Developing Rapid, Cost-effective Methods for Evaluating Coastal Biodiversity and Resilience

Duke University | BASS CONNECTIONS

Bass Connections in Energy & Environment

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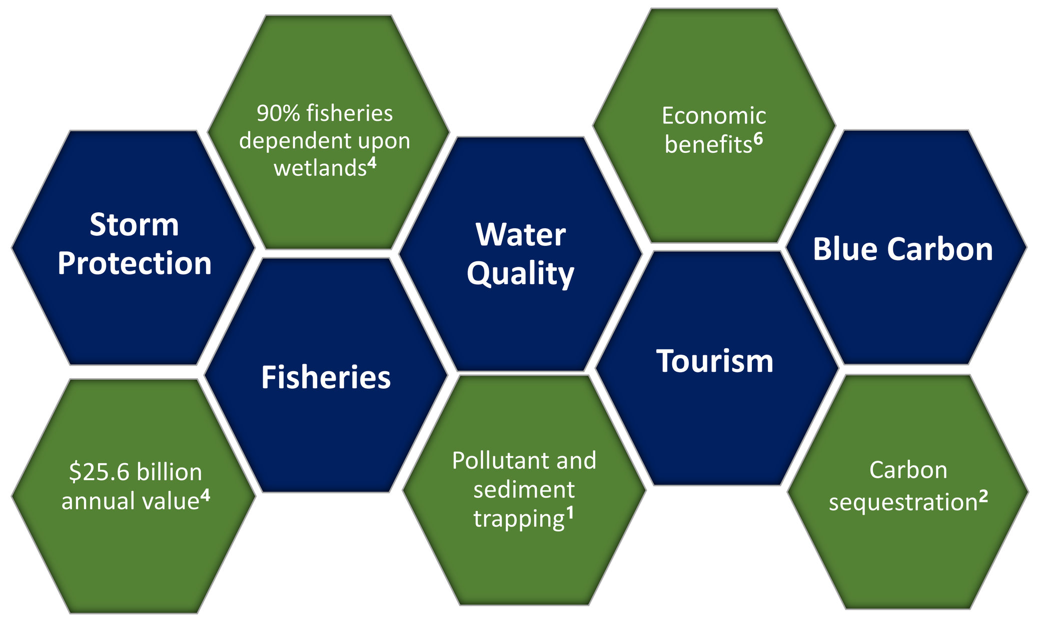
Marine Robotics & Remote Sensing

