Ferry Systems Data, Scheduling, and Billing

Scheduling Systems Analysis

WA-RD 112.2

Final Report
June 1987

Washington State Department of Transportation
Planning, Research and Public Transportation Division

in cooperation with the
United States Department of Transportation
Federal Highway Administration

FERRY SYSTEMS DATA, SCHEDULING AND BILLING

SCHEDULING SYSTEMS ANALYSIS

by

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Final Report

Research Project Y-3399
Task 11

Prepared for

Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

June 8, 1987

TECHNICAL REPORT STANDARD TITLE PAGE

1 REPORT NO.
WA-RD 112.2

2. GOVERNMENT ACCESSION NO.

3 RECIPIENT'S CATALOG NO.

4 TITLE AND SUBTITLE
FERRY SYSTEMS DATA, SCHEDULING AND BILLING

5. REPORT DATE
June 8, 1987

6 PERFORMING ORGANIZATION CODE

7 AUTHOR(S)
Mark E. Hallenbeck

8. PERFORMING ORGANIZATION REPORT NO

9 PERFORMING ORGANIZATION NAME AND ADDRESS
Washington State Transportation Center (TRAC)
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Seattle, Washington 98195

10. WORK UNIT NO.

11. CONTRACT OR GRANT NO.
Y 3399, Task 11

12 SPONSORING AGENCY NAME AND ADDRESS
Washington State Department of Transportation
Transportation Building, KF-10
Olympia, Washington 98504

13. TYPE OF REPORT AN PERIOD COVERED
Final Report

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16 ABSTRACT
This report describes the feasibility, costs and benefits of automating the vessel and crew scheduling functions of the Marine Division of the Washington State Department of Transportation. The project examined the needs of the Marine Division, reviewed its current procedures, and compared available commercial and public domain software packages. Some existing packages intended for use by the transit and airline industries offer promise, but all packages examined require considerable modification to meet the needs of the Marine Division.

17 KEY WORDS
scheduling, crew scheduling, vessel scheduling, ferries, labor rules

18 DISTRIBUTION STATEMENT

19. SECURITY CLASSIF (of this report)
Unclassified

20. SECURITY CLASSIF. (of this page)
Unclassified

21. NO OF PAGES
73

22 PRICE

DOT FORM 310-022 (11 86) 1216

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF EXHIBITS

FOREWORD

This report contains the findings and recommendations of the work performed in Tasks 2 and 3 of the project Ferry Data, Scheduling and Billing. It describes the advantages, disadvantages and related issues entailed in the acquisition and use of automated scheduling assistants for both crew and vessel scheduling.

This is the second of three reports for this project. The first report reviewed the data needs of the Ferry System. The third report will describe the feasibility of automating portions of the commercial vehicle billing procedure by automatically identifying vehicles and recording their use of the ferry system. These other reports have been or will be submitted under separate cover.

EXECUTIVE SUMMARY

This project reviewed the feasibility and cost of developing (or applying previously developed) computerized systems for scheduling crews and vessels for the Marine Division of the Washington State Department of Transportation (WSF). The principal objective of this project was to determine if existing software developed by the Urban Mass Transportation Administration (UMTA) or commercial vendors could be applied to WSF needs, what modifications those systems would require, and what benefits WSF could derive from them. Secondary objectives of the project included determining the approximate costs of developing a system specifically for WSF and determining the specific functions and capabilities such a system should contain.

INTRODUCTION

WSF service is in many ways similar to that provided by urban transit properties and the commercial airline industry. Because these two markets are large, a number of computerized scheduling programs have been written to assist operators in planning and cost-effectively operating airline and transit services. This project investigated the use of this existing software to fill the specific needs of WSF.

This chapter summarizes WSF's current scheduling practice, describes the potential benefits and costs of automating the scheduling process, and summarizes the study's recommendations.

CURRENT WSF PRACTICE

Vessel Scheduling

WSF currently schedules vessels manually. One service planner spends a considerable portion of his/her time developing revisions to existing or historically scheduled service to meet the expected demand. This includes adjusting departure times and vessel deployments to meet changing traffic demand and vessel availability requirements due to maintenance and certification requirements.

The current vessel scheduling practice is performed one vehicle at a time. Rather than scheduling specific trips, as is commonly done in the airline and transit industry (e.g., trips leave at 7:00, 7:30 and 8:00

from Boston to New York) and later determining the number of craft needed to provide that service, ferry service is scheduled by determining the number of vessels available for each route and then optimizing the departure and arrival times possible for those vessels.

Crew Scheduling

Currently WSF assigns vessel and terminal crews manually to particular vessels, terminals or pieces of work. Above-deck crews are assigned differently from below-deck crews as a result of the differences in labor rules governing the crews, and both are subject to rules different from the rules for terminal personnel.

Like vessel schedules, crew schedules are often based on historical schedules. This reduces the time required for developing the schedule and, for the most part, optimizes the use of crews. In recent years, the WSF has increased the number of above-deck crews it moves between routes during their two week work schedules to reduce the total amount of labor required to man all scheduled service. This crew interlining (i.e., using a crew on more than one route) has advantages in that it reduces the total amount of labor required, but it may be causing some morale problems among the crews.

BENEFITS OF AN AUTOMATED SYSTEM

Vessel Scheduling

The primary benefit of automating the vessel scheduling system would come from the increased speed with which schedules could be developed and the consequent increase in flexibility that WSF would have to experiment with alternative schedules and vessel distributions.

A secondary benefit of automating the vessel scheduling process would be the opportunity to improve the production of reports and statistics detailing the service to be provided. Information that could be readily provided includes

- number of trips (by route) per day, week, and quarter,
- number of hours of service provided,
- number of hours of revenue service provided,
- estimated cost of scheduled service,

- vessel miles traveled, and
- capacity provided (passenger and vehicle).

At the present time, this information must be manually generated, a time consuming process that is often neglected. These figures are required for reporting purposes and, when used in conjunction with other system performance information, provide rich data sources for system management.

Crew Scheduling

Automating the crew scheduling would provide three major benefits to the WSF:

- the ability to more effectively analyze scheduling options under existing work rules, possibly resulting in a lower cost allocation of labor,
- the ability to test the financial effects of prospective work rule changes, and
- an increase in the speed with which scheduling can be accomplished.

The fall '86 crew schedules contain roughly 240 hours of unproductive above-deck crew time (dead time) during each two-week period. This surplus comes from the WSF's inability to schedule all paid time as productive time (i.e., scheduled service and associated turn-to and tie-up time). The vast majority of this dead time is the result of restrictive labor rules, and no amount of scheduling ingenuity will reduce it without changes to the basic labor agreements. Dead time costs the WSF roughly $1,024,000 over the course of a year.

To significantly reduce this dead time, or expand service on many routes during peak periods, the WSF needs to obtain work rule changes from its major unions. Prospective labor rule changes include but are not limited to

- a standard work week of either five eight-hour days or four ten-hour days,
- an increase in the number of part-time, above deck employees,
- the ability to schedule small amounts of overtime,
- use of split shifts, and
- the elimination of the five days on/two off or ten days on/four off provision.

Appendix B of this report contains a more thorough examination of prospective work rule changes.

Some cost reductions could be gained with the existing work rules by scheduling crew positions instead of watches, as is currently done. That is, instead of having a few watches during which all positions are scheduled the same, the system would schedule able-bodied seamen (AB) differently than ordinary seamen (OS), and both might be scheduled differently than captains. An example of this technique is provided in Chapter 3 of the main body of this report.

AUTOMATION COSTS AND COMPARISON OF ALTERNATIVES

The costs of automating the vessel and/or crew scheduling systems will vary with the complexity of the computer program(s) developed or purchased, the need for additional computer hardware to run the systems, and the degree to which the WSF wishes to customize the scheduling software. Three basic options exist for acquiring these automated capabilities:

- use of public domain software,
- purchase of commercial software, and
- development of software specifically for WSF.

In addition, to utilize existing public domain or commercial software, WSF will most likely need to customize that software to more closely match its capabilities with WSF's needs.

The project team's review of the available software shows that the public domain software, which is written for the transit industry, does not meet the needs of WSF. The project team believes that the differences between the style of the programs and the needs of WSF are so great that the cost of customizing this software would most likely exceed the cost of developing new software.

WSF could purchase an existing system from a commercial vendor, either as is or modified to better fit the ferry system's needs. Specific costs to WSF for purchasing and installing the indicated software would vary depending on

- the amount of customization done as part of the system installation,
- the amount of hardware that needed to be purchased to run the system, and
- the competitive bidding process.

Most commercially available programs include both vessel and crew scheduling as well as other capabilities. Several of the quoted prices also include the cost of training and the input of system parameters (route characteristics, labor rules, etc.) as part of the purchase price. Unfortunately, the transit vehicle scheduling software that could be reviewed by the project team suffered many of the same limitations as the public domain software. That is, it concentrates on determining the smallest number of vehicles to perform defined service, as opposed to optimizing the use of a defined number of vehicles or vessels. The airline scheduling software concentrated on optimizing the movement of planes between routes so that all planes received scheduled maintenance. The costs for installing bus and airline systems range from $100,000 up. Somewhat more would be required to adapt the systems to WSF's needs.

A more complete description of available public domain and commercial scheduling packages is contained in Chapters 2 and 3 of the report.

The third option for system selection is the development of scheduling systems by WSF. This development could be done by an outside consultant (possibly one of the firms identified above), WSF staff, TRAC, WSDOT MIS, or some combination of the above. TRAC estimates that a complete stand-alone vessel scheduling system could be developed for roughly $75,000. A more limited scheduling assistant that simply automated some of the necessary mathematical calculations required in the scheduling process could be developed for roughly $30,000. A crew scheduling system integrated with a vessel scheduling system might cost up to $150,000 to develop.

INTEGRATION OF VESSEL AND CREW SCHEDULING

A coherent, cost effective vessel schedule can not be made without some knowledge of the labor requirements for meeting that schedule. A crew schedule can not be completed without previously making a vessel schedule. This interrelated scheduling process is shown in Exhibit E-1.

Most of the commercially available transit industry software come with both bus and operator scheduling components. In most of these cases, the integration is accomplished by having the vehicle scheduling sub-system of these programs output a computer file that can be read as input information by the operator scheduling sub-system. The advantage of this type of integration comes from the elimination of the manual preparation, coding and entry of input information for the crew scheduler. This decreases the cost of performing the task, improves the speed with which the task can be accomplished and reduces the chance of inputting erroneous information into the crew scheduler. All of these advantages could result in significant savings to WSF.

