

## ***Nuclear Safety and Knowledge Management after the Fukushima Accident***

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- 1. Current Status of Nuclear Power Plants and Nuclear Safety Regulation in Japan**
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- 3. Future Direction of Research for Safety and Resilient Society**

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## Current Status of Strategic Energy Plan in Japan

- 4<sup>th</sup> Strategic Energy Plan has been determined by the Government on April 11, 2014 to provide basic lines of energy policy with a view to an energy supply-demand structure for the mid to long term for these 20 years.
  - ✓ “Nuclear power is an important baseload electricity source.”
  
- Long Term Plan on April 27, 2015
  - ✓ Contribution of nuclear power in 2030 : 20-22% of total electricity source

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## Situations Surrounding the Use of Nuclear Power in Japan

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2025	2030	2050	
Japan	Related to the Accident at Fukushima Daiichi Nuclear Power Station	▲ Accident at Fukushima Daiichi Nuclear Power Station (March 11, 2011)										Fuel Debris Removal			
												Completion of the Decommissioning			
	Response to the New Regulation Standards	▲ Enforcement of New Regulatory Standards (July 8, 2013)		▲ Restart		Safety Improvement Evaluation									
	Voluntary Efforts to Improve Safety	▲ Establishment of Japan Nuclear Safety Institute (JANSI) (Nov. 5, 2012)										▲ Proposals for Voluntary and Continuous Improvement of Nuclear Safety (May 30, 2014)			
		▲ Establishment of a Proper Risk Governance Framework										▲ Establishment of Nuclear Risk Research Center (NRRC) (Oct. 1, 2014)			
	Decommissioning											Decommissioning			
	Nuclear Fuel Cycle	Interim Storage Facility	Completion of the Mutsu Interim Storage Facility												
	Reprocessing	Completion of the Rokkasho Reprocessing Plant													
	MOX Fuel Processing	Completion of the Rokkasho MOX Fuel Processing Plant													
	Fast Reactors											Practical Application of Fast Reactors			
	Electric Market Reform	Establishment of the Organization for Cross Regional Coordination of Transmission Operators										Full Retail Competition			
												Legal Unbundling of Transmission and Distribution Sectors			
	Strategic Energy Plan	▲ 4 <sup>th</sup> Strategic Energy Plan (April 11, 2014)										Basic line of Energy policy with a view to an energy supply-demand Structure for the Mid to Longterm (20 years)			
Overseas	Nuclear Power	Total capacity of nuclear Power in the world :to grow by about 10 to 90% by 2030 about 10 to 190% by 2030 (IAEA) and by about 60% by 2040 (IEA)										Practical application of fast reactors			
	Related to Climate Change	2nd commitment period of the Kyoto Protocol										Greenhouse gas reduction Whole world: half Developed countries: >80%			
		Submitting Intended Nationally Determined Contribution before COP 21 (end of 2015)													

