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Street-level Flooding Platform: Sensing and Data Sharing for Urban Accessibility and Resilience

May 2021

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16. Abstract

Of the myriad impacts that are predicted to accompany climate change, flooding is expected to have an outsized influence on public health, infrastructure, and mobility in urban areas. In New York City, for example, sea level rise and an increase in the occurrence of high intensity rain storms (which convey large volumes of water to drains, leading to backups and overflows) have led to a dramatic increase in flood risk, particularly in low-lying and coastal neighborhoods. The physical presence of standing water on streets and sidewalks can impede mobility and restrict access to transportation. Access to real-time information on flooding can improve resiliency and efficiency by allowing residents to identify navigable transportation routes and make informed decisions to avoid exposure to floodwater contaminants. However, very little data exist on the frequency and extent of urban surface flooding, and there is an unmet need for hyperlocal information on the presence and depth of street-level floodwater. This unmet need for data from urban floods motivated the development of the FloodSense project in early 2020, with the objective of: developing a platform to provide real-time, street-level flood information - including the presence, frequency, and severity of local surface flood events - to a range of stakeholders, including policy makers, government agencies, citizens, emergency response teams, community advocacy groups, and researchers.

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Street-level Flooding Platform: Sensing and Data Sharing for Urban Accessibility and Resilience

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We would like to acknowledge the Marron Institute, who funded a seed project to study the impact of flooding on urban surfaces, which sparked the question of flood sensing. We would also like to acknowledge the Pinkerton Foundation, who funded work in the Silverman lab, and the Center for Urban Science and Progress (CUSP) at NYU Tandon which provided the sensor lab in which the prototypes described here we developed. We would like to acknowledge the Integrated Design and Media program and the Civil and Urban Engineering department at NYU who both funded Master's students who worked on this project. We would also like to acknowledge our community partner the Gowanus Canal Conservancy for their consistent support and enthusiasm.

This effort is, since its inception, collaborative and democratically driven - and so I would like to give a huge high five to all the NYU Flood Team members for their enthusiasm, hard work, creativity and generosity. This project was mostly executed during pandemic times and our weekly team meetings always felt like a window of lightheartedness and support in strange times.

Finally, I would like to acknowledge our star student, Praneeth Sai Venkat Challagonda. During the Spring 2020 lockdown, he built a flood simulator in his apartment and obtained our first measurements. His unquenchable enthusiasm, motivation and technical skill is key to driving this project forward.

Executive Summary

Of the myriad impacts that are predicted to accompany climate change, flooding is expected to have an outsized influence on public health, infrastructure, and mobility in urban areas. In New York City, for example, sea level rise and an increase in the occurrence of high intensity rain storms (which convey large volumes of water to drains, leading to backups and overflows) have led to a dramatic increase in flood risk, particularly in low-lying and coastal neighborhoods. The physical presence of standing water on streets and sidewalks can impede mobility and restrict access to transportation. Access to real-time information on flooding can improve resiliency and efficiency by allowing residents to identify navigable transportation routes and make informed decisions to avoid exposure to floodwater contaminants. However, very little data exist on the frequency and extent of urban surface flooding, and there is an unmet need for hyperlocal information on the presence and depth of street-level floodwater. This unmet need for data from urban floods motivated the development of the FloodSense project in early 2020, with the objective of: **developing a platform to provide real-time, street-level flood information - including the presence, frequency, and severity of local surface flood events - to a range of stakeholders, including policy makers, government agencies, citizens, emergency response teams, community advocacy groups, and researchers.**

The FloodSense project began in 2020 with funding from the C2SMART Transportation Research Center, with overarching goals to (1) design, build, deploy, and assess robust, low-cost sensors in diverse urban environments to track street-level flood occurrence and depth, and ultimately, (2) to implement an interface to communicate the data to a range of stakeholders. During this time, we have designed, tested and built over 7 iterative prototypes, deployed three final prototypes in the field, and collected over 200 days of data, logging two flood events and their profiles. We have forged collaborations with research partners at CUNY and city agency partners at DEP, DOT, NYC MOR and NYC MOCTO, founding the FloodNet.NYC consortium and collectively applied to additional funding from five state- and federally-funded sources. We have secured an additional 90K in funding from the Empire State Development Fund to continue work started under this grant.

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1. Introduction

Of the myriad impacts that are predicted to accompany climate change, flooding is expected to have an outsized influence on public health, infrastructure, and mobility in urban areas. In New York City, for example, sea level rise and an increase in the occurrence of high intensity rain storms (which convey large volumes of water to drains, leading to backups and overflows) have led to a dramatic increase in flood risk, particularly in low-lying and coastal neighborhoods. [1] The physical presence of standing water on streets and sidewalks can impede mobility and restrict access to transportation.[2] Additionally, urban flood water contains a diverse array of contaminants, including industrial and household chemicals, fuels, and sewage.[3,4] Access to real-time information on flooding can improve resiliency and efficiency by allowing residents to identify navigable transportation routes and make informed decisions to avoid exposure to floodwater contaminants. However, very little data exist on the frequency and extent of urban surface flooding, and there is an unmet need for hyperlocal information on the presence and depth of street-level floodwater. This unmet need for data from urban floods motivated the development of the FloodSense project in early 2020, with the objective of: **developing a platform to provide real-time, street-level flood information - including the presence, frequency, and severity of local surface flood events - to a range of stakeholders, including policy makers, government agencies, citizens, emergency response teams, community advocacy groups, and researchers.**

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- Task 1- Sensor solution discovery and evaluation (including evaluation of sensor, power, connectivity, and data storage and delivery solutions)
- Task 2 - Prototype deployment, assessment, and initial data collection
- Task 3 - Development of an online interface for data communication

With the funding granted from C2SMART in 2020, the FloodSense team made significant progress on each task, outlined in the following sections.

2. Hardware Development and Deployment

The hardware development efforts of the project have been focused on the design of an urban flood sensor that satisfies the following criteria:

1. Ability to sense water depth with an accuracy of < ±1 inch
2. Transmit depth measurements back to a central server every ~30mins
3. Operate autonomously for periods of >3 months under extreme weather conditions
4. Comprise low-cost components for sensor network scalability

5. Independence from existing power and networking infrastructure

The following sections detail the development process of the sensor itself, the overall system architecture, and deployments in two areas prone to tidal and storm water-borne flooding.

Subsection 2.1 Sensor modality testing

Initially, the team has performed drift and varied water level testing on 2 sensor types: ultrasonic range and resistive depth sensor. Ultrasonic range sensors use multiple pulses of ultrasonic sound to remotely determine the distance to a large surface, which can be used to calculate a change in water depth as a range different from the road/sidewalk surface. Resistive depth sensors (labeled eTape) directly measure the depth of water by measuring a change in resistance when the sensor is submerged in water.

To test sensor drift both sensor types were mounted above a static body of water with measurements logged for ~3 days. **Figure 1** shows the depth measurements over time. The observed reduction in depth after 50% of the measurement period is attributed to surface evaporation.

