The 9-day training course in seismology and tsunami warnings was held in the Sofyan Hotel, Jakarta from the 8th-17th May, 2006. The course was designed to improve understanding of the science of earthquake seismology and tsunami warning system operations to 40 new employees of the Indonesian Meteorological and Geophysical Agency (BMG). These scientists will be responsible for the day-to-day operations at the BMG regional centers across Indonesia. In addition, 5 longer standing employees of the BMG and two representatives from the Malaysian Meteorological Service (MMS) also attended. A list of participants is provided in Appendix 1. The training course was sponsored by the US Agency for International Development, the BMG, the UNESCO Intergovernmental Oceanographic Commission and the US Geological Survey.

The training was directly relevant to the daily duties of all participants. The level of previous knowledge of earthquake seismology and tsunami warning was generally quite basic, with most participants holding a bachelors degree in Exploration Geophysics (focusing largely on controlled source normal-incidence seismology) or a more general Earth Science degree. However, all participants had already undergone several weeks of induction training with the BMG.

The course was designed to cover theoretical seismology and the interpretation of seismic data relevant to tsunami warning systems in the first two days, with the third day focused on earthquake forecasting and an introduction to seismic instrumentation and arrays. Learning was directed through lectures complemented with nearly 4 hours of computer-based practical sessions. Days four though six covered seismic instrumentation, siting seismic vaults, data telemetry, station power supply and best practices in deployment and data off-load. This portion of the training was provided by IRIS PASCAL and involved hands-on experience with the instruments.

The seismology training was followed by two days of training in tsunami warnings and warning center operations. Learning was directed entirely through lectures given by experts with considerable experience in operations at the Japan Meteorological Agency and the Pacific Tsunami Warning Center. The topics included: tsunami
Selected quotes from the feedback forms:

“Thank you for your kindness we get many information”

“The course is very important to give new knowledge for new seismologists that the earth science start to grow up in their nation”

“This course can give me many information about my job”

On day nine, a roundtable meeting was held which discussed the current warning system in Indonesia and formulated a plan for future enhancement of the system. The training course agenda is given in Appendix 2.

The lecture and practical material was supported by a course handout which contained information on the training course (such as sponsoring organizations and timetabling) and additional information on the topics covered in the training course. In addition, at the end of the course the participants were all provided with a copy of the lecture PowerPoint slides and the computer codes used in the practical sessions.

At the completion of the seismology component of the course the participants were asked to fill out a questionnaire on the training provided. Feedback was obtained from 39 of the 45 participants. The responses were generally very enthusiastic, with 89% of the participant stating that the course had fulfilled their expectations and all the participants indicating that they had gained knowledge on the course (40% stating that they felt they had learned a great deal).

There were language problems during the training, with many of the participants having difficulty with lectures given in English, particularly from the lecturers without American accents. This was identified as a problem during the training, and an extra effort was made to present the lectures in a clear manner. Despite this, 50% of the participants indicated that they had difficulty with the speed of the lectures. The computer-based practical session were extremely popular with 97% of participants believing that they reinforced the lectures and many people suggesting a greater quantity of hands-on exercises in future training courses.

Quotes regarding the practical sessions:

“Very good to more understand”

“Amazing training”

“I think good if many more practical”
a) Group work on the computer
b) Question during a lecture session
c) Dr Bruce Beaudoin demonstrating instrument set-up
d) Dr Fauzi describing seismicity in Indonesia
e) Dr Yamamoto providing help during a practical session.
## Appendix 1 – Participants

