Fukushima Daiichi (1F)
My Thought on Risk on D&D and Safety

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Risk at 1F

- "Do you think how many different risks at 1F?

https://www.tepco.co.jp/decommission/progress/

Risk to be considered for 1F

- Because of varieties of risks to be considered for D&D, comprehensive decision-making is needed by reflecting associated risks below

  "Risk Informed Decision-Making"

  - 1) Nuclear safety
  - 2) Working Safety irrelevant to radioactivity
  - 3) Increment cost increase needed for D&D
  - 4) Prolonged work period due to D&D
  - 5) Increased amount of waste due to D&D
  - 6) Additional needs to sustain human resources
  - 7) Societal risk like social reputation
  - 8) Others

- **Which is most critical?**

Power Plant vs. 1F D&D

	Power Generation（General）	1F F&D (Unique, Custom-make)
Objectives	Long term safe and stable generation)	Early risk decrease exposed by accident
Features	No large changes at facilities	Continuous changes
Characterization of facilities	Assuredness based on design (mostly design based)	Large uncertainties（site and facilities dependent)
	High energy：rapid accident propagation	Low energy : slow accident propagation
	Integral buildings, structures	Damaged building, structures
	Solid containment (passive boundary)	Incomplete containment (active boundary)
Risk profile	Accident=low frequent but high impact	Normal operation / Assumed events = Frequency occurrence and low impact
Safety management	Plan on design and system	Safety secured by design and operation jointly
Regulation / Code and standard	Reactor Law：comprehensive rule and standard	Specialized Nuclear Facility : rules adjustable
Features of work	Study in advance anticipating all the events	Trial and error, flexible

Y3

Y0

Y1

Y2

Y4

What is the major difference in terms of D&D?

Y0 accident progression
Yamamoto, 2021-10-10T21:55:07.251

Y1 accident progression
Yamamoto, 2021-10-10T21:55:16.787

Y2 confinement
Yamamoto, 2021-10-10T21:55:25.679

Y3) を削除
Yamamoto, 2021-10-10T21:55:42.587

Y4 adaptive rules
Yamamoto, 2021-10-10T21:56:34.200

Management of Projects with large Uncertainties

- PDCA Cycle
  - PDCA：Plan, Do, Check, Action
  - No Go-head without “Plan”?
- DLTG Cycle
  - DLTG：Do, Look, Think, Grow
- Lead & Learn
  - Lead: to go with or in front of a person or an animal to show the way or to make them go in the right direction (Oxford Learner’s Dictionary)

Safety Philosophy under large Uncertainties: Defense in Depth (DiD)

- DiD:

Varieties of protective Measures combined as Preparedness for Uncertainties aiming at the increased trust on whole Protection Measures Y0

  - Combined Prevention of Occurrence, Detection, Mitigation
  - Prepare different angles of protective Measures Y1

スライド 6

Y0 reliability
Yamamoto, 2021-10-10T21:57:01.841

Y1 protections with different natures
Yamamoto, 2021-10-10T21:57:46.126

DiD Example: Car

- Prevention of abnormal Occurrences
  - Ex. No ignition without setting shift lever to “P”
- Mitigation of abnormal Event, Prevention of Progress to Accidents
  - Ex. Brake support (Enhanced automatic brake at hard stoppage)
  - Antiskid brake
- Prevention of Human Damage
  - Seat belt
  - Air bag
- Mitigation of Human Damage
  - Emergency Ambulance

Why DiD needed?

- No needs at "the World without Uncertainties"
  - No needs if all of Accident Sequence known
- DiD should be prepared for Uncertainties
  - What are required for that?
- Single preventive Measure cannot be "Silver Bullet"
  - Single, all mighty measure (either preventive or mitigation) has definite weak point. Trust as a whole to be improved by combining varieties of protective Measures

*) a bullet cast from silver is often one of the few weapons that are effective against a werewolf or witch. The term *silver bullet* is also a metaphor for a simple, seemingly magical, solution to a difficult problem: for example, penicillin circa 1930 was a "silver bullet" that allowed doctors to treat and successfully cure many bacterial infections.
:(Wikipedia)

DiD on Power Plant

	Defense level	Objectives	Measures applied	Plant conditions
Original Design	Level 1	Prevention of abnormal operation and failures	High quality of conservative design and construction/operation	Normal operation
	Level 2	Control of abnormal operation and detection of failures	Surveillance characteristics of control, limitation, protection and other systems	Anticipated Operational Occurrence （AOO）
	Level 3	Control of the accident under design basis	Engineered safety system and accident procedures	Design basis accident (single failure mode)
Beyond Design Basis	Level 4	Control of the plant under severe conditions to prevent accident propagation and mitigation of SA impact conditions	Accident management including aux. Measures and protection of containment	Multiple failure accident（Severe Accident） [Design enlarged conditions] Y0
Emergency	Level 5	Mitigation of the radiation impact due to large scale release of radioactive materials	Off-site emergency preparedness	

How DiD at 1F could be in place?