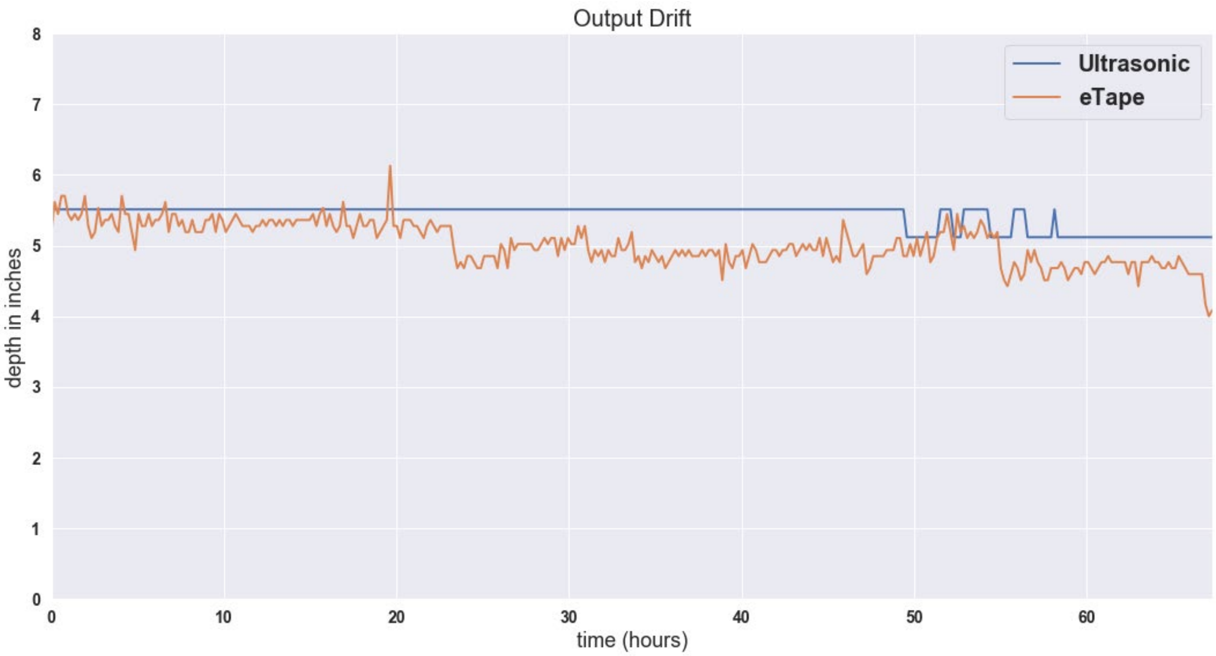


Figure 1: Ultrasonic and eTape sensor drift over ~3 day measurement period

The ultrasonic sensor shows a more stable depth measure over time, however, its lower resolution is apparent but still within our required specifications of ±1 inch. The eTape also exhibits a higher level of drift over time, likely due to variations in its resistivity with prolonged contact with water.

A test rig was built that simulates a flood scenario by pumping water from one vessel to another continuously. This process is controlled by a microcontroller for repeatability. This rig was built to test the reproducibility and consistency of the sensor's output over time. The setup can be seen in **Figure 2**.

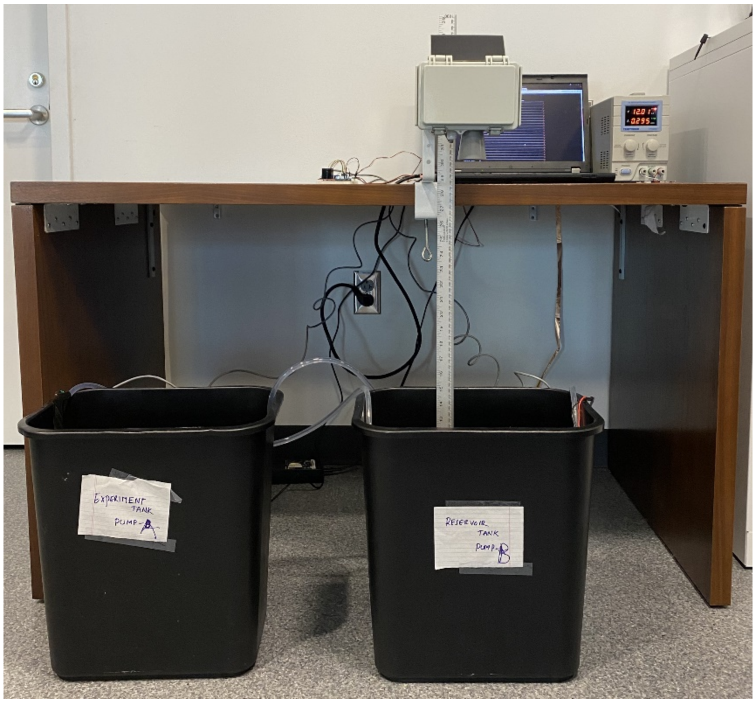


Figure 2: Flood simulator test setup with the ultrasonic sensor mounted above and eTape mounted within the right vessel. Ground truth meter ruler is mounted inside the right vessel.

The level of water in the right vessel was continuously varied to test the sensor’s ability to track varying depths accurately and reliably over time and to determine the minimum measurable depth.

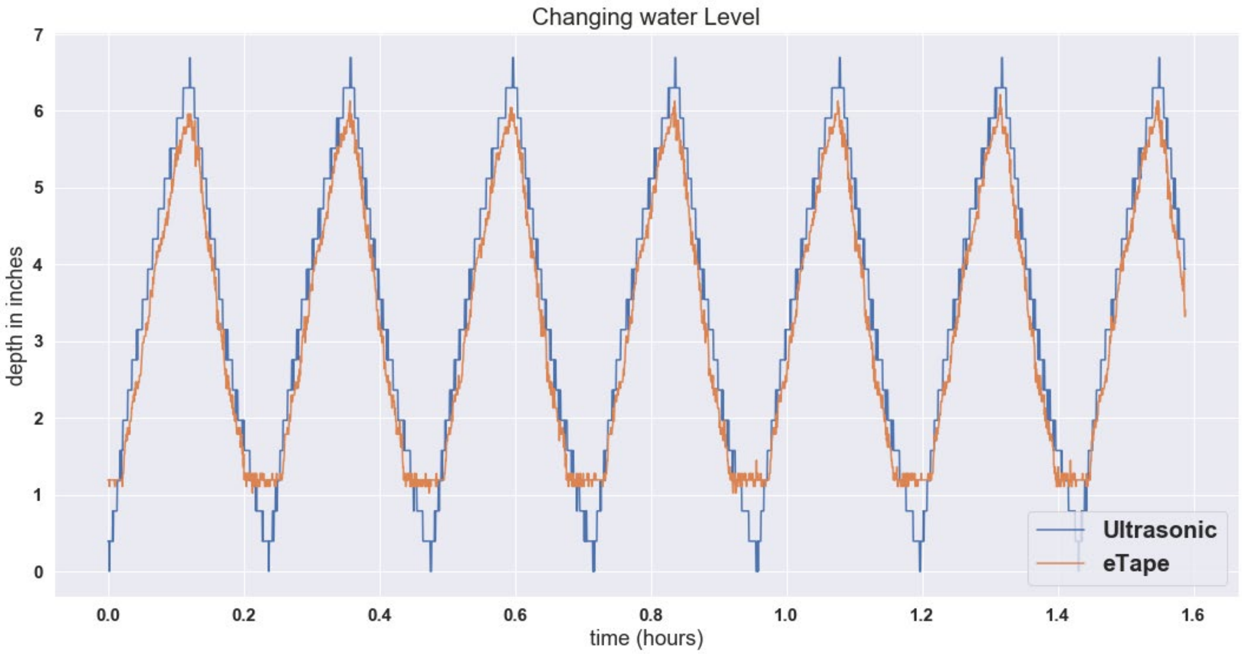


Figure 3: Varying water level measurements for ultrasonic and eTape sensor types

Figure 3 shows the higher accuracy of the ultrasonic sensor compared to the eTape, which underestimated depth on early measurements in the cycle. Of note is the eTape's minimum depth measurement of ~1 inch which indicates this sensor's inability to monitor low-level flooding. The ultrasonic sensor does not suffer from this issue. As the eTape is also of finite size, the maximum flood height it can measure is 24 inches (the maximum available length of eTape).

