UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Bike Theft Reduction at UBC

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Bike Theft Reduction at UBC - Final Report

URSY 520

UNIVERSITY OF BRITISH COLUMBIA

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Executive Summary

The URSY 520 team undertook this engagement with the objective of delivering a suite of novel measures to reduce bike theft on the UBC campus, in an effort to remove this key barrier for students to bike to UBC.

In order to do so, the project team first conducted a baseline analysis of both the status of biking within the mode-split of commuters to UBC, as well as of the status of bike security infrastructure on the UBC campus. This endeavor allowed the team to best understand the strengths and weaknesses of currently deployed solutions.

Following the baseline analysis, a literature review and idea generation phase was undertook to develop a comprehensive list of 13 potential bike security and theft-prevention measures that may be possible.

In order to provide a preliminary level of insight into the merits and drawbacks of each of the options on the aforementioned list, a multi-criterion filtering matrix was developed in consultation with the client, allowing the team to gain a better understanding of how each option performs on each of the key metrics.

The initial filter highlighted above led to a qualitative assessment of the high-ranking alternatives, ultimately leading to a three-pronged solution that encompasses many of the options in the initial filtering matrix.

1. The Bike Kitchen Sharing Hub: refers to the sharing/borrowing of bike safety equipment, including U-locks, bike alarms, and GPS anti-theft devices.

2. Bike Storage Rooms & CCTV: refers to the introduction of bike storage rooms within buildings that are situated in high-theft areas, along with the use of CCTV for areas that this is not a possibility (subject to regulatory restrictions).

3. Theft-deterring Signage and Public Engagement: refers to the use of posters to deter thieves, along with the adoption of a comprehensive public engagement strategy, including social media campaigns, engagement programs, competitions, and a "BikeToUBC Week".

Table of Contents

List of Tables

List of Figures

1

Introduction

1.1 | Background and Objectives

Despite best efforts, bike theft continues to be a problem on the UBC campus, with over 290 bikes stolen in the past two years. Studies of UBC staff has shown that fear of theft is one of the most significant barriers to cycling to campus, with it being ranked as the second-largest barrier, more than weather and commute length combined. As only 1.4% of trips to and from UBC are currently made by bicycle, removing the barriers to biking to campus (in this case, theft), is a critical component of UBC achieving its 2040 transportation target. Per UBC Campus + Community Planning, "cycling is key for UBC to achieve our 2040 transportation target of having 2/3 of all trips to and from campus made by walking, cycling, and transit. Currently only 1.4% of trips to and from UBC are made by bike." In order to promote cycling and increase cycling mode share from 1.4% to 20-25%, UBC Campus + Community Planning needs creative, scalable solutions to solve bike theft on campus.

As such, UBC's SEEDS Sustainability Program has requested the URSY 520 team to develop a comprehensive, scalable and creative bike-theft prevention strategy that is feasible within the program's capital and operational constraints.

1.2 | Scope

The extent of the study is the Vancouver campus of UBC. The key deliverables associated with this project are an examination of a suite of bike security solutions for UBC's Vancouver campus, an evaluation of the merit of multiple scenarios, along an overall set of recommendations and implementation considerations. Historically, municipalities that fund cycling infrastructure see increased ridership, as demonstrated in places like the Netherlands, Denmark, or Germany (Copenhagenize Index). It is our hope that the outcomes of this project will allow UBC to be yet another manifestation of this trend.

2

Theoretical Framework and Methods

The URSY 520 team has employed the following four-stage approach to developing a strategy that is in alignment with UBC SEEDS' objectives.

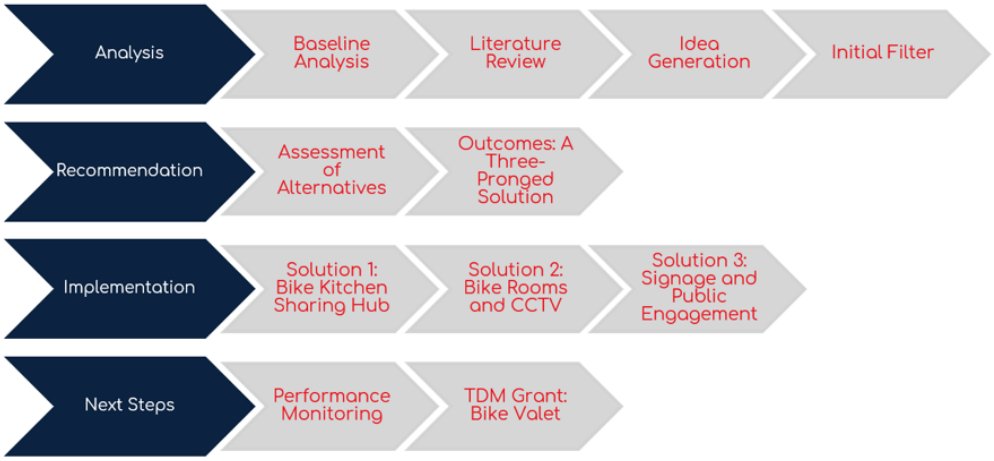

Figure 2.1: Project Roadmap

1. Baseline Condition Review and Analysis (Section 3): Review of the current status of bicycle infrastructure on the UBC campus. Data collection and review of the bike parking infrastructure (quantity, capacity, and location) and the current anti-theft methods adopted by UBC. Review of the information on past theft cases and the associated locations.

2. Literature Review and Idea Generation (Section 4): Study and investigation within existing literature to develop a comprehensive list of bike security strategies, considering a variety of approaches: physical infrastructure, behavioural approaches, programs, etc. Novel ideas from team members that are not present in existing literature have also been captured here.

3. Initial Filter (Section 5): Ranking and filtering the options developed in Stage 2 in accordance with a multi-criterion framework developed in consultation with the

client. This section informs which options will be assessed in greater detail in the following section.

4. Assessment of Alternatives and Recommendations (Section 6): This section outlines the interpretation of the initial filter and highlights the high-level "solutions" that are recommended, each of which are further discussed in the implementation section.

5. Implementation Considerations (Section 7): This section entails developing an implementation roadmap for the options that have been identified as "high-potential" in the preceding stage, including a discussion of key questions that will need to be addressed, and spatial deployment maps, where necessary.

6. Next Steps (Section 8): This section includes a brief discussion of further actions that may bolster bike safety on campus and are recommended for additional examination.

2.1 | Data Collection

SEEDS provided our group informative data on bike parking, academic capacity per building, UBC Transportation, bike theft locations, e-bike programs, etc. Some of these documents proved useful when our group brainstormed bike security ideas. However, in addition to the provided data, and extensive external deep dive was conducted to enhance the team's understanding of the matter at hand, as follows:

Since bike theft remains a pervasive issue globally, our group thoroughly investigated 10+ journal articles to understand the best practices in places as far away as Montreal and Washington, D.C. For example, given that "bad locking accounted for 60% of thefts" and viewing the figure below, "comparison of locks shows effectiveness of U-locks" (Lierop et. al., 2015), this leads to a hypothesis that UBC could spend their bike security funding wisely by promoting good locking techniques and using strong U-locks.

Figure 2.2: Comparison of locks used on stolen bicycles and locks used on current bicycles (Lierop, et al., 2015)

Additional information was collected through meetings with the client, as well as with a manager at the UBC Bike Kitchen, as is detailed in Section 3, Baseline Analysis below.

2.2 | Data Gaps

A key data gap was during the baseline analysis; our group has had difficulty overlaying the bike theft map with a map of bike cages, lockers, and racks. With this info, our group could determine, with a higher degree of accuracy, whether the high-theft areas have the proper bike security infrastructure.

In addition, it is difficult to fully understand the reasons as to why a particular theft may occur, as, when UBC Campus Security notes a bike theft incident, it is unclear if the victim had proper security measures, such as a high-quality lock, in place.

According to the journal article, Breaking into Bicycle Theft: Insights from Montreal, Canada, "The study makes clear that public agencies should act to prevent theft by adding bicycle parking capacity and ensuring that parking facilities are strong (thick metal well-anchored), easy to properly use (locking to bicycle frame and removable parts), visible, and located near destinations such as work, school, shopping, and recreation." Not only is this a data gap for now, but effective bike rack location is subject to interpretation when combined with UBC Planning goals, such as landscape architecture.

