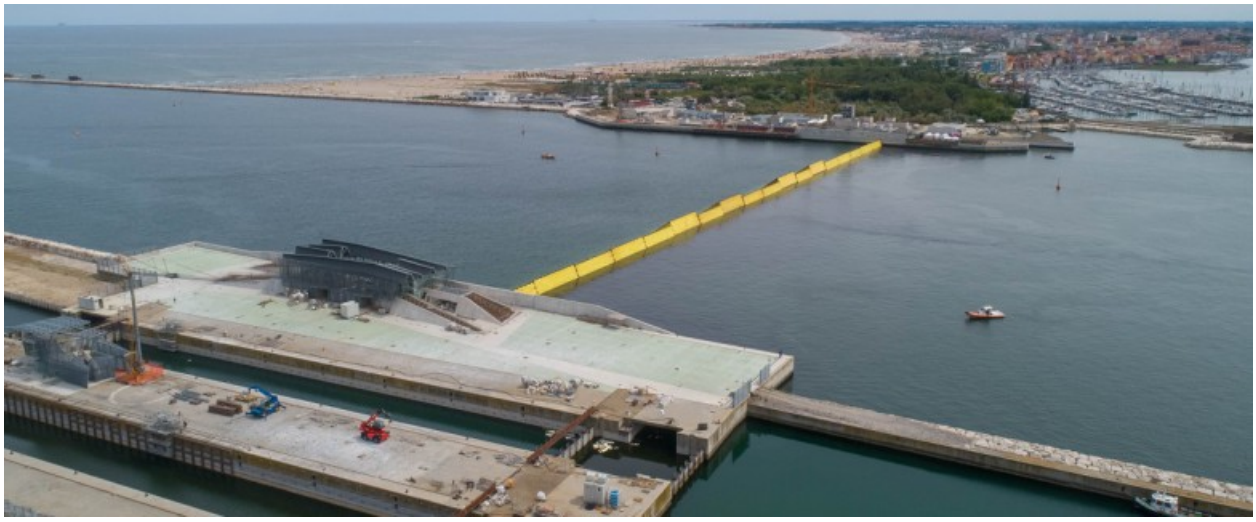
Giving MOSE A Voice

Drew Silvernail, Matthew Boisvert, Dov Ushman, Evans Owusu

Advisors: Fabio Carrera and Lorraine Higgins

Sponsor: by Consorzio Venezia Nuov

December 17, 2022



Executive Summary

The goal of this project was to build a public alert system to notify the people of Venice about high tides and the use of MOSE; the new flood mitigation system. We worked with the Commissario Straordinario per il MOSE, who oversees the MOSE operation. We built upon a simple traffic light warning system that they had in place at the start of this project. By interviewing a total of seven residents and five business owners, we identified information Venetian residents and businesses need for flood prevention and MOSE operation. Using this information, we created a high-fidelity design for a MOSE app. The app provides alerts of approaching high tides, weather forecasts, travel advice, and information about MOSE.

In Venice, flooding is a common weather phenomenon that perpetually affects the lives of its citizens by damaging historical sites, affecting business operations (*Figure 1*), and changing the way people move throughout the city. Citizens need to be informed about natural disasters from the moment danger is spotted in order to protect themselves. The Nov 4. 1966 flood (Acqua Granda) was Venice's most damaging flood. The Acqua Alta reached a height of 194cm, and was a wake-up call for the city to take more initiatives in predicting floods and mitigating their damages. In order to protect Venice, the city instituted several interventions after 1966, including tide forecasting systems and public alert systems based on this data.

Figure 1. Business Flooding in 2019 (Dirnhuber, 2019)

But warnings alone are not enough. Over the course of the past three decades, the number of tides has been increasing drastically. Even when comparing the 2000s to the 2010s, this increase is visible. The frequency of high tides greater than 110 cm rose from approximately 50 tides to 70 tides a year; this increase is a dangerous trend with consequences. The rise in high tide occurrence led to Venice taking action. After the Acque Grande, a competition was held in 1975 to find a design for a structure that could help prevent flooding in Venice. The winning design was named The Modulo Sperimentale Elettromeccanico, Experimental Electromechanical, called MOSE for short. This system consisted of a floodgate and casing attached by a hinge.

This project is located at the three inlets of Venice. These inlets allow water to enter the lagoon. MOSE, when not activated, lays dormant flush to the lagoon floor but when high tides are predicted, MOSE is activated. Pressurized air is pushed into the submerged gates, forcing the

water out, making the gates rise to about a 45° angle, and thereby preventing up to 3m of high tides from entering the Venetian lagoon.

MOSE's implementation has helped Venice face high tides. Through the use of the Commissario's website, the public is informed about MOSE activity through a traffic light system called the Semafori (*Figure 2*). At the start of this project, the system communicated information about the gates in each of the three inlets (with two for Lido). Each inlet was assigned a traffic light. If the light is green, then then the gates at that location are down; if the light is yellow, then there is an impending rising gate; flashing red means the gates are currently being raised; and red means the gates are up. This helped local boat operators know when and if they can safely enter the inlets or whether they will need to wait or pass through a set of locks located nearby. It also allowed the public to know MOSE was activated and that tides inside Venice are different from times outside of the lagoon. As of the rising of the gates on November 5, 2022, the Semafori system had an update. Prior to this update, when the lights on the site were yellow, it indicated a rising gate within the next nine hours. Now, however, the yellow light has become more detailed, and when the light switches to yellow, a countdown displays how much time is left until the gates will rise as well as showing the time and date (normally the current date unless they are being raised at night) when the gates will rise.

Figure 2. Semafori Stoplight System

To better understand what the public needs in an alert app, we interviewed five business owners, and seven residents. We learned that although residents use a variety of existing apps (on weather, on tides, on travel, etc.) there was not one easy to use app containing all of this information and integrating it with information about MOSE operation, which directly affects

tide level in the lagoon. From the interviews, and from our discussion of what they most liked and used in current apps, we developed a list of functionalities for our app:

- An accurate showing of MOSE's position - raised or not
- An alert if MOSE is expected to rise, and when, and an alert if MOSE will definitely rise
- Timely warnings (as precise as possible) about whether Venice will have high tides
- Warnings if Venice will flood in days ahead
- A warning if the area the residents live or work in or the specific area where they will be traveling will flood (providing tide levels without the need for "mental math" to calculate the levels most relevant to them)
- Information on alternative travel routes
- An accurate showing of the tide level in different areas of Venice
- Alerts if public boat routes are being canceled or if the boat schedules are delayed
    - If boats are canceled, what are other routes the user can take

Although some of these features were already available on various apps they used, at the time of this project, no one app included everything they needed .

Through the interviews, we gathered that the most commonly used apps and the apps with the most desired features were Hi!tide Venice, Venice Tide, and Water on Venice Floor (WVF). These apps provide useful information such as the tide height located in Venice, the tide height predicted in Venice for the next two days, maps displaying what areas of Venice are currently flooded, and even what areas of Venice are predicted to be flooded. But none of these apps provide data on the MOSE gates, no travel functionality (like Google Maps), and several unintuitive layouts which went against Android app guidelines.

Once we identified these features, we created mock-ups of an app Using Adobe XD which allowed our team to collaboratively work on the same design at one time. By using multiple designs, discussing among ourselves, and receiving feedback from our sponsor and from local residents who reviewed our mock-ups, we were able to continuously improve upon our design and fine-tune the look and feel of the app to make it more intuitive and appealing

Early in our design process, before making modules, we narrowed down what our four main screens would be: "Home", "Travel", "Weather" and "Updates" screens. Within these screens, we planned to include smaller modules we could work on and easily replace as we gathered feedback. This allowed for rapid prototyping,

When we felt confident about the main screens and functions, we made our mockup interactive, to show how a user might navigate from one part of the app to another. Adobe XD "Prototyping" feature allows for developers to connect different screens and build in reactions. For example, if a user were to press the "Travel" icon on the home page, the app would bring the

user to this page. By creating mock-ups in this manner, we were able to simulate an experience a user might have on our app. And do more high-fidelity testing for additional feedback

During this process, our sponsor actually took some of the app features–specifically providing the exact time the gates will rise on the Semafori system – and applied this idea immediately to a newer, improved version of the Semafori.

From here, we began making the final iterations of our app. Across the project, our four main pages stayed the same, but many new subpages were added. Below, we show the main pages of our apps as well as point out the different information being shown.

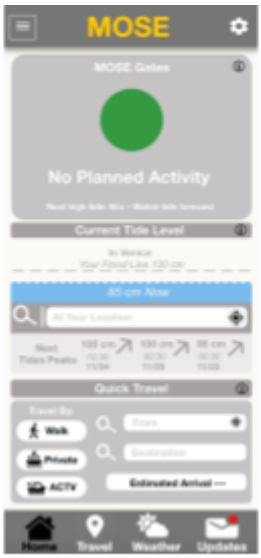


Figure 3. Home Page

The first module is our updated Semafori system (*Figure 3*). It displays current MOSE activity, when all gates are down a green light is shown. If any gates are expected to rise, are rising, or have risen, then the light will split into three lights. Each light has an abbreviation of the inlet in the corresponding light. Next is the tide module, the module displays current tide levels at locations of your choosing. In addition, there's an account feature that lets users save their location. The app will display the saved or searched location "Your Flood Line" graphic. It's the height of the saved or search location floods at. Times and heights of the next three tide peaks in cm are displayed below to inform users. Lastly is the "Quick Travel" module. This module allows users to enter their location (or track their location), then enter their destination and a set of travel directions is generated. By pressing on one of the travel options, the user can select if they want to walk, use a private boat (in combination to walking) and lastly use a combination of the ACTV boats and walking.

On the "Travel" page (*Figure 4*), there is a more informative model of the "Quick Travel" module with a map to find destinations. When information is entered, the user will have a map generated showing their travel path. The path has multiple colors with a legend describing their meanings (ie, bridges are yellow and blue for underwater streets). All trips display useful information surrounding a trip's condition. There is also a recommendation if you should bring boots.

