The Third Space
DURABILITY & RESILIENCE

Contents

This project takes place on the unceded traditional territories of the x□m□□k□□y□□m (Musqueam), S□wx□wú7mesh (Squamish), and s□lilw□ta□ (Tsleil-Waututh) Nations.

Third Space Commons is built in, and designed for, British Columbia (BC). BC is vulnerable to a variety of natural and human-caused disasters including earthquakes, wildfires, drought, flooding, and epidemics. Third Space is designed to endure BC's conditions and respond to disruptions in an efficient and timely manner. Our durability and resilience strategy hinges on two key principles: responsiveness to the environment and system redundancy.

Additionally, programmatic flexibility of the building allows the Third Space to respond to changes in community demands over time. The building can serve as a single-family live-work space, an institutional living lab, an event space, or other settings. These changes in program can also be reflected in adjustments to the building's systems to maintain occupant comfort.

To design and build sustainably, the industry needs to adapt to the idea of retrofits and adaptive reuse. We envision a future where buildings are not static constructs, but rather constantly evolving works that allow for system flexibility. We have designed an integrated monitoring system to allow engineers and scientists to quickly determine the extent of performance losses and to study how retrofit additions to the building can improve durability and resilience throughout the design life of a building.

Envelope Durability

The envelope design applied the following strategies to ensure it is durable: materials selected for durability, careful layering of materials, and detailing for continuity.

The exterior finishes, which are most exposed to Vancouver's rainy climate, were chosen to be particularly durable. The Accoya wood siding and decking is a modified wood product which undergoes acetylation, making it much harder for water to bind to the wood and cause shrinkage and decay. The standing seam metal roofing forms a continuous interlocked surface that reduces the chance of leaks and requires less maintenance than a traditional shingled roof. This metal is likely to outlive the building and may be reused in future projects.

The hempcrete in the walls is "breathable" which gives it moisture buffering capacity to regulate interior relative humidity. This posed a challenge on where to place the control layers, and it was decided that the air control layer would be on the exterior of the walls and there would be no interior vapor control. This is somewhat experimental and will be validated with sensor data in the living lab phase of the building's life.

The envelope's connections were carefully detailed to transition the control layers, using positive lapping and compatible materials, and the design and construction teams made sure the drawings were properly and accurately built. Correct construction is an essential step for control continuity and durability. The wall also features a continuous overhang which will protect the wood siding and windows from rainfall.

Third Space's envelope is resilient in several senses. The thermal mass provided by the hempcrete regulates temperature and promotes night flush cooling, the white roof helps reduce the heat absorbed in the hottest months, and the windows and skylights are placed to enable natural ventilation and cooling. These passive strategies all provide the opportunity for passive thermal control in the case of power outages and during the hottest months.

The building is also resilient in the sense that many of the materials and components will be reusable at the end of the building's life. This is both because of their durability and the exclusion of glue and spray foam during construction, which means they will be easier to deconstruct and reuse.

Seismic Resilience

Being located very near the boundary of two tectonic plates, Vancouver is highly susceptible to seismic activities, which can range from mild intraslab earthquakes to severe megathrust earthquakes. The largest earthquake felt in the region was a magnitude 7.3 event in 1946. It is expected that the "big one", a predicted magnitude 9.0 earthquake will happen along the Cascadia Subduction Zone in the foreseeable future though smaller, still significant earthquakes are also possible in the Third Space's lifetime. With the years growing since the last large earthquake in the region, and new research indicating that future earthquakes will be stronger, Canadian and BC building codes have been imposing more and more stringent guidelines on seismic design values for new buildings. The horizontal Peak Ground Acceleration (PGA) and the horizontal Peak Ground Velocity (PGV) values provided by the provincial government are given for a 2% probability of being exceeded in 50 years (a 2475-year return period).

The potential for these events to occur poses a risk to the Third Space. The structure utilizes a system of strategically placed shear walls that are comprised of dimensional lumber studs arranged flush against a sheet of plywood. These shear walls act as rigid diaphragms and provide lateral support against wind or seismic loads. At other locations of the wall where shear diaphragms are not required, dimensional lumber blocking will be used to provide bracing and further lateral support.

