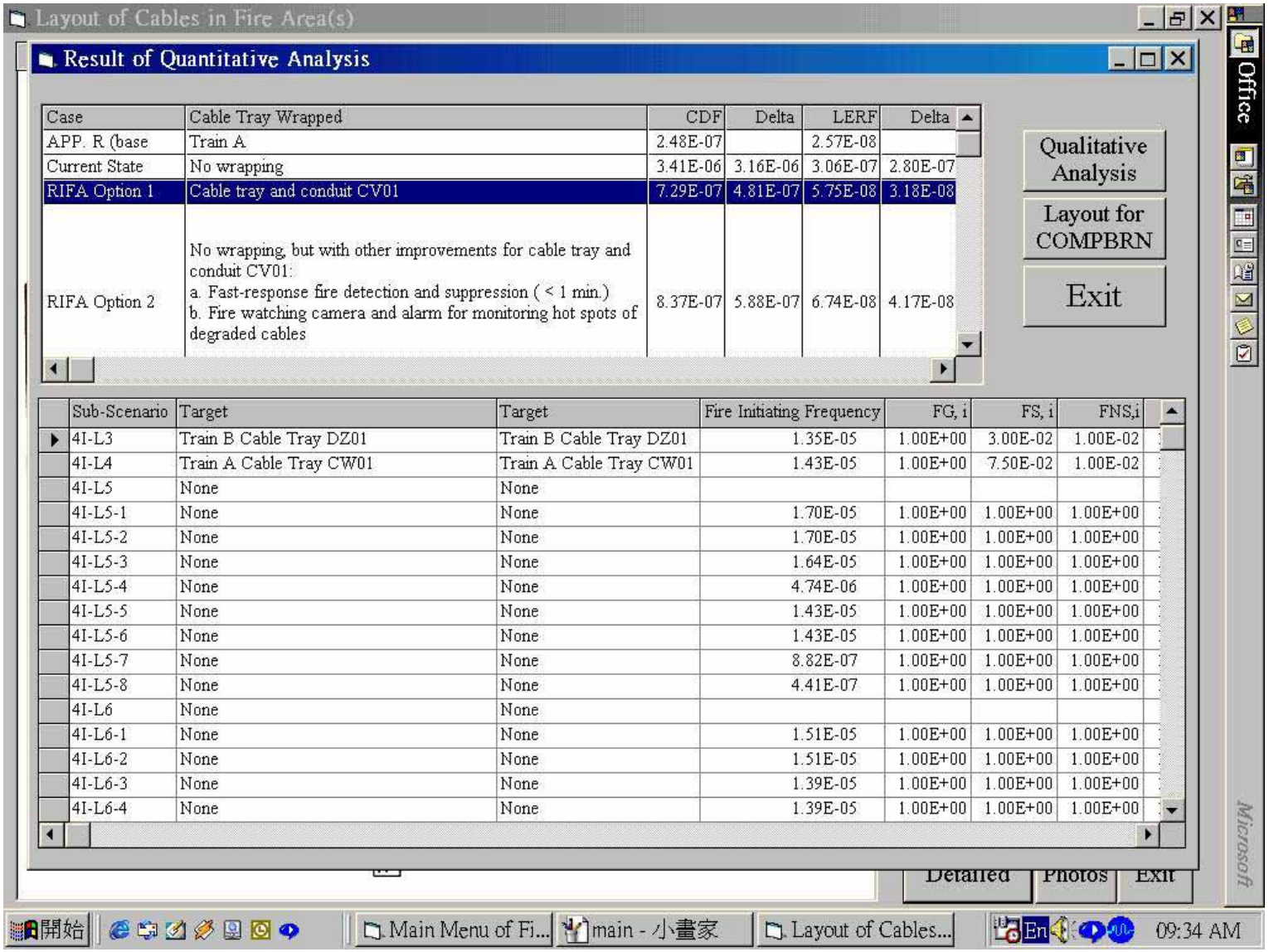
Display of Local Photos



Display of Cable Layout with COMPBRN-IIIe Analysis



Display of Wrapping Options from RIFA



Case	Cable Tray Wrapped	CDF	Delta	LERF	Delta
APP. R (base	Train A	2.48E-07		2.57E-08	
Current State	No wrapping	3.41E-06	3.16E-06	3.06E-07	2.80E-07
RIFA Option 1	Cable tray and conduit CV01	7.29E-07	4.81E-07	5.75E-08	3.18E-08
RIFA Option 2	No wrapping, but with other improvements for cable tray and conduit CV01: a. Fast-response fire detection and suppression (< 1 min.) b. Fire watching camera and alarm for monitoring hot spots of degraded cables	8.37E-07	5.88E-07	6.74E-08	4.17E-08

Sub-Scenario	Target	Target	Fire Initiating Frequency	FG, i	FS, i	FNS,i
4I-L3	Train B Cable Tray DZ01	Train B Cable Tray DZ01	1.35E-05	1.00E+00	3.00E-02	1.00E-02
4I-L4	Train A Cable Tray CW01	Train A Cable Tray CW01	1.43E-05	1.00E+00	7.50E-02	1.00E-02
4I-L5	None	None				
4I-L5-1	None	None	1.70E-05	1.00E+00	1.00E+00	1.00E+00
4I-L5-2	None	None	1.70E-05	1.00E+00	1.00E+00	1.00E+00
4I-L5-3	None	None	1.64E-05	1.00E+00	1.00E+00	1.00E+00
4I-L5-4	None	None	4.74E-06	1.00E+00	1.00E+00	1.00E+00
4I-L5-5	None	None	1.43E-05	1.00E+00	1.00E+00	1.00E+00
