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US Efforts to Support Examinations at Fukushima Dai-ichi

Damian Peko
Department of Energy-Office of Nuclear Energy

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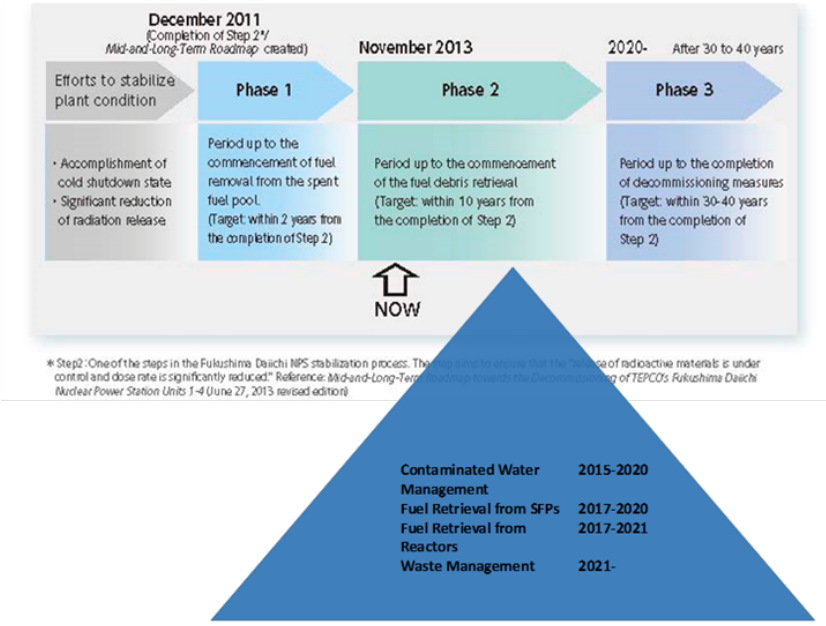
Forensics Efforts Offer US Perspective to Fukushima Daiichi Examination Activities

Objectives:

- Develop consensus US input for *high priority time-sequenced examination tasks and supporting research* that can be completed with *minimal disruption of TEPCO D&D activities*.
- Evaluate obtained information to:
  - Gain a better understanding of events that occurred in each unit at Daiichi
  - Gain insights to reduce uncertainties in predicting phenomena and equipment performance during severe accidents
  - Provide insights beneficial to TEPCO Phase 2 Fuel Debris Retrieval Evaluations
  - Confirm/improve guidance for severe accident prevention, mitigation, and emergency planning
  - Update/refine original information requests.
- Facilitate implementation of Japan-led international efforts (e.g., PreADES, ARC-F, etc.).



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Motivation:

- Provides Japan access to US expertise in plant operations, severe accident modeling & testing, and defueling & cleanup.
- Provides US access to full-scale, prototypic data from multiple units with distinct accident signatures.

