



GENCADE MODEL IMPROVEMENT AND DOCUMENTATION

INLET ENGINEERING TOOLBOX

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District PDT Members

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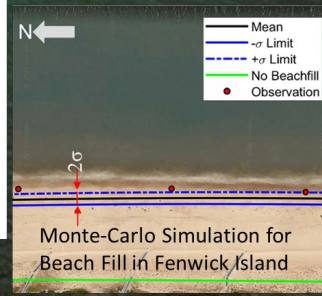
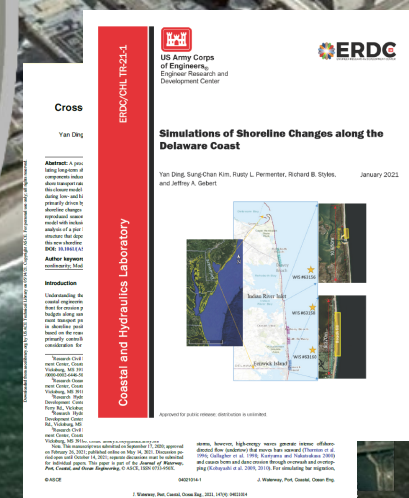
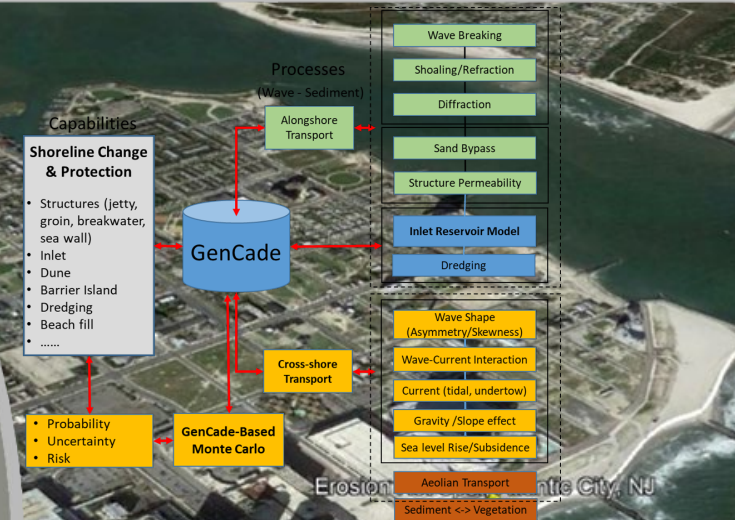
COASTAL INLETS RESEARCH PROGRAM

FY22 IN PROGRESS REVIEW

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Problem Statement

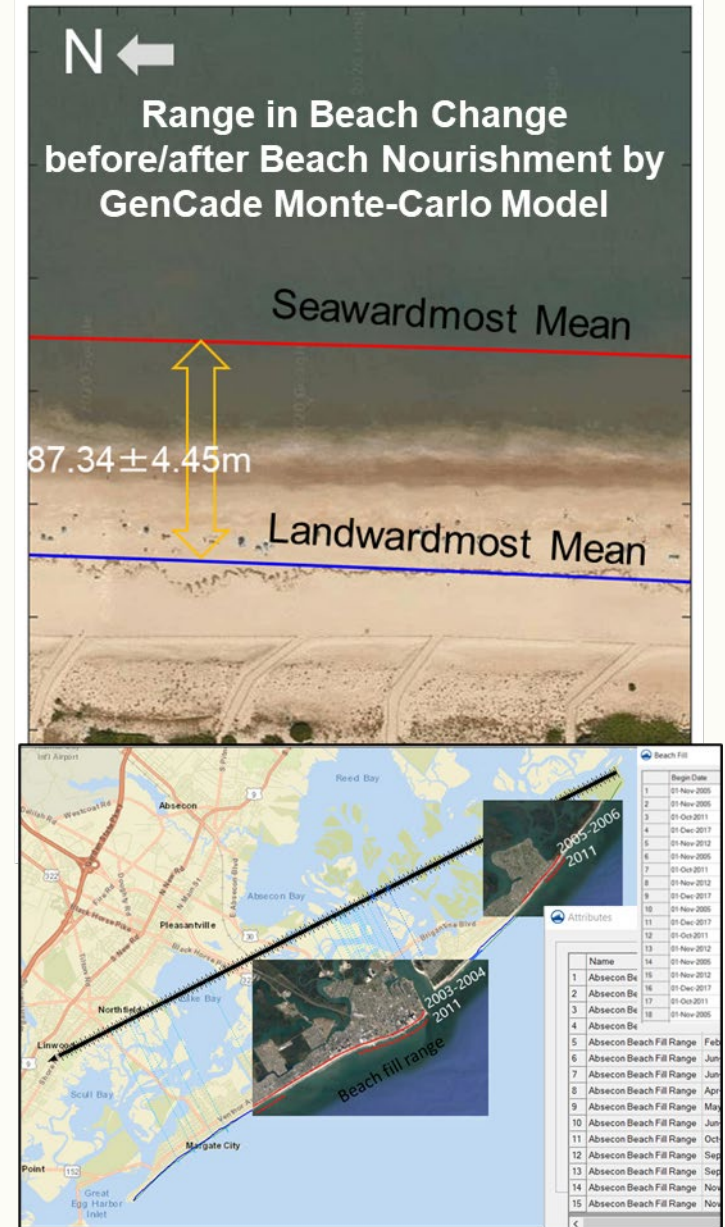
- Prediction of long-term (decadal) and regional ($10^1 \sim 10^2$ km) shoreline changes is a key task in regional coastal management practices.
- A range of methods including beach fills/nourishment, sand bypassing and structures have been utilized to mitigate coastal erosion. The Regional benefits and interactions of these methods are difficult to quantify along regional-scale coastlines.
- Quantifying erosion risk and uncertainty in simulating long-term shoreline changes is essential for risk-based coastal management practice.
- GenCade provides various capabilities for predicting long-term and regional shoreline evolution driven by longshore and cross-shore transport and coastal protection measures. The model has to be validated by applying to engineering practices.