Additionally, double-ply engineered wood trusses were constructed between helical piles to abide by CSA's requirements for foundation system resilience. The building's foundation system was designed to the current BC building code standards for seismic resilience. In fact, 4 piles were added to the foundation system to accommodate for additional lateral resistance needed beyond gravity resistance. Hold downs were also used for all posts to ensure lateral bracing capability.

An added benefit of our helical piles is their applicability to a range of soil conditions. Although Third Space's site has very good bearing capacity, in the event of an earthquake the piles would be able to sustain their support of the building above.

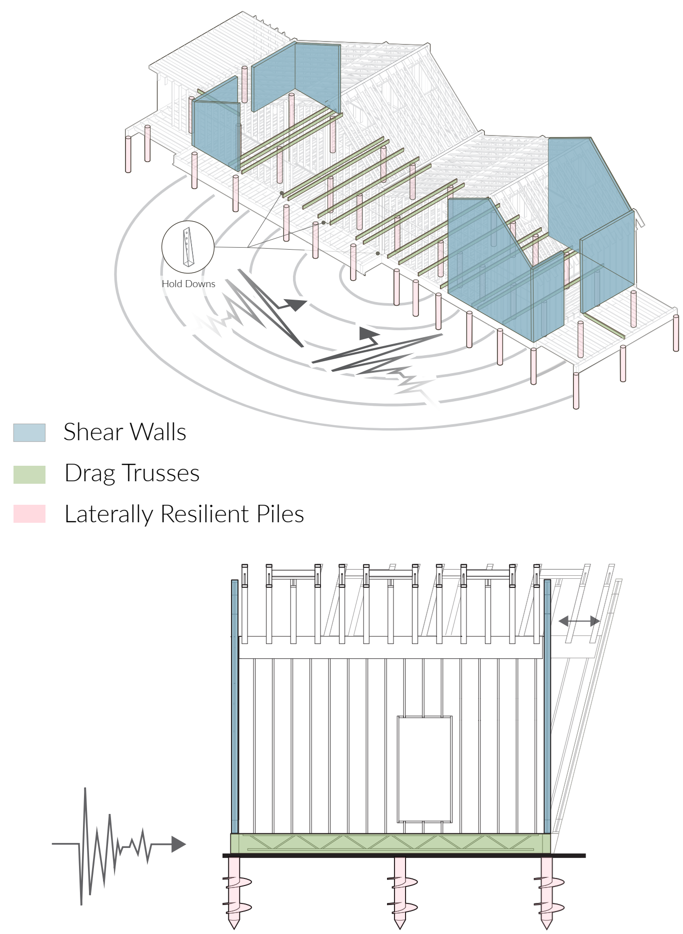

Figure 1- Seismic Resilience Diagram

Extreme Weather Events

The lower mainland of BC is particularly vulnerable to floods. In November 2021, almost 20,000 people were displaced from their homes when an atmospheric river event hit BC. This rain event exceeded the previous 125-year-old record for rain fall in the region and will cost the province over $1 billion in damages. These unprecedented events are happening more and more often and our infrastructure must be designed to adapt to these conditions.

Third Space Commons is resilient to these events with its raised foundation and floor systems. In a flash flooding event, the floor assemblies above will be unaffected by the rising water level below, providing occupants the safety they need in an emergency. The gradual east-to-west slope beneath the building, as water naturally flows away from the building and towards storm sewers downstream. The shrubbery and trees to the west of the building also help to prevent long-term issues from flooding as they absorb water from the surrounding soil.

Third Space has been designed to meet BC Building Code standards which ensure that our building will perform sufficiently in the case of **1 in 50 year wind, rain, and snow events.** The on-site rainwater storage also helps to mitigate the effects of excess rain as it acts as a buffer between the building and the storm sewer. Adopting rainwater storage strategies improves the overall resilience of Vancouver as a whole, since it reduces the amount of water flowing into the sewer and therefore reduces the likelihood of storm system overflow. When this occurs, excess water can seep into the ground and surface water and negatively impact water quality for both humans and the surrounding ecosystem.