From this set of test procedures, the ultrasonic sensor was proven to be more suited to depth-sensing over long periods of time and under varying flood conditions. For these reasons, the ultrasonic sensor was employed in our first set of sensor prototypes.

Subsection 2.2 Initial prototype

The project's first prototype was built and tested in the sensor lab at 370 Jay Street, 13th Floor. **Figure 4** shows it mounted in the lab. The sensor dimensions are 5" x 4" x 4" and it is typically mounted around 12 ft above the ground.

Figure 4: Prototype ultrasonic flood sensor mounted to a pole in sensors lab

The sensor uses a high-end ultrasonic range sensor, the MB7389 from Maxbotix, which provides range detection from 30-500 cm with an accuracy of ±3 mm. The sensor can be pole or wall-mounted. The sensor is battery-powered, with solar energy harvesting for extended operation. Connectivity is provided via a LoRaWAN system described in the following sections. This prototype version of the sensor will typically upload data every 5 mins with faster update rates when flood water is detected.

Subsection 2.2.1 Components

All components are readily available from internet suppliers, primarily NYC-based. **Figure 5** labels the core components within the prototype sensor.

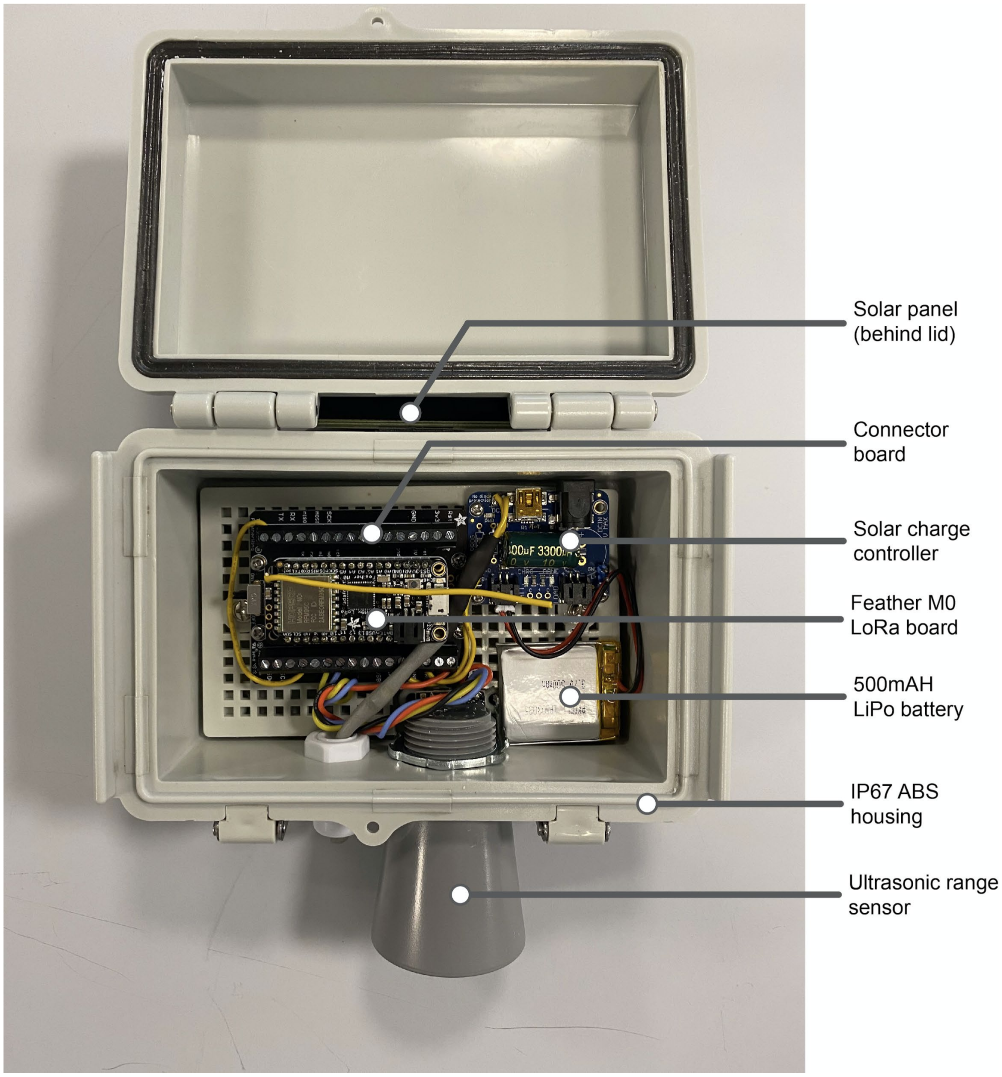


Figure 5: Core components of the prototype sensor unit

The bill of materials excluding mounting hardware costs for the complete sensor prototype are listed in **Table 1**. Each item row is linked to the supplier. Note that the battery listed in **Table 1** has a larger capacity for extended operation when the solar panel is not harvesting enough energy.

Item	Count	Cost
Feather M0	1	$34.95
2200mAh battery	1	$9.95
Connector board	1	$14.95

Solar board	1	$22.90
Ultrasonic sensor	1	$99.95
Mounting headers	1	$9.19
Panel mount	1	$14.09
Housing	1	$17.59
Locknut	1	$5.99
Grand Total		229.56

Table 1: Bill of materials (BOM) for sensor prototype

The build process for the prototype sensor is included on the project's public sensor github repository (github.com/floodsense/floodsense_sensor)

Subsection 2.2.2 Rooftop deployment

Four variants of the first prototype were deployed on the roof of 370 Jay Street for testing. **Figure 6** shows the setup in which the four prototype sensors are mounted onto railings over a pool that can collect rainwater, acting as a flood simulator. On September 10th, 2020, sustained rainfall led to a buildup of water in our flood testbed. This change in water depth, while minimal, was detected by our flood sensors mounted there.