Any complete scheduling system developed or purchased by WSF should, as a minimum, have similar integration, or be capable of that integration if the system is developed one sub-system at a time. WSF may also desire the vessel and crew scheduling systems to have an even greater amount of integration than that present in the existing transit industry software. This added level of integration is explained in Chapter 4 of the report. Essentially, the recommended integration consists of allowing the vessel scheduling software to perform limited crew scheduling while the vessel schedule is being written. This would allow the schedule maker to more readily examine the impacts on operations costs of adding, deleting, or changing selected trips in proposed schedules.

RECOMMENDED ACTIONS

The project team recommends that the WSF develop its own automated vessel scheduling system. It further recommends that WSF either develop its own crew scheduling system or modify one of the existing airline crew scheduling systems for its own use.

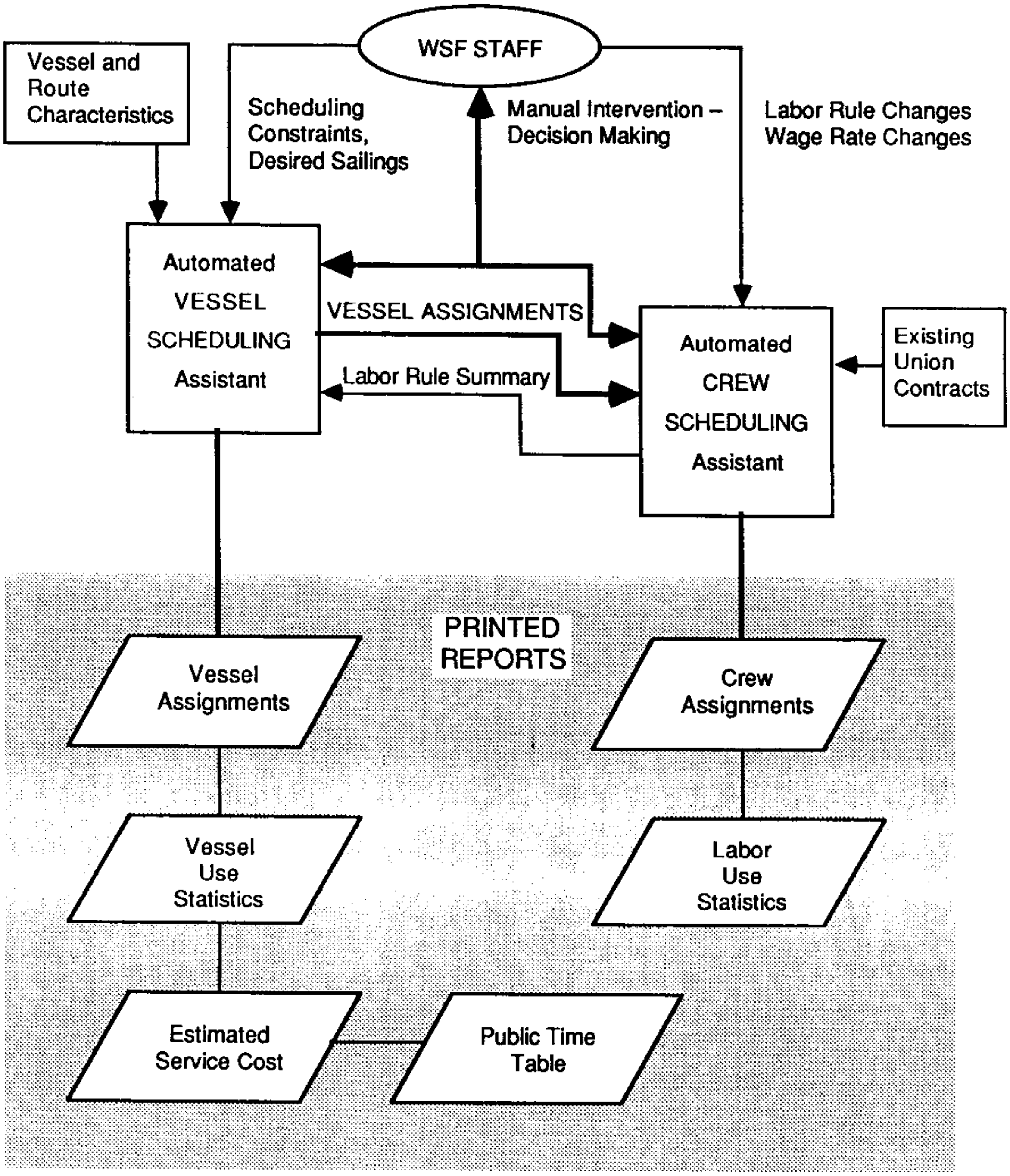
While the expense of obtaining these systems might outweigh the direct financial benefits (i.e., the direct savings through improved scheduling) to be gained at this time, the WSF would gain from significant improvements in its ability to manage its crews and fleet by obtaining an automated scheduling system. These improvements would be gained through:

- improved reporting capabilities,
- improved scheduling flexibility, and
- increased speed in the development of new schedules.

These factors are important within the context of improved quality of work, responsiveness to public concerns and decreased staff time needed for analyzing particular projects.

Exhibit E-1

Flow of Scheduling Process



If labor rules were relaxed, the financial returns from purchasing a combined vessel scheduling/crew scheduling system would probably exceed the cost of that system. The flexibility of the system to examine alternative schedules would allow WSF to take advantage of the new regulations and produce financial savings or substantial increases in service at little or no marginal cost to WSF. Having such a system available during contract negotiations would also provide the WSF with an excellent tool for analyzing different wage and work rule combinations and would allow better decisions based on the financial impacts of those results.

Any system purchased or developed by WSF should allow the flexible revision of key work rule restrictions as new work rules are tested for their effects on the existing labor cost structure. Further, the system developed should allow direct interfacing between the vessel and crew scheduling systems described.

CHAPTER 1
FEASIBILITY OF AUTOMATING THE VESSEL AND CREW SCHEDULING OPERATIONS OF THE WSDOT MARINE DIVISION

This project reviewed the feasibility and cost of developing (or applying previously developed) computerized systems for scheduling crews and vessels for the Marine Division of the Washington State Department of Transportation (WSF). The principal objective of this project was to determine if existing software developed by the Urban Mass Transportation Administration (UMTA) or commercial vendors could be applied to the WSF, what modifications those systems would need, and what benefits WSF could derive from them. Secondary objectives of the project included determining the approximate costs of developing a system specifically for WSF and determining the specific functions and capabilities such a system should contain.

INTRODUCTION

This study examined vessel and crew scheduling operations both independently and as an interrelated entity. Following this basic approach, this report is structured in four sections:

- Introduction to the Project,
- Vessel Scheduling,
- Crew Scheduling, and
- Integration of Vessel and Crew Schedulers.

This first chapter introduces the topics covered in this report. Within the chapters describing the vessel and crew scheduling options, the following topics are discussed:

- how WSF currently performs the function,
- benefits of automating that function,
- costs of automating the system,
- comparison of automation alternatives, and
- recommended actions.

The final chapter summarizes the issues surrounding the need for integrating vessel and crew schedulers and describes how that integration should take place. Two appendices follow the main body of this report and describe the desirable attributes of automated vessel and crew scheduling programs.

This study was undertaken by the Washington State Transportation Center (TRAC) for the Marine Division of the Washington State Department of Transportation. The intent of automating the scheduling operations is to provide the WSF with a set of tools that will assist the system's management in containing or reducing WSF's costs by determining better (i.e., lower cost) schedules for both vessels and crews.

BACKGROUND

UMTA has funded development of computerized scheduling systems for transit agencies throughout the U.S. Commercial vendors have improved on the initial UMTA research (the RUCUS programs), and several alternatives are now commercially available. These programs have resulted in three to five percent reductions in the cost of labor required for operations. These reductions in cost come from more efficient use of equipment and available labor within existing work rules, particularly through the reduction in nonproductive guaranteed pay time and penalty time.

In most cases, the transit systems showing the largest savings from automating their scheduling systems have complex route structures (i.e., many routes where one vehicle may operate on several routes during the service day, a process called interlining) and service days heavily skewed to the morning and evening peak periods. The automated vehicle scheduler is used to determine the optimum number of buses required to provide service along a route or routes at given headways, and to determine where operators would be available for relief by other operators. The automated crew or driver schedulers then determine the labor requirements of those schedules and combine them (given existing labor rules) into a pattern which approximates the least costly solution for the bus operating authority.

Similar scheduling software also exists for the airline industry. While no public domain software exists for this industry, the significance of this market has resulted in the commercial development of scheduling assistant packages for this industry. These schedulers differ from the transit packages in style, capabilities, and to some extent function. They also offer the possibility of providing a framework for assisting the WSF.

Transit Versus Ferry Service

While WSF and transit properties have many similarities, the ferry system is different from bus systems in several important aspects. These differences include

- size of the geographic area served by each authority,
- number of persons per scheduled vehicle,
- length, duration and peaking characteristics of the service day,
- flexibility in vehicle (vessel) assignment,
- labor rules which affect the use and distribution of vehicles and personnel, and
- complexity of routes and interline.

Geography causes problems for the WSF in that the distances involved in traveling between ferry terminals makes transferring crews between routes during the work day difficult and costly. This prohibits the simple exchange of crews and vessels between routes (except in a few rare instances like Bremerton - Seattle - Winslow) as part of the scheduling process. Transit authorities that can schedule buses and bus drivers on more than one route during a day normally can find significant reductions in the number of vehicles and personnel needed for specified levels of service.

The next area in which WSF and urban transit systems differ is that while the ferry system has a relatively large number of operating employees (like a medium or large bus operator), they are distributed over a relatively small number of vehicles and routes. Most bus systems operate a significantly larger number of vehicles and routes and therefore have greater flexibility in moving drivers between routes and runs than are available to WSF. This greater flexibility in the transit business, however, also leads to a more complex problem when trying to optimize the use of drivers.

In urban transit systems, most buses are interchangeable among routes. Buses can be assigned to several different routes on the same day. This is usually not possible for the ferry system. Vessel capacity is also a determinant of route assignment. In contrast, in a bus system, vehicle capacity does not limit route assignment to the same degree.

The last two significant differences are interconnected in that historical differences in the types of service provided have resulted in different types of labor rules for transit and ferry systems. Transit authorities offer primarily weekday service, concentrated during the morning and evening peak periods. WSF offers service that is essentially constant throughout the day; only slight increases in service levels are required to match the weekend recreational peaks and relatively low commuter peaks.

