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The purpose of the Wireless Connection Project was "to provide passengers of the WSF system continuous high-speed Internet access at the dock and onboard ferries while en route to enhance the user experience."

The objective of this evaluation report was to determine if the proposed network design of the Washington State Ferries (WSF) Wireless Connection Project met these evaluation success criteria.

Over the course of a 12-month period, wireless network performance evaluations were conducted on three separate ferry routes designated for the wireless pilot. Lockheed Martin Information Technology was selected to make a non-biased assessment of the proposed network design and installation completed by Mobilisa, Inc. This report details the evaluation criteria, testing procedures, and results of the evaluation. A sample survey and business case analysis also was performed by Lockheed Martin Information Technology to validate the Business Case Study submitted by Mobilisa, Inc.
The results are included in this report.

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Washington State Ferries

Evaluation Results

Wireless Connection Project

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FOREWORD

Working closely with Washington State Ferries (WSF) and funded by a cooperative agreement from the Federal Transit Administration (FTA), Mobilisa, Inc. explored the feasibility of providing passengers on the WSF system continuous high speed internet access while at the dock and onboard the ferries, as a potential enhancement to the passenger experience. The FTA project sponsor, Charlene Wilder, and the WSF Program Sponsor, James Long, provided overall direction of the work.

This report is being published as the result of a third-party evaluation of the Washington State Ferries Wireless Connection Project performed by Mobilisa, Inc.

Over the course of a 12-month period, wireless network performance evaluations were conducted on three separate ferry routes designated for the wireless pilot. Lockheed Martin Information Technology Information Technology was selected to make a non-biased assessment of the proposed network design and installation completed by Mobilisa, Inc. The following report details the evaluation criteria, testing procedures, and results of the evaluation. A sample survey and business case evaluation also was performed by Lockheed Martin Information Technology to validate the Business Case Study submitted by Mobilisa, Inc. These results are included in this report.

This evaluation report is directed to the Washington State Ferries and Federal Transit Administration. The goal of the project was to determine whether or not it is feasible to provide high-speed Internet access onboard ferries and at the dock to enhance user experience. The following report is the final evaluation conducted by Lockheed Martin Information Technology as a third-party evaluator.

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EXECUTIVE SUMMARY

The objective of this evaluation is to determine if the network design proposed by Mobilisa, Inc., for the Washington State Ferries (WSF) Wireless Connection Project meets evaluation success criteria. The purpose of the Wireless Connection Project is "to provide passengers of the WSF system continuous high-speed Internet access at the dock and onboard ferries while en route to enhance the user experience."

To properly identify the continuous (persistent) high-speed Internet connection and substantiate a positive passenger experience, several standard network tests were performed by Lockheed Martin Information Technology on designated routes with wireless services. Before running tests on the WSF wireless network, the same software and hardware were tested in a real-world environment to compare the ferry rider's experience to the experience received at other public hotspots.

Persistent Connection

The persistent connection criterion requires a quantitative approach to analysis; therefore, the evaluation was based on actual data collected, not on the perception of the network performance. Based on the data collected, Lockheed Martin Information Technology determined the persistent connection requirement on the Port Townsend/Keystone route was successful. However, the Seattle/Bainbridge Island and Kingston/Edmonds routes showed a periodic loss of connection. The loss of connection on these routes occurred in predictable patterns. While a loss of connection might create an undesirable experience for the end user, the predictive nature of the incident may be less frustrating than random disconnections.

As with any network, it is difficult to determine the exact number of users that can be supported given the broad variance of usage and applications. Based on experience, data collected, and the design of the wireless network, the current proof-of-concept system may not be able to maintain a quality end user experience with more than 20 to 25 simultaneous users.

End User Experience

End user experience will vary based on the individual needs of the users. For example, the end user experience may be unsatisfactory because of the poor Virtual Private Network (VPN) experience and user intervention for proxy or Internet Protocol (IP) settings. This would also be true for high latency and limited available bandwidth to the vessel for debit or credit card transactions and power users (such as gamers). The casual web browser on the other hand might find the system acceptable, assuming the user base does not exceed the 20 to 25 simultaneous user thresholds.

The sample passenger survey conducted by Lockheed Martin Information Technology during peak commuter traffic periods suggested that the user experience was improved for the passengers using the wireless service. Out of 210 survey responses, 79% of passengers rated the service at 5 or above on a scale of 1 to 10. A very large portion of the passengers felt that the

wireless service was acceptable or better. The lack of a persistent connection was an issue also. Responses were more likely to get a lower rating during peak times where there were a higher number of users (20 or more)[1].

Business Case Evaluation

The Mobilisa, Inc., Business Case Study demonstrated that WSF passengers would like to have a wireless Internet system onboard the ferries and that the volume of users is sufficient to justify further development. It also demonstrated that the system would be most effective by allowing passengers to connect to multiple Internet Service Providers (ISPs), have ISPs pay royalties to the WSF, and have WSF pay maintenance to a third-party (neutral) contractor. Although this conclusion appears reasonable, more information is required to validate the financial feasibility and service pricing. Business case pricing strategies and justifications could change based on the amount of bandwidth needed to the vessel to support end users during peak traffic periods.

Both the initial business survey and subsequent evaluation survey showed that the majority of passengers were willing to pay between $5.00 and $10.00 per month for the wireless service. As the cost increases, service expectations increase also. Having reliable service will be the determining factor on whether passengers will be willing to pay for Internet services and how much they will be willing to pay.

While Lockheed Martin Information Technology's evaluation supports the general findings of Mobilisa, Inc., a reasonable level of service needs to be achieved before charging for wireless Internet service is viable. The wireless network as tested must overcome the challenges identified in this study before moving forward with the production system.

Conclusion

Overall, Lockheed Martin Information Technology evaluators were impressed with the technical hurdles this pilot had to overcome to provide wireless Internet access onboard a moving vessel across the Puget Sound. It must be recognized that this project is still a "Proof-of-Concept," not a production-ready system. While testing indicated latency, bandwidth, and persistence connection issues, Lockheed Martin Information Technology is confident these obstacles can be overcome with additional engineering.

[1] At the time of the survey on the Kingston/Edmonds and Seattle/Bainbridge Island runs, Mobilisa reported over 7,000 registered users and had recorded up to 100 concurrent users during peak periods on these commuter runs. There are generally three heavy commute runs in the morning, and three in the evening.

TERMS

ATM	Automatic Teller Machines
DNS	Domain Name System
DSL	Digital Subscriber Lines
FTP	File Transfer Protocol
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IP	Internet Protocol
IPSEC	Internet Protocol Security
IRC	Internet Relay Chat
ISP	Internet Service Providers
Mobilisa	Mobilisa, Inc.
MSN	Microsoft Network
MV	Marine Vessel
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal Digital Assistant
POP	Post Office Protocol
SMTP	Simple Mail Transfer Protocol
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
VPN	Virtual Private Network
WSF	Washington State Ferries

1.0 INTRODUCTION

1.1 BACKGROUND

The purpose of the Washington State Ferries (WSF) Wireless Connection Project is to research and develop ways to provide passengers of the system with continuous high-speed Internet access at the dock and onboard the ferries while en route. The two main objectives of this project are to improve the rider experience and to maintain a persistent Internet connection. This will be accomplished by allowing passengers to access the Internet while waiting for or riding the ferries.

1.2 OBJECTIVE

The objective of this evaluation is to determine if the proposed network design can meet the evaluation criteria. The evaluation consists of two primary criteria.

The first and foremost evaluation factor is the overall rider experience. This evaluation presents a more qualitative analysis rather than a quantitative analysis. The rider experience will be discussed in more detail as it relates to the various technologies evaluated and discussed in this document.

The second evaluation factor is to maintain a persistent connection to the vessel during the entire route. The persistent connection is viewed from two perspectives. The primary perspective is the ability to maintain a connection to the Internet during the entire route, regardless of the overall available bandwidth to the vessel. The secondary perspective, which directly affects the rider's experience, is the ability to maintain an adequate amount of bandwidth to the vessel during the entire route.

1.3 METHODOLOGY

Before running tests on the WSF wireless network, the evaluation software and hardware were tested in a real-world environment using a hotel's high-speed Internet connection and a Starbuck's T-Mobile Hotspot. The software and hardware testing was finalized with peer-to-peer communications using the ad hoc mode on wireless cards. This allowed verification of test accuracy across multiple public access networks before running an evaluation of the WSF wireless network. The purpose for this baseline was to compare the ferry rider's experience to the experience received at other public hotspots.

1.3.1 Evaluation Plan

The evaluation plan used standard equipment and testing methods.

The following hardware equipment was used in the evaluation plan:

- Dell laptops
- Cisco Wireless Personal Computer Memory Card International Association (PCMCIA) cards
- Lucent ORiNOCO Wireless PCMCIA cards
- Intel Integrated Wireless Centrino cards

Tests performed in the evaluation plan include the following[2].

- User Datagram Protocol (UDP) data streaming
- Transmission Control Protocol (TCP) transfers
- UDP transfers
- Hypertext Transfer Protocol (HTTP), Hypertext Transfer Protocol Secure (HTTPS), and File Transfer Protocol (FTP) transfers
- Standard ping with 32/500/1000 byte packets
- Giganews.com and dslreports.com.

The following software was used in the evaluation plan:

- Windows XP SP1
- Microsoft Internet Explorer Version 6 SP2
- Cisco EasyVPN Client Version 4.04
- Remote Desktop Client.