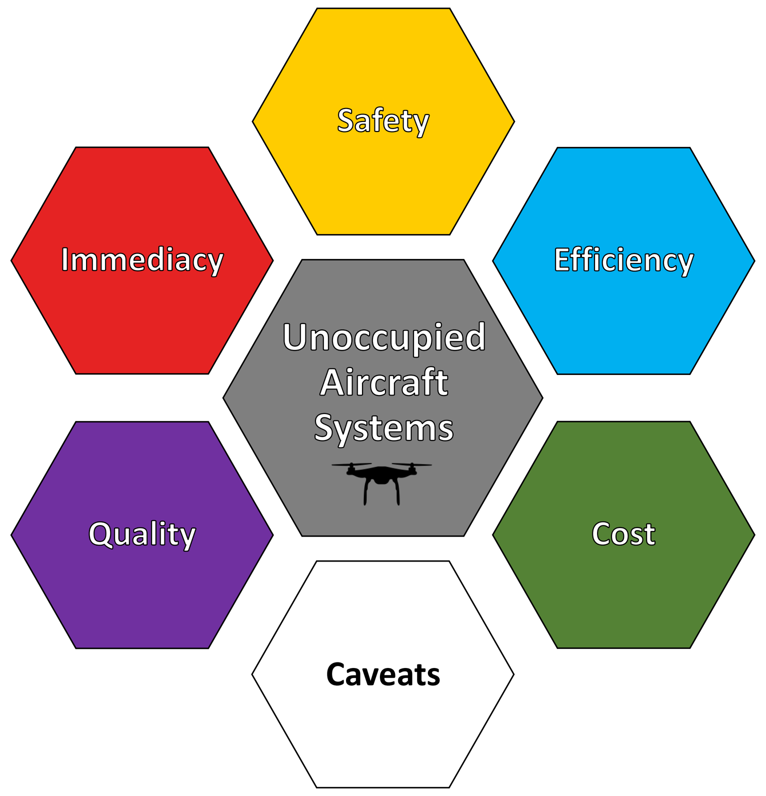
ABSTRACT

Salt marshes provide many critical services (e.g. carbon sequestration), though these habitats are in decline globally. Traditional monitoring methods often result in soil compaction, root death, and habitat destruction. Unoccupied aircraft systems (UAS, AKA drones) enable non-invasive, remote monitoring of marshes while reducing many traditional monitoring costs. Researchers manually collected stem height, density, and ground elevation for comparison to UAS point data. All images were processed in Pix4D and additional UAS point cloud processing was completed in ArcGIS Pro. This high-resolution imagery was most reliable for creating a digital terrain and digital surface model and habitat classification. This data was less reliable as a proxy for above ground biomass.

SALT MARSH BENEFITS



UNOCCUPIED AIRCRAFT SYSTEMS (DRONES)



DATA COLLECTION

Above: Recording location of ground control points (GCPs) with a GPS, which improves data accuracy during processing.

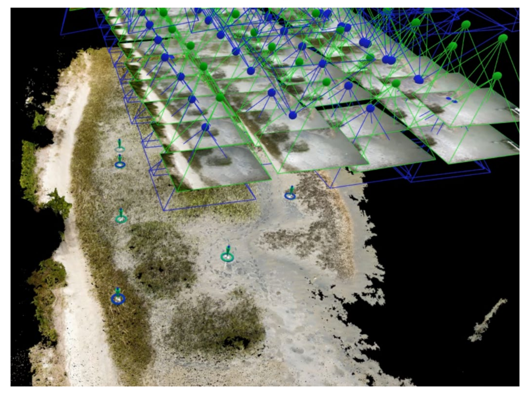
Above: Dr. Ridge uses non-toxic paint to cover marsh grass tops as part of the vertical accuracy assessment.

Above: Black Widow (DJI S900) drone used to collect project data.

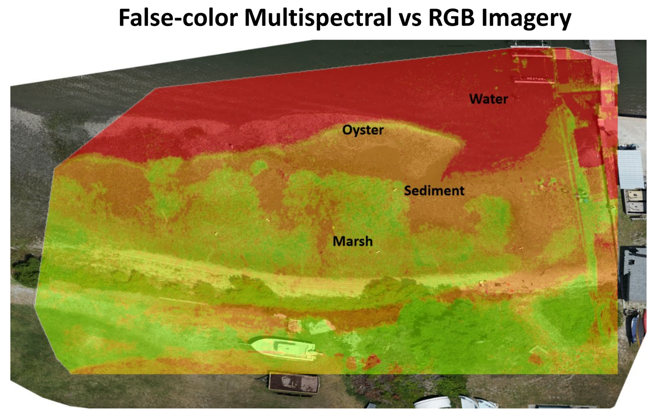
IMAGE PROCESSING

- Photos imported into Pix4D
  - *Top squares*
- GCPs imported
  - *Green and blue targets*
- Follow necessary steps: differ for multispectral and RGB imagery