3

Baseline Analysis

3.1 | Current Transportation Mode Choice

Population at UBC has increased to 71,750 by Fall 2018, including student, staff, and faculty. However, the weekday person-trips to and from UBC by bike has dropped significantly after 2003 when the U-Pass was introduced, accounting for only 1.4% of trips to and from UBC, according to the UBC Vancouver Transportation Status Report of 2018. The figure below shows the average weekday bicycle trips to and from UBC, 1997-2018.

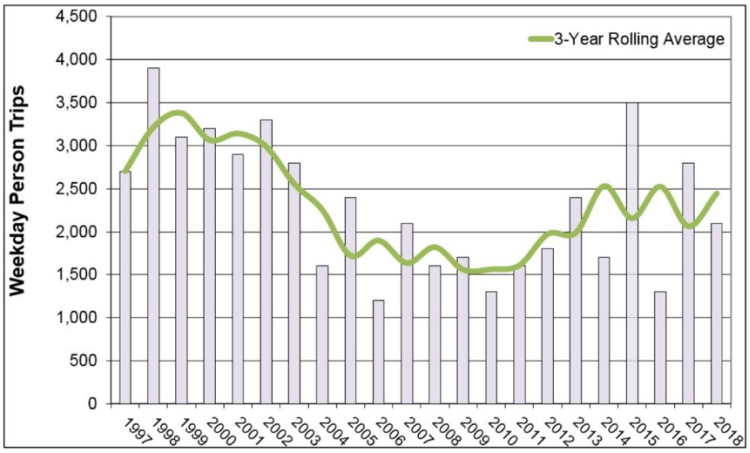

Figure 3.1: Weekday Person-Trips by Bike (UBC Vancouver Transportation Status Report, 2018)

According to the Report, the usage rate of bicycle racks equipped on buses operating on transit routes serving UBC decreased from 5.8% in 2015 to 2.8% in 2018.

3.2 | On-campus Bicycle Storage

Multiple options for bicycle storage are available on campus, which include Bike racks, bike cages, and lockers. Among the 1376 survey respondents who own a bike, 575 of them said that they bring their bicycle to campus.

3.2.1 | Classic Bike Racks

Bike racks facilities are available at most of the buildings and residences. Figure 3.2 below shows an example of the classic bike racks that exist across the UBC campus. As one could easily imagine, the classic bike rack is the easiest to use and deploy among all bike storage facilities. However, it is also the riskiest option in terms of theft, especially at night. According to the Survey conducted by NRG Research Group, among the 575 respondents who bring bicycles to campus, 45% of cyclists use classic bike racks, perhaps due in large part to their comfort and ease of use.

Figure 3.2: Classic Bike Rack

3.2.2 | Bike Cages

Bike cages are a bike storage option administered via UBC's Bike Kitchen. They provide a covered bike rack within a secure enclosure. The Bike Cages are intended for short-term personal bike storage only and are monitored by campus security using CCTV.

The available Bike Cages on campus are shown in the following figure. A total of 12 Bike Cages are provided on campus, as shown in Figure 3.3 below.

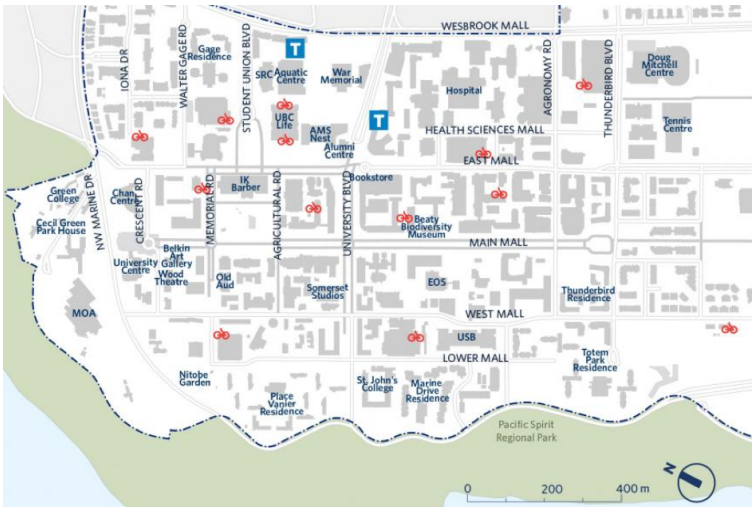

Figure 3.3: Bike Cages on Campus

3.2.3 | Bike Lockers

Bike locker rentals offer the most secure way to lock bikes on campus, whether for daily use or long-term storage. However, this storage option is also the least accessible and least convenient, which requires users to engage with a lock twice, both the bike itself, as well as the locker. Each locker is only accessible by a single renter. The rental fee is $12/month plus a $45 refundable key deposit. In addition, while overnight storage is allowed, it is still not recommended, as it increases the chance of a break-in.

As shown in Figure 3.4 below, bike lockers are installed at 18 locations across campus, with a total 202 lockers available.

Figure 3.4: Bike Lockers on Campus

3.3 | High-theft Areas

As shown in Figure below, the shaded red area indicates the locations with high reports of bike theft incidents in the 2018-2019 academic year.

It can be seen that a significant percentage of the bike theft incidents take place at the residences on campus. This may be because residences are where long-term overnight bike storage is the most prevalent. Most rooms in older residences, including Place Vanier and Totem Park do not have bike hooks equipped in their rooms. A site visit showed that there are only 20 bike lockers are available at each of Place Vanier and Totem Park, which is insufficient for the needs of bike-owning residents. As a result, most bikes are seen to be stored at the bike racks overnight.

As for the central campus areas, including the Irving K. Barber Learning Centre, the Life building, and the Nest, bike storage options in these areas are primarily short term. However, the reason for the high bike theft rate at these locations is likely the high daily

pedestrian volume. In this case, improvements to short term bike-storage facilities may be warranted.

From the group meeting with the SEEDS team, it was determined that last year, most bike thefts occurred at the bike racks, while no thefts were reported from bike lockers, and only one reported from bike cages (an improvement from previous years, when the cages were not monitored by CCTV).

Figure 3.5 below shows that high-theft areas predominantly occur away from bike cages (placed near the main thoroughfares) and closer to the residences where many bicycles are often stored overnight AND outside.

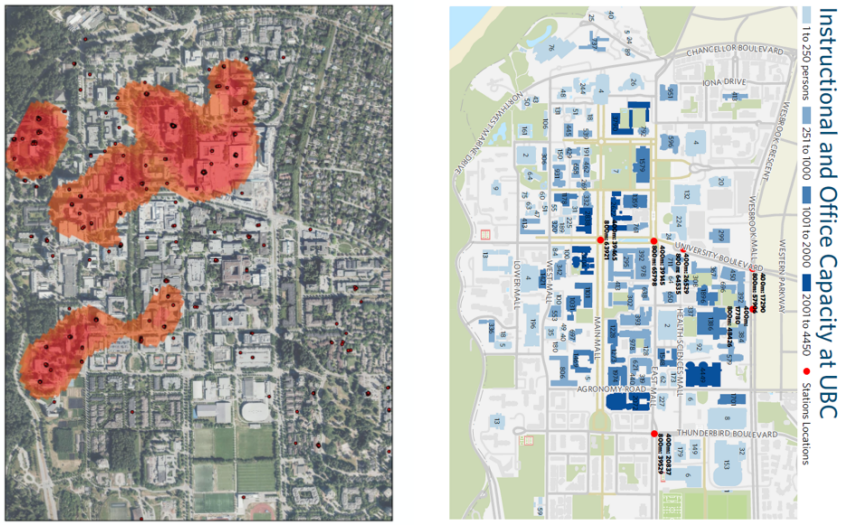

Figure 3.5: Bike Theft Hotspots and Building Capacities

3.4 | Interview Insights

On March 9, 2020, a team member interviewed a manager at UBC's Bike Kitchen. He stated that in the four years he's worked at the Bike Kitchen, burglars attempted to steal (or stole) bikes from their shop's storage areas three times in the past four years. When bike thieves are caught, Bike Kitchen employees do not apprehend or detain suspects for the sake of their safety, nor does UBC Campus Security. Campus Security simply notes the bike theft incidents. As such, organizations like the Bike Kitchen may be well-positioned to encourage cyclists to use a U-lock and avoid locking bikes outside overnight. The manager also noted that most cyclists do not actively register their bikes on the 529 Garage online platform, and echoed sentiments that bike lockers are the safest option at UBC, as indicated by the fact that they accumulate a long waiting list at the beginning of each term.