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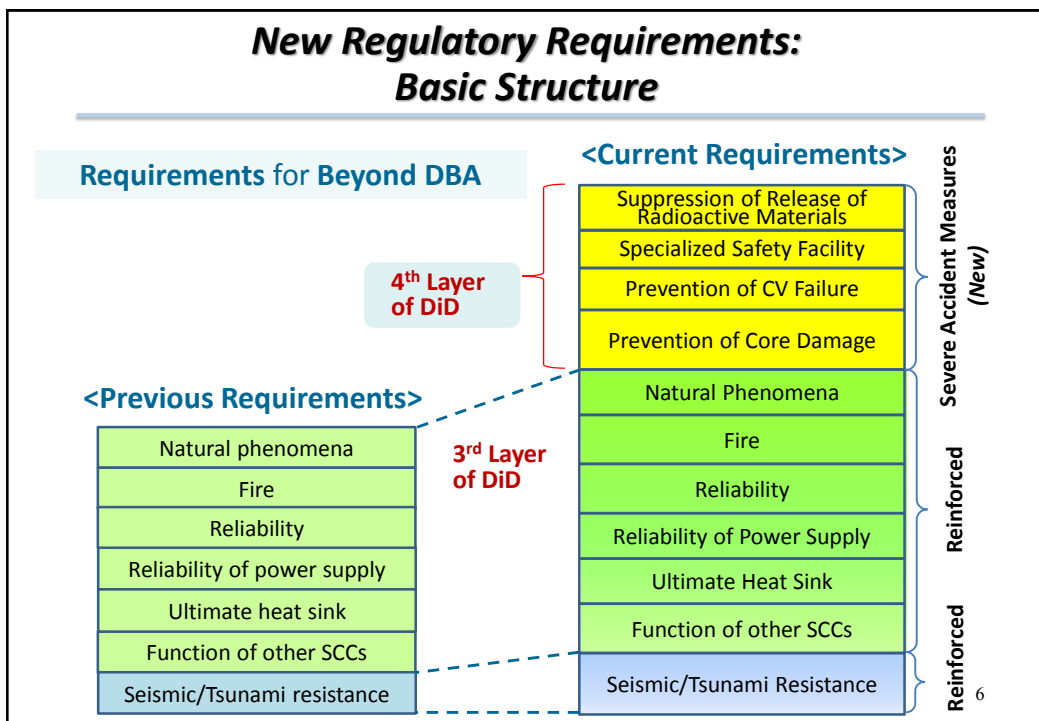
## ***New Nuclear Regulation Systems in Japan***

***Became Effective from July 8, 2013***

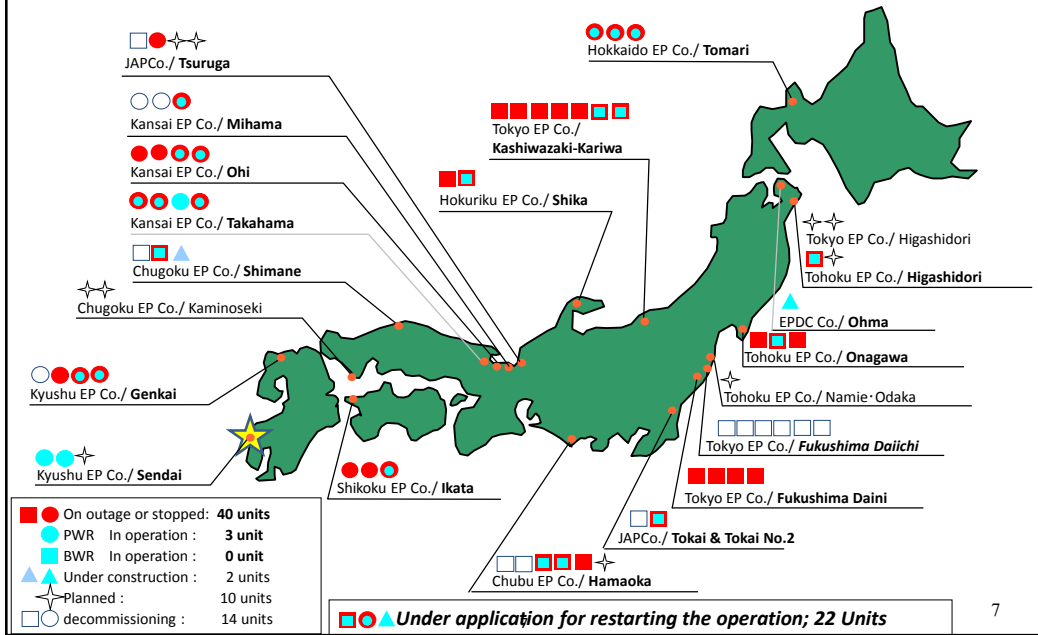
The NRA (Nuclear Regulatory Authority) implement new regulatory systems stipulated in the amended Nuclear Regulation Act ;

- **Regulation taking severe accidents into consideration**
  - Legally request severe accident measures to the licensees
- **Introduction of back-fitting system : Regulation applying latest scientific/technical knowledge on safety issues to existing facilities**
  - Apply new technical requirements to existing licensed nuclear facilities as a legal obligation
- **An operation limit of 40 years to deal with aged reactors**
  - As an exception, **extension (<20 years) will be approved**, only when compliance with the regulatory standards by the Government Order is confirmed.
- **Special safety regulation in Fukushima Daiichi**

