COSINE Timekeeper for Coastal Camera Network Deployment
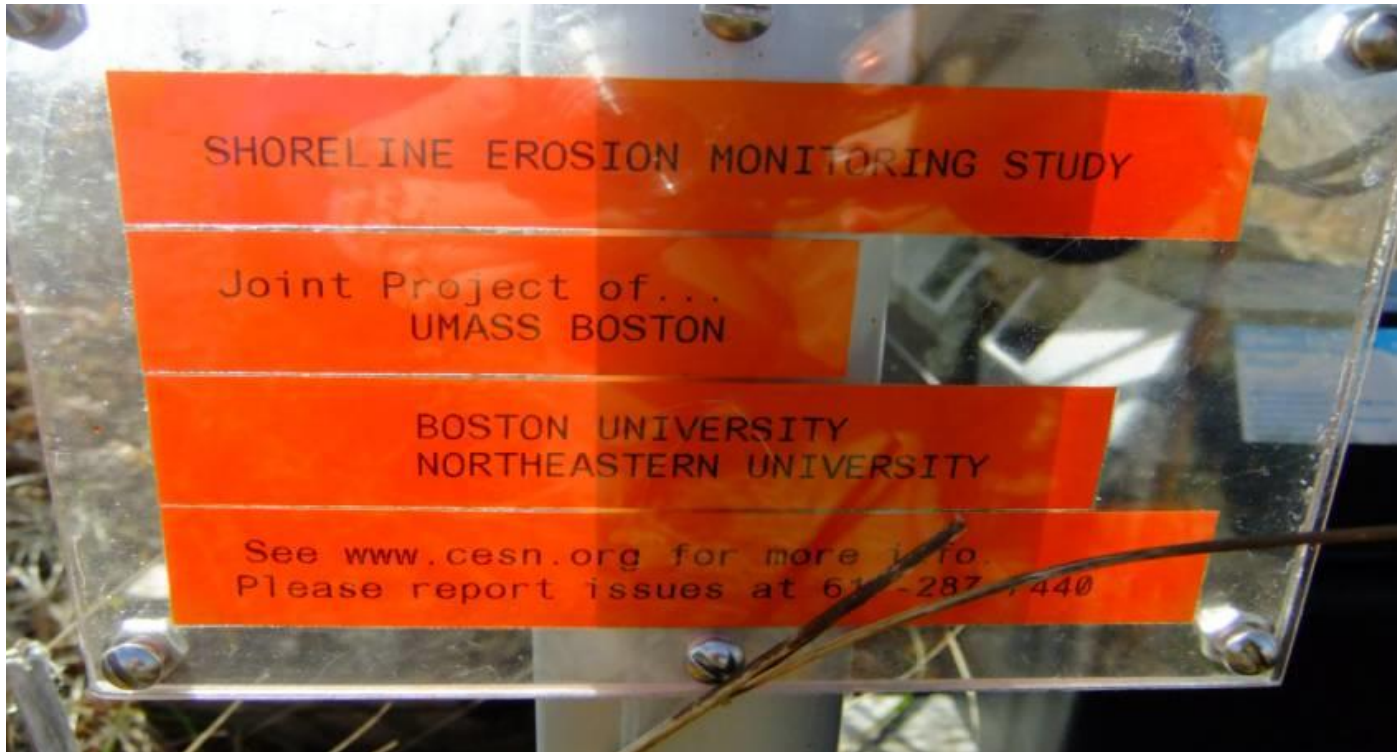
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Outline

- Overview
- COSINE Timekeeper
- Camera System Design
- Network Deployment
- Discovery Results
- Conclusions
- Future Work

Team in COSINE

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Ben Wetherill

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Practical Goals

- Evaluate wireless cameras for coastal science
  - Low cost
  - Low power
  - Remote access
  - Video delivery
  - Low maintenance
  - Energy harvesting
  - Live view
  - Video storage
- Capture short-term bluff erosion process
  - Dynamic schedule at daily high tide

