



石化業之廠務監控系統、防災監控系統與緊急應變系統現況調查研究

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Survey on current status of FMCS, LMS, and ERS of petrochemical industries in Taiwan

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Outline

- Introduction
- Literature Review
- Methodology
- Results and Discussion
- Conclusions
- Future Prospects
- Acknowledgments

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Introduction (1/4)

- The petrochemical industries **are important economic indicators.**
- Kaohsiung County—**Jen Da** (Jen-Wu & Da-She) and **Lin Yuan** Petrochemical Plants.
- **Formosa Plastics Group** announced the establishment of **Mailiao 6th Naphtha Cracking Project.**
- **Kuo Kuang Petrochemical Technology Corp.,** was established on January 19, **2006.**

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Introduction (2/4)

- Petrochemical products are **prevalingly flammable and explosive**.
- **The government rewards** petrochemical companies that **use computer systems to manage and monitor manufacturing process**.
- We attempted **to raise** the awareness of the **importance** of computerized safety monitoring facilities.

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Introduction (3/4)

Research Purposes

- Understand **current status of** facility monitoring & controlling system (**FMCS**), life safety monitoring & control system (**LMS**), and emergency response system (**ERS**) in the petrochemical plants in Taiwan.
- Discuss the **relationship** between emergency response duration and the integration of FMCS, LMS, ERS.

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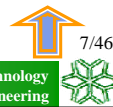




Introduction (4/4)

Hypothesis

- H1: The integration of FMCS, LMS, and ERS is **highly related** to emergency responses.



Literature review

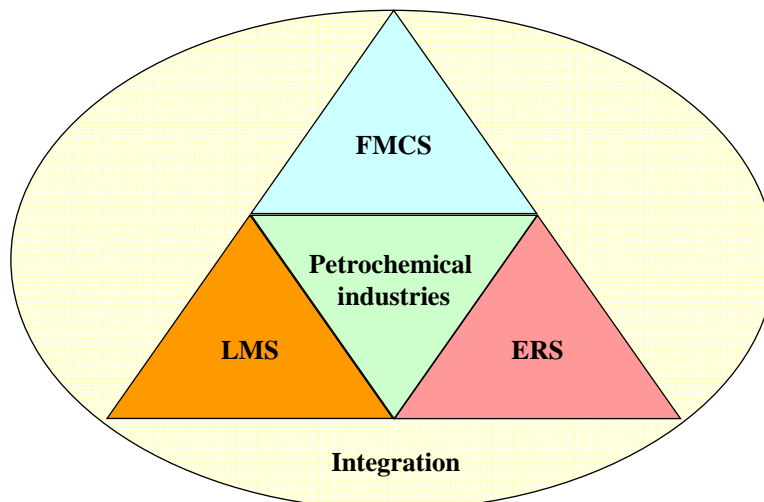
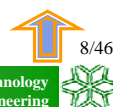


Fig. 1. The frame of literature reviews





Methodology (1/20)

- Framework
- Research scope and targets
- Research tools
- Research procedures

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Methodology (2/20)

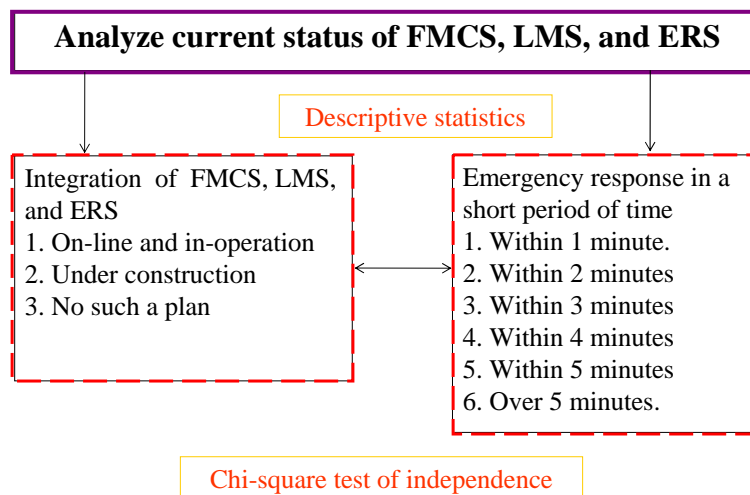


Fig. 2. The frame of research



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Methodology (3/20)

- This survey adopted **descriptive research**.
- The questionnaire was used for **data collection**.
- This study focused on **CPC's and FPG's petrochemical plants** and some **other petrochemical firms**.
- Research targets included **plant management representatives, safety and health representatives, safety and health personnel**, etc.