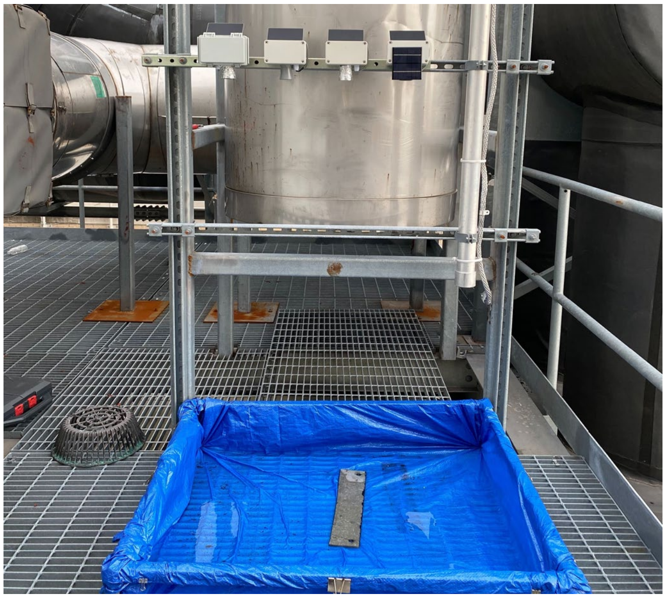


Figure 6: Four sensors mounted on testbed setup on 370 Jay St rooftop

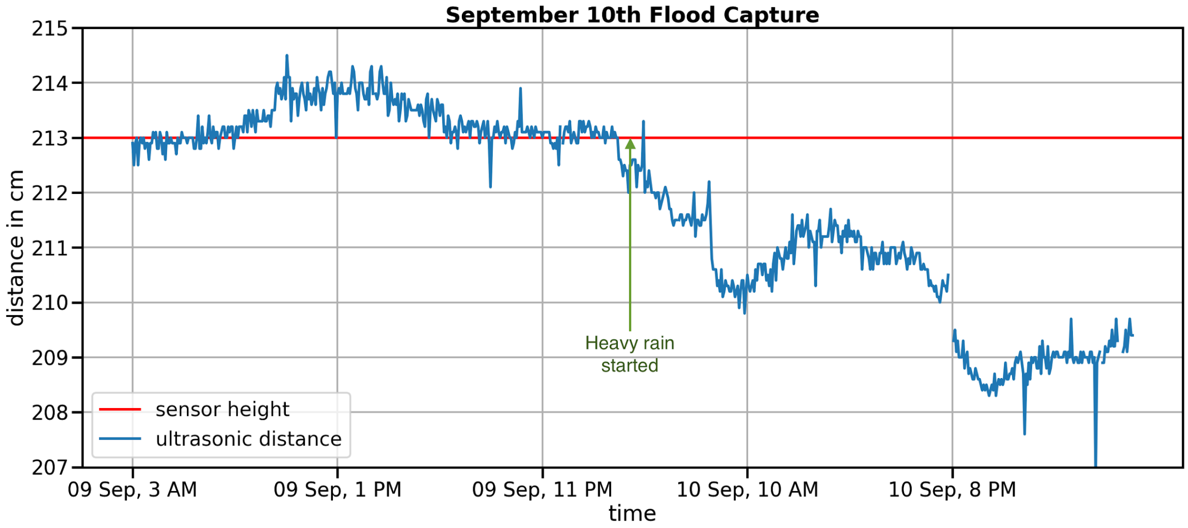


Figure 7: Flood detected in rooftop testbed on September 10th after heavy rainfall

Figure 7 shows the change in distance from the sensor to the water surface. The dropped measurements seen are caused by missing data packets which occur < 0.01% of the time. The influence of sunlight on distance measurements can be observed during early daylight hours, but the flood trend is apparent and could be detected at the server level to trigger alerts and increased data logging frequency. While this *flood event* was minimal, it shows the ability of the sensor system to detect relatively small amounts of water buildup on a surface.

Subsection 2.3 System architecture

To allow for rapid dashboard development and a more extensible platform for sensor data ingestion and storage we moved to an NYU hosted set of open source tools. This combination of docker containers is running a load-balanced web server (NGINX), certificate authority (LetsEncrypt), data routing layer (NodeRed), a database (InfluxDB), and a dashboard platform (Grafana). This is illustrated in **Figure 8**.

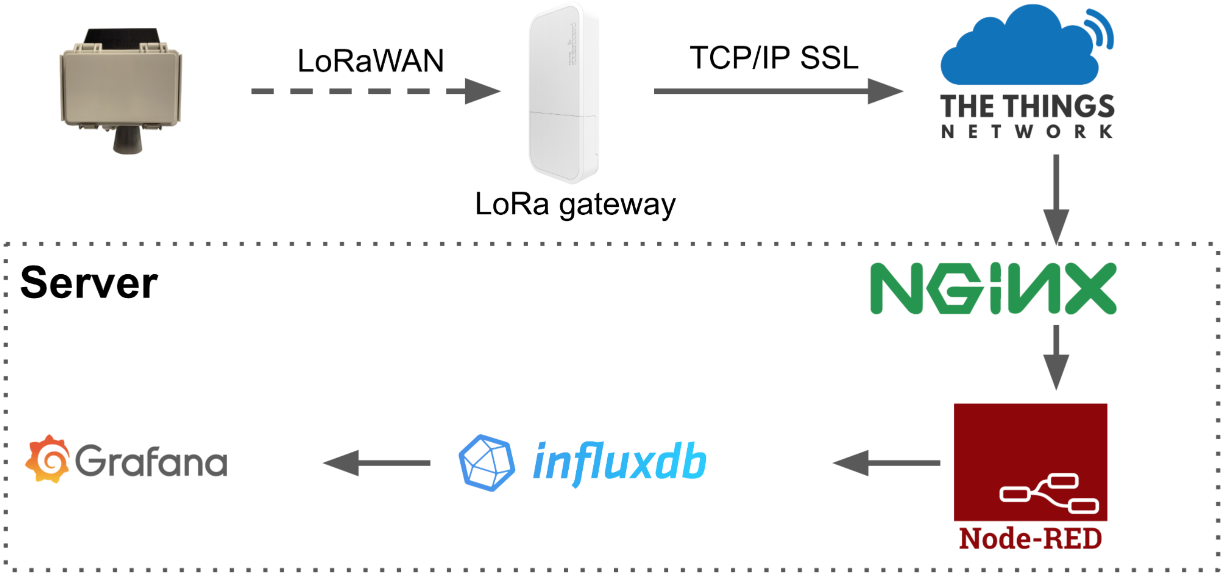
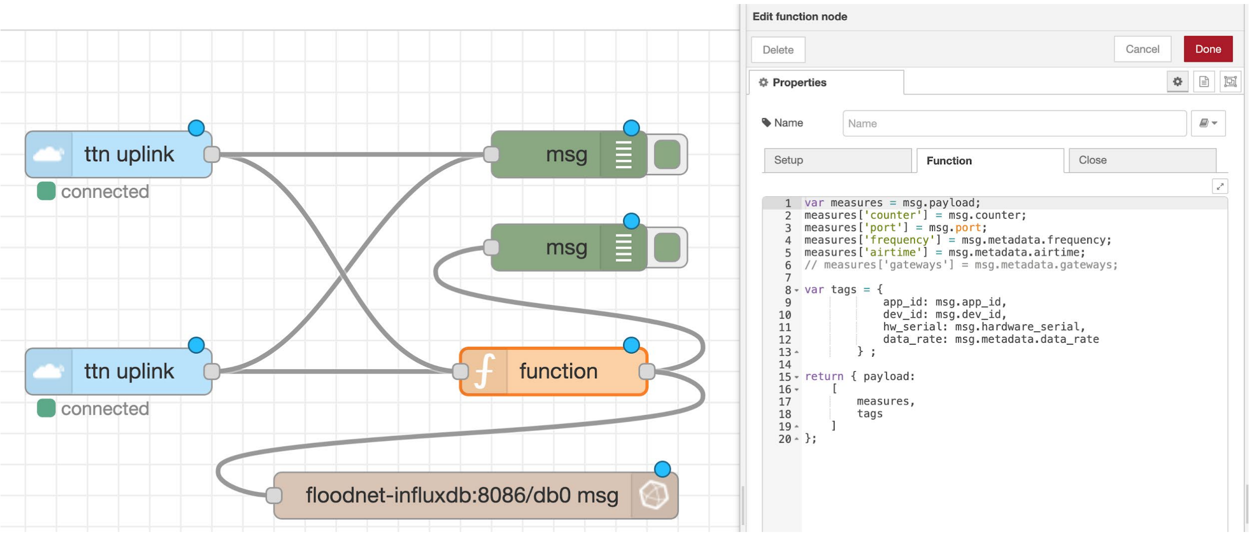


Figure 8: FloodSense system architecture

Data is forwarded from the sensors to a LoRaWAN gateway. From here it is pushed to our project's The Things Network (TTN) application. The data payloads from this application are picked up by our NodeRed flow shown in **Figure 9**.



```
var measures = msg.payload;
measures['counter'] = msg.counter;
measures['port'] = msg.port;
measures['frequency'] = msg.metadata.frequency;
measures['airtime'] = msg.metadata.airtime;
// measures['gateways'] = msg.metadata.gateways;

var tags = {
            app_id: msg.app_id,
            dev_id: msg.dev_id,
            hw_serial: msg.hardware_serial,
            data_rate: msg.metadata.data_rate
        } ;

return { payload:
    [
        measures,
        tags
    ]
};
```

Figure 9: NodeRed application showing data flow and preprocessing function block

This preprocesses the payloads from all of our applications and routes them into the InfluxDB database. From there Grafana handles all visualization through its intuitive dashboarding platform. **Figure 10** shows the Grafana dashboard displaying realtime sensor data. Dashboards can be quickly created using the Grafana GUI.

