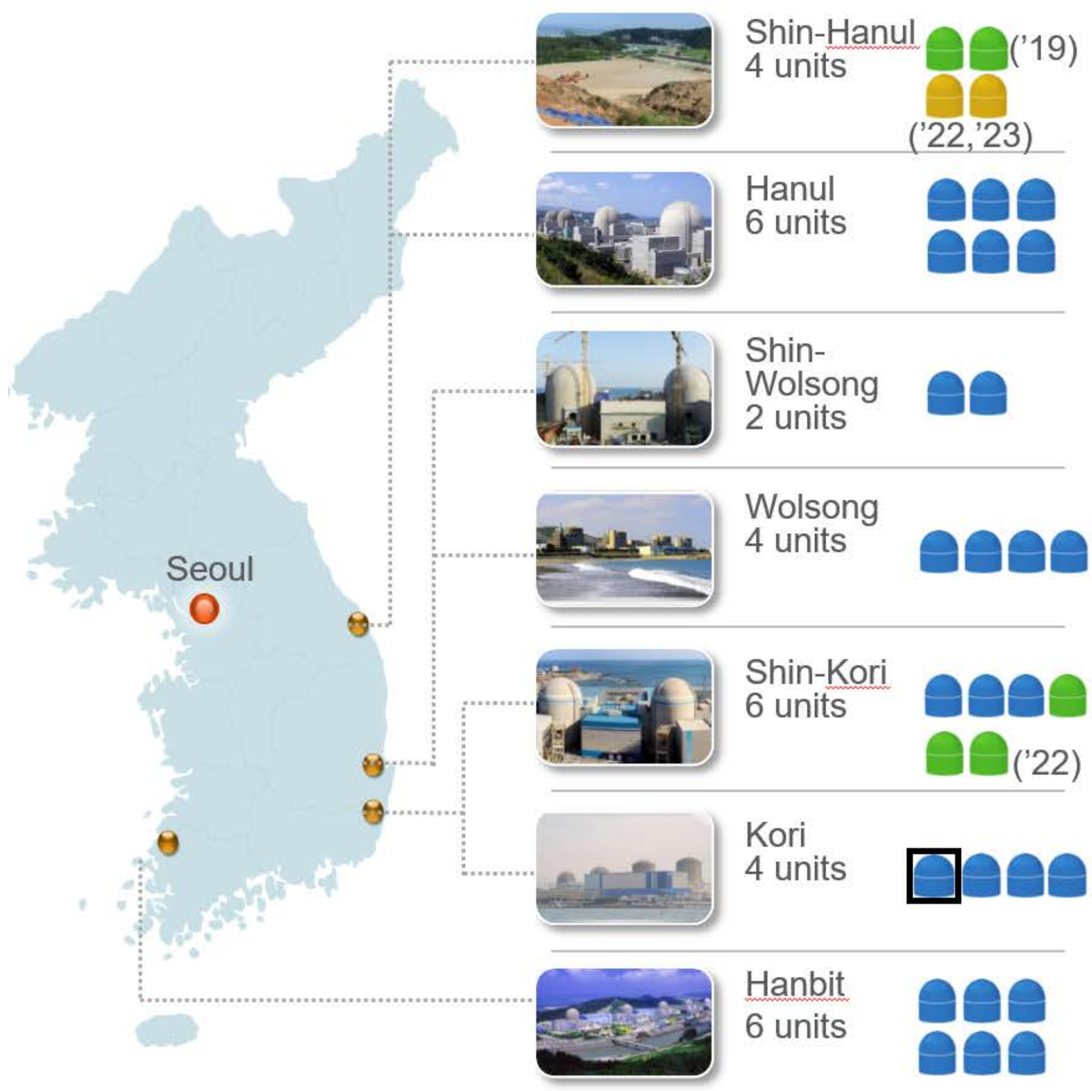
Human Resource Development for Nuclear Security and Nuclear Nonproliferation at KAIST

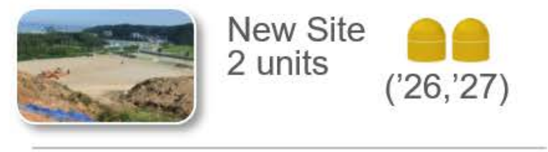
The International Forum on Peaceful Use of Nuclear Energy, Nuclear Nonproliferation and Nuclear Security
ISCN, JAEA
Tokyo, Japan
December 7, 2017

Man-Sung Yim

KAIST

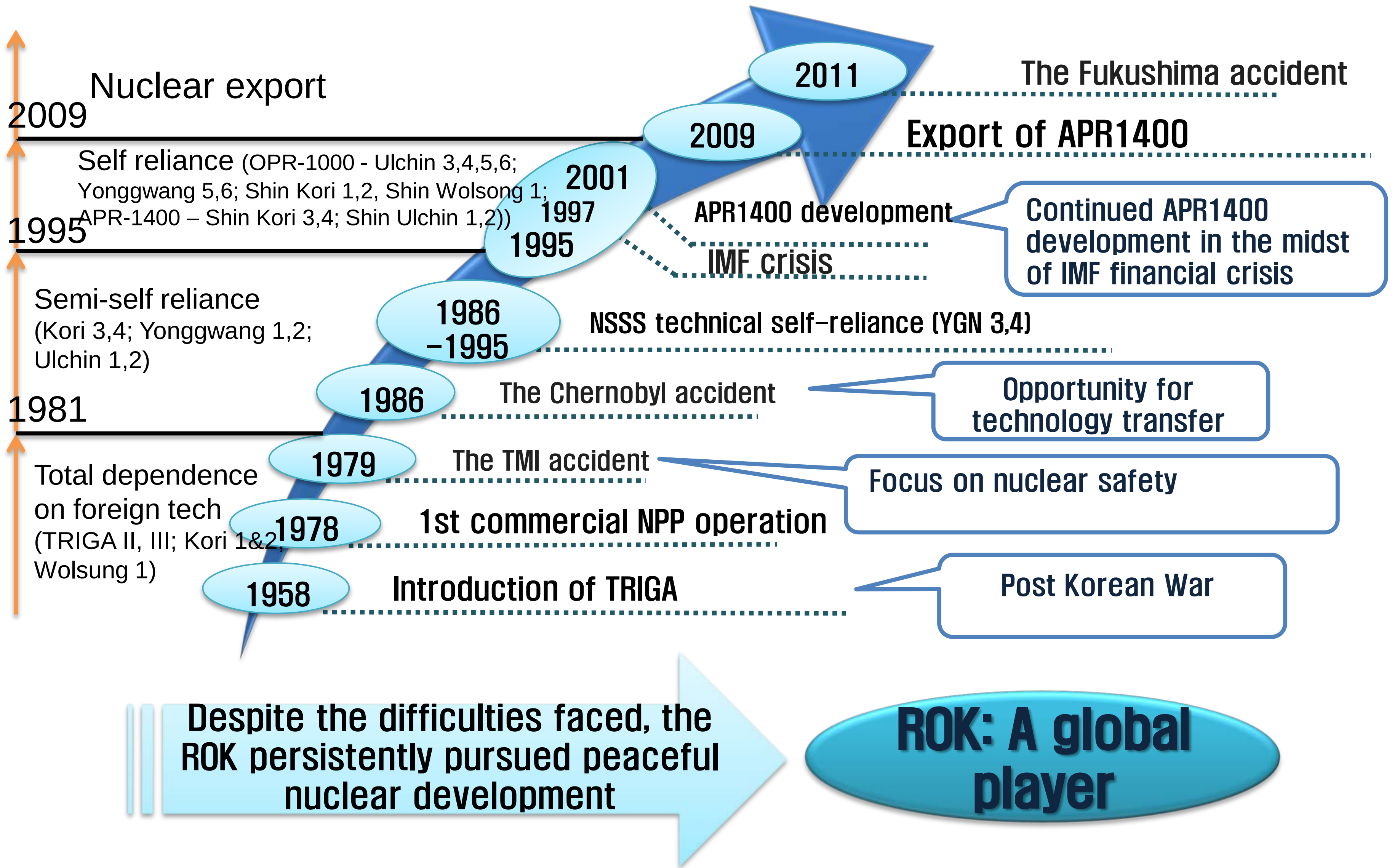
Current Status of NPP in the ROK





- 24 NPPs in operation (23.1 GWe)
- Provide 30.6% of total electricity (162 TWe, 2016)
- 5 APR1400's under construction (7GWe)
- 2 APR1400's and 2 APR+ (1,500MWe) in plan
- Kori #1 : permanent shut down in June 2017

History of ROK's Civilian Nuclear Power Development



Nuclear Nonproliferation/Security Development: Republic of Korea

1) Infancy (1957-1968)
2) Dual purpose (1969-1980)
3) Reorganization (1981-1985)
4) Technological growth (1985-1991)
5) Nuclear accountancy (1991-2004)
6) Enhancing transparency and security (2004-2013)
7) Enhancing safety and security culture (2014-present)

NEREC

KAIST

Observations from the ROK example

- It takes time to build national capacity in nuclear security.
- Efforts in national capacity building in nuclear security does not go hand-in-hand with nuclear technological development.
- Policy making controls the overall structure and goals of nuclear security.
- National effort in capacity building in nuclear security depends on the experienced/perceived threat and the availability of necessary human capital.
- Nuclear security is an integral part of national technology package for nuclear export.
- Raising public awareness in nuclear security is a challenge.