<table>
<thead>
<tr>
<th>NAME</th>
<th>INSTITUTION</th>
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<tbody>
<tr>
<td>Mr. Saw Bun Liong</td>
<td>MMS</td>
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<tr>
<td>Mr. Ahmad Nizam Bin Om</td>
<td>MMS</td>
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<tr>
<td>Ajat Sudrajat</td>
<td>BMG</td>
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<tr>
<td>A. Jeszy Wan Irfandy</td>
<td>BMG</td>
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<tr>
<td>Akbar</td>
<td>BMG</td>
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<tr>
<td>Andi Amran</td>
<td>BMG</td>
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<tr>
<td>Andi Suryani</td>
<td>BMG</td>
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<tr>
<td>Aprilyanto</td>
<td>BMG</td>
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<tr>
<td>Ardhianto Septiadihi</td>
<td>BMG</td>
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<tr>
<td>Ari Sungkowo</td>
<td>BMG</td>
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<tr>
<td>Asep N. Rachman</td>
<td>BMG</td>
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<tr>
<td>Benyamin Heryanto R</td>
<td>BMG</td>
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<tr>
<td>Biana R. Wulandari</td>
<td>BMG</td>
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<tr>
<td>Dian Oktiari</td>
<td>BMG</td>
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<tr>
<td>Firdaus Muhiddin</td>
<td>BMG</td>
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<tr>
<td>Gian Ginanjar</td>
<td>BMG</td>
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<tr>
<td>Gunawan Bayu Aji</td>
<td>BMG</td>
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<tr>
<td>Hamdy Arifin</td>
<td>BMG</td>
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<tr>
<td>Hendrik Leopatty</td>
<td>BMG</td>
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<tr>
<td>Husnul Kamal Zega</td>
<td>BMG</td>
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<td>Kaharuddin</td>
<td>BMG</td>
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<tr>
<td>M. Amin</td>
<td>BMG</td>
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<td>M. Tanviruz Zaman</td>
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<td>Marniati</td>
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<td>Maya Minangsih</td>
<td>BMG</td>
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<tr>
<td>Meida Yustiana</td>
<td>BMG</td>
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<td>Novita Hendrastuti</td>
<td>BMG</td>
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<tr>
<td>Nurhayati P.</td>
<td>BMG</td>
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<tr>
<td>Retno Agung P K</td>
<td>BMG</td>
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<tr>
<td>Rr. Theresia Elvien Setyadhini</td>
<td>BMG</td>
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<tr>
<td>Rudy Teguh I</td>
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<tr>
<td>Sarifuddin</td>
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<tr>
<td>Siti Rahma</td>
<td>BMG</td>
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<tr>
<td>Sri Wahyuni</td>
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<td>Suci Dewi Anugrah</td>
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<td>Suwarto</td>
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<td>Tri Handayani</td>
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<td>Tri Haryono</td>
<td>BMG</td>
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<tr>
<td>Tristin Yosefa</td>
<td>BMG</td>
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<tr>
<td>W. Nugrahani Farisa</td>
<td>BMG</td>
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<tr>
<td>Yahya Darmawan</td>
<td>BMG</td>
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<tr>
<td>Name</td>
<td>Affiliation</td>
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<tr>
<td>Dr Bruce Beaudoin</td>
<td>IRIS PASCAL</td>
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<tr>
<td>Dr Fauzi</td>
<td>BMG</td>
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<tr>
<td>Dr Annabel Kelly</td>
<td>US Geological Survey</td>
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<tr>
<td>Dr Laura Kong</td>
<td>International Tsunami Information Center</td>
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<tr>
<td>Dr Masturyono</td>
<td>BMG</td>
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<tr>
<td>Dr Walter Mooney</td>
<td>US Geological Survey</td>
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<tr>
<td>Dr Stuart Weinstein</td>
<td>Pacific Tsunami Warning Center, Hawaii</td>
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<tr>
<td>Dr Sri Widiantoro</td>
<td>Institute of Technology Bandung</td>
</tr>
<tr>
<td>Dr Masahiro Yamamoto</td>
<td>UNESCO IOC</td>
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</tbody>
</table>
Appendix 2 – Agenda

Day 1 – SEISMOLOGY: Introduction and the Tectonic Situation of Indonesia, Introduction to Earthquakes

9am- Session I.1: Introductions
   Welcome by Indonesia: Dr. Prih Harjadi
   Welcome by US Embassy and USAID: William Frej, Mission Director, USAID/Indonesia
   Welcome on behalf of US IOTWS Program: Orestes Anastasia, USAID
   Outline of Training Course: Annabel Kelly
   Logistical Information (maps, rooms, meals, etc): Dr. Fauzi

10am- Session I.2
   Topic: Introduction to Earthquake Science: A Historical Perspective
   Lecturer: Annabel Kelly

11am- Coffee Break

11:15am- Session I.3
   Topic: The Earth’s Structure and Seismicity
   Lecturer: Annabel Kelly

12:15pm- Lunch Break

1:30pm- Session I.4
   Topic: Theoretical Seismology 1: Sources
   Lecturer: Masahiro Yamamoto

3pm- Coffee Break

3:15pm- Session I.5
   Topic: Theoretical Seismology 1: Wave Propagation
   Lecturer: Masahiro Yamamoto

4:15pm- Discussions

5pm- TV Documentary: Nature Tech Earthquakes

Day 2 – SEISMOLOGY: Seismic Theory & Applications

9am- Session II.1
   Topic: Theoretical Seismology 3: Media, Seismic Tomography
   Lecturer: Dr. Sri Widiantoro

10am- Session II.2
   Topic: Structure & Interpretation of Seismograms 1: Waveforms and Hypocentral Locations
   Lecturer: Walter Mooney