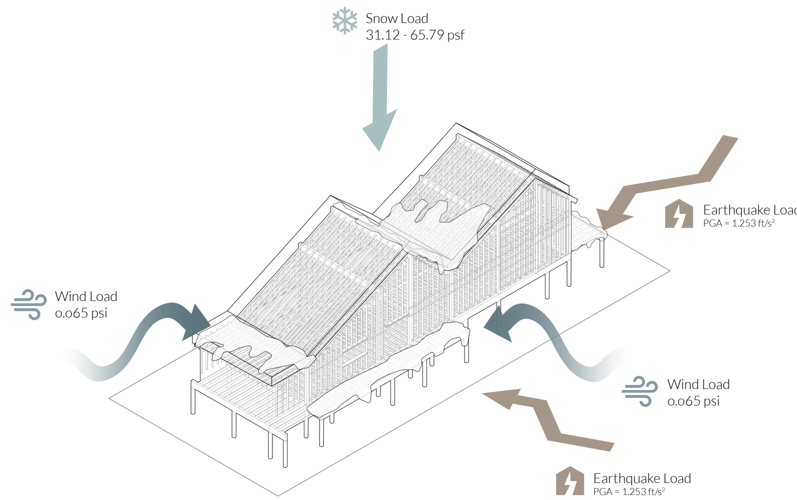

Figure 2- External Loads Diagram

Grid Resilience

Third Space is powered by a combination of on-site solar generation and electricity from BC Hydro's 97% renewable energy grid. The on-site solar system consists of eighteen reused 300W photovoltaic panels. The power optimizing inverter uses its Maximum Power Point Tracking (MPPT) capabilities to produce maximum power output in changing climate conditions. Additionally, as a means of electrical protection, the system is adaptable, ensuring inverter shut-off in response to electrical faults. This direct-grid injection system delivers power from solar to panel board service entrance, allowing for optimal performance, and most importantly, reliable system protection. To further demonstrate resiliency, load management capabilities are implemented in the Third Space by smart electrical load controllers which provide the ability to efficiently shed larger household loads protects and reduces stress on primary power in the event of imbalances in the energy grid.

On multiple instances, large wind events or other unforeseen weather have caused power outages across the Vancouver region with the number of reported outages sitting at around 100/year in BC alone. For instance, on May 23rd 2017 a large wind event left 210,000 Vancouverites without energy[1] . In the event of a city-wide power outage, Third Space's solar panels allow for a source of electricity separate from the grid. The current system was intentionally installed without battery back-up due to our design's emphasis on minimal environmental impact – batteries are carbon-intensive products with many materials that are toxic to the environment at the end of its lifecycle. However, it is possible to retrofit the system with a battery if required in the future, especially if a reused battery is found that aligns with our principle of carbon minimalism.

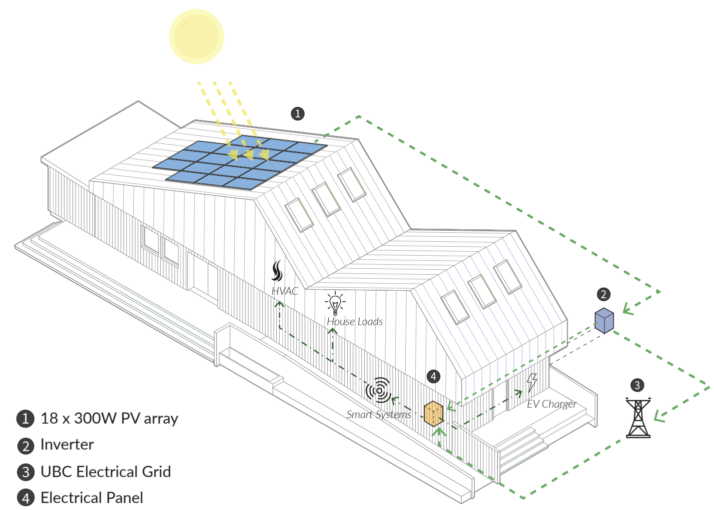

Figure 3- Energy System Diagram

1. EATON, "Blackout Tracker Canada Annual Report 2017," Blackout Tracker Annual Report, 2017, https://www.eaton.com/content/dam/eaton/products/backup-power-ups-surge-it-power-distribution/backup-power-ups/blackout-tracker-/eaton-blackout-tracker-annual-report-canada-2017.pdf..

Air Quality: Pandemic and Forest Fires

The Covid-19 pandemic has affected the world profoundly over the last few years, and Third Space Commons was designed with the intent to address some of the concerns that have arisen. Namely, a flexible building layout to facilitate various needs and a robust ventilation system for superior air quality.

