EVALUATION OF NAVCOM'S VEHICLE GUIDANCE AND TRACKING SYSTEM FOR SNOW REMOVAL MANAGEMENT

FINAL REPORT

April 2003

Submitted to:

District Department of Transportation

District Department of Transportation

Prepared by:

Dr. Errol C. Noel, P.E. & Dr. Stephen Arhin, P.E.
Howard University Transportation Research Center
2366 6th Street, NW, Washington, DC 20059

NAVCOM's Vehicle Guidance and Tracking System for Snow Removal Management

INTRODUCTION

The District of Columbia Department of Transportation (DDOT) is responsible for the operation, planning and maintenance of all roads and ensures the safe and efficient movement of the people and goods in the City. DDOT has over the years been striving to improve on the quality of the service it provides. Some of the tasks undertaken by DDOT in ensuring safety and efficiency include snow removal, tree cutting, pavement repair, signal retiming, traffic calming, among others.

One of these critical operations that interests DDOT and which it (DDOT) constantly wants to improve upon is snow removal. Snow removal is a highly visible public safety activity and is also one of the most time-sensitive and publicly-observed service performed by DDOT.

Although the City's employees operate many of the snow removal vehicles and much of the associated infrastructure, private contractors do an appreciable proportion of the work involved in this operation. The combined effort of the City's employees and private contractors is usually marshaled for quick response to forecasted and unannounced winter-storm conditions in the city.

DDOT faces many challenges when coordinating snow removal operations, street repair and permits, and tree maintenance. The management of information for these operations is time-consuming and involves manual paperwork, facsimiles, radio and telephone communication. The current process does not provide real-time information that would enable the City to improve its management of snow operations. Significant drawbacks to the current system include manual data entry, transportation of paper forms and reports to the field, data redundancy, delayed filing of reports, duplication of effort, delayed auditing and accountability and the inability to provide accurate report to the public about current accomplishments. Faced with the need to improve snow management service across the City, DDOT embarked on exploring satellite-based information system that would provide real-time status information as well as historical records. DDOT envisioned a system that can answer real-time questions with minimum to no delay, such as:

(a) How many trucks are in operation? Where are they deployed and what is their progress or status?
(b) What is the status or percentage of streets with snow that have been cleaned/cleared within the District?
(c) When will all roads or major thoroughfares be cleared?
(d) Has a task been completed or what is its completion status?
(e) How much will this effort/project cost?

PURPOSE AND SCOPE

DDOT estimated that significant cost and time savings could be achieved through improved and automated control of some of the above mentioned operations. As a result, the efficiency of providing services could be improved.

The use of satellite-based snow management has been experiencing

increasing attention among the States. The vast extent of suburban and rural mileage and the availability of undisturbed access to Global Position Satellites have made automation an attractive option for the States. The use of GPS in snow management in urban areas, however, posed a challenge because of tall urban structures that could block the pathway of satellite signals. The densely packed buildings create what engineers call an "urban canyon effect", blocking or distorting signals from the satellites to the service vehicles. The City became aware that the system it needs must be effective despite its built-up characteristics and embarked on three demonstration projects involving satellite-based information systems. The idea is to find the best system that is most responsive to City needs. One of the systems of interest was developed by NAVCOM Inc. LLC. This report focuses only on the NAVCOM system.

DDOT, under an agreement with Howard University, engaged NAVCOM to explore the possibility of achieving the above requirements through a pilot project. In addition to improving DDOT's snow management system, NAVCOM was also required to include the integration of DDOT's current service data entry system program, HANSEN, along with NAVCOM's snow management software. DDOT uses the HANSEN System for logging calls for service from the community. The services include fixing potholes and street lights, etc. Information obtained from calls from citizens requesting DDOT's services are logged into the HANSEN program. The data is printed and submitted manually to the appropriate service agency at which a task order for the service is developed. NAVCOM'S integration software proposed to automatically transmit the electronic request from the HANSEN file developed to the appropriate service agency. This would eliminate the manual submittal of service orders. The real-time information generated by the HANSEN system was to be used in this pilot project.