National Capacity Building

- Policy making
- Regulation
- Technology development
- Human capital development
- Funding/resources
- Coordination and management
- Intergovernmental interactions
- Public involvement
- International cooperation
- Supporting culture development

Nuclear Security Risk

Risk = Threat * Vulnerability * Consequence

- Threat
  - Existing conflicts
  - Presence of terrorist groups
  - insider
  - Capability to obtain nuclear device
    - Material (Nuclear weapons, Nuclear waste, Radiological source)
      - Steal
      - Buy
      - Transfer
    - Construction
    - Transportation
    - Detonation
  - Capability to have access to a nuclear facility
    - Nuclear power plant
    - Nuclear fuel cycle facilities
- Vulnerability
  - Border protection
  - Emergency preparedness
  - Security culture
- Consequence
  - Plume dispersion
  - Population distribution
  - Status of critical infrastructure
  - Response by medical system
  - Continuity of government
  - Dependence on foreign trade

NEREC

KAIST

Role of Academic Community

- To develop necessary human capital with the relevant expertise
  - Characterizing the risk
  - Detecting action
  - Assessing the meaning of events
  - Attempting to dissuade, prevent, deter, or in some cases preempt threatening actions.
- To perform necessary research:
  - Technology development for the reduction of threat, vulnerability, and consequences
  - Development of risk assessment tools
  - Related policy analysis
- Information sharing/dissemination
  - International relations, regional expertise, export controls, nuclear safeguards, arms control, disarmament, verification, information technology, cyber operations, military intelligence, bio-security, artificial intelligence, robotics innovation economics, business management, foreign trade, intellectual property law, investment strategies, science culture, education, development, and ethics
- Policy advice
- National culture development

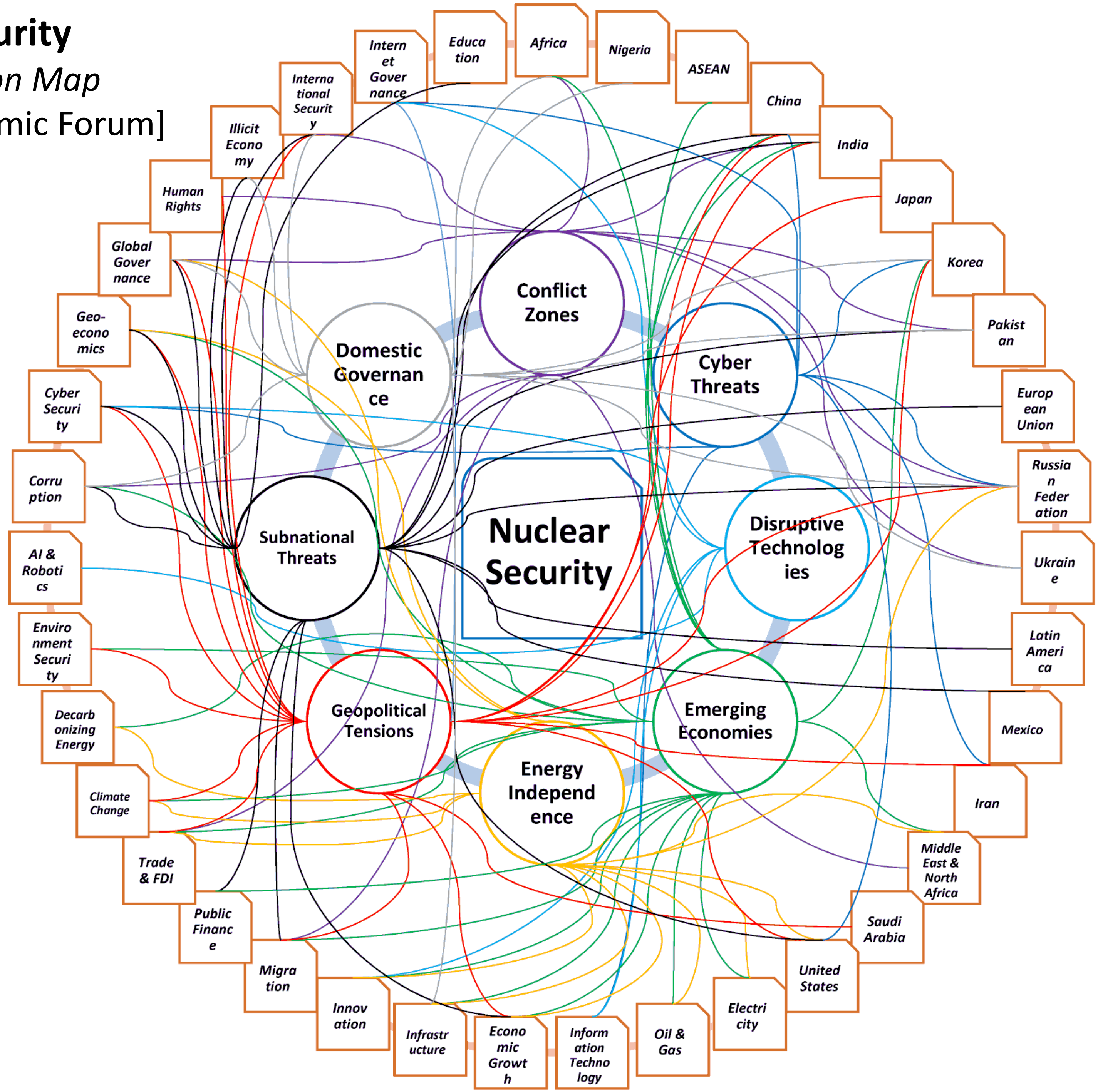
NEREC

KAIST

Nuclear Security

Transformation Map

[World Economic Forum]



Drivers for Change

- Population
- Resources
- Environment
- Technology
- Information
- Economic Integration
- Conflicts
- Challenges of Governance

Technology Diffusion/Technological Latency

Implications

- International cooperation and competition promote the advance and spread of technology.
- Tremendous technological power is increasingly in the hands of everyman.
- The enabling technology for simple and/or advanced weapons is increasingly widespread.
- Countries no longer control research and development of cutting-edge technologies.
- Globalization and intense competition in technology markets feed off the synergy of multi-disciplinary science that is frequently also multi-mission.
- Unexploited technology options create unclear and present dangers of strategic surprise.
- Today, individuals create dynamic global networks to marshal the ideas and resources required to produce technologies latent with far-reaching security, economic, and political consequences.
- The greater ease of access to dual-use technology linked to globalization of science and consumer economies has resulted in greater sophistication of nonstate-aided terrorists, ethnic and communal combatants, affinity groups, and violent transnational entities down to the cell and individual level.
- The political, military, and economic consequences of new technology no longer plod along familiar pathways of development but are instead blazing new byways leading to unknown destinations.
- The growth of megacities and dependence on interconnected transportation and communications introduces common modes of failure and exposure of large population concentrations.

Strategic Latency and World Power: How Technology Is Changing Our Concepts of Security, Zachary Davis, Michael Nacht, Ronald Lehman (ed.) Lawrence Livermore National Laboratory, 2014.

Challenges facing Nuclear Security Education

- Multidisciplinary education
  - Integration of various scientific & technical disciplines
  - Integration of soft and hard science
- Needs for cross-country, cross cultural education
- Needs for hands-on/practical experiences
- Finding nuclear security/nuclear nonproliferation champion(s) at educational institutions
- Securing sustainable funding

Universities Offering Education in Nuclear Engineering in Korea

Number	Type	School
1	Nuclear Engineering	KAIST
2		Seoul National University
3		Hanyang University
4		POSTECH
5		Kyunghee University
6		UNIST
7		Chosun University
8		Jeju University
9		Dongguk University
10		Sejong University
11		Inje University
12		Danguk University
13		Junbook University
14	Energy Engineering	Kyungbook University
15		Pusan University
16		Youngnam University
17		ChoongAng University
18		Wieduk University
19	Graduate Only Program	KEPCO International Nuclear Graduate School
20		University of Science and Technology

Korean Universities
Nuclear Engineering Departments

(Unit : Numbers)

Name	Gov/ Private	Year started	Full time faculty	BS incoming	Students				Graduates (Cumulative)			
					BS	MS	PhD	Total	BS	MS	PhD	Total
Hanyang	P	1958	8	39	200	27	62	289	2,224	335	79	2,638
SNU	G	1959	14	32	168	83	61	312	1,476	536	219	2.231
Kyunghee	P	1979	9	58	226	32	16	274	1,256	214	25	1,495
KAIST (%)	G	1980	18	20	81	91	143	315	202 (3%)	730 (35%)	360 (50%)	1,292 (13%)
Jeju	G	1984	6	29	197	18	16	231	673	75	12	760
Chosun	P	1985	6	49	229	59	22	310	1,037	134	7	1,178
Dongguk	P	2008	6	71	524	7	6	537	200	16	1	217
UNIST	G	2009	8	30	75	22	27	124	49	5	5	59
Pusan	G	2011	4	29	38	12	11	61	72	20	0	92
POSTECH	P	2011	9	-	-	9	33	42	-	18	4	22
Yungnam	P	2011	4	40	156	-	-	156	89	-	-	89
JoongAng	P	2013	3	100	258	-	-	258	0	-	-	0
Sejong	P	2013	6	22	85	7	0	92	0	-	-	0
Total	-	-	101	519	2,237	367	397	3,001	7,278	2,083	712	10.073

※ (%) : Compared to national total

KAIST

- Established in 1971 to model a research focused university and to foster elite human resources in science and technology needed by the nation.
- Public University under the Ministry of Science, ICT & Future Planning (not under Ministry of Education)
- No tuition and fees. Scholarship for all students
- Exemption of military service for male Ph.D. students


KAIST Today

Brief Statistics

KAIST

Enrollment
(as of 2017)

11,583

Undergraduate 4,540 | Graduate 2,872
Joint M.S./Ph.D. 1,269 | Ph.D. 2,902

Degrees Conferred
(as of 2017)

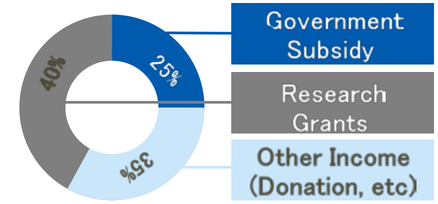
58,389

B.S. 16,482
M.S. 30,176 | Ph.D. 11,731

Faculty & Staff
(as of 2017)

1,117

Faculty 624
Staff 493



Budget
(as of 2017)

727.7 Million USD

THOMSON REUTERS
6th
2016 The World's Most Innovative Universities

THOMSON REUTERS
1st
2017 Asia's Most Innovative Universities

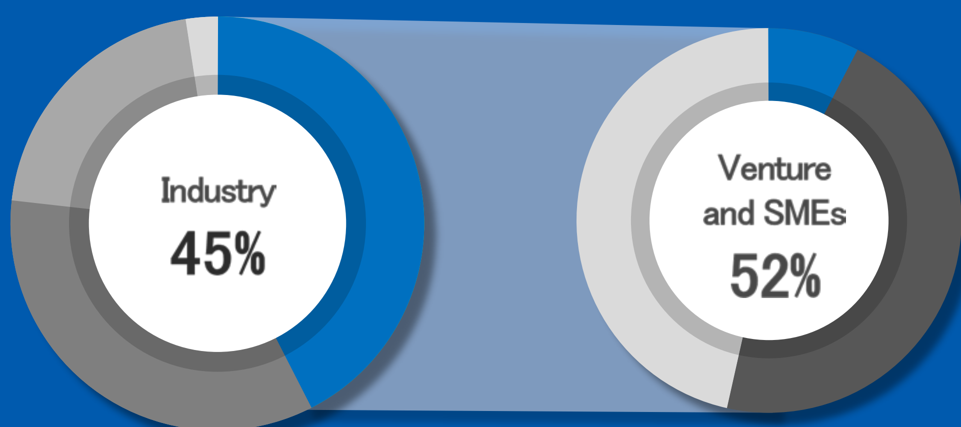
QS
41st
2017 QS World University Rankings

SAMSUNG
Nearly 25%
of Samsung's R&D workforce are KAIST graduates

Professorship
Nearly 20%
of all Korean universities' engineering faculty are KAIST graduates

Career Status of Ph.D. Graduates
(as of 2015)

- University Faculty: 31%
- Government and Public Institution: 21%
- Overseas Residence: 3%



Belong to SMEs and Venture 1700 persons

20%
Working as CEO

KAIST Nuclear and Quantum Engineering
Current Full-Time Faculty Members

• TH & Nuclear Safety

Soon Heung Chang
PhD : MIT
Energy System Design
and Safety Lab.