11:00am- Coffee Break

11:15am- Session II.3
   Topic: Structure & Interpretation of Seismograms 2: Magnitude and Source Mechanisms
   Lecturer: Walter Mooney

12:15pm- Lunch Break

1:30pm- Session II.4
   Topic: Computer Exercises, Seismic Data Exercise, or Hypocenter Exercise
   Lecturer: Annabel Kelly

3:15pm- Coffee Break

3:30pm- Session II.5
   Topic: Damaging Effect of Earthquakes / Hazard Assessment
   Lecturer: Annabel Kelly
4:45pm - Discussions
5pm - TV Documentary: Nature Tech Tsunamis

Day 3 – SEISMOLOGY: Global and Local Seismic Networks, Instrumentation & Seismic Data Analysis

9am - Session III.1
   Topic: Earthquake Forecasting
   Lecturer: Annabel Kelly

9:45am - Session III.2
   Topic: Instrumentation, Recording systems, Data Transmission & Archiving
   Lecturer: Masahiro Yamamoto

10:30am - Session III.3
   Topic: Global & Local Arrays
   Lecturer: Walter Mooney

11am - Coffee Break

11:15pm - Session III.4
   Topic: Evaluation of current Seismic Network of BMG
   Lecturer: Masturyono

12:45pm - Lunch Break

2:15pm – Session III.5
   Topic: Computer Exercises, Seismic Data Exercise, or Hypocenter Exercise
   Lecturer: Annabel Kelly

4:15pm - Coffee Break

4:30pm - Discussions

6pm - Dinner

Days 4-6 - IRIS Instrumentation Training

Lecturer: Bruce Beaudoin

Topics:
Introduction to IRIS
Introduction to portable seismic experiments
Tasks of an Instrument Facility
   Logistics
   Field support
   Maintenance and repair
   Training
   Data reduction support

Instrumentation - hands on setup and operation
   Sensors - general overview, operation, maintenance
      Passive velocity transducers (ie L22, L4, HS10, S6000)
      Active broadband seismometer (ie, STS2, CMG 3T, CMG 3ESP)
   Data acquisition systems - general overview, maintenance
      Reftek R130
      Quanterra Q330

Power systems
   Designing a power system for given a location and instrument load

Communications
   Types of RF data transmission using spread spectrum radios
   RF surveys, interference problems
   VSAT systems ... survey of units used in the USA
Integration of DAS with communications systems

Portable Broadband Sensor Vaults
- Elements required for a good vault (coupling, thermal stability, protection)
- Examples from over 15 years of portable deployments
- Comparison of various portable and semi-portable broadband vaults

Station Siting
- Noise sources to avoid (rules of thumb and examples)
- Security
- Flooding risk - mitigating techniques

Data Handling & Software for field and lab QC
- Viewing waveforms
- Accessing State of Health Data
- Manipulating mseed files

Day 7 - Tsunami Warnings and Tsunami Warning Center Operations

9am – Session VII.1
Topic: Tsunami Science
  a. Wave characteristics
  b. Source Zones
  c. Source types, Generation, Propagation, and Directivity
  d. Travel-times and coastal inundation
Lecturer: S. Weinstein

10am- Coffee Break

10:15am - Session VII.2
Topic: Tsunami Warning System
  a. History & Mission
  b. Components (communication, research, outreach, and education)
  c. Organizational structure
  d. TWS Partners (Met. Services, Emergency management, IRIS, GEOSS, etc)
Topic: Tsunami Warning Center Operations
  a. Objectives and Activities of Warning Centers
  b. Guidance on developing new National Warning Centers
Topic: Tsunami Warning Center Event Processing
  Overview - procedures, event flowcharts
Lecturer: BMG and/or L. Kong

12pm - Lunch Break

1:30pm- Session VII.3
Topic: Tsunami Warning Center Event Processing (Seismic Analysis)
  a. Signal acquisition and transmission formats
  b. Earthquake locations and associations
  c. Magnitudes and mechanisms
  d. Alarm types and Duty Personnel notifications
Lecturer: S. Weinstein, M. Yamamoto, L. Kong

3pm- - Coffee Break

3:15pm- Session VII.4
Topic: Tsunami Warning Center Products - Message Dissemination
  a. Types of Products and Criteria for Product Issuance
     Pacific and Indian Ocean scenarios
  b. Methods of Dissemination
  c. Communications Tests
Lecturer: S. Weinstein, M, Yamamoto, L. Kong

