Hazard Mitigation Program, 
State Hazard Mitigation Plan, 
and 
Current Projects

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Guam Homeland Security/Office of Civil Defense 

Pacific Star Resort and Spa, Tumon, Guam 
06 February 2019
Hazard Mitigation Program

• FEMA Hazard Mitigation Assistance (HMA) Program
  • Hazard Mitigation Grant Program (HMGP)
  • Flood Mitigation Assistance (FMA)
  • Pre-Disaster Mitigation (PDM) Grant Program

• NOAA/NWS National Tsunami Hazard Mitigation Program (NTHMP)

• FEMA National Earthquake Hazards Reduction Program (NEHRP)

• DHS/FEMA
  • Emergency Management Performance Grant (EMPG) Program
  • Homeland Security Grants Program (HSGP)
State Hazard Mitigation Plan

• Approved: 24 July 2014
• The 2014 Guam HMP is authorized by the Guam Civil Defense Act of 1951, as amended by Public Law 24-298 (included in Original Government Code of Guam enacted by Public Law 1-88, 1952), and Executive Order 97-18
• State standard plan
• Currently being updated in-house
• Attention invited on:
  • Risk Assessment
  • Mitigation Strategy*
• Challenges:
  • Data collection
  • Baselines/data update
  • GIS support
State Hazard Mitigation Plan

- Soils
- Geology
- Vegetation
- Population
State Hazard Mitigation Plan

- Essential Facilities
- Major Utilities
- Transportation System
- General Building Stock
State Hazard Mitigation Plan

- Faults
- Liquefaction
- Local Seismicity
- Flooding
Guam Comprehensive Emergency Management Plan

• Approved: 13 Dec 2016
• Currently being updated in-house
• Pursuant to Guam Civil Defense Act of 1951, the Guam Comprehensive Emergency Management Plan (GUAM CEMP) is the master operations document for the Territory of Guam in responding to all emergencies, and all catastrophic, major, and minor disasters.

• The GUAM CEMP defines the responsibilities of all levels of government, private, volunteer and non-governmental organizations (NGOs) that make up the Guam Emergency Operations Center Emergency Support Function (EOC ESF) Team.

• The GUAM CEMP also captures the authority and role of the federal government in response to incidents and emergency events on Guam, including those which are presidentially declared disasters.

• The GUAM CEMP ensures that all levels of government are able to mobilize as a unified emergency organization to safeguard the well-being of Guam’s residents and visitors.
Guam Catastrophic Plan

- Jointly approved: 13 Feb 2018
- This *2018 Guam Catastrophic Typhoon Plan* is a capabilities-based document that follows National Incident Management System (NIMS)/Incident Command System (ICS) principles and will facilitate effective and efficient response and recovery operations in the response to a catastrophic typhoon strike on Guam.
- This plan was developed collaboratively with local, territorial, federal, nongovernmental, and private sector partners, consistent with the Whole Community doctrine.
- This plan presents actions that key Core Capability stakeholders may take to save and sustain lives and protect property of survivors impacted by a catastrophic typhoon on Guam.
## Concept of Operations – Time Phased

<table>
<thead>
<tr>
<th>COR 4</th>
<th>COR 1</th>
<th>2</th>
<th>3</th>
<th>COR 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 3</strong> Recovery</td>
<td><strong>Phase 2c</strong> Intermediate Operations</td>
<td><strong>Phase 2b</strong> Employment, Stabilization</td>
<td><strong>Phase 2a</strong> Activation, Situational Assessment</td>
<td><strong>Phase 1c</strong> Near certainty</td>
</tr>
</tbody>
</table>

### Notes
- **Long-term recovery Mitigation**
  - Private Sector Mass care, infrastructure Joint execution
  - Task Forces Water, Power, Transportation Federal push of resources
  - Activation Deploy capabilities Joint Planning
**Phase 1b: 5 days prior to anticipated landfall**

- Activations (RRCC, IMAT+)
  - ESF 8
  - ESF 3 power coordination team
- Development of logistics capability
  - Facilities (DC, ISB, Staging)
  - Staging Management Teams
  - Transportation capability
- Identify 1c push requirements
**Task Forces:**
- Form TF organization in Operations Section
- Develop planning cycle
- Identify capabilities
- Identify potential requirements

**Phase 1c: 48 hours prior to landfall**
- RSOI – Mobilization Support Operations
- Activate transportation capabilities (Air, Ground)
- Form the UCG
- Form Task Forces in Operations Section
- Push package (1c)
  - USACE Power PRT, 249th Prime Power, Advanced Contracting Initiative capabilities
  - NDMS
- Identify and activate resource capability (TF)
- Pre-landfall assessments
**Phase 2a**