Figure 10: Grafana dashboard for the first deployment

All of these platforms are accessible, in their development state, from anywhere, using the project urls: floodnet-grafana.sonycproject.com (dashboard), and floodnet-nodered.sonycproject.com (Node Red).

Subsection 2.4 Deployment

On October 3rd, a LoRaWAN gateway and two flood sensors were deployed in the Gowanus area of Brooklyn. Through conversations with the NYCDOT Assistant Commissioner of Traffic Control & Engineering, permission was granted to mount sensors on traffic signs (U-Bar mounted signs, not traffic lights or street lights). This opened up many opportunities for sensor deployments on flood-prone roadways. A key factor in gaining these permissions was the sensor's small size, weight, and lack of reliance on existing power and connectivity resources. Street signposts provide an ideal mounting condition with steel U-Bar for variable mount heights. The NYCDOT stipulations were that the sensor should be mounted at least 7ft from the ground to reduce the chance of vandalism. Between the creation of this document and the deployment, the mounting hardware changed slightly.

Subsection 2.4.1 LoRaWAN gateway deployment

This gateway forwards LoRa traffic received from sensors to The Things Network where it is routed to specific project servers. The gateway's antenna is mounted at around 25ft above ground height on a rooftop next to the Gowanus Canal and provides LoRa sensor coverage for a ~2km radius. It is mounted on the rooftop of a private local business that has kindly granted their permission through the duration of the project. The business owner is a member of the Gowanus community and has felt the impact of urban street flooding so has a vested interest in the project and its goals.

Figure 11: LoRaWAN gateway mounted (inset) with approximate 4km diameter coverage area highlighted in green

Figure 11 shows the gateway mounted with its location and approximate coverage. This coverage alleviates a large number of concerns around sensor connectivity and should provide for the deployment of any number of sensors in the project focus areas.

Subsection 2.4.2 Sensor deployments

To test the ability of the sensor to detect water level changes under real-world conditions, one was mounted above the Gowanus Canal. Figure 12 shows this deployment and the way in which we mounted the solar panel separately to the sensor. This was a decision made on site as the panel ideally needs to be south facing at a rough 45° angle and the top/front-mounted solar panel of the sensor’s default configuration wouldn't have allowed for this.

Figure 12: Gowanus Canal mounted distance sensor showing rear-mounted solar panel

The second sensor is mounted on a street sign post at a location known to be flood-prone, at the corner of 5th St and Hoyt St. **Figure 13** shows this mounted sensor with a height of around 11ft to reduce the chances of vandalism.

Figure 13: Street signpost mounted sensor in at 5th St and Hoyt St, in Gowanus. Inset shows front-facing closeup of sensor.

This signpost deployment is particularly interesting as it features an uneven surface on the sidewalk with grass and weeds growing between sidewalk paving slabs. The mounting process was quick and required a small ladder to reach the required height. Based on ground conditions, this sensor would have been better mounted on the reverse side of this post where there is a flatter and more consistent sidewalk surface for ultrasound reflections. As the solar panel was pre-mounted to the sensor top this forced the sensor's body to be south facing. In light of this, we are implementing a smaller solar panel and mount that is detachable from the sensor body with an extendable shielded cable so the panel can be mounted independently of the sensor's orientation.

Subsection 2.4.3 Power Requirements

Battery operation of the deployed sensors has been promising. **Figure 14** shows the two sensors' battery charge levels increase after deployment on a sunny day to a constant charge drain cycle. The difference in average voltage levels between sensors is a result of battery differences and is normal in lithium polymer batteries.

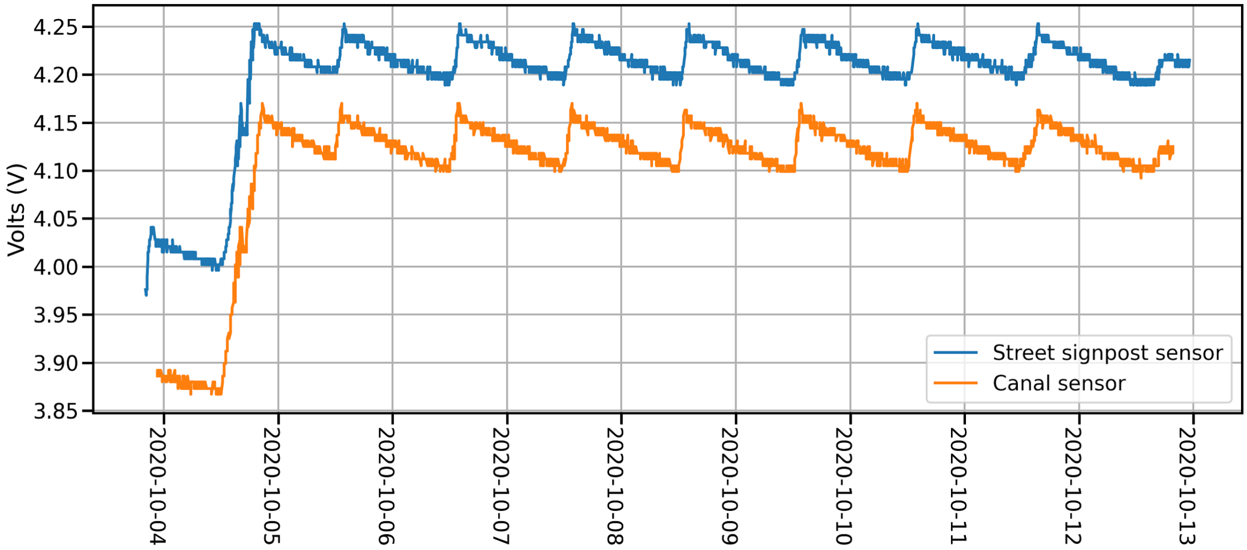


Figure 14: Battery voltage plot for two deployed sensors with solar harvesting fully charging the cells daily

A key point is that the 2200mAh battery is being fully charged within 2 hours of receiving direct sunlight on its panel. The amount of direct sunlight the panels receive will reduce in the winter months but there is a lot of headroom built into this power harvesting configuration to accommodate this. Estimated battery life without any solar input would be 36 days in the event of prolonged snow cover on panels or panel failure.

Subsection 2.4.4 Data collection

As of April 29, 2021, the two deployed sensors have collected 207 days of data, equating to ~60,000 measurements per sensor. The street mounted sensor has collected data from 2 flood events on November 15th and 30th, with several snow buildups detected over the winter. **Figures 15** and 16 show the depth profiles of these street flood events using data from the deployed sensor.