Strategic R&D: Innovation in Sediment Management (Shoreline Erosion)

SoN #1846 - Development of Long-term Simulation Capabilities to Predict Risk-Based Shoreline Changes in Regional-Scale Coast

SoN-NAV-1726 (Nearshore Nourishment Best Management Practices)

SoN-1386 (Strategic Nearshore Placement of Dredged Material to Sustain Coastal Beach & Dune Resilience)



Capability and Strategic Impact Statement

CAPABILITIES

- GenCade simulates **long-term** shoreline change, longshore and cross-shore sand transport, and inlet morphology on a local to **regional** scale.
- Provides long-term impact assessment of structure and non-structural protection measures for engineering planning.
- Operated in SMS, GenCade brings functionality of a georeferenced environment together with accessibility of other USACE numerical models (CMS, SBAS, etc).
- The GenCade team provides training workshops, technical services, and trouble shooting.



APPLICATIONS

- GenCade shoreline evolution model has been successfully applied to reproduce long-term shoreline changes with various erosion protection measures.
- Long-term shoreline simulations are essential to evaluate long-term (e.g., a life cycle) effect of erosion protection.
- GenCade Monte-Carlo simulation provides an effective tool to estimate uncertainties of shoreline changes and sediment transport driven by wave conditions and erosion protections.

BENEFITS

- Predictions of shoreline changes and sediment transport volumes facilitate optimization of regional sediment management, which can provide cost-effective solutions.
- Quantify erosion risks and uncertainty of protection measures for risk-based coast design.
- Continuous improvement of simulation capabilities, user training, and technical services broaden benefits of GenCade for CSRМ practices.

GenCade – SMS 13.2+ interface (DMI and others)

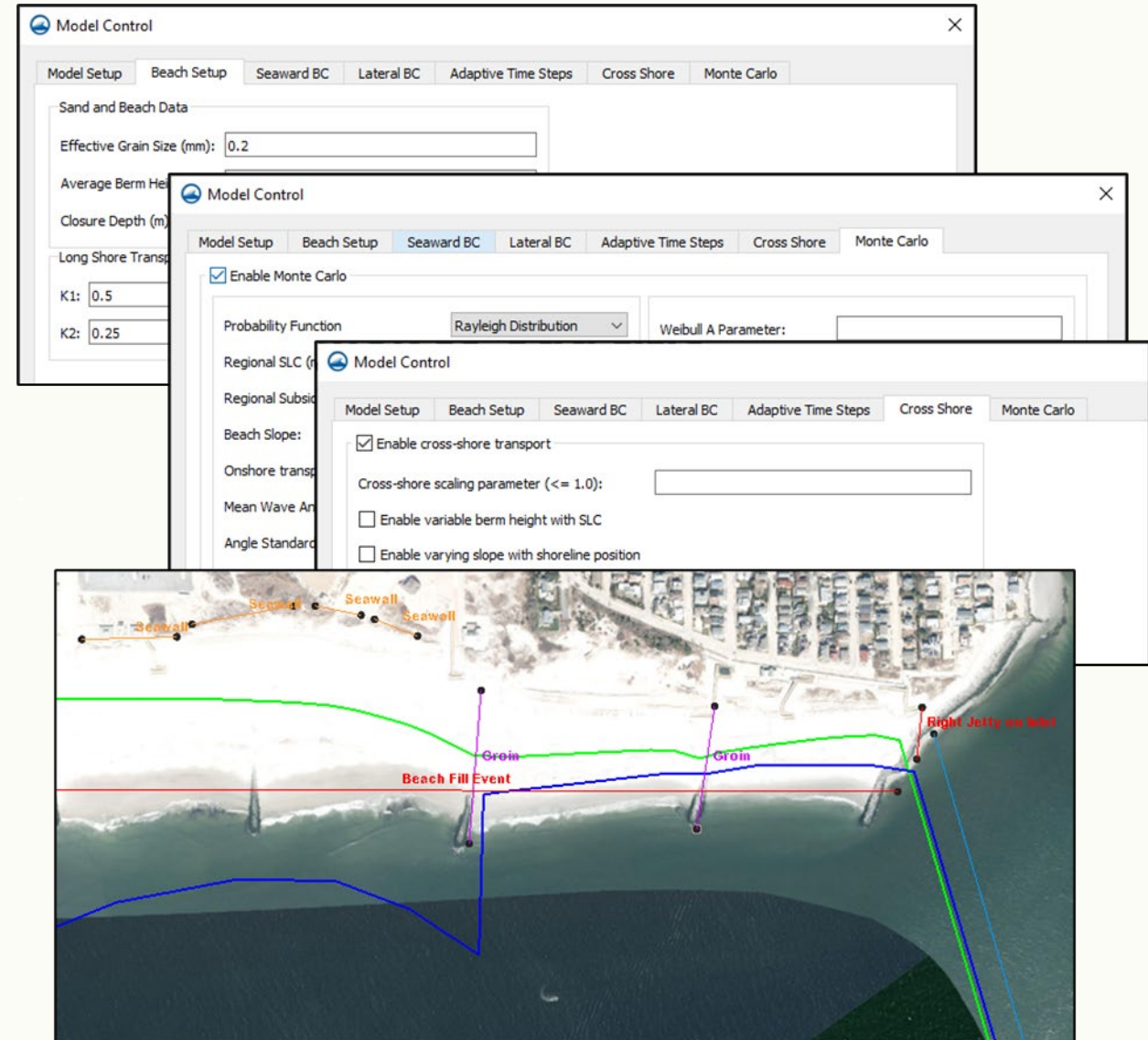
Approximately 70% complete.
Will finish Q3 FY23