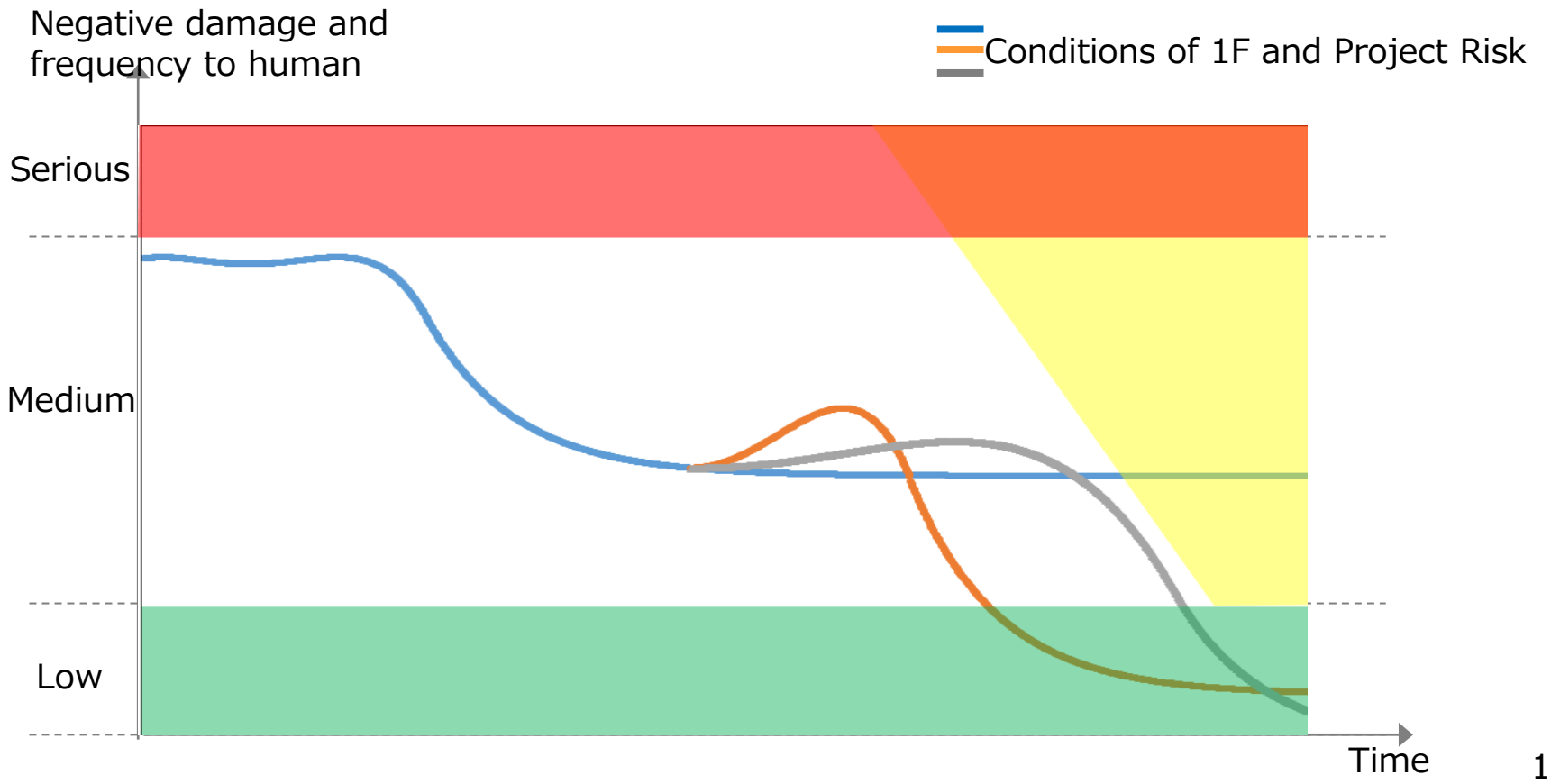
Refer AESJ-SC-TR005 (ANX):2013 ON Fundamental Philosophy of Nuclear Safety, Vol.1 App. Philosophy of Defense in Depth

