Introduction to GenCade

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Outline

- What is GenCade?
- Background, overview, and conceptual coverage
- GenCade capabilities
- GenCade limitations and assumptions
- Workflow
- Model theory and formulation
- I/O Files and Cards
GENESIS + Cascade → GenCade

**Cascade (top to bottom)**
- Planning tool (RSM Support)
- Time scales: months to centuries
- Multiple inlets, shoals, and barrier islands; cumulative impacts; retains curvature of regional geomorphology
- Fast
- Typical grid resolution ~ 500 m

**GENESIS (bottom to top)**
- Engineering design tool
- Can represent all engineering details – structures, etc.
- Mature technology – big payback by updating
- Typical grid resolution ~ 25 m

**Strategy**: Add Cascade capabilities to GENESIS to automatically include all GENESIS features.
GENESIS + Cascade → GenCade

- Integrate from planning through engineering design
- Cover time scales from one year to centuries
- Preserve regional trends
- Furnish regionally consistent boundary conditions to local projects
- Represent cumulative local projects interacting regionally
- Represent inlet bypassing and tidal delta evolution
- Resolve engineered elements
- Include variable grid resolution for accuracy and efficiency
- Improve computational efficiency (over GENESIS)

**Strategy**: Add Cascade capabilities to GENESIS to automatically include all GENESIS features
Innovative solutions for a safer, better world

BUILDING STRONG®

GenCade Webinar, Coastal Inlets Research Program, 16-18 October 2012

GenCade Conceptual Processes:
Coastal Sediment Dynamics

Ebb shoal

Fire Island

Moriches Bay

Flood shoal

Atlantic Ocean

Dune erosion

Coastal Structures:
- Impoundment
- Bypassing

Wind-blown sand

Overwash

Cross-shore Transport

Longshore Transport

~150,000 m³/yr

$D_{50} = 0.27 \text{ (W)}$
$0.38 \text{ (E)}$

11-17-04
GenCade Applicability

Regional processes, Long-term morphology change

Project Planning & Design

Habitat Change

- Regional Sediment Management
  - Beach fills
  - Inlet bypassing
  - Channel maintenance
- Unifying technology for multiple projects
- Intuitive interface (SMS)
Model Functionality and Capabilities

- Variable resolution grids
- Inlet bypassing
- Inlet Reservoir Model for calculation of shoal and inlet feature sediment balance
- Representation of regional morphologic trends
- Multiple wave input forcing locations
- Representation of coastal structures: groins, jetties, seawalls, t-head groins, breakwaters, etc.
- Calculation of salients and tombolos behind breakwaters
- Time-dependent detached breakwater transmission
- Efficient calculation of breaking wave properties in internal wave model
GenCade Assumptions

- Beach profile maintains a constant average shape
- Longshore transport occurs only between top of berm and depth of closure (or active transport)
- Sand transported alongshore by breaking waves is not affected by nearshore current patterns
- There is a long-term trend in shoreline evolution
- The detailed structure of the nearshore circulation is ignored
General Workflow

- Coastal Problem
  - Formulate question
  - Identify constraints
  - Develop criteria to review and evaluate the solutions
- Assemble and analyze relevant input data
- Develop engineering solutions and alternatives
- Develop and execute GenCade to optimize project solutions and alternatives
- Calibrate, Validate, Evaluate Alternatives
- Evaluate results
GenCade Workflow

- Compile project data
- Assimilate data as GenCade forcing or BC input
- Develop conceptual model from input data
- Develop GenCade project grid and alternatives

- Execute calibration simulations/sensitivity tests
- Review and analyze calibration results
- Refine setups
- Execute production simulations

- Review results
- Analyze and post-process results
GenCade Workflow

Inputs:
- Survey data
- Waves
- Structure information
- Inlet information
- Beach Fill
- Dredging

Pre-process inputs → GenCade grid regular/irregular

Develop initial shoreline
Develop regional contour
Assign wave inputs
Supply input control parameters
Structures or coastal projects
Inlets, shoals, dredging events
Beach fill events

Simulation outputs:
GenCade solution files
Innovative solutions for a safer, better world

GenCade Workflow

Inputs:
GenCade Solution files; Measured Data

Post-process outputs:
Calculations, figures, images, exported data

Post-process

Transport rates
Sediment budgets
Shoreline Change
Inlet bypass/shoal evolution
Compare measured
Compare alternatives
Model Formulation

Longshore Net Volume Change:  \[
\frac{dQ}{dt} = \left( \frac{\partial Q}{\partial x} \right) dx dt
\]

Cross-shore Net Volume Change:  \[
dqdt
\]

Total Volume Change:  \[
dV = dx dy (D_B + D_C) = \left( \frac{\partial Q}{\partial x} \right) dx dt + q dx dt
\]

∴ as \( dt \to 0 \):  \[
\frac{\partial y}{\partial t} + \frac{1}{D_B + D_C} \left[ \frac{\partial Q}{\partial x} - q \right] = 0
\]
Model Formulation

Sediment transport rate $Q$ (m$^3$/s):

$$Q = \left( H^2 C_g \right)_b \left( a_1 \sin 2\alpha_{bs} - a_2 \cos \alpha_{bs} \frac{\partial H_b}{\partial x} \right)$$

Where,
- $H =$ wave height (m)
- $C_g =$ wave group speed (m/s)
- $\alpha_{bs} =$ angle of the breaking

$$a_1 = \frac{K_1}{16(\rho_s / \rho - 1)(1 - p)1.416^{5/2}}$$

$$a_2 = \frac{K_2}{8(\rho_s / \rho - 1)(1 - p)\tan \beta 1.416^{5/2}}$$

Typically, value of $K_2$ is:
$$0.5K_1 < K_2 < 1.5K_1$$

Where,
- $K_1 =$ Primary empirical transport coefficient (controls magnitude of longshore transport rate)
- $K_2 =$ Secondary empirical transport coefficient (controls distribution of sand within an area; esp. where large wave height gradients, e.g. salients)
- $\tan \beta =$ average bottom slope
Inlet Reservoir Model
Inlet bypassing and evolution of inlet deltas

Ocean

Up-Drift Barrier Is.