Completed:

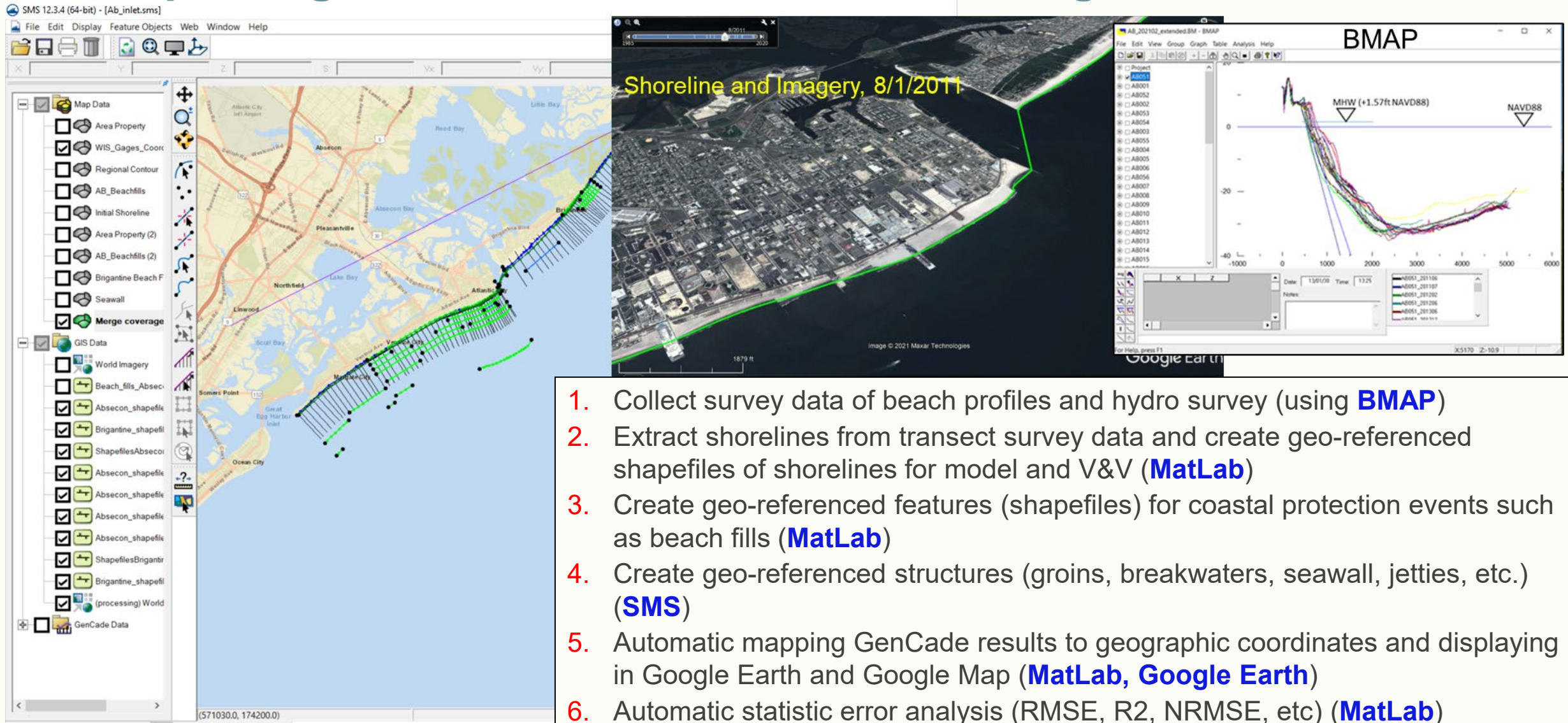
- Recreate all feature arc types with more user-friendly look and feel.
- Generation of 1d grid
- Model Control including new Cross-shore and Monte Carlo