Hee Cheon No
PhD : MIT
Nuclear/Hydrogen
System Lab.

Yong Hoon Jeong
PhD : KAIST
Nuclear Energy Conversion
and Electrification Lab.

Jeong Ik Lee
PhD : MIT
Nuclear Power
and Propulsion Lab.

• Nuclear Materials

Changheui Jang
PhD : MIT
Nuclear and High Tempera
Materials Lab.

Ho Jin Ryu
PhD : KAIST
Nuclear Fuel Materials Lab.

Dongchan Jang
PhD : U Michigan
Nuclear Materials and
Nanomechanics Lab.

• Nuclear I&C/MMI

Poong Hyun Seong
PhD : MIT
Nuclear I&C and
Information Engineering Lab.

• Reactor Physics

Yonghee Kim
PhD : KAIST
Nuclear Reactor Core
Design and Transmutation Lab.

• Fuel Cycle/Energy Policy

Man Sung Yim
PhD : Harvard U.
Nuclear Environment and Security Lab.

Jong-Il Yun
PhD : RWTH Aachen;
Radiochemistry and Laser Spectroscopy Lab.

Sungyeol Choi
PhD: SNU
Nuclear Fuel Cycle Laboratory,
Nonproliferation & Nuclear security

• Nuclear Fusion/Plasma

Young Chul Ghim
PhD : Oxford U.
Nuclear Fusion and Plasma Lab.

• Radiation Detection/Medical Imaging

Gyuseong Cho
PhD : UC Berkeley
Radiation Detection
and Medical Image Sensor Lab.

Seungryong Cho
PhD : U. Chicago
Medical Imaging and
Radiotherapeutics Lab.

• Neutron Science

Sung-Min Choi
PhD : MIT
Neutron Scattering
and Nanoscale Materials Lab.

• Electron/Photon Eng

Sung Oh Cho
PhD : SNU
Quantum Beam Engineering Lab

NEREC (**N**uclear Nonproliferation **E**ducation and **RE**search **C**enter)

- Established in 2014 with the funding from the Ministry of Science& Technology of Korea
- Currently the sole university organization for nuclear nonproliferation education and research in Korea

Mission

- An independent think tank undertaking education and research to foster global nuclear nonproliferation conducive to peaceful use of nuclear technology

Objectives

- To train and nurture nuclear nonproliferation human resources
- To conduct nuclear nonproliferation policy research combining technical expertise and policy insights
- To lead discussions on the peaceful use of nuclear technology and various aspects of nuclear nonproliferation

Organization and R&D Structure

KAIST NEREC

- Prof. Man-Sung Yim (Director, Dean, KUSTAR-KAIST Institute, KAIST)
- Prof. Soyoung Kim, (Deputy Director, Head of Graduate School of Science, Technology, and Policy)

Director

Advisory Board

- Universities: SNU, Kyunghee U, KNDU, Handong U
- [Technology] KAERI, KEPCO, KINAC
- [Policy] The Sejong Institute
- Steve Miller, Harvard
- Scott Sagan, Stanford

Faculty

- Prof. Bong-Geun Jun (Korea National Diplomatic Academy)
- Dr. Sanghyeon Lee (The Sejong Institute)
- Dr. Kwangseok Lee (KAERI)
- Prof. Hyunseok Park (School of Humanities and Social Sciences, KAIST)

Researcher

- MS/PhD students of NQE, KAIST
- MA/PhD students of Graduate School of S&T Policy, KAIST

Staff

- Program Manager
- Administrative Staff

Collaboration within KAIST

- Dept. of Nuclear & Quantum Engineering
- Graduate School of Science and Technology Policy
- School of Humanities and Social Sciences
- Graduate School of Information Security

Domestic Cooperation Partners

- Korea Nuclear Policy Society
- Korea Nuclear Society
- [Nuclear] KAERI, KINAC/INSA, KONICOF, KORAD, Doosan Heavy Industry
- [Think-tank] KNDA, EAI, Sejong Institute, Korea National Defense Agency
- [Gov] NSSC, MST, MOF

Overseas Cooperation Partners

- (US) Harvard Belfer, Stanford CISAC, MIT, Georgia Tech, Tennessee U, USKI at SAIS, Partnership for Global Security
- (China) CIIA, SIIA, Tsinghua U, Shanghai Jiaotong U, Fudan U
- (Japan) JAEA, TITECH, Nagasaki U
- (EU) KTH, SIPRI

NEREC Activities

- **Education**
  - Graduate degree education
    - Dept. of Nuclear & Quantum Engineering (3 MS, 6 PhD candidates)
    - Graduate School of Science Technology and Policy (1 MS, 1 PhD candidates)
  - International Summer Fellows program for college/graduate students
  - Public/college outreach for nuclear nonproliferation & security culture
  - Short courses
- **Research**
  - Nuclear nonproliferation
  - Nuclear security
  - Nuclear fuel cycle
- **International Cooperation**
  - NEREC Conference on Nuclear Nonproliferation
  - Educational cooperation and outreach
  - Research collaboration

NEREC Summer Fellows Program

- International intensive short-term education and training course of nuclear nonproliferation for undergrad, graduate and high-school students
- Date/Place: from late June to August / KAIST, Daejeon, ROK
- Activities: Lectures and seminars, field trips, group research and its poster presentation, and Alumni meeting, etc.
- Two track approach (As of the 4th year program in 2017)

Program	Participants	Period	No.	Countries
Young Fellows	College students	Jul 9 – Aug 8 (5 Weeks)	15	USA, Brazil, Russia, Bangladesh, Malaysia, Indonesia, Singapore, Egypt, Iran, Korea
Graduate Fellows	MS/MA or PhD course students	Jul 9 – Aug 19 (6 Weeks)	15	USA, UK, China, India, Indonesia, Bangladesh, Kuwait, (Japan, Saudi Arabia), Korea

2017 NEREC Summer Fellows

Salman AHSANULLAH
Bangladesh
National Research Nuclear University MEPhI
Nuclear Engineering

Vladislav CHERNAVSKIKH
Russia
Ural Federal University
International Relations

Behieh ELAHI
Iran
University of Sharjah
Nuclear Engineering

Rachel KELLEY
USA
University of Georgia
International Affairs

Asmaa Salem FARAG
Egypt
Alexandria University
Nuclear and Radiation Engineering

Lynn LEE
ROK
Georgetown University
International Politics

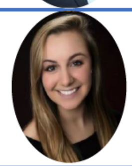
Valeria FRANCA
Brazil
Federal University of Rio de Janeiro
Nuclear Engineering

Faiq Adi PRATOMO
Indonesia
Universitas Gadjah Mada
International Relations

Hansol KO
ROK
Kyung Hee University
Nuclear Engineering

Murry Dan SMITH
USA
Georgia Institute of Technology
International Affairs

Fatin PADZLI
Malaysia
Missouri University of Science and Technology
Nuclear Engineering



Gabrielle TARINI
USA
Boston College
International Studies

Azman RAFEE
Bangladesh
University of Dhaka
Nuclear Engineering

Shawn THAM
Singapore
Nanyang Technological University
History

Syed ALAM
Bangladeshi
University of Cambridge
Nuclear Engineering
PhD

Sarah KUNIS
USA
Seoul National University
International Cooperation
Master

Thaqal ALHUZAYMI
Saudi Arabian
Missouri University of Science and Technology
Nuclear Engineering
PhD

Leah MATCHETT
USA
University of Oxford
International Relations
MPhil

Bader ALMUTAIRI
Kuwait
Missouri University of Science and Technology
Nuclear Engineering
PhD

Claudia NG
UK
Harvard University
Public Policy
Master

Alan CHARLES
UK
University of Cambridge
Nuclear Engineering
PhD

Kya PALOMAKI
USA
George Washington University
Security Policy
Master

Sobin CHO
ROK
Korea Advanced Institute of Science and Technology
Nuclear and Quantum Engineering
MA

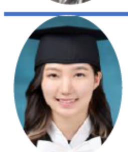
Renu RANA
India
Fudan University
International Politics
PhD

Su-Hyeon KIM
ROK
Kyung Hee university
Nuclear Engineering
MA

Cristina SISERMAN
Romania
University of Vienna, Austria
International Law
PhD

Fajar MUHAMMAD
Indonesia
Tokyo Institute of Technology
Nuclear Engineering
MA

Eriko STRONACH
USA
Tufts University
Pacific Asia and Security
Master



Minji PARK
ROK
Seoul National University
Nuclear Engineering
PhD

Luyi ZHAO
China
Tongji University
Political Science and Administration
MA


경
축
제69주년
제헌절

NEREC Summer Fellows Program 2017

- **Overall Schedule: July 9 to August 19**

W	Time	Mon	Tue	Wed	Thu	Fri
W 1	10-12	Lecture 1	Lecture 3	Lecture 5	Field Trip (1) - Seoul July 13 (Thu) ~ 15 (Sat)	
	13-15	NRM(1)	NRM(2)	NRM(3)		
	15-17	Lecture 2	Lecture 4	Lecture 6		
	17-18	*	*	Field Trip Preview		
W 2	10-12	Lecture 7	Lecture 9	Lecture 10	Lecture 12	*
	13-15	Lecture 8	Group Research Proposal (YF)	Lecture 11	Lecture 13	Lecture 14
	15-17	Group Research Proposal (GF)	*	Team-building exercise	*	*
W 3	10-12	Field Trip (2) - Gyeongju July 24 (Mon) ~ 26 (Wed)			NRM(4)	NRM(5)
	13-15				*	*
	15-17				*	*
W 4	10-12	NRM(6)	NRM(7)	NRM(8)	*	*
	13-15	Field Trip Review Sharing	*	Research Poster Presentation Preparation	*	*
	15-17	Group Research Final Presentation	*	Team-building exercise	*	*
W 5		2017 Conference on Nuclear Nonproliferation (Poster Presentation, Commencement Ceremony, NEREC Fellows Alumni Meeting) *The end of YF Program*		Research Paper Preparation		
W 6		Field Trip to China and Japan (GF) August 12 (Sat)~19 (Sat) *The end of GF Program*				