Energy Neutral Operation

Dynamically schedule 'ON' time every day

|	Schedule Programmability	Power Consumption	Cost
Charge Controller	🔴	🟡	🔴
Timer Switch	🟡	🔴	🟡
Web Relay	🟡	🔴	🔴
COSINE Timekeeper	🟢	🟢	🟢

RENOGY ViewStar

Cnok CN101

WebRelay

COSINE Timekeeper

- "Shield" circuit design with the Arduino
- Power management software
- Keeps time and schedules alarms
- Ultra low power consumption
- Power protection
- Low cost approximately $50
- Extendable to remote program

Shield Circuit
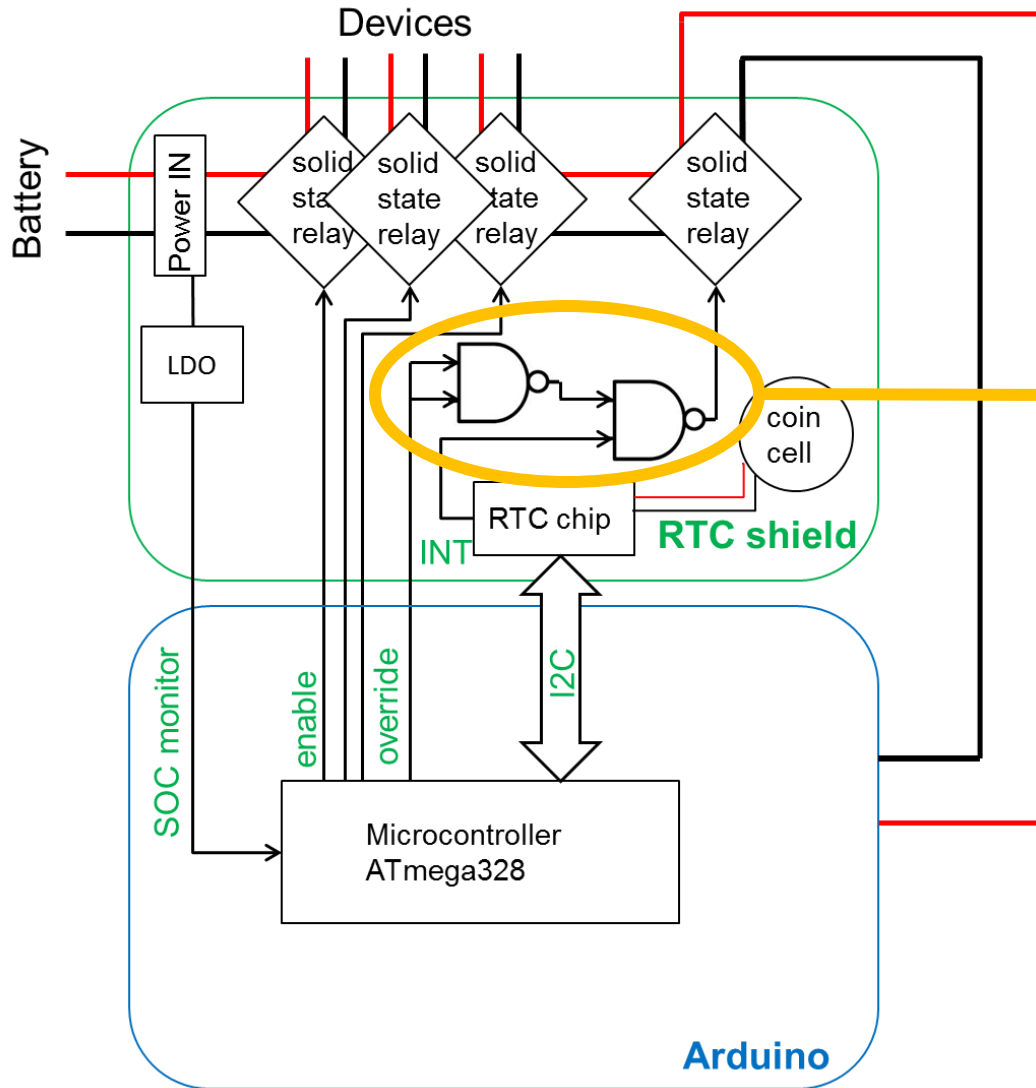
Alarm Reset by NAND

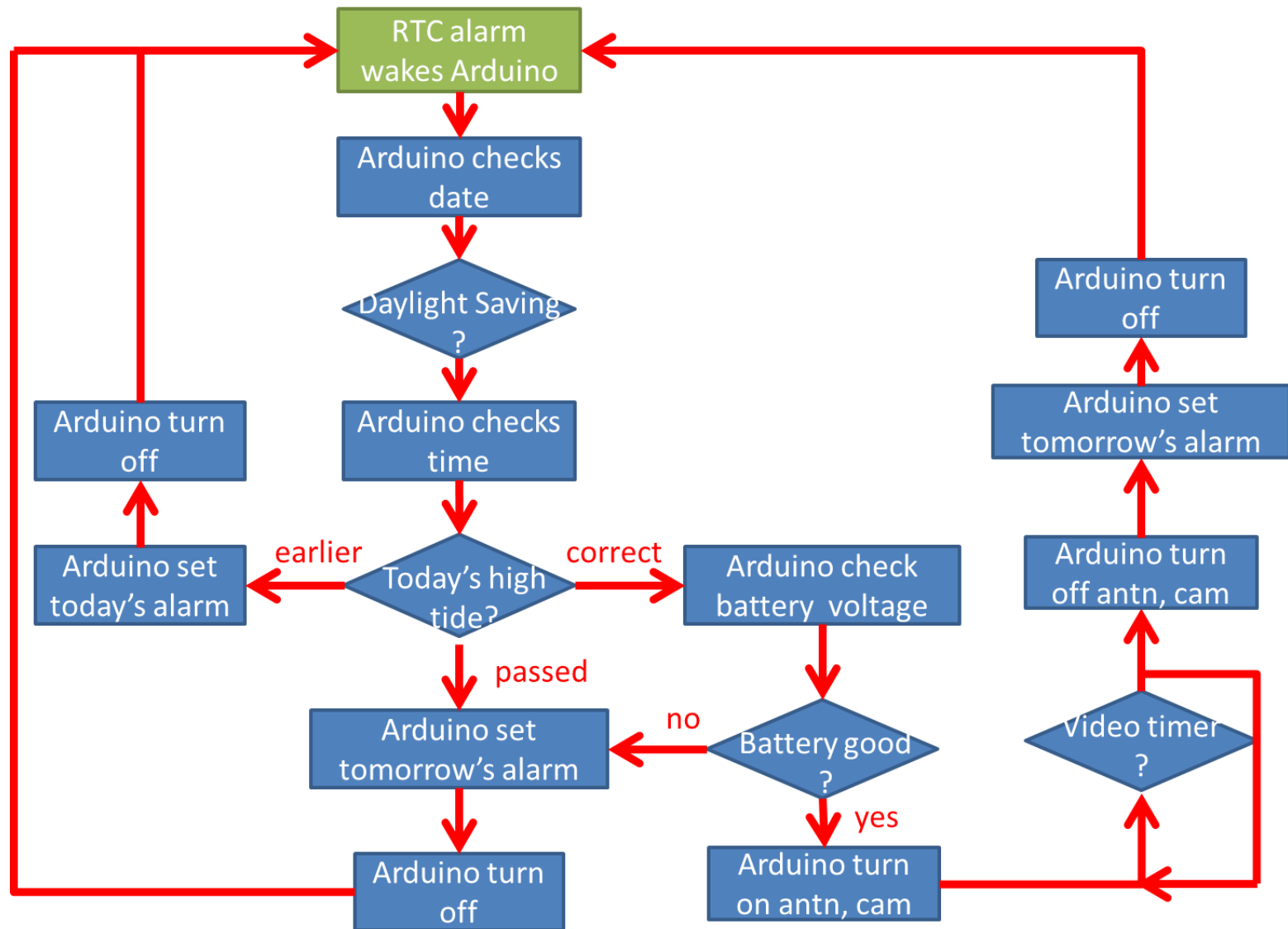| Override	INT	Relay	Note
0	1	0	Initial
0	0	1	Alarms
1	0	1	Overrides
1	1	1	Reset
0	1	0	'OFF'