4

Literature Review and Idea Generation

4.1 | Literature Review Insights

A literature review and precedent analysis was key to developing a comprehensive list of potential bike security and theft-prevention measures. Key insights from the conducted literature review/precedent study are included in this section.

At nearby Simon Fraser University (SFU), they've mostly taken a lock-at-your-own-risk stance if other options are full. For example, SFU states "bike lockers are complimentary" on a "first come" basis for a $20-25 deposit. SFU also offers bike racks inside bicycle compounds at street level, bike racks at the Harbour Centre Complex and bike lockers on the vault level. Also, if students or faculty "require a bike lock on a temporary basis, they are available from SFU security". SFU advocates personnel to lock bikes "in a well-lit area where other bikes are located" and to "only lock your bike to a properly installed bike rack" using U-locks and cable locks. In the San Francisco Bay Area, local police advocate two essentials: where to lock your bike and what to lock your bike with. For a "where" example, keeping your bicycle inside the home or "somewhere that's inaccessible and invisible to prowlers." For a "what" example, local police recommend two U-locks, sometimes smaller U-locks "that don't accommodate pry bars", and novel solutions like Skunklock, that sprays regurgitation-inducing chemicals when tampered with (Metcalfe, 2017). In the City of Richmond, the "RCMP is deploying bait bikes alongside cutting-edge bike registration and recovery from Project 529" (Richmond News). At Princeton University in New Jersey, the Department of Public Safety planted around campus "a few locked bicycles equipped with GPS tracking devices - known as bait bikes" with an aim to "reduce theft and encourage people to lock their bikes and register them with the University" (Princeton.edu).

Nearly an institutional icon for cycling in Copenhagen, the design firm, Copenhagenize, publishes an annual Copenhagenize Index to give an overall snapshot of bicycle-friendliness worldwide. "The Copenhagenize Index gives cities points for their efforts towards re-establishing the bicycle as a feasible, accepted and practical form of trans-

port. Countless cities around the world are taking up the challenge of modernising their public realm, to chip away at the decades of auto-oriented street design – implementing bicycle infrastructure, better policy, bike share systems, restricting car use and more." The Copenhagenize Index promotes cycling based on three parameters: 1. Streetscape (bicycle infrastructure, bicycle facilities, traffic calming) 2. Culture (gender split, modal share for bicycles, modal share increases, indicators of safety, bikes for cargo) 3. Ambition (advocacy, politics, bike share, urban planning)

4.2 | Ideation and List of Potential Solutions

The comprehensive literature review conducted by our team was supplemented by an internal ideation process, in order to identify other potential solutions to bike theft on the UBC campus that may not be well-recorded or mentioned in existing literature and precedent studies. The result of this process is shown in Table 4.1 below.

Table 4.1: List of Potential Solutions

Bike Theft Prevention Measure	**Description**	**Type**
U-lock sharing (free or subsidized)	Providing U-locks to cyclists on campus though a university-administered system.	Prevent
Bike cages in high-theft areas	Increasing the number of bike cages on campus, particularly high-theft areas.	Prevent
Theft-deterring signage/ public edu.	Posting signage that deters thieves and encourages bike safety measures with other public engagement measures	Prevent
Bike alarm sharing (free or subsidized)	Providing bike alarms to cyclists on campus though a university-administered system.	Prevent
Facilitation of seat removal	Providing tools to cyclists to be able to easily remove the seat of their bike, along with a place to store the seat.	Prevent
Bike storage rooms	Providing dedicated storage rooms in buildings that are situated in high-theft areas.	Prevent
Manned storage locations, bike valets	The establishment of a staffed bike valet where cyclists can leave their bike under supervision for a set period of time.	Prevent
More (Class I) bike racks and locations	Increasing the number of classic bike racks on campus, particularly high-theft areas.	Prevent
Bike lockers	Increasing the number of bike lockers on campus, particularly high-theft areas.	Prevent
GPS anti-theft devices	Providing GPS anti-theft devices to cyclists on campus though a university-administered system.	Prevent/ Recover
CCTV in high-theft areas	Introducing CCTV surveillance to high-theft area on campus, including public areas	Prevent/ Recover
RFID anti-theft devices	Providing RFID tags to cyclists on campus though a university-administered system.	Recover
GPS-tracked bait bikes	Placing bait bikes on campus to identify and prosecute frequent offenders.	Recover

5

Initial Filter

In order to reduce the scope of the assessment of alternatives to one that is within the time and resources of the URSY 520 team, a multi-criterion filtering matrix was chosen, as this would provide a high-level understanding of the merits and weaknesses of each of the alternatives highlighted in Section 4.2.

5.1 | Filtering Criteria

In order to use a filtering matrix as an analysis tool, it was first necessary to develop a robust set of criteria that encompass client priorities. As such, a draft list of filtering criteria (along with weights for each) was developed by the team and presented to the client and was subsequently adjusted to best align with the client's including. The final criteria and weighting, approved by the client, is included in Table 5.1 below.

Note that the utmost effort has been made to normalize the criteria and provide clear definitions for each, such that the analysis remains as objective as possible. For some metrics, such as operational cost, quantification became more challenging and access to accurate information was limited. As such, in these instances, the determination of scores has been left to the judgement of the team.

Table 5.1: Filtering Criteria

Criterion	Description	Weight
Effectiveness	■ **4**: virtually no thefts possible/100% likelihood of recovery, ■ **3**: low chance of theft/high chance of recovery, ■ **2**: moderate chance of theft/recover, ■ **1**: possible decrease in theft/increase in recovery ability, ■ **0**: ineffective	6
Operational Complexity	■ **4**: very easy to operate (no additional staff or resources needed), ■ **3**: requires minimal ongoing support and oversight, ■ **2**: requires a moderate degree of staff support, resources and administration, ■ **1**: requires extensive ongoing staff, resources and administrative capacity, ■ **0**: requires dedicated specialized team	2
Implementation Complexity	■ **4**: virtually no changes to current operations, all resources in place, ■ **3**: minimal changes to status-quo operations, ■ **2**: moderate organizational change, training, resources etc. necessary, ■ **1**: many changes/additions to existing practices required, ■ **0**: extensive training, tech tools, expert implementation team required	2
UBC culture fit / interest	■ **4**: high fit with UBC culture (almost all bike-riders would use this), ■ **3**: good fit (high interest from bike riding population), ■ **2**: moderate fit (some bike riders would use this), ■ **1**: low fit (almost no bike riders would use this), ■ **0**: poor fit (no riders would use this) [NOTE: this is irrespective of price.]	2
Space Requirement	■ **4**: this option will require no additional space, ■ **3**: this option will require a small amount of dedicated space, ■ **2**: this option will require a fair amount of dedicated space, ■ **1**: this option will require extensive space, ■ **0**: this option will require extensive hard-to-obtain space (e.g. indoor space)	3
Capital Cost	■ **4**: $0-$20 per bike, ■ **3**: $20-$50 per bike, ■ **2**: $50-$100 per bike, ■ **1**: $100-$300 per bike, ■ **0**: $300+ per bike	4
Operational Cost	■ **4**: no OpEx (operational expenses), ■ **3**: minimal OpEx, ■ **2**: moderate OpEx, ■ **1**: high OpEx, ■ **0**: too expensive	4
Regulatory Barriers	■ **4**: requires no changes to existing UBC or gov't regulations, ■ **3**: may require minor changes/approvals, ■ **2**: may have sizable regulation concerns, ■ **1**: difficult to implement under current regulatory conditions, ■ **0**: currently banned	2
	Sum of Weights:	25