The "Snow Management and Vehicle Tracking System" involved the acquisition and installation of NAVCOM's units in sixteen (16) vehicles as well as the installation of software at DDOT for managerial and operational purposes. The proposed snow management system was to manage a fleet of vehicles used in snow removal, street maintenance and other service operations.

The basic elements of the proposed snow management system in this pilot study were:

- to provide equipment and install software
- to train and educate users at DDOT, and
- to ensure the functionality and reliability of the systems and software as a whole during snow removal and other field operations.

NAVCOM's integration software was to be installed on designated computers located at DDOT and provided by NAVCOM under the sub-contract. Call logs from the HANSEN system were to be exported into the NAVCOM software which, in turn, would send each complaint or call for service to the appropriate service unit. In principle, the NAVCOM software was supposed to be able to convey all service calls to the point of service with minimal delay. All calls were to be time-stamped and dated on both the sending and receiving ends. The service manager or supervisor was expected to convey service requests to service vehicle and to monitor progress using the NAVCOM Guidance and Tracking System (GTS). In addition, the service manager should be able to determine when a service vehicle arrives at the appropriate location to execute

the service and when the service is completed.

SYSTEMS INSTALLATION

NAVCOM's GTS units were installed in six (6) out of the proposed sixteen (16) vehicles. Four (4) of the vehicles were from the Service Inspection Division while two (2) were from the Maintenance Division. The installations were done at the Fleet Department premises off New York Avenue NE, DC and at the Maintenance Department off Rhode Island Avenue. These were typically done during normal weekday business hours. In some cases, installations were done over a weekend, with the permission of DDOT officials. The installation team of NAVCOM wired the vehicles from the sensors in the main engine block before installing the GTS unit itself on a stand in the vehicle. The wiring from the sensors enables the detection of forward and reverse moments of the vehicle as well as the location detection and tracking capabilities of the NAVCOM system. The vehicle's battery supplies electrical power to the GTS unit. NAVCOM's Guidance and Tracking software was installed on the GTS units.

In addition, NAVCOM provided a server with a monitor at DDOT's office (Reeves Center). The NAVCOM Guidance and Tracking and the HANSEN Integration software programs were installed on the server. The Guidance and Tracking Software includes a map overlay for the visual display of vehicles on local streets.

METHOD

The primary objective evaluated was whether NAVCOM's GTS would provide management of snow removal operations and services with accurate real-time information that would enable DDOT to use available resources more effectively while providing better services to the community. HUTRC was tasked to conduct this evaluation and to develop a comprehensive evaluation plan that would also be suitable for evaluating similar systems. The evaluation plan is presented in the Appendix. HUTRC was to evaluate NAVCOM's GTS and Integration Software in the following areas:

1. Functionality of the GTS
2. Functionality of the HANSEN Integration Software
3. Reliability of the GTS, and
4. Reliability of the HANSEN Integration Software

Sixteen vehicles were designated for this pilot project. Some of the functions of the proposed NAVCOM GTS evaluated include:

- ability to send/receive messages to/from the management center at DDOT
- ability to send/receive messages to/from NAVCOM units in service vehicles
- ability to track vehicles at management center during snow operations on a map overlay
- ability to determine the status of snow removal operations on a map overlay.

FINDINGS AND DISCUSSION

Although the purpose of this 9-month pilot project was to evaluate the functionality and reliability of the system during snow operations, good weather

conditions during winter months did not allow a full scale exposure of the system during the intended season. The notice to proceed was obtained in January 2002 while the contract termination date was September 2002. For various technical, logistical and administrative reasons, the entire NAVCOM system was not fully operable by the contract expiration date. The findings presented below are based on assessments of what were accomplished within the contract period.