Remaining:

- Refine points for 1d grid
- Tables for events (beach fill, bypassing, etc.)
- Wave points
- Import/Export parameter files

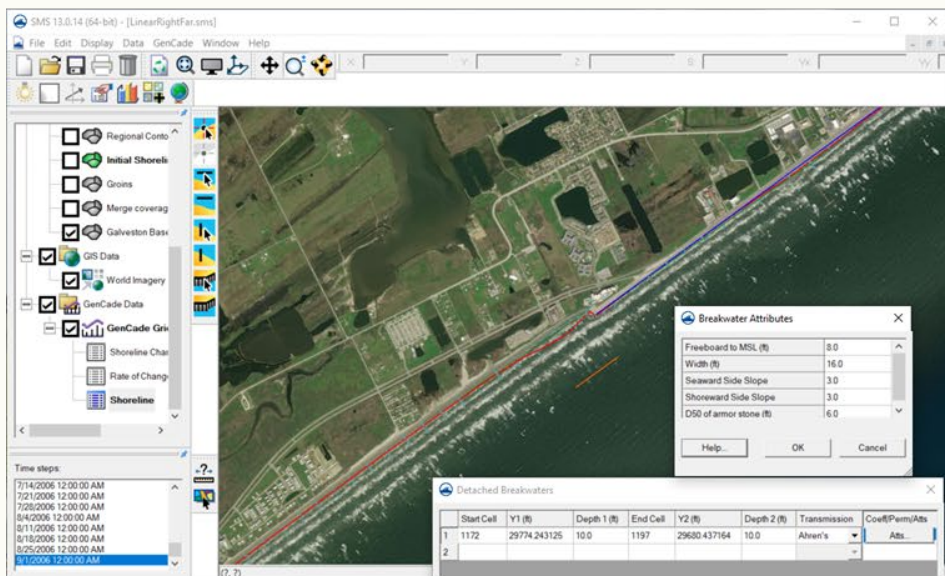


Develop a Regional Scale GenCade Model using GIS & Others



GenCade: Technical Transfer

- Internally release GenCade v2.0 (to SWG, SPL)
- GenCade Workshop, Mobile District, Mobile, AL, 09/22/2022
- CIRP TD on GenCade and CMS for Absecon Inlet, 10/25/2022
- One presentation in Coastal Sediments 2023 (NAP-Absecon)
- One presentation about GenCade in Lynnhaven Inlet to NAO
- One oral-presentation planned for ASCE-EWRI' 23,06/21/2023
- Assisted SWG for running GenCade, Aug.-Sept. 2022
- Assisted NAP to organize review meeting of NAP project