The tests were run from several locations at each dock and on the passenger decks of the MV Klickitat, MV Puyallup, MV Spokane, MV Tacoma, and MV Wenatchee.

1.4 SCOPE OF PROJECT

Over a 12-month period, wireless network performance evaluations were conducted on three separate ferry routes designated for the wireless pilot. Lockheed Martin Information Technology was selected to make a non-biased assessment of the proposed network design and installation completed by Mobilisa, Inc. (Mobilisa). This report details the evaluation criteria, testing procedures, and results of the evaluation. A sample survey and a business case evaluation also were performed by Lockheed Martin Information Technology to validate the Business Case Study submitted by Mobilisa. The results are included in this report.

[2] Every type of test was not performed on every Marine Vessel (MV).

1.5 ORGANIZATION OF CONTENT

The evaluations were divided into two phases. Phase I included testing on the Port Townsend/Keystone route and Phase II included testing on the Seattle/Bainbridge Island and Kingston/Edmonds routes. The report breaks out these phases, including testing procedures, results, and conclusion. The third portion of this report includes the business case evaluation, survey results, and conclusion and recommendations.

2.0 PHASE I EVALUATION RESULTS – PORT TOWNSEND/KEYSTONE ROUTE

The Port Townsend/Keystone route was evaluated during Phase I. The evaluation was performed on MV Klickitat. The evaluation of end user experience included initial logon, web page load times, Virtual Private Network (VPN) connection, and web-based email. The persistent connection evaluation included download and upload transfer rates, packet loss, and latency.

2.1 END USER EXPERIENCE—MV KLICKITAT

2.1.1 Initial Logon

The basic functionality of the login page worked in comparison with most other wireless networks. Regardless of the home page settings, the connection was redirected to the WSF/Mobilisa login page. There were several instances during testing where the redirect took longer than two minutes to load, which could create doubt or confusion with some end users. Given the architecture of the pilot network, it is recognized that the delay could be related to a number of issues outside the control of WSF or Mobilisa.

Proxy settings commonly are used with business enterprise networks; therefore, it is fair to assume that the majority of business ferry passengers will have proxy settings enabled by their corporate information technology staff. This means that under the current logon application, the traveler will have to turn off their proxy settings to connect to the WSF wireless system and turn their proxy settings back on when they get to the office. This could prevent riders from connecting if they are unknowledgeable about proxy settings.[3] This should not be considered a major issue and can be addressed with existing solutions on the market as an initiative to improve end user experience. The same is true for Internet Protocol (IP) settings that are statically configured.

Another minor login issue that occurred after the first time registration was a web page redirect back to the initial sign on page. This was slightly confusing. At first it did not appear as if the logon was successful, but the sign-on information access was provided after re-entering. This is a common occurrence in the wireless industry. However, several hotspots have developed logon applications that transfer the end user to their requested page after successful sign-on. Although not necessary, it could improve end user experience. On occasion during testing, other network login pages superseded the WSF Wireless system. This is a common occurrence, and there are numerous hotspots in the Puget Sound area. But, this could confuse the casual user. After the initial account was setup and the login established, each subsequent login was successful.

[3] Mobilisa provides a toll free user support phone line, web-based comment cards and support, and provides "Connection Tips" on the http://www.mobilisa.net website to assist new users.

2.1.2 Web Page Load Times

During the testing on MV Klickitat, all requested web pages were loaded successfully without the need to “refresh” the page or re-enter the website address. Three tests were conducted. The results were consistent in all three tests and demonstrate a persistent connection from the end user perspective. Standard web pages loaded within 2 to 4 seconds at the dock or close to the dock. Network performance began to degrade once the vessel left the dock. After approximately the first third of the route, performance degradation became noticeable. At the middle of the route, the standard web page load time ranged from 19 seconds to 34 seconds. This most likely would be deemed a negative experience for riders accustomed to other, more efficient broadband services. As the vessel approached the last third of the trip, closer to the destination dock, the web page load times improved and loaded within 2 to 4 seconds again. Given the technical challenges that WSF and Mobilisa face, and the technical limitations of the 802.11 a/b/g standard, it was determined that the overall experience for standard web browsing was satisfactory at the dock and during the first third of the route. The middle third of the route is questionable for web page loading and refresh under the current bandwidth constraints.

2.1.3 Virtual Private Network Connection

The Internet Protocol Security (IPSEC) functionality of the network was tested on MV Klickitat by using Cisco EasyVPN Client, which connected back to Lockheed Martin Information Technology’s operating facility in Richland, Washington. The VPN Client uses 3DES-168 encryption and UDP for transport. This type of IPSEC setup is relatively common, and it provides a solid test for the majority of VPN users.

The overall user experience with VPN Client was poor. During the test, a connection was made at both docks; while en route; however, the performance of the VPN was extremely slow, making the application unusable.

2.1.4 Web-Based Email

During testing on the MV Klickitat, web-based email performed similar to standard web browsing by incurring various loading times. An HTTPS connection was used to connect to a Microsoft Exchange server supported by Lockheed Martin Information Technology to further test the web-based email application. Both the HTTP and HTTPS tests technically were successful for a persistent connection. Web-based email was satisfactory at the dock and during the first third of the route. The middle third of the route is questionable under the current bandwidth constraints. If excessive load times occur, it may cause user confusion and frustration, making the rider’s experience negative.

2.2 PERSISTENT CONNECTION—MV KLICKITAT

To identify the persistent connection and validate a summary for the passenger experience, several standard network tests were performed on the Port Townsend/Keystone route. Every attempt was made to isolate variables that were outside of Mobilisa's or WSF's control and that could have affected the test results. Sections 2.2.1 through 2.2.4 show the results of the tests performed on July 8, July 9, and August 10, 2004. (See Appendix A, Test Performance, for a description of how tests were executed.)

2.2.1 Download Transfer Rate

Keystone Dock. The download transfer rate at the Keystone dock averaged 468 kbps. Several different tests were performed to validate the results. The first test was an HTTP transfer from a server on Benton County Public Utility District's fiber optic network. This server was chosen because the load was near 0% with a direct fiber connection to NoaNet, a Tier 2 provider that terminates in the Westin building in Seattle, Washington. Several download tests were performed from multiple sources (e.g., giganews.com, dslreports.com, peer-to-peer) with all results within 5% of each other.

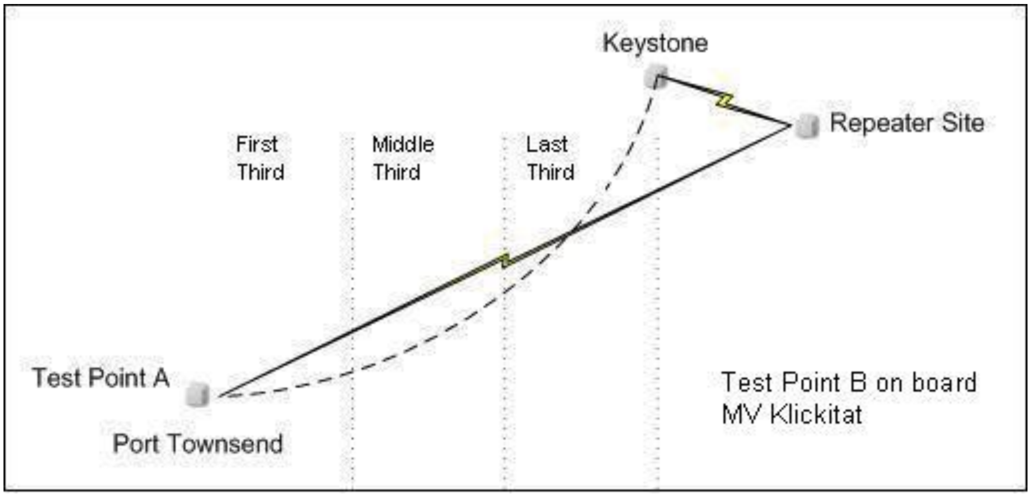
Port Townsend Dock. The download transfer rate at the Port Townsend dock averaged 646 kbps. The same tests were performed at this location and the Keystone dock. The download transfer speed differences between the Keystone and Port Townsend docks are associated with the latency on the backhaul. This is not uncommon for a pilot project, and there are multiple ways to improve this during final design.

Note: Both tests at the docks used the entire infrastructure. All testing was associated to the WSF access points at each dock, using the backhaul in place. All traffic was sent across a 6 Mbps-capable cable modem that provides the Internet access for this project.

Onboard MV Klickitat. Several tests were performed onboard MV Klickitat. TCP and UDP traffic was tested to best simulate the real world. These tests were performed with one laptop directly connected to the backhaul at Port Townsend (Point A) and the other laptop connected directly to the switch onboard MV Klickitat (Point B). This method bypassed access points on the vessel and eliminated the 2-Mbps Internet connection from the testing procedures to reduce variables outside WSF and Mobilisa control. (See Appendix A, Test Performance.)

The route shown in Figure 2-1, Port Townsend/Keystone Route, is broken into three parts represented by the dotted vertical lines. The dashed horizontal line represents the approximate path of the ferry. The solid line represents the line of site path taken by the wireless frequency. The test results in Figure 2-2, Streaming User Datagram Protocol Data, and Figure 2-3, Throughput (Transmission Control Protocol Data), correspond to the three sections of the route shown in Figure 2-1.