Power Management Software

- Arduino basic script:
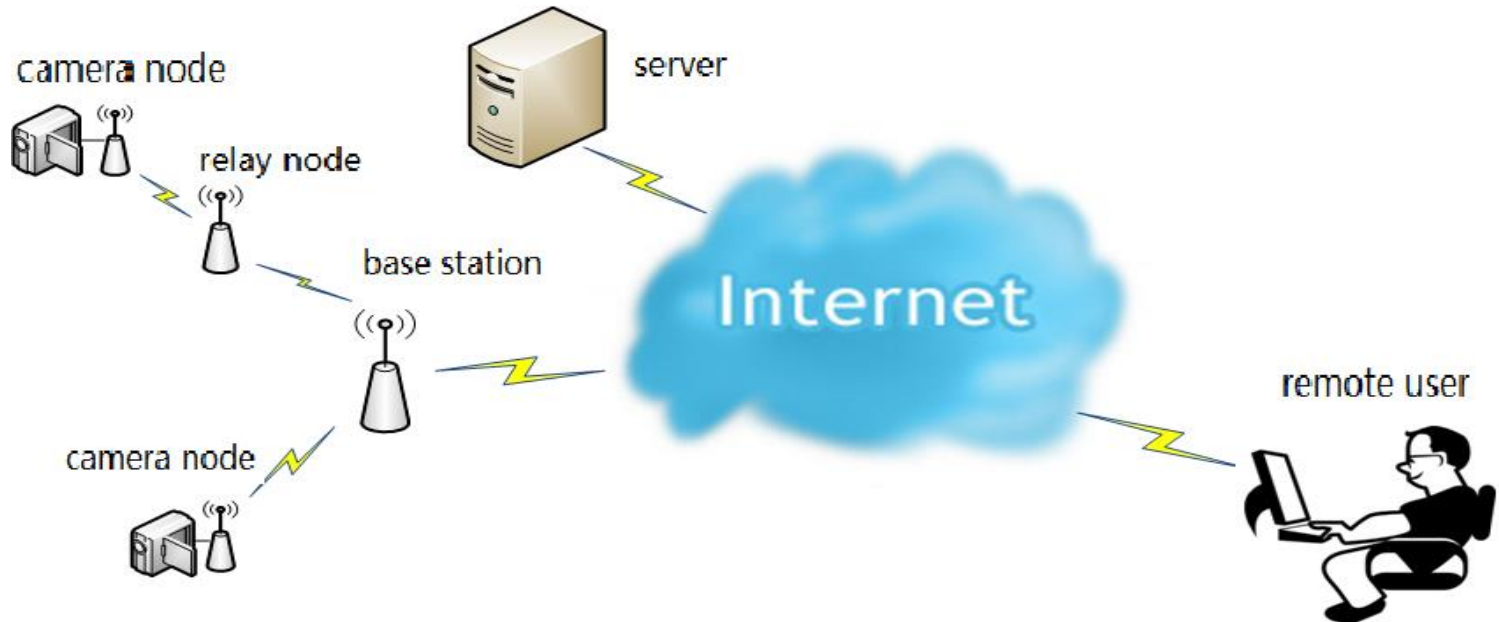
```
setup()
loop()
```

- Power management software:
  - 6 months tide table in flash memory
  - Software compensation Daylight Saving Time
  - Multiple wake-up alarms

Control Flow: Time and Tides

RTC alarm wakes Arduino

Arduino checks date

Daylight Saving ?