Figure 4. Travel Page

The “Weather” page (*Figure 5*) is composed of two screens - “Tides" and a“Weather” Screen. On the “Tides" screen, it displays a location of your choosing and shows the current tide as and if it’ll rise or lower with an arrow. Below is a table showing the next three peaks and three lows as in the day and when. Beneath it, is a “Venice 5-day Tide Forecast.” It includes a simplified tide graph for the next five days. The graphic displays forecasted tide heights in and out of Venice. The “Weather” screen shows the current weather and a five-day forecast. It has a visual representation of the weather for all days alongside their max and lowest temperatures,

Figure 5. Weather Page

Likewise, the “Updates” page (*Figure 6*), similar to the “Weather” page is comprised of two screens - the “Updates” screen and the “MOSE” screen. The updates screen has a list of updates that might affect daily life in the lagoon. This includes boat cancellations or extreme weather that might cause boat delays. To help sort this page, there is also a filter system at the top that will highlight all the corresponding events. There is also a search bar for a specific type of event. On the “MOSE” screen, at the top is a counter which shows how many times MOSE has ever lifted and next to it is the amount of times MOSE has lifted in the current year. Below this is a list of MOSE related events. These events include announcements of when MOSE is being lifted, when maintenance is occurring and lastly articles about the success of MOSE after lifting. Both of these pages send out alerts when new announcements appear in the app. This is a feature that no other application currently does.

Figure 6. News and MOSE Updates Page

Besides these key pages, there is an abundance of small pages for the user to utilize (*Figure 7*). These pages are more standard practice pages and pages that are available but not necessary to use the app. These pages include “Settings”, “Account”, “Help & Feedback”, and “About MOSE”. All of these pages are located through the “three-bar menu button” in the top left corner of all screens. The “Settings” and “Account” page holds standard app settings and account information in these pages. The “Help & Feedback” page allows users to leave developers feedback for

future iterations. Lastly, the "About MOSE" page displays information about MOSE so users can learn about the MOSE gates and MOSE's effects on the lagoon.

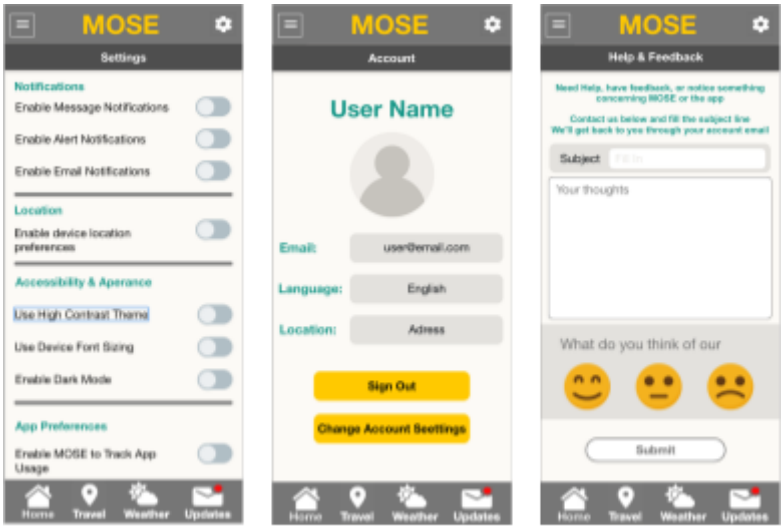


Figure 7. Account and Settings Pages

In addition to delivering our final mock-up to our sponsor the Commissario, we also provided them with specifications for implementing the final app.

For the MOSE app to one day be more than just a series of mock-ups and designs, the functionalities described must be connected to databases from where real-time weather, tides, and MOSE information can be pulled. The most important specification is that MOSE data must be pulled through their system which will allow for our features to be updated Semafori systems but the times displaying when events will occur will be shown. All other specifications can be found in *Appendix C*.

Outside of providing specifications, we recommended that any future designs should once again go through user testing and take users' needs and desires into consideration. Finally, since most Italians use an Android device, we would recommend making an Android app as opposed to an IOS app.

Our interactive mockup can be accessed here:

Abstract

With rising tides, a sinking city, and extreme weather conditions, Venice is experiencing more flooding than ever. Luckily, the city now has MOSE. MOSE (Modulo Sperimentale Elettromeccanico, Experimental Electromechanical Module) is a series of modular gates at the three inlets to the Venetian lagoon that rise from the seafloor to prevent more water from flowing into the lagoon during high tides. In this project, a series of interviews were completed to find what information residents and business owners currently have access to regarding tide data, flooding, MOSE operations, and how the gates may affect flooding in their area. The data we obtained was then used to design a potential MOSE phone app which was then returned to interviewees for further feedback. Our final app includes MOSE gate status and updates, tide and weather forecasting, as well as travel information during a flood event. The final model was handed to our sponsor, Commisario Venezia Nuova, so they can fully implement the final MOSE application to our specifications.

Introduction

In order to protect themselves, citizens need to be informed about natural disasters from the moment danger is spotted until the threat has passed. In Venice, flooding is a natural weather phenomenon that perpetually affects the lives of its citizens by damaging historical sites, affecting business operations (*Figure 1*), and changing the way people move throughout the city. According to Data Dive: Flooding in Venice, floods are hitting Venice more and more frequently. In just the past three decades, the number of tides has increased from about 50 to 70 a year (*Figure 2*). That's nearly a dramatic 50% increase.

Figure 1. Business Flooding in 2019 (Dirnhuber, 2019)

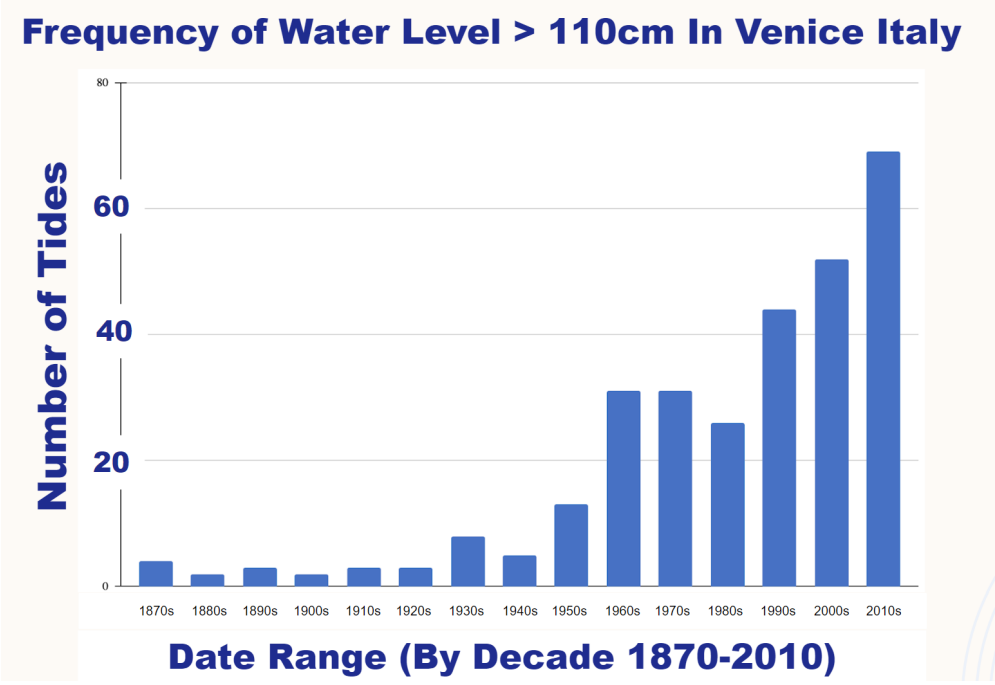


Figure 2. Graph of frequency of floods higher than 110 cm per decade (Ha & Schleiger, 2022)

To prevent the damage of flooding, Venice recently implemented a unique system of watergates at the inlets of the Venetian lagoon. The system, called MOSE (Modulo Sperimentale Elettromeccanico, Experimental Electromechanical Module), was completed in 2020 (Consorzio

Venezia Nuova (CVN, 2022) and consists of a series of modular gates at the three inlets to the Venetian Lagoon (*Figure 3*) that rise up from the sea floor during high tides to impede rising waters from entering the lagoon. MOSE itself is informed by advanced meteorological data, including winds, tide levels, and previous tidal data used to predict *acqua alta* or high tides (CVN, 2022).

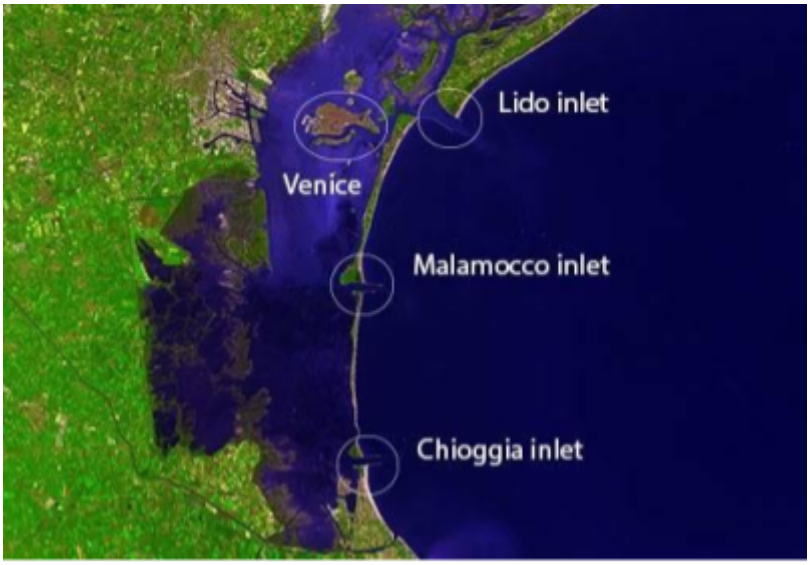


Figure 3. Venice Inlets and MOSE Gate Locations (NASA, 2013)

Although Venice has implemented systems for providing alerts to the public regarding flooding and a rudimentary system for MOSE's operation, there is a desire for more streamlined and accessible information that is both more useful and easier to digest. People in charge of significant aspects of Venetian life and large ship captains are notified of MOSE's activity, but most other people are left in the dark and do not know if and when some parts of the city will be flooded. This notification system is essential, as MOSE could create problems for boat operators trying to get in and out of the lagoon when its raised gates block inlets during times of flood risk. Although many Venetians follow tide information, there is no one place where they can go to get the most updated information on tides and flooding, supplemented by alerts of how and when MOSE may be operating. Residents and street-level shops would benefit from precise warnings of water level changes, allowing them to plan ahead.

Venetians need to know whether their neighborhood will flood, if the gates will be operating to mitigate the effects of a high tide, and where boats around the lagoon can enter the canal when the gates are raised. There needs to be a way to convey relevant alerts, flood plans, and MOSE activity to the public in a digestible, easy-to-access manner. That way, MOSE can protect the city and its people and genuinely be seen as an asset to the city.