GenCade for Galveston Island

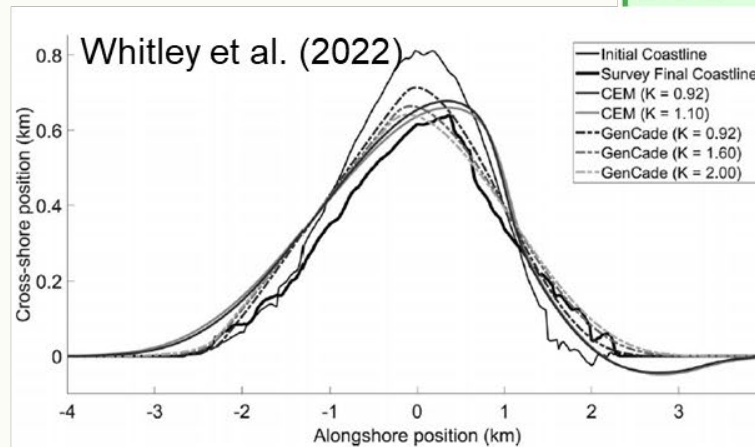


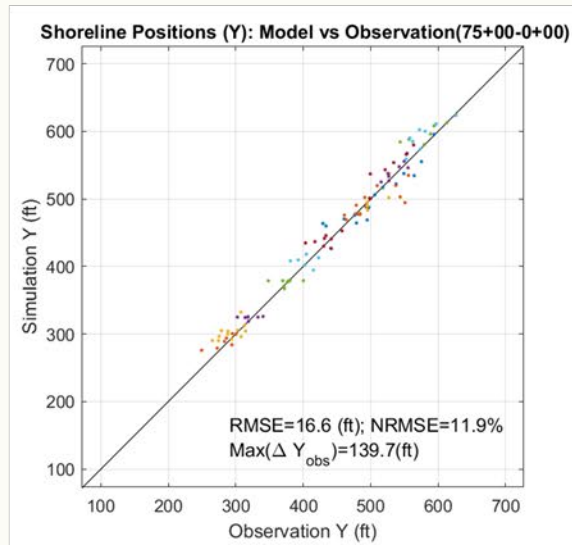
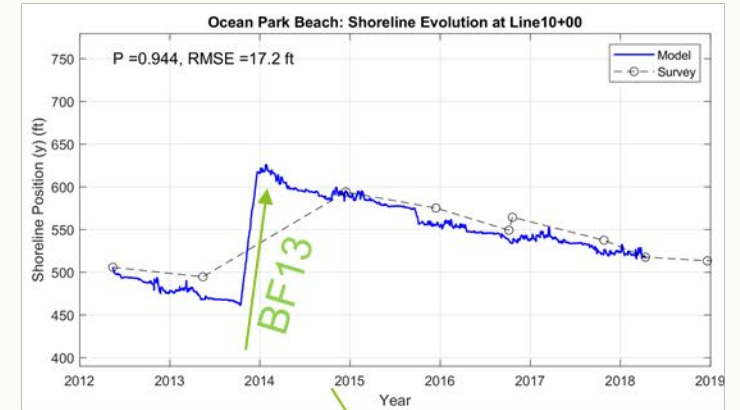
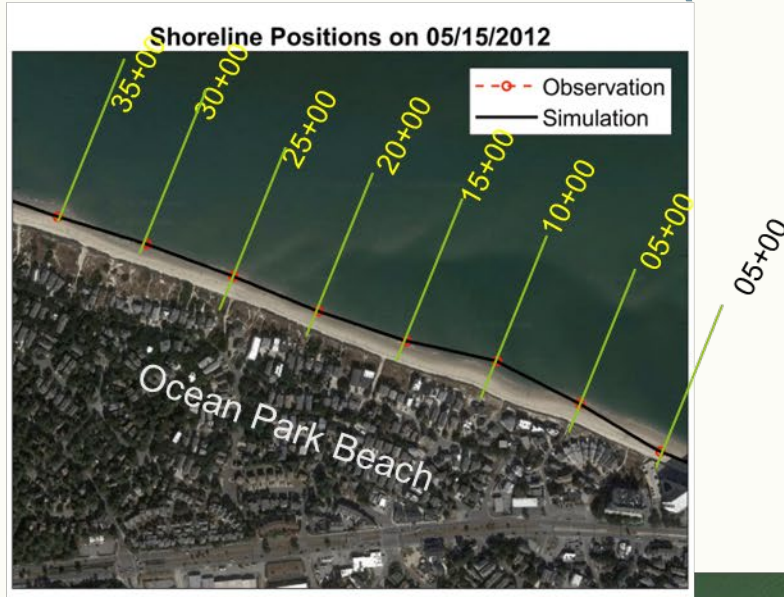
Figure 5. Measured and simulated shoreline positions (initial to final after 3.5 years) for CEM and GenCade. The model results with the best-performing metrics are shown. Note that cross-shore scale is stretched to aid in visualization of modeled shoreline differences.

GenCade for Mega-nourishment evolution

Sep	Tue, 20 Sep	Wed, 21 Sep	Thu, 22 Sep	Fri, 23 Sep
	CMS (v5.2) Flow grid creation Flow model control hands-on	CMS (v5.2) Steering Post-processing Hydro-validation hands-on	GenCade (v1.1.8) Introduction to GenCade Simple Example Walk-Thru hands-on	CMS (v5.2) Multiple Sediment Grain Sizes Advanced Topics SMS 13.2 demo Final Questions Workshop Concludes
Lunch on your own				
	CMS (v5.2) Wave grid creation Wave model control hands-on	CMS (v5.2) Sediment Transport Morphology Change hands-on	GenCade (v1.1.8) hands-on New topics: Cross-shore Monte Carlo Q&A session	

Regional-Scale Shoreline Evolution Simulations (FY23 Reimbursable Projects)

- Lynnhaven Inlet (NAN)