## ***New Regulatory Requirements: Basic Structure***

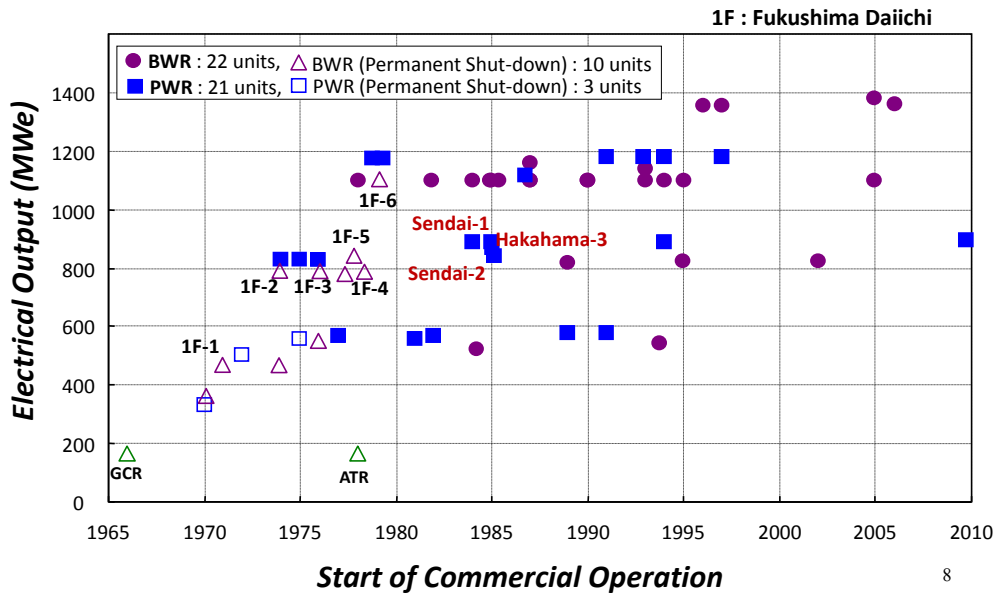


## Nuclear Power Plants in Japan as of February, 2016



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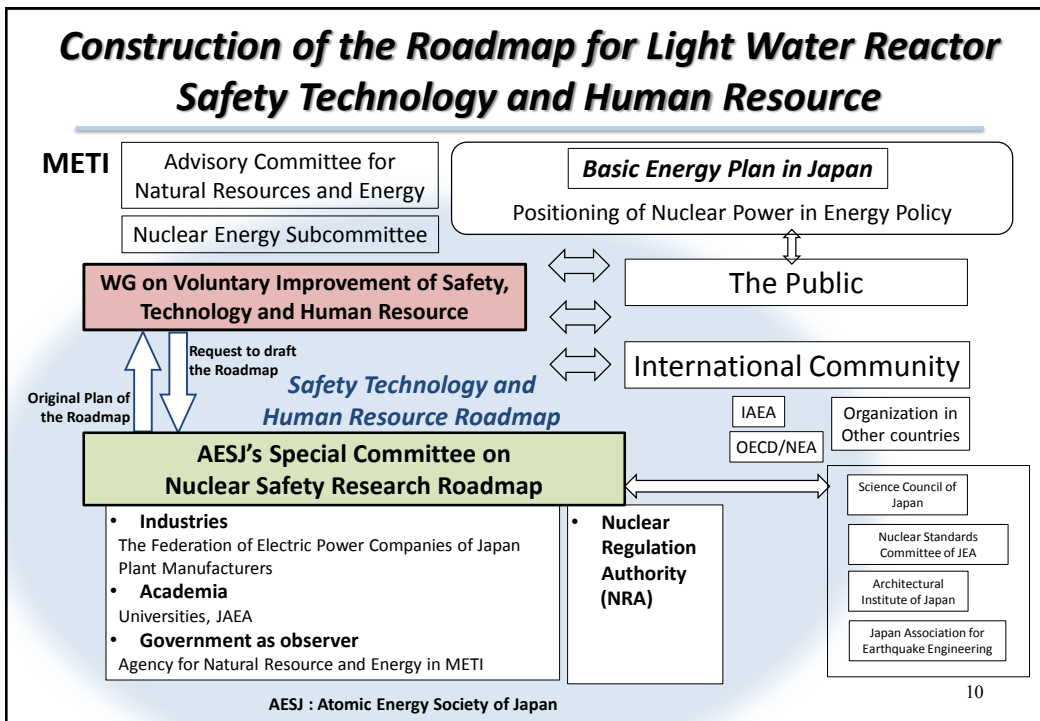
## Nuclear Power Plants in Japan