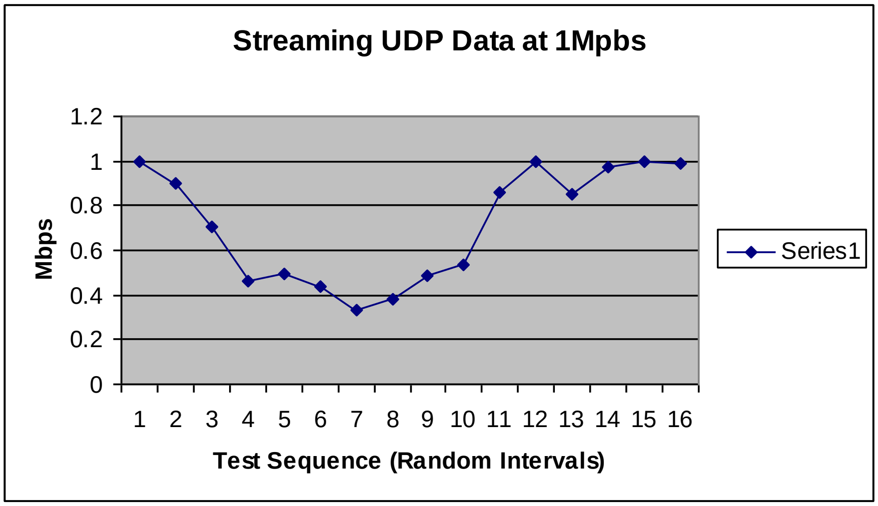
Figure 2-1. Port Townsend/Keystone Route.



When the test results showed performance degradation, extra tests were performed in rapid succession to validate that the results were not isolated to the previous test. Each test was performed in random intervals, each 30 seconds in duration. By testing the route at a relatively high sample rate, a more granular or realistic view of the network was captured.

Figure 2-2, Streaming User Datagram Protocol Data, was plotted using random intervals of streaming UDP data at a rate of 1 Mbps.

Figure 2-2. Streaming User Datagram Protocol Data.



The UDP stream divided the 1 Mb of data into equal 101-byte datagram's for the duration of the 30-second testing intervals. Each datagram consisted of a 64-byte payload, a 20-byte IP header, an 8-byte standard UDP header, and a 9-byte NetIQ endpoint header. Because the UDP protocol does not require acknowledgements or session control, UDP tests typically show a higher throughput than TCP data.

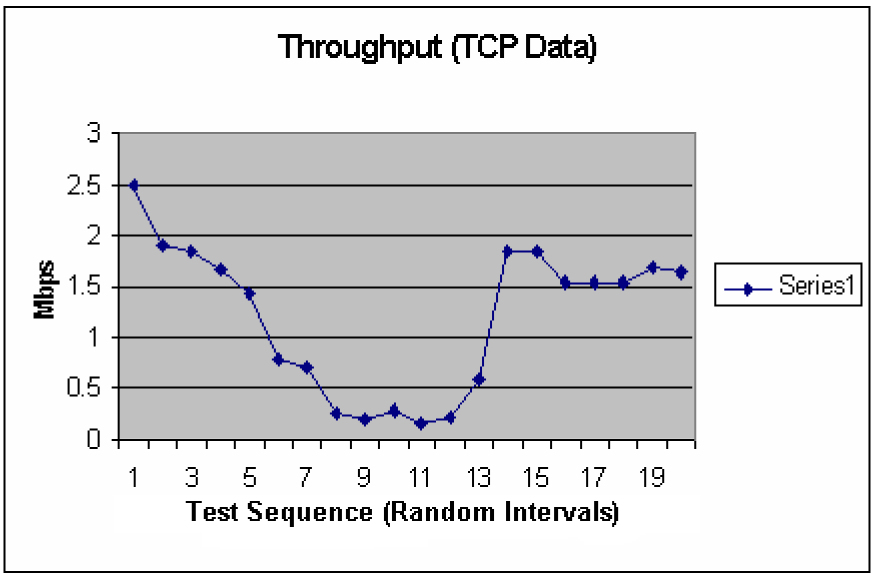
The throughput test performed simple, application-level throughput measurements. Throughput was calculated using the following formula:

Throughput = (bytes sent + bytes received) / measured time.

The throughput value and the value seen if an analyzer is used on the wire are not the same values. The test did not include any of the protocol overhead (e.g., headers, trailers, flow control, and connection setup). The throughput variance for the different data sizes was very minimal and, therefore, is not included on the graph.

Figure 2-3, Throughput (Transmission Control Protocol Data), was plotted using random intervals of 100 kBytes to 1,000 kBytes of TCP data.

Figure 2-3. Throughput (Transmission Control Protocol Data).

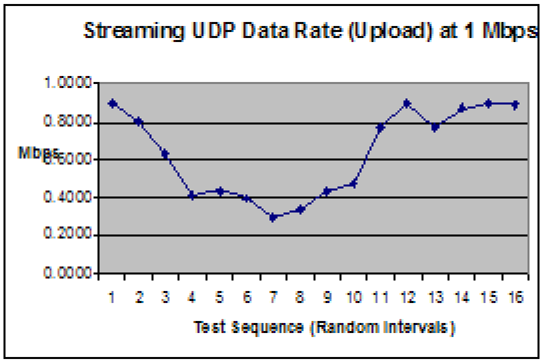


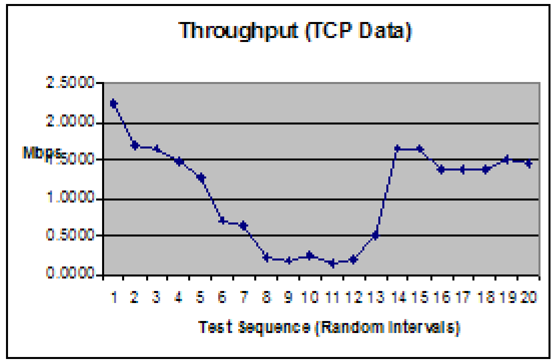
Both Figures 2.2 and 2.3 demonstrate that the wireless network was able to maintain a persistent connection from dock to dock. However, the bandwidth performance drops significantly for the middle third (approximately 10 minutes) into the route.

2.2.2 Upload Transfer Rate

Similar tests were completed to verify the upload performance of the system. Again, these tests were completed by isolating the backhaul portion of the network from the Internet and the access points onboard the vessel as described under Section 2.2.1. Figure 2--4, Upload Performance—MV Klickitat, reflects the results.

Figure 2-4. Upload Performance-MV Klickitat.





2.2.3 Network Load

As part of the network load tests, it was determined that the network load was insignificant and would not skew the test results. This was accomplished by monitoring the bandwidth at the dock and during the entire route. The available bandwidth did not decrease as passengers boarded the vessel and made their way to the passenger deck. Therefore, no significant reduction in bandwidth can be credited to network load. This was consistent on three different days, during different times of the day.

2.2.4 Packet Loss and Latency

In conjunction with the available bandwidth to the vessel, packet loss and latency also should be considered as part of the persistent connection requirement. Packet loss measures the reliability of a connection. The higher the packet loss percentage, the slower the connection will work because in most instances it has to send the same piece of information several times. If excessive packet loss or latency exists on the network, the scalability and user experience will degrade significantly. At the most basic level, latency is the measurement of time it takes a packet to travel from the source (Point A) to the destination (Point B).

2.2.4.1 Packet Loss

More than 12 tests were performed to validate packet loss on the network. The overall average for packet loss was 6%. Packet loss was tested with various packets sizes (32, 100, 500, and 1,000 bytes). Tests were performed throughout the day to various locations across the Internet, and packet loss on the network was found to be well within the acceptable range. The packet loss was low enough that any significant increase in the user base would most likely not affect the performance of the network. The network packet loss performance was given an excellent rating.

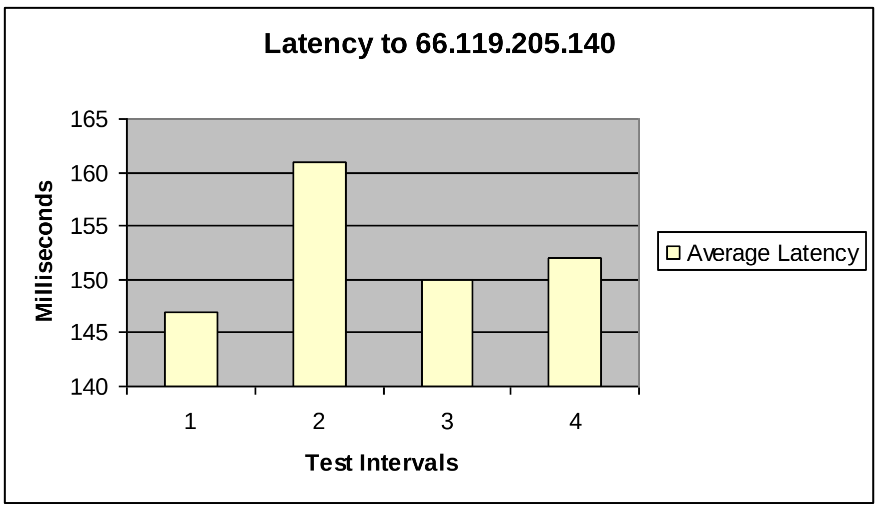
2.2.4.2 Latency

Latency across the Internet is difficult to maintain without a high-quality Tier 1 or Tier 2 connection with a strong service level agreement that specifies maximum/average/minimum latency.