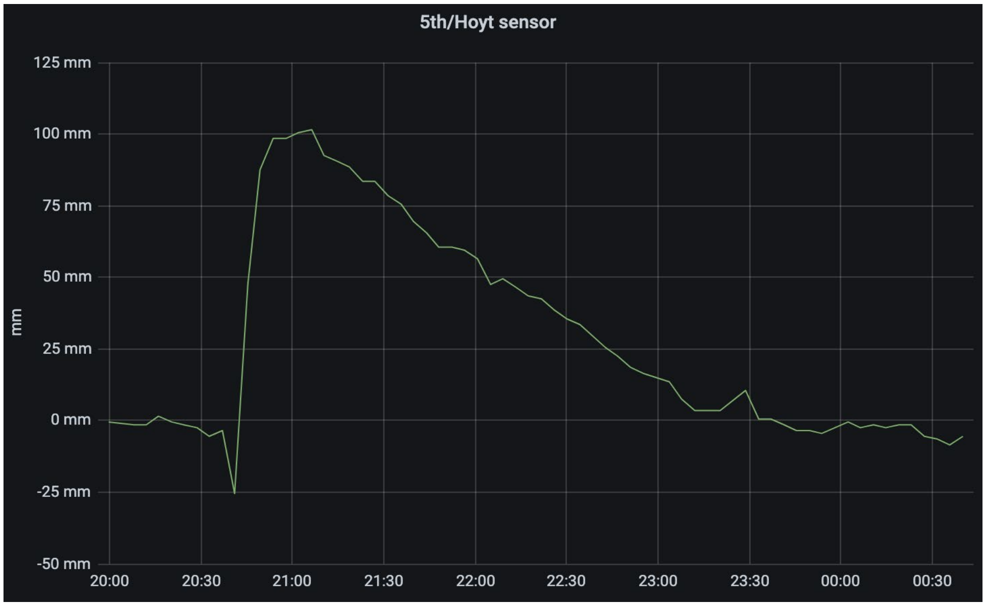


Figure 15: 5th/Hoyt St sensor showing flood depth over time on November 15th, 2020

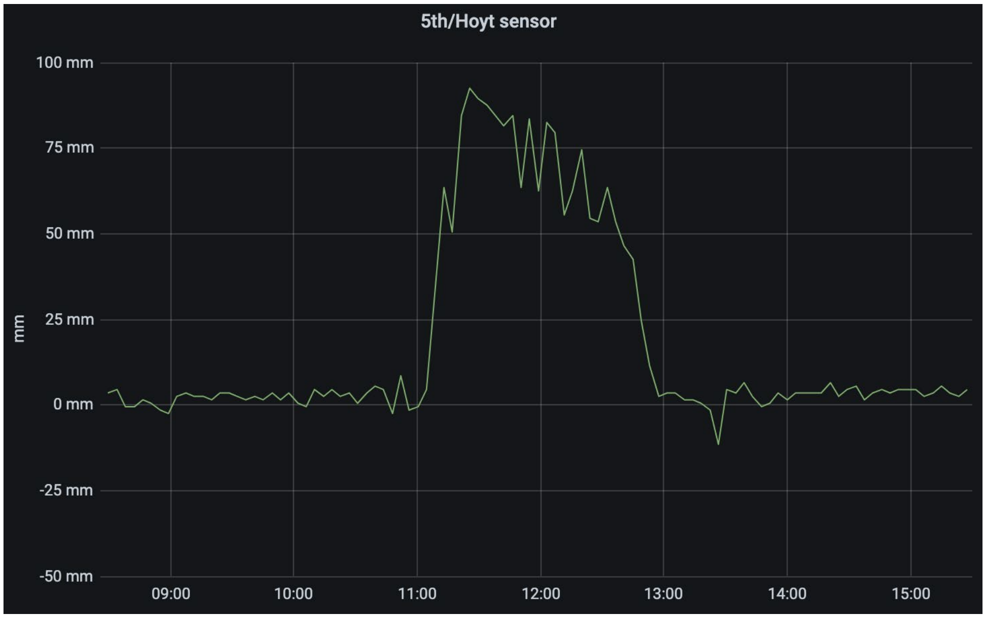


Figure 16: 5th/Hoyt St sensor showing flood depth over time on November 30th, 2020

Of note is the difference in profiles between the two floods. The first flood shown in **Figure 15** developed significantly faster than the other shown in **Figure 16,** and took a far longer time to dissipate (~2.5 hours vs ~1 hour). This information can be used to determine the extent of the drainage problem for a particular localized set of storm water drains, of relevance to our DEP partners. This level of temporal detail also allows for alerting when flood levels rise and fall above thresholds that could block vehicular and pedestrian traffic, of relevance to our DOT partners. This feature is built into the Grafana dashboard system with alerts sent via email, text message and chat-app message.

Subsection 2.4.5 Solar heat gain issue

After a number of days of street data collection, an anomalous dip in surface depth below 0 mm was observed. This only occurs during bright sunny days and was determined to be caused by direct sunlight falling on the ultrasonic sensor's plastic housing, raising its overall temperature above the ambient temperature. The internal temperature of the ultrasonic sensor is used to compensate for the varying speed of sound according to temperature, and when overheated in the housing, leads to over-compensation for an apparent rise in temperature, resulting in an overestimation of the speed of sound and thus a negative flood depth measured. On non-flooding days this can be ignored but if the sensor was hit with direct sunlight during a flood event, the data would show that the flood depth was reducing over time as the ultrasonic sensor heats up. To mitigate the effects of this, a number of housing configuration are under test. These aim to block direct sunlight from falling on the ultrasonic sensor housing.

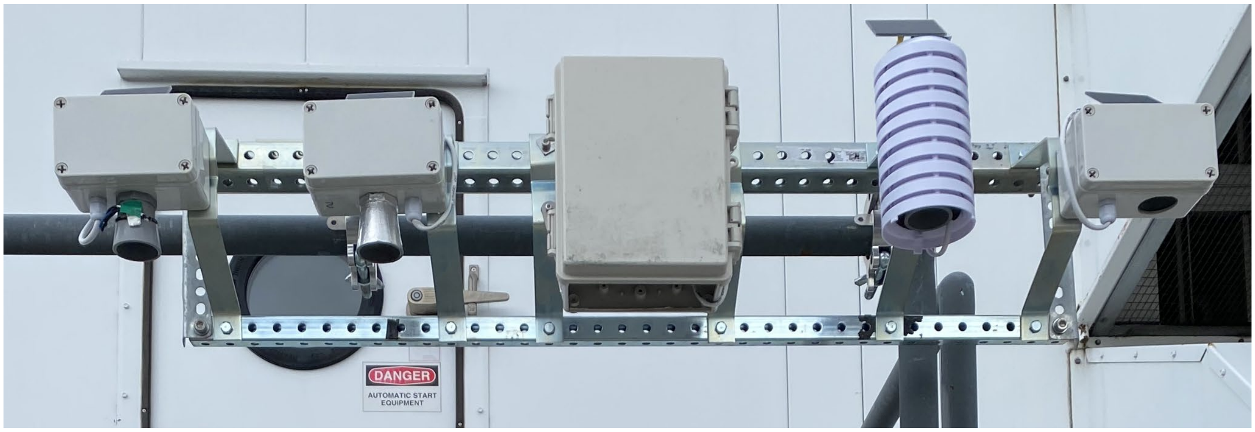


Figure 17: Housing Configuration Test Rig Mounted on a South Facing Rooftop

Figure 17 shows these different housing configurations mounted to a test rig on a south facing rooftop. From initial data collection, the best performance is shown by the second from right louvered design. **Figure 18** shows this initial data collected over 5 days. The least promising design has the ultrasonic sensor mounted inside the housing, which is presumably heating up and maintaining its high internal temperature for longer with reduced impact from wind cooling.