The goal of this project was to design an application to communicate MOSE floodgate activity to residents, businesses, small boat operators, and visitors while considering these users' specific needs. Hartson and Pyla (2019) noted the importance of basing designs on use cases; thus, we interviewed Venetians and worked in parallel with them to get feedback on our design ideas.

Background

How and where Venice was built is crucial to understanding why Venice is flooding. In this section, we discuss the flooding risk and provide some history of how the city has attempted to deal with it.

Venice and its Risk of Flooding

The historic city of Venice is built on a lagoon in the Adriatic Sea, to the east of mainland Italy—which makes it unique but also vulnerable. The three inlets, Lido, Malamocco, and Chioggia, allow ocean water into the lagoon, causing the water to rise and flood the city when tides are high. When Venice's structures were built, foundations were created by draining marshy areas and then adding wooden pilings from giant logs into the muddy substrate. The foundations for roads and buildings were built atop those pilings, and they still stand today, but slowly, the foundations are settling and the city's elevation has come closer to sea level over time. There are 150 canals flowing around the city's many islands which are connected by bridges (Macchioni et al., 2016). As a result of its watery home, much of the city is at risk for flooding, especially in the context of rising sea levels due to climate change. Given that the city's elevation is only 1 meter above sea level, the height of the tide can greatly influence the residents. When the sea level rises to 110 cm, 12% of the city floods, and if the sea level reaches 140 cm, 50% of the city floods (Peacock, n.d.). *Figure 4* shows the tide level at which certain areas will begin to flood. Residents and businesses located centrally and along the borders of the city are most likely to experience flooding at lower levels.

To understand the importance of the MOSE flood gates as a means to reduce flooding, it is crucial for us to look to the past to understand the damage that has been done by floods—the worst of which occurred in 1966, 1979, and 2019. In 1966 a massive flood hit the historic city. There were multiple direct causes for the flood. According to Fabio Trincardi (2016), a researcher for the National Research Council of Italy, the flood was caused by extremely heavy rain in the region. In the Northeast parts of Italy, over two days, rainfall was recorded up to 750 mm. This, in addition to high Sirocco winds (winds come from the southeast), led to high waves in the Northeast. All of these factors caused a record-breaking high tide. In what is now named the "Acqua Granda", on November 4, 1966, water levels reached up to 194 cm damaging homes, businesses, and historical sites.

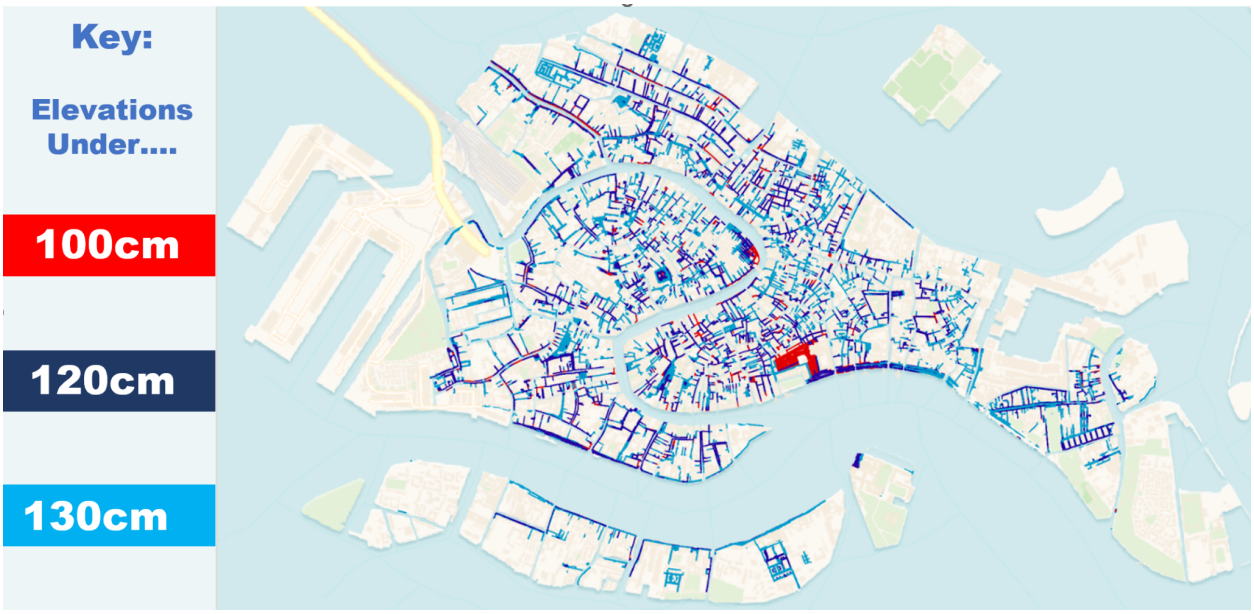


Figure 4. Areas That Will Flood at 100, 120 and 130 cm in Venice

About a decade later, in 1979, Venice was flooded again. On December 22, 1979, the water level rose to 166 cm (*Le Acque Alte Eccezional*, 2021). This resulted in flooding for residents and businesses that live and operate on the ground floor of buildings. In recent years, flooding has not stopped. 2019, in particular, was a challenging year for Venice. In 2019 alone, 28 storm surges occurred, all with the water level reaching over 110 cm (Mikhailova, 2021). Unlike 1966, high winds, a full moon, and higher-than-average tides during the month were key contributing factors (Mikhailova, 2021). At the peak of this flood, the water level reached 187 cm, making it the second-largest flood ever in Venice (*Le Acque Alte Eccezional*, 2021; Mikhailova, 2021).

Prevention Systems

Following the Flood of 1966, Venice began to take measures to prevent another disaster of this magnitude. The Italian government enacted legislation targeted to protect Venice, which included funding to address flooding problems. In 1968, Venice erected a siren system that was set up on different towers throughout the city to warn residents of impending flooding based on whether the tide level was predicted to be higher than average. This system still exists today, and Venice has recently upgraded its speaker system (*Servizi Di Allertamento*, n.d.). The Città di Venezia (City of Venice) has stated that the switch from electroacoustic sirens to a new digital sound system in 2008 has provided better sound quality and more efficient flood warnings since the new sirens are located all across the city, coast, and islands. Specifically, 15 sirens are in the

historic center, three are on the islands, and five are on the coast. *Figure 5* shows siren locations in the historic center. According to Trincardi, from 1984-2019, "about 13 billion euros were assigned by the Italian government to fund intervention… 46% of which has been used [from 1984-2012] toward flood protection and physical restoration" (2016, p. 7).

Figure 5. Location of the 15 Sirens Within the Historic Center (Sirene Allertamento Acqua Alta, n.d.)

In addition, these new speakers allow for much more accurate warnings since they can play different notes to indicate the severity of the impending flood: if the sea level is expected to reach 110 cm, then a long note is played; if the sea level will be above 120 cm, then two different notes with increasing scale are played; if the sea level will be above 130 cm, then three notes with increasing scale are played; and lastly, if the sea level will be above 140cm, then four notes with increasing scale are played. These sirens go off about three hours before the flood is predicted to begin. This system allows for a broad range of notes and could be expanded to provide warnings for other types of disasters (*Sirene Allertamento Acqua Alta*, n.d.).

SMS alerts sent out by the city of Venice (to residents who sign up for the service) are also now used as part of the alert system. Texts are automatically sent out if the tide is predicted to be over 110 cm, and through a free service, can be set up so if a user texts "TIDE" to a specific phone number, a reply will be sent stating the current tide level in addition to other related values (*Servizi Di Allertamento*, n.d.).

MOSE Floodgate Operations

Having seen the strength and frequency of higher tides, Venice enacted a call of action. This call of action was through a competition for engineering ideas to safeguard Venice. At the end of this competition, MOSE was selected. MOSE is a chain of metal gates with hydraulics inside them that span three inlets where the sea enters the lagoon. MOSE is designed to act as an on-demand dam. The gates are filled with water, so they sink to the lagoon's floor when they do not need to be raised. The gates rest on a bed of underwater concrete and are hydraulically filled with air when needed to stop incoming tides. Buoyant forces cause them to float upwards, creating a temporary flood barrier (*Figure 6*).

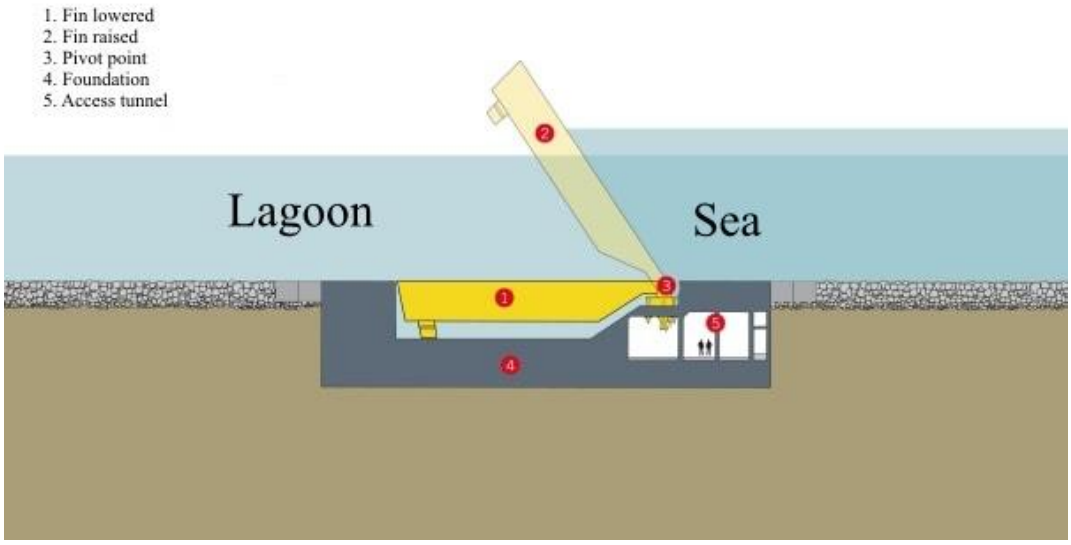


Figure 6. MOSE Components (CVN, 2020)

MOSE was controlled by the Consorzio Venezia Nuova (CVN) but is now under the control of the Comissario. Established in 1982, the Consorzio Venezia Nuova is a set of private construction companies that work together to maintain Venice's historical and cultural value. The CVN directly produces public works and safeguards for Venice on behalf of the Italian government. A full timeline of MOSE history can be seen in *Figure 7*. On the MOSE website, the CVN explains that each barrier has different lengths and thicknesses proportional to the depth of the mouth channel where it is installed (*Figure 8*).