The latency of the Wireless Connection Project network is high and will affect the overall performance and scalability of the system. To validate the latency test results, two types of latency tests were performed: Internet latency tests and peer-to-peer latency (dock-to-vessel) tests.

Figure 2-5, Internet Latency, shows tests to a server that is connected to a Tier 2 provider via fiber to the Westin building in Seattle, Washington.

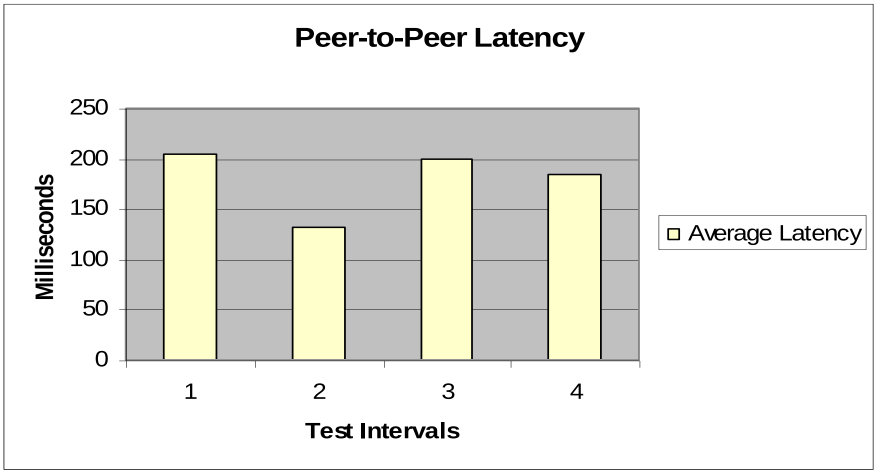
Figure 2-5. Internet Latency.



The latency of the local network to the Westin building is a maximum of 16 ms. The average Internet latency for the Wireless Connection Project was 152 ms on the wireless network and Internet connection. The Wireless Connection Project contributes 136 ms of that latency (e.g., 152 ms minus 16 ms).

Two standard tests were performed to validate that the peer-to-peer latency test was localized. The first latency test was with both laptops at the dock. The results were an average latency of 4 ms, which is unattainable from most Internet Service Providers' (ISP) service connections (e.g., digital subscriber lines [DSL], cable modem, T-1, satellite). The second test was a speed test between the laptops, which achieved a maximum of 2.4 Mbps. The 2.4 Mbps far exceeded any bandwidth tests to the Internet, therefore verifying the data path being tested was local or peer-to-peer data. The peer-to-peer latency test data appears in Figure 2-6, Peer-to-Peer Latency (Dock to Vessel).

Figure 2-6. Peer-to-Peer Latency (Dock to Vessel).



2.3 CONCLUSION AND RECOMMENDATIONS, PHASE I

2.3.1 End User Experience—MV Klickitat

As with any network, it is difficult to determine the exact number of users that can be supported given the broad variance of usage and applications that will be consumed on the network. The current amount of bandwidth available during testing on MV Klickitat limits the network to an estimated 20 to 25 simultaneous users. Based on experience, data collected, and the design of the wireless network, the current proof-of-concept system may not be able to maintain a quality end user experience beyond the 20 to 25 simultaneous average users.

It is recognized that the end user experience will vary based on the individual needs of the users. For example, the end user experience may be unsatisfactory based on the poor VPN experience and user intervention for proxy or IP settings. This would also be true for high latency and limited available bandwidth to the vessel for debit or credit card transactions and power users, such as gamers. The casual web browser on the other hand might find the system acceptable, assuming the user base does not exceed the 20 to 25 simultaneous user thresholds.

2.3.2 Persistent Connection—MV Klickitat

The intent of this evaluation was to verify a persistent connection to the vessel from dock to dock. The persistent connection criterion requires a quantitative approach to analysis; therefore, the summary is based on the data collected, not on the perception of the network performance. Based on the data collected, Lockheed Martin Information Technology determined the persistent connection requirement was successful.

It should be noted that the documented high latency, limited bandwidth while en route, initial logon issues with proxy and static IP setting limitations, and poor IPSEC performance are severe limitations to the overall long-term success of this program. WSF and Mobilisa have the expertise necessary to overcome these issues using various off-the-shelf solutions and by building a successful broadband network that will provide a quality rider experience. The business case evaluation will explore whether this build-out can be done at a price point the end user can afford.

3.0 PHASE II EVALUATION RESULTS – SEATTLE/BAINBRIDGE ISLAND AND KINGSTON/EDMONDS ROUTES

The Seattle/Bainbridge Island route and the Kingston/Edmonds route were evaluated during Phase II. The evaluation of the Seattle/Bainbridge Island route was conducted on MV Wenatchee and MV Tacoma. The evaluation of the Kingston/Edmonds route was conducted on MV Spokane and MV Puyallup. To eliminate replication, end user test methods described in the Phase I evaluation are not repeated in this portion of the evaluation results.

3.1 END USER EXPERIENCE—MV WENATCHEE, MV SPOKANE, MV PUYALLUP, AND MV TACOMA

3.1.1 Initial Logon

There were no logon issues during Phase II testing because an account already had been set up during Phase I for the Keystone/Port Townsend evaluation. Concerns regarding web browser proxy settings and static TCP/IP settings are the same as those discussed in Section 2.1.1.

3.1.2 Web Page Load Times

Web page load times were comparable to results on the MV Klickitat. All requested web pages were loaded successfully without the need to “refresh” the page or re-enter the website address. The results were consistent on more than a dozen tests performed on each Marine Vessel. Long load times were not encountered on this test as they were on the MV Klickitat. A loss of connection was encountered on all of these vessels with the exception of MV Puyallup going from Kingston to Edmonds. While testing of web page load times was not being performed during the loss of connection, this loss of connection would have resulted in the web pages failing to load. In summary, the web page load time performance was above satisfactory, with exception to the loss of connection.

3.1.3 Virtual Private Network Connection

The same IPSEC that was used on the MV Klickitat was used to test the MV Wenatchee, MV Spokane, MV Puyallup, and MV Tacoma. The VPN tunnel performed well while all vessels were at the dock or near the dock; however, the VPN tunnel during the route had very slow response times. In addition, on many occasions the VPN tunnel was disconnected and had to be restarted. This likely would be an unpleasant experience for the end user.

3.1.4 Web-Based Email

During testing, web-based email (e.g., Gmail, Yahoo, Microsoft Network [MSN]) performed similar to standard web browsing by incurring various loading times. An HTTPS connection was used to connect to a Microsoft Exchange server supported by Lockheed Martin Information Technology. This allowed further testing of the web-based email application, with a secure connection. The web-based email performed equally as well as the web browsing onboard each vessel. A loss of connection was encountered on all of these vessels with the exception of MV Puyallup going from Kingston to Edmonds. This loss of connection caused a temporary disconnect from the email server. When the connection was re-established, the web-based email resumed without the need to reconnect to the email server. Therefore, the end users' experience would depend greatly on whether they were sending/receiving email or were just reading email that was already loaded. In summary, the web-based email performance was above satisfactory, with the exception of the loss of connection.

3.2 PERSISTENT CONNECTION—MV WENATCHEE, MV SPOKANE, MV PUYALLUP, AND MV TACOMA

During the Phase I evaluation onboard the MV Klickitat, testing for a persistent connection was performed from the dock to the vessel and from the vessel to the Internet. The purpose of that test was to verify the available local bandwidth to the vessel without using the Internet. For the second phase of the evaluation, the focus was on the "end users" perspective entirely. Therefore, the only tests performed used the Internet connection provided.

The persistence connection information is captured in Table 3-1, Connection Test 1, and Table 3-2, Connection Test 2. It was felt that any loss of connection less than 60 seconds might be tolerable to most users of the system.

It is important to remember that extensive testing was not performed. The tester simply surfed, downloaded, and watched a continuous ping. When a connection was lost, it was time stamped by viewing the clock on the computer that was being used. Table 3-1 displays test results from the first test that was conducted.

Table 3-1. Connection Test 1.

Line	Vessel and Route	Connection Fail	Time of Failure	Notes
1	MV Klickitat - Port Townsend to Keystone	Yes	20 seconds	Able to reconnect
2	MV Klickitat - Keystone to Port Townsend	Yes	24 seconds	Able to reconnect
3	MV Wenatchee - Bainbridge to Seattle	Yes	60 seconds	Able to reconnect
4	MV Wenatchee - Seattle to Bainbridge	Yes	180 seconds	Able to reconnect
5	MV Puyallup - Edmonds to Kingston	Yes	480 seconds	Able to reconnect
6	MV Puyallup - Kingston to Edmonds	No	0 seconds	
7	MV Spokane - Kingston to Edmonds	Yes	20 seconds	
8	MV Spokane - Edmonds to Kingston	Yes	14 minutes	Unable to reconnect

Table 3-1. Connection Test 1.

Line	Vessel and Route	Connection Fail	Time of Failure	Notes
9	MV Spokane - Edmonds to Kingston Run 2	Yes	40 seconds	Able to reconnect
10	MV Spokane - Edmonds to Kingston Run 3	Yes	45 seconds	Able to reconnect
11	MV Tacoma - Bainbridge to Seattle	Yes	60 seconds	Able to reconnect
12	MV Tacoma - Bainbridge to Seattle	Yes	20 seconds	Able to reconnect
13	MV Tacoma - Bainbridge to Seattle	Yes	20 seconds	Able to reconnect
14	MV Tacoma - Seattle to Bainbridge	Yes	120 seconds	Able to reconnect

The MV Spokane and the MV Tacoma experienced some connection difficulties. To validate the first test results, the connection was tested again at a different time. All results were recorded in Table 3-2.