*Group Research Work

Common Lectures & Domestic Field Trips

Lectures (for NEREC Summer Fellows)

Theme	Topic
Nuclear Technology	Overview of Nuclear Energy
	Nuclear Fuel Cycle
Nuclear Nonproliferation & Security	Introduction to Nuclear Nonproliferation
	Nonproliferation Regime and Export Control
	Terrorism & International Security
	North Korean Nuclear Problem
International Relations	International Relations Theories
	International Law: focusing on the Non-Proliferation Treaty
	International Organization
	International History: from the Cold War to a new era
Nuclear S&T and Policy Issue	Spent Nuclear Fuel Management
	Role of Nuclear Power and Public Acceptance
	Nuclear Exporter and Importer, and their Responsibilities
	Global Nuclear Governance
	Connection between Nuclear Technology and Proliferation Dynamics
Research Methodology	S&T Policy
	Quantitative Analysis Methodology
Others	Korean History and Hangul
	Global Leadership

Field Trips (Seoul and Gyeongju)

- Government and its agencies, think-tanks, nuclear research institutes, and cultural activities

Ministry of Foreign Affairs

KINAC

The Sejong Institute

KORAD


The Nat'l Assembly, ROK


DMZ security tour

Lecture for Fellows & Overseas Field Trip

Nuclear Risk Management

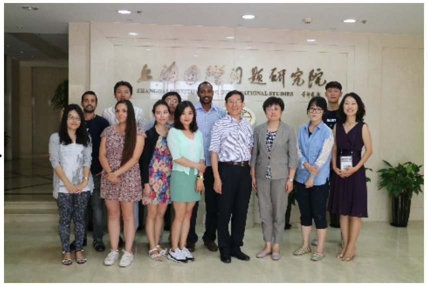
Lecturer	**Prof. Man-Sung Yim**
Credit	**1**
Lecture Topics	
Basics of risk Emerging global issues Technological risk Risk assessment	
Risk of nuclear power Nuclear accident risk assessment Radiation risk Uncertainty and probabilistic modeling Management of risk of nuclear power	
Risk of nuclear weapons History of nuclear proliferation Management of risk from nuclear weapons Nuclear safeguards Nuclear security	
Nuclear risk perception and communications	

Field Trips (China & Japan)

- China: Tsinghua U, Chinese Academy of Social Science, Shanghai Jiaotong U, Fudan U, Shanghai Institute of Int'l Studies
- Japan: Tokyo Inst. Technology, JIEE JAEA, Tokai NPP

Beijing>

Shanghai>



Mito>

Public Outreach

- **An open forum for nuclear nonproliferation culture development**

  - Purpose: To raise public awareness on nuclear nonproliferation and to enhance nuclear nonproliferation culture

  - Program: Keynote speech, expert panel discussion, students panel discussion and open floor discussion (~100 mins)

  - Survey on public awareness of nuclear nonproliferation among college students

- **Five round of forums held in 2015**

[1st]
KAIST
Daejeon
60 participants
on 31, March

[2nd]
Gyeonghei Univ.
Gyeonggi
80 participants
On 29, April

[3rd]
Seoul Nat'l Univ.
Seoul
30 participants
on 5, June

[4th]
Chosun Univ.
Gwangju
45 parcipants
On 7, October

[5th]
Hanyang Univ.
Seoul
60 parcipants
On 24, November

NEREC Conference on Nuclear Nonproliferation

- **An annual international conference** to share knowledge and insights of nuclear nonproliferation research/education community with the focus on the connection between nuclear power and nuclear nonproliferation
- A multi-session professional conference with over 20 invited speakers from all over the world, and open to undergraduate/graduate students

NPLI PATH (Policy and Technology) Fellowship

- Established in 2016
- **Co-hosted by KAIST NEREC, Partnership for Global Security and US-Korea Institute at SAIS**
- A short (4 weeks) intensive education and training program of nuclear policy for master or PhD students in Korea to enhance research capabilities in the field and to build networks with policy experts in the U.S.
- Place: Washington D.C.
- Program: Lectures/Seminars, Debate, Role Play, Site Visits and Group Presentation

No	Sector	Expert	Affiliation	Title
1	Academia	Frank Von Hippel	Princeton University	Co-director
2	Government	Michael Butera	DOS	Presidential Management Fellow
3	Government	Andrew Hood	NNSA	Director
4	Government	Joseph Rivers	NRC	Senior Level Advisor on Security
5	Government	Aaron Weston	US House Committee on Science, Space, and Technology	Counsel
6	Government	Mark Holt	Congressional Research Service	Specialist in Energy Policy
7	Industry	Jack Edlow	Edlow Int'l Company	President
8	Industry	Robert Kidwell	Enercon Services	Senior Technical Specialist
9	Industry	Everett Redmond	NEI	Senior Director
10	Industry	Susan Perkins-Grew	NEI	Senior Director
11	Industry	William Fork	Pillsbury Winthrop Shaw Pittmann LLP	Senior Lawyer
12	Industry	Steven Casazza	Sierra Nevada Corporation	Manager
13	Industry	Terrence Reis	Talisman Int'l	Director
14	Industry	John Bendo	ASME	Manager
15	National Lab	Warren Stern	Brookhaven NL	Senior Advisor
16	National Lab	Benn Tannenbaum	Sandia NL	Head
17	National Lab	Jae Soo Ryu	KAERI	Head and Principal Researcher
18	NGO	Kingston Rief	Arms Control Association	Director
19	NGO	Kelsey Davenport	Arms Control Association	Director
20	NGO	Daryl Kimbell	Arms Control Association	Executive Director
21	NGO	Andrew Newman	NTI	Senior Program Officer
22	NGO	Jenny Town	US-Korea Institute at SAIS	Assistant Director
23	NGO	Ken Luongo	Partnership for Global Security	President
24	NGO	Anita Nilsson	A&N Associates	President
25	NGO	Caroline Jorant	SDRI Consulting	President
26	NGO	John Bernhard	Former Denish Amb. to the IAEA	Consultant
27	INGO	UN 1540 Committee		

[Lecture & Discussion]

[UNSC 1540 Committee]

[NRC Visit]

NEREC Research Fellowship

- A one-year fellowship to enhance the nuclear policy research capabilities of students in political or social science domain and to contribute to building up policy development capacity in Korea (Applicants: MA or Ph.D. students of political or social science major)
- Research areas: Domestic and international policy issues on nuclear nonproliferation and nuclear security for peaceful use of nuclear energy
- **The NEREC Research Fellows in 2016 & 2017**

Name	Affiliation	Major	Research Topic
Eunjung Cho	Center for Int'l Studies	Politics and Int'l relations	Policy implications of bilateral nuclear cooperation agreement of the United States on the international control of nuclear power
Jeongje Hong	Seoul National University	Political Science and International Relations	Factor analysis of the conclusion of Additional Protocol to the IAEA Safeguards Agreement
Shymanska Alina	Kyung Hee University	International Politics	Problems of nonproliferation policy toward North Korea and the significance of denuclearization on the Korea Peninsula
Eunji Kim	Seoul National University	Political Science and International Relations	Analysis on policy and national security factors of sensitive nuclear technology transfer
Solah Kim	Seoul National U	Political Science	Public acceptance and nuclear power
Dongjoon Lee	KAIST	Science, Technology, Policy	MNA for spent fuel management
Jaewon Lee	Seoul National U	International Relations	Additional protocol and Saudi Arabia's nuclear power development
Jinwon Lee	Korea National Diplomatic Academy	International Security	Enhancing nuclear export control from functional theory perspectives
Young Ran Moon	Seoul National U	International Relations	Balancing strategy between NWS and NNWS

R&D Strategy: **Domestic and Int'l Cooperation**

- **Utilizing the established networks among domestic experts**
  - **Korea Institute of Nuclear Nonproliferation and Control & INSA** (Joint conference, joint research, facility training, etc.)
  - Korea Nuclear Policy Society
  - Korea Nuclear Society
  - Korea Institute for Nuclear Materials Management (joint meetings)
  - Korea Atomic Energy Research Institute
  - Korea Hydro and Nuclear Power Company (Site nuclear security tour)
  - Seoul National University and other major universities
  - Korea Ministry of Foreign Affairs/Korea National Diplomatic Agency
  - East Asia Institute
  - The Sejong Institute
- **Collaboration with overseas experts and organizations**
  - Policy-related: Stanford University, Harvard University, Princeton University, George Washington, Georgetown, Johns Hopkins, Georgia Tech, Shanghai Jiatong University, Fudan University, etc.
  - Engineering-related: Tokyo Ins. Technology, UC Berkeley, Texas/Austin, U Utah, U New Mexico, Texas A&M, MIT, Tennessee, NC State, etc.
  - National Labs: Japan Atomic Energy Agency, Oak Ridge National Laboratory, Los Alamos National Laboratory, Idaho National Laboratory, Argonne National Laboratory, Lawrence Livermore National Laboratory, etc.
  - Think-tanks: CSIS, Carnegie Endowment, NTI, Brookings, MIIS/CNS, SIPRI, etc.
  - Networking with IAEA and countries in Europe and Asia (e.g., member of INSEN)
- **Holding a regular domestic or international workshop**
  - Research on nuclear nonproliferation, nuclear security, and related regional & international issues
  - Discussions on nuclear nonproliferation related to the peaceful use of nuclear energy(or other global issues) in a private sector
- **Enhancing a state-level nuclear transparency**

Recent Research Presentations: Examples

2017 INMM Conference, July 16-20, Indian Wells, CA, USA

1. Viet Phuong Nguyen and Man-Sung Yim, "Nonproliferation and security implications of the evolving nuclear export market"
2. Haneol Lee and Man-Sung Yim, "Development of computational model for a scintillator based partial defect detector to safeguard PWR spent fuel assemblies"
3. Young A Suh and Man-Sung Yim, "Examining the Application of EEG Monitoring for Identifying an Insider."

2016 INMM Conference, July 24-28, Atlanta, GA, USA

1. So Young Kim and Man-Sung Yim, "Global Nuclear Public Opinion and Policy Implications: A Cross-National Analysis of Surveys and Polls on Nuclear Security and Nonproliferation"
2. Chan Kim, Man-Sung Yim, and Viet Phuong Nguyen, "Quantification of State-Level Nuclear Security - An Integrative Approach for Quantitative and Qualitative Analysis".
3. Young A Suh and Man-Sung Yim, "An Investigation into the Applicability of Biodata, from Health Wearable Devices to Insider Threat Detection in Nuclear Power Plants".
4. Chul Min Kim and Man-Sung Yim, "Investigating Pyroprocessing Safeguards Systems Analysis Framework".