5.2 | Results of Initial Filter

Following the determination of the filtering criteria and weights, the team conducted a comprehensive research effort to determine the merit of each of the alternatives within each of the criterion. The result of this endeavour can be seen in Table 5.2 below:

Table 5.2: Initial Filtering Matrix

	Effect.	Implem. Complex.	Operat. Complex.	Culture Fit	Space Req't	Cap. Cost	Opera. Cost	Regul. Barrier	Score (/100)
Theft-deterring signage/ public education	2	3	4	4	4	4	3	4	82
Bike alarm sharing (free or subsidized)	3	2	2	3	4	3	4	4	80
GPS anti-theft devices	3	2	3	2	4	3	3	4	76
U-lock sharing (free or subsidized)	2	2	2	3	4	3	4	4	74
RFID anti-theft devices	2	2	2	3	4	4	2	3	68
bike storage room	4	2	3	4	1	2	2	3	67
Bike lockers	4	1	2	3	2	1	2	4	62
GPS-tracked bait bikes	2	2	2	1	3	4	3	1	61
CCTV in high-theft areas	3	1	2	2	4	3	1	2	60
Facilitation of seat removal	4	1	1	1	2	2	2	2	56
More (Class I) bike racks and locations	1	2	4	3	2	0	4	4	54
Bike cages in high-theft areas	4	0	3	3	1	0	2	3	53
Manned storage locations, bike/event valets	4	0	1	2	2	1	0	2	44

It is important to note that while scores for all criteria have been provided out of 4, the final score out of 100 is reflective of the weights shown in Table 5.1.

6

Assessment of Alternatives

6.1 | Key Insights and Assessment of Alternatives

Upon developing the initial filtering matrix shown in Figure 3 on the previous page, it was then necessary to select a suite of promising options as "preliminary" recommendations. In order to do so, the filtering matrix acted as a guide, but not the sole determinant in the selection of the final set of options to move forward with, given the limited availability of data and the "high-level" nature of the endeavour.

The first key insight from the filtering matrix is that despite their limited effectivity, theft-deterring signage public education/engagement has occupied the top position, with a score of 82 out of 100, due in large part to its low cost and limited barriers to adoption. While it is not likely that such efforts alone can contribute significantly to the reduction of bike theft on campus, they are easy to deploy in tandem with other measures and can be used as a reinforcement that drives the adoption of other higher-impact solutions.

Another key observation from the filtering matrix is that the broad concept of UBC providing a form of free or subsidized "shared" access to equipment that can either prevent theft (U-locks and bike alarms) or assist in recovery (GPS trackers) consistently do well with the three aforementioned alternatives occupying the second, third, and fourth spots on the filtering matrix. As such, the team considered the consolidation of these measures into a single overarching solution that can be offered through the UBC Bike Kitchen, where students are able to borrow the devices above at no charge (or for a nominal fee).

Occupying the fifth position in the filtering matrix lies "RFID anti-theft devices". These devices are, in essence, small tags that are attached to a bike that include detailed information on the owner, date of purchase, etc. However, it was found that such devices require a larger ecosystem in place in order to be effective, such as in the UK, where ImmobiTag data is linked to all UK police force databases (ImmobiTag.com). In addition, Garage 529 already offers a similar service, rendering UBC offering a similar solution a potentially redundant effort, and perhaps it would serve UBC best to simply encourage

Garage 529 registration through public engagement measures, as part of a broader array of strategies.

Following RFID tags in the filtering matrix lies "bike storage rooms" in the sixth position, which have scored quite higher than "bike lockers", which occupies the next position (67 vs. 62). Bike storage rooms provide the unique opportunity to provide both short-term and long-term/overnight parking solutions across campus, including at residences and high-traffic academic buildings in the central campus core. It also provides the opportunity to reduce the cost-per-bike, as, contrary to bike lockers, an efficient high-capacity bike room design can spread the capital cost of the equipment over a larger volume of bikes. However, a key barrier to widespread adoption will be the space requirement, as many buildings situated in high-theft areas may not be able to provide a room dedicated for this purpose. As such, CCTV, despite a rank of 9 out of 13, may be considered a suitable complementary measure, particularly for high-theft areas that may not be able to accommodate bike rooms. It is recognized that the introduction of CCTV in public areas may not be a possibility given the current regulatory landscape. However, it is noted as a potential supplementary measure, given its ability to both deter thieves and assist with recovery, particularly in high-theft areas where bike rooms may not be a possibility, and students must resort to the use of classic bike racks.

While GPS-tracked bait bikes ranked higher than CCTV in the in the initial filtering matrix, they were not explored further due to the necessity of such an effort to be led by the UBC RCMP, given the limited power of UBC staff of campus security to independently apprehend thieves, and the existing uncertainty surrounding the feasibility of such an endeavour. However, the team encourages further examination of a potential collaboration with the UBC RCMP in order to arrest frequent offenders and potential members of bike theft rings.

Other solutions presented in the filtering matrix that have not been discussed thus far were not explored further due to their overall poor performance in the initial filtering process. The only exception to this is "manned bike storage", which received only a score of 44 out of 100, primarily due to uncertainty surrounding implementation complexity, and the need for the ongoing incurring of labour costs to administer the program. However, at the request of the client, the possibility of a "bike valet" has briefly been discussed in Section 8 (Next Step) as a potential candidate for the TransLink TDM grant.

6.2 | Recommendations: A Three-Pronged Solution

In alignment with the initial objective to offer a suite of recommendations to tackle the issue of bike theft on the UBC campus, and following the analysis provided in Section 6.1 above, the URSY 520 team recommends a three-pronged solution:

1. The Bike Kitchen Sharing Hub
2. Bike Rooms CCTV
3. Theft-deterring Signage and Public Engagement

The **Bike Kitchen Sharing Hub** refers to the establishment of a program to share/borrow bike security equipment (U-locks, bike alarms and GPS trackers), similar to UmbraCity (for umbrellas), or borrowing AV equipment from the UBC Library. While it is initially recommended that all three equipment be launched as part of a pilot program, the scope of the official launch may be reduced to include only one of two of the aforementioned devices. A discussion of key implementation considerations is included in Section 7 below, including possible pilot scenarios.

Bike Rooms and CCTV refers to the strategic deployment of both bike storage rooms and CCTV cameras in order to provide full coverage of the high-theft areas on the UBC campus. A discussion of the spatial deployment strategy, along with potential equipment and configurations for bike storage rooms is included in Section 7.

Finally, **Theft-deterring Signage and Public Engagement** refers to the overarching endeavour to both install signage that discourages theft, as well as the use of varied public engagement approaches (posters, social media, contests, and campaigns) to encourage both biking to UBC, but particularly, following best practices surrounding bike safety. Such measures can also be used to promote the options above, including the Bike Kitchen Sharing Hub and the use of Bike Rooms. A preliminary strategy surrounding theft-deterrence and public engagement is presented in Section 7.

7

Implementation

This section aims to provide a set of preliminary considerations surrounding each of the three solutions presented in Section 6 above, in an effort to assist the client in further planning, decision-making and capital procurement efforts. It is not intended to be an exhaustive examination of each option, but rather a guiding framework for future execution.

7.1 | Bike Kitchen Sharing Hub

The Bike Kitchen Sharing Hub is envisioned as a service operated through the UBC Bike Kitchen, solely accessible to students, that allows them to gain access to a U-lock, bike alarm or GPS tracking device. The figure 7.1 below provides a high-level implementation outline from a device life-cycle perspective.