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## ***Proposals for Voluntary and Continuous Improvement of Nuclear Safety (May 30, 2014)***

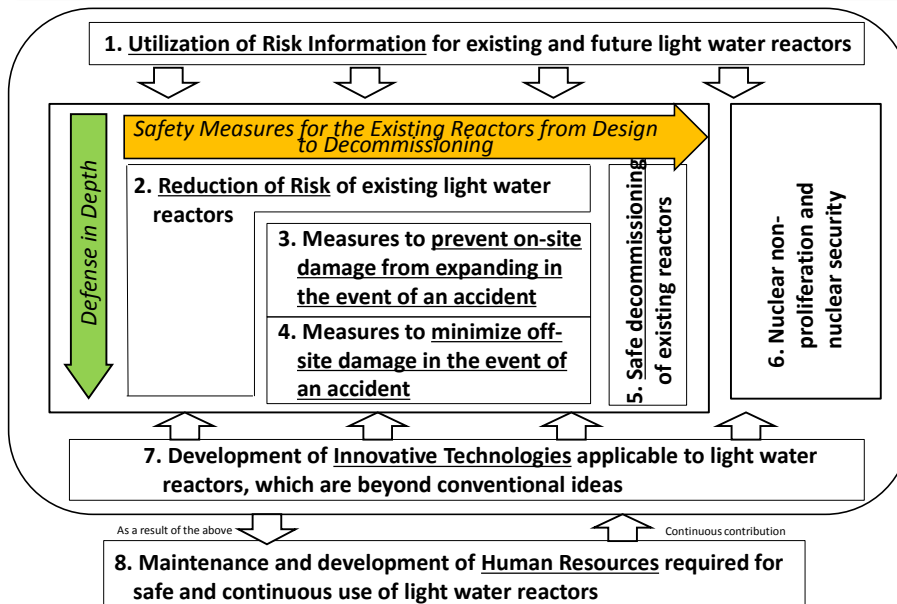
Report by the WG on Voluntary Efforts and Continuous Improvement of Nuclear Safety,  
Nuclear Energy Subcommittee, the Advisory Committee for Natural Resources and Energy in METI

Recommendations on Desirable Efforts for the Future Activities and R&D

- ✓ **Implementation of Risk Management under an Appropriate Risk Governance Framework**
- ✓ **Activities required to be implemented with Lessons Learned from the Accident at TEPCO's Fukushima Daiichi NPS**
  - Implementation of exhaustive and comprehensive risk assessments including low-frequency events
  - Reduction of residual risk through strengthening "defense in depth"
  - Identifying the accident sequences and cliff edges at each plant, focusing on external events, and improving resilience
  - Reorganization of research for improving the safety of light water reactors and reinforcement of research coordination