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Methodology (4/20)

Table 1. Percentage and numbers of questionnaires

Company	Questionnaires dispatched	Questionnaires collected	Recycling rate	Rank
CPC	50	48	96%	1
FPG	50	37	74%	3
Others	60	50	83.33%	2
Total	160	135	90%	

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Methodology (5/20)

Table 2. The analysis of samples

Position Firm	Plant management representative	Safety and health management representative	Safety and health personnel	Others	Total
CPC	0	5	21	21	47
FPG	2	2	27	5	36
Others	1	7	33	9	50
Total	3	14	81	35	133

62%



Methodology (6/20)

- Questionnaire
 - [Company profile](#)
 - [Introduction of FMCS, LMS, and ERS](#)
 - [Questionnaire contents](#)
- Validity verification
 - [Expert validity](#)
 - [Construction of validity—Factor analysis](#)
- Reliability verification
 - [Cronbach's \$\alpha\$](#)





Methodology (7/20)

Questionnaire Content (5 parts)

- Gas leak alarm, fire alarm, and very early smoke detection apparatus (VESDA) survey
- Survey on other major related concepts
- Survey on intra-integration of FMCS, LMS, and ERS, respectively
- Survey on inter-integration of FMCS, LMS, and ERS, respectively
- Risk assessment of petrochemical plants from insurance companies

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Methodology (8/20)

Table 3. Questionnaire contents about gas leak alarm, fire alarm, and VESDA survey

Alarm type	Number of questions	Question content
Gas leak alarm	3	1. Time needed from gas leak alarm to cause confirmed. 2. Time needed from gas leak alarm to location validated. 3. Time needed from gas leak alarm to arrive at location.
Fire alarm	3	4. Time needed from fire alarm to cause confirmed. 5. Time needed from fire alarm to location validated. 6. Time needed from fire alarm to arrive at location.
VESDA	3	7. Time needed from VESDA to cause confirmed. 8. Time needed from VESDA to location validated. 9. Time needed from VESDA to arrive at location.

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Methodology (9/20)

Table 4. Questionnaire contents about major related concepts survey

Related concepts	Number of questions	Question content
Integrated system	1	10. Can actions be controlled from each system integrated in the central monitoring system?
P&ID	1	11. P&ID e-file centralized update period.
Access control facility	1	12. Front-end facility of access control points of plants.
Reasons for integration failure	1	13. Wanted to establish this integrated system (FMCS, LMS, and ERS) to shorten response time and efficiently improve disaster prevention, but gave up for the following reasons.

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Methodology (10/20)

Table 5. Questionnaire contents about intra-integrations of FMCS, LMS, and ERS, respectively

System	Number of questions	Question content
FMCS	4	14. Construction status of FMCS.
		15. Is development of FMCS conducted by itself or outsourced?
		16. Which department is in charge of FMCS?
		17. Integration of FMCS sub-systems.
LMS	4	18. Construction status of LMS.
		19. Is development of LMS conducted by itself or outsourced?
		20. Which department is in charge of LMS?
		21. Integration of LMS sub-systems.
ERS	3	22. Construction status of ERS.
		23. Is development of ERS conducted by itself or outsourced?
		24. Which department is in charge of ERS?

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Methodology (11/20)

Table 6. Questionnaire content about inter-integration of FMCS, LMS, and ERS

	Number of questions	Question content
FMCS, LMS, and ERS, Integration	1	25. Integration status of FMCS, LMS, and ERS.
	1	26. Construction status of FMCS, LMS, and ERS integration .
	1	27. Is FMCS, LMS, and ERS, integration included into procurement at the stage of plant design and planning or not?



Methodology (12/20)

Table 7. Questionnaire contents about insurance companies' risk assessment

	Number of questions	Question content
Risk assessment	1	28. Integration status of FMCS, LMS, and ERS.
	1	29. Construction status of FMCS, LMS, and ERS integration .