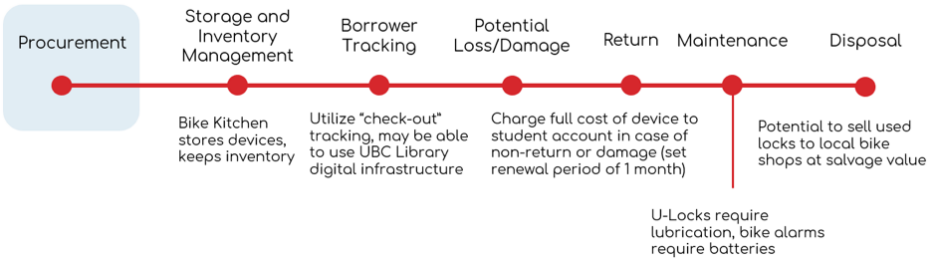

Figure 7.1: Bike Kitchen Sharing Hub Implementation Overview

It may be possible for this service to be administered using existing UBC Library check-out infrastructure, such that students produce their student ID, which is scanned by Bike Kitchen Staff, in turn providing the employee with access to the student's profile. This would significantly reduce both the cost and complexity of implementation, though a platform local to the Bike Kitchen is also not expected to be cost-prohibitive.

In order to address the potential risk of theft or resale of the devices, it is suggested that a "renewal period" be defined (e.g. 1-month), such that students must report back

to the bike kitchen with their equipment, pass a condition inspection, and "renew" their possession for another defined period (and so on). A failure to do so would then incur, at a minimum, the retail price of the equipment (NOT the cost incurred by UBC, in order to disincentive resale).

The following sub-sections provide a discussion of "things to consider" when selecting the specific type and brand of equipment for this program (as highlighted in Figure 7.1 above, Procurement). The section specific to GPS trackers also discusses nuances specific to the deployment of this type of device. Finally, potential pilot scenarios have been suggested.

7.1.1 | U-Locks

While U-Locks are highly regarded as the safest types of locks, there exists significant variety in models, brands, sizes, and materials, making the decision of what U-Lock to select, particularly at the scale suggested for the Bike Kitchen Sharing Hub, a non-trivial matter. Fortunately, rating agencies such as The ART Foundation (StitchingArt.nl) and Sold Secure (SoldSecure.com) have decreased this burden by testing hundreds of bike locks and providing a score for various models.

Figure 7.2: Sold Secure and ART U-Lock Rating Agencies

The ART rating is from 0 to 5 stars, while Sold Secure provides a rating from Bronze to Gold. The ART ranking system is known as the more stringent of the two, while Sold Secure has tested a larger library of locks – i.e. there are more locks available with Sold Secure rankings than ART ones (TheBestBikeLock.com). It is recommended that only locks with at least a 5-start rating from ART or a Gold rating from Sold Secure be considered for the Bike Kitchen Sharing Hub (ideally both), given the importance of providing students the highest-quality available lock, given that they are often the ones most cost-prohibitive to students to purchase on their own.

Apart from the ratings noted above, other criteria to keep in mind when selecting a U-Lock are included in Table 7.1 below.

Table 7.1: Key U-Lock Selection Criteria

Shackle Thickness	Ensure a shackle thickness of at least 16 mm, which cannot be cut by bolt cutters. Shackles between 13 mm and 15 mm can be cut by large bolt cutters (36”-42”), while shackles thinner than 13 mm can be cut with most medium-sized bolt cutters.
Material	Ensure use of hardened steel material for high durability and limited corrosion.
Size	Test size of U-Lock with multiple sizes and types of bikes to ensure universal fit.
Mount	Check for existence of convenient bike mount for lock, test with variety of bikes.

While there are many U-locks that meet the criteria outlined above, a sample comparison table of promising brands and models has been developed below. These models are by no means the definitive “best”, but simply potential options. It is recommended that additional consultation with commercial wholesalers and local bike shops be conducted to ensure the lowest price is considered for each potential option, as current price values have been collected from Amazon.ca and are for a single purchase rather than one at volume (which is expected to yield a lower per-unit price).

Table 7.2: Promising U-Lock Brands and Models

Model	**Ratings**	**Price**	**Key Considerations**
Kryptonite York Standard	Sold Secure Gold and ART 5-star	$120-$140	Well-known brand, known for high quality support
OnGuard Brute	Sold Secure Gold	$70-$90	Largest shackle thickness, at 16.8 mm
ABUS Granit X-Plus	Sold Secure Gold and ART 5-star	$140-$170	Known for high durability, very light

An image of the Kryptonite York Standard U-Lock is included as an example in Figure 7.3 below:

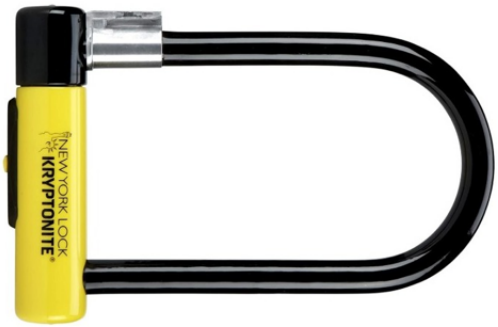

Figure 7.3: Kryptonite York Standard U-Lock

7.1.2 | Bike Alarms

Contrary to U-Locks, which are well-established, widely manufactured by recognized brands, and certified by dedicated rating agencies, bike alarms are non-mainstream products with more limited high-quality options. However, many models tend to be of lower cost than high-quality U-Locks, while providing a loud alarm noise that can both deter thieves when tampered with and alert those nearby of suspicious behaviour.

Some bike alarms are simply motion activated (sounded if the bike moves prior to the alarm being disengaged by the owner using a key) and need to be used in tandem with a basic lock, while others act as a lock with the alarm being an additional layer of protection. An overview of the functionality of the Wsdcam Bike Lock and Alarm is included in Figure 7.4 below.

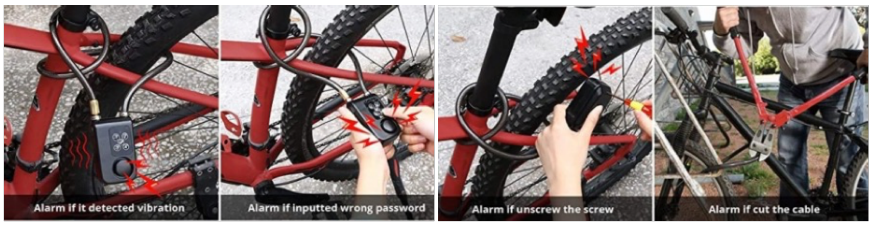

Figure 7.4: Wsdcam Bike Lock and Alarm Feature Overview

Similar to Table 7.2, a sample comparison table of promising brands and models has been developed below in the figure 7.3. As with Table 7.2, these models are by no means the definitive "best", but simply potential options.

Table 7.3: Promising Bike Alarm Brands and Models

Model	Price	Key Considerations
Wsdcam Bike Lock and Alarm	$30-$50	Doubles as lock and alarm, unknown brand
G-Keni Bike Tail Alarm	$30-$50	Motion-activated, unknown brand
ABUS Bordo Alarm	$150-$170	Well-known brand, doubles as high-security metal lock

7.1.3 | GPS Anti-Theft Devices

GPS anti-theft devices, contrary to both U-Locks and bike alarms, can act as both a prevention and recovery mechanism, as they are equipped with smartphone apps that show the bike's live location, making collaboration with police for effective recovery very convenient.

The limited number of prominent GPS tracking devices on the market allowed for a more rigorous assessment of the merits of each, with reference to four separate online rankings websites:

- Smart Home Scout (Postscapes.com, 2020)
- Cycling Weekly (Arthurs-Brennan, 2019)
- Make Use Of (Brookes, 2019)
- Cyclist (Cyclist.co.uk, 2019)

Table 7.4 shows the top GPS anti-theft devices from each ranking and highlights those that appear in multiple rankings.

Table 7.4: GPS Anti-Theft Device Comparison

Rank	Smart Home Scout	Cycling Weekly	MakeUseOf	Cyclist
1	Sherlock GPS	Guardian Light Tracker	Boomerang CycloTrac	Guardian Light Tracker
2	Boomerang CycloTrac	Sherlock GPS	Sherlock GPS	Spybike
3		Boomerang CycloTrac	Spybike	Velocate
4		SmrtGRiPS		Sherlock GPS
5		Caveotrac		Boomerang CycloTrac

As can be observed, the Sherlock GPS and Boomerang CycloTrac devices are listed in all four lists, while the Guardian Light Tracker and the Spybike Top Cap Tracker are listed in two of the four lists. Table 7.5 shows how each of those four models compare in retail price:

Table 7.5: GPS Anti-Theft Device Price

Device	Retail Price
Sherlock GPS	$140
Boomerang CycloTrac	$75
Guardian bike light tracker	$160
Spybike top cap tracker	$125

While both the Sherlock GPS as well as the Boomerang CycloTrac appear in all four rankings and the Sherlock GPS outranks the Boomerang CycloTrac in three of those four rankings, the stark cost difference leads the CycloTrac to take the place of the URSY team's preliminary recommendation, though a change in the pricing landscape may warrant revisiting this determination.