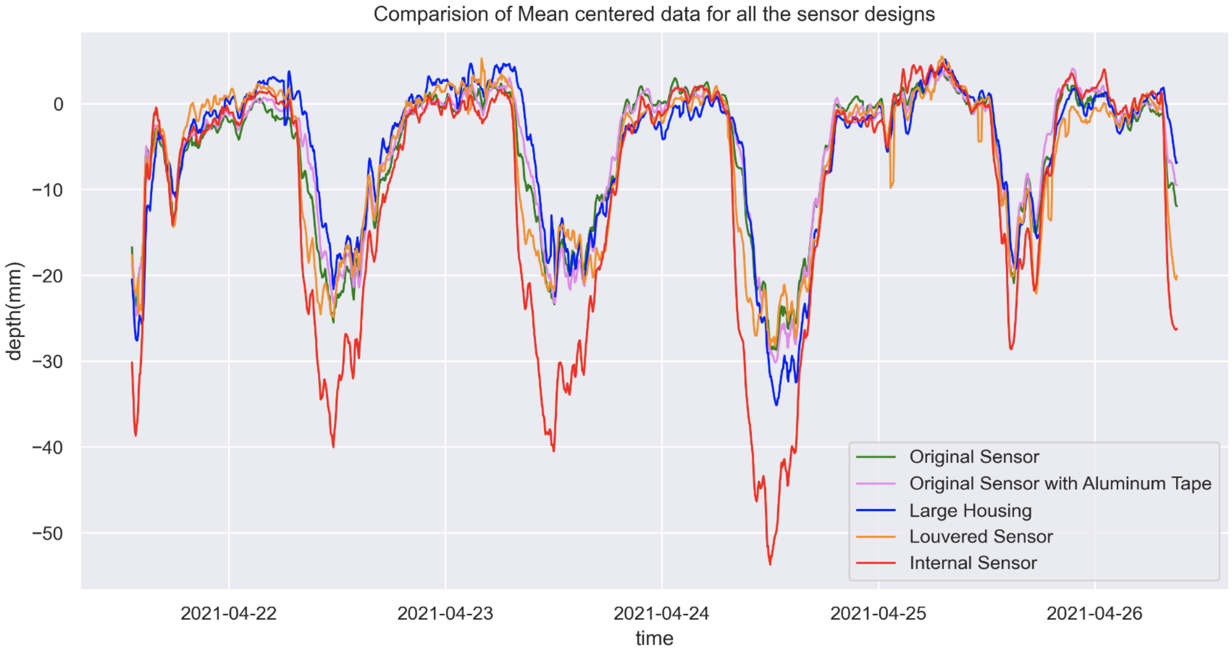


Figure 18: Initial depth data from rooftop design configuration deployment aimed at reducing solar heat gain influence on measurement accuracy.

This experimental work is ongoing, with plans to publish in a top tier sensor/IoT journal such as MDPI Sensors, IEEE Sensors Journal, Sensors and Actuators A: Physical, and International Journal of Distributed Sensor Networks.

Section 3. Collaborations, Stakeholder Needs and Impact Identification

Subsection 3.1 Collaborators and stakeholders

Since the start of the project we have expanded our network of partners, who represent a range of stakeholder categories and have identified different needs:

Researchers - we established a partnership with researchers at CUNY (Prof. Brett Branco and Dr. Ricardo Toledo-Crow) over the summer of 2020. Data needs identified by NYU and CUNY researchers include flood alerts to indicate when to visit sites to collect water samples for research on flood water contaminants, and data to develop flood forecasting models. Prof. Branco is the Director of the Science and Resilience Institute at Jamaica Bay (SRIJB), which has been working closely with communities in the Jamaica Bay watershed to record flood events through the FloodWatch citizen science project. Dr. Toledo-Crow has also been working on sensor design to aid in validating FloodWatch reports; through this collaboration, we have (1) been connected with community groups in the Jamaica Bay watershed, and (2) harmonized aspects of the sensor design with Dr. Toledo Crow, and co-deployed sensors, as described further in Section 4 (Sensor Co-Deployment).

In early 2021, our research team collaborated with researchers at the New School, Barnard College, Pratt, Arizona State University, and the USDA Forest Service (led by Prof. Timon McPhearson at the New School) on a proposal to the National Science Foundation Smart and Connected Communities program ("SCC-IRG Track 1: RE-ACT: Coproducing urban flood data and knowledge networks for community resilience action"). The team is largely comprised of social scientists interested in the ways in which flood-related data is actually used for action towards community resilience. The role of our team and the flood sensors is to provide real-time flood data that can be used as a tool to assess its utility in community-led and city agency-led flood mitigation and adaptation.

Preliminary conversations with Prof. Franco Montalvo and his research team at Drexel University have revolved around the use of the sensors to evaluate green infrastructure for stormwater detention and treatment; this collaboration may lead to proposals to the National Science Foundation.

NYC Agencies - we have developed a strong and fruitful partnership with the NYC Mayors' Office of the Chief Technology Officer (NYC MOCTO) and NYC Mayor's Office of Resiliency (NYC MOR), and meet with representatives from both on a weekly basis. NYC MOR has subsequently arranged for ongoing monthly progress meetings with relevant personnel from the NYC DOT and NYC Department of Environmental Protection (NYC DEP), which has aided us in gaining permission to use DOT U-poles to deploy sensors and allowed us to assess the needs of city agency stakeholders. The identified needs include data for resiliency planning, for transportation planning, to validate anecdotal evidence of flood extent (e.g., community reports and 311 flood complaints), and to validate complex hydrological models NYC has developed for future flood predictions. City agencies also view this data as novel baseline data to monitor changes in flood extent and patterns into the future.

Citizens/Community Organizations - in addition to our existing partnership with GCC in Gowanus, we have connections to communities and community groups in the neighborhoods around Jamaica Bay (which experience tidally influenced flooding) through our CUNY and SRIJB partners. CUNY and SRIJB have very close working relationships with the Rockaway Institute for Sustainability and Equity (RISE), and the New Hamilton Beach Civic Association. Identified data needs include data for advocacy and data for day-to-day decision-making surrounding living with water.

Education and curriculum development, We have collaborated with Dr. Kayla Desportes and Dr. Maaike Bouwmeester from NYU Steinhardt, who teach a Design Process for Learning course in which students develop curriculum around STEM learning objectives. They used our project as a case study, and two student groups addressed it from different angles with STEM learning and environmental stewardship objectives, respectively. Over the semester, students interfaced with the Gowanus Canal Conservancy's education and outreach teams to define learning objectives relevant to their community members. Additionally, PIs Brain and Henaff secured a grant from the Bennett Polonsky foundation for interdisciplinary undergraduate curriculum development in collaboration with two NYU Humanities faculty, in which this project was featured as a case study as well.

Industry collaboration Over the course of this project, we have collaborated with various companies who have supported the project with in-kind donations and consulting support. These include Voltaic, a solar panel company, that has supplied 12 solar panels for our use and testing, the Things Network, who have provided two industrial LoRaWAN gateways, one of which has been mounted on the roof of 370 Jay Street, Brooklyn, providing LoRaWAN coverage for many miles around.