Arduino checks time

Today's high tide?
- earlier → Arduino set today's alarm → Arduino turn off
- correct → Arduino check battery voltage
- passed → Arduino set tomorrow's alarm → Arduino turn off

Battery good ?
- no → Arduino set tomorrow's alarm
- yes → Arduino turn on antn, cam

Video timer ?

Arduino turn off antn, cam

Arduino set tomorrow's alarm

Arduino turn off

Network Design

- Network infrastructure

- Power planning
  - Solar Power-IN must be greater than Power-Out!
  - Reservoir for consecutive days

Network Node/Hop Design

- Modular devices selected based on power planning
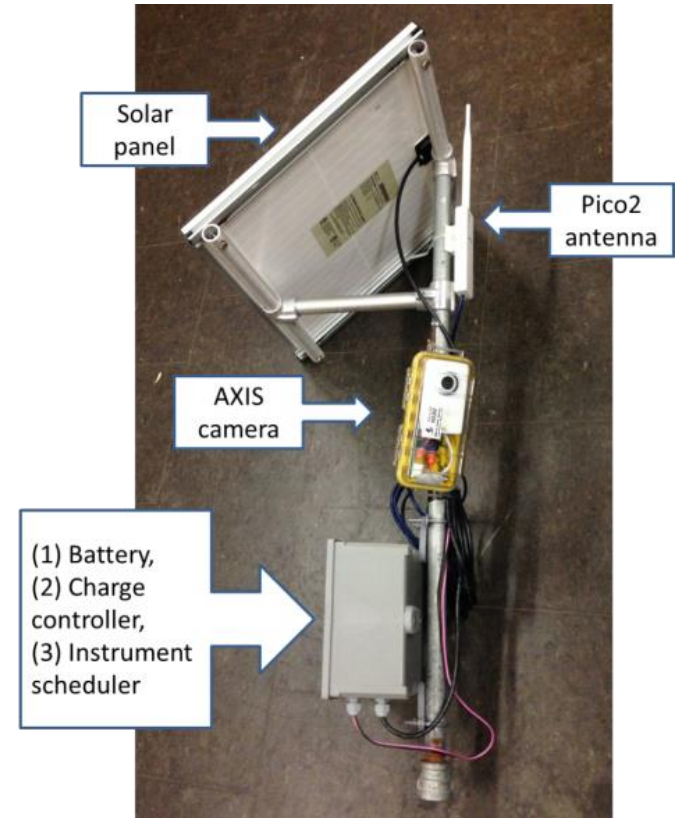- Costs vary respectively

Solar panel	Charge controller	Battery	COSINE Timekeeper	Antenna	Camera
$150	$30	$100	$50	$80	$180

