

# A UAV Rapidly-deployable Stage Sensor Package for Flood Monitoring in Undersampled Watersheds

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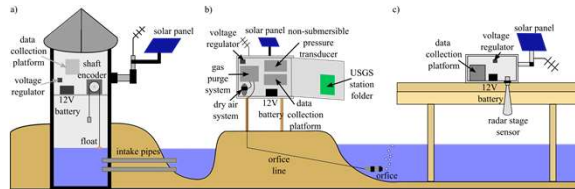
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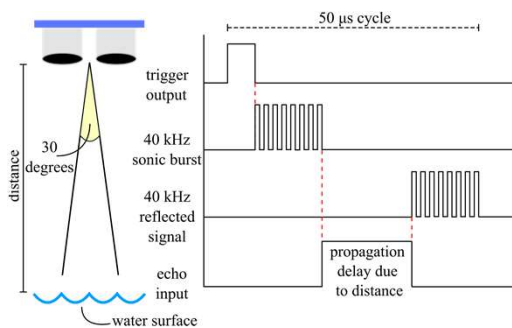
## Background

- Stage is the vertical height of the water surface from a defined zero point
- USGS has streamgages to measure stage
- USGS gages are permanent and expensive



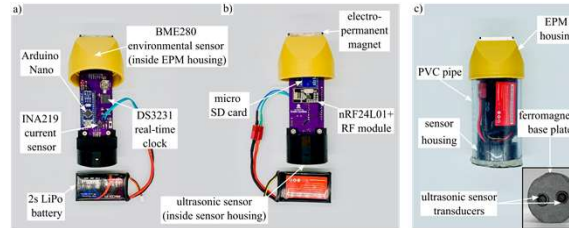
Types of USGS gages: a) stilling well; b) bubble gage with look-in housing; c) rapid-deployment gage.

- Urban watershed with a high percentage of impervious surfaces are prone to flash flooding
- Pictured right: July 16, 2021: flash flood behind 300 Main St
- No gages were present in this area to detect flash flooding
- USGS gages further upstream and downstream, but none to alert of flooding behind building
- Arduino microcontrollers are a smaller, cheaper alternative to traditional datalogging
- Ultrasonic sensors contactlessly measure distance using a reflected burst of ultrasound



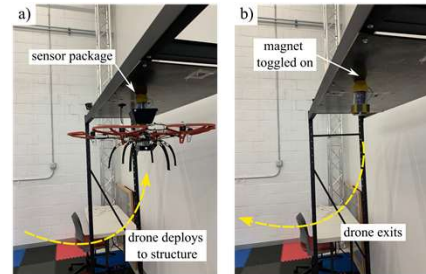
Timing diagram of the HC-SR04 ultrasonic sensor.

## Design



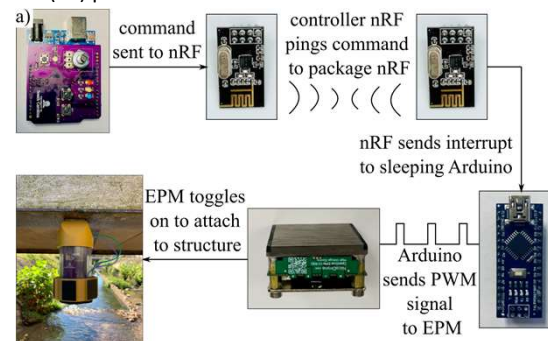
Internal components of sensor package a) front, b) back, and c) external assembly during deployment.

- Microcontroller-based datalogger
- Ultrasonic sensor measures stage
- Under \$300 per unit
- 0.02 – 4 meter range with a 6.9 mm accuracy



UAV a) deploying and b) retrieving sensor package.

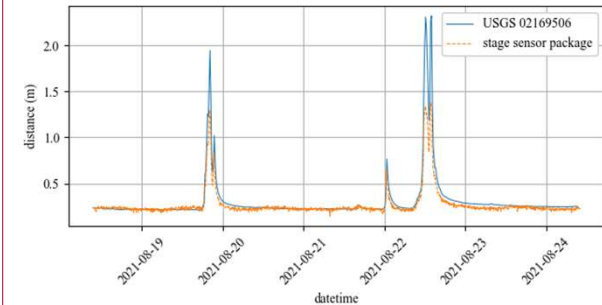
- Electro-permanent magnet can be toggled on and off for UAV deployment
- Can be controlled wirelessly using radio frequency (RF) protocol



Control sequence for RF communication with EPM.

## Testing and Results

- Package was deployed for six days
- Readings saved on SD card and plotted against USGS streamgage values
- Amplitude of peaks vary due to changes in channel profile, but peaks line up



Field test deployment from August 19 – 24 2021.

Table 1. Design characteristics

Weight	0.38 kg
Battery life	2.8 – 6.4 days
Peak current draw	384 mA
Active current draw	31 mA
Steady state current draw	22 mA
Stage range	0.02 – 4.0 m
RF range	10 m

## Conclusions

- The stage sensor package presented provides an effective and cost-efficient solution for monitoring undersampled watersheds
- Greater data resolution for urban watersheds will provide more insight into nuisance flooding
- This project is fully open-sourced
- Open Science Framework repository: <https://doi.org/10.17605/OSF.IO/A874U>

## References

1. C. Smith, J. Satme, R. Matthews, S. Anjum, D. Gibson, J. Imran, N. Vitzilaio, and A. Downey, "UAV-deployable sensor packages for the measurement of hydraulic parameters." [Online]. Available: [http://www.me.sc.edu/research/downey/publications/Conference\\_presentations/Smith\\_2021\\_UAV\\_deployable\\_Sensor.pdf](http://www.me.sc.edu/research/downey/publications/Conference_presentations/Smith_2021_UAV_deployable_Sensor.pdf)
2. C. Smith, J. Satme, J. Martin, A. Downey, N. Vitzilaio, and J. Imran, "UAV Rapidly-Deployable Stage Sensor with Electro-permanent Magnet Docking Mechanism for Flood Monitoring in Undersampled Watersheds (in preparation)."