Considerations for pandemics are becoming more important as scientists predict that they will become three times more likely with climate change, in addition to the impacts of COVID-19 which will continue for many more years to come[1]

Third Space Commons has a mixed-mode ventilation system, capable of being entirely naturally ventilated, entirely mechanically ventilated, or somewhere in between. The HRV is able to provide up to 600CFM, far above the ASHRAE requirements for a single-family dwelling, while the natural ventilation strategy is able to provide up to 6ACH. The unit's powerful ECM fans enable the ventilation system to be fitted with high-efficiency particulate absorbing (HEPA) filters when pristine filtration is required. During times where air quality or transmission of viruses is of paramount concern, the ability to ramp up the ventilation system and remove fine contaminants is invaluable. The ability of our system to mitigate poor air quality is also hugely important for BC in particular, as we have been experiencing seasonal air quality deterioration due to increasing frequency and intensity of wildfires.

n 2021 alone, 8,693 square km burned during the BC wildfire season. While most of these were caused by lightning (68%), 31.4% were caused by humans. However, most years the human caused fires are even higher.[2] The effects of wildfires in the USA have also been acutely felt in Vancouver, such as the 2020 California fires. Reduced outdoor air quality due to wildfires has become an annual reality for BC residents and their homes should be able to protect them during these events.

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Third Space Commons is equipped with **indoor air quality sensors that detect CO2, VOCs, and particulate matter.** Particulate matter smaller than 2.5 microns is of great concern when it comes to wildfire smoke. BC monitors particulate matter smaller than 2.5 microns, ground-level ozone, and nitrogen dioxide. This data is used to compute an air quality health index, which ranges from 1 (low risk) to 10+ (very high risk). The Home Assistant monitoring system can be configured to notify occupants when the government releases Vancouver air quality advisories. A future outdoor air quality sensor is also planned to be integrated into the network. In the event of compromised air quality, the system could advise residents to close doors or windows and switch out the HRV's standard MERV13 filter to HEPA filters if necessary.

1. Marco Marani et al., "Intensity and Frequency of Extreme Novel Epidemics," Proceedings of the National Academy of Sciences 118, no. 35 (August 23, 2021), .

2. Akshay Kulkarni, "A Look Back on the 2022 B.C. Wildfire Season — and What It Can Teach Us about What's Coming Next," CBC, December 26, 2022, .

Fire Response

Though Third Space's building classification does not require sprinklers by code, the team opted to include a sprinkler system in order to align with Vancouver's goals regarding building resilience. The system complies with NFPA 13D for residential homes.

In the event of fire, the sprinklers react automatically to quench the flames while a flow sensor activates an alarm bell to warn occupants. The flow-through system refreshes the water inside the sprinkler pipes with each toilet flush, thus preventing water within them from becoming putrid and stagnant, which would cause additional damage to the building when released.

Resource Management

With the integration of passive strategies into Third Space Commons, we use less energy and resources than the typical building. Additionally, our ability to produce our own power, collect rainwater, and grow vegetation limits our reliance on outside resources.

Our PV panel system collects solar energy, decreasing the amount of electricity extracted externally and providing a source of power even if the UBC grid goes down.

Low-flow fixtures and a rainwater harvesting system reduce the building's reliance on an external water supply. The rainwater harvesting system channels rainfall from the roof through a first-flush filter, and into a 1000L storage tank. The storage can be used for hand-watering plants and landscaping, offsetting a major source of water consumption in residential homes.

Reducing reliance on external resources also improves the resilience and durability of Vancouver's infrastructure in totality. As more buildings adopt rainwater collection strategies, the load on municipal infrastructure is reduced. This is especially important during extreme weather events, where it is essential to mitigate the risk of sewer overflow into ground and surface water. With the rising implementation of high-efficiency appliances and on-site power generation, loads on BC Hydro's electrical grid are reduced. As the world leans away from fossil fuels and toward electricity as a form of power for both buildings and transportation, the ability to supply such vast amounts of power is of great concern. Third Space's passive systems, high efficiency appliances, and solar generation all contribute to decreasing peak loads and preventing the need to construct additional carbon-intensive municipal infrastructure to meet power demands.