The excerpt below from the Boomerang CycloTrac website highlights some of the key features of the device. Additional information can be found on boomerangbike.com.

"If the bike is armed and someone moves it, the owner gets a message. We can also create a Geo-fence, a virtual barrier that is created by using the GPS to define geographical boundaries. If

the bike leaves or crosses these boundaries, an alert will be triggered and sent to the bike owner's device. The fence can be at any distance to be at mile, 3 miles, or 10 miles. The alert goes to anyone you choose. There are two ways to monitor your bike. You can set the alarm and if your bike is disturbed you receive a message. Or you can just watch your bike on the App or dashboard, and you will see if it moves."

Figure 7.5: Boomerang CycloTrac

Contrary to U-Locks and bike alarms, which primarily entail the capital expense to procure the equipment, the Boomerang CycloTrac requires a nominal monthly expense with a recurring payment processed on a credit card on file, and the app needs to be set up on a student's smartphone along with a dedicated login. As such, two implementation scenarios present themselves, as shown in Figure 7.6 below:

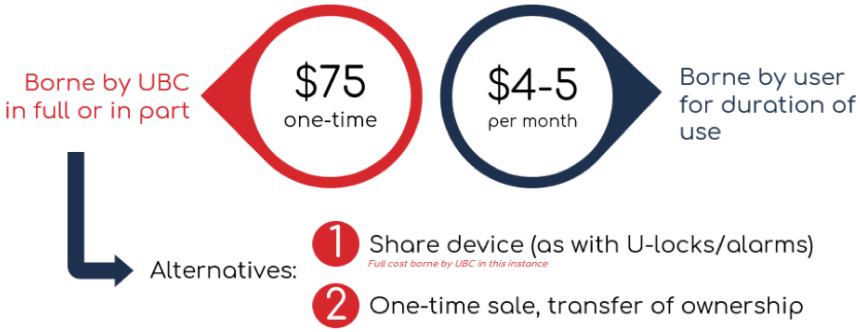

Figure 7.6: GPS Anti-Theft Devices Implementation Alternatives

In the first scenario ("share device") the GPS devices could be included alongside U-Locks and bike alarms as an alternative option for student, such that they do not pay for the device itself, and simply pay the monthly fee for the duration of use. However, this option introduces sizable implementation challenges, as when students return the GPS tracker to the Bike Kitchen, they would also need to suspend and/or transfer their monthly data usage plan. The process of suspending and transferring of plans may introduce significant overhead to Bike Kitchen Operation and hinder the convenience of the initiative.

In the second scenario ("one-time sale, transfer of ownership"), however, UBC simply subsidizes the devices and sells it directly to students. With widespread advertising and promotion, the Bike Kitchen can sell Boomerang CycloTrac devices.

It is important to note that since each individual registers for GPS tracking via Boomerang's service with their own personal information and personal credit card, either of the above options should not create significant cause for concern surrounding data privacy issues. However, herein lies a potential for partnership between UBC and Boomerang users to share user data. By receiving GPS data with signed consent from volunteer purchasers in exchange for a 0-100% rebate of the purchase price and/or monthly fees, UBC gains access to valuable data for future planning purposes, while program participants benefit from high-quality protection.

7.1.4 | Pilot Scenarios

While the sections above have discussed each of U-Locks, bike alarms and GPS trackers in detail, it may in fact be difficult and/or redundant to offer all three in tandem with one another. As such, the following potential pilot scenarios will allow for a trial period, during which feedback can be gathered from early-adopting students, not just with respect to each of the three types of equipment, but also the strengths and weaknesses of various models within each, particularly for U-Locks and bike alarms.

For the purposes of presenting the three scenarios below, the equipment models mentioned in the sections above have been used. However, further research into the various types of devices may ultimately yield a different outcome in practice.

Tables 7.6, 7.7 and 7.8 below summarize each of the three scenarios.

Table 7.6: Pilot Scenario 1

	Device	Unit Price	Quantity	Total
U-Lock	Kryptonite York Standard	$130	10	$1,300
	OnGuard Brute	$80	10	$800
	ABUS Granite X-Plus	$155	10	$1,550
Bike Alarm	Wsdcam Bike Lock and Alarm	$40	10	$400
	G-Keni Bike Tail Alarm	$40	10	$400
	ABUS Bordo Alarm	$160	10	$1,600
GPS Device	Boomerang CycloTrac	$75	10	$750
			Total for 70 devices:	**$6,800**

Table 7.7: Pilot Scenario 2

	Device	Unit Price	Quantity	Total
U-Lock	Kryptonite York Standard	$130	20	$2,600
	OnGuard Brute	$80	20	$1,600
	ABUS Granite X-Plus	$155	20	$3,100
Bike Alarm	Wsdcam Bike Lock and Alarm	$40	20	$800
	G-Keni Bike Tail Alarm	$40	20	$800
	ABUS Bordo Alarm	$160	20	$3,200
GPS Device	Boomerang CycloTrac	$75	20	$1,500
			Total for 140 devices:	**$13,600**

Table 7.8: Pilot Scenario 3

Device		Unit Price	Quantity	Total
U-Lock	OnGuard Brute (cheapest)	$80	100	$8,000
Bike Alarm	Wsdcam Bike Lock and Alarm (cheapest)	$40	100	$4,000
GPS Device	Boomerang CycloTrac	$75	100	$7,500
			Total for 300 devices:	**$19,500**

Of the above pilot scenarios, Scenario 1 (Table 7.8), or a scenario of similar scale, is recommended, as it is incurs the lowest capital expense and is thus expected to be easier to launch. It also includes a variety of models for each type of device, allowing feedback to be collected on the merits and weaknesses of each. However, given the low volumes, the scenario is unlikely to allow for bulk discounts that may be possible at higher volumes.

7.2 | Bike Rooms and CCTV

This section provides an overview of equipment options for use in bike storage rooms, as well as sample room configuration and capital cost estimate. A discussion of key considerations surrounding spatial deployment in tandem with CCTV cameras is also included, with the underlying goal being to provide bike storage rooms in all high-theft areas possible, and using CCTV as a supplementary measure to "fill the gaps", subject to regulatory constraints.

7.2.1 | Equipment Options

Several equipment options are available for indoor bike storage rooms, which include but are not limited to the following: bike wall racks, classic inverted U-shape bike racks, high-density bike racks, and angled bike storage. A brief discussion of each is included below.

7.2.1.1 | Wall Racks

Bike wall racks are simple, space saving, and economical bike storage systems, and the curved tire support suitably encompasses the shape of a bike wheel. They also allow for the hanging of helmets or other bicycle gear and are easy to use – users can simply roll the bike up into the wall racks. A 45 angle fit tool is also available for additional space efficiency requirements. In addition, locking the bike on a wall rack secures both the wheel and the frame. The estimated capital cost for one single-bike rack is $70-$90.

Figure 7.7: Bike Wall Racks

7.2.1.2 | Classic Racks

The classic inverted U-shape bike rack is able to accommodate two bicycles per rack, securing both the wheel and frame. These racks are covered by durable, maintenance-free plastisol coating that protect bikes from scratches. While they are typically used outdoors, as shown in the figure 3.2 they can be used in the context of bike rooms as well, though they do not provide the best use of space. The estimated capital cost for a classic bike rack is $160-180$ for a two-bike rack ($70-$90/bike).