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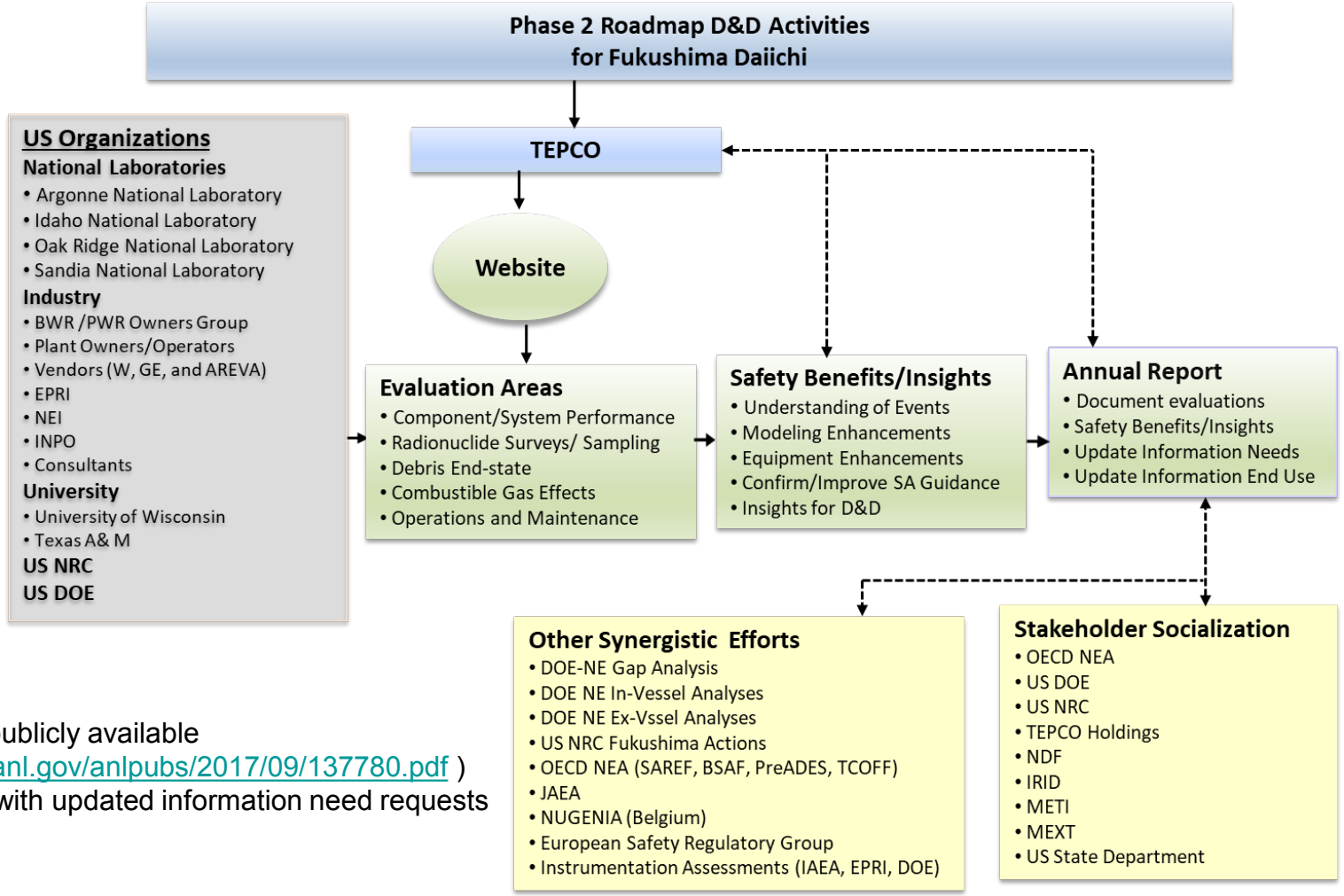
U.S. Efforts Coordinated with Phase 2 Roadmap D&D Activities and Other Programs



- FY2017 report publicly available (http://www.ipd.anl.gov/anlpubs/2017/09/137780.pdf)
- FY2018 report with updated information need requests (Sept. 2018)

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U.S. Efforts Coordinated with Phase II D&D Activities and Other Programs

Region	Examination Classification[1]			
	Visual	Near-Proximity	Destructive	Analytical
Reactor Building				
RCIC	****	***	**	
HPCI	****		***	
Building	****	***	**	*
Primary Containment Vessel				
MSL and SRVs	****		***	
DW Area	****	***	**	*
Suppression Chamber	****	***		
Pedestal / RPV-lower head	****		***	**
Instrumentation		****	***	
Reactor Pressure Vessel				
Upper Vessel Penetrations	****		***	**
Upper Internals	****	***	**	*
Core Regions & Shroud	****		***	**
Lower Plenum	****		***	**

[1]***Examination Classification Examples:***
Visual– Videos, Photographs, etc.
Near-Proximity– Radionuclide Surveys, Seismic Integrity Examinations, Bolt Tension Examinations, Instrumentation Recalibration
Destructive– System or Component Disassembly, Sampling, etc.
Analytical– Chemical Analysis, Metallurgical Analysis, Gamma Scanning, etc.