Pix4D Processing Software



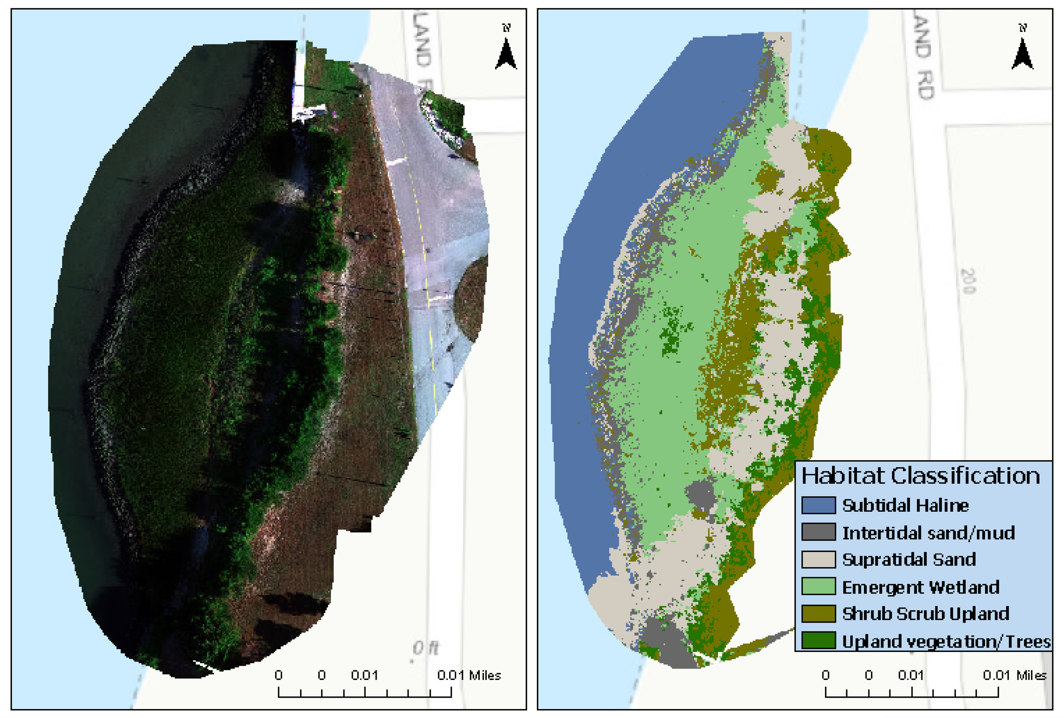
False-color Multispectral vs RGB Imagery



- Multispectral imagery (false color overlay) includes NIR/IR bands
  - Calculates NDVI
  - Green = healthy plants
  - Red = no plants
- Multispectral imagery can be used to determine habitat health and extent

HABITAT CLASSIFICATION

Multispectral UAS Imagery | **Wetland Habitat Classification**

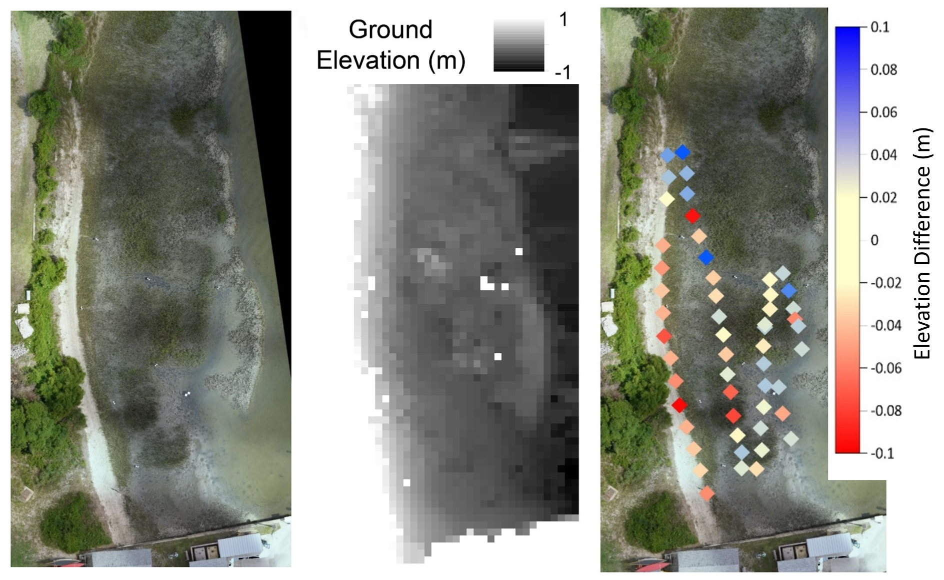


Left: High resolution multispectral composite band mosaic image collected by UAS of Pivers Island salt marsh located at the Duke University Marine Lab (Beaufort, NC). Right: Habitat classification map generated based on the multispectral orthomosaic.