4I-L5-6	None	None	1.43E-05	1.00E+00	1.00E+00	1.00E+00
4I-L5-7	None	None	8.82E-07	1.00E+00	1.00E+00	1.00E+00
4I-L5-8	None	None	4.41E-07	1.00E+00	1.00E+00	1.00E+00
4I-L6	None	None				
4I-L6-1	None	None	1.51E-05	1.00E+00	1.00E+00	1.00E+00
4I-L6-2	None	None	1.51E-05	1.00E+00	1.00E+00	1.00E+00
4I-L6-3	None	None	1.39E-05	1.00E+00	1.00E+00	1.00E+00
4I-L6-4	None	None	1.39E-05	1.00E+00	1.00E+00	1.00E+00

Display of Value-Impact Assessment

建議	2G	2H	2M	2P	2T	3	4D	4G	4H	4I	效益	影響	報酬率	淨利
R	R	R	R	R	R	R	R	R	R	R	13620.0	234422.1	0.1	-220802.1
21	1	1	1	1	1	1	3	1	1	1	39929.9	5660.7	7.1	34269.2
26	1	1	1	1	1	1	3	1	2	1	40037.4	6360.7	6.3	33676.6
11	1	1	1	1	1	1	2	1	1	1	39930.9	6360.7	6.3	33570.2
16	1	1	1	1	1	1	2	1	2	1	40038.4	7060.7	5.7	32977.7
101	2	1	1	1	1	1	3	1	1	1	41115.1	7571.5	5.4	33543.6
1	1	1	1	1	1	1	1	1	1	1	40241.0	7760.7	5.2	32480.3
25	1	1	1	1	1	1	3	1	1	5	40515.4	7760.7	5.2	32754.7
106	2	1	1	1	1	1	3	1	2	1	41222.5	8271.5	5.0	32951.0
91	2	1	1	1	1	1	2	1	1	1	41116.1	8271.5	5.0	32844.6
6	1	1	1	1	1	1	1	1	2	1	40348.4	8460.7	4.8	31887.7
30	1	1	1	1	1	1	3	1	2	5	40622.9	8460.7	4.8	32162.1
15	1	1	1	1	1	1	2	1	1	5	40516.5	8460.7	4.8	32055.7
96	2	1	1	1	1	1	2	1	2	1	41223.6	8971.5	4.6	32252.1
23	1	1	1	1	1	1	3	1	1	3	31336.2	7000.0	4.5	24336.2