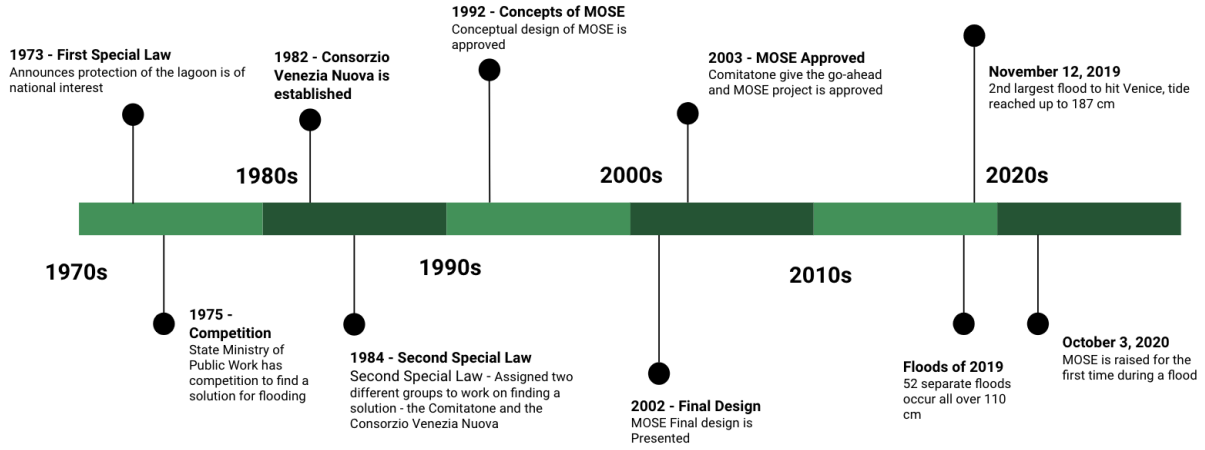


Figure 7. Key Events in MOSE's Kistory

Gate Location	Lido - Treporti Channel	Lido - San Nicolò	Malamocco	Chioggia
Number of gates	21	20	19	18
Gate Length (m)	18.55	26.6	29.5	27.3
Gate Width (m)	20	20	20	20
Thickness (m)	3.6	4	4.5	5

Figure 8. Number of Gates and Dimensions at Each of the Lagoon Inlets (CVN, 2020)

The site also outlines the configuration of the floodgates. The Lido inlet is split into two different channels of gates; the north channel is made with 21 gates, and the South channel is made with 20 floodgates. As for the Malamocco and Chioggia inlets, they are made up of 19 barriers and 18 barriers, respectively. Besides the barriers themselves, each inlet has other features. All inlets have navigation locks (*Figure 9*) for specific types of ships to travel while MOSE is active. Every lock has a protective docking area for ships as well as breakwater structures in front of the inlet to dampen or break incoming waves *(Figure 10)*. Currently, Lido has the only operational navigation lock. The locks take roughly an hour for a boat to enter, dock, and leave the area. During this cycle, a small boat will enter the lock and will be closed inside. The level of the water in the lock is then lowered to match the level of the water in the lagoon. The boat is then able to proceed into the lagoon. All navigation locks are expected to be fully functioning by the summer of 2023. The Lido lock is designated for small leisure boats, Chioggia is used mainly by fishing boats, and Malmocco for larger ships (S.Libardo, personal communication, Nov 7, 2022). An example of an inlet and all of its components can be seen in *Figure 11*.

Figure 9. Navigation Lock at Lido Inlet (CVN, 2020)

Figure 10. Breakwater in front of Chioggia Inlet (Venice Water Authority, 2020)

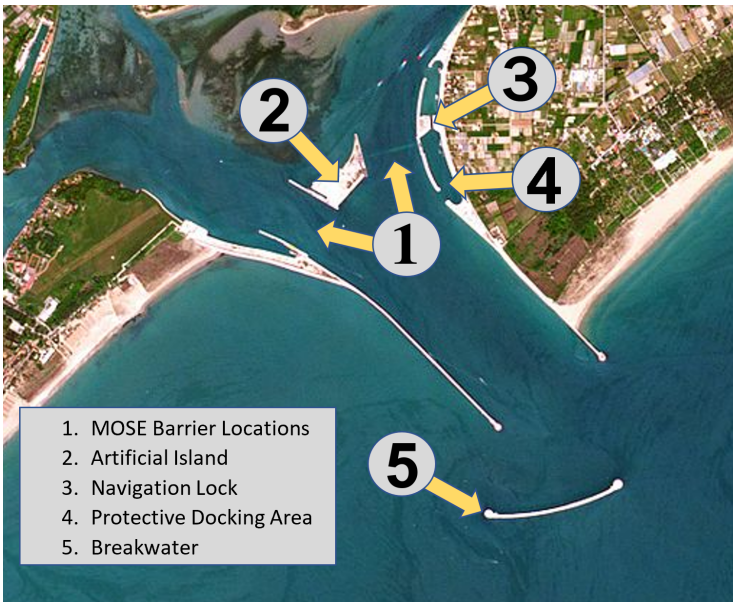


Figure 11. MOSE Floodgate Location at Lido Inlet (adapted from Google Maps)

MOSE is activated based on data collected by the Commissario Venezia Nuova computer forecasting system. Computer models are vital to MOSE operations because they forecast tides and water levels, identifying when to activate the flood barriers and for how long. They also predict final water levels within the lagoon while the gates are active. According to MOSE, their predictive computer systems make calculations by considering current tide level, wind speed, and elements like "high water forecasts, data on tide levels and the increase in water level in the lagoon while the inlets are closed" (CVN, 2020). The tide levels are constantly recorded by tide

gauges located in front of each inlet. The Commissario has a five-day forecast that updates every five minutes. This allows them to give preemptive warnings of when the tides are expected to exceed 110 cm. This is the point at which the gates are lifted.

This reliable process enables the Commissario to alert other authorities about incoming floods 48 hours ahead. For example, the Commissario maintains contact with Venice Port Authority 48, 22, 12, 9, and six hours before any event. MOSE cannot be activated without alerting other local government bodies, such as the Port Authority and ACTV public boat transport. The Port Authority communicates MOSE activation to all ships. The ACTV receives alerts regarding tide height to track what boat routes are canceled (S.Libardo, personal communication, Nov 7, 2022). Venice, as a whole, sends the SMS messages mentioned previously based on this information.

Impacts of Floodgate Use

This system is not without its controversies. Decades of construction problems, criminal mismanagement, and political hiccups over 20 years resulted in the project being taken over by the government and in the MOSE's testing being delayed until 2020. The level of tide at which the gates are raised is currently 130 cm, but some have argued for a lower threshold as historic locations such as St. Mark's Square still flood at a tide level of only 90 cm.

With a big project such as MOSE, there are bound to be positive and negative impacts. Not surprisingly, the floodgates have positively impacted life in the lagoon by functioning as intended. The barriers serve as protection from large tidal waves and have mitigated the level of flooding, such as the high tide of Nov 22nd (Zorzi, 2022). MOSE states on its website that the barriers can stop up to 3m of tidal waves and have been operated successfully 20 times since they were first used in October 2020. A study done on the hydrodynamic effects from the MOSE gates has also backed up its effectiveness inside the lagoon. The study concluded that in all cases that were observed, the gates were effective in keeping water out of the lagoon, and the amount of water that did get through the gates was minuscule (Carniello, 2021). During this paper's writing, Venice was threatened when the largest predicted tide hit the city. On November 22nd, 2022, a tide of 204 cm was predicted to flood the city (Zorzi, 2022). MOSE was activated, and this flood was kept at bay (*Figure 12*).

Figure 12. St. Mark's Square During Exceptional High Tide as the Flood Barriers were Raised, November 22, 2022. (REUTERS/Manuel Silvestri, 2022)

While the floodgates have thus far performed as intended regarding flood mitigation, they also bring about impacts that can be considered less than ideal. These negatives were also highlighted in the study previously mentioned. First, when the gates are active, the wind effects in the lagoon are enhanced. In examining MOSE's second use (during the storm of Oct 15, 2020), Carniello concluded that "the second use of the wind setup between PS and Chioggia, ΔSL, was up to three times larger during the closure of the MOSE barriers" (2021, sec. 3.3.3). The report also highlighted disturbances in the Adriatic Sea from the barriers, "the sea level increases up to 25 cm in front of the gates and to less than 10 cm out of the inlet jetties. This difference in levels triggers a long, small-amplitude wave that propagates in the Northern Adriatic Sea…" (2021, sec. 4). Both of these impacts may seem minimal but can in fact, make a difference for boats outside of the lagoon and conditions for people on the mainland.

How MOSE & Flood Activity is Currently Shared

At the time of this project's inception, the Commissario was using two different types of systems to alert the public and marine authorities of MOSE operation. The first was an online stoplight system known as the Semaphore system, the only online tool that residents, boat operators, and business owners could use (CVN, 2022). It was released in April 2021 and is available to the public via a website (Velavente, 2021). The alert system was based on a traffic light metaphor where green means no activity, yellow means the gates will likely rise in 9 hours, flashing red means the gates are currently rising, and red means they are currently lifted. As discussed later, this system was updated shortly after we met with MOSE officials.

In total, four traffic lights appeared for all three inlets (Velavente, 2021) (*Figure 13)*. This information is managed by the Comissario Venezia Nuova, which utilizes a central operation room that watches, predicts, and manages incoming meteorological data.

Figure 13. Semafori Traffic Light System (CVN, 2022)

(CVN, 2022). They receive information about tide levels, weather forecasting, and gate simulations (CVN, 2022).

A second alert system is more sophisticated and shares detailed info with local authorities and relevant media outlets, including the Venice Port Authority and ACTV public boat transport, major news outlets such as ANSA, and historical committees, to name a few. This happens through email subscription and is admittedly easy to do so.