- Mosaic *(left)* created using Pix4D and ArcGIS Pro
- Multispectral bands combined to create one composite
- Classification scheme created using Arc Classification Wizard
  - Object-based classification used to create a cleaner classification scheme
- Can provide more reliable data than satellites (e.g. avoids cloud cover) [3]
- Enables managers to calculate wetland area with reduced physical impact to the environment

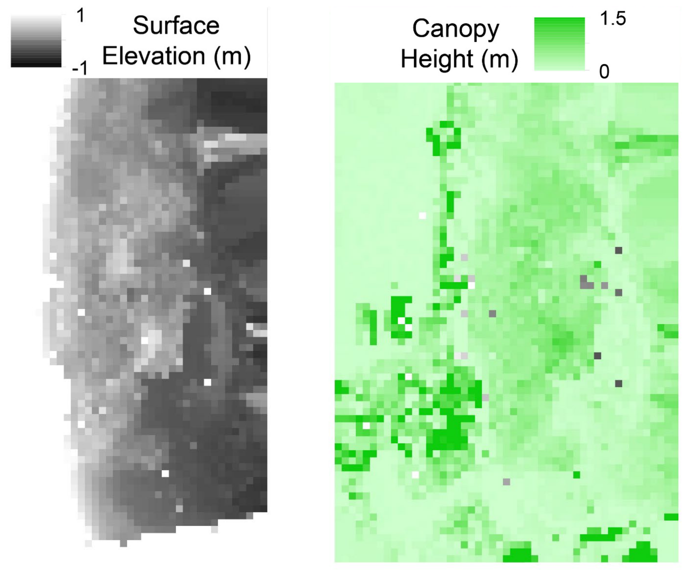
CANOPY HEIGHT MODEL: DIGITAL TERRAIN & SURFACE MODELS

Digital Terrain Model and Ground Point Comparison

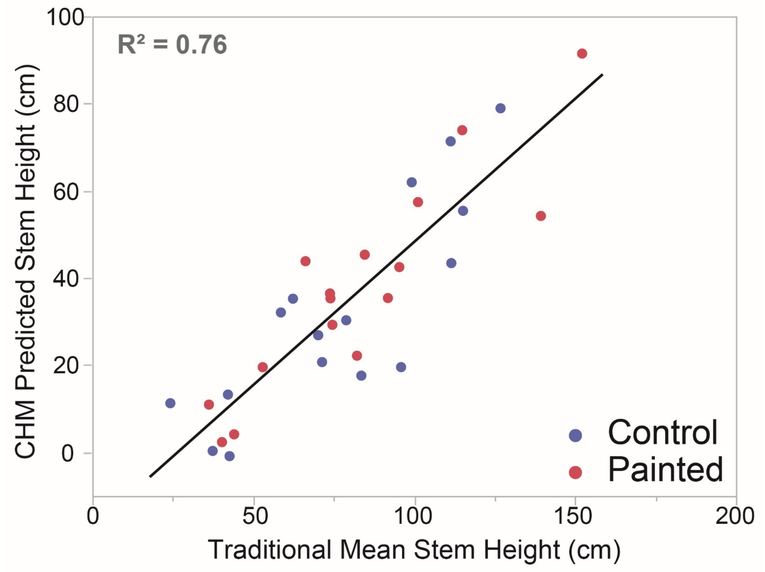


Above: Difference between ground points (ground elevation taken with GPS) and UAS calculated digital terrain model (DTM). Mean error between Z-values of ground points and UAS generated DTM was 4.4cm.

Generating Canopy Height



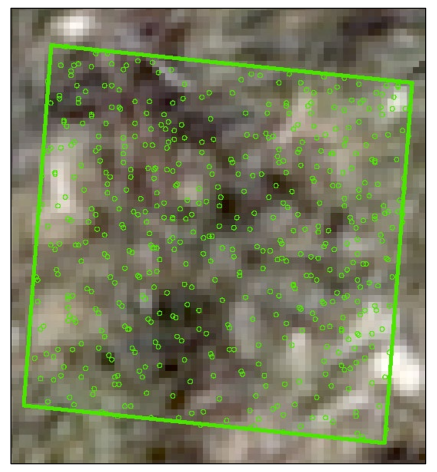
Above: UAS multispectral point cloud used to filter vegetation points using ArcGIS LAS tools and then generate a digital surface model (DSM). The difference between the DSM and DTM is the vegetation height (or canopy height).



Above: Canopy height determination from UAS data (in LAS form) compared to groundtruthed plant heights.