Bay

Down-Drift Barrier Is.

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## Output File Format for GenCade

### Instantaneous Net Transport at Output Time (*.qtr) File

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2 through Column NX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date (yyyymmdd)</td>
<td>Net sediment transport (length³/year) for each grid cell</td>
</tr>
</tbody>
</table>

### Mean Net Transport Over Simulation or Specified Time (*.mqn) File

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2 through Column NX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date (yyyymmdd)</td>
<td>Net sediment transport (length³/year) for each grid cell averaged over entire simulation (and optionally from start to specified times)</td>
</tr>
</tbody>
</table>

### Mean Left Transport Over Simulation or Specified Time (*.mql) File

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2 through Column NX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date (yyyymmdd)</td>
<td>Sediment transport (length³/year) to left for each grid cell averaged over entire simulation (and optionally from start to specified times)</td>
</tr>
</tbody>
</table>

### Mean Right Transport Over Simulation or Specified Time (*.mqr) File

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2 through Column NX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date (yyyymmdd)</td>
<td>Sediment transport (length³/year) to right for each grid cell averaged over entire simulation (and optionally from start to specified times)</td>
</tr>
</tbody>
</table>
### Output File Format for GenCade

#### Shoreline Position at Output Time (*.slo) File

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2 through Column NX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date (yyyymmdd)</td>
<td>Y-position of shoreline (length unit) for each grid cell</td>
</tr>
</tbody>
</table>

#### Calculated Offshore Contour at Output Time (*.off) File

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2 through Column NX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date (yyyymmdd)</td>
<td>Y-position of offshore contour applied to wave transformation (length unit) for each grid cell</td>
</tr>
</tbody>
</table>

#### Inlet Shoal Volume Output (*.irv) File (one file for each inlet)

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2 Through Column 16</th>
<th>Column 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-step at which shoal volumes are printed as output</td>
<td>Shoal volume (length(^3)) or in ./out volume at each shoal output time-step for the morphological shoal features identified in the figure below</td>
<td>Date (yyyymmdd)</td>
</tr>
</tbody>
</table>
GenCade Input Cards

- **TITLE** Title of simulation run
- **INIFILE** Path and name of initial shoreline file
- **REGFILE** Path and name of regional shoreline file
- **NUMWAVES** Number of wave input locations/files
- **WAVEID** Cell ID; Depth; number of wave events; and file path/name of wave input data (1 WAVEID line/file)
- **PROFILE** Path and name of printed output file
- **GENUNITS** (ft) or (m) System of units for model I/O
- **X0** X-origin
- **Y0** Y-origin
- **AZIMUTH** Angle (deg) of grid rotation about origin
- **NX** Number of alongshore cells
- **DX** Cell resolution or -1 indicates variable resolution
- **SIMDATS** YYYYYMMDD Start date of simulation
- **SIMDATE** YYYYYMMDD Ending date of simulation
- **DT** 1.0 Time step in hours
- **DTSAVE** 10.0 Data (shoreline/transport) output times
- **K1** 0.5 Longshore sediment transport coefficient 1
- **K2** 0.25 Longshore sediment transport coefficient 2
- **PRTOUT** Output to PROFILE yes (t), no (f)
- **PRWARN** Print warnings yes (t), no (f)
- **PRDATE** Dates to save simulated shoreline
- **ISMOOTH** 11 #cells in offshore contour smoothing
- **IREG** Include regional contour (1 = yes; 0 = no)
- **HAMP** 1.0 Height amplification factor
- **THETAAMP** 1.0 Angle amplification factor
- **THETADEL** 0.0 Angle offset
- **LMOVY** 0.0 Leftward shoreline displacement velocity
- **D50** 0.33 Grain size diameter in millimeters
- **BERMHT** 2 Average berm height
- **DCLOS** 8 Depth of closure
- **LBCTYPE** 0 Left boundary condition type
- **LMOVY** 0.0 Leftward shoreline displacement velocity
- **LMOVPER** 1 Simulation period (0), day(1), time step (2) period for LMOVY
- **LGROINY** 0.0 Length of left groin from shoreline to seaward tip
- **RBCTYPE** 0 Right boundary condition type
- **RMOVY** 0.0 Rightward shoreline displacement velocity
- **RMOVPER** 1 Simulation period (0), day(1), time step (2) period for RMOVY
- **RGROINY** 0.0 Length of right groin from shoreline to seaward tip
GenCade – Variable Grid Alongshore

Detached Breakwater
3-month simulation

250 m offshore
100 m long

$H = 1 \, \text{m}, \, T = 5 \, \text{sec}, \, \theta = -5 \, \text{deg.}$

$N = 200$
$DX = 10 \, \text{m}$

$N = 40$
$DX_{\text{max}} = 100 \, \text{m}$
$DX_{\text{min}} = 10 \, \text{m}$
GenCade – Transmissive Breakwater

Detached Breakwater
12-month simulation

60 m offshore
100 m long

H = 1 m, T = 5 sec, θ = -5 deg.

N = 200
DX = 10 m
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http://cirpwiki.info/wiki/GenCade
http://cirp.usace.army.mil/products