2015 INMM Conference, July 12-16, Indian Wells, CA, USA

1. Chul Min Kim, Man-Sung Yim, and Hyeon Seok Park, "Challenges of Quantitative Nuclear Proliferation Modeling".
2. Jee-Min Ha, Man-Sung Yim, Hyeon Seok Park, and So Young Kim, "Examination of Relationship between Nuclear Transparency and Nonproliferation".
3. Kyo-Nam Kim, Young-A Suh, Man-Sung Yim, Erich Schneider, "Game Theoretic Modeling of Physical Protection System Design Encompassing Insider Threat Analysis". (Best Paper Award)
4. Viet Phuong Nguyen and Man-Sung Yim, "Bilateral Nuclear Cooperation in the Post-Cold War Era and Its Implication for Nuclear Nonproliferation". (Best Paper Award)
5. Chan Kim, Man-Sung Yim, and So Young Kim, "Examination of State-Level Nuclear Security Method".
6. Seok-ki Cho and Man-Sung Yim, "Whistleblowing Analysis for Detection of Insider Threat in a Multicultural Environment".
7. Jieun Joo, Man-Sung Yim, "Examining Prospects of Public Acceptance of Nuclear Power in the Republic of Korea".

Journal Paper Publication (2017)

No.	Title	Authors	Journal Title	Publication Date
1	Examination of scintillator-photovoltaic cell-based spent fuel radiation energy conversion for electricity generation	Haneol Lee, Man-Sung Yim	PROGRESS IN NUCLEAR ENERGY	2017.01
2	A study of insider threat in nuclear security analysis using game theoretic modeling	Kyonam Kim, Man-Sung Yim, Schneider, Erich	ANNALS OF NUCLEAR ENERGY	2017.10
3	Building Trust in Nonproliferation: Nuclear Transparency in Nuclear Power Development	Viet Phuong Nguyen, Man-Sung Yim	Nonproliferation Review	2017.12.
4	High Risk Non-Initiating Insider" Identification based on EEG analysis for Enhancing Nuclear Security	Younga Suh, Man-Sung Yim	ANNALS OF NUCLEAR ENERGY	2017.12

THE DETECTION AND PREDICTION OF INSIDER THREAT USING BIO-SIGNALS IN NUCLEAR POWER PLANTS

Young A Suh and Man-Sung Yim
Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology
dreameryounga@kaist.ac.kr

1. Introduction

1.1 Background

- With the on-going global war on terror, the potential for a terrorist attack on a Nuclear Power Plant (NPP) is receiving a great deal of attention. The potential threat from an insider could lead to a grave outcome and deserves serious consideration.

1.2 IAEA Preventive and Protective Measures for Insider Threats

- (1) Exclude access to potential insiders by identifying undesirable behavior or characteristics, which may indicate inappropriate motivation.
- (2) Remove from the premises individuals (potential insider) with undesirable behavior or characteristics after they have accessed the NPP.
- (3) Minimize opportunities for malicious acts by limiting access, authority and knowledge, by all available means.
- (4) Detect, delay and respond to malicious acts.
- (5) Mitigate or minimize the consequences resulting from malicious acts.

1.3 Objectives of Research

- To propose a framework for detecting and predicting potential insiders.
- To investigate the feasibility of detecting and predicting an insider threat by using human biodata, from smart wearable devices.
- To develop the Conceptual Model for Screening System Technology for detecting and predicting an insider.
- To develop the Conceptual Model for the Intention-Based Access Authority System technology for minimizing the opportunity to commit a crime.

2. Insider Detection Monitoring

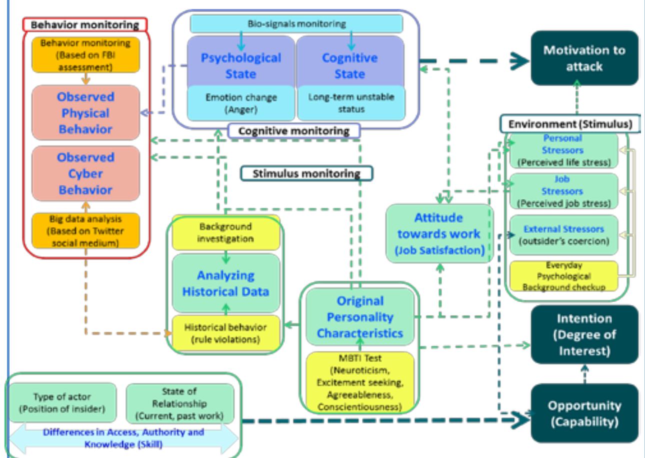


Fig.1. Insider Detection and Prediction Monitoring Model

3. Preliminary Experiment

- General Deterrence Theory (GDT): Person commits crime if expected benefit outweighs cost of action.
- Theory of Planned Behavior (TPB): Person's intention (attitude, subjective norms and perceived behavior control) towards crime is a key factor in predicting behavior Situational Crime

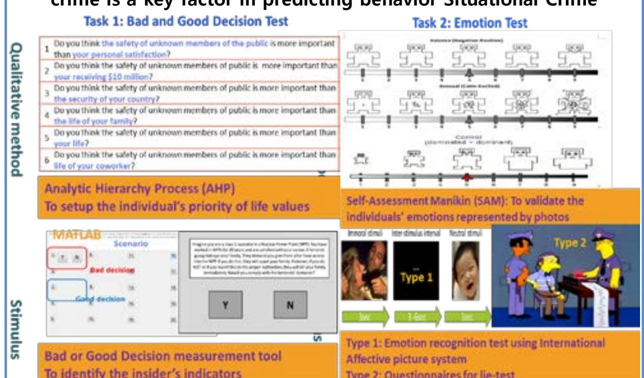


Fig.2. Task 1 Design

Fig.3. Task 2 Design

4. Preliminary Results

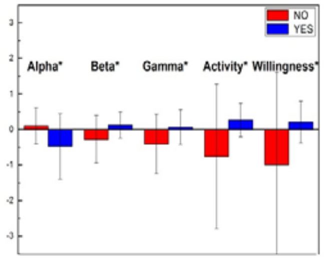


Fig.4. Means and Standard Deviations of obtained EEG indicators values

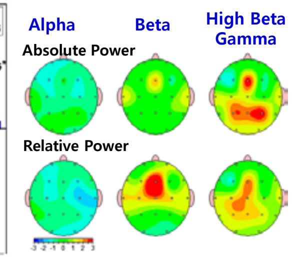


Fig.5. Related Brain Region

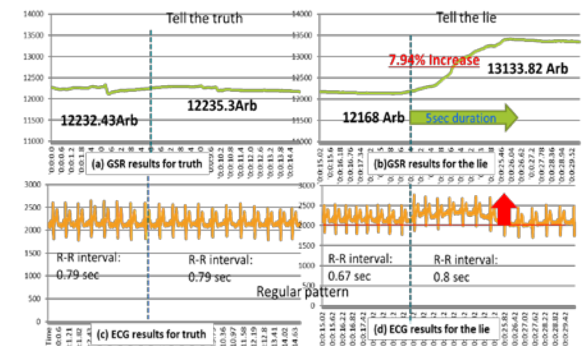


Fig.6. GSR and ECG analysis for two cases: (a, c) telling the truth and (b,d) telling a lie

5. Discussion and Summary

- Current Limitations and Challenges of using bio-signals: Emotion signals (EEG, GSR,ECG) generally lack ground truth.
- Ethical and Legal Issues: Invasion of privacy
- As a result of the EEG analysis, these four indicators(Beta, Gama, Beta/Alpha and Gamma/Alpha) can be used to identify an initiating insider.
- As a result of the GSR and ECG analysis, it is possible to detect the insider's emotional states because we can identify when a lie is being told.

NENS Nuclear energy Environment and Nuclear Security Laboratory

Investigation of scintillator based partial defect detection (SPDD) for spent fuel safeguards

Haneol Lee and Man-Sung Yim

Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology, lee1012@kaist.ac.kr

1. Introduction

1.1. Objective of safeguards (INFCIRC/153)

- Timely detection of diversion of significant quantities (SQ) of nuclear material and deterrence of such diversion by the risk of early detection.

1.2. Partial defect (IAEA-NP-T-2.9)

- Refers to an item or batch that has been falsified to such an extent that some fraction of the declared amount of material is actually present

1.3. Previous research for partial defect detection

Table 1. Previous studies on partial defect detection

Type of detector	Capabilities	Characteristics	Limitations
Safeguards MOX Python [SMOPY] (IAEA-SM-367/14/03)	- Distinguish LEU/MOX spent fuel assembly - LEU spent fuel characterization - Partial defect detection	- Accurate characterization of spent fuel assemblies	- It takes time to analyze a spent fuel assembly.
Partial defect detector [PDET] (Ham et al., 2010)	- Qualitative analysis - System application inside guide tubes	- Without assembly movement	- Low resolution for small pin diversion
Gamma Emission Tomography (STUK-YTO-TR-189)	- Two dimensional (2-D) image reconstruction from measured activity profiles	- Fuel pin level partial defect detection	- It takes long time to analyze a spent fuel assembly.
Cerenkov Viewing devices [ICVD, DCVD] (J. D. Chen et al., 2010)	- Qualitative analysis - Detection of Cerenkov radiation at directly above an assembly	- Easy, fast, and non-intrusive.	- Cannot be applied out of cooling pool

1.4. Purpose of the research

- To develop scintillator based "simple and fast" partial defect detector.

2. SPDD Design

2.1. Conceptual design of SPDD

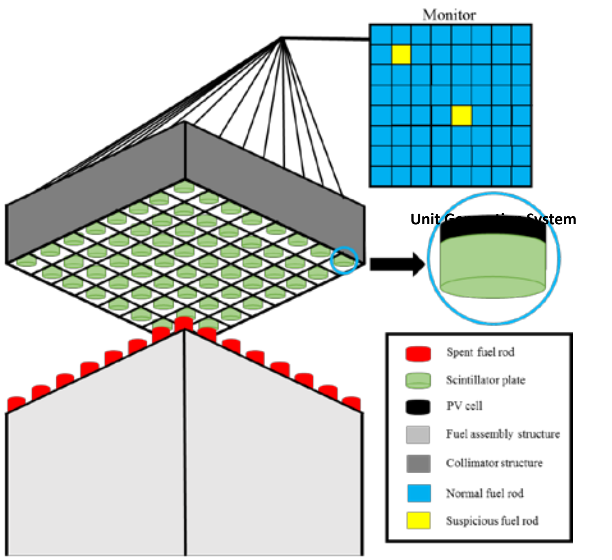


Fig. 1. Conceptual design of a scintillator based partial defect detector (SPDD).