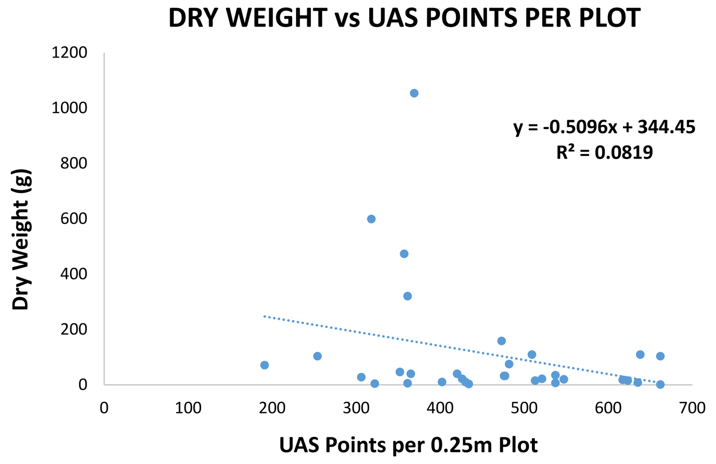
PLANT DENSITY

Above: Researchers collect stem density and stem height measurements for ground truthing. These measures can be used to determine marsh health.



Above: Representative plot and filtered point cloud (NDVI >0.4499). These green points correspond with pixels that captured vegetation.

DRY WEIGHT vs UAS POINTS PER PLOT

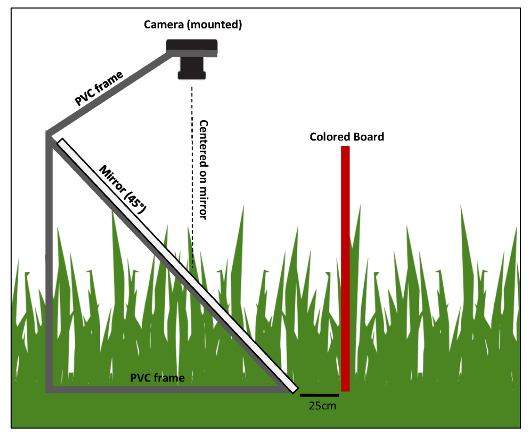


Above: Relationship between unfiltered UAS point cloud density and above ground biomass (AGB). Calculations determined with regional regression equation developed by Davis *et al.* 2015[2], where *y* is dry stem weight and *x* is average stem height (cm):

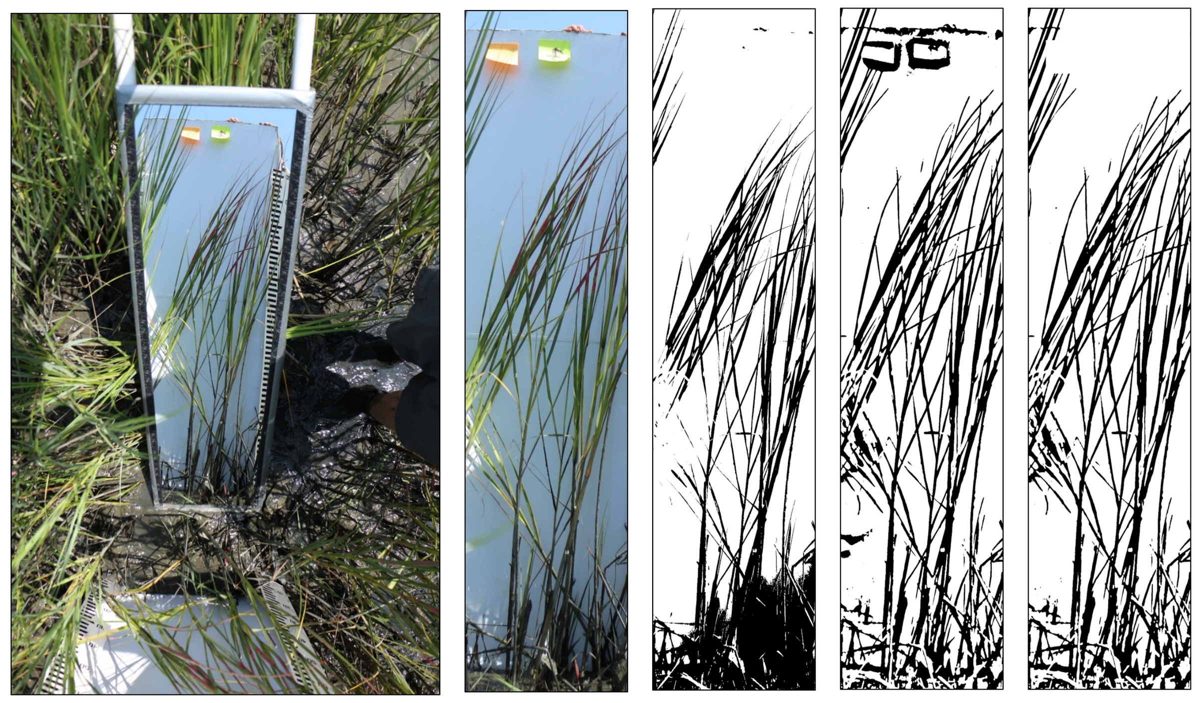
$$y = 0.00005x^3 + 0.0003x^2 + 0.0008x$$