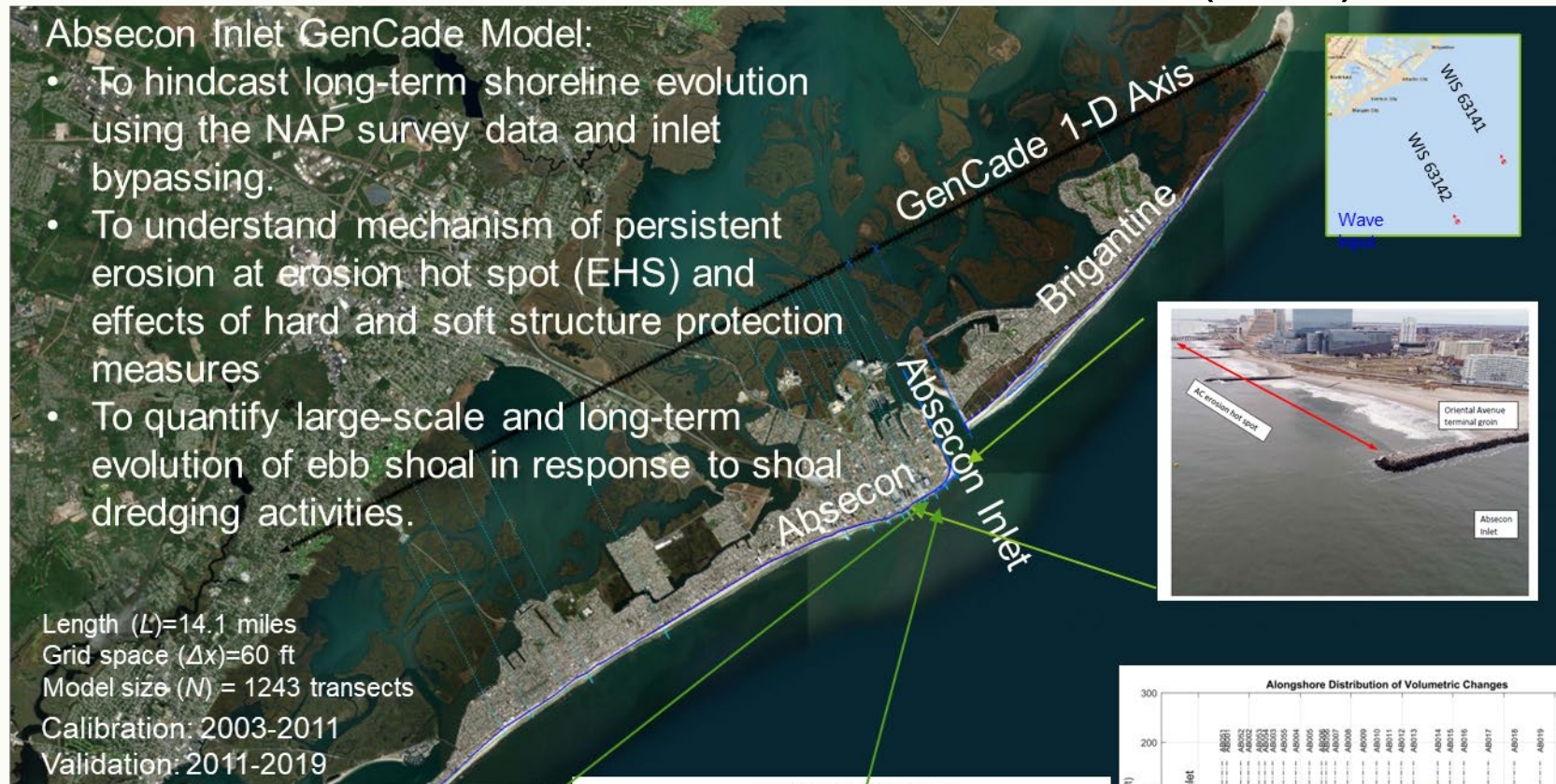


GenCade Shoreline Model for Absecon Inlet (NAP)

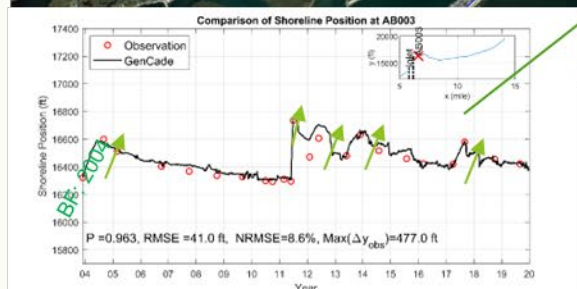
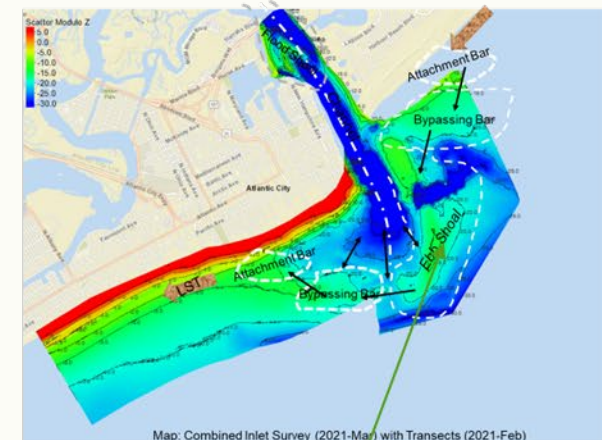
Absecon Inlet GenCade Model:

- To hindcast long-term shoreline evolution using the NAP survey data and inlet bypassing
- To understand mechanism of persistent erosion at erosion hot spot (EHS) and effects of hard and soft structure protection measures
- To quantify large-scale and long-term evolution of ebb shoal in response to shoal dredging activities.