7.2.1.3 | High-density Racks

For maximum capacity, the high-density bike rack offers cost-efficient bike parking with two tier capacity. The rack is covered with standard zinc primer TGIC polyester powder cost in order to protect the bikes from damage. The use of high-density bike racks is also easy, users simply roll the bike along the channel provided to secure the wheel and bike frame in space. The modular configuration makes the rack fit different room types and sizes readily. The estimated price for this type of bike rack is approximately $2700-$3000 per four bike racks.

Figure 7.8: High-density Racks

7.2.1.4 | Angled Storage

Angled bike storage is designed to provide storage for up to eight bikes per five-foot section. The frame of the stall is made of galvanized steel, and the installation of the bike stall is available in post-mount or strut-mount configurations. Bikes stored in Angled Bike Storage can be placed at 45 angles to allow for wider aisles. The price is not readily available due to the variation of price depending on the precise order specifications.

Figure 7.9: Angled Storage

7.2.2 | Sample Storage Room Layout and Capital Cost Estimate

It is recommended that indoor bike storage rooms be located near building exits and avoid stairs or narrow hallways. Any obstructions such as pillars, doors, windows, utility access, and ceiling pipes should also be avoided. It is recommended that storage rooms be located near a floor drain. A minimum aisle width of 54 inches is suggested for one person to use and 72 inches to accommodate simultaneous users. These measures

will ensure that the impact of having a bike room in the building will introduce the least amount of disruption to existing users, while also being convenient enough to encourage widespread adoption.

A sample bike storage room layout is shown in the Figure 7.10 below. The estimated capital cost is determined to be approximately $4800-$5000 for a capacity of 60 bikes.

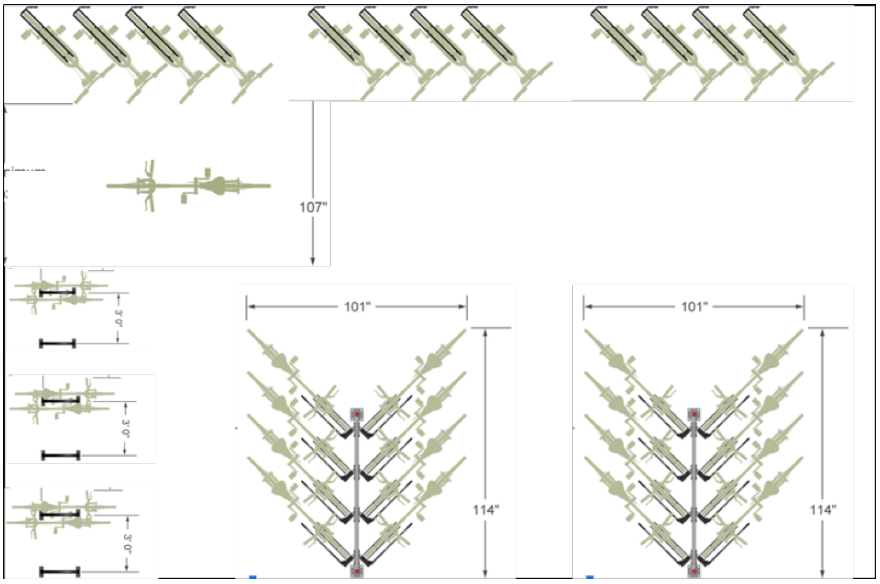

Figure 7.10: Sample Bike Room Layout

7.2.3 | Spatial Deployment Considerations

The areas of high bike theft on the UBC campus are generally divided into six sections, among which four are residence areas. These four are shown in yellow in Figure 7.11 below, and refer to Totem Park, Place Vanier, Ponderosa and Walter Gage. Given the high demand for overnight bike storage in these areas, it is recommended that further collaboration with each of the residences be pursued to identify potentially unused common areas that may be able to be used as a bike room. Opportunities may exist to even "carve out" bike rooms out of lobby areas that are underutilized using glass panes or other types of partitioning retrofits.

The area labelled in green is the central district of the campus and includes both the Life and Nest buildings, both key hubs of activity with the potential for identifying locations that can act as bike storage rooms.

The central area labelled in blue, on the other hand, includes primarily faculty buildings that may not be able to accommodate bike storage rooms within them. In such instances, the use of CCTV is recommended as an added security for students parking their bikes along Main Mall. It is recognized that this may not be possible at this stage, but is included nevertheless for future consideration.

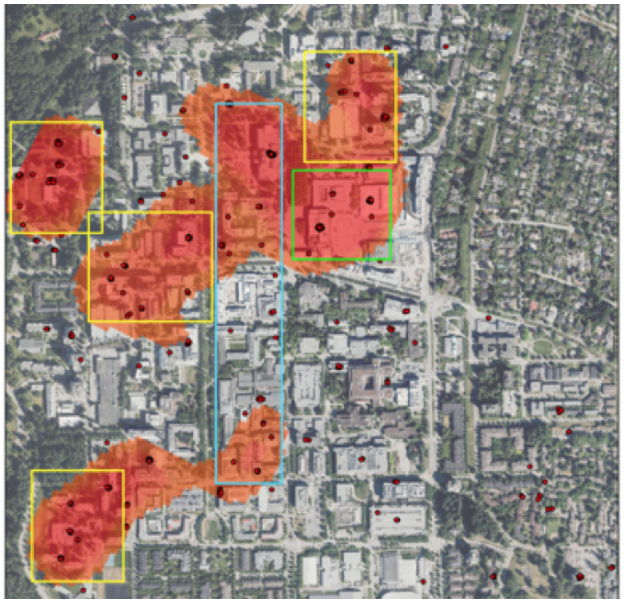

Figure 7.11: Spatial Deployment of Bike Storage Rooms and CCTV

7.3 | Theft-deterring Signage and Public Engagement

7.3.1 | Theft-deterring Signage

The display of certain signage such as 'watching eyes' has shown to make people behave in more socially desirable ways. Experimental research on such signages has shown positive results in reducing bike theft. One such research article on bicycle theft records a 62% decrease in bicycle theft at high-theft areas on university campuses after the implementation of 'watching eyes' signages (Nettle et. al., 2012). Therefore, the effectiveness of this affordable and straightforward intervention suggests its more widespread adoption, even in the absence of surveillance itself.

Figure 7.12: Sample Theft-Deterring Sign

Key considerations for the implementation of such signage are included below:

1. Maximum visibility: Signage should be Installed at a height of 1.5-2 m for maximum visibility. For greatest visibility of letters, use colours that contrast with the background color of the sign. The general rule of thumb is to use a light-colored background with dark letters. Signs should be positioned perpendicular to the line of sight of a pedestrian for better visibility. Nonetheless, any text out of the line of sight can be made more visible by increasing the font size even if they are placed parallel to the line of sight. Signages with lighter colors should be placed in the sunlight as it reduces visibility. If possible, avoid direct light as it affects the quality of the sign.

2. Avoid the offset effect: A study of theft-deterring signage by Nettle et. al. has shown that the reduction in bike theft due to the implementation of signage (in experimental locations) had an offset effect, as it increased theft from locations elsewhere on the campus where signage were deliberately not set up (in controlled locations), suggesting that the major effect of the signs was to displace offenders from their immediate vicinity (Figure 7.14). Despite this strong displacement effect, there is a significant opportunity for UBC to achieve reductions in bike theft by the blanket application of this intervention at all bicycle parking infrastructure through the campus.

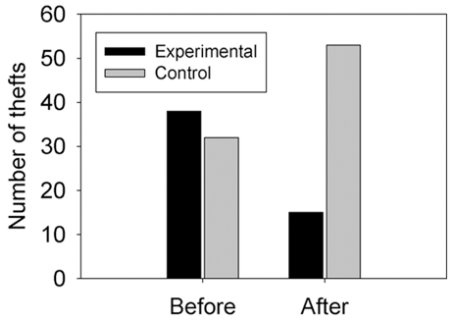

Figure 7.13: The Offset Effect (Nettle et. al., 2020)

Figure 7.14 below includes addition examples of theft-deterring signage that can be deployed in lieu of physical surveillance infrastructure.

Figure 7.14: Theft-deterring Signage Example

7.3.2 | #BikeToUBC Campaign

It is recommended that the use of theft-deterring signage, as discussed above, be implemented in tandem with a comprehensive public engagement platform. This section highlights a sample four-pronged campaign to not only encourage biking to UBC, but promote bike safety practices. Figure 7.15 below provides an overview of this sample strategy.

