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The importance of V&V in CAE

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Outline

1. V&V (Verification and Validation)
   1.1 Background and the current status of V&V
   1.2 Technical Standard at Japan Society of Computational Engineering and Science
2. The accident at Fukushima nuclear plant and engineering simulation
   2.1 The problem regarding the accident
   2.2 The role in the new safety regulation

V&V (Verification and Validation)

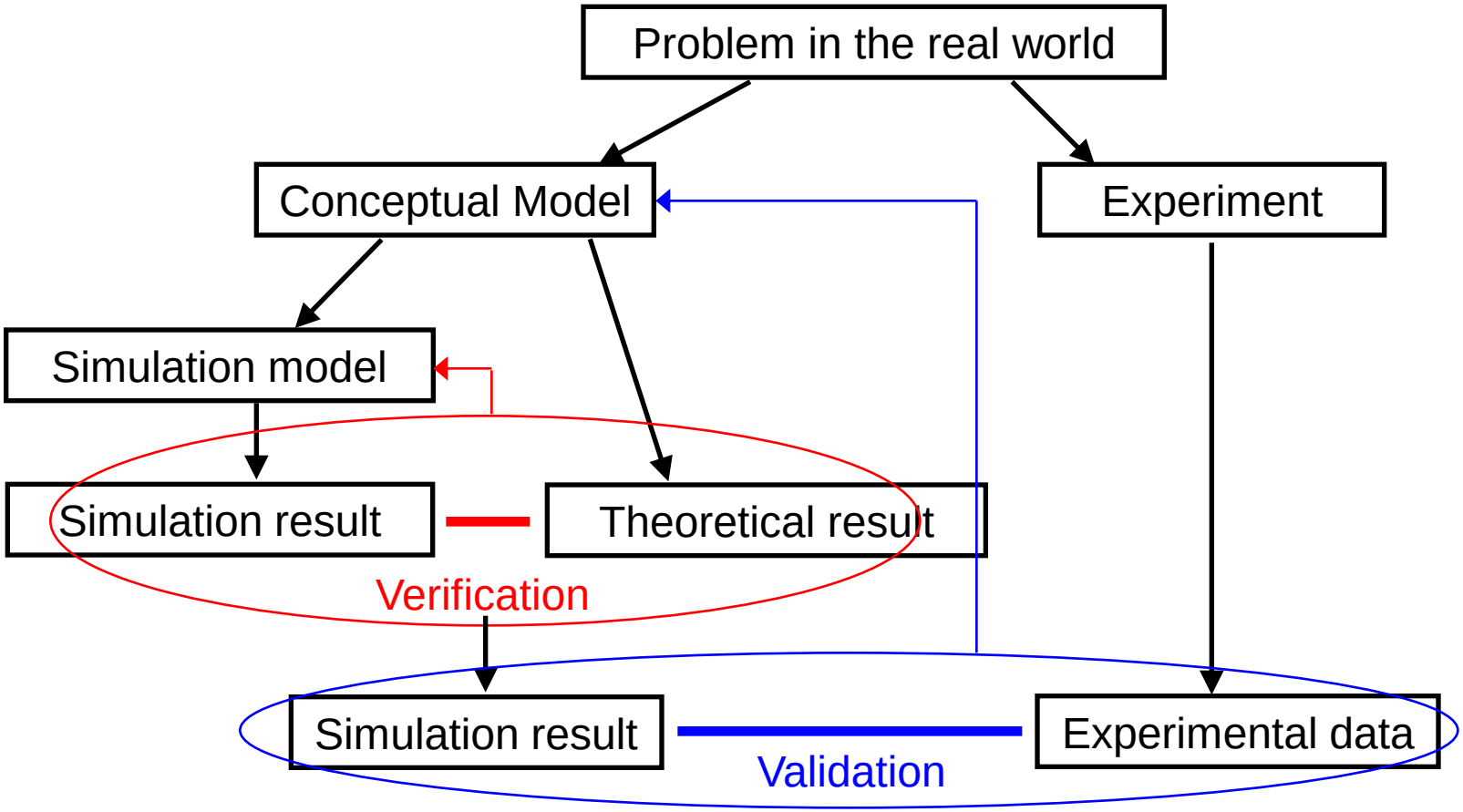
V&V (Verification and Validation)