Table 3 2. Connection Test 2.

Line	Vessel and Route	Connection Fail	Time Lost	Time Reconnected
1	MV Klickitat - Port Townsend to Keystone	Yes	Not recorded	Not recorded
2	MV Klickitat - Keystone to Port Townsend	Yes	Not recorded	Not recorded
3	MV Wenatchee - Bainbridge to Seattle	Yes	Not recorded	Not recorded
4	MV Wenatchee - Seattle to Bainbridge	Yes	12:23 p.m.	12:26 p.m.
5	MV Puyallup - Edmonds to Kingston	Yes	10:19 a.m.	10:27 a.m.
6	MV Spokane - Kingston to Edmonds	Yes	1:06 p.m.	106 p.m.
7	MV Spokane - Edmonds to Kingston	Yes	1:48 p.m.	Unable to reconnect
8	MV Spokane - Edmonds to Kingston Run 2	Yes	11:38 a.m.	11:39 a.m.
9	MV Spokane - Edmonds to Kingston Run 3	Yes	11:45 a.m.	11:46 a.m.
10	MV Tacoma - Bainbridge to Seattle	Yes	3:58 p.m.	3:59 p.m.
11	MV Tacoma - Bainbridge to Seattle	Yes	4:09 p.m.	4:09 p.m.
12	MV Tacoma - Bainbridge to Seattle	Yes	4:15 p.m.	4:15 p.m.
13	MV Tacoma - Seattle to Bainbridge	Yes	Not recorded	Not recorded

The loss of connection on all the routes occurred in a predictable pattern. Loss of connection would be deemed a negative experience for riders; however, the predictable, rather than random, behavior of the loss might reduce the frustration level of the end user

3.2.1 Latency

At the most basic level, latency is the measurement of time it takes a packet to travel from the source (Point A) to the destination (Point B). On a network running TCP/IP the two main protocols used for transmission are TCP and UDP. Latency has a nearly immeasurable result on UDP traffic; therefore, our focus is on TCP traffic.

The TCP protocol uses a "sliding window" that determines how many packets will be transmitted before requesting an acknowledgement from the remote end. The latency of a network will affect the "sliding window" of TCP-based applications, thereby affecting the effective throughput of TCP traffic. Latency is a concern because HTTP, HTTPS, Simple Mail Transfer Protocol (SMTP), Post Office Protocol 2 (POP2), Post Office Protocol 3 (POP3), IPSEC/TCP, FTP, Domain Name System (DNS), and Internet Relay Chat (IRC) all use TCP as the transmission protocol. This will affect web browsing, email, TCP-based VPN, file transfer, and online chat. The effect of throughput of TCP compared with UDP are shown for the Seattle/Bainbridge Island route (Figures 3.1, Latency Graphs—Seattle/Bainbridge Island Route) the Kingston/Edmonds route (Figure 3.2, Latency Graphs—Kingston/Edmonds Route).

Figure 3-1. Latency Graphs—Seattle/Bainbridge Island Route.

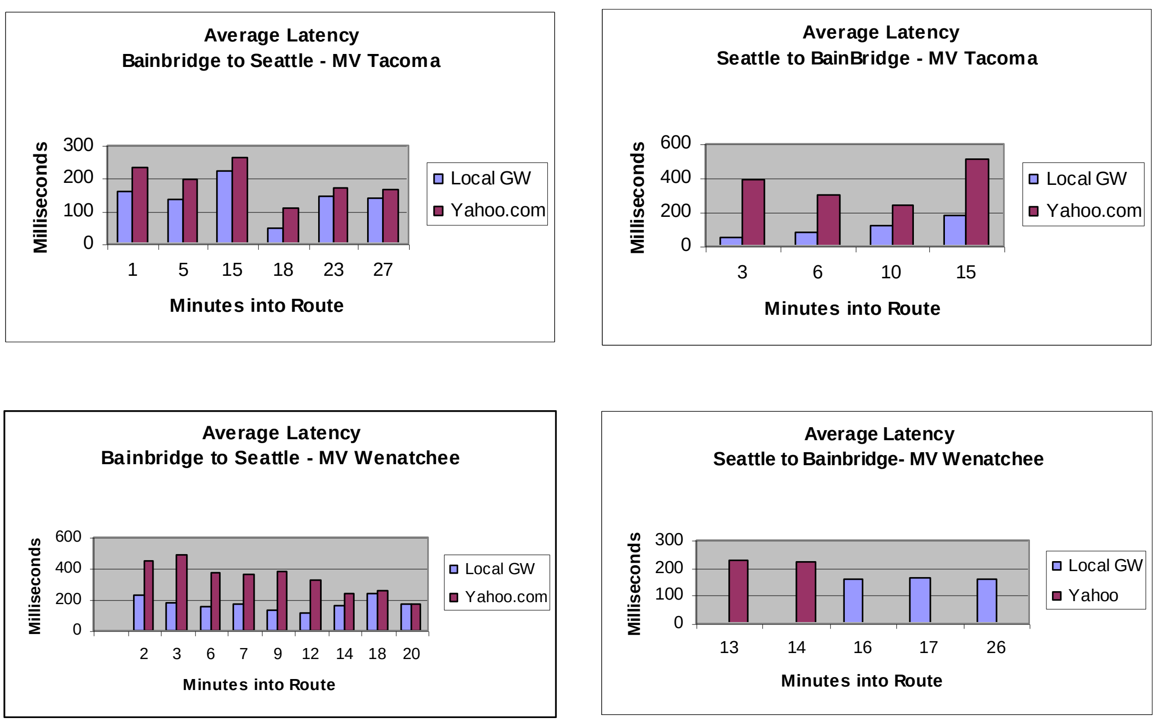
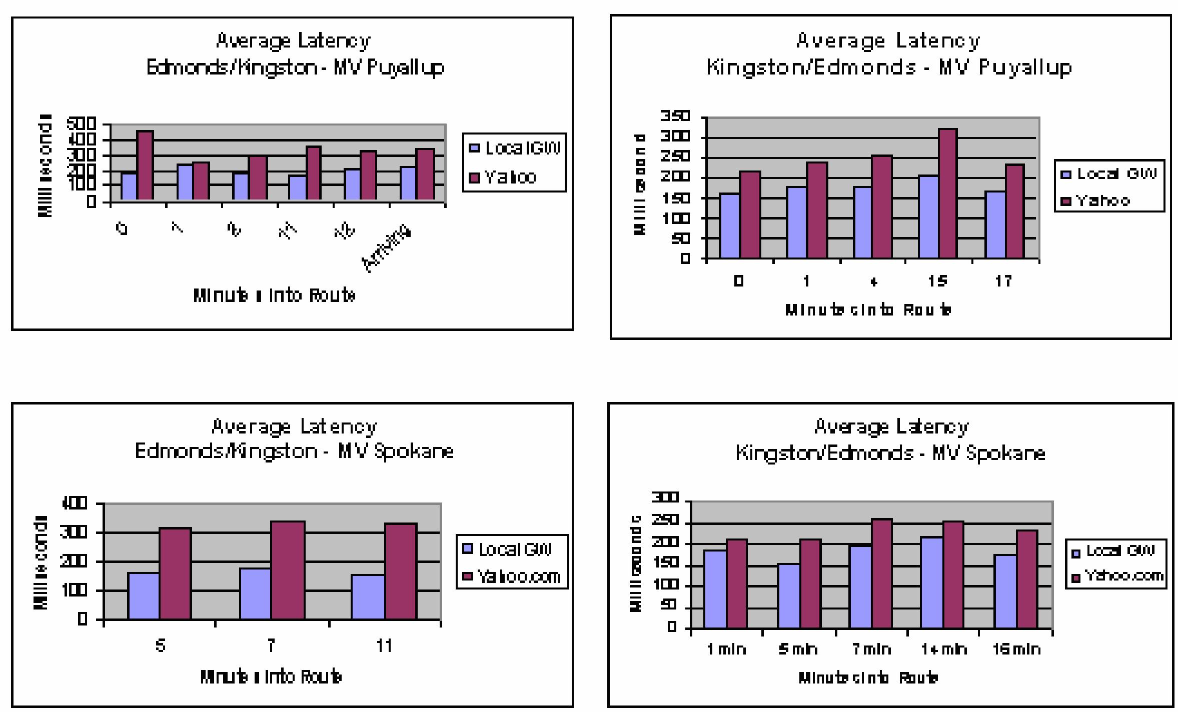


Figure 3-2. Latency Graphs—Kingston/Edmonds Route.



The system was tested to the local gateway address to determine the local latency. The system then tested latency to Yahoo.com. The latency to Yahoo.com is somewhat arbitrary because it was used for all latency tests; however, it provides for a good baseline and comparison. The main area for concern would be the local latency. This is the variable that is within control of the Wireless-On-Water administrator.

It should be clearly understood that latency exists on all networks and is a necessary evil that must be dealt with. It is our opinion that the latency will have a significant effect on the scalability and performance of the system.

3.2.2 Bandwidth

Downloads from Microsoft.com were performed to allow for a high-quality and consistent transfer rate. The Microsoft downloads were performed randomly during the route; the results are graphed in Figure 3-3, Bandwidth (Download) Graphs—Seattle/Bainbridge Island Route, and Figure 3-4, Bandwidth (Download) Graphs—Kingston/Edmonds Route. Because this phase of the evaluation was strictly from the end users perspective, only the download speed was tested. Downloading is likely to be the majority of traffic used.