High Level Findings:

- Much examination information already exists to address some information needs.
- Maximum benefit from this information requires:
- Reviews by cognizant experts
- Posting for easy-to-use access
- Interactions with Japan
- Interactions with code assessments.
- Several important insights already obtained in areas selected for emphasis:
  - Component/system performance
  - Radionuclide surveys/sampling
  - Debris end-state location
  - Combustible gas effects
  - Operations & maintenance

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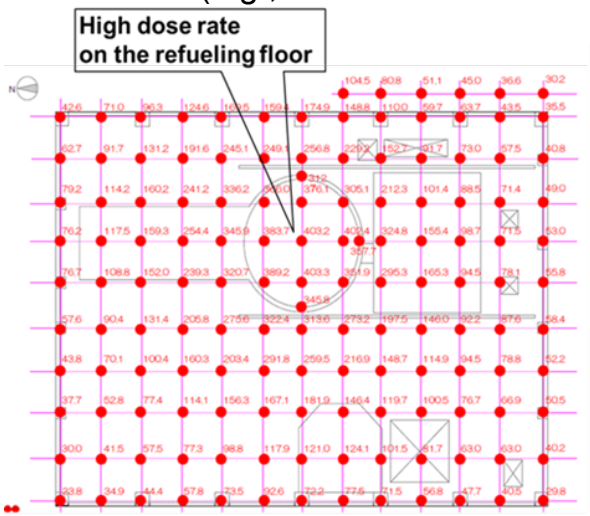
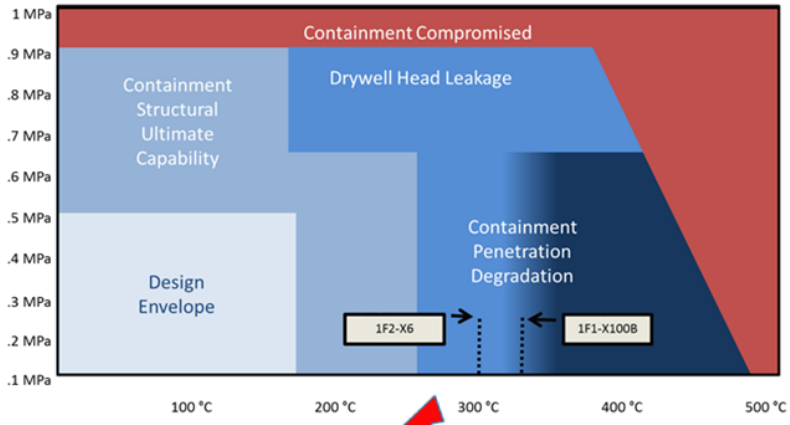
Forensics Already Yielding Important Insights and Recommendations

- **Area 1 - Component /System Degradation:**
  - Confirm revised BWR/PWR owners group guidance for containment venting and control of fission product releases (e.g., NEI 13-02).
  - Identify enhancements for systems codes (e.g., enhanced MAAP nodalization to consider PCV stratification, multiple leakage locations, etc.)
- **Area 2 - Radionuclide Sampling/Dose Surveys:**
  - Identify RPV and PCV leakage locations and timing (e.g., seals, drywell head, etc.).
  - Characterizing differences in 1F1, 1F2, and 1F3 accident progression (e.g., Cs-137/Cs-134 ratios in soil and spent fuel storage pool water samples)



Unit-3 Dose rate: mSv/h (5m above the floor) before decontamination works (Nov.16-17, 2013)

Unit-3 Picture taken on March 16, 2011



Graphics courtesy of TEPCO and NEI/Jensen Hughes

Examination information from each unit compared with recent industry guidance published in NEI 13-02.