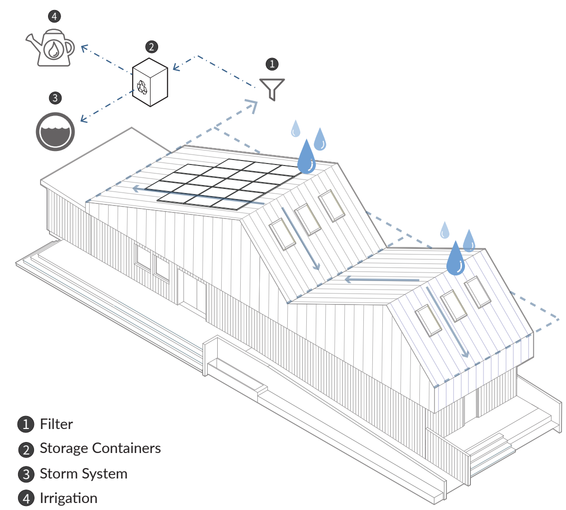

Figure 4- Rainwater Harvesting System

The south-facing sunroom provides space for indoor plants, while planters on the north deck and ample greenspace surrounding the building provide area for external vegetation. Edible plants can be sustained with water from the rainwater storage system, providing occupants a local, supplementary food source that reduces their reliance on outside systems.

Resilient Building Use

The ability to adapt to changing conditions is at the core of resilience and durability. Depending on the needs of its occupants, Third Space Commons can adapt to a variety of use cases, from a home to study space to gathering area. This increases the usefulness and therefore the longevity of the space, as it can be transitioned to suit the future needs of UBC and the local community, whatever they may be.

The building is divided by a set of sliding partitions at the valley, allowing it to be separated into a family area and bedroom area for a residence, or a commons area and seminar space for its institutional use. As working from home becomes more and more common, the ability to separate the space can allow for a home office to be sectioned off from areas of rest.

Sliding doors along the east walls in the kitchen and seminar space can also be used to open and close off locations as the occupants see fit. These sliders double as pin-up boards and whiteboards, which can be used for architectural studios, corporate meetings, and home scheduling alike.

Walkable access panels line the top surface of the bulkhead, allowing for the space to be used as a bedroom loft, storage area, or elevated office while permitting easy maintenance and retrofits of the mechanical and electrical systems.

The structure and form of Third Space Commons were intentionally designed to be transported via roadway. The helical pile foundation makes it simple to lift and its narrow massing complies with maximum load width. If the building will better serve the community by moving off-site to become a home for a family in need, then it can do just that.

If the building has outlived its use, many elements of it can be easily deconstructed and repurposed. The solar panels, standing seam metal roof, and helical piles are some particularly notable features that are long-lasting, easy to separate from the building, and reusable. The floating wood floors were installed without any fasteners or glue, so they can easily be removed and reused along with the heating mats and cork lining beneath. Third Space Commons is built to endure, even as just its constituent parts.

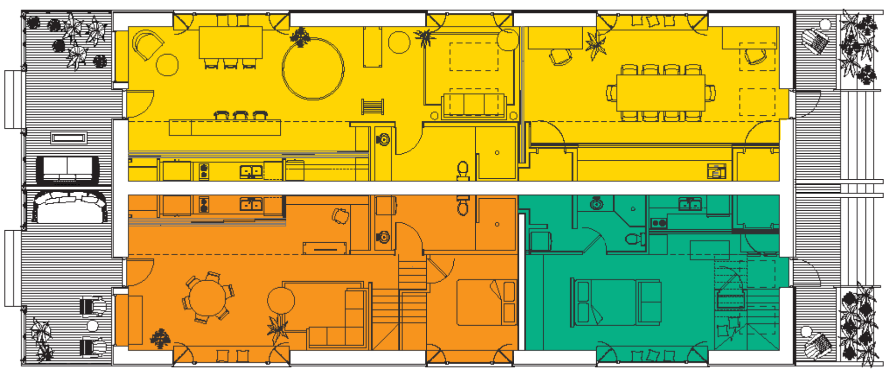

Figure 5- Architectural Configurations

Living Lab

The Home Assistant monitoring and control network can measure building performance in the face of extreme weather events, wildfires, and more. This includes the effectiveness of active, passive, and mixed-mode systems to maintain quality and comfort in the face of disruption. This data can not only be used to improve the durability of our building, but also to improve the durability of other current and future developments. If there are particular strategies that work better than others, the data that we collect can encourage future developments to implement better-performing solutions.

