Motivation, Primary Objectives and Prospective Outcomes of DFG - Round Table Discussion

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- Managing Director joint Coastal Research Centre (FZK) of Universities of Hannover and Braunschweig, Hannover
How to Avoid Future Disasters Similar to that of the 2004 Tsunami?

Mitigation Efforts after the 2004 Tsunami

- More towards rapid recovery & Set-up of Warning Systems
- Much less towards structural mitigation measures

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Structural measures against tsunami

Need for multiple defence line strategy in which type, number and size of man-made/natural barriers should be adapted to the vulnerability of specific flood prone area and further local conditions

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Need to close the knowledge gaps & improve modelling particularly for:

- Nearshore and onshore tsunami propagation
- Tsunami effects nearshore and onshore, including interaction with structures and further obstacles, sediments, debris...
Primary Objectives

1. Briefly report on ongoing and planned research activities

2. Identify knowledge gaps/ modelling weaknesses and research needs at:
   - Source Level
   - Pathway Level
   - Receptor Level

   to

   - Implement Multiple Defence Line Strategy
   - Implement “Integrated Risk-Analysis & Management Framework”

3. Derive from results in items (1) and (2) the priority research topics for which
   - Closer Cooperation between German researcher (DFG-funding), US-researchers (NSF-funding) and other foreign researchers will substantially contribute to avoid duplications and to save time and financial resources
   - Cross-fertilization between Geoscience and Coastal Engineering Researchers is urgently required
Prospective Major Outcomes

1. Define mechanisms / procedures for exchanging results of completed and ongoing related research projects

2. Specify “Individual Research Projects” (IRP) to be incorporated in “Joint Project Clusters” (JPC). Possible JPC-candidates are for instance:

   ➢ JPC1: Nearshore effects on tsunami propagation and modelling, including interactions with natural barriers (coral reefs, sand banks, etc.) and man-made structures (artificial reefs, breakwater, groins, etc.)

   ➢ JPC2: Onshore effects on tsunami propagation and modelling, including interactions with natural barrier (beaches, dunes, forest vegetation, etc.) and man-made structures (sea walls, reinforces dunes, buildings and infrastructure)

   ➢ JPC3: Effects of debris on tsunami propagation and modelling, including the impact of debris flow on buildings, infrastructures, etc.
Further Possible Outcomes

- Although Tsunami in the open Sea is outside the scope of the proposed theme of the DFG-Round Table:
  - JPC4: Tsunami Generation and Modelling in the Open Sea might also be considered because:
    1. Knowledge on tsunami parameters is still too poor and uncertainty bands of both seismic data and water wave characteristics are still too large
    2. Reliable near- and onshore tsunami parameters strategy depend on the water wave characteristic at the tsunami source
    3. Occurrence probability of tsunami with certain heights and periods also strongly depend on generation mechanisms and their reliable modelling

- Exploration of possibilities:
  1. To elaborate a “Joint data Base for Model Validation”, incl. specification of standard procedures
  2. To jointly use unique experimental facilities for tsunami research.
### PART I: Near- and Onshore Tsunami Effects: Ongoing and Planned Research

**Session 1: US Experience and Related Projects**  
Chairman: Hocine Oumeraci, Forschungszentrum Küste (FZK)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Institution</th>
<th>Presentation</th>
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</thead>
</table>
| 10:45 | Philip Liu | Cornell University  
| 11:30 | Patrick Lynett | Texas A&M University  
Station College | Parallel and hybrid approaches to tsunami modelling (ongoing research) and hydrodynamic information in tsunami deposits (planned research) |
| 12:15 | Harry Yeh | Oregon State University  
Corvallis | Tsunami loading on structures: ongoing and planned research |
| 13:30 | Costas Synolakis | Tsunami Research Center  
University of Southern California, Los Angeles | Lessons learned from tsunami field surveys and related projects |

**LUNCH**

At least 10 min. should be left for discussion after each presentation.
## Part I: Near- and Onshore Tsunami Effects: Ongoing and Planned Research