Partly as a result of the small increase in straight service during the peak commuter period, WSF labor rules are based on time for employees (i.e., eight consecutive hours). Consequently, the WSF does not have the ability to schedule split shifts for its operating employees as do most transit agencies. This significantly reduces its flexibility to expand "commuter" service as urban areas grow to encompass the existing ferry service areas.

Airline Versus Ferry Service

In many ways, the WSF more closely resembles the commercial airline industry than it does the transit industry, although this may change as commuter ridership on the ferries increases. With airlines, the geographic separation of airports and the duration of flights resemble the geographic arrangement of the WSF. However, airlines have greater flexibility in rotating aircraft through particular terminals than does WSF, and therefore can more easily interline crews and aircraft. WSF may gain similar flexibility if it expands passenger-only ferry service to include Vashon to Seattle service, or other new routes.

Like WSF, most airlines do not use a large number of part-time employees, nor do they use split shifts. They must also be concerned with the phenomenon WSF calls "touring watches," in which a crew serves two shifts within a 24-hour period and spend some nights away from their home base. Airlines typically use work periods in which work is scheduled intensely over a short period of time, with longer periods of time off. This is similar to the WSF engineer's schedule of seven, 12-hour days followed by seven days off. Finally, airlines use a relatively large number of employees per aircraft, and the specific complement of employees per aircraft changes depending on the model of aircraft (e.g., a 747 crew is different than a 737 crew). This is similar to the differing WSF crewing needs for different vessel classes.

Besides WSF's limited ability to interline, the biggest difference between ferry system and airline scheduling comes not from the types of rules applied, but in the specifics of those rules (e.g., the number of hours that can be worked in a 24-hour period, the number of days that can be worked in a row, types of equipment that can be operated, etc.). These differences can often be easily accounted for by specifying parameters to the crew scheduling programs. Thus, existing airline scheduling software might be very useful to WSF.

STUDY METHODOLOGY

This project included a review of WSF's existing vessel scheduling and crew scheduling procedures. The review entailed a literature search for descriptions of existing software capable of performing or assisting in the performance of these operations. Follow-up letters were sent and telephone calls made to secure additional information from specific transit authorities and software manufacturers identified through the literature search. In addition, some public domain software was tested to determine its applicability to WSF practices.

Three industries were examined for examples of automated vehicle and crew scheduling systems. These included

- transit properties,
- ferry operators (including Alaska Marine Highway System, BC Ferries, Golden Gate Bridge, Highway and Transportation Authority, Staten Island Ferries, and Sealink/Hoverspeed in the United Kingdom), and
- airlines.

None of the ferry operators had an automated scheduling system, although several did express an interest in the outcome of this study.

Along with the investigation of available computer systems, the existing WSF procedures were analyzed to determine the capabilities required of a computerized scheduling program. These needs were then compared with the known capabilities of existing software, and conclusions were drawn about the applicability of that software to WSF. Estimates were then made of the need for customization of existing software to more closely match the needs of the WSF. The comparisons and conclusions are presented in Chapters 2 and 3 of this report.

CHAPTER 2
VESSEL SCHEDULING

This chapter discusses the merits and costs of alternative automated vessel scheduling systems that WSF could use. It describes current WSF practices, available commercial and public domain software, comments on the merits of these programs, and recommends alternatives WSF should pursue.

CURRENT WSF PRACTICE

WSF currently schedules vessels manually. One service planner spends a considerable portion of his/her time developing revisions to existing or historical service to meet the expected demand. This includes adjustments to departure times and vessel deployments to meet changing traffic demand and vessel availability requirements due to maintenance and certification requirements.

The use of historical schedules as the basis for new schedules allows the planner to produce a functional schedule within the limited time frame available for this activity. It also provides a reasonable and perhaps optimal schedule in that small changes to existing schedules approach the maximum performance possible within existing scheduling constraints. The fact that only limited revisions are required in most cases is primarily due to

- fairly constant levels of traffic demand,
- the limited number of vessels to deploy, and
- restrictions placed on vessel deployment and use by labor usage constraints,

The use of historical schedules also allows WSF the flexibility of having a starting point for determining personnel requirements and consequently reduces the time and cost necessary for developing operations plans for new schedules. However, this dependence on historical schedules reduces the incentive to look for innovative vessel deployments that might reduce total operating costs. A second disincentive to examining "what if" vessel deployments is the difficulty and time consuming nature of manually assigning the various vessels to alternative routes and schedules.

The current vessel scheduling practice is performed one vehicle at a time. Rather than scheduling specific trips, as is commonly done in the airline and transit industry (i.e., there will be trips leaving at 7:00, 7:30 and 8:00 from Boston to New York), and later determining the number of craft needed to provide that service, ferry service is scheduled by determining the number of vessels available for each route and then optimizing the departure and arrival times possible for those vessels. This is a reasonable method for scheduling, in that the inability to move vessels between routes and the limited number of vessels available significantly limits the placement of vehicles, whereas transit and most airline operators have considerable flexibility in interlining routes and thus improving vehicle usage.

CURRENT REPORTING

The current manual system outputs line or running schedules for each route. These documents show the departure times of each vessel assigned to operate on that route. Vessel assignment sheets, similar to "paddles" in the transit industry, are not produced for individual vessels. Vessel captains use the route schedules for determining vessel operating instructions. These schedules provide only a limited amount of information concerning a vessel's expected operations, its interaction with other WSF vessels and facilities and interconnecting transit systems (see Exhibit 2-1). Because of this, a need exists for additional documentation to provide more descriptive information to the operators of the vessels. Information that might be included on an operator's sheet might include

- trip-by-trip descriptions of connections that should be made, either with other ferries or with land based transportation systems (i.e., buses),
- specific turn-to, tie-up and relief times,
- desired handle speeds at which vessels should be operated under normal conditions,
- special instructions concerning fueling, deadheading, sewage pumping and load limits.

Exhibit 2-2 provides an example of what such an information sheet might look like.

After proposed vessel schedules are prepared, they are circulated within WSF for management review. After this review, they are finalized and distributed to the appropriate WSF staff. After the final

Exhibit 2-1

Fall Schedule – Seattle-Bremerton (Effective: September 15, 1986)

<u>Weekday</u>

	Lv Seattle			Lv Bremerton		
	2	5:50	am	1	5:40	am
	1	6:50		2	6:55	
	2	8:00		1	8:00	
	1	9:10		2	9:10	
	2	10:20		1	10:20	
	1	11:30		2	11:30	
	2	1:20	pm	1	1:00	pm
	1	2:30		2	2:30	
	2	3:55		1	3:50	
	1	5:00		2	5:00	
	2	6:10		1	6:10	
	1	7:15		2	7:15	
	1	9:30		1	8:20	
	1	11:45		1	10:35	
*	1	2:10	am	1	12:50	am

	Lv Seattle			Lv Bremerton		
	1	6:35	am	1	5:30	am
	2	7:45		1	8:00	
	1	9:15		2	9:00	
	2	10:10		1	10:30	
	1	11:45		2	11:20	
	2	1:20	pm	1	1:20	pm
	1	2:40		2	2:30	
	2	4:15		1	3:55	
	1	5:00		2	5:25	
	2	6:30		1	6:10	
	1	7:15		2	7:35	
	1	9:30		1	8:20	
	1	11:45		1	10:35	
*	1	2:10	am	1	12:50	am

* - Via Winslow

Exhibit 2-2

Boat Summary for Seatle-Bremerton Passenger-only Vessel
Schedule no. 1

Effective: 10/15/86
Last Update: 9/24/86

Weekday

Eastbound						Westbound					
Turn To	Special Instructions	Depart Bremerton	Dep./Arr. Eagle Harbor	Arrive Seattle	Tie Up	Turn To	Special Instructions	Depart Seattle	Dep./Arr. Eagle Harbor	Arrive Bremerton	Tie Up
		0535		0610		0430	Deadhead to Bremerton		>0450	0520	
		0715		0750				0625		0700	
		0905		0940				0805		0840	
1500	Deadhead to Seattle		>1510	1530			Wait until SAGA has loaded – then deadhead first to Hbr. Isl. for fueling, and then to Egl. Hbr.	1000	1115>		1130
		1635		1710				1545		1620	
		1815		1850				1725		1800	
	M-Th: Deadhead to Egl. Hbr.	1955	2025>		2040			1905		1940	
	F: Dep. for Seattle at 2000	2000		2035			Trip operates Fridays only	2050		2125	
	Trip operates Fridays only	2140		2215			Trip operates Fridays only	2230		2305	
	Deadhead to Eagle Harbor	2315	2345>		0000						

Saturday

Eastbound						Westbound					
Turn To	Special Instructions	Depart Bremerton	Dep./Arr. Eagle Harbor	Arrive Seattle	Tie Up	Turn To	Special Instructions	Depart Seattle	Dep./Arr. Eagle Harbor	Arrive Bremerton	Tie Up
						1055	Deadhead to Bremerton		>1115	1145	
		1200		1235				1250		1325	
		1340		1415				1425		1500	
		1515		1550				1610		1645	
		1700		1735				1750		1825	
	Deadhead to Eagle Harbor	1835	1905>		1955						

Note (1): Sailing times between Seattle and Bremerton are estimated to be 35 minutes during normal daylight conditions, and 40 minutes at night. Feel free, however, to make the crossing in less time if you find that you can do so. Please report any inaccuracies in sailing times, or any suggestions you may have for ways of improving this schedule to Steve Smith, Service Planning Manager (464-7234).

Note (2): If you are going to arrive late in Bremerton, and therefore possibly miss a bus connection, please contact the Bremerton Terminal Agent so that he can notify Kitsap Transit's Dispatch Office.

schedules are distributed internally, WSF staff begin working on the above and below deck crew schedules, and seller and traffic director staffing needs.

At this time, summary statistics from the planned schedules are not prepared for annual reporting or comparison with actually performed service. Information required for Section 15 and other reporting needs are collected as required from historical documents, and such data are not otherwise used.

BENEFITS OF AN AUTOMATED SYSTEM

The primary benefits of automating the vessel scheduling system come from the increased speed in which schedules could be developed, the consequent increase in flexibility the WSF would have to experiment with alternative schedules and vessel distributions, and the ability to increase the amount of descriptive information that is routinely output from the scheduling process for management use.