These collaborations have been key in accomplishing our research goals and defining new research directions. For example, the collaboration with NYC MOR led to DOT granting access to u-pole signposts for mounting our hardware. The collaboration with CUNY researchers led to four collaborative grant proposals, submitted to federal, state, and city institutions. Collaboration with DEP has led to defining a new research aim, that of benchmarking their hydrological models by placing flood sensors at locations relevant to their calculations. Finally, collaborations with our community partners have led to insights as to sensor placement and derived flooding impacts.

Subsection 3.2 Sensor co-deployment

In February 2021, two sensors were deployed alongside CUNY sensors for comparative data collection. The CUNY sensor design uses the same core hardware components and the same firmware but includes a 10 ft long, 6-inch-wide PVC pipe to reduce the chance of erroneous readings and false positive flood detections caused by debris below the sensor.

Figure 19: CUNY (left green pipe) & NYU (white pole mounted) sensor co-deployment in Hamilton Beach, NY

These sensors have measured four tidal flooding events and have shown strong agreement in the depth profile throughout these events. Further deployments like this are planned for locations in Far Rockaway.

Subsection 3.3 Community outreach talks and presentations

Due to COVID19 social distancing requirements, we have conducted community outreach through online presentations and limited in-person site visits.

We led a workshop with the Gowanus Canal Conservancy team on March 19th, 2021 to share the status of the project and gain further information of their stakeholder needs. We conducted a site visit with Amy Motzny, Watershed Senior Planner of the GCC in November 2020 to show her the two deployment sites in the Gowanus area.

As a group, we have given several public talks and presentations, outlined here:

Date	Event	Link
2021-03-12	NYC Open Data Week: Living with Water: Using Qualitative and Quantitative Data on Flooding to engage with Communities and Agencies	https://2021.open-data.nyc/#details2163
2021-03-06	NYU Urban Research Day: Flooding and the Urban Microbiome	https://www.nyu.edu/content/dam/nyu/urbanInitiative/documents/2021%20URD%20Digital%20Booklet.pdf
2020-12-04	FloodSense talk at C2SMART / CUSP	https://engineering.nyu.edu/events/2020/12/04/cusp-research-seminar-floodsense-longitudinal-remote-urban-flood-monitoring

Table 2: Public talks and presentations given

Section 4. Applications for Additional Funding

Based on the successes and partnerships developed during the grant period, we submitted proposals to additional funding opportunities, to further support the project. The submitted proposals and outcomes are as follows:

a. **New York State Empire State Development Smart Cities Initiative:**
Smart Cities Application for Real-Time Flood Monitoring
Status: AWARDED
Total Requested: $90,420
Funding period: 5/1/2021-4/30/2022 (original start date was 1/1/2021 but was delayed)
Collaborators: CUNY, Science and Resilience Institute of Jamaica Bay, NYC MOR and NYC MOCTO

Objective of this proposal is to design, develop, and implement a public-facing data dashboard for the flood sensor data, through a community-engaged approach. This grant will help extend the work of the C2SMART grant; as such funding will be used to pay a software developer to build the web-portal, and an NYU student researcher to contribute to community outreach, project management and facilitation.

b. **National Science Foundation Smart and Connected Communities:**
SCC-IRG Track 1: RE-ACT: Coproducing urban flood data and knowledge networks for community resilience action
Status: Pending
Total Requested: $2,500,000
Funding period: 1/1/2022-12/31/2025
Collaborators: The New School, Barnard College, Pratt, USDA Forest Service, Arizona State University, Science and Resilience Institute of Jamaica Bay, NYC MOR, NYC MOCTO, and community partners.

The objective of the proposed work is to develop a community-based, technologically advanced *RE-ACT Codesign Platform (RCP)* that integrates novel data visualization technologies, real-time local flooding data and infrastructure conditions, outputs from flood forecasting models, and information on community knowledge and networks related to flood resilience, using a strong community engagement process to enable problems, strategies, solutions, and visualizations to be *co-produced, co-analyzed* and *co-evaluated* by community members. The RCP will be used to answer the overarching research question: *How can co-design and community engagement in different neighborhoods be combined with smart technology (through advanced Big Data, real-time sensors, qualitative data, data science, and data visualization) to improve actionable local and municipal knowledge systems that increase flood resilience*? As such, the project team includes a strong knowledge base in the social sciences, to better understand how flood sensor data is actually used for actionable resilience planning.

c. **Congressional Community Appropriations Funding**
FloodNet: Community-engaged Hyperlocal Flood Monitoring to Support Urban Resilience
Status: Pending
Total Requested: $653,605

Funding period: 1 year duration
Collaborators: CUNY

The objective of the proposal is to further develop the FloodNet platform for actionable use by communities and city agencies. Goals include: (1) Deployment of sensors in our focus communities, with specific locations determined through engagement with community and city agency partners. (2) Ongoing development of an accessible, public-facing dashboard that provides flood sensor data in a manner that meets the needs of various stakeholders. (3) Ongoing iterative sensor development based on feedback from community and city agency partners. (4) Development of quality control processes, lesson plans, construction guides and workshops to enable community members to build sensors and incorporate them into the network. As such, we plan to work with Gowanus Canal Conservancy to incorporate the sensors in their community outreach, education, and engagement activities.

d. National Science Foundation CIVIC Innovation Challenge:
SCC-CIVIC-PG Track B: Living with Water: Co-produced data collection network for resilience to chronic and extreme urban flooding
Status: Declined
Total Requested: $40,000 for the Phase 1 planning grant
Funding period: 1/1/2021-4/1/2021
Collaborators: CUNY, NY Sea Grant, Stevens Institute, USDA Forest Service, Science and Resilience Institute of Jamaica Bay, NYC MOR, NYC MOCTO, and community partners.
Objective of the planning grant was to bring together researchers, city agencies, and community partners to co-develop a full project proposal around the vision of creating a co-produced flood monitoring, forecasting and alert network that integrates robust and sustained engagement among civic partners, community organizations, and researchers. This network would harmonize government and community priorities and improve the collection and use of physical and social urban flood data.

Section 5. Press

This FloodNet project was named the Metrolab “Innovation of the month” and was featured in this publication in February. It was also mentioned in the Queens Chronicle in March as well as discussed in public forums like NYC City Council Meeting.

a. *Metrolab February 2021 Innovation of the Month:* https://www.govtech.com/public-safety/Data-Project-May-Drive-Policy-for-Hyperlocal-Flooding-in-NYC.html
b. Testimony of the Mayor’s Office of Resiliency Before the New York City Council Committee on Environmental Protection (December 2020)

c. *Queens Chronicle: https://www.qchron.com/editions/queenswide/neighbors-join-effort-to-document-flooding/article_d692a319-86ad-5a72-bdd4-4a6802114b5f.html*

Section 6. Next Steps

The collaborations that we've formed with NYC MOR, NYC MOCTO, SRIJB and CUNY has led to the official formation of the FloodNet consortium and the development of www.floodnet.nyc/, which will eventually house our data dashboard. FloodNet brings together innovative sources of information on street flooding impacts in neighborhoods that are vulnerable to high tides, storm surge, and stormwater runoff.

Given the success and lessons learned from our research program over the last year, the goal for next year is to expand sensor deployment and transfer data to our stakeholders through FloodNet and the following objectives: (1) expand the flood sensor network (2) develop a public-facing data dashboard to transfer flood data to a range of stakeholders, and (3) evaluate feasibility of new flood sensor modalities.

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3. Makepeace, D. K., Smith, D. W. & Stanley, S. J. Urban stormwater quality: Summary of contaminant data. Critical Reviews in Environmental Science and Technology 25, 93–139 (1995).

4. NYC Office of Emergency Management. NYC's Risk Landscape: A Guide to Hazard Mitigation (2014).