Methodology (13/20)

Questionnaire

- Four questions for “company profile”.
- No questions asked for “FMCS, LMS, and ERS, introduction”.
- Twenty nine questions for the contents of the questionnaire.
- Altogether, there were 33 questions.



Methodology (14/20)

Table 8. Expert roster

Company/institution	Position	Name
CPC Environmental Protection Division	Deputy division chief	Yung-Ming Tsai
Southern Taiwan Science Park	Section chief	Chia-Ming Kuan
Science Park Administration Labor Relations Division	Division chief	Kuang-Jung Lo
Central Taiwan Science Park	Division chief	Shih-Ying Liu
CPC Specialty Chemical Transportation Planning Division	Director	Ching-Ping Wu
Mao Tung Ltd., Co.	Chairman	Shih-Chieh Weng
Institute of Occupational Safety and Health, Council of Labor Affairs, Council of Labor, Executive Yuan	Doctor	Cheng-Ming Chang
Department of Safety Health and Environment Engineering, National Yunlin University of Science and Technology	Professor	Chi-Min Shu





Methodology (15/20)

KMO = 0.669

P-Value = 0.001 < α = 0.01

Table 9. Statistics of eigenvalue

Component	Initial eigenvalue			Extraction sums of squared loadings		
	Sum	Variance %	Cumulative%	Sum	Variance %	Cumulative %
1	4.203	46.699	46.699	4.203	46.699	46.699
2	2.112	23.463	70.162	2.112	23.463	70.162
3	1.169	12.988	83.150	1.169	12.988	83.150
4	0.578	6.426	89.576	>1		
5	0.466	5.181	94.757			
6	0.170	1.894	96.650			
7	0.137	1.526	98.176			
8	0.098	1.089	99.265			
9	0.066	0.735	100.00			

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Methodology (16/20)

Scree Plot

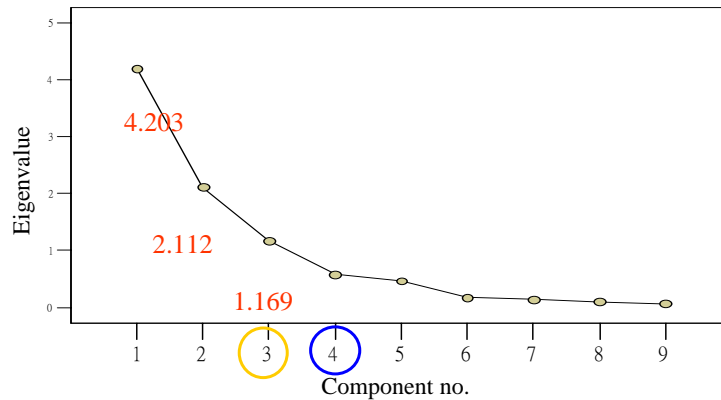


Fig. 3. Eigenvalue of scree plot

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Methodology (17/20)

Table 10. Statistics of factor analysis

Question contents	>0.45	Component		
		1	2	3
1. Time needed from gas leak alarm to cause confirmed.		0.158	0.204	0.891
2. Time needed from gas leak alarm to location validated.	0.889	0.078	0.074	
3. Time needed from gas leak alarm to arrive at location.	0.819	0.138	0.152	
4. Time needed from fire alarm to cause confirmed.		0.282	0.129	0.884
5. Time needed from fire alarm to location validated.	0.913	0.042	0.101	
6. Time needed from fire alarm to arrive at location.	0.755	0.083	0.341	
7. Time needed from VESDA to cause confirmed.		0.041	0.780	0.526
8. Time needed from VESDA to location validated.		0.142	0.944	0.056
9. Time needed from VESDA to arrive at location.		0.091	0.931	0.120

- **Factor 1:** Location validation & arrival at location
- **Factor 2:** VESDA
- **Factor 3:** Cause confirmation

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Methodology (18/20)

Table 11. Statistics of reliability verification (1/2)