- The methodology to specifically establish the reliability of simulation result
- The reliability of simulation result is a necessary requirement in CAE(Computer-Aided Engineering)(=simulation usage in industry)
- 2 directions: **Model V&V and Quality V&V**

Reference literature: “Quality assurance and V&V for engineering simulation” written by Masaki Shiratori, Seiichi Koshizuka, Yuichiro Yoshida, Hitoshi Nakaymura, Akitoshi Hotta, Naoki Takano, Maruzen Publication 2013

Model V&V

(V&V in modeling and simulation)



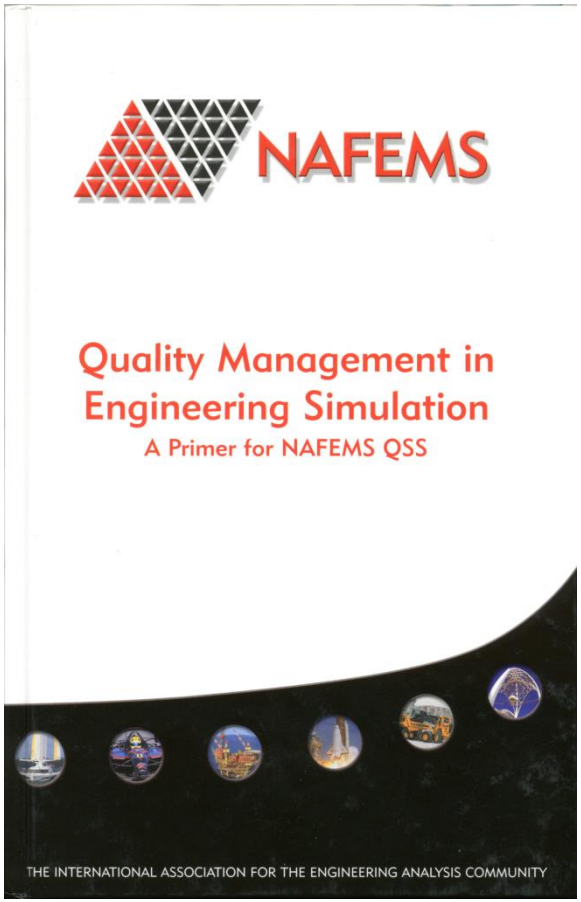
Model V&V（US）

- U.S.DoD, 1996(2003), "DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)," DoD Instruction 5000.61, Defense of Modeling and Simulation Office
- AIAA, 1998, **Guide** for the Verification and Validation of **Computational Fluid Dynamics** Simulations, AIAA G-077-1998, American Institute of Aeronautics and Astronautics
- ASME, 2006, **Guide** for Verification and Validation in **Computational Solid Mechanics**, ASME V&V 10-2006, American Society of Mechanical Engineers
- ASME, 2009, **Standard** for Verification and Validation in **Computational Fluid Dynamics and Heat Transfer**, ASME V&V 20-2009, American Society of Mechanical Engineers

Quality V&V
(V&V in quality management)

NAFEMS

- NPO in UK
- Preparing quality assurance standard of the simulation work which is compliant to **ISO9001**
- Many publications including EM structural analysis
- Importance of the engineers skill management



http://www.nafems.org/

Difference between Model V&V and Quality V&V

- The aim is;
  - Model V&V: real world
  - Quality V&V: customer
- Target field
  - Model V&V: Computational simulation
  - Quality V&V: Company activities->Software operation->Simulation

Japan society of Computational engineering and Science

- "Study and research for quality and reliability of simulation" working group (HQC working group)
  - Manager : Masaki Shiratori (Yokohama National University)
  - Vice manager: Naoki Takano (Keio University), Takahiro Yamada (Yokohama National University) , Seiichi Koshizuka (The University of Tokyo)
  - Main member: Yuichiro Yoshida (Toshiba IS), Hitoshi Nakamura (CTC), Katsutoshi Hotta(JNES)
  - Members fields : Automotive, Electric, Nuclear, Construction, CAE, Universities
  - Phase1 : Holding meetings from 1st to 9th (2009.6~2011.3)
  - Published the Japanese standard for ISO9001 V&V(2011.5)
    - Quality management of engineering simulation, JSCES-S-HQC001:2011
    - Standard procedure of engineering simulation, JSCES-S-HQC002:2011
  - Phase 2 : Holding meetings from 1st to 8th (2011.4~2013.3)
  - Phase 3 : Holding meetings from 1st to 2nd (2013.4~)
  - Organizing V&V training session