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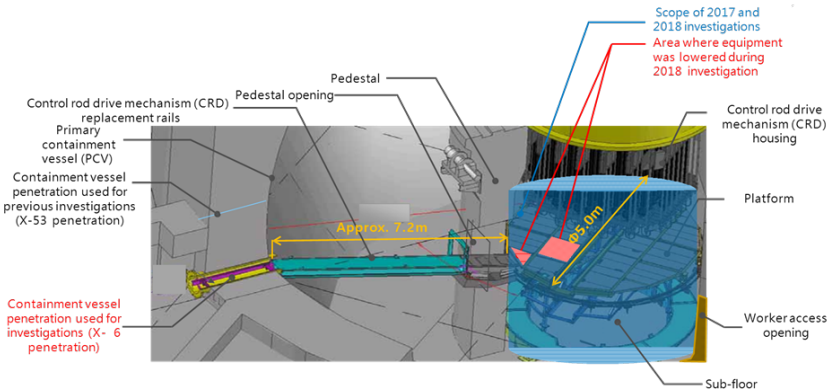
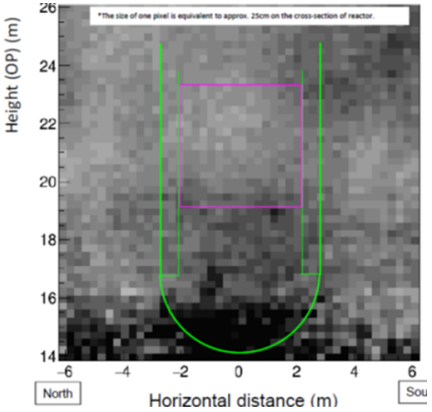
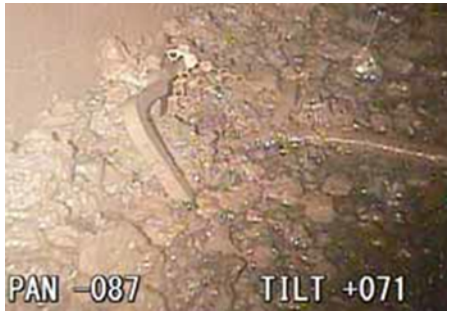
Forensics Already Yielding Important Insights and Recommendations (cont.)

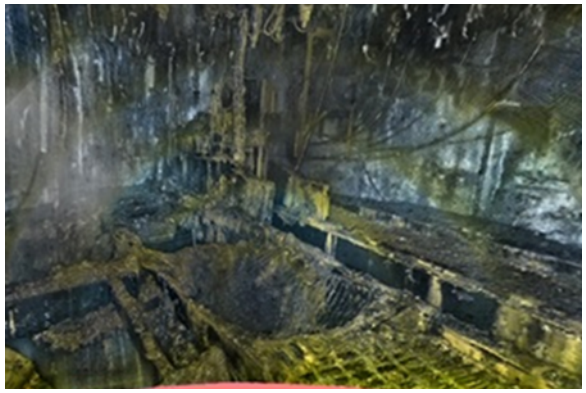
- **Area 3 - Debris Endstate:**
  - Estimate debris end-state location in 1F1, 1F2, and 1F3 using available information (photos, data, muon tomography, etc.) and analysis results.
  - Confirm revised BWR/PWR owners group guidance on water addition strategies
  - Provide insights regarding vessel failure and ex-vessel accident progression.

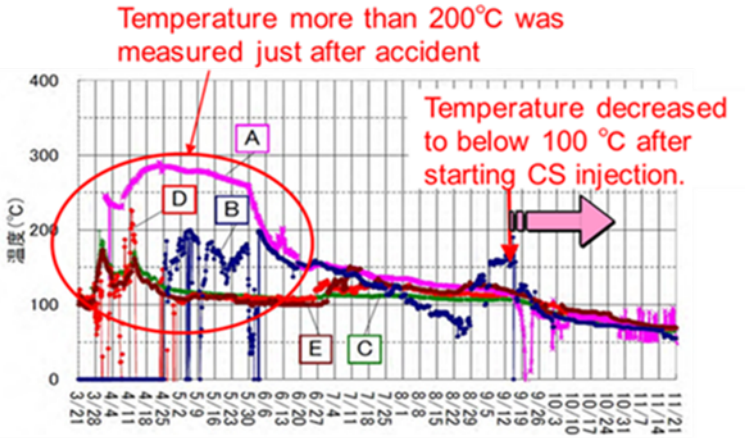


1F2 information provides consistent information regarding debris endstate and confirm US industry guidance for water addition.