Although not provided by MOSE, Venetians can find related information via an SMS system. Sent by the Centro Previsioni e Segnalazioni Maree (CPSM), which translates to Tide Forecast and Reporting Centre, this text includes the status of MOSE (if it is raised or not). If MOSE is raised, then the text will also include the inlets where the gates are raised, what the peak tide level will be outside of the gates (and the time this will occur), and what the peak tide level will be inside the lagoon. If MOSE is not being raised, then this will be said in the text, and the text will also provide the high tide for the day, and the time it will occur. In either case, a link is provided to the CPSM webpage, where the daily tide chart can be found.

The semafori alert system was a good first step in communicating basic information on gate operation to business owners and residents, but our sponsor wanted to provide more detailed information that might serve the public's needs. For example, information such as what parts of Venice will be flooded or where boats can freely move. Much of the Comissario is still in development due to MOSE's quick activation in 2020. Although a great deal of information that could be useful exists out there on various other apps, it was not combined in one user-friendly

MOSE app. This information could help Venetians live safely and with fewer inconveniences during high tides.

Effective UX Design and their Impact

Knowing what Venetians need is first and foremost, but we will also need to consider formats that might appeal to users. We discovered that Venetians primarily use Android devices, thus, we planned around this, consulting Android guidelines found in *Figure 14,* which shows a few grid specifications. These guidelines denote such things as margins and icon sizes.

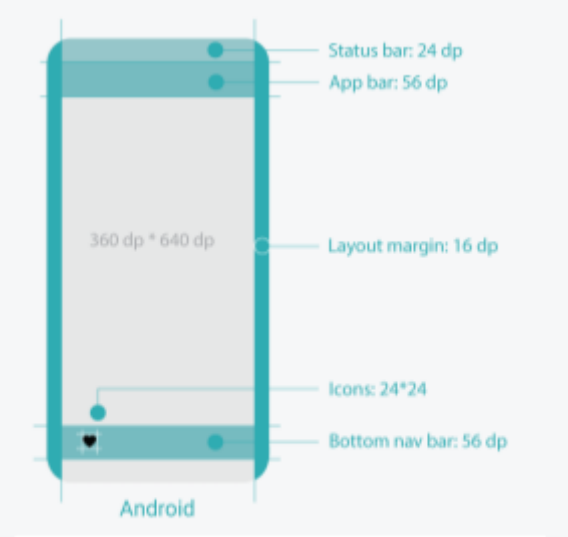


Figure 14. Android Guidelines - Grid Specification (*Understanding the iOS and Android UI Guidelines*, 2021)

UX design is a specific process to accomplish this. UX design is the principle of making a system to fit the users' experience (Hartson et al,2019). This can be completed in a variety of ways. What must be taken into account in any method are usability, usefulness, emotional impact, and meaningfulness (Hartson et al., 2019).

Designed for Venetians, the app holds relevant aspects of flooding, as mentioned above and as indicated by the people we interviewed. This will ensure we include helpful information for users. For example, given an emergency, can they find shelter, plan when to put away valuables, or decide to close up shop? Situations like these add longevity and meaningful connection to the app. The flood apps we looked at in Thailand, and China found great success because people were able to make long-term relationships with flood app services (Leeawalt et al, 2013; Ding et al, 2022). An important aspect of designing an app is also its usability which represents how well people can operate an app (Hartson et al, 2019). We sought to create an intuitive design.

Tools used for user-testing and designing apps

Adobe XD is a mock-up software that can help designers create and get feedback on mock websites, game interfaces, phone apps, and more without full implementation (Adobe, 2019). The software can model many human-to-computer interactions.

Adobe XD can be used as part of an iterative design process. (Henriques et al., 2022). For example, previous WPI student research titled "Towards Inclusive Learning and Research with Sign Language Surveys" utilized Adobe XD to iteratively create, test, and revise online survey

models. They were able to create models in Adobe XD and demonstrate them to their users. The students conducted participatory design activities with potential users by using two significant features of Adobe XD: collaboration and exporting models. These features allow researchers to share their projects with others, to work collaboratively to design the functions and layout of an app, and to export their models into an online link that can be sent to participants to test the models (Adobe, 2019). In the WPI study, Users, alongside the student research team, reviewed survey models and then made new variations (Henriques et al., 2022).

In designing our mock-up, we also adopted popular features from other flood and weather alert apps, such as hi!tide Venice, Venice Tide, and WVF (Water on the Venice Floor). In addition, this research was done to find common themes surrounding an app's navigation and UI. We also consulted Android guidelines for the design due to the overwhelming prevalence of Android devices in Italy (StatCounter, 2022).

Our low-fidelity mock-ups took the form of storyboards. Each storyboard visually details the action, idea, and need of the use cases. This enabled us to design an app that flowed and was easy for users to navigate. An example of a storyboard used to design a self-ordering system for a restaurant is shown in (*Figure 15*).

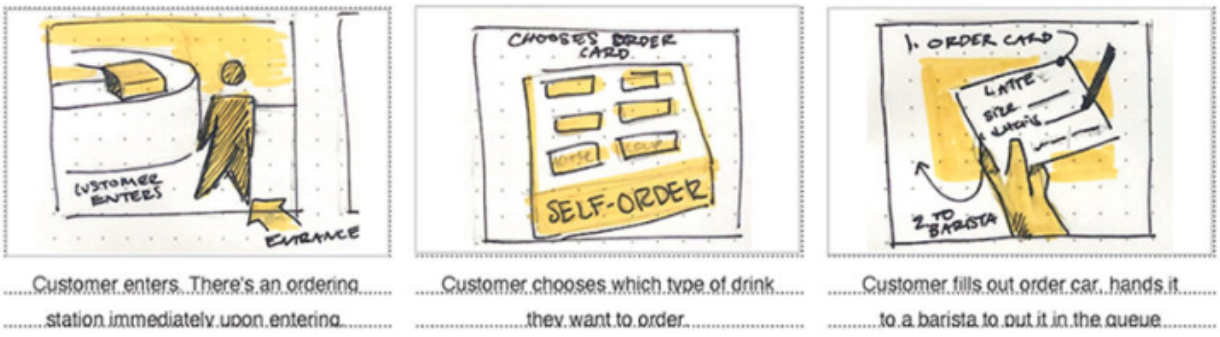


Figure 15. Storyboard of Customer Self-Service System (Campbell, 2020)

Methods and Results

The goal of our project was to create a prototype application to communicate MOSE floodgate activity to residents, businesses, boat operators, and visitors. To achieve this goal, we developed three project objectives following an iterative design process involving a cycle of user feedback and revision.

1. Develop use cases based on stakeholder and end-user needs
2. Design and test app
3. Develop specifications for the final app

Our research targeted the people most affected by tide levels, flooding, and the activation of the MOSE system, including residents and business owners in the Historic City of Venice. This chapter details the methods used to gather feedback from these stakeholders, how that feedback was implemented in our app design, and how gathered and implemented feedback *(Figure 16)* depicts the overall iterative design cycle and where these objectives arise.

Figure 16. Iterative Design Approach Based on three Objectives

Developing the Use Cases

To develop an effective app, we learned what information different users needed. Our group collected information about how floods, flood alerts, and MOSE operations affect or could affect residents, business owners, and visitors of Venice. We also sought to understand how they would use a MOSE app and their recommendations for its design. Our primary method for collecting this information was through interviews via purposeful recruiting of interviewees in the Cannaregio, San Marco, Castello, and Giudecca areas. We primarily targeted areas closer to water or at higher risk of flooding. *Figure 17* shows the questions which we asked different Venetians to learn about how flooding affects them, how they receive information about tide levels, and what they would like to see in a MOSE app. Our questions, while very similar, were tailored to the type of person we were interviewing - specifically if they were a business owner or a resident.

Interview Questions
Business Owners: 1. At what tide level does your shop flood? 2. Where do you get information about flooding? Apps, SMS, etc. 3. What do you think (app being used) could this app do better? 4. Would you like an app to tell you about the levels ahead of time? 5. Would you like an app to tell you about MOSE? 6. What information would you like to be more readily available involving flooding/MOSE? 7. How would you use this information? 8. When would you like to be notified about this information? 9. Do you get information about the MOSE floodgate operations? If so, how?
Residents: 1. We are developing an app to improve communication of MOSE floodgate activity to aid residents, business owners, and boat operators. Knowing this, are there any features/types of information you think should be included? 2. When would you like to be notified of this information? 3. What area of Venice do you live in? What street? 4. Has your house ever experienced flooding? If so, at what tide level? 5. Where do you get information about flooding? Apps, SMS, etc. 6. What features do you like about the method you use to access that information?

Figure 17. Interview Questions

Design and Testing

In designing our app, we took the use cases we obtained through our interviews and structured our app around meeting those needs. Basing design choices and features that we implemented on the feedback found in *Appendix B*, we designed an app that would best meet our interviewees needs. After designing simple mock-ups in Adobe XD, we took these mock-ups

back to our interviewees and showed them what we had created. After getting a sense of how they used the app and their feedback on it, we went back to the design phase to make more edits based on the feedback. We iterated this phase about three times before we felt like the app was in a solid place that most people liked.

Results

Our group completed 12 interviews (seven residents, five business owners). We found several common themes in analyzing their responses, and these influenced the design of our first mock-up. Participants first wanted an app personalized to their daily lives. This included knowing exactly when and if their homes or businesses would flood on a given day. One resident also explained that when flooding occurs, the boat they normally use can be canceled, so having information on boat cancellations and alternate routes would also be beneficial.

The next thing most people agreed on was to improve upon the existing tide elevation apps. Almost all of the participants we interviewed used the “high!tide” app to determine if their area would flood. Suggestions that people made to improve the app included making tide information available as soon as possible as well as taking out the mental math required for using the app. Having to do ‘mental math’ results from tide apps being broad in terms of the tide in areas. Specifically, high tide allows the user to check the level at notable landmarks, and some boat stops. However, the regular citizen would benefit from a cohesive flood map info no matter where in Venice you are located. Finally, people would like access to more information about MOSE, such as cost, environmental impacts, and the effectiveness of the gates. More detailed information from all our participants can be seen in the table in (Appendix B). Having this data as well as prior app design experience, we then developed the first mock-up of the app.