Computational Engineering Vol.16(4) (2011)

The magazine published by JSCES

Special “Quality Assurance of Simulation”

- Idea of special topic: Masaki Shiratori
- Trend of Simulation in other countries: Seiichi Koshizuka
- Trend of Simulation Accuracy in Nuclear Energy Industry: Katsutoshi Hotta
- Quality Assurance of Simulation in Automotive Industry: Ryusaku Sawada
- Quality Management of Engineering Simulation: Yuichiro Yoshida
- Standard Procedure of Engineering Simulation: Hitoshi Nakamura

JSCES “Quality Management of Engineering Simulation” JSCES S-HQC001:2011
JSCES “A model procedure for Engineering Simulation” JSCES S-HQC002:2011

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（以上、50 音順、敬称略）

Training Session

- The first session “Aiming for quality improvement of simulation in manufacturing industry”
  - January 1, 2011
  - At KEIO University
- The second session ”Quality assurance of engineering simulation”An explanation of the guideline for quality assurance of engineering simulation and its effective use”
  - June 28, 2012
  - At Arcadia Ichigaya

The Fukushima Nuclear Plant Accident and Engineering Simulation

The investigation of the Fukushima Nuclear Plant accident

- Reports from 4 different accident investigation commissions
  - TEPCO, National Diet, Government, Private
  - All 4 reports were presented by July 2012
- The accident investigation commission of Atomic Energy Society of Japan
  - Established in August 2012, The summary of final report was presented in September 2013
  - **Computational Science and Engineering Division** has been in charge of the simulation problem for the accident

The accident investigation commission of the government : Team manager
The accident investigation commission of Society: Core Member
Computational Science and Engineering Division : Vice Manager 2010~2012, Manager 2013

The problems of the simulation for Fukushima Nuclear Plant Accident

Computational Science and Engineering Division in Atomic Energy Society of Japan

- SPEEDI
  - Complementary use with monitoring data
- Aseismic calculation
  - Reasonable analysis using the leading technology
- Tsunami Numerical Calculation
  - Tsunami source
  - 3D analysis of the water run up on the ground
- Severe accident analysis
  - Haven't been able to do the reproduction analysis of the Fukushima Plant Accident

The time series of SPEEDI

- The role of SPEEDI in disaster prevention planning
  - ERSS : Prediction of the emission source of radioactive material
  - SPEEDI : Prediction of the air diffusion of radioactive material by entering ERSS and weather data, and distribution to related institutions

- March 11, 2011
  - 14:46 Tohoku Earthquake occurred (M9.0)
  - 15:27 The first Tsunami wave reached Fukushima Daiichi Plant
  - 15:42 The warning by the Article 10 of the Special Law for measurement of Nuclear Disaster
  - 16:43 ERSS data transmitting stopped
  - 16:49 SPEEDI was switched to emergency mode

    ・Calculation result by assuming a unit emission source was automatically sent to related ministries every hour

    ・The Nuclear Agency, “Ministry of Education, Culture, Sports, Science and Technology” and Nuclear Safety Commission received various results

Official Announcement of SPEEDI data

- March 15
  - “Ministry of Education, Culture, Sports, Science and Technology” was asked to announce SPEEDI data during the press conference
- March 23
  - Nuclear Safety Commission announced the SPEEDI calculation result by inverse analysis

平成23年4月24日の線量率

Evaluation of SPEEDI

- National diet accident investigation commission
  - SPEEDI was not valid as the initial decision of evacuation
- Government accident investigation commission
  - The problem was that there was no action to use SPEEDI for evacuation measure
- Atomic Energy Society of Japan accident investigation commission
  - The decision not to use SPEEDI for evacuation directive in the early stage, was correct
  - However SPEEDI might had been effective for the evacuation directive after March 15
- Science Council of Japan
  - A commission related to simulation: Scientists efforts for self-directive information transmission is necessary. Depending on one opinion is the problem