• ***Vehicle Installations***

The wiring together with the GTS unit and the stand were generally not appealing in appearance. On the whole, the items installed in the vehicle were not to DDOT's expectations and generally looked unprofessional. Apparently, NAVCOM had not considered ergonomics in the design and placement of equipment and their mounting structures. This was a critical failure on NAVCOM's part since damage to vehicles became a concern of DDOT officials. In addition, NAVCOM's installation process was tedious and time-consuming. It took almost five (5) days to complete installations on the first vehicle. Each subsequent vehicle was completely installed on a 2-day average period. On the other hand, some of the vehicles were not readily available since they had also been earmarked for other similar pilot projects.

• ***Server Installations***

NAVCOM also provided a server at DDOT for the purpose of managing the vehicle dispatch and coordinating service (management center). The two software programs for managing and coordinating snow removal operations as well as for other services were installed on the server. As at the end of the contract, the server could not adequately communicate with the units installed in the six (6) vehicles. Although NAVCOM was provided with both internal and external IP (Internet Protocol) addresses for the purposes of this pilot study, and additional time beyond the contract termination date, the problem persisted and seemed to be related to NAVCOM's technology and software program itself. It was therefore evident that NAVCOM could not put the server to its operational use. Repeated efforts to rectify the problem resulted in marginal incremental improvement, but not to the expected communication standards. There was no seamless communication.

• ***Training***

NAVCOM provided training to two (2) drivers who usually operate vehicles for inspecting services completed or in progress. Feedback from the drivers indicated a complex NAVCOM system which needs extensive education for an ordinary driver. In addition, the instructor/trainer did not clearly and exquisitely explain the steps to be taken to successfully operate the system. This resulted in critical and potential users showing a disinterest in the system. In addition, the display on Palm computers was not designed for ease of comprehension. It would appear that NAVCOM did not consider the driving chore in designing the display for the various messages.

• ***Demonstration***

On a demonstration to HUTRC where NAVCOM used its own vehicle

(1 vehicle), the system was found to be able to track the movement of vehicles and send messages without messages being truncated. A Palm Pilot (1705) was used as the GTS unit in the vehicle. On display was also the map overlay which located the vehicle in 30-second intervals. Using a cellular phone, the driver gave the location of the vehicle which was then checked with the location on the map overlay. The locations on the map were found to be fairly accurate, however, the 30-second delay made it impossible to track the vehicle in real-time. Moreover, this demonstration did not reveal any improvement in the design of information layout on the Palm Pilot screen. The ergonomics issue remained. Messages sent from the vehicle were not easily readable. Messages sent to the vehicle were easier to read. However, since the Palm Pilot (i705) used in this demonstration was not mounted in the vehicle, the ease with which a driver could clearly read a message without endangering or hampering his/her driving operation could not be evaluated.

- ***GTS and HANSEN Integration Software***

The GTS software which includes *Map Magic* software for the visual display of vehicles was briefly evaluated during NAVCOM's demonstration to HUTRC. The GTS software itself was found to be not very user-friendly. The Map Magic software fairly showed vehicle locations and movements in 30-second intervals. The capability of the map overlay to display a variety of colors which could indicate vehicle tracking between origin and destination and whether streets with snow have been cleared or not could not be demonstrated. The system was not sufficiently developed to provide this type of information.

- ***NAVCOM Management***

NAVCOM's technical staff and support team showed some level of unprofessional attitude regarding DDOT and University protocol. In addition, the entire team was centered on a single hardware technician, whose expertise could not be utilized to solve recurring problems encountered in various phases of the pilot project. NAVCOM also demonstrated poor managerial and customer relations that dampen the building of trust between itself and DDOT officials who had to provide access to secure computer systems at a time when the Nation is at war against terrorism.

CONCLUSION

The following conclusions were reached:

- Statistical data were not captured. The lack of statistically meaningful and reliable data set as a result of the non-functional NAVCOM GTS, compounded by NAVCOM's staffing deficiencies, resulted in no collected data for evaluating the functionality and reliability of the system.
- NAVCOM lacked the technical staff and support to completely make its system fully operational. In addition, the staff who worked on this pilot project lacked the managerial and interpersonal skills to effectively communicate with DDOT officials as well as resolve any outstanding technical issues which were encountered. NAVCOM's personnel lacked the skills for training DDOT officials on the operation of its system as well as the trust to enable the officials involve them in decisions on DDOT's vehicles and secure computer systems.