The average bandwidth available on the runs was 500 kbps or below. It was taken into consideration that the speed of the landline Internet connection was unknown. However, when the graphs are viewed, the variation in available bandwidth indicates that the bandwidth to the vessel is inconsistent. Figure 3.3 and Figure 3-4 show throughput tests from the dock to the vessel independent of the Internet.

Figure 3-3. Bandwidth (Download) Graphs—Seattle/Bainbridge Island Route.

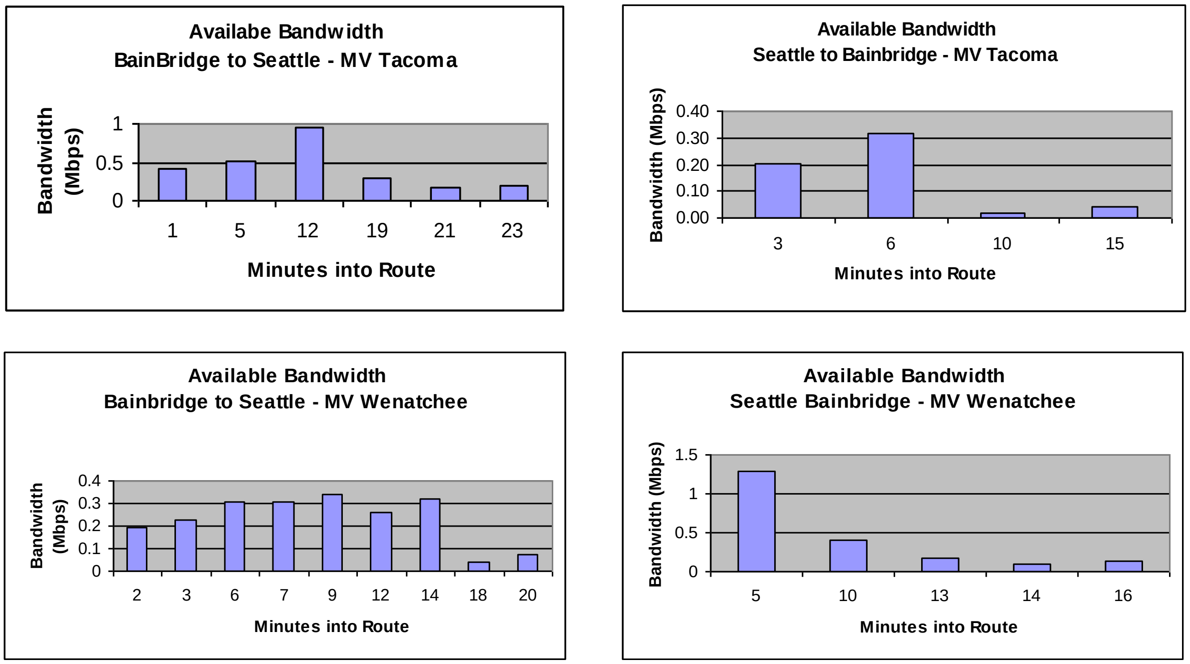
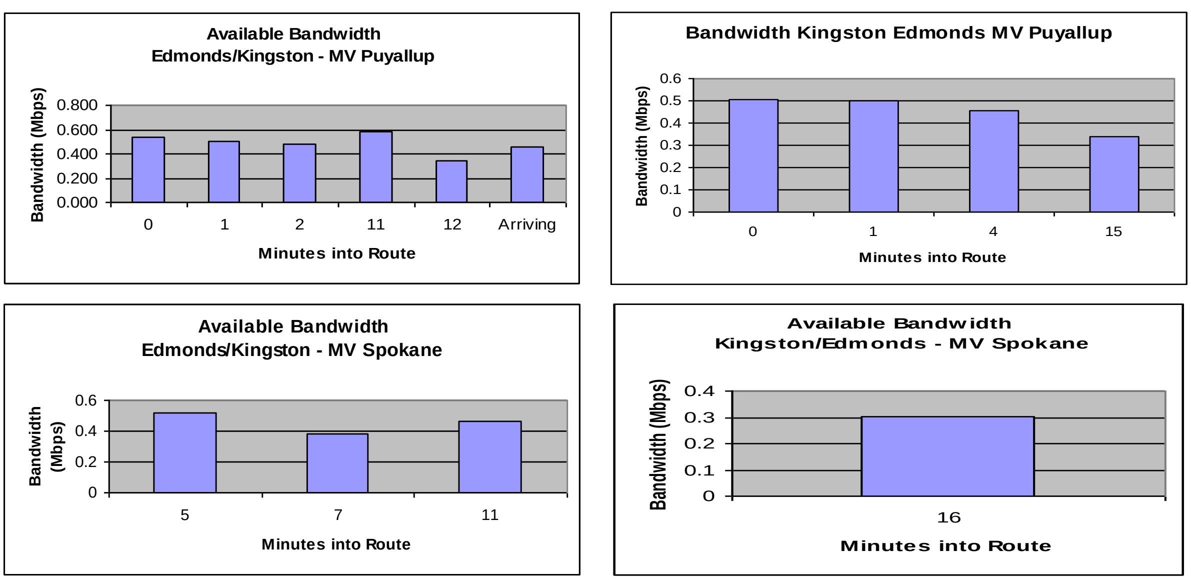


Figure 3-4. Bandwidth (Download) Graphs—Kingston/Edmonds Route.



3.3 CONCLUSION AND RECOMMENDATIONS, PHASE II

In summary, Lockheed Martin Information Technology evaluators were impressed with the level of bandwidth that was provided given the extremely difficult radio frequency environment. However, there is concern that providing enough bandwidth to the vessel during the entire route, to provide a quality end user experience, remains a challenge. This challenge increases when the potential number of wireless users during peak commute times is considered. A separate engineering study focusing entirely on bandwidth to the vessel may have to be performed.

3.3.1 End User Experience—MV Wenatchee, MV Spokane, MV Puyallup, MV Tacoma

The persistent connection failed on many of the routes and vessels tested. In some instances when the connection was lost, re-association with the access point did not occur until the wireless card was restarted. This happened on different laptops with different hardware platforms; therefore, it does not appear to be the end user device. While a loss of connection over 60 seconds might create an undesirable experience for the end user; the predictive nature of the incident may compensate for the disconnection as users become accustomed, much like the use of mobile phones today.

3.3.2 Persistent Connection—MV Wenatchee, MV Spokane, MV Puyallup, MV Tacoma

In general, Lockheed Martin Information Technology evaluators were impressed with the technical hurdles this pilot had to overcome to provide wireless Internet access onboard a moving vessel across the Puget Sound. While testing indicated latency, bandwidth, and persistence connection issues, Lockheed Martin Information Technology is confident these obstacles can be overcome with additional engineering. However, it is prudent to caution WSF that the wireless network as tested must overcome the challenges identified in this study before moving forward with the project.

4.0 BUSINESS CASE EVALUATION

In this section, references will be made to the Mobilisa Business Case Study (Business Case), which is attached as Appendix E.

4.1 BUSINESS CASE OVERALL OBJECTIVE

The Business Case successfully introduced the overall goal to enhance the end user experience by providing continuous 802.11 Wi-Fi network connectivity to ferry passengers. It identified also four major items to be considered up front as they relate to wireless Internet services on the WSF Marine Vessels:

- Types of use for wireless broadband
- Different wireless equipment used by passengers
- Different types of end users
- Results of an online survey.

The purpose of the Business Case was to present information on demographics, other wireless uses, pricing strategies, cost-benefit analysis, end user licensing agreements, and customer privacy based on the information gathered from the four major items and other research.

4.2 TYPES OF USE FOR WIRELESS BROADBAND

The Business Case successfully addresses the types of use and devices that will be used by ferry passengers. The most common uses of the wireless system by passengers are for accessing work information systems, browsing the web, chatting online, accessing email, reading the news, and downloading music. Email, business work, and web browsing make up 79% to 90% of the top uses for passengers (Business Case, Section 5.2.1).

4.3 DIFFERENT WIRELESS EQUIPMENT USED BY PASSENGERS

Using market research and passenger online surveys, the Business Case successfully identified the types of wireless equipment that could be used by passengers. Of the passengers responding to the survey, 91% own devices capable of wireless networking; of those, 95% said they would use that capability on the ferries if it were available. The most common device is the laptop computer. Other devices that could use wireless service are Personal Digital Assistants (PDAs), cellular/PDA phones, gaming devices, music devices, and digital cameras.

4.4 DIFFERENT TYPES OF END USERS

Using existing WSF data and the online survey, the Business Case successfully identified the types of ferry riders. According to the Business Case, there are 26 million rider events per year made up of vehicles (drivers and passengers) and walk-on passengers. Commuters are employers, employees, students, and tourists. Season, time of day, and day of the week affect passenger volumes. The busiest routes and volume are listed below.

Seattle/Bainbridge Island route covers 7.5 nautical miles, takes 35 minutes, and carries an estimated 7,140,000 passengers per year (most used route in system).

Kingston/Edmonds route covers 4.5 nautical miles, takes 30 minutes, and carries an estimated 4,758,000 passengers per year.

Bremerton/Seattle route covers 13.5 nautical miles, takes 60 minutes, and carries an estimated 2,405,000 passengers per year.