### Session 2: Ongoing and Planned Tsunami Research in Germany

Chairman: Werner Zielke, Forschungszentrum Küste (FZK)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker and Affiliation</th>
<th>Title</th>
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<tbody>
<tr>
<td>15:15</td>
<td>Klaus Schwarzer, Universität Kiel</td>
<td>Joint Thai-German TRIAS-Research Project - Tracing tsunami on- and offshore in the Andaman Sea Region (DFG-NRCT Coop.)</td>
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<tr>
<td>15:45</td>
<td>Jörn Lauterjung, Geoforschungszentrum (GFZ) Potsdam</td>
<td>German-Indonesian Tsunami Early Warning System (GITEWS): Present state and next steps</td>
</tr>
<tr>
<td>16:15</td>
<td>Jörn Behrens, AWI Bremerhaven</td>
<td>Development of an operational tsunami model for inclusion into the Indian Ocean Tsunami Early Warning System (GITEWS)</td>
</tr>
<tr>
<td>16:45</td>
<td>Torsten Schlurmann, Leibniz Universität Hannover, Franzius Institut</td>
<td>Ongoing tsunami projects in UNU-EHS (Capacity Building, Numerical Last Miles)</td>
</tr>
<tr>
<td>17:15</td>
<td>Dieter Kelletat and Anja Scheffers, Universität Duisburg, Essen</td>
<td>Tsunami deposits: Tasks for hydrodynamists towards more reliable tsunami hindcast</td>
</tr>
<tr>
<td>17:45</td>
<td>Joachim Grüne, Forschungszentrum Küste (FZK), Hannover</td>
<td>Tsunami shoaling and run-up in the Large Wave Flume of Hannover: Introduction to the demonstration tests</td>
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At least 5 min. should be left for discussion after each presentation.

### Demonstration Tests in the Large Wave Flume (GWK) of Forschungszentrum Küste (FZK)

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<tbody>
<tr>
<td>18:00</td>
<td>Demonstration tests in GWK (incl. transportation)</td>
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<td>20:00</td>
<td>DINNER</td>
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<td>Time</td>
<td>Speaker/Institution</td>
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<tr>
<td>08:30</td>
<td>Fumihiko Imamura</td>
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<td></td>
<td>Tsunami Engineering Disaster Control Center Tohoku University, Japan</td>
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<tr>
<td>09:00</td>
<td>Hamzah Latief</td>
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<td></td>
<td>Institute of Technology Bandung (ITB), Indonesia</td>
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<tr>
<td>09:30</td>
<td>Janaka Wijetunge</td>
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<td></td>
<td>Disaster Management Post Graduate Programme, University of Peradeniya, Sri Lanka</td>
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<td>10:00</td>
<td>V. Sundar</td>
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<td></td>
<td>Dept. of Ocean Engineering Indian Institute of Technology Madras, India</td>
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**Session 3: Experience and Related Research in Southeast Asia and Japan**

Chairman: Torsten Schlurmann, Leibniz University Hannover, Franzius Institute

At least 5 min. should be left for discussion after each lecture
### Session 4: Knowledge Gaps and Modelling Weaknesses

**Chairman:** Philip Liu, **Provocateur:** Patrick Lynett

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>11:00</td>
<td>Identification of basic knowledge gaps and priority research needs</td>
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<tr>
<td>12:00</td>
<td>Identification of modelling weaknesses and priority development needs</td>
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<tr>
<td>12:30</td>
<td>Summary of discussion results by the chairman</td>
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### Session 5: Potential Joint Research and Cooperation