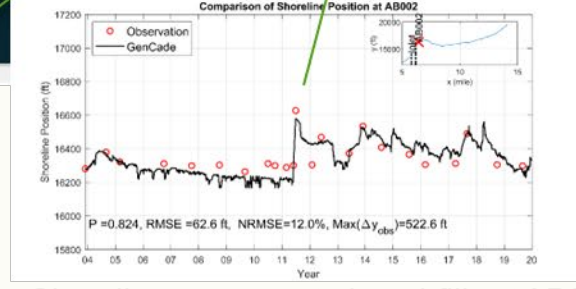
Length (L)=14.1 miles
 Grid space (Δx)=60 ft
 Model size (N) = 1243 transects
 Calibration: 2003-2011
 Validation: 2011-2019



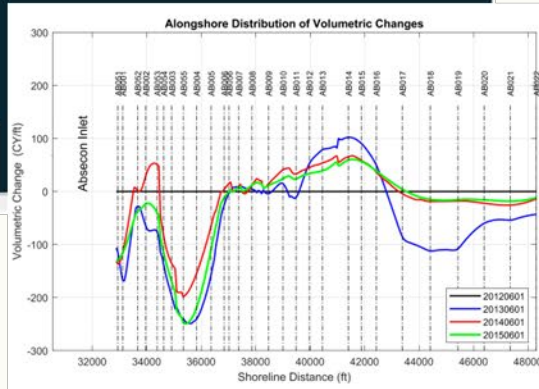
Absecon Inlet Reservoir Model for Inlet Morphology



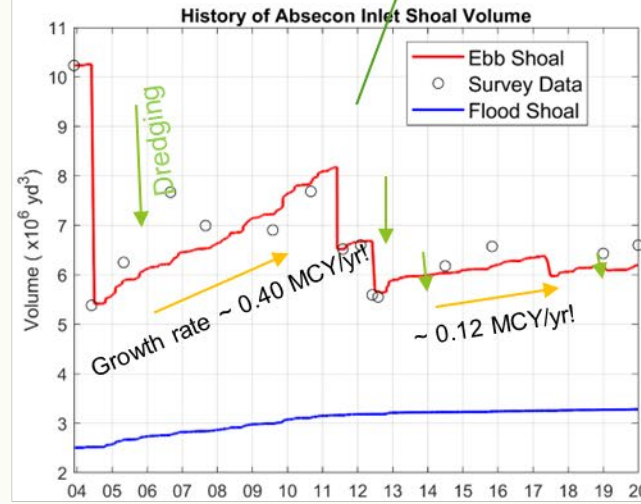
Shoreline response to beachfills at AB003



Shoreline response to beachfills at AB002



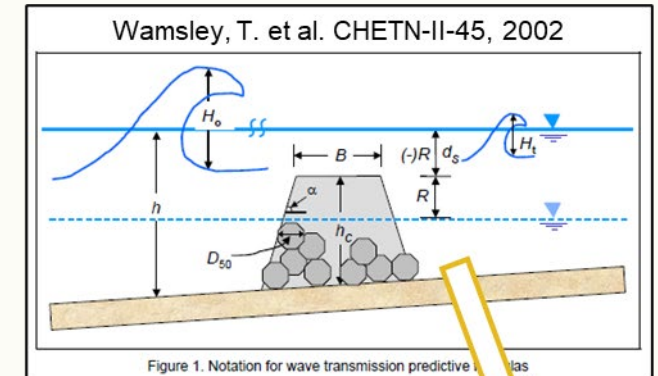
Volume Changes at EHS



Volume Changes of Ebb Shoals and Effect of Dredging (2003-2020) by GenCade-IRM model

GenCade: Code Improvement and Accessory Tool Development

- Develop a new version (v2p0) by merging the version with cross-shore and Monte-Carlo into the released version V1r8. The DMI in SMS 13.1 will be available for it.
- Bug fixed for calculation wave transmission by 3 formulations (Seabrook & Hall, Ahren, d'Angremond)
- Debugging, testing, and V&V about modeling structures:
 - Bugs in wave diffracting calculation, seawall module, and buried structures
 - New bypassing algorithm: Types of structures: Groin, Jetty,
- Develop a suite of tools (Matlab and Fortran) for statistic error analysis for
 - (1) Quantifying model skill performance (model skill assessment metrics)
 - (2) Monte-Carlo result analysis (including maximum likelihood analysis for extreme shoreline changes, uncertainty estimation, erosion estimation in return periods)
 - (3) Spectral analysis of waves to determine random wave conditions
 - (4) User-defined wave inputs for Monte-Carlo simulations
- Develop a procedure to use both GenCade and CMS model for beach erosion protection (NAP)
- Update GenCade wiki site
- Converting the old Fortran codes to Fortran 90 (modernize the codes)
- Code management



SMS 12.3

Breakwater Attributes

Freeboard to MSL (m)	3.0
Width (m)	3.0
Seaward Side Slope	0.333
Shoreward Side Slope	0.53
D50 of armor stone (m)	0.9