The Port Townsend/Keystone route also is identified (covers 4.3 nautical miles, takes 30 minutes, and carries an estimated 840,000 passengers per year) because it is the pilot route.

The plan does not quantify properly the number of riders "per vessel" that would use the wireless devices and services identified. This is explained in Section 4.5, Results of Online Survey.

4.5 RESULTS OF ONLINE SURVEY

The primary goal of the online survey was to determine how many of the ferry passengers would be interested in using wireless Internet. The survey was posted on the WSF web site from December 9, 2003, to January 7, 2004, and had 2,136 surveys submitted. The Business Case identified that approximately half of the 2,136 survey respondents were regular commuters, with the next highest percent boarding a ferry one to four times per week. No information was provided beyond these results.

Section 4.1 of the Business Case states that 2,136 surveys were submitted. However, Section 5.1 states that the top three routes—Seattle/Bainbridge (927), Seattle/Bremerton (666), and Edmonds/Kingston (545)—make up 58% of the total responses, yet the total cumulative value (see Table 4-1, Survey Totals) of these top three routes is greater then the number 2,136. This needs further explanation.

Table 4-1. Survey Totals.

Route	**Number of Surveys Returned**
Seattle/Bainbridge Island	927
Seattle/Bremerton	666
Edmonds/Kingston	545
Total	2,138

The Business Case (Section 5.2.2) states that 91% of the passengers responding to the survey own devices capable of wireless networking and 95% of them said they would use that capability on the ferries if it were available. Table 4-2, Wireless Users, attempts to calculate how many passengers would use Internet access using the information above and the information provided in response to wireless services.

Table 4.2. Wireless Users.

Responders	**% of Responders**	**Total Responders**	**Seattle/ Bainbridge Island Route**	**Seattle/ Bremerton Route**	**Edmonds/ Kingston Route**
Total survey responders (see Section 4.1)	100%	2,136	927	666	545
Responders with wireless devices	91%	1,944	844	606	496
Responders that would use wireless devices on ferry	95%	1,847	801	576	522

The most common boarding times (6 a.m. to 8 a.m. and 4 p.m. to 6 p.m.) are in support of commuter passengers traveling to and from work. What is not clear is how many of the passengers requiring wireless service will be riding during the common boarding times. This is important in determining the amount of bandwidth needed to the vessel to support the peak traffic periods, and could change the business case pricing strategies and justifications.

The Business Case (Section 5.4) results successfully identify how the passengers want to pay for the wireless service. Passengers were split in the following manner: 54% would use wireless service on a per-use bases, 46% would use it on a monthly subscription basis. The vessel survey and subsequent electronic survey, both conducted by Lockheed Martin Information Technology, showed that a majority of the users (60.5%) preferred a monthly charge, with 83% of users not willing to pay a per-use charge. Table 4-3, Monthly Subscription Amounts, shows the amount that passengers expect to pay for a monthly subscription for the wireless service. Table 4-4, Per-Use Subscription Amounts, shows the amount that passengers expect to pay for the wireless service on a per-use basis.

Table 4-3. Monthly Subscription Amounts.

Expected Pricing	**Number of Responses**	**Percent**	**Total Percent**
Free	26	4%	4%
$1 to $4	115	16%	85%
$5 to $10	272	37%	
$11 to $14	116	16%	
$15 to $20	127	17%	
$21 to $24	34	5%	11%
$25 to $30	38	5%	
$31 and above	9	1%	
Totals	**737**	**100%**	**100%**

Table 4-4. Per-Use Subscription Amounts.

Expected Pricing	**Number of Responses**	**Percent**	**Total Percent**
Free	42	5%	5%
$0.00 to $0.99	232	30%	89%
$1.00 to $2.00	170	22%	
$2.01 to $3.00	144	18%	
$3.01 to $4.00	24	3%	
$4.01 to $5.00	126	16%	
$5.01 to $6.00	10	1%	5%
$6.01 to 10.00	25	3%	
$10.01 and above	6	1%	
Totals	**779**	**100%**	**100%**

It would appear the expected monthly revenue would be from $5 to $20 and that the per-use revenue would be $1.00 to $5.00 based on passenger survey data. Based on evaluation by Lockheed Martin Information Technology as discussed in Section 4.5.1, Passenger Survey Validation, it would appear that the recommended $39.99 per month and $5.99 per-use charges in the business case is not feasible. This statement assumes the service is equivalent to what others (e.g., Wayport, Boingo) provide for less. It should be noted also that having a captive audience such as ferry passengers may help drive the pricing higher towards the $39.99 scenario. What is not clear is the percentage of wireless subscribers that would be willing to pay the higher price.

Section 8.1 of the Business Case successfully compares other like services available today for commuters, but does not provide information on what services or bandwidth is included with that price. This would be helpful in understanding what the passengers are going to expect from the ferry wireless system.

The Business Case also identifies other uses that are helpful in determining the overall revenue potential for a wireless infrastructure on the ferries.

Galley could use system for debit and credit card transaction.

Ship services could consist of automatic teller machines (ATMs) and kiosks services.

Smart Card systems could be used to pay for public transportation services (buses and ferries).

The Business Case states that a third party could be used to operate and maintain the system and allow the passengers to choose the ISP (e.g., Wayport, Boingo) they prefer. It is suggested that the royalties gathered from the ISPs could pay for the expense. What is not clear is if this includes the capital investment to build the networks. The Business Case needs to identify who is responsible for that initial capital investment. In addition, it needs to provide a better breakdown of all the costs associated with delivering the service before the break-even point of 600 users can be validated.

In addition, the estimated operation costs are identified as $281,784 annually but does not identify if these costs are per route, per boat, or system-wide. It also does not provide a breakdown of what makes up those costs; e.g., employee count, employee type (full-time or part-time), benefits, bandwidth per location, amount of equipment installed (e.g., backhaul, on the vessel). The Business Case needs to identify core assumptions (e.g., the initial investment will be paid for outside operations).

The Business Case identifies the break-even point of 600 subscribers regularly assuming $39.00 per month can be collected. This assumes that 100% of the $39.00 monthly fee is being applied to the entire operating costs. This does not account for any profit sharing, WSF royalties, or initial investment costs, which directly affect how the system will be operated and maintained.

4.5.1 Passenger Survey Validation

A sample passenger survey was performed by Lockheed Martin Information Technology in March 2005 on the Edmonds/Kingston route and the Seattle/Bainbridge Island route. The sample survey was used to validate previous online surveys performed by Mobilisa as part of their Business Case.

Interviews were conducted by a survey team of four Lockheed Martin Information Technology staff (two per vessel), during peak and non-peak routes. The routes included MV Puyallup and MV Spokane on the Kingston/Edmonds route and MV Wenatchee and MV Tacoma on the Seattle/Bainbridge Island route.

The vehicle and passenger capacities are as follows:

MV Tacoma, MV Wenatchee, and MV Puyallup

218 automobiles
2,500 passengers

MV Spokane

206 automobiles
2,000 passengers.

A form was developed to ensure surveyors used a set of standard questions for each passenger interviewed. In addition to the survey conducted on the vessel, the same form was distributed electronically by WSF to their passenger email list. Both vessel and email survey responses were collected by the Lockheed Martin Information Technology team for evaluation. Appendix D, Passenger Survey Forms, includes all completed surveys received.

The physical surveys performed on the Edmonds/Kingston and Seattle/Bainbridge Island routes yielded 152 passengers surveyed. All of the passengers interviewed were seated in the main deck area of the ferry. The electronic survey results yielded an additional 71 surveys, for a total of 223 surveys completed. The passengers interviewed were very receptive to the survey crew and were willing to give honest evaluations of the wireless service they had been using on the ferries. Table 4-5, Passenger Survey Results, shows the breakdown of surveys received and identifies from which route the customer was responding.

Table 4-5. Passenger Survey Results.

Ferry Route	Personal Interview	Electronic	Total Number of Surveys Received
Edmonds/Kingston	34	4	38
Seattle/ Bainbridge Island	118	56	175
(Not Listed/Other)		11	11

Table 4-5. Passenger Survey Results.

Ferry Route	Personal Interview	Electronic	Total Number of Surveys Received
Total Surveys			223

Passengers were questioned first on which wireless services they currently used. The most common responses were for conducting business/work, accessing email, and browsing the web. While some passengers had used the wireless services in both the holding area and on the main deck, the majority of passengers were using the services on the main deck of the Marine Vessels only. A few passengers noted that the service in the holding area was not as good as what was available on the main passenger deck. When asked whether or not they would use wireless service in the car deck, 73% of the responses were yes.