**Chairman:** Hocine Oumeraci, **Provocateur:** Harry Yeh

<table>
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<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>12:40</td>
<td>Sören Dürr&lt;br&gt;Deutsche Forschungsgemeinschaft (DFG), Bonn&lt;br&gt;DFG - framework and opportunities for joint research and international cooperation</td>
</tr>
<tr>
<td>12:50</td>
<td>Reinhold Ollig, &quot;System Earth&quot;&lt;br&gt;Federal Ministry of Education and Research (BMBF), Bonn&lt;br&gt;BMBF - framework and opportunities for joint research and international cooperation</td>
</tr>
<tr>
<td>13:00</td>
<td>Harry Yeh&lt;br&gt;on behalf of Richard Fragaszy&lt;br&gt;National Science Foundation Directorate for Engineering (NSF), USA&lt;br&gt;NSF - framework and opportunities for joint research and international cooperation</td>
</tr>
<tr>
<td>13:10</td>
<td>Discussion</td>
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<td>13:30</td>
<td>LUNCH</td>
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<tr>
<td>14:30</td>
<td>Identification of joint research projects, including tentative agreements</td>
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<td>15:30</td>
<td>Identification of joint or other forms and procedures for cooperation (e.g. exchanges of research results, joint data base for model validation, benchmark tests, joint use of unique experimental faculties, etc.)</td>
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<tr>
<td>16:10</td>
<td>COFFEE BREAK</td>
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<tr>
<td>16:45</td>
<td>Summary of discussion results by the chairman</td>
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<td>17:00</td>
<td>Final Discussion</td>
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<td>17:15</td>
<td>Closure</td>
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ANNEXES
Multiple Defence Line Strategy

A major Tsunami is
- too difficult to predict
- too strong to control

Apparent uncontrollability and invincibility of major tsunami

Divide and Rule Defence strategy (DRDS)

Multiple Defence Lines, with the types, number and size of barriers to be adapted to local conditions and vulnerability of flood prone area

Man-Made Barriers
- ARTIFICIAL REEFS
  - Technical feasibility:
    - Hydraulic performance
  - Structural integrity (incl. scour)
- SEA WALLS
  - Overtopping performance, etc.
  - Structural integrity (incl. scour and scour protection)
- FORESTS
  - Damping performance
  - Structural integrity
- DUNES
  - Stability and breaching of natural and reinforced dunes
- RAISED BUILDINGS
  - Tsunami loading and structural integrity
  - Scour and scour protection
- MOBILE DEFENCE SYSTEMS
  - Development of further innovative systems
  - loading, structural integrity and overtopping performance
Multiple Defence Lines Strategy for Densely Urbanized Areas (schematic)

(1a) Innovative wave absorbers

(1b) Mega-Geo-Containers

(2a) Mangrove forests

(2b) Beach reinforcement (geotextile containers) sea walls, etc.

Coastal forests (casuarinaceae etc.) Alternatively: innovative damping structures (Norderney Type further developed for tsunami)

(3) Raised Buildings

(4) Damped Tsunami

(5a) Multipurpose Tsunami Resistant Buildings (Car parking etc.)

Tsunami resistant Building (Car park etc.)

or

(5b) Mobile flood defences for “hotspots” “critical facilities” 1 - 6

1 2 3

Damped Tsunami

4 5 6

“Critical facilities” (power plants, etc.)

Individual mobile flood defence

5
Research Needs to implement the multiple defence line system for the full range of Tsunami periods (T=5-60min).

- **How much?** > 500m
- **250 - 500m?**
- **50 - 100m?**

**(5a) Multipurpose Tsunami Resistant Buildings (Car parking etc.)**
- Tsunami damping for different types of forest
- Tsunami loads on single trees
- Hydraulic performance
- Structural integrity, incl. scour
- Overtopping performance
- Structural integrity, incl. scour

- Tsunami resistant Building
  (Car park etc.)

or

**(5b) Mobile flood defences for “hotspots” “critical facilities” 1 - 6**
- "Critical facilities" (power plants, etc.)
- Individual mobile flood defence

- **Damped Tsunami**
- Raised Buildings
- Very Large Artificial Reef

- HWL
- MWL
- LWL
Innovative Artificial Reef

- Developed and tested for wind waves in large wave flume
- Linearized theoretical model for the design developed and verified


Feasibility for the full range of wave periods of tsunami (5-60 mn) has to be first checked by numerical modelling before embarking into detailed studies (BOUSSINESQ-like Model in progress).