Help... OK Cancel

Detached Breakwaters

	Start Cell	Y1 (ft)	Depth 1 (ft)	End Cell	Y2 (ft)	Depth 2 (ft)	Transmission	Coef/Perm/Atts
1	576	16836.77767	17.57	584	16836.77767	17.57	Ahren's	Atts...
2							Constant	

Transmission dropdown menu options: Ahren's, Constant, Ahren's, Seabrook & Hall d'Angremond

Summary

FY22 Major Advances in Capability

- Internally release GenCade v2.0
- Develop DMI GenCade Interface (near completion)
- Upgraded GenCade to include Monte-Carlo and Cross-Shore transport
- Debug and optimize codes
- Reimbursable projects (NAP, NAO, EWN/SAS, SAM)
- Publications and technical transfer

FY22 Major Products & Collaborations

- 1 LR: LR for NAP project (LR-23-01) ,
- 1 TR GenCade Monte-Carlo simulation, *TR-xx-DRAFT*, in preparation, will be drafted by Q3
- 1 CP: in Coastal Sediments 23 Proceeding
- 1 Training Workshop: 09/21/2022
- 4 Oral Presentations in conferences
- 3 Reimbursable Projects: NAP, SAS, SPL
- Leveraging to other Programs: CMS (wave/flow/sediment)

Planned Outyear Products/Advances

- Continue working on DMI development with Aquaveo (FY23)
- Review numerical technology to couple shoreline model with regional morphology models (FY23)
- Propose a coupling algorithm for shoreline evolution and sediment transport by GenCade+CMS (FY23)
- Release GenCade V.2.0 (Cross-shore + Monte-Carlo), publish TR (FY23)
- Cross-shore transport for beach fill / nourishment and nearshore placement:
- Data assimilation for predicting long-term and regional shoreline evolution (CODS task)
- Stochastic Wave Climate model (SWCM) under CODS will leverage the capability of GenCade-MC
- CoastSat for GenCade
- Collaboration with universities and other agencies (USGS-CoSMoS)

US Army Corps of Engineers • Engineer Research and Development Center • Coastal and Hydraulics Laboratory

Recent Publications on GenCade

- USACE Reports
 - Ding, Y., Styles, R., Kim, S-C, Permenter, R., Frey, A. (2020). Cross-Shore Transport Feature for GenCade, ERDC/CHL CHETN-IV-123, April 2020.
 - Kim, S. C., Styles, R., Rosati, J., Y. Ding, and R. Permenter (2020). A Comparison of GenCade, Pelnard-Considere, and LITPACK, ERDC/CHL CHETN-IV-124, April 2020
 - Ding, Y., S. C. Kim, R. Permenter, R. Styles, and Gebert, J. A. (2021). Simulations of Shoreline Changes along the Delaware Coast, ERDC/CHL TR-21-1, Vicksburg, MS: US Army Engineer Research and Development Center, <http://dx.doi.org/10.21079/11681/39559>, January 2021
 - Ding, Y., Hampson, R., Friebel, H., Watson, K., and Kim, S.-K. (2022). Calibration and Validation of Shoreline Evolution Model on the Erosion Hot Spot near Absecon Inlet, Atlantic City, New Jersey, ERDC-CHL LR-23-1.
- Journal Publications
 - Ding, Y., Styles, R., Kim, S.-C., Permenter, R.L., and Frey A.E. (2021). Cross-shore sediment transport for modeling long-term shoreline evolution, J. Waterway, Port, Coastal, Ocean Eng., 2021, 147(4): 04021014, 25pp., DOI: 10.1061/(ASCE)WW.1943-5460.0000644
 - Whitley, A. E., Figlus, J., Valsamidis, A., and Reeve, D. E. (2021). One-line modeling of mega-nourishment evolution. Journal of Coastal Research, 37(6), 1224–1234. <https://doi.org/10.2112/JCOASTRES-D-20-00157.1>
- Conference Papers
 - Ding, Y. (2022). Long-term and Regional Shoreline Evolution around Coastal Inlets, in Proceedings of the ASCE-EWRI 2022 Congress, 11p, pp379-389, <https://doi.org/10.1061/9780784484258.035>.
 - Ding, Y., Hampson, R., Friebel, H., and Watson, K. (2023). Long-term and regional shoreline evolution along Ab second Island, New Jersey, In: Proceeding of Coastal Sediments 2023, pp1466-1476. World Scientific, https://doi.org/10.1142/9789811275135_0136
 - Buonaiuto, F., Heer, A., and Rice, S. (2023) . South shore of LongIsland, New York regional sediment management investigation, In: Proceeding of Coastal Sediments 2023, pp1645-1660. World Scientific https://doi.org/10.1142/9789811275135_0152
- Training Materials
 - GenCade and Sediment Budget Analysis System (SBAS) , <https://cirp.usace.army.mil/techtransfer/webinars/FY21/18Nov2020-webinar.php>.
 - GenCade Workshop (Hands-on example, ppts, etc.) , <https://cirp.usace.army.mil/techtransfer/workshops/SAM-2022/SAM-Workshop.php>