Question content	Cronbach's α
1. Time needed from gas leak alarm to cause confirmed.	0.836
2. Time needed from gas leak alarm to location validated.	0.841
3. Time needed from gas leak alarm to arrive at location.	0.839
4. Time needed from fire alarm to cause confirmed.	0.832
5. Time needed from fire alarm to location validated.	0.840
6. Time needed from fire alarm to arrive at location.	0.837
7. Time needed from VESDA to cause confirmed.	0.826
8. Time needed from VESDA to location validated.	0.840
9. Time needed from VESDA to arrive at location.	0.839
Total reliability statistics	Highly reliable 0.852

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Methodology (19/20)

Table 12. Statistics of reliability verification (2/2)

Cronbach's α	Factor 1 0.852	Factor 2 0.910	Factor 3 0.834
1.			0.722
2.	0.838		0.741
3.	0.856		0.847
4.			
5.	0.821		
6.	0.881		
7.		0.908	
8.		0.845	
9.		0.856	

Highly reliable
All questions are kept. The factor analysis is effective.

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Methodology (20/20)

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graph TD
  A[Research background, motive, questions] --> B[Literature review]
  B --> C[Methodology]
  C --> D[Data collection and analyses]
  D --> E[Results and discussion]
  E --> F[Conclusions and future prospects]
  
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Fig. 4. Research procedures

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Results and Discussion (1/13)

Descriptive statistics (Frequency distribution)

- Understanding of **current status of FMCS, LMS, and ERS**, in the petrochemical plants in Taiwan.

Contingency table (chi-square test of independence)

- Discussion of the **relationship** between emergency responses and the integration of FMCS, LMS, and ERS.

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Results and Discussion (2/13)