- NAVCOM's technology may be promising. However, on this pilot project, NAVCOM could not take the opportunity to fully test, upgrade and debug its system due to reasons mentioned above.
- The safety of vehicle operators may be hampered if the system were functional. The use of a palm pilot (i705) as a communication device during snow removal and the provision of other services may endanger the vehicle operators. The size of the palm pilot (1705) calls for complete attention during its usage.
- NAVCOM's technology is challenged by changes in IP addresses and did not consider possible changes in developing its software. Government agencies such as DDOT need to secure their computer systems. This has become more critical since September 11, 2001 events involving terrorists. NAVCOM demonstrated a reluctance and inability to make source code revisions whenever an IP address is changed to enable its system operate fully. The time taken to make IP address-driven source code changes appeared to be excessive, given the current awareness of the need to secure all government computer systems.

EVALUATION PLAN

INTRODUCTION

The District of Columbia Department of Transportation (DDOT) has contracted Howard University to evaluate the "Snow Management and Vehicle Tracking System" and the "Integration of the HANSEN System with NAVCOM Information System". Both of these tasks are being performed by NAVCOM Tesfa LLC under a subcontract with Howard University. The Howard University Transportation Research Center (HUTRC) is responsible for conducting the evaluation. The nature of each task and the procedure for their evaluation are outlined in this report.

SNOW MANAGEMENT AND VEHICLE TRACKING

The "Snow Management and Vehicle Tracking System" involves the acquisition and installation of equipment on sixteen (16) vehicles and the installation of software at the headquarters of DDOT for managerial and operational purposes. The snow management system is designed to manage a fleet of vehicles used in snow removal, street maintenance or construction operations. In this study, the emphasis is placed on snow removal operations.

The basic elements of the snow management demonstration, as stipulated in NAVCOM Tesfa's proposal, are as follows:

- Equipment and software installation,
- Training and education of users at DC DPW, and
- Functionality and reliability of the systems and software during snow removal and other field demonstrations.

Evaluation of Equipment and Software Installation

Objective: To ensure that the equipment and software installed are within specifications.

Equipment: The NAVCOM Guidance and Tracking System (GTS) is expected to be composed of three (3) separate sub-systems that offer the capability to guide and track a vehicle. These are the GTS Mobile Unit (a LCD display unit with 8 rows by 20 columns and with 10 keys on a keyboard, etc), the Communication System

(ITS protocol), and Management Center Unit (Server with software, tied to the internet).

Method of Evaluation: HUTRC will inspect all the systems installed by NAVCOM to ensure compliance. The systems will be evaluated according to the specifications as outlined in the proposal. HUTRC will also ensure that the equipment installed are functional.

Data Collection*: A* simple check list, provided in Table I in the Appendix, will be used to evaluate the equipment provided and software installed by NAVCOM.

Criteria: A rating of at least 95% will be required for a satisfactory compliance of equipment acquisition and software installation as per the specifications in the proposal.

Evaluation of Training and Education of Users at DDOT

Objective: To train and educate expected users of the NAVCOM Systems at DDOT.

Training and Education: NAVCOM is expected to educate the proposed users of its system in the areas of operation, management, interpretation, and possibly, troubleshooting. The typical users will be snow truck drivers, the principal investigator(s) at HUTRC, and snow management personnel of DDOT.

Data Collection: DDOT personnel who received training on the NAVCOM system DDOT will be surveyed. The survey will contain questions regarding the adequacy of the education and training on the systems provided by NAVCOM. The survey will give the users the opportunity to rate the effectiveness of the education on a scale of I (ineffective) through 3 (very effective). Open comments will be obtained from the users after they have actually used NAVCOM's equipment in the field. The users will be given the opportunity to comment on the training provided in conjunction with the actual operation of NAVCOM's systems.