2.2. Methods to distinguish defect spent fuel assembly using SPDD – 2 methods

- In each unit generation system of a SPDD, spent fuel radiation is converted into visible photons via scintillator and PV cell generates electricity using the photons. (Lee and Yim, 2016)

2.2.1. Method 1

- Calculate relative generated electricity of each unit generation system of a test case assembly compared to the same location of a reference assembly.

  [Relative electricity generation of unit "n", $R1_n \equiv \left(\frac{I_{n,case}}{I_{n,ref}}\right)$]

2.2.2. Method 2

- Calculate relative electricity generation of each unit generation system of a test case assembly compared to the maximum value within the test case assembly. [Relative electricity generation of unit "n", $R2_n \equiv \left(\frac{I_{n,assembly}}{I_{max,assembly}}\right)$]

- If an assembly contains relative generated electricity out of compliance boundary or the pattern is distorted, it becomes suspicious spent fuel assembly.

3. SPDD Feasibility Demonstration

3.1. Computational model based approach

- SCALE-DEPL, OrigenArp: Spent fuel gamma source analysis
- MCNPX: Scintillated photon analysis

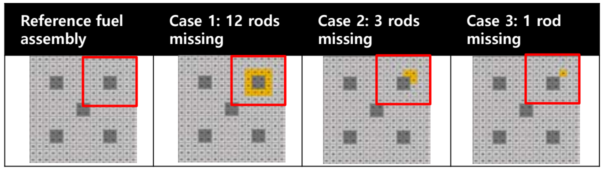


Fig. 2. Test case spent and reference PLUS7 fuel assembly.
(Light gray: normal pin, Orange: diverted pin, Dark gray: guide tube)

- Test case discharge burnup and cooling time:
- 47.34 GWd/tU, Three irradiation cycles, 50 days downtime, 10 years cooling.
- Method and assumption used to analyze spent fuel radiation.
- Pin-wise burnup distribution was performed using the SCALE-DEPL and OrigenArp code
- Fission product along axial direction follows cosine distribution.

3.2. Compliance boundary setup

- Since the performance of SPDD is analyzed using the MCNPX code, relative error is accompanied for every tally results.
  (Relative error for every tally result < 0.075)
- Difference between an assembly and normal assembly > 0.2121
  → out of 95% confidence interval with conservative assumption

3.3. Results of SPDD feasibility demonstration

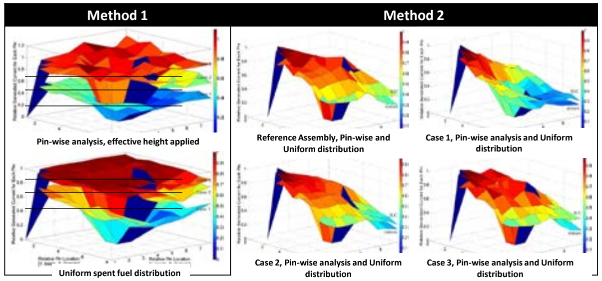


Fig. 3. SPDD feasibility demonstration results for applying method 1 and 2. Results include both uniform spent fuel gamma source case and pin-wise spent fuel gamma source calculation case.

3.4. Conclusions and Future work

- SPDD is able to detect defective spent fuel assembly based on measuring electricity even for single pin diversion case.
- The performance of SPDD is demonstrated using computational model.
- The low burnup and cooling time limit for the application of SPDD have to be examined.
- The effect of neighboring assemblies has to be considered.

Analyzing Security/Safeguards-by-Design (SSBD) requirements of ATOM (Autonomous, Transportable, On-demand, Modular) Reactor

Chul Min Kim, Sobin Cho, Vu Duc Giang, Philseo Kim and Man-Sung Yim
Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology
usekim00@kaist.ac.kr / msyim@kaist.ac.kr

1. Introduction

ATOM (Autonomous, Transportable, On-demand, Modular) reactor is a conceptual Small Modular Reactor (SMR), based on the Pressurized Water Reactor (PWR), which is suggested by Korea Advanced Institute of Science and Technology (KAIST). When developing the design requirements of ATOM, Security/Safeguards-by-design (SSBD) should be considered at the earliest stage of the design process to optimize the system. However, previous designs of SMRs did not consider the security and safeguards aspects of their design. As the initial investigation into evaluating and identifying SSBD for the Autonomous Small Modular Reactor (ASMR), we analyze the design features that could cause new challenges, or enhance the effectiveness of security or safeguards aspects in each stage of the fuel cycle.

2. Project Information

Part of the ATOM (Autonomous, Transportable, On-demand, Modular) Reactor Design Project, Center of Autonomous Small Modular Reactor Research (CASMRR), directed by Prof. Yonghee Kim

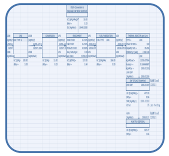
- 1st phase (4 years): 2016.5 ~ 2019.12
- 2nd phase (3 years): 2020.1 ~ 2022.12
- Participating students: Chul Min Kim, Sobin Cho, Vu Duc Giang, Philseo Kim

3. Expected Outcome for Students

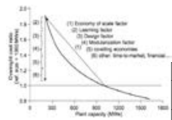
1) Understanding mass flow and economic analysis of nuclear fuel cycle system
2) Understanding the concept of proliferation resistance based on the security/safeguards analysis
3) Understanding nuclear power plant components based on the study of SMR
4) Understanding social issues related to nuclear power industry

4. Research Topics

Developing economic assessment framework of SMR fuel cycle



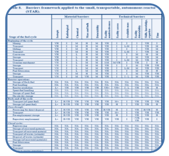
- Construction cost
- Fuel cycle cost
- Operation & Management (O&M) cost



Burnup (GWd/MTU)	FCC ($/MWh)	FCC ($/MWh)
33	9.87	13
44	7.4	9.75
49.5	5.92	8.67

Power (MWe)	100	150	200	250	300
Scaling factor (n=0.61)	2.68	2.29	2.05	1.88	1.75
Modular design	0.69	0.74	0.78	0.82	0.83
Total	1.8492	1.6946	1.599	1.5416	1.4525

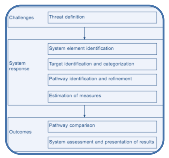
Proliferation resistance analysis of SMR fuel cycle



- Proliferation resistance analysis based on various core performance requirements
- Developing the evaluation framework of design candidates (physical protection, safeguardability)

Mean Burnup	Isotopic Barrier			
	Critical Mass Material	Isotope enrichment	Neutron emission	Heat emission
MWd/MTU	Pu	Pu-239/Pu	(Pu-240+Pu-242) / Pu	Pu-238/Pu
33000	Same	56.6	27.9	1.3
43000		52.5	30.3	2.0
53000		50.4	31.2	2.7

Developing security/safeguards requirements

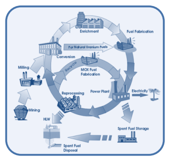


- Physical protection, vital area analysis
- Facility safeguardability assessment

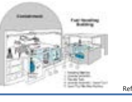
Ref: Integrating Safety, Operations, Security, and Safeguards into the Design of SMRs: A Handbook, SAND2013-9429..

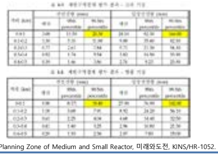
Ref: S. Prasad et al. (2014), Nonproliferation Improvements and Challenges Presented by SMRs, Progress in Nuclear Energy 80: 102-109.

Analyzing the uncertainties from the characteristics of SMR



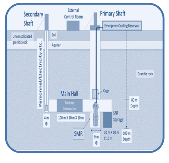
- External cost (public acceptance, reduced EPZ, etc.)
- Decommissioning and spent fuel management strategy





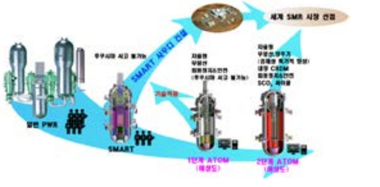
Ref: Evaluation of Emergency Planning Zone of Medium and Small Reactor, 미래와도전, KINS/HR-1052.

Analyzing the feasibility of new design concepts



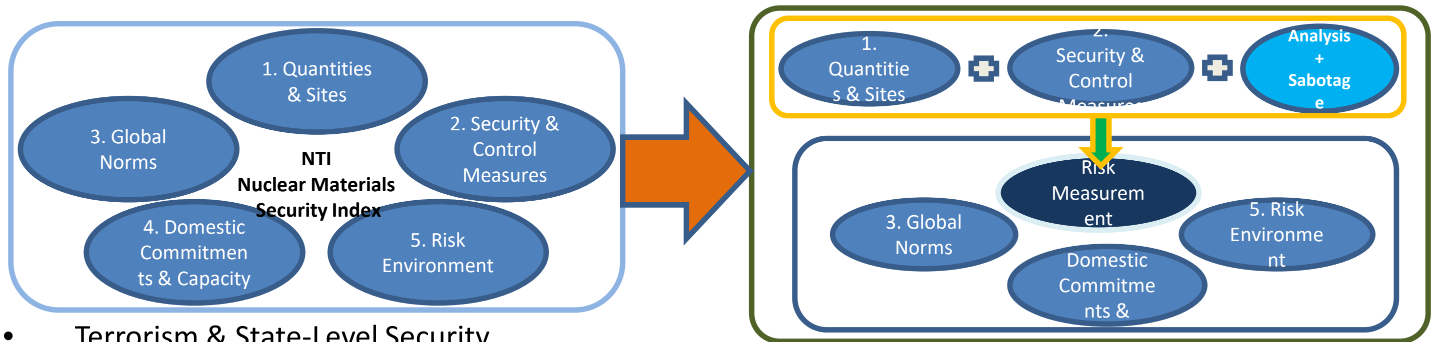
- Batch operation
- Modular design
- Underground design
- Nuclear/Renewable hybrid system

Ref: S.M. Bragg-Sitton et al., "Nuclear-Renewable Hybrid Energy Systems:2016 Technology Development Program Plan", INL, 2016



- Supporting ATOM development
- Security/Safeguards-by-Design
- Comprehensive evaluation of design chracteristics