4:15pm- Discussions

5pm- End
Day 8 - Tsunami Warnings and Tsunami Warning Center Operations

**9:30am** – Session VIII.1
**Topic:** Tsunami Warning Center Data Processing (Sea Level Analysis)
  a. Geographical Information system
  b. Sea Level Analysis
  c. Tsunami models (BMG)
  d. Tsunami travel-time software
**Lecturer:** S. Weinstein, BMG

**10:30am** - Coffee Break

**10:45am** - Session VIII.2
**Topic:** Tsunami Warning Center Staffing and Training
  a. Staffing profile and workday flow
  b. Staff Training requirements
  c. Exercises and Drills
**Topic:** Indonesia Seismic and Tsunami Monitoring – Present and Future
**Lecturer:** M. Yamamoto, BMG

**11:45am** - Tsunami Teacher Resource Toolkit – L. Kong

**12:15pm** - Lunch Break

**1:45pm** - Session VIII.3
**Topic:** Tsunami Emergency Response after Tsunami Warnings Issued, including operation centers, warning dissemination, evacuation, shelters, etc
  a. Objectives and Activities involved in Emergency Response
  b. Guidance on developing tsunami response
  c. RANET and other methods of alert
**Topic:** Indonesia Tsunami Emergency Response – Present and Future
**Lecturer:** L. Kong, BMG

**3pm** - Coffee Break

**3:15pm** - Session VIII.4
**Topic:** Tsunami Hazard Mitigation - Preparedness, Education, and Outreach, including Earthquake Hazard Mitigation building codes and engineering design guidance
  a. Preparedness - risk assessment, exercises and drills, structural mitigation
  b. Education and Outreach - reasons for, examples, and how carried out
**Topic:** Indonesia Tsunami Preparedness Program – Present and Future
**Lecturer:** L. Kong, BMG

**4:30pm** - Discussions:
  Comments from Lecturers & Participants, Recommendations, Conclusions

**5:15 pm** - Presentation of Certificates, Closing Ceremony

**5:30 pm** - End of Training

Day 9 - Roundtable – Tsunami Warnings for Indonesia

**Participants:**
Indonesian Government Representatives and other invited responsible organizations
Pacific Tsunami Warning Center, Deputy Director
Japan Meteorological Agency, represented by IOC Tsunami Senior Advisor
International Tsunami Information Centre, Director
Training participants

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<tr>
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<th>Event</th>
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<tr>
<td>8.0 – 9.00</td>
<td>Registration</td>
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<td>9.00 – 9:10</td>
<td>Opening remark (DG of BMG)</td>
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<td>Time</td>
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<td>9.10 – 9.30</td>
<td><strong>Key note speech, DR. Jan Sopaleuwakan</strong></td>
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<tr>
<td>9.30 – 10.00</td>
<td><strong>Key note speech, DR. Laura Kong</strong></td>
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<td>10.00 – 10.30</td>
<td><strong>Coffee break</strong></td>
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<td><strong>Monitoring, current status and plan in TWS</strong></td>
<td>Chair: DR. Prih Harjadi</td>
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<td>10.30 – 10.45</td>
<td>DART-buoy, BPPT</td>
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<td>10.45 – 11.00</td>
<td>Tide Gauges, BAKOSURTANAL</td>
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<td>11.00 – 11.15</td>
<td>GPS network, BAKOSURTANAL</td>
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<td>11.15 – 11.30</td>
<td>Earth Observation, LAPAN</td>
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<td>11.45 – 12.00</td>
<td>Seismic Network, BMG</td>
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<td>12.00 – 12.15</td>
<td><strong>Operation Center of EITWC, BMG</strong></td>
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<td>12.15 – 13.15</td>
<td><strong>Lunch</strong></td>
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<td><strong>Preparedness and Mitigation</strong></td>
<td>current status and plan in TWS</td>
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<td>13.15 – 13.30</td>
<td>Tsunami Modeling, ITB or BPPT</td>
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<td>13.30 – 13.45</td>
<td>Operation center of BAKORNAS, BAKORNAS</td>
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<td>13.45 – 14.00</td>
<td>System Dissemination, Kominfo</td>
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<td>14.00 – 14.15</td>
<td>Public preparedness, LIPI</td>
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<td>14.15 – 14.30</td>
<td>Scenario</td>
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<td><strong>Panel Discussion, scenario and plan for a drill 26 December 2006</strong></td>
<td>DR. Laura Kong&lt;br&gt;DR. Prih Haryadi</td>
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<td>14.30 – 17.40</td>
<td>DR. Laura Kong&lt;br&gt;MR. Yamamoto&lt;br&gt;DR. Weinstein&lt;br&gt;DR. Jan Sopaleuwakan</td>
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<tr>
<td>17.40 – 18.00</td>
<td>Closing</td>
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