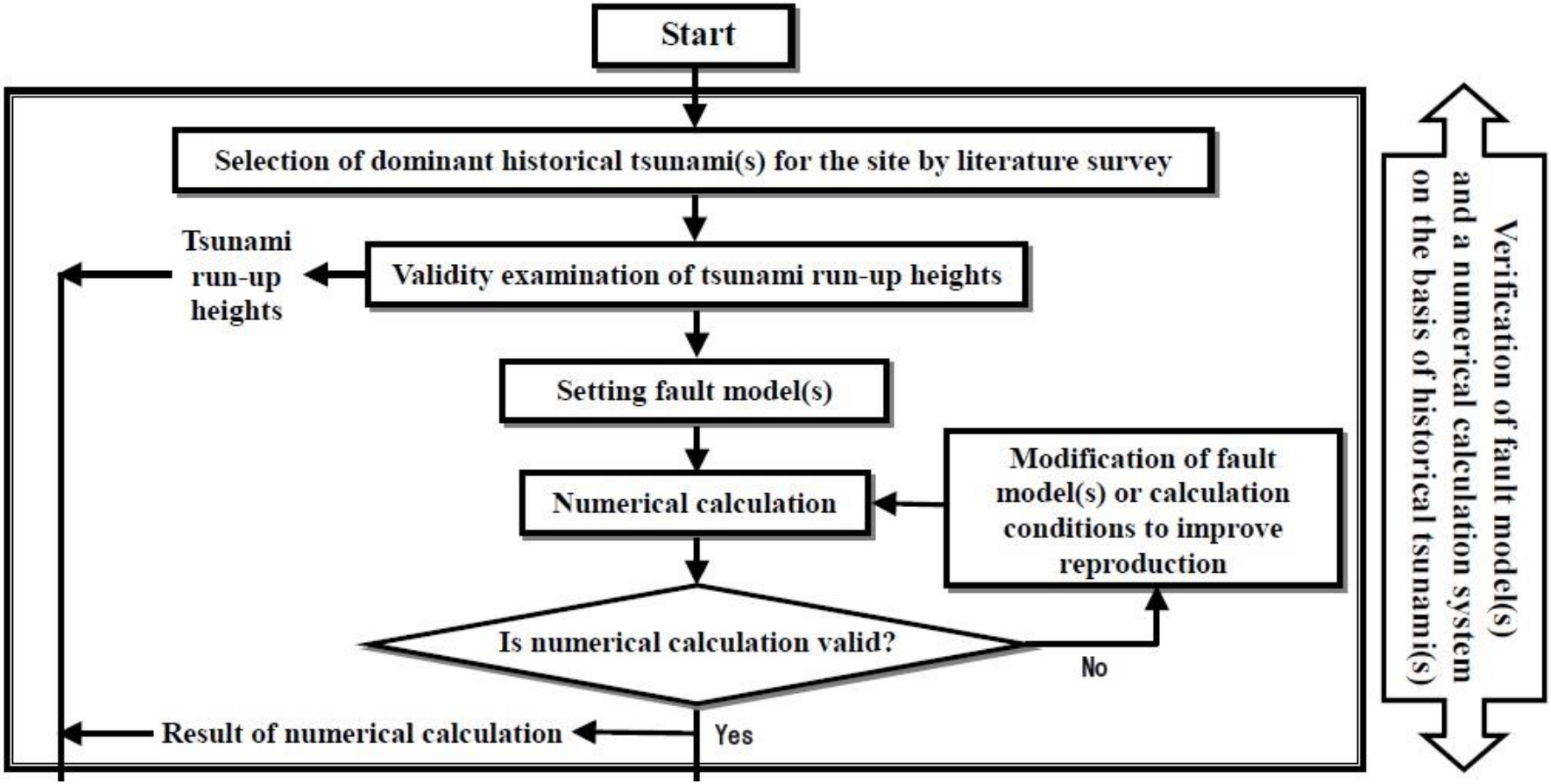
Supposed Tsunami height in Nuclear Plants at the time of disaster occurence