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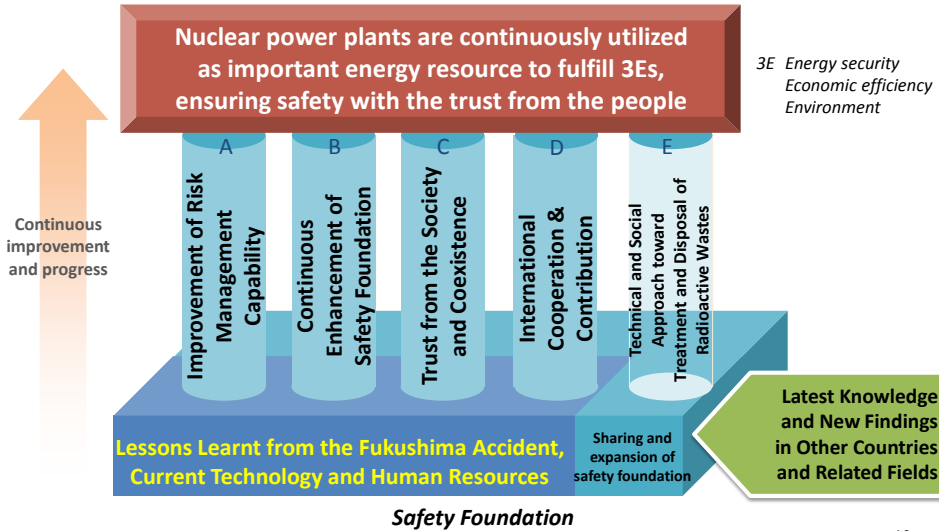
### ***Eight Categories of Challenges for Improvement of Safety, Technology & Human Resource***



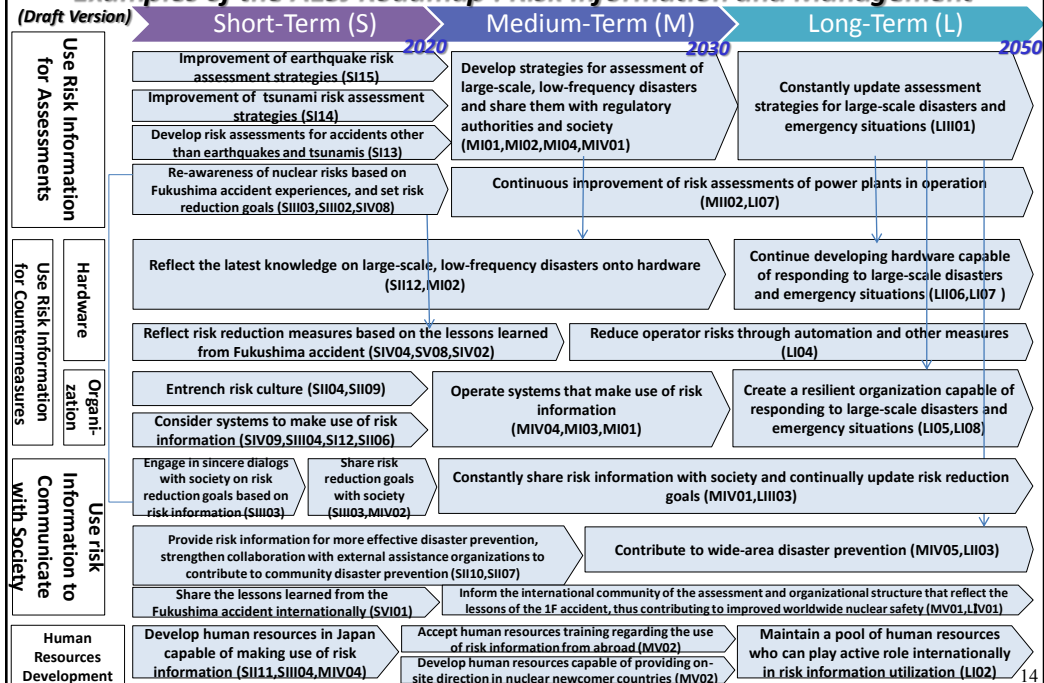
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# Objective and Pillars in the Roadmap for Light Water Reactor Safety Technology and Human Resource

Long-term Objectives of the Roadmap



## Examples of the AESJ Roadmap : Risk Information and Management



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*Report on the Fukushima Accident, March 2013*  
*The Nuclear Safety Division of the Atomic Energy Society of Japan*

***Report of Seminars to Investigate the Accident  
at the Fukushima Dai-ichi Nuclear Power Station  
– What were wrong? What should be done from now on?***