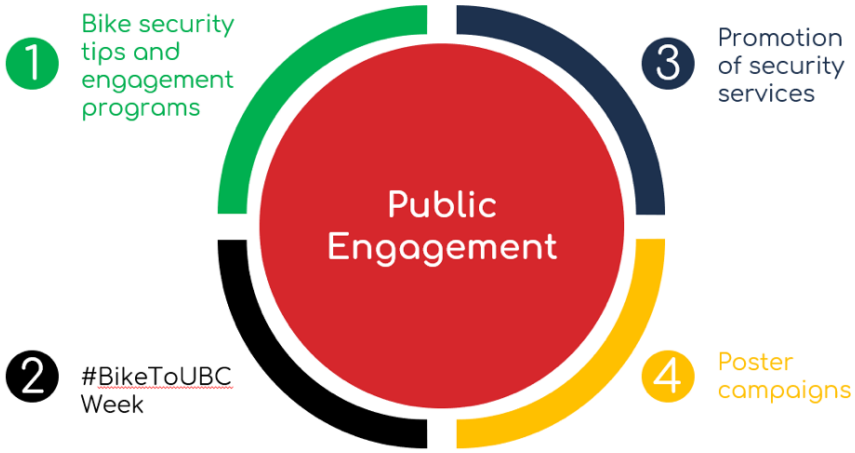

Figure 7.15: Preliminary Public Engagement Strategy

7.3.2.1 | Bike Security Tips and Engagement Programs

The first component of this public engagement strategy is to leverage social media and in-person programs to share bike safety tips and best practices, in turn bolstering the community of biker on the UBC campus. Examples of such practices include:

- Promoting a "Do's and Don'ts" Checklist: For the ease of riders, a checklist can be prepared to be handed to bikers on campus. The following is a list that can act as the checklist (not exhaustive and subject to refinement) 1) Avoid using a cable lock 2) Lock wheels and frame together 3) Use secure bike parking (sign poles, trees, fences are not as secure) 4) Lock your bike in a well-lit and well-traveled area 5) Take lights and other easily removed items with you 6) Never leave your bike outside overnight
- Video Campaigns: Video campaigns can assist riders in learning how to lock the bikes properly. It can be rolled out on the social media platforms and show correct examples of parking using the variety of existing infrastructure at UBC.
- Engagement Programs: Rider engagement is important to encourage students and staff to continue to follow appropriate safety measures. It can also act as a platform to motivate the non-rider to change their mode of transport to bicycling, as the propagation of effective safety measures on campus is demonstrated to them

by such efforts. Examples of some engagement programs are: 1) Online content 2) Interactive webinars (on topics related to bike safety) 3) Campus events

7.3.2.2 | #BikeToUBC Week

While there exist numerous events encouraging biking within the Vancouver area, a UBC-specific BikeToUBC week may be a unique opportunity to encourage biking to campus, perhaps with biker-specific incentives, while raising awareness surrounding resources available to bikers on campus. Sample events include: 1) Bicycle tune-up sessions 2) Win a bike contest 3) Safety and security sessions 4) Biker commuter's breakfast 5) Group charity rides

7.3.2.3 | Promotion of Bike Security Services

As has been noted, the suite of solutions presented in this report work best when deployed together. In particular, promotional efforts have the potential to significantly drive the usage of both the Bike Kitchen Sharing Hub as well as bike storage rooms, lockers and cages. Some possible avenues are highlighted below:

- Promoting the Bike Kitchen Sharing Hub: 1) Social media campaigns 2) Advocates and ambassadors (e.g. standing in Nest)
- Campus bike security infrastructure (storage rooms, lockers and cages): 1) Increased maps showing infrastructure location 2) Signage directing towards bike rooms/cages (e.g. on ground)

7.3.2.4 | Poster Campaigns

Posters provide a low-cost opportunity to encourage many of the measures highlighted above, including a bike safety checklist, locking and registration via 529 Garage, and the use of the Bike Kitchen Sharing Hub. Samples of such posters are included in Figure 7.16 below.

Figure 7.16: Sample Posters – checklist (left), locking and registration (middle), lock sharing program (right)

8

Next Steps

This report has aimed to provide a thorough examination of prevalent bike theft prevention measures, in an effort to provide a suite of recommendations that will assist UBC in reducing bike theft numbers and ultimately encouraging higher bike ridership to the UBC campus. In addition to the three-pronged solution proposed herein, two additional "next steps" have been briefly discussed in this concluding section.

8.1 | Performance Monitoring

After the deployment of the theft prevention solutions, it is important to measure their performance and effectiveness. Therefore, a robust monitoring process must be in place. The following may act as a preliminary framework towards developing a comprehensive performance monitoring plan.

1. Collect accurate annual theft data from campus security on parameters such as:

- Area/building/neighbourhood
- Bike parking infrastructure
- Bicycle type
- Type of lock used
- Date and time
- Bike components stolen (if partial theft)

2. Analyse for pattern and identify vulnerabilities: develop layered theft map, including locations of deployed solutions and previous theft data in order to identify gaps.

3. Re-deploy/re-assess solutions to address gaps

8.2 | TransLink TDM Grant

The option of establishing a staffed bike valet on the UBC campus did not score well on the initial filter conducted by the team, due in large part to the ongoing labor cost associated with offering this type of service. However, this option has been identified by the client as a potential candidate for the TransLink TDM Grant, which would alleviate concerns surrounding supplying the additional staffing cost of operating a bike valet, while providing the UBC with yet another bike security service.

While the specifics of this grant application requires further research, the URSY 520 team's understanding of the current array of bike security services, as well as the spatial distribution of theft, leads us to recommend the AMS Nest or Life building as the site for establishing a valet of this sort. This is because a daytime valet would primarily target commuters rather than on-campus residents, and these buildings are situation in the central campus core, adjacent to most bus routes and easily accessible to bikers entering the UBC campus from 4th and 10th streets. Locating a bike valet in one of these buildings also allows for potential operational and administrative synergies, as it would be located near the UBC Bike Kitchen.

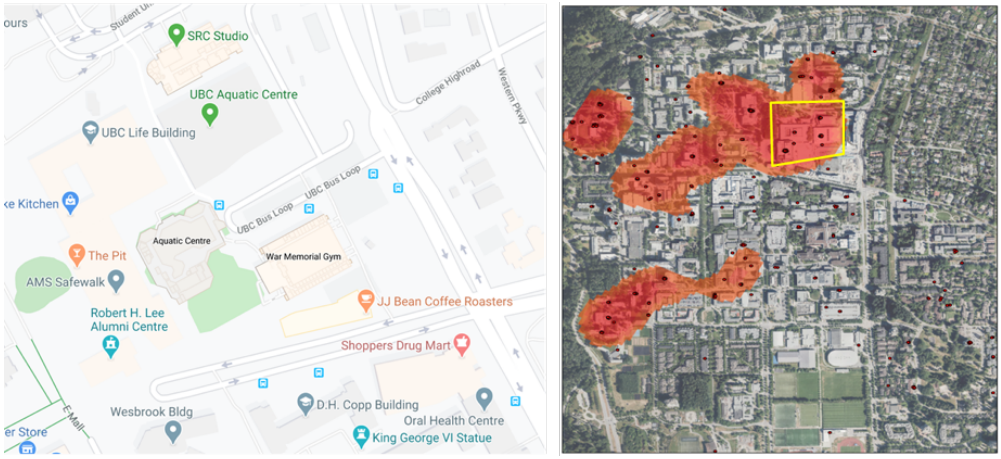

Figure 8.1: Proposed Bike Valet Location

8.3 | Closing

It is the sincere hope of the URSY 520 project team that the analysis provided in this report, leading to the recommendation of a suite of bike theft prevention measures – i.e. the Bike Kitchen Sharing Hub, bike storage rooms CCTV, theft deterring signage and public education – has proved useful and will contribute to widespread efforts across the campus to reduce bike theft and encourage biking to UBC.

9

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