Node Design and Deployment
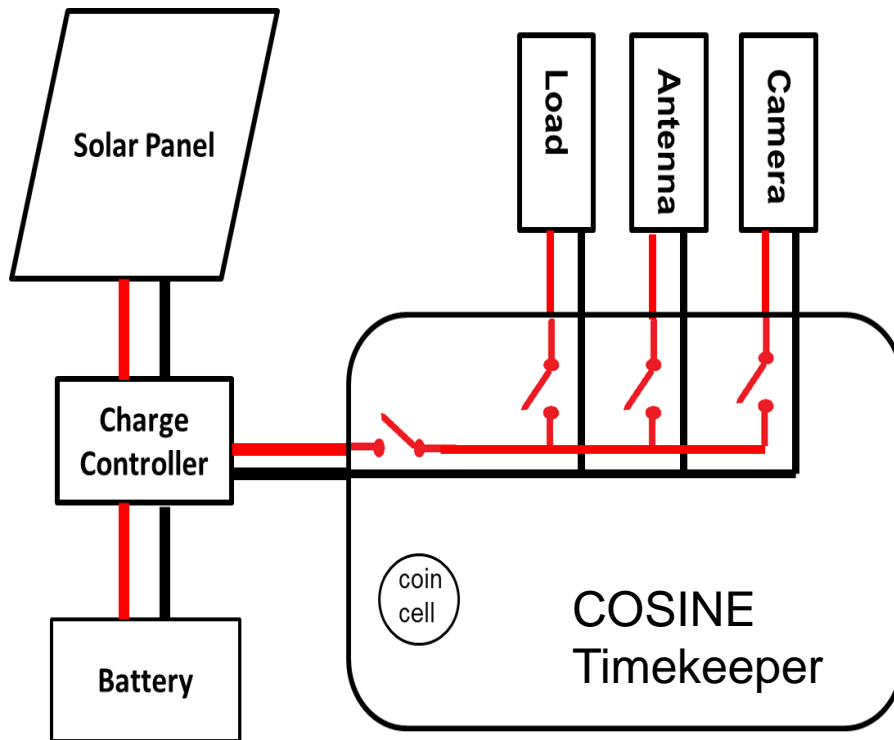
System Deployment I.

- Thompson Island, Boston, MA in October 2012
  - Cameras at bluff and beach
  - Wireless transmission to UMass Boston
  - 3 nodes spanning ~3.5 km
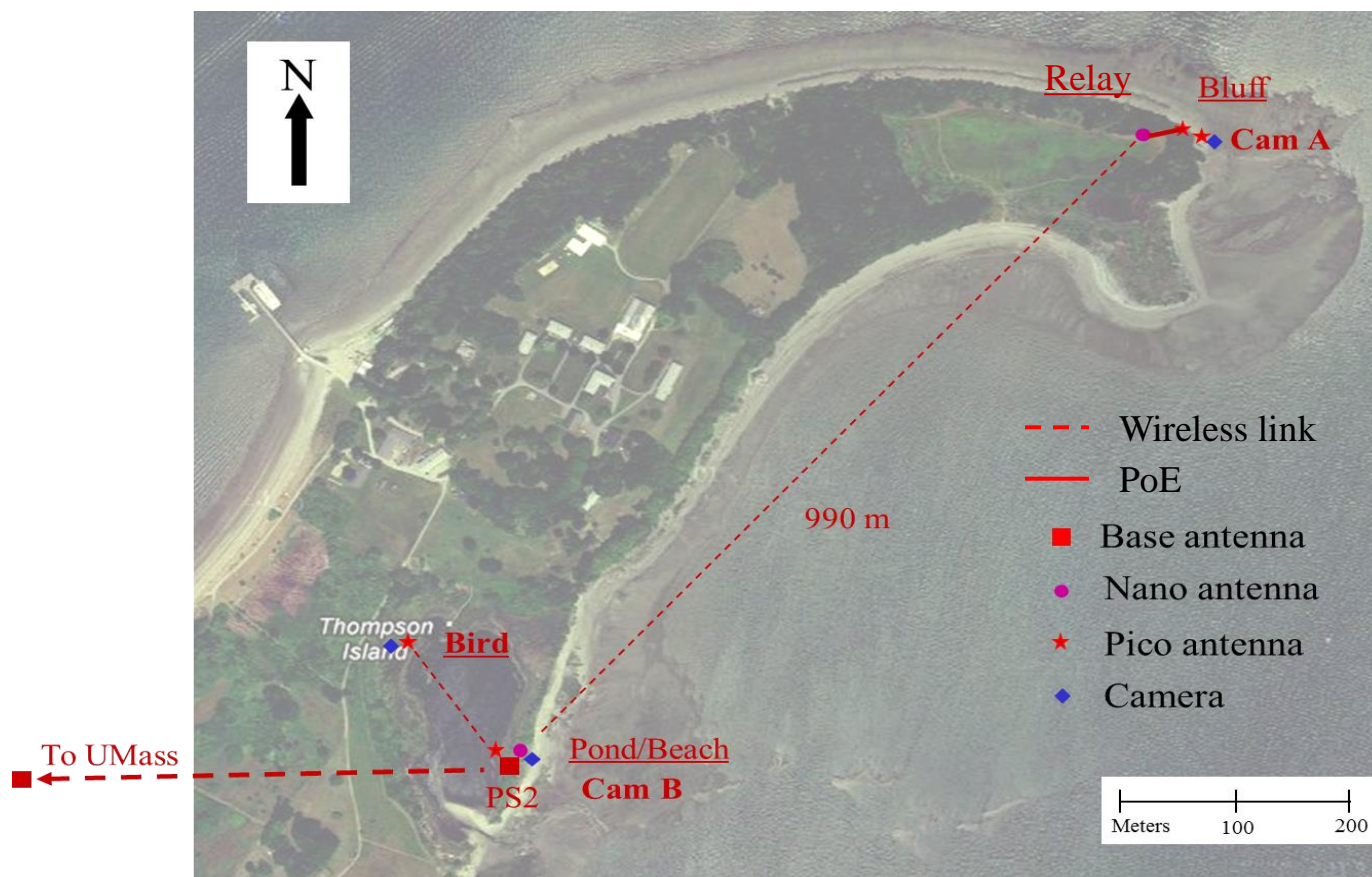
System Deployment II.