Y0 extended

Yamamoto, 2021-10-10T21:59:58.525

Risk Management at D&D Work

- Transition of nuclear safety risk, worker's exposure risk, occupational damage risk, environmental damage risk



Risk Management at D&D

- Short-term and long-term Risk
  - Short-term Risk; Risk at certain unit of time

    Long-term Risk; Integrated risk at certain time duration
  - Possible increase of short-term risk at site work of 1F due to time constraint
  - Allowable increase of short-term risk could be considered by using the optimization concept used for radiation protection in contrast to long-term risk decrease

Risk Management at D&D

	Long-term · Increase	Long-term · No change	Long-term · Decrease
Short term · Increase	Not allowed	Not allowed	Large long-term risk decrease justifiable, when assessing short-tem risk increase carefully, in consideration of the long-term risk decrease. Measures to decrease short-term risk as much as possible is needed
Short-term · No change	Not allowed	No effect and not recommendable in terms of cost vs. benefit	Recommendable
Short-term · Decrease	Likely when avoiding imminent risk. Low possibility for D&D work but justifiable only avoidance of imminent risk. Risk decrease measures requested afterwards.	Recommendable	Recommendable

10 Years Look Back

	Time	Event
Time of Emergency（2011～2013）		
	2011.3.11	1F Accident occurred（Nuclear Emergency Response Headquarters）
	2011.12.16	Step 2 "Reactor Cold Shutdown" achieved addressed to termination of the accident / Mid-and-Long Term (M&L) Roadmap (ver.1) (12.21)
	2012.11.7	1F site categorized as Specialized Nuclear Facility（9.19 @NRA）
	2013	Messed with varieties of troubles（station blackout caused by rat, leakage from underground storage tank, leakage from contaminated water tank etc.）
	2013.11.18	Start of spent fuel (SF) removal at unit 4（End of M&L Road Map）
Time of risk assessment and M&L plan（2014～		
	2014.4.1	TEPCO' s D&D Company / NDF's decommissioning facilitation operation（2014.8.18）
	2015.5.27	High density contaminated water treatment / Seaside impermeable wall completed (10.26)) / Frozen soil wall completed (2018.3.7)
	2017.9.26	Fuel debris retrieval policy determined (M&L Road Map ver.4) / First unit of fuel debris retrieval and associated method (2019.12.27)
Time for establishing Quality Management System (2019～		
	2019.4.15	Start of SF removal at unit 3（Quality issue focused）
Time for full-scale Project Management (2020～		
	2020.4.1	Restructuring of TEPCO D&D company (Project Management Organization･D&D Safety Quality Office)

スライド 13

Y0 loss of power
Yamamoto, 2021-10-10T22:03:40.094

Y1 Highly
Yamamoto, 2021-10-10T22:04:55.906

Change Management

- Temporary→Enhanced Reliability→Permanent
- Not optimized→Locally→Partially→Overall optimization
- "Safety Culture" for D&D?
  - IAEA GSR Part 2:" Leadership and management for safety is essential for the fostering and sustaining strong safety culture"
  - IAEA INSAG-4: "Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance"

Who do you think takes the leadership to implement D&D in safe and rational manner?

Change Management

- Learning from Jane Jacobs' "Systems of Survival: A Dialogue on the Moral Foundations of Commerce and Politics"
- Moral foundations of Politics（ex. Aiming at Royalty, sustainability of order in the organization)
  - Avoid trade / Be brave / Compliance / Risk of rank / Be royal / Revenge / Betray for the purposes / Make full use of leisure / Show off / Be a generous giver / Be exclusive / Be resolute / Accept destiny / Respect honor
- Moral foundation of Commerce（ex. Aiming at Sincerity, cooperative relationship with others)
  - Exclude violence / Agree voluntarily / Be honest / Easy cooperation with others or foreigners / Sense of Invention / Open to novelty / High efficiency / Improved comfort and convenience / Disagree depending on the purposes / Invest for production / Be diligent / Save money / Be optimistic
- To distinguish two Moral Foundations and select intentionally
- Never confuse, Risky mixture!
- D&D work necessitates both moral foundation for commerce and politics

1F D&D, Tomorrow

- Work with high difficulty like fuel debris retrieval to come from now
- Needless to say off-site work is important, while to secure and sustain safety at on site would be further important
- More important with overall optimization
- Change mind : To pursue both moral foundation of politics and commerce at one time together