Final Design

Based on the above information, we then designed a mock-up that included desired content and features that emerged from the above interviews. Each screen was designed to represent a set of actions participants can take to fulfill their needs and wants in a useful manner. We obtained feedback on these mockups, realizing that we needed to change/add some of our existing features and layouts. The most feedback we received came during a meeting with our sponsor. After going through the app with them, we reworked both our tide module and MOSE status module on the home screen. We also took note of the app's look, specifically the lack of color and the consistency of color. After those changes, we proceeded to test the app on three separate users. All three users reacted positively to the app and had no glaring issues. They did however give some helpful feedback for final changes and cleanup. The important recommendations we got included making the travel screen more clear while also adding the ability to filter and subscribe to certain notifications in the updates tab. All of these ideas from

our sponsor and resident testers were used to create the final design of the app. Below is the set of screens with explanations about the different functionalities and content we included and why we included them. The hierarchy of our app screens can be found in *Figure 18*. The app includes 5 main screens: Home, Travel, Weather, Updates, and More. There is a heavy emphasis on our home tab which leads to most other tabs. We wanted users to have all the important features and information on the home page right as they open the app.

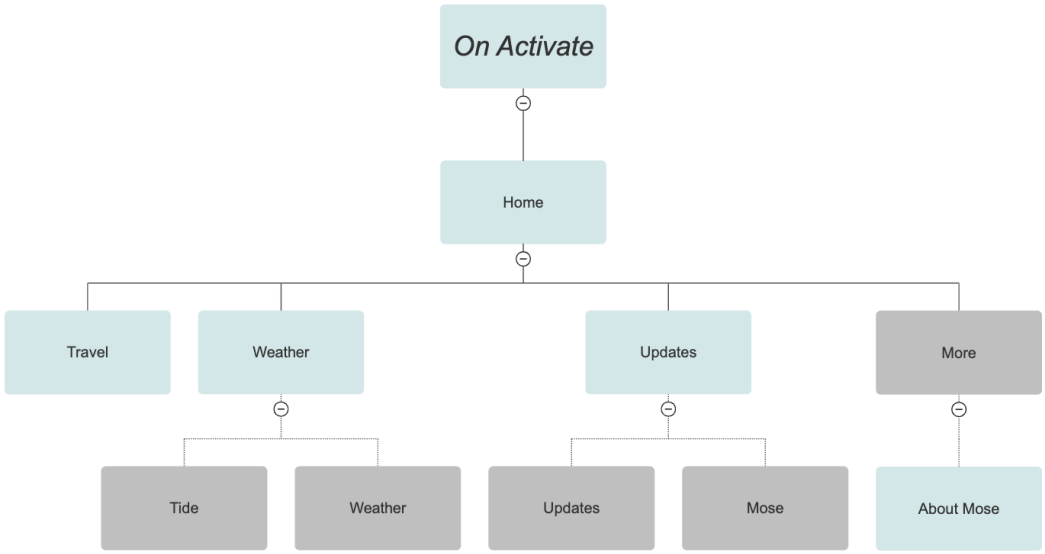


Figure 18. Hierarchy of App Pages and Where They Lead

Rapid Prototyping

The primary method we used to test and refine our mock-up was going back to our interviewees and sponsor, showing them our design choices, and updating the app mock-up as a result. First, we met with our sponsor to get general ideas about the operation of MOSE and relevant information to include in our app. We then took our refined model and had our interviewees interact with the model and had them give us feedback based on their experience. Adobe XD functioned as the primary interaction and testing medium. Our participants interacted with this mockup like a normal app via Adobe XD. In Adobe XD, high-fidelity mock-ups are advanced interactive storyboards. Users can tap, play videos, simulate app transitions, and see changing screen components. This process allowed us to see participants in action with the app. We gathered notes on what features they found useful, where they got stuck, found confusing, and everything related to their user experience. This was followed by a brief dialogue where we discussed how they felt about the app design. We took these notes and updated our app further. Features we added based on this testing include suggestions for general design layout, using a separate indicator for each lagoon inlet, and more specific countdowns to the next tidal event. In what follows, we describe the resulting final design.

Home Screen

The first screen users see upon opening the app is the home screen (*Figure 19*). Our home screen was designed to give users access to most of the features they would need on a day-to-day basis right at their fingertips: a tide module, a MOSE module, and a quick travel module (top to bottom sections). This will help users get quick information about most of the things related to flooding in Venice right from the home page. Included at the top is a three-bar menu icon, which brings additional navigation options alongside a settings cog icon. At the bottom, users can find a navigation bar that brings them to the other three main tabs available in the app: travel, weather, and updates.

Figure 19. Home Page

Mose Module

The MOSE module found at the top—which was included to meet our sponsor's request and was supported by feedback from a business owner (*Appendix B*) — is reminiscent of the Semafori system stoplights. To have explicit and accessible information, we replaced the four different stop lights for each inlet with one indicator representing the current state of each inlet. The indicator changes color depending on MOSE's current activity. Green represents no planned activity, yellow indicates a possible lifting in the near future, blinking yellow means a raising is planned to happen, blinking red means the gates are actively being raised, and solid red means MOSE is activated, and the lagoon is closed off by the gates. It is worth noting that while the meaning of the lights directly reflects the semafori system, after the meeting with our sponsor, our team decided to add the blinking yellow for further communication.

Tide Module

Following the MOSE module, underneath users will find the tide module. The tide module comprises three main features: the current tide level, a location selector to personalize tide levels where the user is located or wants to travel, and tidal peaks with times at the bottom. During a tidal event (when MOSE activation is anticipated), the water visual in the middle of the tide page will split in two to display. The split represents the difference in height of the lagoon in Venice/Chioggia and at sea beyond MOSE. This module was included to give users quick information about tides in the lagoon alongside a representation of MOSE's effectiveness (Resident 4, *Appendix B*).

Quick Travel Module

Finally at the bottom is the "Quick Travel" module. Users can input their location and destination to get a quick estimate of the length of their journey. They also have their preference in transportation methods for their trip: walking, ACTV, and private boats. For certain routes, transportation methods may be combined for optimization (such as walking & ACTV), but the user's preference is still factored in. Once all information is set, pressing "Start" next to the estimated arrival will redirect them to the travel screen with a filled-in map and path to their destination.

Travel Page

After typing in location and destination data into the quick travel tab or pressing the travel icon in the navigation bar, users will be taken to this screen which they can use to plan routes throughout the city (*Figure 20*). The three buttons at the top indicate different methods of transportation the user prefers to use like the quick travel module: walking, ACTV, and private boats.

Once users input their location and destination, the map will be filled in with the fastest route to the user's desired destination. This system would

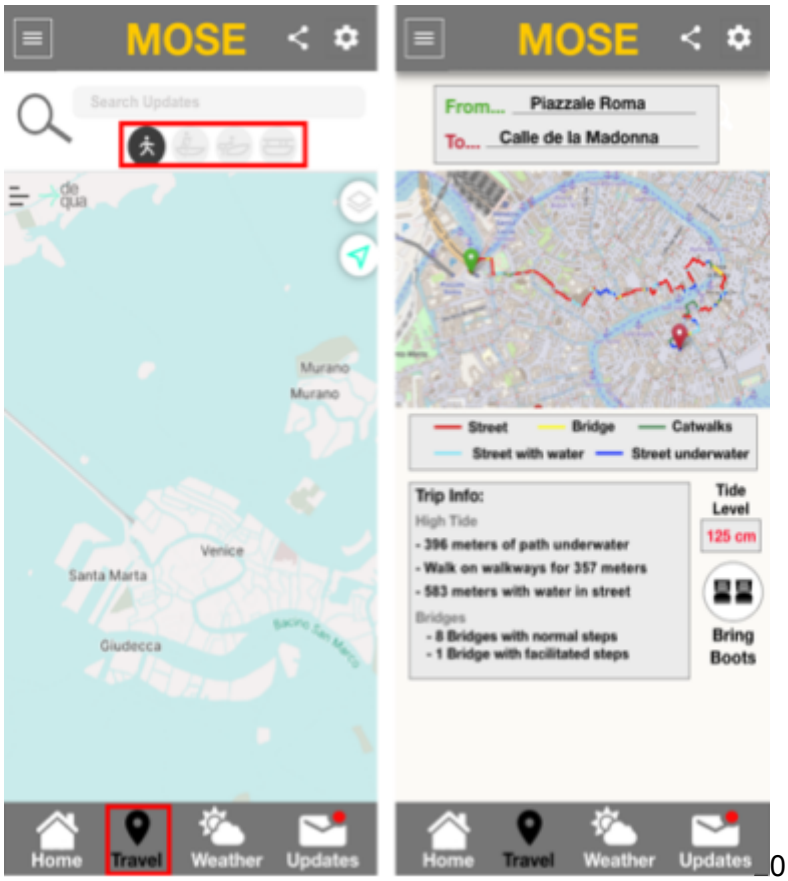


Figure 20. Travel Page

take into account several factors including current tide levels, the elevation of pathways, and bridge heights. Both the user testing and initial interviews had users who wanted to be informed while traveling (Resident 6, *Appendix B*). Possible conditions include whether parts of their path will be flooded, whether there are walkways built above flooding, accessibility options, and paths available by wearing flood boots requested by our participants (*Appendix B*). From here, users can use the navigation tab to access either the weather or updates pages.

Weather and Forecasting Page

For our weather and tide page, simple seemed to be best. When interviewing Venetians, we discovered they wanted useful features in addition to MOSE status (Business Owner 4, Appendix B). But since the weather is not the app's core design, we created these two pages to enrich more relevant data about tides and MOSE. Users can now know more about the current condition of the Venetian lagoon as a whole. (*Figure 21 [Left] Weather and tide pages).* Included here is the current weather condition with temperature, precipitation, forecasts for future rainfall, and a standard multi-day forecast for the coming days.

Figure 21. Weather Page

Currently, users would scroll through the weather forecast at the bottom of the page to see the other days of the week to conserve space. The second tab on our weather section is the dedicated Tides screen. This screen consists of two modules, one that shows high and low tides and when they will occur with the current tide level above them with an arrow indicating whether the tide is getting higher or lower. Underneath that module is a graphical representation of similar data.

Following the weather page, the user can navigate to the updates page by pressing the bottom on the far right of the navigation tab.

Updates page

The updates page will include various news and information about MOSE, its impact, and its results (*Figure 22*). News articles about MOSE's operation will be found here, along with information about possible maintenance, boat cancellations (Resident 6, Appendix B), and other news about the lagoon as a whole. Users can scroll down to find additional and past information. We also included filters to sort the results within the tab and also information regarding the number of times MOSE has been activated in total and in the current year. At the top right, users will discover a bell icon that users can tap on to bring them to their notification preferences which we included as a result of feedback from our participants (Appendix B).