Graphics courtesy of TEPCO

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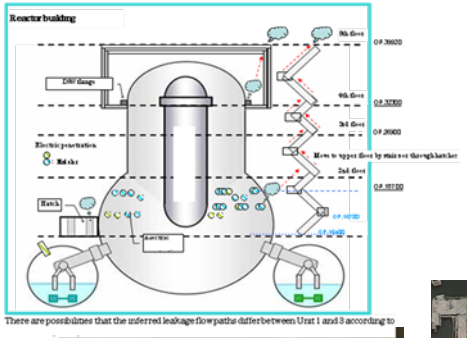
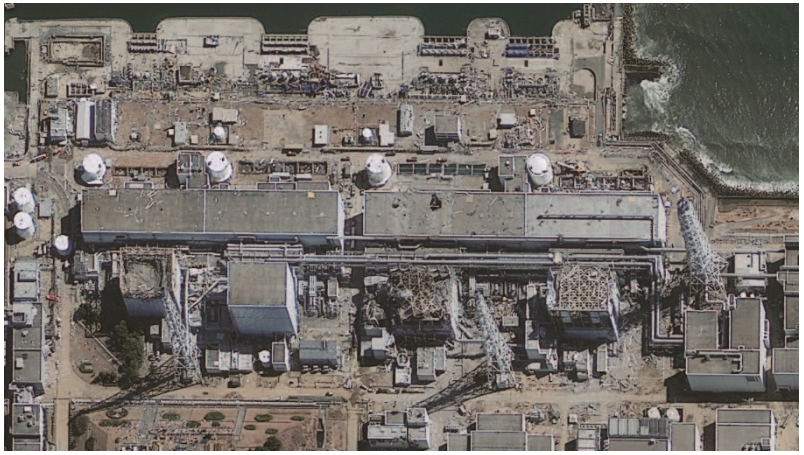
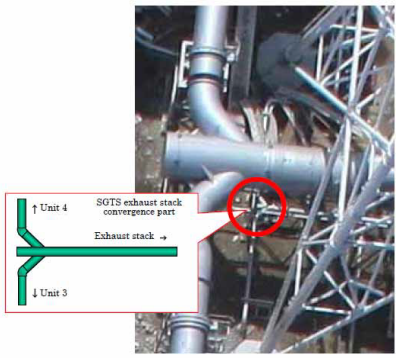
Forensics Already Yielding Important Insights and Recommendations (cont.)

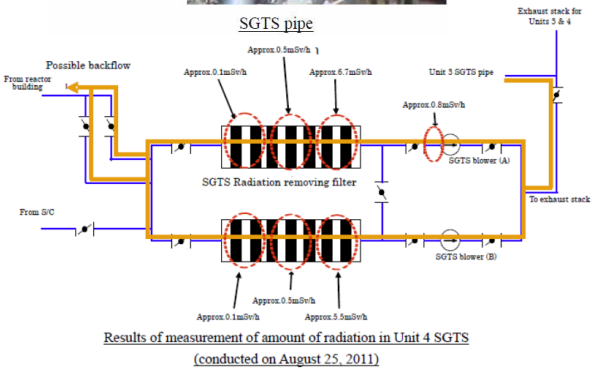
- **Area 4 - Combustible Gas Effects:**
  - No 1F2 ignition (e.g., early venting).
  - 1F1, 1F3, and 1F4 ignition locations and sources (e.g., multiple leak locations, multi-unit effects).
  - Confirm revised BWR/PWR owners group severe accident guidance for backup power, water addition, and/or early venting.
  - Provide insights for MAAP/MELCOR modeling enhancements.



Combustible gas information confirms updated industry guidance for and identifies MAAP/MELCOR modeling enhancements.