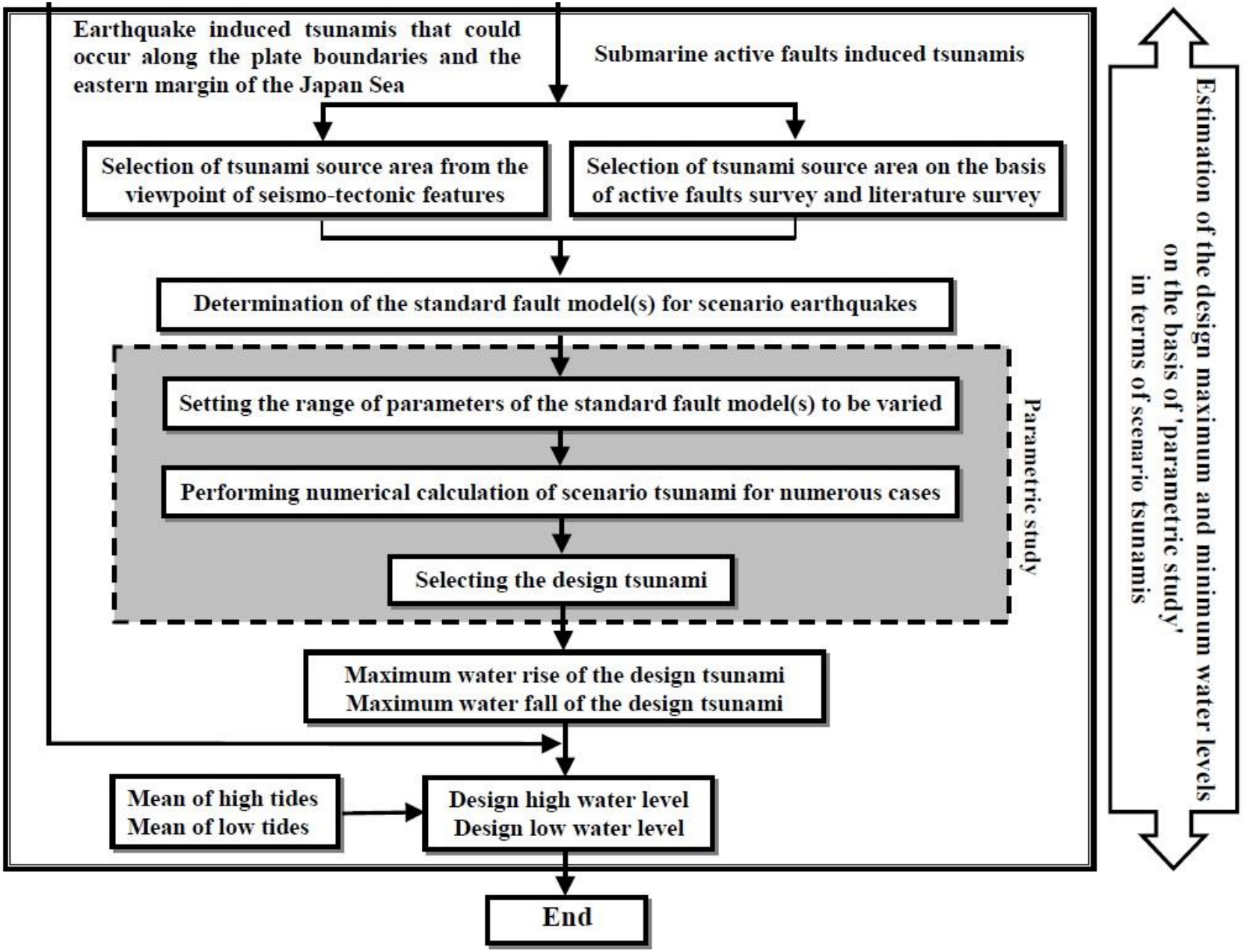
- Nucear Civil Engineering Tsunami Evaluation working group of Japan Society of Civil Engineers”Tsunami evaluation technology for Nuclear plant”(2002)
  → Tsunami height evaluation