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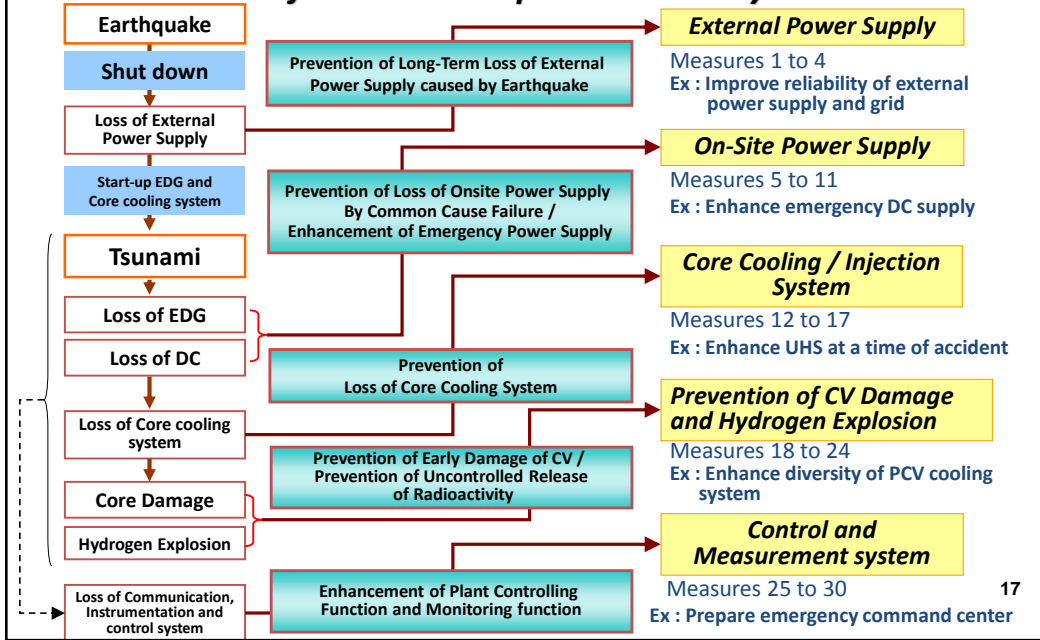
### ***“Defense-in-Depth” Protection against External Events***

- Tsunami height for design base was underestimated.
- Site level was not high enough to prevent inundation of tsunami as the 1<sup>st</sup> layer of Defense-in-Depth.
- Common cause failure by the Tsunami;
  - Equipments as 3<sup>rd</sup> and 4<sup>th</sup> layers of Defense-in-Depth lost their functions by the Tsunami.

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## 30 Measures that Should Be Addressed to Regulation Identified in NISA Report in February 2012



## Importance of Design and Management and Communication between Stakeholders

### ✓ Safety Provisions and Defense-in-Depth

	Level 1	<b>Normal Operation</b>	Conservative design and high quality in construction and operation
	Level 2	<b>Operational Occurrences</b>	Control, limiting and protection systems and other surveillance features
	Level 3	<b>Design Base Accidents</b>	Engineered safety features and accident procedures
	Level 4	<b>Beyond Design Base Accidents</b>	Complementary measures and onsite accident management
	Level 5	<b>Significant off site release of radioactivity</b>	Off-site emergency response and accident management

### ✓ Communication for Safety Improvement

Experts for Nuclear and Non-Nuclear Fields  
Stakeholders (Regulatory Bodies, Utilities, Plant Fabricators & Fuel Fabricators, Research Institutes, Academia, Media, Local Government, Public, ....)