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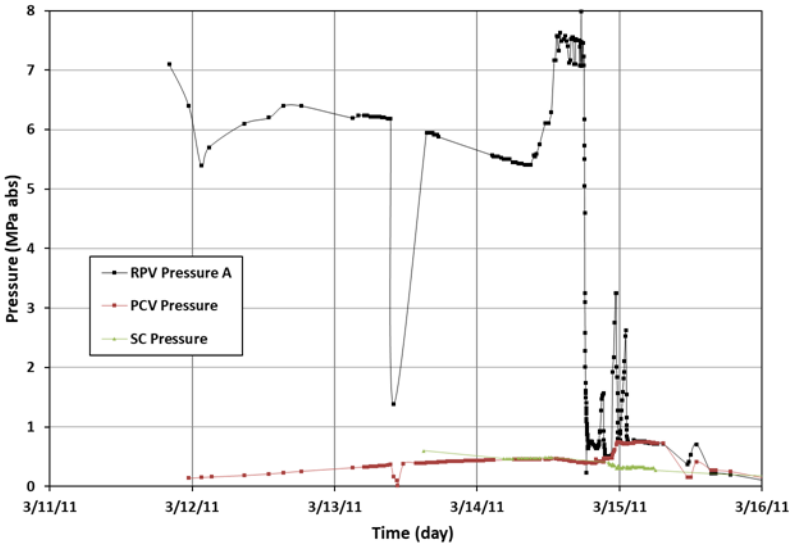
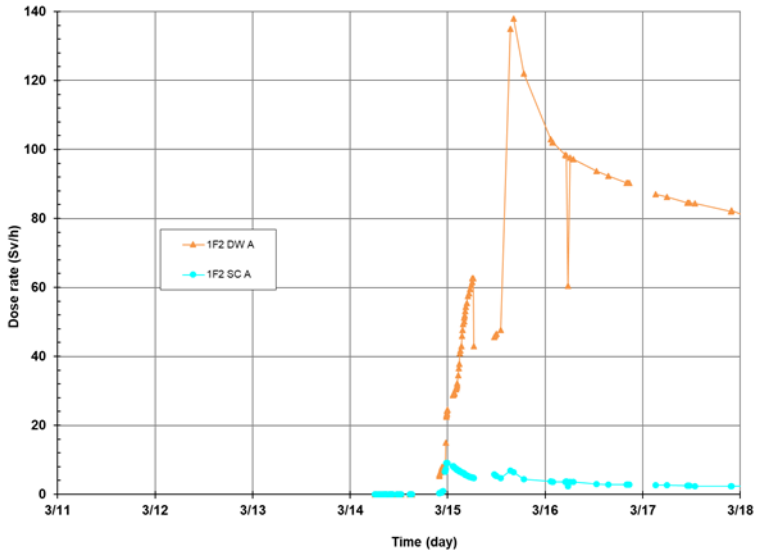
Forensics Already Yielding Important Insights and Recommendations (cont.)

- **Area 5 – Operations and Maintenance:**
  - Confirmation of updated industry guidance for using instrumentation in severe accident conditions
    - Confirm RCIC and HPCI system operation
    - Infer PCV and RPV failure times
  - Potential regulatory credit for instrumentation operation under beyond design basis conditions.
  - Potential regulatory credit for extended RCIC operation





1F2 pressure and CAMS data suggest PCV failure (after 7:20 on 3/15/11) and RPV failure (after 13:00 on 3/15/11).

Graphics courtesy of TEPCO

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Summary

- **Available Daiichi instrumentation data and examination information:**
  - **Confirm revised severe accident management guidance for water addition, containment venting, and use of instrumentation data**
  - **Indicate vessel failure occurred at all three units; additional information needed to discern mode(s) of vessel failure and holdup on ex-vessel structures**
  - **Indicate PCV failure occurred at all three units; possibly at multiple locations**
  - **Suggest additional regulatory credit may be possible for RCIC and instrumentation operation in beyond design basis conditions**
  - **Suggest multi-unit effects should be considered (most were NOT advantageous).**
- **U.S. Forensics Effort emphasizing information requests affecting models for melt relocation, holdup on in-vessel and ex-vessel structures, mode of RPV and PCV failure, and ex-vessel melt spreading, cooling, and interactions with concrete.**
  - **Maximum benefit from examinations requires periodic review of examination information by plant operations and reactor safety experts**
  - **TEPCO input and review critical for prioritizing examination need requests.**
  - **Important to provide detailed documentation of high priority information need requests**

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Japan-Led OECD/NEA Efforts
To Support Research and 1F Decommissioning

BSAF: Benchmark Study of the Accident at the Fukushima
- Study of accident progressions of 1F units 1-3

SAREF: Senior Expert Group on Safety Research Opportunities Post-Fukushima
- Identify research to address safety research knowledge gaps

PreADES: Preparatory Study on Analysis of Fuel Debris
- Improve fuel debris characterization; plan future R&D using 1F fuel debris

ARC-F: Analysis of Information from Reactor Building and Containment Vessel and Water Sampling in Fukushima
- Analyses of 1F visual inspections and water samples

Thank You

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