Examination of State-Level Nuclear Security Evaluation Method



- Terrorism & State-Level Security
- Introducing Traditional Risk Formula into "Risk Measurement"
  - Risk = Threat × Vulnerability × Consequence
  - Using proxy – data refinement for measuring Terrorist Organizations' intention and capability
- Relative Weights Determination by AHP and experts survey

Ranking Comparison with NTI Index

Countries with Material (25 states)

NTI overall			New overall		
1	Austrailia		1	Austrailia	0
2	Canada		2	Canada	0
3	Switzerland		3	Norway	2
4	Germany		4	Switzerland	-1
5	Norway		5	Netherlands	2
6	Poland		6	Germany	-2
7	France		7	France	0
7	Netherlands		8	Belgium	2
9	Belarus		9	United Kingdom	2
10	Belgium		10	Poland	-4
11	United Kingdom		11	Japan	2
11	United States		12	United States	-1
13	Argentina		13	Argentina	0
13	Japan		14	Belarus	-5
15	Kazahkstan		15	South Africa	1
16	South Africa		16	Kazakhstan	-1
17	Italy		17	Italy	0
18	Russia		18	Russia	0
18	Uzbekistan		19	China	1
20	China		20	Uzbekistan	-2
21	Israel		21	Israel	0
22	Pakistan		22	Pakistan	0
23	India		23	India	0
24	Iran		24	Iran	0
25	North Korea		25	North Korea	0

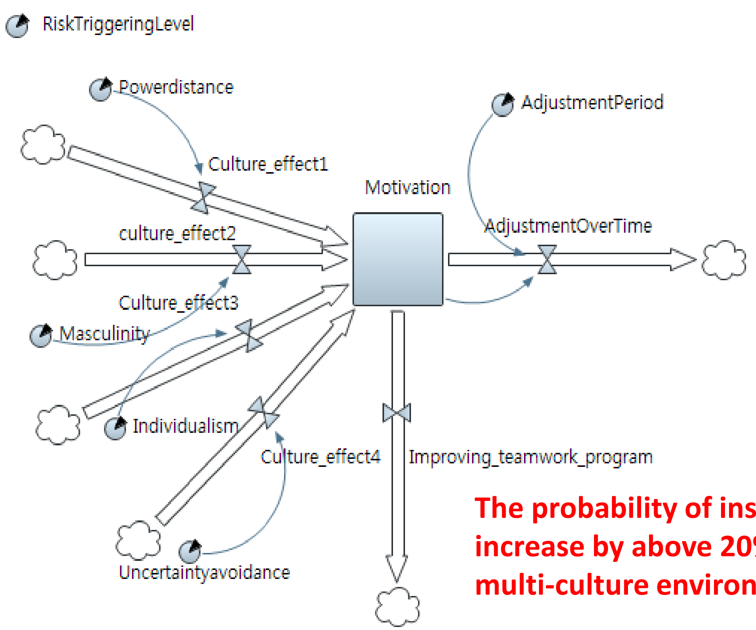
e.g.) Sri Lanka (-30), Afghanistan (-25), Thailand (-21), Iraq (-20), Philippines (-20), Lebanon (-17), etc.

Countries without Material (151 states)

NTI Overall		New Overall		Δ
1	Denmark	1	Finland	1
2	Finland	2	Slovenia	3
3	Sweden	3	Sweden	
4	Spain	4	Denmark	-3
5	Slovenia	5	Slovakia	1
6	Slovakia	6	Luxembourg	14
7	Lithuania	7	New Zealand	5
8	Czech Republic	8	Czech Republic	
9	Latvia	9	Hungary	2
10	Austria	10	Malta	5
11	Hungary	11	Lithuania	-4
12	New Zealand	12	Iceland	7
13	Portugal	13	Romania	4
14	Mexico	14	Latvia	-5
15	Malta	15	South Korea	3
16	Estonia	16	Spain	-12
17	Romania	17	Austria	-7
18	South Korea	18	Bulgaria	4
19	Iceland	19	Portugal	-6
20	Cyprus	20	Estonia	-4
20	Luxembourg	21	Cyprus	-1
22	Bulgaria	22	Armenia	3
23	United Arab Emirates	23	Cuba	4
24	Ukraine	24	Croatia	4
25	Armenia	25	Mexico	-11
26	Chile	26	Chile	
27	Cuba	27	Uruguay	7
28	Croatia	28	United Arab Emirates	-5
29	Serbia	29	Serbia	
30	Macedonia	30	Mongolia	6
31	Ireland	31	Costa Rica	14
32	Greece	32	Ukraine	-8
33	Peru	33	Ghana	6
34	Uruguay	34	Seychelles	14
35	Turkey	35	Botswana	15

Examination of multi-culture issues in nuclear security analysis

Multi-culture issues in nuclear security analysis(VISA model)



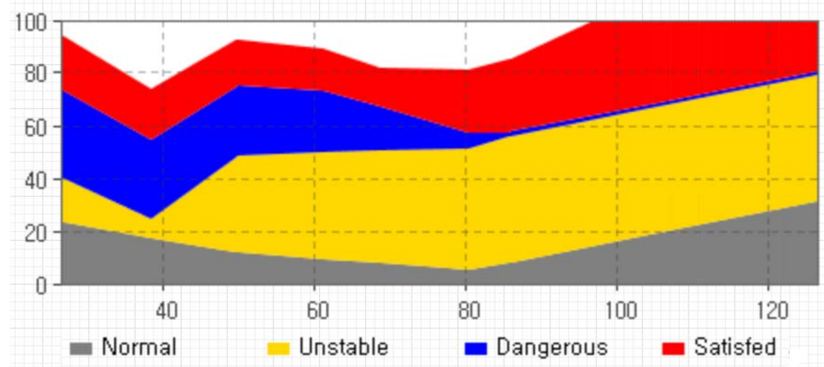
The probability of insider threats might increase by above 20% in the initial stage in multi-culture environment.

Fig.2. System dynamics modeling on potential workers' behavior

	The original Scenario	Modified Scenario1	Modified Scenario2
Insider threat affected by multi-culture	X	O (high authority insiders)	O (Response forces insiders)
Threat	High	Very High	Very High
Vulnerability (=1-prob.of system effectiveness)	High	Very High	Very High
Nuclear Security risk	High	Very High	Very High

Table I. Comparison on relative nuclear security risks

Fig.3. Results of state transition on multicultural workforce



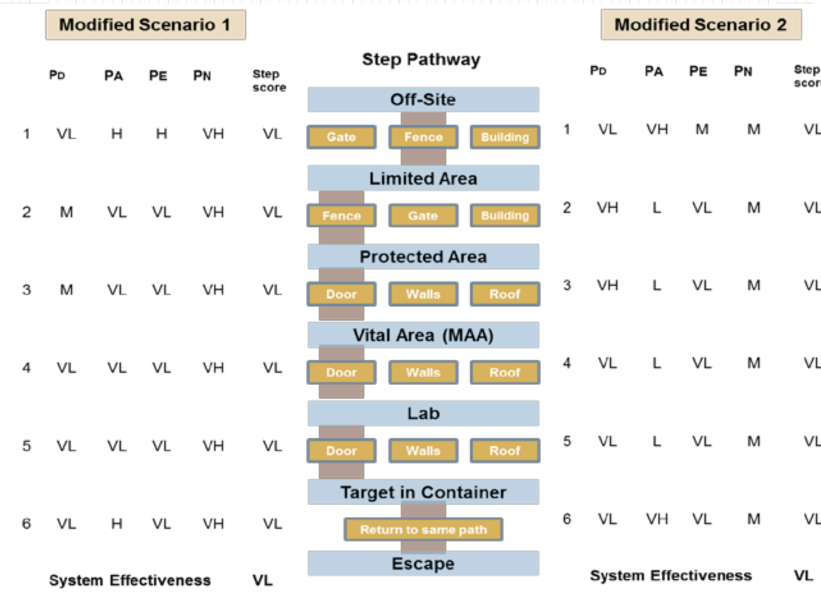


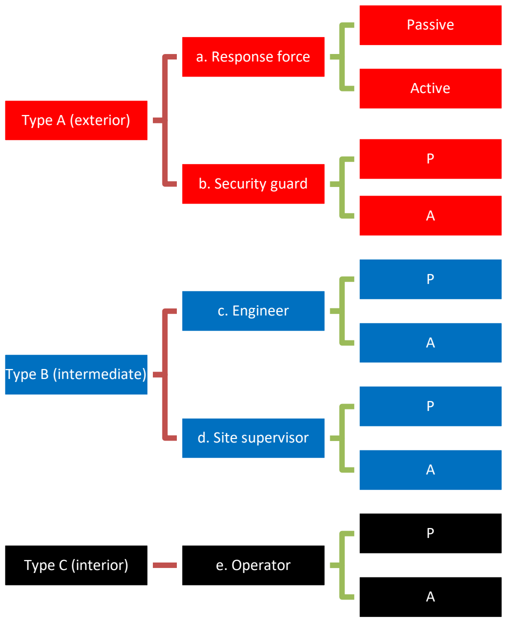
Fig.4. Evaluate the modified Scenarios using VISA methodology

$$R = P_A \times [1 - P_I] \times C$$

- Results show that multi-culture environment would increase both insider and outsider threats affecting system effectiveness.