**Task Forces:**
- Conduct post landfall assessments
- Develop response concepts
- Build capability (MAs, contracts, activations)

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**Hawaii**

**Phase 2a: Post-landfall**
- Continue RSOI function
- Transition movement coordination to a pull system
- Support assessments and build capability

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**Joint Organization**

- IOF
- FSA
- A. B. Won Pat International
- Andersen AFB
- Hawaii DC
- Hickam AFB APOD
- RRCC
- ISB
- Moffett DC

**Transportation Capability**

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**Final Plan Brief**
February 13, 2018
Task Forces:
- Build capability
- Execute (direct) operations
- Maintain a continuous assessment
- Maintain planning cycle

Phase 2b: Post-landfall
- Continue RSOI functions
- Transition movement coordination to a pull system
- Support assessment and build capability
Phase 2c

Task Forces:
- Execute (direct) operations
- Maintain a continuous assessment
- Maintain planning cycle

Joint Organization
JFO
Andersen AFB
Hawaii DC
A. B. Won Pat International
FSA
Guam DC
Hickam AFB
APOD
RRCC
Mobilization Support Facility
ISB
Moffett DC
Travis AFB
Hawaii

Pull resources as required from HI and CONUS
TF staff and capabilities as required

Phase 2c: Post-landfall
- Phase out RSOL functions
- Transition operational control and movement coordination to field

Shift focus of the operation to the field
Typhoon “Pakyo” Exercise

Tabletop Exercise
  • Date: 2\textsuperscript{nd} Week of June 2019

Full Scale Exercise
  • Date: 2\textsuperscript{nd} Week of June 2020

Pacific Wave Exercise
  • Date: TBA
NeoWave Tsunami Modeling for Apra Harbor, Guam
Basic Concepts and Terminology

- Distant (far-field) versus local (near-field) tsunamis
- Wave speed up to 950 km/hr (wave speed ≠ flow speed)
- Different flow characteristics from wind waves or swell
- 3D physical problems
- 2D mathematical models with pre-defined flow patterns over water column
- Inundation versus flow depth & runup
Community Input and Participation

Site visits and stakeholder meetings to define data products (January 16 – 18, 2018)

USCG Sector Guam
• Potential use of advisory-level tsunami scenarios in its severe weather plan
• Potential use of extreme tsunami scenarios for evacuation guidance
• Coordination with Port Authority of Guam and Naval Base Guam in plan development

Guam Power Authority
• Utilization of extreme tsunami scenarios in impact assessment of its power plant and fuel storage as well as siting of new facilities at Apra harbor

Guam Waterworks Authority
• Utilization of extreme tsunami scenarios in vulnerability assessment of its wastewater treatment plant at Agana Bay
Tsunami Surge Elevation offshore of Apra Harbor, Guam

From Mw 8.5 earthquakes at Pacific Subduction Zones

Four critical source locations identified

[Map showing tsunami surge elevation with various magnitudes indicated]
Critical Tsunami Sources for Guam

Source characteristics
- USGS and NOAA PMEL fault parameterization (Gica et al., 2008)
- Global Earthquake Model (Berryman et al., 2015)

<table>
<thead>
<tr>
<th>Direction</th>
<th>Tsunami Source</th>
<th>Dip (°)</th>
<th>Convergence Rate (mm/yr)</th>
<th>Coupling Coef (Preferred)</th>
<th>Magnitude (Preferred max)</th>
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</thead>
<tbody>
<tr>
<td>Local</td>
<td>Marianas*</td>
<td>22</td>
<td>63</td>
<td>0.1 – 0.7 (0.2)</td>
<td>7.2 – 9.5 (8.3)</td>
</tr>
<tr>
<td>North</td>
<td>Nankai*</td>
<td>13</td>
<td>50</td>
<td>0.8 – 1.0 (0.9)</td>
<td>8.5 – 8.9 (8.7)</td>
</tr>
<tr>
<td></td>
<td>Ryukyu</td>
<td>17</td>
<td>96</td>
<td>0.1 – 0.7 (0.2)</td>
<td>8.0 – 9.1 (8.5)</td>
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<tr>
<td>West</td>
<td>Philippine*</td>
<td>46</td>
<td>36</td>
<td>0.1 – 0.8 (0.3)</td>
<td>7.6 – 9.3 (8.5)</td>
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<tr>
<td>South</td>
<td>New Guinea*</td>
<td>8</td>
<td>22</td>
<td>0.6 – 0.8 (0.7)</td>
<td>8.2 – 9.4 (8.8)</td>
</tr>
<tr>
<td></td>
<td>Manus</td>
<td>15</td>
<td>9</td>
<td>0.3 – 0.7 (0.5)</td>
<td>7.5 – 9.5 (8.5)</td>
</tr>
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</table>