## Summary of Root Causes of Fukushima Accidents: Insights from Beyond Design Basis Considerations

### Inadequate Consideration of Beyond Design Basis Accidents (BDBA)

Inadequate Assurance of Core Cooling Capability for BDBA Scenarios in the Design

Inadequate Consideration of BDBA in Accident Management

Failure to ensure core cooling in BDBA conditions

Failure of plant indication in MCRs and ERCs

BDBA documented guidance inadequate

Insufficient classroom training, drills and exercises

MCR : Main Control Room  
ERC : Emergency Response Center

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## Resilience of Complex Systems

Relationship between Components of Resilience and Resilience-enhancing Measures

Anticipate	Resist	Absorb	Respond	Adapt	Recover
<b>Preparedness</b>	<b>Mitigation</b>		<b>Response</b>		<b>Recovery</b>
Activities taken by an entity to define the hazard environment to which it is subject	Activities taken prior to an event to reduce the severity or consequences of a hazard		Immediate and ongoing activities, tasks, programs, and systems that have been undertaken or developed to manage the adverse effects of an event		Activities and programs designed to effectively and efficiently return conditions to a level that is acceptable to the entity

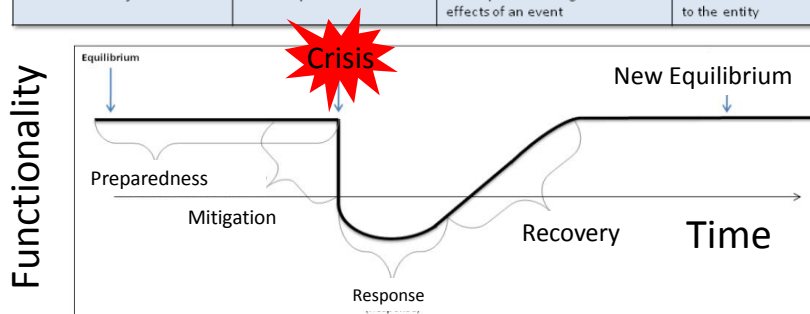
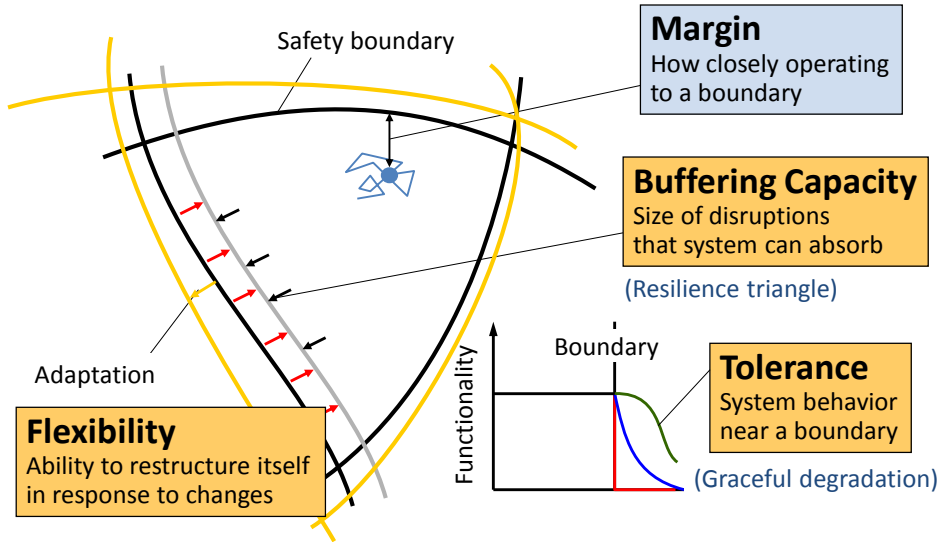


Figure 1: Components of Resilience and the Timing of an Adverse Event

ANL/DIS-12-1 Resilience: Theory and Applications (Jan. 2012)

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## Safety Margin and Relevant Essential Characteristics of Resilience



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## Resilience and Safety

Erik Hollnagel, "Safety-I and Safety-II" p. 148 (2014, ASHGATE Publishing)



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## ***Summary : Future Direction of Research***

- **Resilience of Complex Systems**
- **Resilience of Energy Portfolio**
  - Flexibility of Adjusting (increase or decrease) Share of Nuclear Power, depending on situations/needs
- **Resilience of Society**
  - Public Participatory System for Decision Making
  - Sharing the common directions with Complicated stakeholders

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***Thank you very much for your attention***