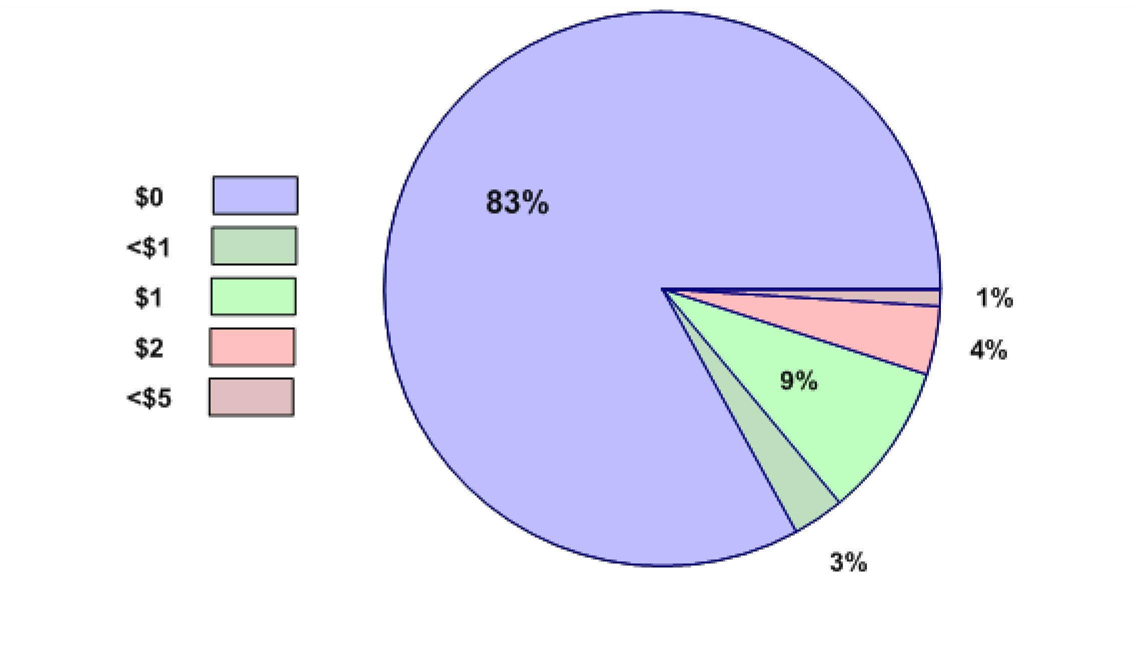
Passengers were questioned next on how the wireless service on the ferries compared to other wireless services they have used, and how they like having the service available. While some users realized that service would be more reliable in a non-moving environment, many found the service to be less than comparable to other wireless service that they had encountered. The degraded service is likely because of slower and less persistent connection times.

Passengers also were asked to discuss any issues they had encountered with the service. It was noted by the survey team that during peak ridership hours, passengers were less satisfied with the level of service because of slower connection times and lack of a persistent connection. Users during off-peak times, where fewer users were present, had better connection quality. This was especially true on the Edmonds/Kingston route, where there were not more than five wireless users during any particular crossing surveyed.

The Seattle/Bainbridge Island route had exceptionally more users during all times reported and more comments regarding lower service performance levels. The survey team noted that during peak travel times on the Seattle/Bainbridge Island route, approximately 20 surveys were completed per crossing. More users were observed using wireless devices during these routes, but all were not interviewed because of the time constraints.

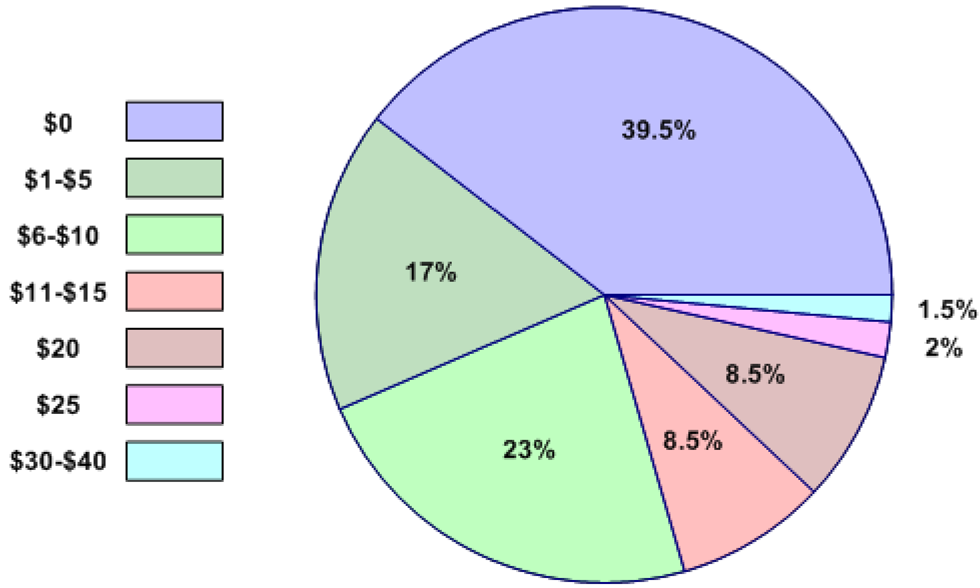
Another question posed to the passengers is how much they would pay for the wireless service if offered either monthly or as a per-use basis. The majority of passengers preferred a monthly service fee. As shown in Figure 4-1, Expected Pay-Per-Use Fee, very few (83%) of the passengers were interested in a pay-per-service fee. Of the remaining 17%, the most common response that passengers would be willing to pay was $1.00 and not more than $5.00 per use.

Figure 4-1. Expected Pay-Per-Use Fee.



When asked how much passengers felt would be a fair monthly charge for service, 39.5% of the responses were $0.00. As depicted in Figure 4-2, Expected Monthly Service Fee, the next highest majority came in at 23% of respondents who where willing to pay approximately $10.00 per month for service. Based on the results, the responses were split at 39.5% not willing to pay for service, 40% willing to pay $10.00 or less, and the remaining 20% willing to pay more than $10.00 and up to $40.00.

Figure 4-2. Expected Monthly Service Fee.



The final question that was posed to passengers was how they would rate the overall wireless experience on the ferries. The rating was based on a scale of 1 to 10, with 1 being poor, 5 being acceptable, and 10 being excellent. Again, the survey team noted that the responses were more likely to get a lower rating during peak times where there were a higher number of users (20 or more).

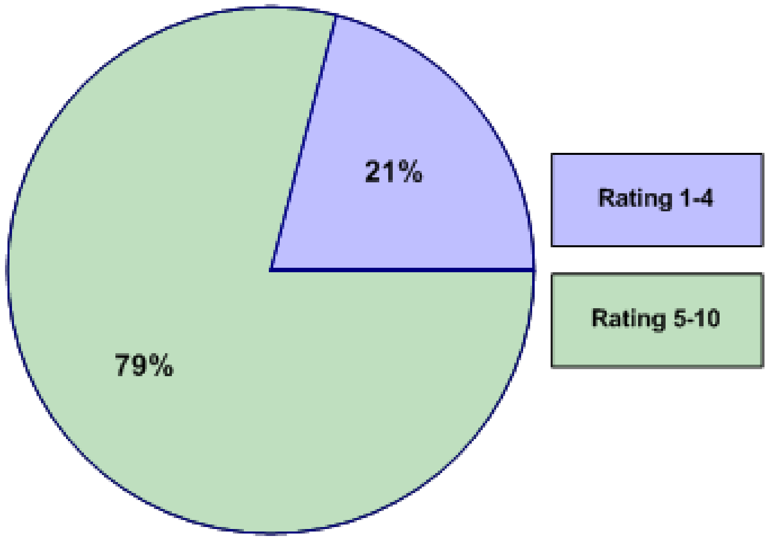
Table 4-6, Total Ratings on a Scale of 1 to10, shows the number of passengers that gave each level of rating on the 1 to 10 scale. This provides a method of evaluating overall customer satisfaction with the ferry wireless service. The row titled “Percentage” correlates to Figure 4-3, Overall Service Rating by Customers.

Table 4-6. Total Ratings on a Scale of 1 to 10.

Scale	1	2	3	4	5	6	7	8	9	10
Total Ratings	8	7	14	16	27	29	35	36	20	18
Percentage	21%				79%					

Figure 4-3 shows that 21% of responses were under a rating of 5 on the 1 to10 scale. Of the responses, 79% were 5 or above, which represents a very large portion of passengers feeling that the wireless service is at least acceptable or better.

Figure 4-3. Overall Service Rating by Customers.



The survey did not support the Business Case suggested customer offerings for a pay-per-use cost model, but did support the findings for a monthly service fee. The suggested price of $15.99 per month in the Business Case is probably too high, where $10.00 per month would seem more feasible at this point.

The majority of passengers using wireless services commented that they were pleased about having the service onboard the ferries. Overall, the user experience appeared to be improved for the passengers taking advantage of the wireless service. It also was apparent that the lack of a persistent connection was determined to be an issue with passengers. This could be because of loss of connection during the route. Also, the bandwidth available could be affected by the number of users at any given time.

According to passenger comments, service performance will be a major factor in whether or not users would pay for the wireless service if offered and how much they would consider a fair price. Having reliable service will be the determining factor on whether passengers will be willing to pay for Internet services and how much they are willing to pay.

4.6 CONCLUSION AND RECOMMENDATIONS, BUSINESS CASE EVALUATION

The Business Case and subsequent site survey by Lockheed Martin Information Technology demonstrated that providing a wireless Internet system onboard the WSF system is desired by the WSF passengers and that the volume of users is sufficient to justify further development. It also demonstrated that the following situations would be most effective:

Passengers would be allowed to connect to multiple ISPs

ISPs would pay royalties to ferries

Maintenance would be paid by WSF to third-party contractor.

Although the conclusion of Mobilisa’s Business Case appears reasonable, additional costing data, as it relates to the level of service needed, is required to validate the financial feasibility and service pricing.

The bandwidth requirement to support the number of wireless connections during peak periods is critical to a business case study because it impacts cost and service, as validated in the sample surveys that were conducted.

While Lockheed Martin Information Technology’s evaluation supports the general findings of Mobilisa, a reasonable level of service needs to be achieved before charging for the wireless service is viable.