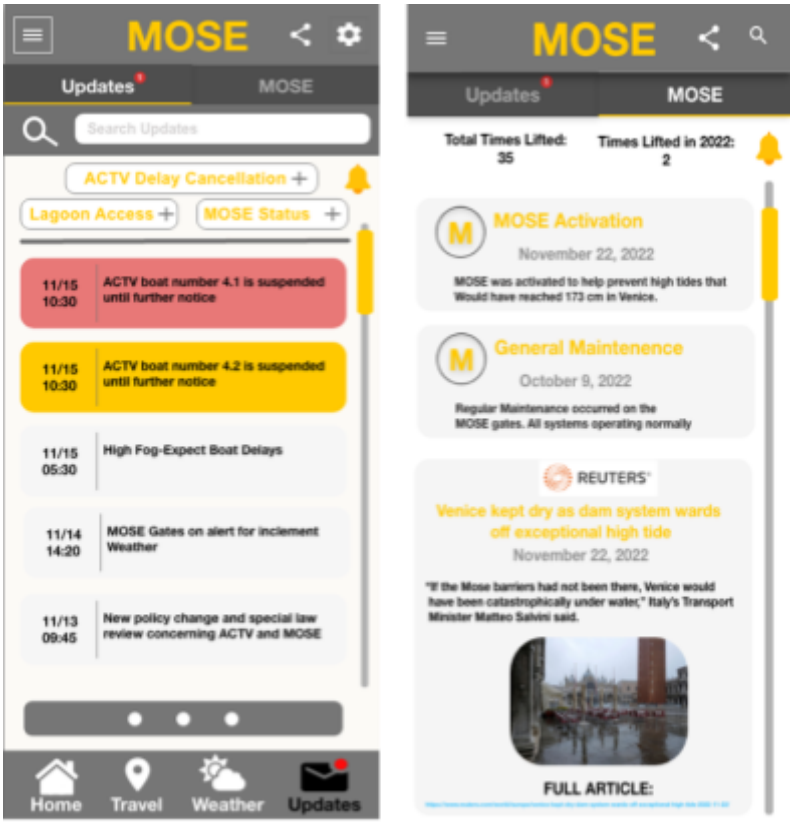


Figure 22. News and MOSE Updates Page

Conclusion

With the goal of improving MOSE communication, we used an iterative approach to designing our app. We began by identifying users' needs through our interviews, designing our app around these needs, sharing mock-ups and getting feedback, then making changes for a final design. Usability and accessibility were at the forefront of our designs, so we included the most relevant information right at the front of our app on the home screen.

The various tools in our app must draw from a variety of external databases, so we developed a set of specifications for its final implementation.

Entire App

For the entire app, several APIs and databases are needed for functionality. The specific databases are Centro Maree/MOSE tide forecasting, MOSE semafori alert, and information from government operations described below for each page. All of this information will be condensed into an Android app. Android phones are the most dominant phone type in Italy (StatCounter,

2022). Thus, any work related to the app should follow android guidelines. Furthermore, the app should match the Google Playstore's (most dominant android app store) standards as well. Other big aspects to manage are device location and communication interfaces (ie. email, notifications, and sms).

Every page has its own unique features and aspects of design in place. It's imperative for developers to follow our specific recommendations below (a condensed table view of the specifications can be found in Appendix C).

Home Page

The homepage consists of three high-fidelity modules, two of which are highly intertwined and are visually dynamic. We recommend a conditional design approach for the MOSE and Tide module. Both require live APIs or stimuli from MOSE systems for tide forecasting and semafori alerts. It's only natural that the code put in place should have both their states of change combined in a cause-and-effect relationship. Whereas tides reach a peak that activates MOSE, the MOSE alerts will be displayed alongside the tide modules' second form (display tide in Venice and at sea). The travel module is a little different. As it redirects the user to a planned route, our discussion is now centered around the travel page.

Travel Page

The travel page owes much of its design to Dequa. Dequa's nuanced design comes from its own databases regarding Venice streets and their elevations. Most importantly is their ability to connect to location/global positioning services like that of Google Maps. For a travel page to be as successful, we recommend future communications to developers at Dequa. These conversations should revolve around how to add Dequaa itself to the app. Alternatively, it could be how to set calls for planning travel routes based on Venice's various elevations, bridges, boat transportation, and tides all in one accurate route.

Weather and Tide Pages

Likewise the weather screens consist of systems that'll need to connect to a user's location, and date, and report local meteorological data. The Commissario and Centro Maree have tools and APIs around these systems. Their forecast capabilities should be used for the app's 5-day tide forecast, weather for the week (including temperature), and the day's current tides. These data calls will act as stimuli for the app's weather modules to change according to the user's time and place.

Updates and MOSE News Pages

The updates pages will not require as many API calls like the other forecasting systems. The content of the update pages will revolve around notifications from the Comissario, ACTV, Port Authority, and other government bodies. We recommend that a system be put in place around how information about MOSE and ACTV boat changes is currently shared in Venice's governing bodies. This system would be a database of alerts that these entities can send updates to as soon as changes are decided upon. There's already a precedent for this in the Centro Maree SMS system. Recently they've included MOSE activations and can easily add any ACTV schedule changes. This database should include any sources of news/articles that the Comissario would like to share on the MOSE news page.

Extra Pages

Future designs and development of any additional pages should follow a user-friendly design. For example look at the current settings page, which incorporates accessibility options, and the security needs of the user. "Help & Feedback" and "About MOSE" allows all users to contact and learn directly about MOSE. This gives Venetians the communication they desire from MOSE. The account page helps prolong this communication through email messaging. It also enables people to easily log in with their settings preferences and location.

Closing Thoughts

Given all these components, we believe that we have produced a cohesive app that accomplishes the goal given to us by our sponsor. Not only does this app design communicate MOSE gate status and updates, but it also contains additional features users will find useful so that they will continue to use the app year-round. We hope that the design we have presented is useful and provides good information and ideas for when the real app is developed. Our team thoroughly enjoyed the entire app designing process and are thankful for the opportunity to offer our services and recommendation. We are all excited to see what the Commisario's team develops for Venice and its people.

Appendix A

Local Apps	 Hi!tide Venice	 WVF (Water on Venice Floor)	 Venice Tide
Features	- Has tide forecast for current day and following 2 days - Shows current tide level - Shows tide information at custom places & ferry stops	- Has a map of Venice which shows boat paths (supposedly turns red when areas are flooded) - Shows percentage of the city that floods with different tide levels	- Main purpose is to have a map which shows what streets are currently flooded - Takes MOSE into consideration when making flood level predictions
Alerts	- Non-existent - Must manually check the general tide or the custom saved places	- Non-existent - Must manually check the map to see if areas are flooded	- Non-existent - Must manually check the map to see if areas are flooded
Design	- Clean & simple - 3 main tabs - Displays current tide at all times	- Unintuitive - Has a nav bar on home page which disappears when on other pages	- Clean looking - Somewhat unintuitive - when on home page, it is gray and the map is blue on nav bar
Follows Android Guidelines	- Can see tides information at custom places & ferries	- When the 4th icon is selected, the highlight never goes away (despite being told this function is unavailable)	- When using the nav bar, there is an inconsistent way to tell which page is being selected
Forecasting Process	- Recieves info by the Istituzione Centro Previsioni e Segnalazioni Maree	– Uses tide data by the Centro Previsioni e Segnalazioni Maree - Doesn’t show any	- Receives Data from the Municipality of Venice and processed by the Tide &

	(ICPSM) - Shows current day and 2 days out - Doesn't show any weather just the tide forecast	weather just the tide forecast	Forecasting and Reporting Center of the Municipality of Venice - Doesn't show any weather just the tide forecast
Unique Problems	- Doesn't say where the tide level is being recorded from (location in Venice)	- According to reviews of the app it was very useful but hasn't worked since late 2019	- Only works in Italian - Must pay for a premium version for full functionality – When paying can see what streets will look like within the next 24 hours at different tide peaks

Appendix B

Type	Flood Height (m)	Services Used	Notes/Suggestions
Business Owner 1	1.3	High Tide	Wants notifications asap “Lost Project” in reference to perception of MOSE and its past Moved out of Venice due to difficulty living in the city Deeply affected by 2019 floods. “A little tsunami” had damaged the shop
Business Owner 2	1.27	MOSE Semafori stoplight, Venice Tide	Wants to know where to use shoes and other available routes Would like to know what clearance level bridges have for certain boats
Business Owner 3	1.4	SMS, High tide	Distrust of MOSE Concerns on how MOSE affects the lagoon Hightide is sufficient but requires mental work to prepare for any weather
Business Owner 4	.90	Official Website of Converssario An app that reads the Conoverssario	Lives in Giudecca Would like a any and all information Would like to have a geographical international system for weather Would like to have a synoptic vision of maps
Business Owner 5	1.10	High Tide, SMS	Lives on artificial land barrier

			Wants to know if MOSE is on duty or not Struggles having to wake up at night to check on shop High Tide is sufficient but could use more work Talks to boaters MOSE has affected fishing lines Delghate of Lido for Mayor of Venice “Two nights ago I didn’t if MOSE was on duty or not” “We need to adapt to change instead of fixing it”
Resident 1	N/A	High Tide	Lived in Venice since 2016 Would like to know if they need flood shoes before leaving home Would like to know where there is exactly high water
Resident 2	N/A	High Tide	High Tide is not region specific and requires mental work to make Doesn’t want an app that is totally useless based on water height alone
Resident 3	1.30	High Tide, Telegram made by the municipality of Venice	Want a day before notification Wants to see public information about MOSE (CO2 release, cost, environmental impact)

			Telegram provides too much information to digest and use
Resident 4	N/A		Giudecca Resident Some ACTV boats cancel based on high lagoon water levels. Notably 4,2 which get them to work Needs maps routes for boats that cancel Would like to know how long the flood/inclimate weather will last Wants to know when to use boats
Resident 5	1.20	SMS, High Tide	Wants advance notice as much as possible Doesn't experience a lot of flooding at home but on route to work City Council Service requires registration and is not clear on information it provides
Resident 6	1.35	Water on Venice Floor, High tide, email & SMS	Resident lives on mainland but commutes to work ACTV updates and line closures are important to daily routine Needs to know what boat lines close as well as alternate routes "Knowing how to travel while the city is flooded would be a great feature for the app"
Resident 7	1.25	Email updates,	Wants an app that is better than

		High tide	high tide “High tide does not give an accurate tide level where my house is” Thinks MOSE does not help Wants to know how much money it is costing to use MOSE