- Jones River watershed, Kingston, MA
  - Monitor salt marsh erosion
  - Live update to www.cesn.org since September 2013

Discovery - Erosion

- Capture episodic erosion events
  - Before/after storms, big waves, rock fall, frost heave, etc.

Pre-hurricane

Post-hurricane

Extreme tides & wind

Winter settling

Discovery - Erosion

- Capture episodic erosion events
  - Before/after storms, big waves, rock fall, frost heave, etc.
- Tidal effects
  - Need both extreme high tide and sustained storm waves
  - Boat wakes not prolonged enough
- Effects of frost
  - Gradual noticeable settling
  - May be significant

Images and videos are available on
www.cesn.org/live/thompson_bluff.php
[Zhang, et. al., Ecological Informatics, 2014]

Conclusions

- COSINE Timekeeps
  - Programmability, low power, low cost
- Wireless camera network
  - Low cost, low maintenance, etc.
  - Energy neutral operation
- Modular design and methodology benefit more environmental and ecological studies

Future Work

- Open source CAD files of COSINE Timekeeper
- Update documentation
  - Hardware modules
  - Network configuration
- More applications
  - Wave monitoring
  - Wildlife monitoring
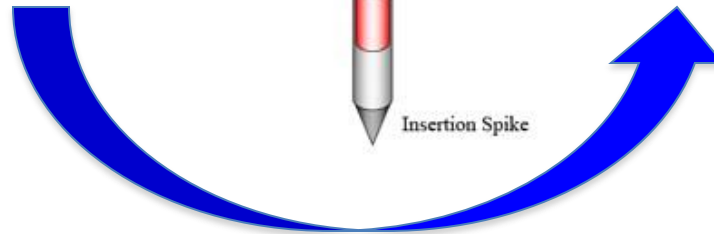 - Phenology monitoring
- Outreach education

What next?

141 million phones discarded (2009)

Antenna

Sun Visor

Hyperbolic
Mirror
Sensor
Electronics

Solar Panel
(on tilting axis)

Rigid
Casing

Batteries

Insertion Spike

Large-scale geographic observation

Acknowledgement

- MIT Sea Grant
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- Thompson Island Outward Bound Education Center
- Boston Harbor Islands
- U.S. National Park Service
- Jones River Watershed Association

THANK YOU!

QUESTIONS?

Hardware, Software, and Prototype are available for sharing by contact,

Prof. Thomas Little, tdcl@bu.edu