Does it work for tsunami?
Does it work for Tsunami? (2)

Submerged three-Filter System subject to a solitary wave

Incident wave

Reflected wave

Transmitted wave

Surface elevation $\eta$ [m]

Time relative to wave crest [s]

Incident wave

Reflected wave

Transmitted wave

$h_s = 3.94 \text{m}$

$h = 4.00 \text{m}$

$\eta = 20\%$  $11\%$  $5\%$

Wave gauge

$52.23 \text{m}$

$182.40 \text{m}$

$\text{t} = 188.024 \text{s}$  $\text{t} = 210.63 \text{s}$  $\text{t} = 208.19 \text{s}$

$\text{hs} = 3.94 \text{m}$

$h = 4.00 \text{m}$

$c_T = 0.33$

$c_R = 0.18$
Required Sand Reef parameters to be determined by numerical modelling (Technical and economic feasibility)

Reef Parameters

- Location depth \( h \)
- Structure width \( B \) and slope steepness \( 1:n \) and \( 1:m \)
- Reef height \( h_R \) and submergence depth \( R \)
- Size (volume, weight) of geotextile containers

must be determined as a function of target incident Tsunami wave parameters and target level of tsunami attenuation (transmitted wave parameters). The latter will depend on the nature of the next defence line(s) and the vulnerability of the flood prone area.
Example of Mega Geocontainers used for a surfing Reef in Australia

Feasibility for the full range of wave periods (5 - 60 minutes) of tsunamis has first to be first checked.
Develop generic Methodology for Parameterization of single Tree and Entire Forest

Systematic Laboratory Experiments on Hydraulic Performance for typical Mangrove Forest and Typical Beach Forest (Global Processes)

Large-Scale Experiments on Hydraulic Loading and Hydraulic Resistance (Local Processes)

Mathematical/ Numerical Modelling, Including Validation by Laboratory and Field Data
**Soft Tsunami Man-Made Barriers**

**Objective:**
⇒ To progressively weaken tsunami power without completely blocking inundation, but with additional benefit of broadly blocking floating debris.

**Application:**
⇒ As multi-purpose structures everywhere where planting of coastal forests is not feasible
⇒ Especially appropriate for touristic and urbanized coastal areas where man-made protective structures should be fitted aesthetically into the local marine landscape.

a) Design (Computer Animation)  

b) Built in Norderney (North Sea)
This light version has proved to be efficient against river floods. A more robust construction for tsunami is needed.

Credit: KWS (Switzerland)
New KWS - Mobile defence system for Coastal Zones

„Hot Spot“ (critical facilities to be protected)

Inflatable Tubes (Water)

Parapet

Gate

Net

45°

Shore
Concluding Remarks

Elaboration of a CEDM-TP (*) towards practical implementation of suggested „Divide and Rule Defence Strategy“ (multiple defence lines) requires additional research on the hydraulic performance, loading and structural integrity of each types of man-made and natural barriers which compose the entire defence system, incl.:

- Different types of artificial reefs (first defence line)
- Different types of sea walls
- Different types of forests
- Natural and reinforced dunes
- Raised buildings (e.g. for vertical evacuation)
- Mobile defence systems (last defence line)

However, the efficiency of the whole defence system strongly depends on the technical feasibility and performance of the first defence line (Artificial Reef).

Therefore the first research proposals should focus on this issue.

(*) CEDM-TP = Coastal Engineering Design Manual for Tsunami Protection
Future Research Topics

- Generation of Tsunami Wave trains instead of single solitary wave: This is important because generally the tsunami reach the nearshore-zone as a train of waves having the same propagation behaviour as solitary waves.

- Effect of Tsunami wave train on wave run-up and overwash as well as on down rush.

- Shoaling properties, incipient wave breaking and process of tsunami-wave train.

- Tsunami damping performance of different types of forest (mangroves, casuarinacciaeae) and man-made structures.

- Tsunami-induced Scour in front and around structures.
Thank you for your attention!