Appendix C

Screens	Data to be pulled	Purpose (Module)	Notes
Home	- The current status of the MOSE gates should be pulled via an API (or other stimuli) from MOSE - The current tide as well as predicted tide should be pulled via an API (or other stimuli) from MOSE	- Semafori system - Tide forecast - Travel	- Semafori system and tide forecast should be updating constantly (or time at set interval, we recommend every hour or as needed) - Despite the travel module being on the home page, reference the travel screen section for information on this module
Travel	- The recorded elevations of all of Venice should be pulled from SMU (sistema di manutenzione urbana) (http://smu.insula.it/index.php.html) - The elevations of different bridges in Venice should be pulled from the VPC project “Piera Alta” (https://sites.google.com/site/ve14alta/)	- To help find what streets are currently flooded based on tide elevation - To help show what bridges would not be able to be passed through by a private boat	- This designed is heavily based on Dequa (with their approval), and this page could potentially be completed with their help
Weather	- Data should be pulled from the users device; specifically the users location and the date - The current weather forecast should be pulled via an API (we recommend the	- The users location should be pulled so weather is always to their location unless manually switched, and the date is so the app can pull the current dates information	- In terms of the weather API, there are many alternatives that would work, if there is an internal weather forecast already being used then we would recommend that is

	OpenWeatherMap API)	- The weather API should be used to pull the 5-day forecast and the current weather	used for the app
Updates	- We recommend that the data being shared between MOSE, ACTV, Port Authority and other government bodies to be somehow pulled into the app (please see note for more information)	- The data being shared would be used to create the alerts in the update system related to non-MOSE activities (e.x. ACTV boat cancellations)	- We are unaware if the data being shared by the ACTV, Port Authority, and other government bodies is from a database and if there is an API so if there is no easy way for this data to be shared and constantly updated (not needing a human to manually input), then we recommend this to be created - Another piece of information has to do with user accounts so more information can be found the “Notes” column of the “Other” row
Other	**Settings** - Data should be pulled from the users device, specifically accessibility options and security needs **Account** - Data is not need to be pulled please check the “Notes” section for the description of what is needed	- The users accessibility settings and security needs should be pulled front he phone to make the app easier for users by automatically adjusting to desired font sizes as well as any other unique settings	- For the “Account” page, the gmail API should be used so users can be able to receive alerts via email if they desire

References

Adobe. (2019). *Download free Adobe XD | UX/UI design and collaboration tool*. Adobe.com. https://www.adobe.com/products/xd.html

Android. (2021, May 6). *Design for Android*. Android Developers. Retrieved October 2, 2022, from https://developer.android.com/design

ANSA, R. (2021, November 2). *Venice on flood alert all week, Mose in action - english*. ANSA.it. Retrieved September 15, 2022, from https://www.ansa.it/english/news/2021/11/02/venice-on-flood-alert-all-week-mose-in-action_ad80bd21-0049-41a5-9c53-b05b2adca635.html

Campbell, N. (2020, December). *IDEO U: Service design course project*. Natalie Campbell. Retrieved October 7, 2022, from https://www.nataliecampbell.co/ideo-u-service-design

Campostrini, P., & CORILA. (2010, October 8). *EFDRR Resilient Venice*. PreventionWeb. Retrieved October 11, 2022, from https://www.preventionweb.net/files/15110_21campostrinifragileandresilientven.pdf

Carniello, L., Riccardo , M., Daniele, V., Andrea, D., Luigi, D. (2021). The first operations of M.O.S.E system to prevent the flooding of Venice: insights on the hydrodynamics of a regulated. *Journal of Estuarine, Coastal and Shelf Science*

C. Hayes, Engineering flood defense: Venice keeps Adriatic at bay. (2021) *in Engineering & Technology, vol. 16, no. 7, pp. 46-47, Aug. 2021, doi: 10.1049/et.2021.0707.*

Consorzio Venezia Nuova. (n.d.). MOSE Venezia. Retrieved October 3, 2022, from https://www.mosevenezia.eu/consorzio-venezia-nuova/

Conzorzio Venezia Nuova. (n.d.). News. MOSE Venezia. Retrieved September 15, 2022, from https://www.mosevenezia.eu/

Cipri, R. (n.d.). *Commissario Straordinario Mose: Semafori*. Commissario Straordinario Mose: Semafori. Retrieved September 10, 2022, from https://www.commissariostraordinariomose.it/

Creswell, J. W. (2013). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th ed.). Sage Publications Ltd.

CVN. (2022, May 13). Semafori. Commissario Straordinario Mose. Retrieved September 15, 2022, from https://www.commissariostraordinariomose.it/

Ding. (2022). Mobile Apps for Flood Emergency Management in China: Functionality, Usefulness, and Coproduction. China Media Research, 18(1), 38–.

Elevation of Venice,Italy Elevation Map, Topography, Contour. (n.d.). Flood Map. Retrieved September 15, 2022, from https://www.floodmap.net/elevation/ElevationMap/?gi=3164603

Frequently Asked Questions About Venice's Canals. (n.d.). Venice Carnival. Retrieved September 27, 2022, from https://www.venice-carnival-italy.com/frequently-asked-questions-about-venices-canals/

Hartson, Rex Pyla, Pardha. (2019). *UX Book - Agile UX Design for a Quality User Experience (2nd Edition)*. Elsevier. Retrieved from

https://app.knovel.com/hotlink/toc/id:kpUXBAUXD2/ux-book-agile-ux-design/ux-book-agile-ux-design

Hartson Rex, & Pyla Pardha. (2019). UX Design Requirements: User Stories and Requirements. In UX Book - Agile UX Design for a Quality User Experience (2nd Edition, pp. 1–1). Elsevier. From https://app.knovel.com/web/view/khtml/show.v/rcid:kpUXBAUXD2/cid:kt011YB2T3/viewerType:khtml/root_slug:ux-book-agile-ux-design/url_slug:the-components-of-ux?&b-toc-cid=kpUXBAUXD2&b-toc-root-slug=ux-book-agile-ux-design&b-toc-title=UX%20Book%20-%20Agile%20UX%20Design%20for%20a%20Quality%20User%20Experience%20%282nd%20Edition%29&b-toc-url-slug=part-i-introduction&kpromoter=federation&page=7&view=collapsed&zoom=1

Henriques, B., & Cordova, I. (2022). *Towards Inclusive Learning and Research with Sign Language Surveys*. : Worcester Polytechnic Institute.

IDEO. (2015). *The field guide to human-centered design.* IDEO [Ca.]

Le acque alte eccezionali. (2021, 08 04). Comune di Venezia. Retrieved September 15, 2022, from https://www.comune.venezia.it/it/content/le-acque-alte-eccezionali

Leelawat, N., Pee, L. G., & Iijima, J. (2013). Mobile apps in flood disasters: What information do users prefer? from .https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1014&context=icmb2013

Lune, H., & Berg, B. L. (2017). *Qualitative research methods for the social sciences*. Pearson.

Macchioni, Pizzo, B., & Capretti, C. (2016). An investigation into preservation of wood from Venice foundations. *Construction & Building Materials*, *111*, 652–661. https://doi.org/10.1016/j.conbuildmat.2016.02.144

Map of Venice Centre. (n.d.). World Easy Guides. Retrieved September 27, 2022, from http://www.worldeasyguides.com/italy/venice/map/map-of-venice-centre/

Mel, R. M., Carniello, L. C., & D'Alpaos, L. D. (2021). How long the Mo.S.E. barriers will be effective in protecting all urban settlements within the Venice Lagoon? The wind setup constraint, Coastal Engineering, Volume 168. Science Direct. https://www.sciencedirect.com/science/article/pii/S0378383921000831

Mikhailova, M. V. (2021, September 15). *Floods in the Venetian Lagoon and Their Causes*. Springer Link. Retrieved September 15, 2022, from https://doi.org/10.1134/S0097807821050134

Nunno, F., Granata, F., Gargano, R., Marinis, G. (2021). Forecasting of Extreme Storm Tide Events Using NARX Neural Network-Based Models. *Article of Department of Civil and Mechanical Engineering (DICEM), University of Cassino and Southern Lazio*

Peacock, A. (n.d.). *A Guide to Acqua Alta: What to Do in Venice When it Floods*. Tuscany Now. Retrieved September 15, 2022, from https://www.tuscanynowandmore.com/discover-italy/essential-advice/guide-acqua-alta

Servizi di allertamento. (n.d.). Comune di Venezia. Retrieved September 15, 2022, from https://www.comune.venezia.it/it/content/servizi-allertamento

Sirene allertamento acqua alta [High Water Warning Siren]. (n.d.). Comune di Venezia [City of Venice]. Retrieved September 15, 2022, from https://www.comune.venezia.it/it/content/sirene-allertamento-acqua-alta

StatCounter. (2022, January). *Italy: market share of mobile operating systems 2010-2021*. Statista. Retrieved October 5, 2022, from https://www.statista.com/statistics/623153/leading-mobile-operating-systems-ranked-by-market-share-in-italy/

Trincardi, F., Barbanti, A., Bastianini, M., Benetazzo, A., Cavaleri, L., Chiggiato, J., Papa, A., Pomaro, A., Sclavo, M., Tosi, L., & Umgiesser, G. (2016). The 1966 Flooding of Venice: WHAT TIME TAUGHT US FOR THE FUTURE. Oceanography, 29(4), 178–186. http://www.jstor.org/stable/24862293

Understanding the iOS and Android UI Guidelines. (2021, March 24). Designflyover. Retrieved October 3, 2022, from https://designflyover.com/understanding-the-ios-and-android-ui-guidelines/

Velaventa. (2021, April 16). *Mo.s.e.: Un Sistema Online A semaforo per I Sollevamenti delle Barriere*. Velaveneta.it | Un mare di notizie. Retrieved September 15, 2022, from https://www.velaveneta.it/2021/04/16/mo-s-e-un-sistema-online-a-semaforo-per-i-sollevamenti-delle-barriere/

Zorzi, A. (2022, November 22). *Marea a Venezia. Il Mose salva la città, l'acqua tocca 204 centimetri*. Corriere veneto. Retrieved December 5, 2022, from https://corrieredelveneto.corriere.it/venezia-mestre/cronaca/22_novembre_22/mose-salva-venezia-un-alta-marea-livelli-devastanti-2019-1e2ca57e-6a47-11ed-81f6-85bdc84d778d.shtml