	Supposed height	**Real height on March 11**
Onagawa Plant (3 units)	9.1	13
Fukushima Daiichi Plant (6 units) Core damage：Unit 1, 2, 3 Hydrogen explosion：Unit 1, 3, 4	5.7	15
Fukushima Daini Plant (4 units)	5.2	7
Tokai Daini Plant (1 unit)	5.72	5.4

[m]

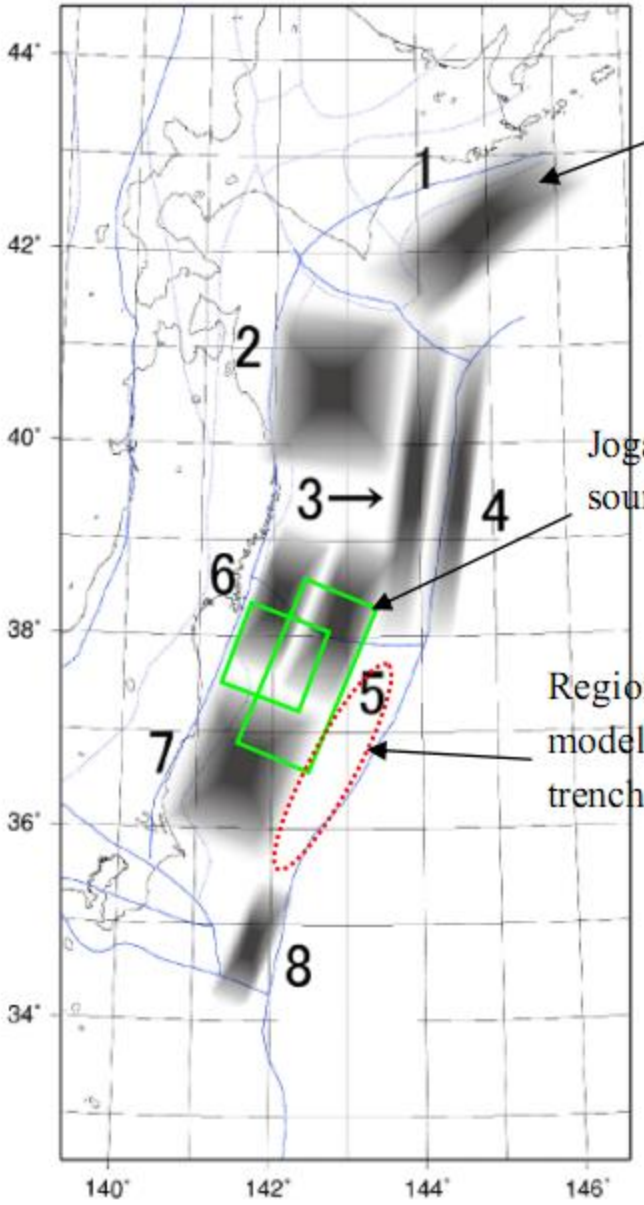
Japan Society of Civil Engineers : Tsunami Assessment Method for Nuclear Power Plants (2002)