建議 21	2G	2H	2M	2P	2T	3	4D	4G	4H	4I
建議案組合	1	1	1	1	1	1	3	1	1	1
效益(仟元)	0	0	0	0	0	0	3.08E+04	0	0	9.18E+03
公眾健康	0	0	0	0	0	0	1.19E+04	0	0	3.54E+03
職業暴露(意外)	0	0	0	0	0	0	1.05E+02	0	0	3.13E+01
職業暴露(例行)	0	0	0	0	0	0	-5.88E-02	0	0	-1.34E-02
廠外財產	0	0	0	0	0	0	8.05E+03	0	0	2.40E+03
廠內財產	0	0	0	0	0	0	1.07E+04	0	0	3.20E+03
影響(仟元)	0	0	0	0	0	0	4.90E+03	0	0	7.61E+02
業界執行成本	0	0	0	0	0	0	4.90E+03	0	0	5.23E+02
業界運轉成本	0	0	0	0	0	0	0	0	0	2.38E+02
總結										
投資報酬率							6.28E+00			1.21E+01
淨利(仟元)	0	0	0	0	0	0	2.59E+04	0	0	8.42E+03
分析整理										
		總效益	3.99E+04			總報酬率	7.05E+00			
		總影響	5.66E+03			淨利總和	3.43E+04			

Recent Activities of RIFA (1 of 3)

- Chinshan RIFA Project was reviewed in the first meeting on June 11, 2004.
- Benchmark of COMPBRN-IIIe with FDS 4.0 was sponsored by TAEC and made by INER and a third party.
- Chinshan RIFA Project was reviewed again in the second meeting on April 14, 2005.
- The result of Benchmark of COMPBRN-IIIe with FDS 4.0 was presented and accepted in the second review meeting.

Recent Activities of RIFA (2 of 3)

- Major concerns in the Chinshan RIFA Project second review meeting were
  - Why did USNRC remove COMPBRN-IIIe from the list in DG-1139?
  - How will the plant treat the impact of a DCR (design change request) to Appendix R (or its alternatives)?
  - The non-conservative result of COMPBRN-IIIe compared to FDS 4.0 was noted in the fire scenarios that the cable trays were directly above the pilot fire.
  - More safety margin was given for those fire scenarios as the cable trays were assumed damaged in the same time as the fire occurred.

Recent Activities of RIFA (3 of 3)

- Sensitivity study of the reliability of the early-detection and fast-response fire suppression system was made by INER and Minimum acceptable value was found as 75% by risk-informed criteria.
- Some experiments of cable fire and fire suppression system are requested in the further project.
- A tool for FHA (fire hazard analysis) and FPSDP (fire protection significance determination process) is proposed for plant self fire assessment and for fire inspection findings.

Conclusions (1 of 3)

- For Chinshan NPP, RIFA project to assess the optimal alternative approach for cable tray fire wrapping issues was accomplished in January 2002.
  - Detailed fire hazard analysis for cable tray fire scenarios was completed.
  - Alternative approaches with value-impact analysis (VIA) were suggested.
  - The optimal option was proposed in conjunction with some cables re-routing and fire suppression system improvement plan.
  - A display system (RIFADISP) for the most important result is developed.

Conclusions (2 of 3)

- For Kousheng NPP, the similar RIFA (RIFA-2) project was finished in November 2004.
  - The optimal option was proposed in conjunction with six cables re-routing only.
- For Maanshan NPP, the similar RIFA (RIFA-2) project was kicked off in March 2004, and will be finished by the end of 2005.

Conclusions (3 of 3)

- The results of VIA have shown that the optimal options for both Chinshan and Kuosheng NPPs have huge benefits and safety could be ensured at the same time.
- During the execution of RIFA projects for the three NPPs, including the response to the review comments, fire assessment ability of the plant staff has been improved. This effect will be enhanced after the fire tools are developed in the near future.