Gas Leak Alarm

Cause confirmed

Location validated

Arrive at location

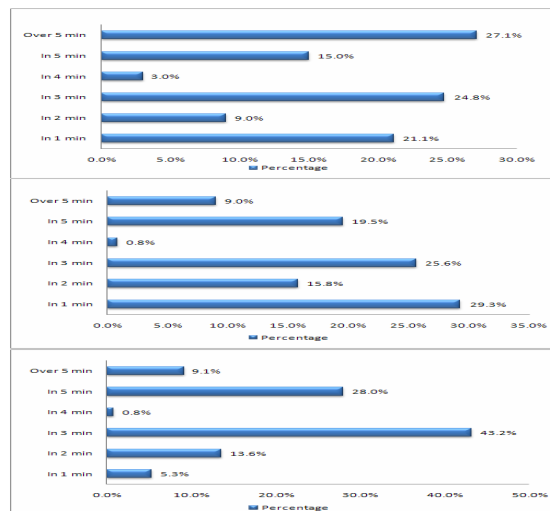
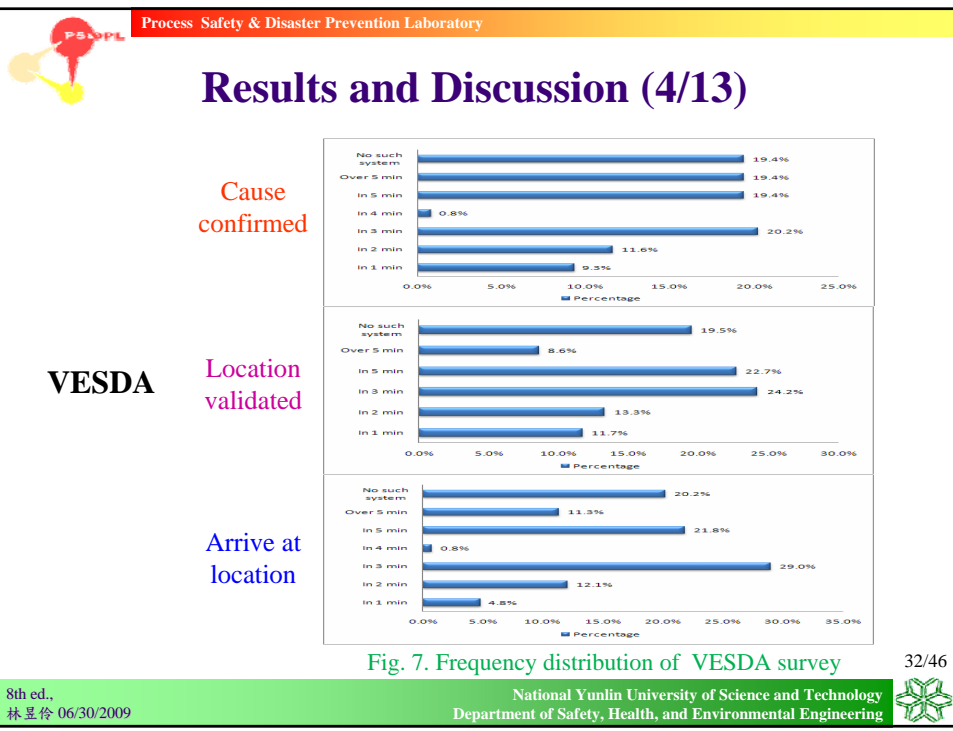
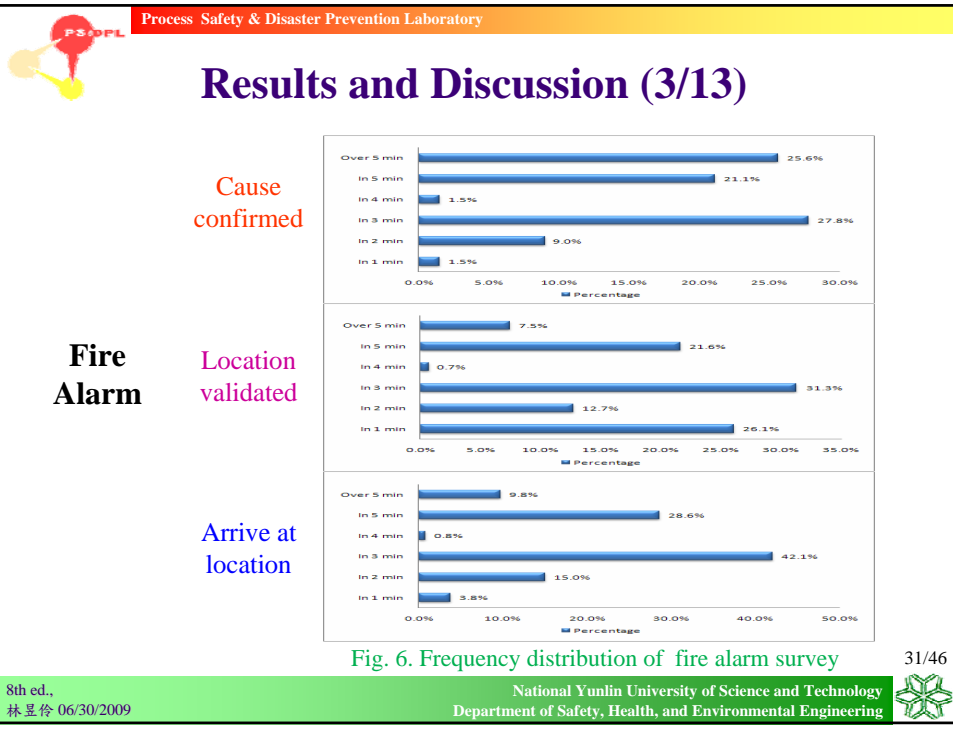


Fig. 5. Frequency distribution of gas leak alarm survey

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Results and Discussion (5/13)

Central monitoring system

Other Major Related Concepts

P&ID updated

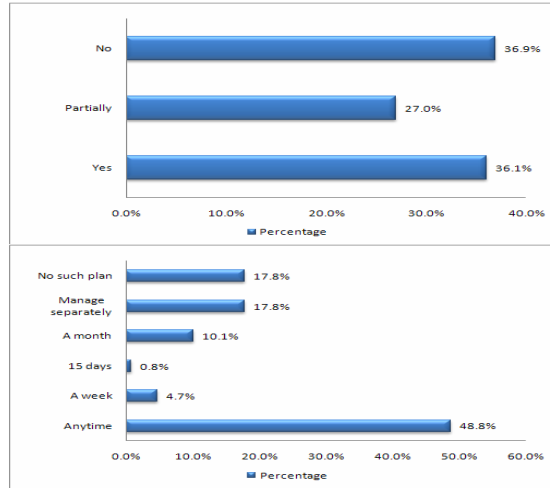


Fig. 8. Frequency distribution of other major related concepts survey

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Results and Discussion (6/13)