VERTICAL ACCURACY ASSESSMENT

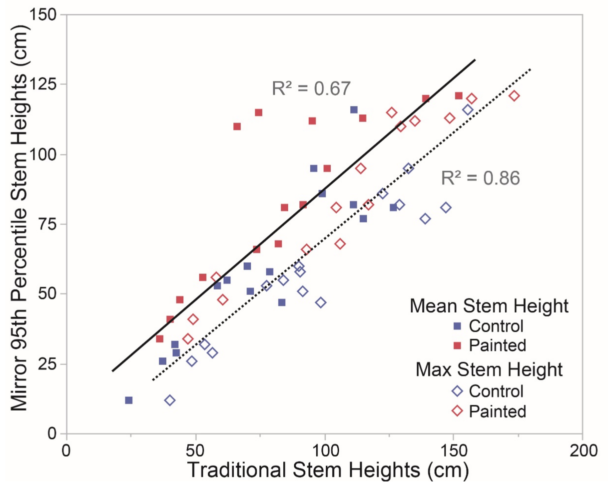
Above: Conducting vertical accuracy assessment with mirror apparatus.



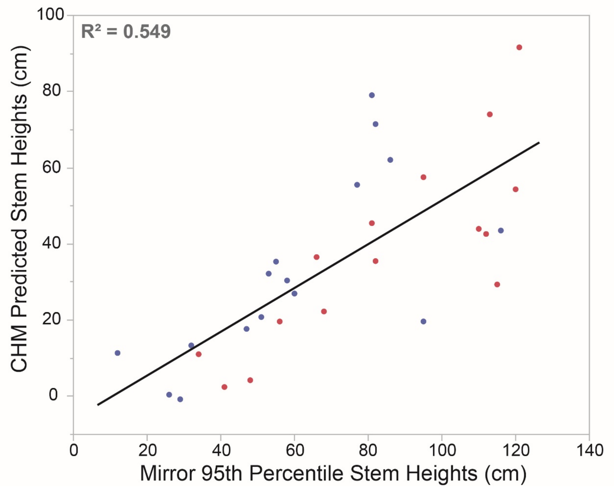
Above: Mirror apparatus schematic to assess vertical accuracy of canopy height (adapted from Neumeier 2005[5])



From left to right: Raw mirror image, Rotated and cropped mirror image, Global thresholded image, Adaptive thresholded image, Manually cleaned up adaptive threshold image ready for analysis.



Above: Comparison of stem height manually collected (traditional) and calculated based on plant reflections in mirror.



Above: Comparison of stem heights calculated based on plant reflections in mirror to predicted stem heights from the Canopy Height Model.

DISCUSSION

Declining salt marshes are now primarily lost due to wave action from increased storms and sea level rise (SLR)[1]. Rapid monitoring is needed to assess whether individual marshes recover from storms and accrete sediment to outpace SLR. The developed workflow for extracting canopy height, marsh bed elevation, classification, and habitat extent provide a feasible, non-invasive method for marsh habitat monitoring. Using the UAS point cloud to determine DTM and DSM is a reasonable way to collect this data; the mean Z-value error differ by <5cm, indicating this is a useful method to monitor long term changes in marsh elevation. Further, these methods are useful for classifying marsh habitat and calculating area which can provide rapid assessment of habitat loss. Monitoring more sites over time may demonstrate an improved relationship between UAS point density and AGB. Future research may determine whether these methods work for salt marsh not dominated by *Spartina,* as well as whether these methods can be applied to other coastal canopies such as mangroves.

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