The passive cooling system is one such avenue for experimentation within Third Space Commons. The growing frequency and intensity of heat waves in BC has been of significant concern for the past few years, leading to health issues and deaths associated with dehydration and heat exhaustion. The vast majority of homes in Vancouver are not equipped with any active cooling system, leaving occupants to resort to fans or purchasing portable AC units that rapidly go out of stock. Third Space Commons was intentionally designed without a cooling system, aligning with our principles of carbon minimalism as well as living lab. In its life after the competition, the building is specifically intended to undergo tests during a summer heat dome event in order to see how it performs. The knowledge gained from such studies can be used not just for future building developments, but also to educate current homeowners on the best strategies to passively cool their homes when they have no other options. Tests can include analysis of the purely passive systems, plus the addition of future ceiling fans and powering the HRV. The impact of thermal mass on temperature control is also of particular interest. The accessible bulkhead is also intended to house future cooling retrofits, specifically innovative up-and-coming radiant cooling technologies.

Though Third Space Commons will ultimately be used as an institutional space, its adaptable furniture and layout still allow for future case-studies where it is staged and operated as a single-family home.

Living lab experiments do not have to be limited to the realms of engineering. During the pandemic, homes became our workplaces and our social hubs. Third Space Commons can be used to test interior configurations and optimize them for their intended purpose. With the adaptable furniture layout, studies regarding productivity and creativity of first, second, and third spaces could be conducted. The influence of biophilia, such as within the sunroom, on psychological health could be evaluated.

Third Space Commons will be a test bed for novel green building solutions, and we hope that the resulting research will encourage industry to trial these solutions for themselves.

Passive Systems

Passive principles have been at the forefront of Third Space's design from the very beginning. In addition to reducing energy consumption, our natural ventilation, cooling, and daylighting strategies allow the building to remain habitable even if active systems go offline.

To optimize natural daylighting, all glazing has been deliberately placed to reduce glare and create diffuse light. The interior finishes are primarily white or light to ensure that the space is adequately bright. The windows have been strategically located to utilize the existing vegetation on site which will provide shading in the summer and let in light in the winter. Doors have glazing to maximize light, especially on the east and north facades. This ensures that occupants have sufficient illumination for day-to-day activities, even without any electrified lighting systems.

Windows and skylights have been chosen and located with a passive cooling strategy in mind. All operable glazing units have been placed according to neutral pressure line calculations to allow for stack effect. Systems have been designed to encourage night flush cooling which is an automated process where the building is allowed to cool overnight when the exterior temperature naturally falls. The thermal mass in the walls provided by hempcrete absorbs heat during the day and then slowly releases it at night, allowing interior temperatures to stay comfortable and regulated. Casements and vents will open to allow the warm stale air that accumulates during the day to be flushed and replaced with fresh air, without disturbing occupant comfort. High elevation skylights allow for occupants to ventilate their homes safely and securely, even during the night.

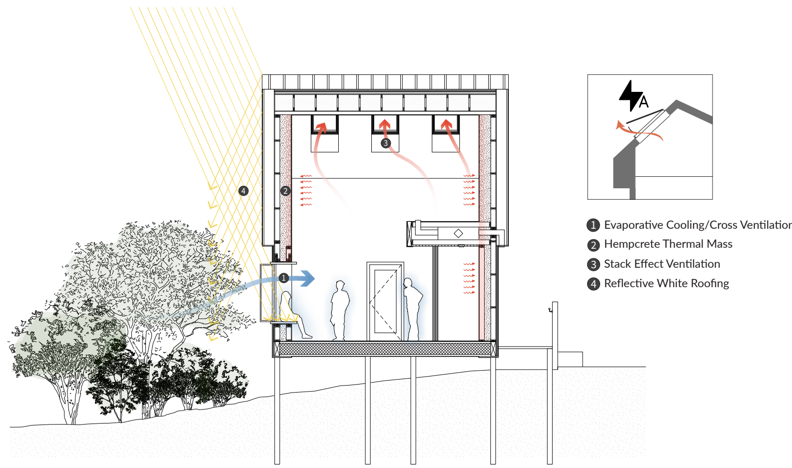

Figure 6- Passive Systems Diagram