The improvement in WSF's ability to examine alternative schedules would allow the ferry system to develop new schedules that would more cost effectively utilize the system's resources. For example, it would allow system planners to experiment with moving different size vessels between routes to determine how best to both meet demand and reduce the cost of service. This need for flexibility is especially important as the WSF moves towards expanded peak period service and introduces new technologies such as the high speed passenger ferry. Flexibility would also significantly help WSF respond to citizen complaints about arrival and departure times or major service adjustments necessary as a result of vessel breakdowns or other unscheduled repair needs.

A secondary benefit of automating the vessel scheduling process is the opportunity to improve the production of reports and statistics detailing the service to be provided. Information that could be readily provided includes

- number of trips (by route) per day, week, and quarter,
- number of hours of service provided,
- number of hours of revenue service provided,
- estimated cost of scheduled service,

- vessel miles traveled, and
- capacity provided (passenger and vehicle).

At the present time, this information must be manually generated, a time consuming process that is often neglected. These figures are required for reporting purposes and, when used in conjunction with other system performance information, provide rich data sources for system management. The production of these figures is actually fairly straightforward but requires lengthy calculation, which, when done manually, can be reasonably expensive. Because much of this information is needed for federal reporting purposes, the automation of this operation could reduce staff requirements for generating these numbers.

AUTOMATION COSTS

The costs of automating the vessel scheduling system will vary with the complexity of the computer program developed or purchased, the need for additional computer hardware by WSF, and the degree to which the WSF wishes to customize the scheduling software. Three basic options exist for acquiring these automated capabilities:

- use of public domain software,
- purchase of commercial software, and
- development of software specifically for WSF.

The purchase of either public domain or commercial software might also entail the need for customization of that software to more closely match its capabilities with WSF's needs.

Public Domain Software

Public domain software is almost entirely aimed at small to mid-sized transit authorities. Purchasing these scheduling packages through UMTA means an initial capital outlay of roughly $10 to $35 dollars for software diskettes and documentation. While the purchase price of UMTA software is negligible, the project team's experimentation with the available software indicates that the existing public domain programs would be of little use to the WSF. The differences between WSF's scheduling needs are so extensive that using the public domain software as a starting point would actually slow down the development process and head to a less useful product than starting from scratch would create.

While the Ferry System and transit authorities have many scheduling similarities, the differences are sufficiently large to make the available software cumbersome when applied to the WSF. Most of the public domain software performs scheduling by inputting desired headways on specific lines. The system then calculates the number of buses required for that service. This process would work for a few WSF routes, but it breaks down when (among other items):

- a route does not operate on consistent headways,
- vessels of different speeds are used on one route,
- small changes in departure times are required to meet desired sailing times, or
- when vessel routings change (i.e., which islands are visited and in what order).

In addition, the public domain software does not recognize the significant effect that crew size, labor rules and geographical distribution of the system's routes have on the deployment of vessels, as it contains no algorithms to make these calculations. The cost of customizing this public domain software would most likely exceed the cost of developing new software, in that the existing software would need to be completely rewritten.

Commercial Software

The second option available to the WSF would be to purchase an existing system from a commercial vendor, either as is or modified to better fit the ferry system's needs. As noted above, two sources of these scheduling programs exist. The first set of programs is designed for the transit industry and includes systems such as HASTUS, marketed by Multisystems, Inc., and RAMCUTTER, marketed by SAGE, which are mostly used by large transit authorities. The second set of programs is designed for the airline industry and includes programs such as SWITCH by David Johnson and Associates.

Exhibit 2-3 presents a table of approximate system costs for a representative group of vehicle scheduling packages identified during this project. This table presents information provided by several transit properties that have purchased software in the last five years and by program suppliers. Specific costs to WSF for purchasing and installing the indicated software would vary depending on

- the amount of customization done as part of the system installation,
- the amount of hardware that needed to be purchased to run the system, and
- the competitive bidding process.

Note that programs included in this exhibit often include crew scheduling and other capabilities in addition to the vehicle schedulers, and that the WSF would consequently gain capabilities in addition to vessel scheduling when purchasing that system. Finally, most of the quoted prices include the cost of some customization to make the software function within the constraints of the purchasing corporation. However, the extent of customization required to install the program for WSF is unknown and may be considerable.

Development of Software for WSF

The third option for system selection is the development of a vessel scheduling system by WSF. This development could be done by an outside consultant (possibly one of the firms identified above), WSF staff, TRAC, WSDOT MIS, or some combination of the above. TRAC estimates that a complete stand-alone vessel scheduling system could be developed for roughly $75,000. This would include several weeks of WSF staff time for consultation on the interfaces required and to clarify some of the rules used in the scheduling process. A more limited system that simply automated some of the necessary mathematical calculations required in the scheduling process could be developed for roughly $30,000. Such a system would not contain a sophisticated cost model or state-of-the-art on-screen graphics or user assistance.

COMPARISON OF ALTERNATIVES

As noted above, the use of UMTA public domain software represents the lowest initial capital investment by WSF. The software would run on available computers, further decreasing the cost of installing such a system. As part of this project, several of the public domain programs were tested, including the Chapel Hill Scheduler and the Desktop Scheduler. The project team believes that neither of these programs is suitable for WSF. The cost and effort needed to modify these programs would also be higher than the effort needed to develop a WSF specific system. Therefore, the project team recommends that the WSF not attempt to use public domain scheduling software, despite its low cost.

Exhibit 2-3

Summary of Vessel Scheduler Costs

Product	Company	Cost	Hardware Required	Contains Other Functions
Chapel Hill Scheduler	Made available by UMTA to the TIME Support Center	Public Domain $20 to cover copying charges	IBM PC	No
Desk Top Scheduler	Made available by UMTA to the UTP Support Center	Public Domain $40 to cover copying charges	IBM PC	No
HASTUS	Multisystems, Inc.	$80,000 Software License Fee 50,000 Training, Installation, etc. $130,000 TOTAL	IBM mainframe & PC-AT; Prime; Micro Vax; Plexus	Operator Scheduling
OPTIBUS	Befag Transport AG	no estimate given	PDP 11; Vax	Operator Scheduling
Quik/Pac RAMCUTTER	SAGE Management Systems, Corp.	$45,000 Software only	IBM PC-AT	Operator Scheduling
Transit Management System: Scheduling and Runcutting	Vista Systems, Inc.	no estimate given	Prime; Primos; Unix, IBM	Operator Scheduling; part of complete transit sys. acct. pkg.
Switch	David Johnson and Associates	no estimate given	IBM PC	Connects to other systems for maintenance scheduling

The study team could not locate any commercial software that might be of assistance to WSF without significant modification. The airline scheduling software appears to be aimed at optimizing the rotation of planes between routes to meet maintenance and crew needs. It concentrates on the ability of the scheduler to determine where aircraft may be interchanged and substituted to account for schedule disruptions due to weather and mechanical breakdown. For WSF, these issues are of lesser concern because the vessels used in revenue service do not move easily between routes, and the substitution of vessels when breakdowns occur is usually a straightforward decision.

Similarly, the commercial transit vehicle scheduling systems are good at what they are designed to do, but this does not match well with WSF's needs. Transit vehicle schedulers are designed to provide service at specified headways for specific routes with a minimum number of vehicles. Therefore, these systems schedule trips and then determine how many vehicles are needed to make those trips. The limited number of vessels and the inability to easily interline routes makes this an inefficient and cumbersome approach to ferry scheduling.

One final problem with all of the available vehicle scheduling software is that none of it directly takes into account the impact of labor rules on vessel usage. The current WSF labor rules create significant cost implications for scheduling vessels over 8 or 16 hours per day. An automated vehicle scheduler should be able to monitor the total number of hours of vehicle deployment and estimate the effects of added service on total operating costs. None of the examined software contains this capability.

Recommended Actions

The project team recommends that the WSF develop its own automated vessel scheduling system. Given the costs of developing such software, the expense of obtaining a system at this time appears to outweigh the financial benefits (i.e., the direct savings through improved scheduling) to be gained. However, if labor rules were relaxed, the financial returns from purchasing a combined vessel scheduling/crew scheduling system would probably exceed the cost of that system. The flexibility of the system to examine alternative vessel schedules would allow WSF to take advantage of the new regulations, and produce financial savings or substantial increases in service at little or no marginal cost to WSF.

Although the financial returns without labor rule changes are not substantial, the WSF would gain significant improvements in its ability to manage its fleet by obtaining an automated system. These improvements would be gained through improved reporting capabilities, improved scheduling flexibility, and increased speed in the development of new schedules. These factors are important within the context of improved quality of work, responsiveness to public concerns and decreased staff time needed for particular projects.

CHAPTER 3
CREW SCHEDULING

This chapter discusses the merits and costs of alternative automated crew scheduling systems that WSF could use. It describes the existing WSF crew scheduling system, describes available commercial and public domain software, comments on the advantages and disadvantages of these programs, determines the costs of in-house program development, and makes recommendations about the purchase/development of such a system.

CURRENT WSF PRACTICE

Currently WSF assigns vessel and terminal crews manually to particular vessels, terminals or pieces of work. Above-deck crews are assigned differently from below-deck crews as a result of the differences in labor rules governing the crews, and both are subject to rules different from the rules for terminal personnel. Each of these groups of employees will be discussed separately below.

Like vessel schedules, crew schedules are often based on historical schedules. This reduces the time required for developing the schedule and, for the most part, optimizes the use of crews. In recent years, the WSF has increased the number of above-deck crews it moves between routes during their two week work schedule to reduce the total amount of labor required to man all scheduled service. This crew interlining (i.e., using a crew on more than one route) has advantages in that it reduces the total amount of labor required, but it has caused some morale problems among the crews. Some WSF personnel feel that these morale problems may have caused increases in sick time and absenteeism. Some personnel also expressed to the project team that the switching of crews between different types of vessels may have contributed to some incidents in which patrons' vehicles were damaged when being loaded onto a ferry, since boats of different classes have different height restrictions and therefore different vehicle loading characteristics.

Below-Deck Crew

For the most part, below-deck crews are assigned to seven consecutive shifts of 12 hours on and 12 hours off. This is then followed with seven days off. Specific work rules can be found in the WSF union contracts.

Below-deck crews are normally assigned to specific vessels, as opposed to routes or vessel runs. The engineers and oilers perform maintenance when the vessels are not in revenue service. This differs from bus and airplane service, where routine maintenance is performed by separate maintenance personnel at specific maintenance facilities. WSF does perform major maintenance at a similar facility at Eagle Harbor, but routine maintenance is done by on-board engineers. This use of full-time crewing means that the below-deck crew schedule does not include any "dead time" (i.e., unproductive time), provided that the engineers use their non-revenue service time productively.