*Selected for modeling
Earthquake Source Models

Tectonics
• Mw 0.1 interval up to the GEM preferred maximum magnitude
• USGS/PMEL seismic source parameters and geometry

Rupture scenarios
• Ye, Lay, Kanamori & Rivera (2016a, b, JGR Solid Earth)
• Scaling relation from Mw 7.0+ megathrust earthquakes from 1990 to 2016
• Dimensions constrained by local subduction zone

• Slip determined from seismic moment with assumed rigidity of $3 \times 10^{10}$ N/m$^2$

Earthquake location
• Most direct path of the tsunami to Guam
## Digital Elevation Model – Data Sources

<table>
<thead>
<tr>
<th>Year</th>
<th>Dataset</th>
<th>Resolution</th>
<th>Coverage</th>
<th>Source</th>
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<tr>
<td>2009</td>
<td>GEBCO</td>
<td>0.5 min</td>
<td>Global</td>
<td>BODC</td>
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<tr>
<td>2003</td>
<td>Multi-beam bathymetry</td>
<td>60 m</td>
<td>Guam (~3.5 km depth)</td>
<td>UH SOEST</td>
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<tr>
<td>2007</td>
<td>Multi-beam bathymetry</td>
<td>5 m</td>
<td>Guam (~400 m depth)</td>
<td>UH SOEST</td>
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<td>2008</td>
<td>Multi-beam bathymetry</td>
<td>1 m</td>
<td>Apra Harbor</td>
<td>NOAA PSC</td>
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<tr>
<td>2001</td>
<td>SHOALS bathymetry</td>
<td>3~4 m</td>
<td>Guam (~40 m depth)</td>
<td>USACE</td>
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<tr>
<td>2007</td>
<td>LiDAR bathymetry</td>
<td>4 m</td>
<td>Guam (~40 m depth)</td>
<td>NOAA PSC</td>
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<tr>
<td>2007</td>
<td>LiDAR topography</td>
<td>0.5 m</td>
<td>Guam</td>
<td>NOAA PSC</td>
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<td>Chart Nos. 4196, 4197</td>
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<td>Apra Harbor &amp; Vicinity</td>
<td>NOAA</td>
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<td>2018</td>
<td>Site Visit</td>
<td>-</td>
<td>Apra Harbor &amp; Vicinity</td>
<td>-</td>
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Computational Grids

Nested grid systems
- Four levels of two-way nested grids
- Telescoping from the tsunami sources to Apra Harbor
- Removal of pile supported piers and docks from terrain model
Mw 8.5 Nankai Earthquake Scenario
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2015 NTHMP Benchmark Results

Models 1-8: 2D

Models 9-12: 2D+
41% in speed

Models 13 & 14: 3D
26%
14%

Lloyd & Stansby (1997, J Hyd Eng)
Lynett et al. (2017 Ocean Modelling)
Nankai Trough Earthquake Scenarios
Philippine Trench Earthquake Scenarios

Surge

Drawdown

Current

Mw 8.1

Mw 8.3

Mw 8.5
Mw 8.0 Mariana Trench Earthquake Scenario
Mariana Trench Earthquake Scenarios
Maximum Philippine Scenario: Guidance for Ship Evacuation
Summary and Continuing Work

Data products include
- In-harbor hazard maps of surge, drawdown, and currents for advisory-level tsunami scenarios from four critical source locations.
- Maps of offshore surge and current for preferred maximum tsunamis from the critical source locations

Discussion
- Summary tables for advisory-level scenarios
- Aggregation of maximum scenarios to one set of hazard maps
- Data format: pdf, ArcGIS, Google XML

Continuing and Future work
- Tumon and Agana Bays
- Agat Marina
- Pago Bay
Save-The-Date

• Response Activity Coordinators/Emergency Support Function Coordinators Workshop
  Date: 19 Mar 2019
  Venue: TBA

• Mitigation Strategies and Opportunities Workshop
  Date: 26-27 Mar 2019
  Venue: Westin Resort Guam, Tumon
Thank you!

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