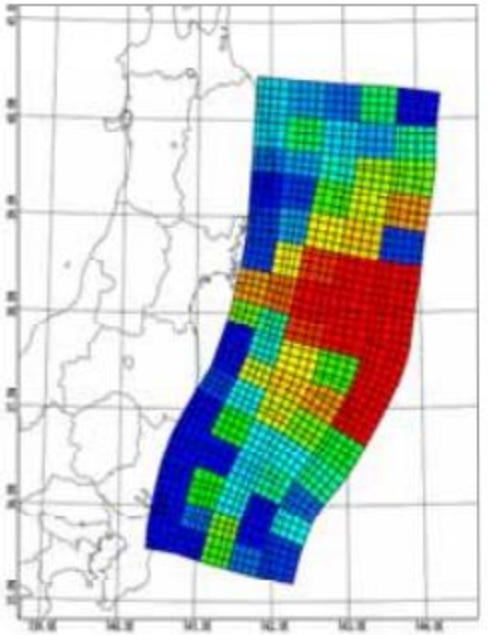

Earthquake induced tsunamis that could occur along the plate boundaries and the eastern margin of the Japan Sea
Submarine active faults induced tsunamis
Selection of tsunami source area from the viewpoint of seismo-tectonic features
Selection of tsunami source area on the basis of active faults survey and literature survey
Determination of the standard fault model(s) for scenario earthquakes
Setting the range of parameters of the standard fault model(s) to be varied
Performing numerical calculation of scenario tsunami for numerous cases
Selecting the design tsunami
Parametric study
Maximum water rise of the design tsunami
Maximum water fall of the design tsunami
Mean of high tides
Mean of low tides
Design high water level
Design low water level
End
Estimation of the design maximum and minimum water levels on the basis of 'parametric study' in terms of scenario tsunamis

History of Tsunami measurement（Midterm report from Government accident investigation commission）

Year. Month. Date	Events
901	Nihon Sandai Jitsuroku "The True History of Three Reigns of Japan“ was completed. Jogan Tsunami (869) was written in the text.
1966-1972	TEPCO Fukushima Daiichi Plant was approved to set under the condition of Tsunami Height OP+3.122m
2002.2	“Tsunami evaluation technology for nuclear plant” was published by Japan Society of Civil Engineers
2002.3	TEPCO recalculated the Tsunami height OP+5.4-5.7m. The countermeasure was taken.
2002.7	The headquarters for Earthquake Research Promotion reported that Tsunami Earthquake can occur anywhere in the area near an ocean trench.
2006.9	Nuclear Safety Commission renewed the safety review guide for seismic design.
	Nuclear and Industrial Safety Agency requested the seismic back check.
2008	Satake’s paper was published. It showed the wave source model of Jogan Tsunami.
2008.5-6	TEPCO gained the calculation result of Tsunami height OP+9.3-15.7m by diverting the wave source model in coast of Sanriku to coast of Fukushima.
	Gained Tsunami height OP+8.6-9.2m using Satake’s wave source model.
	TEPCO set up a working group and started the investigation of Tsunami sediment and explaining to specialists.
2009.9	TEPCO reported to Nuclear and Industrial Safety Agency about the calculation result OP+8.6-8.9m.
2011.3.7	Nuclear and Industrial Safety Agency interviewed TEPCO about the calculation result of OP+9.3-15.7m and OP+8.6-9.2m.
2011.3.11	Tohoku Earthquake occurred.



JSCE's wave source and Jogan tsunami's wave source (Jogan tsunami's wave source was evaluated based on Satake et al., 2008)



Wave source of the tsunami on March 11 (Evaluated by TEPCO)