Table 13. Percentage and numbers of the situation of access control points

Category label	Count	Percentage of cases
Open/close real-time reporting	50	47.2%
Real-time reporting when action	9	8.5%
No open/close real-time reporting	11	10.4%
No real-time reporting when action fails	9	8.5%
Open/close central control system	28	26.4%
No open/close central control system	34	32.1%
Total responses	141	133%

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Results and Discussion (7/13)

Table 14. Percentage and numbers of gave up for the following reasons

Category label	Count	Percentage of cases
Financial difficulty	30	25%
Inter-system integration difficulty	42	35%
No consensus with supervisors	19	15.8%
Not conforming to return on investment	17	14.2%
Lack of manpower	13	10.8%
Never thought of it	13	10.8%
Lack of time	1	0.8%
No related references	35	29.2%
Too many troubles	4	3.3%
Others	9	7.5%
Total responses	141	133%

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Results and Discussion (8/13)

System Construction Status

FMCS

LMS

ERS

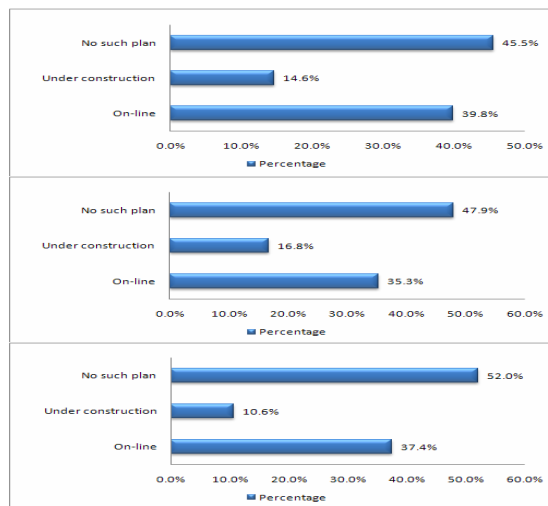
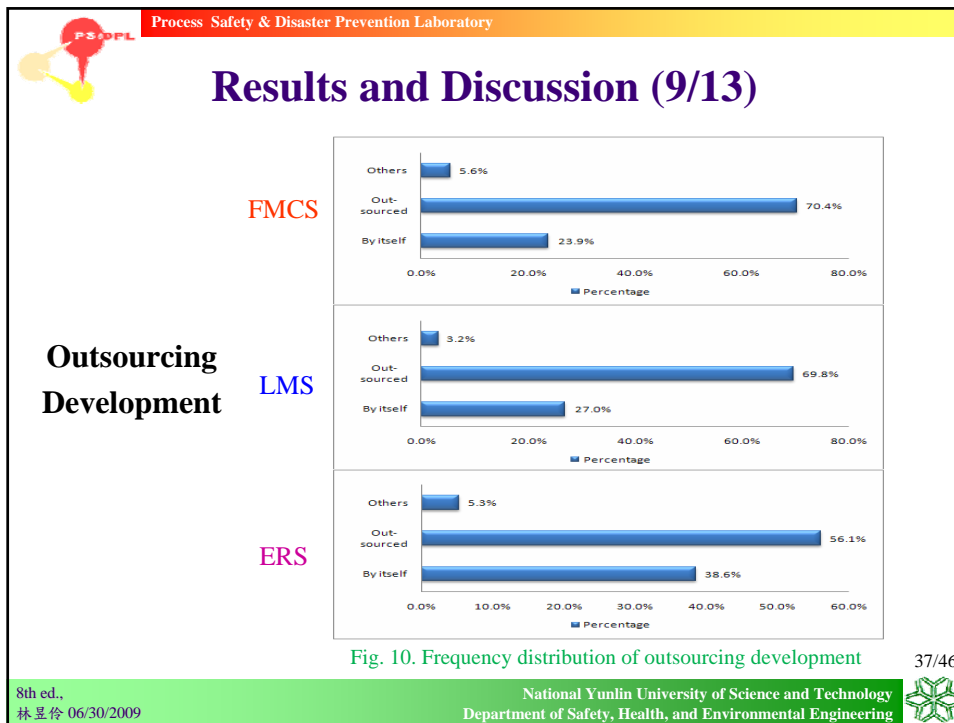