Above-Deck Crew

Above-deck crews are normally scheduled for 10 consecutive shifts of eight hours on and 16 hours off, followed by four days off, or five consecutive days on followed by two days off. Some differences in the above schedules occur as a result of the vessel schedules and WSF's attempts to minimize crew costs. These differences occur primarily in the San Juan Island routes, where "touring" watches are scheduled. Touring watches allow up to 16 hours of service on two shifts within a 24-hour period, so long as a six-hour break is provided between shifts.

Above-deck crews are normally assigned to vessels or position numbers (a position number is used to designate trips made by an unnamed vessel: for example, if two vessels alternate taking the first trip in the morning) as a group or "watch." Each watch consists of the crew positions necessary to operate the specific type of vessel assigned to that route and boat number (e.g., an above-deck watch might include one captain, one mate, two able bodied seamen, two ordinary seamen, and one matron). Watches generally stay together throughout a two-week schedule period. If the crew moves to a vessel with smaller crewing requirements, the extra crew is carried despite the lack of need.

Terminal Staff

The primary terminal staffing requirements are determined by the terminal agents at each dock. The Assistant Terminals Manager helps coordinate the movement of terminal staff between terminals.

Terminal staff generally work exclusively at one terminal. Staff assignments are a function of historical traffic demand, vessel sailing times, estimated rates for selling tickets, and the number of available ticket windows. A crew scheduling system could provide a terminal staff schedule as well as vessel crewing requirements. However, such a system would require access to passenger and vehicle traffic statistics and sales rate data. It would also be necessary to move the primary scheduling function into Coleman Dock (away from the individual terminals) to obtain access and benefits to the system.

BENEFITS OF AUTOMATION

Automating the crew scheduling would provide three major benefits to the WSF:

- the ability to more effectively analyze scheduling options under existing work rules, possibly resulting in a lower cost allocation of labor,
- the ability to test the financial benefits of prospective work rule changes, and
- an increase in the speed with which scheduling can be accomplished.

These advantages are described later in this section.

The fall '86 crew schedules contain roughly 240 hours of unproductive above-deck crew time (dead time) during each two week period. This surplus comes from the WSF's inability to schedule all paid time as productive time (i.e., scheduled service and associated turn to and tie up time). The above dead time costs the WSF roughly $1,024,000 over a year's time. The current dead time is shown in Exhibit 3-1. Note that WSF uses some of this "unproductive" time to provide occasional gas trips to various islands as well as other vessel moving chores.

The vast majority of this dead time is the result of restrictive labor rules, and no amount of scheduling ingenuity will reduce it without changes to the basic labor agreements. To significantly reduce this dead time, or expand service on many routes during peak periods, the WSF will need to obtain work rule changes from its major unions. Prospective labor rule changes include but are not limited to

- a standard work week of four 10-hour days,
- an increase in the number of part-time above deck employees,
- the ability to schedule small amounts of overtime,
- use of split shifts, and
- elimination of the five days on/two off or 10 days on/four off provision.

Appendix B contains a more thorough examination of prospective work rule changes.

Some cost reductions could be gained with the existing work rules by scheduling crew positions instead of watches, as is currently done. That is, instead of having a few watches during which all positions are scheduled the same, the system would schedule able bodied seamen (AB) differently than ordinary seamen (OS), and both might be scheduled differently than captains.

Scheduling By Position

An example of how this scheduling system might work is shown in Exhibit 3-2. This example uses two Super class ferries, each operating 16 hours per day. Each Super has a complement consisting of four ABs. As can be seen in this example, a total of 23 ABs are required to cover one week's (or two week's) service period. The 23rd AB has three days per week available to relieve sick employees or to assist on another route. Conventional scheduling would require six watches for these two vessels, or 24 ABs. Scheduling by position would thus save one position in this case.

Scheduling By Position: Advantages. Scheduling by position has two advantages. One is that crew designations that have multiple positions within a current watch can often save one or more full position as demonstrated in Exhibit 3-2. Essentially, the "dead time" of several positions can be used to replace one position.

Funds can also be saved in those few instances in which a crew that is larger than required operates a vessel. This occurs now because crews move between vessels as a group. If crews moved between vessels as individuals, the "extra" crew members would not be scheduled for that move and would instead be assigned to some other vessel or used to relieve crew members, thus reducing the cost for replacing sick crew members.

Exhibit 3-1
Comparison of Minimum Above Deck Labor Costs vs. Existing Above Deck Labor Costs [1]

Vessel Class	Above Deck Labor Cost per Hour	Existing Pay Hours per Two Weeks	Actual Operating Hours per Two Weeks [2]	Existing Above Deck Labor Cost per Two Weeks	Minimum Above Deck Labor Cost per Two Weeks	Maximum Potential Savings in Above Deck Labor Cost per Two Weeks
Jumbo	$ 201	448	443.70	$ 90,048	$ 89,183.70	$ 864
Super	193	720	693.83	138,960	133,909.19	5,050
Issaquah	143	1,264	1,105.13	180,752	158,033.59	22,718
Evergreen State	161	640	517.30	103,040	83,285.30	19,754
Steel Electric	125	210[5]	282.00	26,250	35,250	(9,000
Hiyu	85	224	224.00	19,040	19,040	0
	Totals:	3,506	3,265.96	$ 558,090	$ 518,701.78	$ 39,388

Maximum potential savings in above deck labor costs per two week interval:	**$39,388.22**
Maximum potential annual savings in above deck labor costs:	**$ 1,024,093.7** [4]

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[1] Figures are based on the Fall '86 schedule

[2] Actual operating hours is defined as the time from the turn to the tie up of a vessel, and includes deck times.

[3] Part of the savings will be through the elimination of overcrewing (eg. the Steel Electric on the Fauntleroy/Vashon/Southworth line).

[4] This figure asumes that the service levels operated throughout the year are the same as the fall schedule. Because the service level operated during the summer is higher than that operated during the fall, the actual savings would probably be higher.

[5] One steel electric is crewed by an Evergreen State sized crew during part of the week on the Fauntleroy/Vashon/Southworth line. The existing pay hours appear under "Evergreen State," while the actual operating hours appear under "Steel Electric."

EXHIBIT 3-2

SCHEDULING BY POSITION VERSUS WATCH**
(Super Class - 4 ABs / Watch)

BY POSITION

Crew Position	Day of Week							Vessel
	M	T	W	T	F	S	S	
1	X	X	X	X	X			BOAT 1 AM (6 AM TO 2 PM)
2		X	X	X	X	X		
3			X	X	X	X	X	
4	X			X	X	X	X	
5	X	X	X			X	X	
6	X	X					X	
6*			X	X				BOAT 2 AM (6 AM TO 2 PM)
7	X	X	X	X	X			
8	X	X			X	X	X	
9			X	X	X	X	X	
10	X	X	X	X	X			
11	X	X				X	X	
12						X	X	
11*					X			BOAT 1 PM (2 PM TO 10 PM)
12*	X	X	X					
13			X	X	X	X	X	
14	X	X			X	X	X	
15	X	X	X	X			X	
16	X			X	X	X	X	
17		X	X	X		X		
17*					X			BOAT 2 PM (2 PM TO 10 PM)
18	X	X	X	X			X	
19	X	X			X	X	X	
20			X	X	X	X	X	
21		X	X	X	X	X		
22	X	X	X	X			X	
23	X					X		
23*		X	X				X	Available for Relief
Total AB's 23								

BY WATCH

Watch**	M	T	W	T	F	S	S	Vessel
A	A	A	A	A	A			BOAT 1 AM
C						C	C	
B			B	B	B	B	B	BOAT 2 AM
C *	C	C						
D	D	D	D	D	D			BOAT 1 PM
E						E	E	
E *	E	E						BOAT 2 PM
F			F	F	F	F	F	
			C		E			Available for Relief
Total AB's 24								

* This watch or crew is assigned to more than one boat or time period.

** A watch consists of 4 ABs.

Unfortunately, this type of scheduling is quite complicated and works only when several positions that can be manipulated are available within a worker classification, or when crew members can serve under more than one worker classification. For example, if the 23rd AB from Exhibit 3-2 can be used as an OS for two days per week, one OS position can also be saved from the two super class vessels used in that exhibit. This is demonstrated in Exhibit 3-3.

Scheduling By Position: Disadvantages. There are two disadvantages to using this type of crew scheduling technique: complexity of the scheduling process, and the effects of the technique on employee morale and supervisory relationships. These issues are discussed below. Automating the scheduling process can help alleviate the problems caused by complexity, but WSF management will need to examine the issue of crew morale and supervision and its effect on system performance.

Complexity comes from the fact that position based scheduling increases the number of "watches" the scheduler must track roughly eightfold over the number required by the crew based system. The added complexity slows down the scheduling process. It also makes keeping track of the different individual crew positions quite difficult. When performed manually, this type of scheduling leads to a greater opportunity for error. However, an automated scheduler more easily maintains the diverse individual positions and is more likely to approach the optimum schedule. Thus, if WSF wishes to use this system to reduce labor costs, it will need to automate the scheduling process.

The impact of this system on crew morale and functioning is difficult for the project team to estimate. Throughout this project, a number of WSF employees expressed their strong conviction that crews operated best when left as a "team" (i.e., the same individuals operating the same vessel). The use of scheduling by position would alter this "team" structure, in that the crew make-up would vary from day to day. As part of this changing crew make-up, the work assignment of each individual may change throughout the week For example, a crew member might be the highest ranking AB on a vessel on two days, the second senior AB on two days and the third AB on the fifth day. This may cause some confusion in job responsibilities, supervisory roles and result in a degradation of job performance. On the other hand, it may actually improve job performance in that individuals have more varied work, reducing boredom and leading to more attention being paid to their work.

Testing Potential Labor Rule Changes

Another benefit that could be gained from acquiring an automated scheduling system is the ability to test the effects of alternative work rules on labor costs and to easily revise schedules based on accepted work rule changes. Modern, full function crew schedulers allow alternative work rules to be input as part of the normal operation of the system. Complete, revised work schedules and their associated costs and statistics (e.g., labor usage reports) can be produced simply by rerunning the scheduling program with a different set of labor rule inputs. In this manner, the actual benefits that can be gained from alternative work rules can be measured. Such information can then be used in labor negotiations or as information for legislative action.