Examination of an insider threat in nuclear security analysis

Insider threat in nuclear security analysis



Basic event	Specific situation		Influence	Note
	Intention	Capability		
Aap	0.1	0.5	0.05	Response force (Military force, armed workers)
Aaa	0.9	0.5	0.45	
Abp	0.1	0.7	0.07	Security guards who work in the security B/D
Aba	0.9	0.7	0.63	
Bcp	0.1	0.3	0.03	Engineers, researchers, unarmed workers
Bca	0.9	0.3	0.27	
Bdp	0.1	0.5	0.05	Site supervisors, site engineers
Bda	0.9	0.5	0.45	
Cep	0.1	0.9	0.09	Executive operating and control manager, high-security authorized workers
Cea	0.9	0.9	0.81	

- Combination of non-detection probability and influence of insider
  - $P_{ND} - P_D$
  - $P'_{ND} = 1 - \{(1 - P_{ND}) \times (1 - P_I)\}$
  - $\{P'_{ND}\} = \{(Aap + Aaa + Abp + Aba) \times (P_{ND,12} + P_{ND,13} + P_{ND,14})\} + \{(Bcp +$

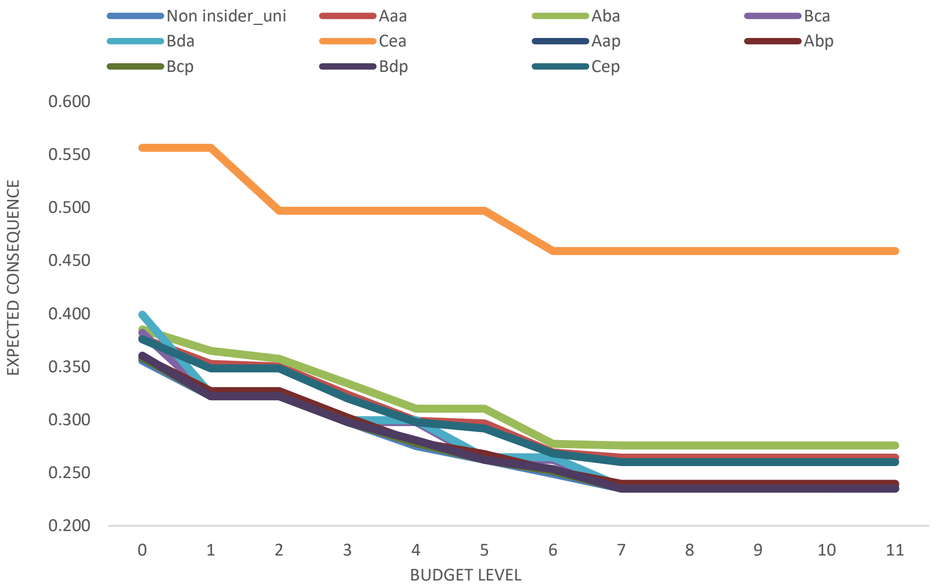


Fig 1. Comparison of expected consequence value along the budget level among non-insider type, active insider types and passive insider types

- Insider type Cea has the highest expected consequence values.
- The implications of passive insiders except type Cep are extremely low.
- Generally, the implications of an active insider are high although those of type B is relatively low.
- But results of insider type Cep is higher than those of active insider type B

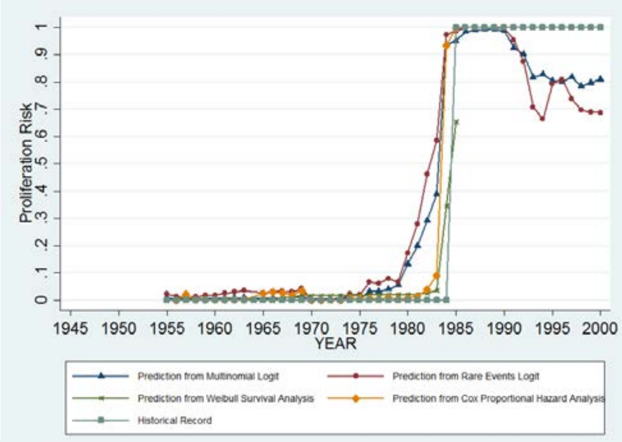
Modeling Nuclear Proliferation Risk

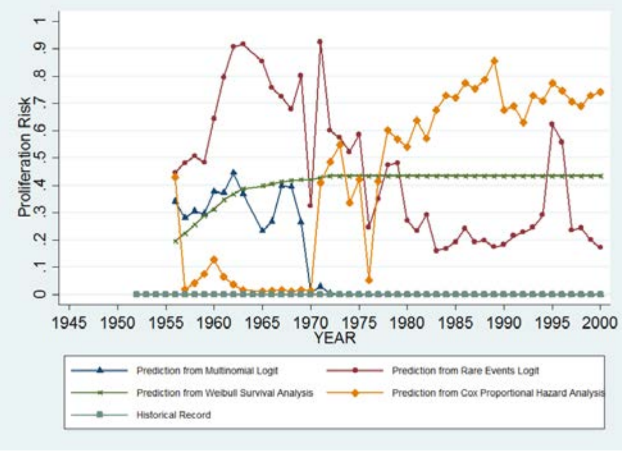
Dependent variable: Proliferation history

Level	Name	Description
0	No interest	No proliferation attempts
1	Exploration	Country considered nuclear weapons and conducted some exploratory work
2	Pursuit	Country started a nuclear weapons development program
3	Acquisition	First explosion/assembly of nuclear weapon

Regression

Event History





Independent variable: proliferation determinants

Category	Description
Capability	Economic, technological, material
Domestic Politics	Regime type, leader's characteristics, veto players, domestic unrest
International Security	Rivaly, alliance, cooperation, domestic isolation, power of nation
International Norms	Agreements, Treaty

Uncertainties of the result (False alarms)

1. History Datasets/Codings
2. Regression vs. Event History Analysis
3. Country/Time Coverage

Robustness test for existing studies

Bleek(2014) – international security

Fuhrmann(2015) – domestic politics

Significance change

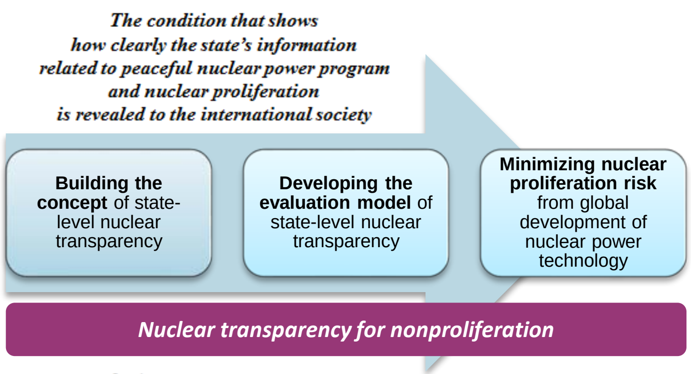
Effect change (positive -> negative)

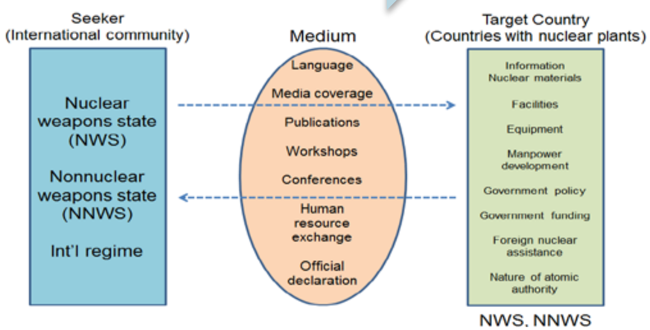
Proliferation Level	Exploration	Pursuit	Acquisition
Irregular entry	+ / -	- / -	- / -
Conventional threat	+ / +**	+** / +***	+** / +
Major power	+ / +**	+* / +***	+** / +**
Sensitive nuclear assistance	+*** / +	+ / +**	+ / +

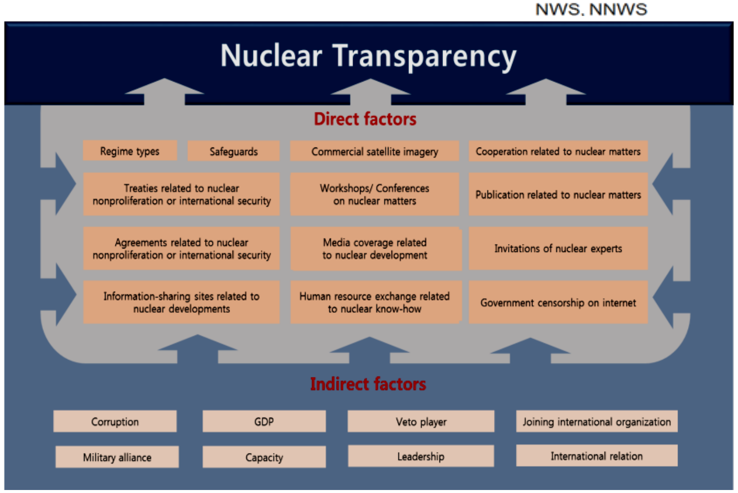
Examining Relationship between Nuclear Transparency and Nonproliferation

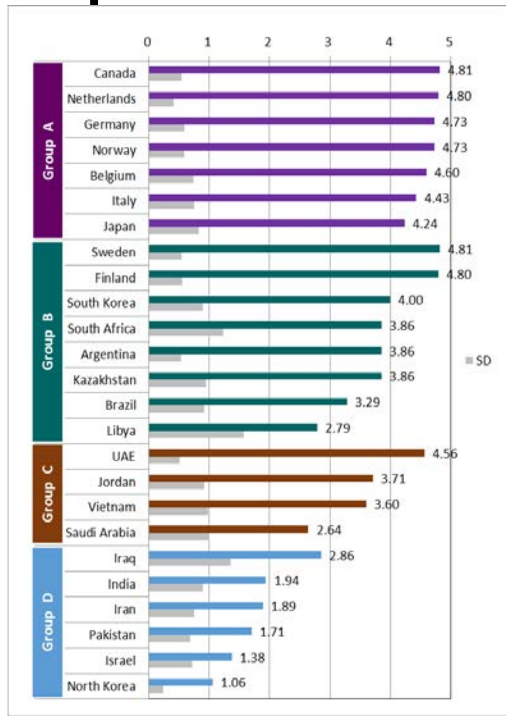
Identifying Nuclear Transparency

"State-level Nuclear Transparency"









	Crucial factors for the high score	Crucial factors for the low score
Group A	• Allowing visits to former fissile material production plants	• Determination to keep fissile material stockpiles
Group B	• Removal of nuclear weapons-related equipment	• The record of unreported experiments • Willingness to enrichment and reprocessing activities • No functioning government
Group C	• Abandonment of enrichment and reprocessing (Gold standard)	• Willingness to enrichment and reprocessing activities
Group D	• Implementing IAEA Additional Protocol • Removal of nuclear weapons-related equipment	• Not NPT party • Existence of its nuclear weapons program

How would transparency of nuclear power development in a country be related to nuclear nonproliferation commitment of the state?

- The global community demands transparency in relation to nonproliferation norms.
- Serve as a confidence building measure for nuclear nonproliferation
- States should enhance nuclear transparency in order to gain international recognition of the country's nonproliferation commitment.

How can state-level nuclear transparency be evaluated?

- Nuclear transparency is subjective concept rather than objective concept.
- Index or evaluation model of state-level nuclear transparency will provide more objective point of view and will suggest the part which should be corrected in order to build confidence.
- According to the expert survey, most of reasons to score nuclear transparency for each states was about nuclear nonproliferation.
- Commonly, voluntary activities(e.g., removal of nuclear weapon-related equipment) and function of government have the greatest impact on evaluating state-level nuclear transparency.

Thank You!

Prof. Man-Sung Yim

Nuclear and Quantum Engineering Department

KAIST, Daejeon, ROK

Email: msyim@kaist.ac.kr

Home page: http://nerec.kaist.ac.kr/