Fig. 9. Frequency distribution of construction status

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Results and Discussion (10/13)

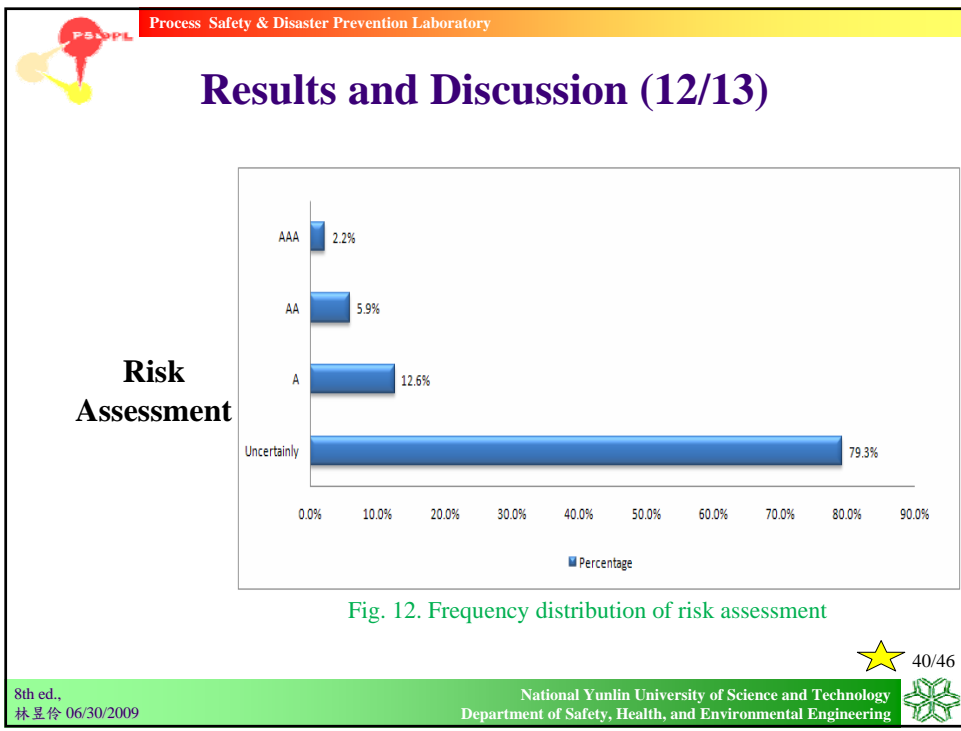
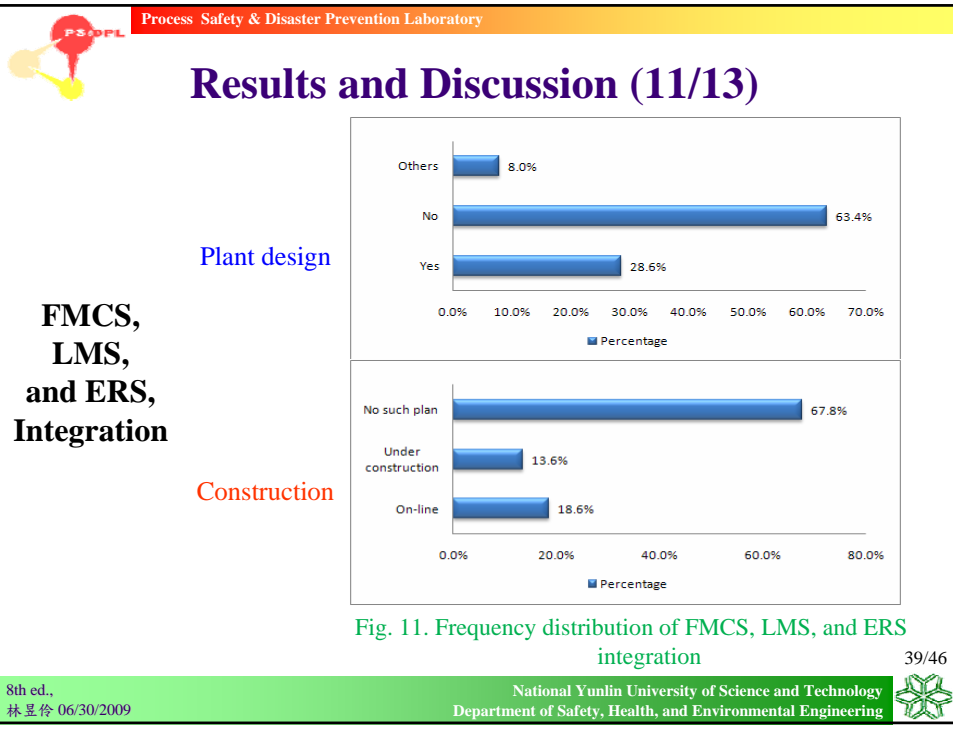
Table 15. Rank of integration of sub-systems