Speed

The last major benefit of an automated scheduler is speed. The speed of the automated scheduler would allow WSF personnel to accurately determine the crewing costs of several alternative revisions to the existing vessel schedules. In particular, the addition of new service could accurately be budgeted, since a complete crew schedule could be determined quickly, thus reducing the need to rely on budget estimates of labor costs based on averaged costs per hour of service. The speed of such a system would also increase existing labor productivity for existing staff, although probably not to the point where actual staff reductions might be achieved.

COSTS OF AUTOMATION

As with vessel scheduling, the cost of developing or purchasing a previously developed crew scheduling system varies with the complexity of the selected system. Existing public domain software for the transit industry can be purchased at nominal expense, although like the public domain vehicle scheduling systems, a considerable investment would be needed to make the software valuable to WSF. That investment might be greater than developing custom software from scratch, and could result in an inferior product. Existing commercial software has list prices ranging between $45,000 and $300,000. Full software costs would be somewhat above these costs depending on the functions desired, the amount of custom programming

EXHIBIT 3-3

SCHEDULING ABs as OSs AS REQUIRED
(Super Class - 2 OSs / Watch)

BY POSITION

Crew Position	Day of Week							Vessel
	M	T	W	T	F	S	S	
1	X	X	X	X	X			BOAT 1 AM
2			X	X	X	X	X	(6 AM TO 2 PM)
3	X	X				X	X	
3**			X					
4	X			X	X	X	X	BOAT 2 AM
5		X	X	X	X	X		(6 AM TO 2 PM)
6	X	X					X	
6**			X	X				
7	X	X			X	X	X	BOAT 1 PM
8	X	X	X	X	X			(2 PM TO 10 PM)
9						X	X	
9**	X	X	X					
10	X			X	X	X	X	BOAT 2 PM
11			X	X	X	X	X	(2 PM TO 10 PM)
AB *		AB						

BY WATCH

Watch***	M	T	W	T	F	S	S	Vessel
A	A	A	A	A	A			BOAT 1 AM
C						C	C	
B			B	B	B	B	B	BOAT 2 AM
C **	C	C						
D	D	D	D	D	D			BOAT 1 PM
E						E	E	
E **	E	E						BOAT 2 PM
F			F	F	F	F	F	
			C		E			Available for Relief

Total OS's 12

* AB comes from position 23. See Exhibit 3-2.

** This watch or crew position is assigned to more than one boat or time period.

*** A watch consists of 2 OS positions

Conclusion: Savings of one OS position, at the cost of one shift where an OS position is paid for at an AB rate. These savings are in addition to the savings of one AB from Exhibit 3-2.

Exhibit 3-4

Summary of Crew Scheduler Costs

Product	Company	Cost	Hardware Required	Contains Other Functions
HASTUS	Multisystems, Inc.	$80,000 Software License Fee 50,000 Training, Installation, etc. $130,000 TOTAL	IBM mainframe & PC-AT; Prime; Micro Vax; Plexus	Vehicle Scheduling
OPTIBUS	Befag Transport AG	no estimate given	PDP-11; Vax	Vehicle Scheduling
Quik/Pak RAMCUTTER	SAGE Management Systems, Corp.	$45,000 Software only (Total installation at TRI-MET in Portland, $100,000 - Run Cut Software only)	IBM PC-AT	Vehicle Scheduling
Rucus I and II	UMTA	Public Domain	RUCUS I: IBM Mainframe; RUCUS II: IBM PC	Vehicle Scheduling
SBS Crew Scheduling and Operations Control System	Selective Bidding Systems, Inc.	$6,000 a month, and up, to lease $2,5000 a month, for time share $3-400,000 stand-alone system	Prime	Incl. various other payroll & crew dispatching capabilities
Transit Management Systems Scheduling and Runcutting	Vista Systems, Inc.	no estimate given	Prime; Primos; Unix, IBM	Vehicle Scheduling; part of complete transit sys. acct. pkg.
TRIP – Trip Reallocation and Improvement Program	David R. Bomeman and Associates	~$150,000 Mainframe version ~$75,000 Micro version	IBM Mainframe & PC-AT	None

necessary and the need for new computer hardware. Exhibit 3-4 is a table listing the prices of commercially available software for the transit and airline industries. Note that some of these prices include vessel scheduling and other functions.

WSF could also develop, either internally, through TRAC, competitive bid, or through WSDOT MIS, the crew scheduling software. TRAC estimates that development of crew scheduling software would cost roughly $150,000 for a system fully integrated with the vessel scheduling software described in the previous chapter.

Other expenses for implementing the purchased or developed package include

- WSF staff time for training,
- the cost of any additional computer hardware, and
- possible negative reactions by employees to changing schedules caused by techniques such as scheduling by position instead of by an entire watch.

The expenses due to employee reactions are difficult to estimate, but, depending on the changes made, such reactions could be significant.

COMPARISON OF ALTERNATIVES

The study team's review of available software found that airline industry software more closely met the needs of the WSF than any of the other alternatives. The airline packages are geared toward multiple destination trip making and scheduling across weeks, as opposed to optimizing within a day. Note that most of the airline packages do not come with flight (vessel) schedulers and would need to be modified to interface with a vessel scheduling package. This should not be a significant issue. WSF would also need to modify some of this software to handle the differing needs of terminal staff scheduling, if this were to be handled in a centralized capacity.

The transit industry packages are possible choices, but they appear to need much more customization than their airline counterparts. The transit industry software is most adept at minimizing "dead time" through the optimization of split shifts and part time workers. They concentrate on the optimization of schedules within a day, as opposed to the scheduling of personnel over a one- or two-week pay period. While work rule changes within WSF may allow similar labor rules, it is the project team's opinion that split shifts are the least likely of all labor saving changes to be undertaken by WSF.

WSF could develop its own crew scheduling system. This would best be done either by TRAC or through competitive bid. The advantage of choosing this alternative would be that the differences in scheduling below-deck, above-deck and terminal staff could be accounted for in the basic system design. Consequently, WSF would need to exert less effort to force its scheduling needs to fit a prearranged solution. Such a system would most likely be the easiest to implement and would require the fewest changes in current WSF procedures and lines of responsibility.

The project team does not recommend using public domain software. The software available in this area is out-of-date and ill-equipped to deal with the unique scheduling problems of the WSF. A considerable amount of software development would be required to make this software usable, and WSF would be better served if such a development effort were used to develop a system specific to WSF.

Recommended Actions

The project team recommends that the WSF pursue the development of, or purchase of, an existing automated crew scheduling system. As with the vessel scheduling system, however, the vigor with which this system should be pursued depends directly on the chance for changes in labor work rules. The greater the WSF need to investigate or apply alternative work rules, the greater the need for an automated crew scheduler.

Given existing labor rules and prices of commercially available software, the expense of purchasing a system at this time appears to outweigh the financial benefits to be gained. However, if labor rules were to be relaxed, the financial returns from purchasing a combined vessel scheduling/crew scheduling system should exceed the cost of that system.

The development of an automated scheduler will take roughly 18 months to two years. The purchase, customization and installation of an existing system would take between 12 and 18 months. The WSF should take these time frames into consideration when selecting the appropriate time to purchase a system. The project team recommends that this be roughly one to two years before labor rule revisions are expected to take effect, or before WSF wishes to be able to thoroughly examine the impacts tentative work rule changes would have on vessel schedules and system operating costs.

Any system purchased or developed by WSF should allow the flexible revision of key work rule restrictions as new work rules are tested for their effects on the existing labor cost structure. Further, the system should interface with the vessel scheduling system described in the preceding chapter. The reasons for this interface and a description of the interface are described in the following chapter.

CHAPTER 4
INTEGRATION OF VESSEL AND CREW SCHEDULING

This chapter discusses the integration of vessel and crew scheduling systems. It describes the need for integration and the benefits that are gained through the electronic interaction of the two scheduling components. Finally, it suggests two potential processes for achieving that integration.

ADVANTAGES OF INTEGRATION

As is apparent from the discussions in the first three chapters of this report, vessel and crew scheduling are interdependent. A coherent, cost effective vessel schedule can not be made without some knowledge of the labor requirements for meeting that schedule. A crew schedule can not be completed without previously making a vessel schedule. This interrelated scheduling process is shown in Exhibit 4-1.

Because these two schedules are systematically intertwined, and despite the fact that they are usually created independently of each other systems designed to perform these functions logically should be interconnected as well. In fact, most of the commercially available transit industry software come with both bus and operator scheduling components. This integration is accomplished by directing the vehicle scheduling sub-system of these programs to output a computer file that the operator scheduling subsystem can read as input information.

The advantage of this type of integration comes from the elimination of the manual preparation, coding and entry of input information for the crew scheduler. This decreases the cost of performing the task, improves the speed with which the task can be accomplished, and reduces the chance of inputting erroneous information into the crew scheduler. All of these advantages can result in significant savings to WSF.

WSF NEEDS

Any complete scheduling system developed or purchased by WSF should, as a minimum, have integration similar to that described above for transit software, or be capable of integration if the system is developed one sub-system at a time. That is, if a vessel scheduling assistant is purchased, but the purchase of a crew scheduling system is delayed, the vessel scheduler should be capable of integrating with the crew scheduler when that second system is added. Furthermore, WSF may desire that the vessel and crew scheduling systems have an even better ability to integrate the systems present in existing transit industry software.

In the transit industry, adding hours of service to specific bus routes is relatively easy. Because the transit industry uses split shifts and part-time workers, a good operator scheduling system can provide the incremental labor required for marginal service additions at a relatively low marginal cost. That is, the marginal operating cost of one hour of additional revenue service is roughly equal to one hour of driver time and the associated fuel costs. Consequently, transit operators have little need for transit vehicle scheduling systems to contain more integration than the limited ability to write files to the operator scheduler.

For the WSF, the addition of marginal increases in service can significantly increase the required crewing levels. Because WSF employs few part-time vessel personnel and split shifts are not allowed, the WSF must tailor its service to average a multiple of eight hours per day per vessel. That is, over a two-week period, for every vessel that operates for nine or seventeen hours per day, one must operate for seven or fifteen hours per day. If these basic rules are not followed, in most cases any service in addition to the "standard" eight hour shift costs as much as an eight hour shift.