TEPCO committee report

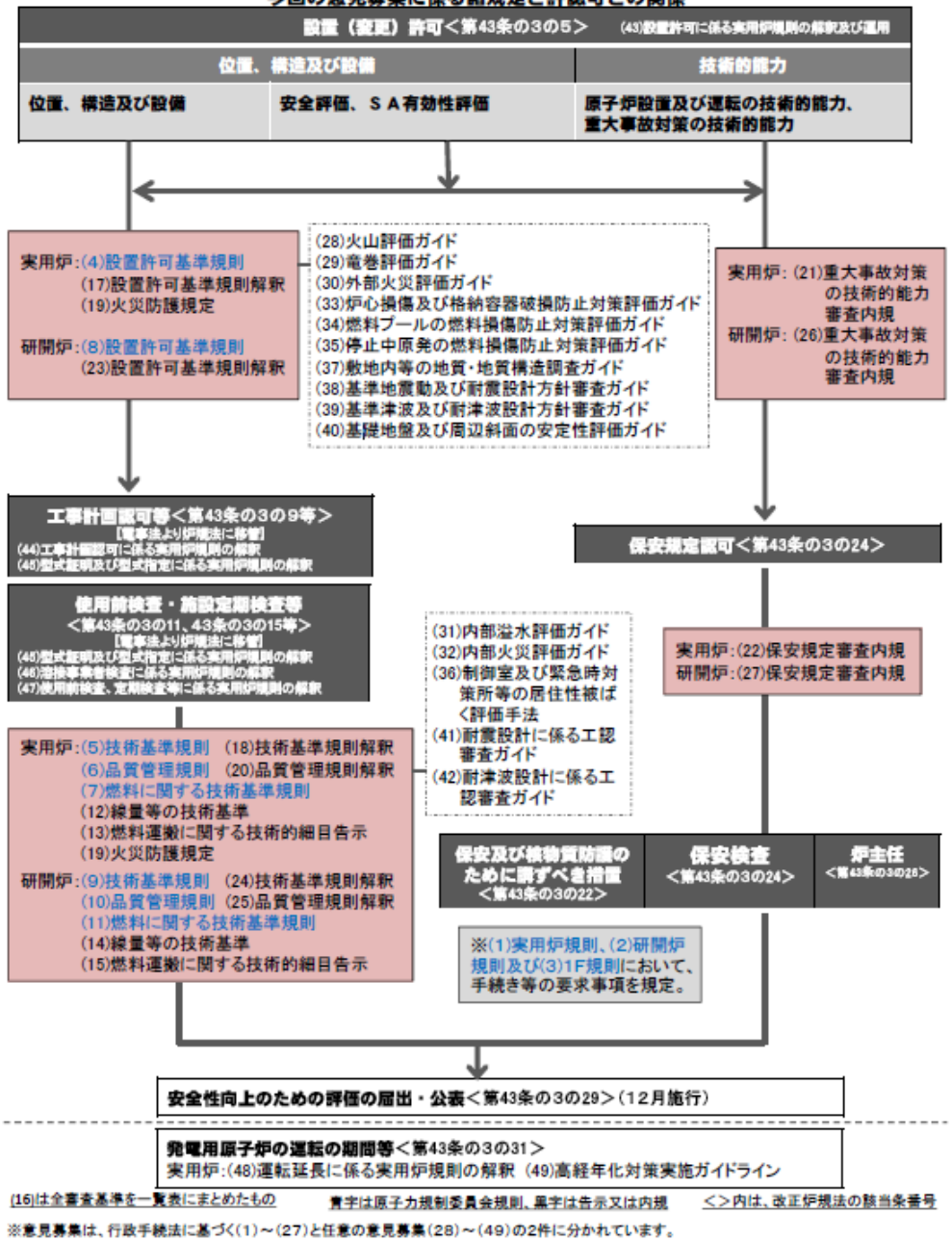
Background of the Problem

- Simulation has an extremely important part in modern society
- However, the knowledge about the reliability of simulation result was missing.
  - SPEEDI : was not expected to be used for evacuation plans as the simulation result was thought to be unreliable.
  - Tsunami Supposition : The calculation using the assumed wave source predicted almost the exact Tsunami Height. However, most people could not imagine that such a high Tsunami would actually occur.
- Technical standards to effectively use simulation hasn't been prepared.

The role under the new regulation standard (executed by Nuclear Regulation Authority July 8, 2013)

- Analysis method for external events
  - The guidance for earthquake, Tsunami, flooding, fire and tornado was created.
- Severe accident analysis
  - Severe accident measure is now defined in the necessity regulation : Necessity of the effectiveness evaluation
- Risk evaluation by using probabilistic approach
  - Active use for the evaluation to improve the safety (applied by each organization)
- V&V
  - Quality V&V : The quality assurance guideline is expanded from the operation stage to the design/construction stage under the new regulation standard. (including the safety analysis)
  - Model V&V : absolutely necessary for the technical standard to use simulation, code certification system

今回の意見募集に係る諸規定と許認可との関係



(16)は全審査基準を一覧表にまとめたもの　　青字は原子力規制委員会規則、黒字は告示又は内規　　＜＞内は、改正炉規法の該当条番号

※意見募集は、行政手続法に基づく(1)～(27)と任意の意見募集(28)～(49)の2件に分かれています。

Summary

- As V&V is important for CAE, JSCES published 2 technical standard texts in 2011.
- There were serious problems related to simulation such as SPEEDI and Tsunami supposition in the Fukushima Plant Accident. It also means that simulation has a very important role.
- Simulation role increased in the new nuclear safety regulation learning from the accident, and new problems appeared.