System	Category label	Rank
FMCS	Audio alarm vs Fire alarm	1
	Audio alarm vs Liquid, gas leak alarm	2
	Electric power monitor vs Audio alarm	3
LMS	Broadcasting system vs Fire alarm	1
	Broadcasting system vs Liquid, gas leak alarm	2
	Liquid, gas leak alarm vs Fire alarm	3

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Results and Discussion (13/13)

Table 16. Chi-square test of independence

<0.05

Category label	Value	Degree of freedom	Significance
Q 26 vs Q 1	30.126	10.000	0.001
Q 26 vs Q 2	23.098	10.000	0.010
Q 26 vs Q 3	15.288	10.000	0.122
Q 26 vs Q 4	10.421	10.000	0.404
Q 26 vs Q 5	17.989	10.000	0.055
Q 26 vs Q 6	17.743	10.000	0.059
Q 26 vs Q 7	27.338	12.000	0.007
Q 26 vs Q 8	20.448	10.000	0.025
Q 26 vs Q 9	20.001	12.000	0.067



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Conclusions (1/2)

The results showed the following direction from frequency distribution:

- The disaster time and spots could be well controlled in all situations and arrive at the spot **in three minutes**.
- Only few systems can be **directly detected** and controlled by central monitoring system.
- The highest percentage was that no such plan about the structure of **FMCS, LMS, and ERS**.
- Not willing to integrate the three systems now and in the future.
- In terms of failure causes, the main reason was the difficulty by inter-system integration.

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Conclusions (2/2)

It demonstrated the following direction from chi-square test:

- The integration of FMCS, LMS, and ERS was **highly related** to **gas leak alarm** to **cause confirmed**.
- The integration of FMCS, LMS, and ERS was **highly related** to **gas leak alarm** to **location being validated**.
- The integration of FMCS, LMS, and ERS was **highly related** to **VESDA** to **cause confirmed**.
- The integration of FMCS, LMS, and ERS was **highly related** to **VESDA** to **location being validated**.



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Future Prospects


- If the **degree of integration** of FMCS, LMS, and ERS can be enhanced, we will fully exploit it and facilitate the emergency response in terms of time-saving and life-saving.
- According to the real risk assessment in the petrochemical plants, if the insurance premium could be adjusted to **a lower rate**, the industries would be encouraged to implement the system.



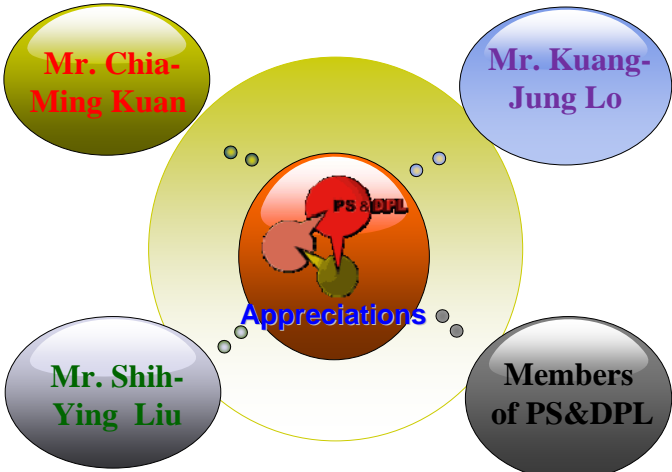
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Thank you for your attention!

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