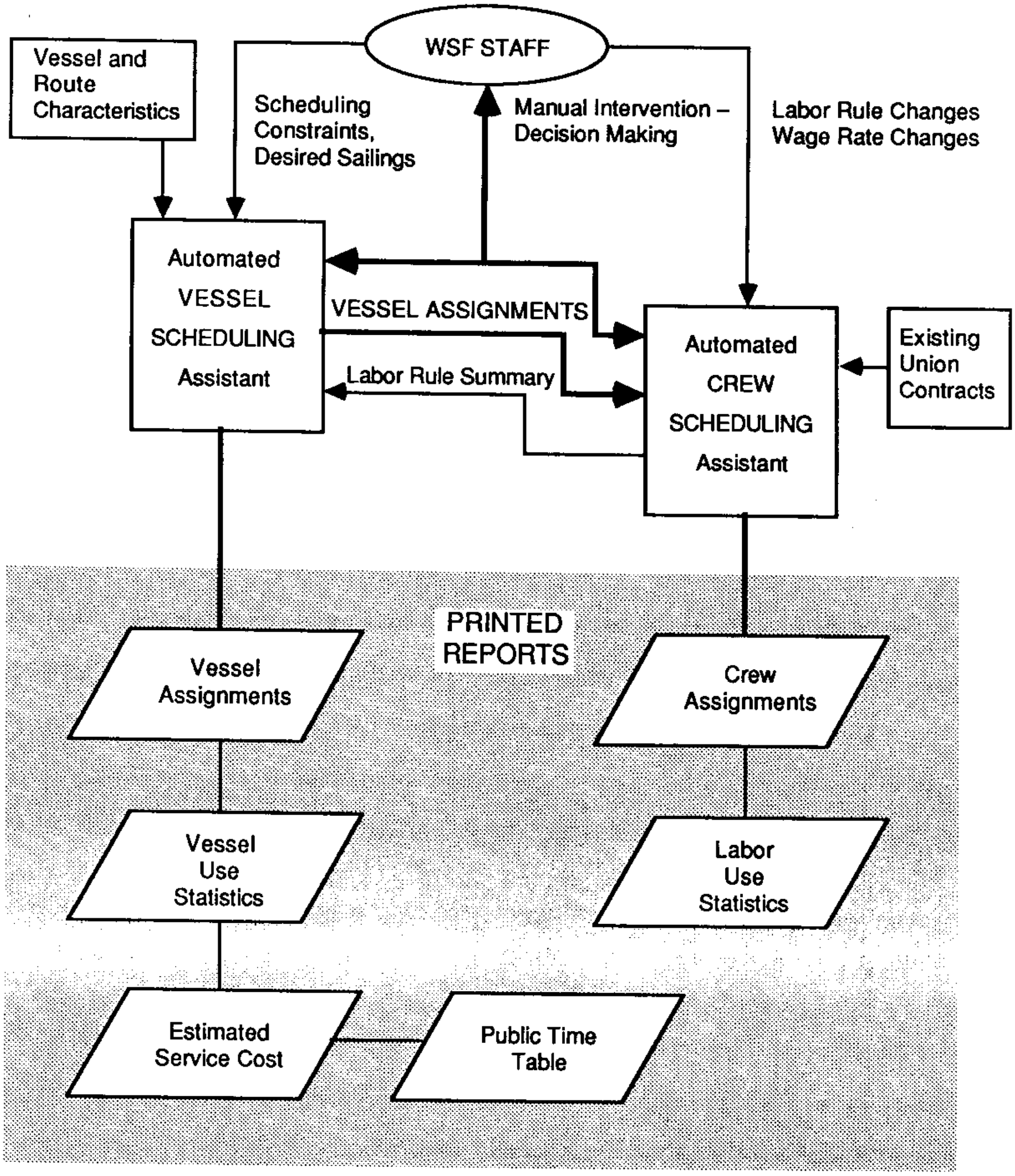
By following the eight-hour scheduling criteria, a crew scheduler can relatively easily avoid hiring a crew that operates a vessel for less than eight hours but is paid an eight hour guaranteed wage. However, as WSF work rules change to include ten-hour days, more part-time employees, rostering, and other new variables, the crew scheduler will find it more and more difficult to manually determine the effects on labor requirements of small additions or subtractions in service levels. Therefore, WSF should ensure that the vessel and crew scheduling sub-systems be sufficiently integrated that a quick crew schedule can be computed at any time during the vessel scheduling process. This could be done by either

- including a basic set of work rules within the vessel scheduling system itself, or
- temporarily suspending operation of the vessel scheduler to run the crew scheduler and returning to the vessel scheduler with crewing information after completion of that task.

These two options are described below.

Exhibit 4-1

Flow of Scheduling Process



Within Vessel System Crew Estimation

The first of these options could be performed by a stand-alone vessel scheduling system. It might function by tracking scheduled hours of service against a set of criteria indicating the cost of reaching certain levels of service per route, and associating that level of service with a specific cost. Such a system would, by necessity, be less complex and less accurate than the alternative described below but it would probably operate faster and require less initial programing.

Depending upon the systems' degree of integration, work rule changes in such a system could either be made directly within the vessel scheduler (i.e., the set of criteria) or within the integrated crew scheduler, which would automatically update the criteria used within the vessel sub-system.

Temporary Suspension of Vessel Scheduling

The second option, the request for a crew cost estimate, would cause a temporary file to be written as input to the crew scheduling sub-system, and the current vessel schedule would be saved on computer disk. The crew scheduler would then produce an initial crew schedule (without human input) and estimate the cost of that schedule. After producing reports that document the labor costs and distributions, the system would return to the vessel scheduler for additions and changes to the vessel schedules.

By suspending the vessel sub-system to run the actual crew system, a more accurate cost estimate of the actual labor requirements would be provided, since running the complete crew scheduling system would allow the program to use all of the optimization routines, not just follow a few basic criteria. It would also more readily allow the program to split crews between routes to make maximum use of availability.

Because of its more complex computational abilities, this option would slow the vessel scheduling process, since as the vessel scheduler would have to wait for the crew scheduler to finish before continuing with another route or additional changes. This option also presents some programming complexities that may increase the cost of developing and operating such a system.

The advantage to WSF of this second level of integration is that the schedule writer could more easily determine the true costs of alternative vessel schedules. This would allow more informed decision making on the part of WSF staff and result in lower costs per hour of operation.

In both options above, after the vessel schedule was completed, the crew scheduler would be run again with human input to determine the final crew schedules and budgeted costs. These schedules might differ slightly from those schedules produced as part of the vessel scheduling computations described above.

APPENDIX A
REQUIREMENTS OF AN AUTOMATED VESSEL SCHEDULING SYSTEM

APPENDIX A
REQUIREMENTS OF AN AUTOMATED VESSEL SCHEDULING SYSTEM

This appendix contains a summary of the basic operations a WSF automated vessel scheduling system should perform. A glossary of terms used in this appendix, and throughout the report, is included in Appendix D.

This appendix is structured in three parts:

- program setup,
- scheduling capabilities, and
- reporting.

Each of these topics contains several recommended functions.

PROGRAM SETUP

- The user must be able to update vessel operating costs, crew requirements, and dock times.
- The user must be able to add new vessel classes to the system.
- The user must be able to add new routes to the system.
- The program must contain the distance in nautical miles between terminals and the speed ranges of each vessel class.

SCHEDULING CAPABILITIES

- The user must easily be able to make changes to specific trips or groups of trips.
- Changes made in one trip should be reflected in other trips in the schedule, unless specific actions are taken to protect specific trips from changes (i.e., there must be a trip leaving from this terminal at this time).
- Where changes in one trip prohibit a protected trip from being made (e.g., insufficient turn-around time exists), the user should be able to override system defaults for load/unload times or other constraints.
- The user should be able to add or delete trips as desired.

- The user must be able to input the class of vessel to be used on a route or trip.
- The program should maintain a listing of available vessels (i.e., those not currently deployed).
- The program should maintain and utilize average sailing and dock times per vessel class for each route.
- For any particular route, the user must be able to create different and/or duplicate schedules for each day of the week.
- The program should be able to schedule trips that do not appear on the printed "official" schedule but can be made if traffic demand warrants.
- The user should be able to alter trip patterns as desired (e.g., not all trips between Anacortes and Orcas stop at Lopez).
- The program must be able to generate schedules in which the first vessel to arrive at a terminal is not always the first to depart.

REPORTING

- The program should be able to generate line schedules for each route.
- It should be able to produce vessel summaries for each vessel in the system.
- The program should be able to generate graphic displays of time-sequenced schedules.
- Ideally, based on input traffic statistics, the program should be able to estimate vehicle and passenger loadings for specific trips.
- The program should be able to produce reports containing the following summaries:
    - total operating hours (includes turn-to, tie up and dock times),
    - total revenue hours (excludes turn-to, tie up and dock times),
    - total revenue hours/total operating hours,
    - total operating cost,
    - total operating cost per hour,
    - total capacity provided per route, and
    - total space hours (vessels times revenue hours).

APPENDIX B
REQUIREMENTS OF AN AUTOMATED CREW SCHEDULING SYSTEM

APPENDIX B
REQUIREMENTS OF AN AUTOMATED CREW SCHEDULING SYSTEM

This appendix contains a summary of the basic operations an automated crew scheduling system acquired by WSF should perform.

1. The program should be able to generate an optimal (i.e., least cost) crew schedule based on WSF's existing work rules. It should also have the following abilities to allow modification to the rules in response to changes to the labor contract.
    a. the ability to increase the maximum percentage or total number of part-time employees allowed (i.e., employees who do not have an 80-hour guarantee per two-week pay period, and who generally work only during the commuter periods or on weekends);
    b. the ability to deliberately schedule overtime;
    c. the ability to schedule employees to work any combination of days on or off as long as their total pay hours within a two-week period equals 80 (rostering). An example of this is a shift which works for seven days on, followed by three days off, followed by three days on, followed by one day off. A variation on this work rule change is the ability to schedule employees to work for four ten-hour days, followed by three days off. Rostering assumes an elimination of the "five days on followed by two days off" provision of the contract;
    d. the ability to schedule by position rather than by crew -- a technique not currently prohibited by the contract but difficult to employ if personnel are scheduled manually.
    e. the ability to schedule a certain percentage or number of employees to have split shifts (e.g., employees are scheduled for approximately four hours in the morning and approximately four hours in the afternoon and have an unpaid break in the

middle of the day). Within this change, an automated crew scheduling system must be able to

- modify the maximum percentage/total number of split shifts allowed,
- modify allowed spread time (after which penalty pay is incurred),
- modify the rate at which penalty pay is incurred after the maximum allowed spread time has been exceeded;

f. the ability to schedule higher pay workers for lower paying positions, if such substitutions result in savings to WSF.

2. The user should be able to easily modify the computer generated optimal crew schedule (i.e., she/he must be able to tailor it).
3. The program must be able to generate line-by-line crew schedules.
4. The program must be able to generate day-by-day shift assignments (i.e., relief times, place of relief, hours worked, position number(s) worked, days off, open work days, etc.).
5. The program must be able to generate basic crew schedule statistics (i.e., total number of crew members or shifts required by worker classification; total pay/hours over a two-week period; amount of travel pay incurred; number of part-time, straight and split shifts; etc.).
6. The program must account for the fact that although IBU and MM & P <u>shifts</u> must begin and end their duties at the same terminal (if not, they are paid mileage and wages), <u>lines</u> can have more than one relief terminal.
7. The program should balance total hours assigned per person over a two-week period (i.e., one day of less than eight hours of work followed by a day of greater than eight hours of work, equaling 16 hours of work at the end of the second day). It is possible for workers to have a light week (less than 40 hours) followed by a heavy week (greater than 40 hours), or vice versa.

8. The program should be able to use surplus crews/shifts from a route as part of the makeup crew (extra board) and, similarly, it should be able to use makeup crews to crew regular service on other routes. The program should calculate travel costs for use of these crews.

9. The program should be able to schedule touring watches (i.e., shifts which end their duty away from their home terminal and will operate the vessel the next morning).

APPENDIX C
SUMMARY OF WSF'S CURRENT WORK RULES PERTAINING TO CREW SCHEDULING

APPENDIX C
SUMMARY OF WSF's CURRENT WORK RULES PERTAINING TO CREW SCHEDULING

ABOVE DECK (MM & P, IBU) PERSONNEL

- No deck crew can be on duty for greater than 16 hours on two work shifts within one 24-hour tour.
- Shifts can be either five consecutive days on followed by two consecutive days off, or ten consecutive days on followed by four consecutive days off. MM & P and IBU workers have an 80-hour guarantee in a two-week pay period.
- Shifts must not be greater than 80 scheduled hours in a 14-day period.
- Shifts can be greater than eight hours, but not greater than nine hours (except in the San Juan Islands).
- All crews are relieved at the same terminal where they began their shifts; if not, they are paid mileage and wages.
- For touring watches (two shifts within 24 hours), crews must have at least six hours off between shifts. Also, both shifts must not total greater than 16 hours for MM & Ps, or 27 hours for IBUs. There cannot be greater than five consecutive tours (ten days) followed by not less than four consecutive days off.
- Employees assigned to more than one route or terminal shall be assigned to a home terminal and will be paid mileage and travel time to compensate the balance of their tour.
- Part-time employees have a four-hour guarantee.
- Only ten vessel department and 35 terminal department part-time employees are allowed.
- Crews on extra service vessels can be worked for four ten-hour days, which must be followed by three consecutive days off.

BELOW-DECK (MEBA) PERSONNEL

- MEBA (Engineering Department) workers work for either eight- or 12-hour days, and have an 80-hour, two-week guarantee.

- Vessels (not boats) that are scheduled for more than 16 hours in service a day are engineered by MEBA personnel working 12-hour days, seven days on, followed by seven days off. Although they work for 84 hours, they are paid for 80, and four go into compensation time.
- MEBA workers receive overtime after 12 hours of continuous work and receive triple time after 16 hours of continuous work.
- Vessels that are scheduled for less than 16 hours in service a day are engineered by MEBA workers working either 12- or eight-hour days. MEBA workers working eight-hour days work five days on, two days off (not ten on, four off).
- MEBA personnel can work four ten-hour days on non-scheduled or seasonal vessels.
- Regular relief MEBA employees work according to the following schedule: their work scheduling cycle runs from the last two-week period of the previous quarter to the end of the last two-week period in the current quarter.
- Engine Department personnel are assigned to a vessel and begin and end their duties at the same terminal.
- Engine Department watch relieving terminals are as follows:
    - Fauntleroy-Vashon-Southworth = Fauntleroy
    - Seattle-Bremerton = Seattle
    - Seattle-Winslow = Seattle
    - Edmonds-Kingston = Edmonds
    - Mukilteo-Clinton = Mukilteo
    - Port Townsend-Keystone = Port Townsend
    - Anacortes-San Juan Islands-Sidney = Anacortes

APPENDIX D
GLOSSARY OF SCHEDULING TERMS

APPENDIX D
GLOSSARY OF SCHEDULING TERMS

Allowed time	The difference between total pay hours and total operating hours. Can be calculated on either a systemwide or a vessel-specific basis. When allowed time is equal to zero, labor is being utilized to the greatest extent possible.
Blocking	The process of assigning vehicles to specific trips.
Block time	The difference between the time a vessel is scheduled to depart from the terminal at one end of a line and the time it is scheduled to depart for the terminal at the other end of the line. Block time is generally equal to one-half of a vessel's round trip sailing time.
Clear time	The time a shift or watch is scheduled to go off duty. Can be the same as or later than a vessel's tie-up time.
Crew	Although occasionally used synonymously with the term "watch," more commonly refers to the entire unionized operating staff.
Crew scheduling	The process of assigning shifts or watches (not specific employees) to available pieces of work.
Deadhead time	The amount of time a vessel spends operating in non-revenue service. Deadheading is necessary for positioning vessels between terminals and other terminals, maintenance facilities and fueling docks.
Dispatch	The process of assigning personnel to substitute for absent employees. Analogous to the term "extra-board management" used in the transit industry.
Dock time	The amount of time a vessel spends between sailings while berthed at a terminal. Analogous to the terms "layover" or "recovery time" used in the transit industry.
Extra service	Supplemental service which does not appear in the public timetable. Extra service is either scheduled in advance or is made at the terminal agent's discretion if extended or more frequent service is temporarily needed on a route.
Headway	The amount of time elapsed between consecutive vessel departures from a terminal.
Interline	The scheduling of a vessel to operate on two or more separately identified routes during the course of its service day. Used to maximize vessel utilization and/or to provide a more desirable timing of trips.

Make-up crew	Employees who are used to substitute for employees unable to report to work because of illness, or emergency. Make-up crew employees work on a year around basis and are guaranteed 40 hours of straight time pay per week. Make-up crews can, if needed, be used on a repeating basis to crew regularly scheduled service.
Multiple piece straight	A shift in which an employee works on two or more different vessels during the course of his work day and does not have an unpaid break.
On call employee	An employee who may or may not be working on a year around basis, and who is not guaranteed 40 hours of straight time pay per week. The employee is assigned work based on his date of hire and availability.
Open work day	A day in a watch's work schedule during which employees are not assigned to specific work, but must be available to perform any necessary duties (e.g., the provision of extra service).
Operating hours	The amount of time elapsed between the turn to and the tie-up of a vessel including dock times. Can be calculated on either a systemwide or a vessel-specific basis. Analogous to the term "platform time" used in the transit industry.
Part-time employee	An employee who may or may not be working on a year around basis, and who is not guaranteed 40 hours of straight time pay per week, but does have a regular schedule assignment.
Pay hours	The amount of hours required to crew a vessel without violating the constraints of the labor agreement. Can be calculated on either a systemwide or a vessel-specific basis.
Pay period	Compensation earned between the first and the fifteenth day of each calendar month, or compensation earned between the sixteenth and the last day of each calendar month. There are 24 pay periods during each calendar year.
Position number	A term used for identifying a specific schedule assignment within a running schedule.
Position scheduling	A type of scheduling in which employees are scheduled individually in shifts rather than in groups or watches. Analogous to the term "runcutting" used in the transit industry.
Relief employee	Employees who are used to substitute for employees who were able to give advance notice of an upcoming absence, such as a vacation. Relief employees work on a year around basis, and are guaranteed at least 40 hours of straight time pay per week.
Relief terminal	The terminal at which a shift or watch is scheduled to make reliefs. Travel to or from any other terminal must be paid at the regular straight time rate plus mileage compensation.

Report time	The time a shift or watch is scheduled to go on duty. Can be the same as or earlier than a vessel's turn to time.
Revenue hours	The amount of time a vessel is scheduled to be generating revenue. Does not include turn to, tie-up, deadhead or dock times. Can be calculated on either a systemwide or a vessel-specific basis.
Rostering	A type of scheduling in which employees are scheduled to work any combination of days on or off as long as their total pay within a certain period of time equals a certain number of hours.
Rotation of vessels	A situation in which a vessel is used on one schedule assignment one day and on another the next day. This usually occurs when a vessel is scheduled to begin its service day at one terminal and end it at another.
Running schedule (entire line)	A schedule format in which the schedules of each vessel operating on a line are displayed within the same timetable. Analogous to the term "headway sheet" used in the transit industry.
Running schedule (individual vessel)	A schedule format in which the schedules of each vessel in the system are identified separately. Analogous to the terms "block summary" and "paddle" used in the transit industry.
Sailing time	The time required for a vessel to travel between terminals at a given speed. Measured from the time the tie down ropes are removed at one terminal to the time they are replaced at the next terminal.
Scheduled overtime	Overtime which is scheduled in advance and which is not in violation of the labor contract.
Single piece straight	A shift in which an employee works on the same vessel during the course of his work day and does not have an unpaid break.
Space allocation	The allocation to different terminals of a specific number of vehicle spaces per departure. Used primarily in the San Juan Islands.
Space hours	Maximum vehicle capacity of a vessel multiplied by the number of revenue hours of service for that vessel over a certain period of time. Used as a measure of quantity of service supplied, both in terms of capacity and frequency.
Split shift	A shift in which an employee's work day is broken into two segments separated by an unpaid break.
Spread time	Used with split shifts as a measure of the amount of time elapsed between an employee's first report time and last clear time.
Swing time	Used with split shifts as a measure of the amount of time an employee has off between work segments (i.e., his break time).
Tie up time	The time a vessel goes out of operating service for the day or a certain period of time and is no longer in need of operating personnel.

Touring watch	A watch that is assigned to be on duty for two successive work shifts not exceeding 16 working hours during a maximum period of 27 hours. These shifts must be separated by a minimum of six hours off.
Travel allowance	The time allowed and paid an employee to travel between relief terminals.
Turn to time	The time a vessel goes into operating service and is in need of operating personnel.
Two week work schedule	A period of time consisting of 14 consecutive days at the end of which full-time employees are required to receive 80 pay hours.
Watch	A group of employees having the same two-week work schedule assignment. Often referred to as a "crew."
Year around position	A position which receives at least 80 hours of scheduled straight time work within 14 consecutive days during periods of the lowest level of scheduled service.