Analysis Method: All ratings provided by the personnel surveyed will be analyzed. A simple percentage method for the ratings will be used. An overall percentage for these ratings will also be computed.

Criteria: An overall percentage of 85(%) or more of "very effective" will be used as a satisfactory indication of the effectiveness and adequacy of the training and education provided by NAVCOM.

Evaluation of the Functions Capabilities and Reliability of the NAVCOM GTS

There are several functions of the NAVCOM GTS. The system to be deployed consists of a Dispatch Center (Management Center) that will communicate with service vehicles, vehicle operations and field supervisors. The basic functions which will be evaluated by HUTRC are as follows:

(i) Two-way-text-messaging/communication system

(ii) Trace of vehicles with different colors showing the cleaning and/or salting operation on a map overlay

(iii) Vehicle position tracking

(iv) Data display to operator of vehicle and supervisor (field and office)

(v) Sending messages for service to specific service vehicles, along with the turn-by-turn directional instructions

(vi) Display of limited information on the internet

Objective: To evaluate the outlined functions for capability and reliability.

Capabilities: For each function of the GTS outlined above, HUTRC will evaluate the ability of the NAVCOM system to perform a series of subsidiary functions. These capabilities include:

Two-way text-messaging/communication system

- Ability to send messages **to** the Management Center using Keypad
- Ability to receive messages **from** Management Center using Keypad
- Ability to display data sent through the Sensor tracking facility

- Ability to obtain information on the operational mode of vehicle (Snow plow blade position and dispenser operation) at remote monitoring stations.

Vehicle Operators using Navcom System

- Ability to send messages **to** the Management Center using Key pad and display
- Ability to receive messages **from** Management Center using Key pad and display
- Ability to display data collected through the Sensor tracking facility

Management Traffic Control Center

- Ability to show a trace with different colors outlining the cleaning and/or salting operation of each vehicle displayed on a map overlay
- Quality of tracing displays
- Ability to display the location of each vehicle with the GTS system.

Data Collection: The NAVCOM GTS units will be installed on sixteen (16) vehicles. For collecting data on some of the capabilities, the snow vehicle drivers/operators will be provided with cellular phones (hands-free) to provide answers to questions posed by the ITUTRC evaluator. Other data on these functions and capabilities will be obtained either by the evaluator's personal examination or by interviewing operators in the field or at the offices. Typical data for each of the capabilities of the NAVCOM GTS will be obtained using the Tables (3 - 8) presented in the Appendix.

Criteria/Analysis: It is hypothesized that the NAVCOM GTS will be deemed effective and reliable if:

(i) it is able to perform at least an average of 95% of each capability on all the installed units,

(ii) it is able to perform at least an average of 90% of <u>all</u> the capabilities evaluated and,

(iii) reliability is statistically significant at 5% level of significance.

For each capability, a simple percentage based on "Yes" and "No" answers will be computed. This should result in at least 95% of "Yes" for NAVCOM's system to be deemed effective for that particular ability.

Similar computation will be conducted for each capability. An average of all the "Yes" percentages will be computed to represent the overall capability of the NAVCOM system. This should result in at least 90% of "Yes" for the NAVCOM system to be deemed effective. The standard deviation of the percentages of "Yes" will also be computed.

Reliability Test: The overall percentage of "Yes" will be tested at 5% level of statistical significance. Since the sample size chosen is small, (i.e. n=7), the student's t-test will be used. It is hypothesized that the mean of the percentage of "Yes" is greater than 90%. Thus the t-test to be used will be test the following hypothesis:

H_o: $Y < 0.9$

H_1: $Y > 0.9$

A 95% confidence interval for this mean percentage will also be calculated.

INTEGRATION OF THE HANSEN SYSTEM WITH NAVCOM

DDOT uses the HANSEN system for logging calls for service from the community. These services include fixing potholes and street lights, etc. The existing database generated by the HANSEN system in real-time will be used in this study. NAVCOM's software will be installed on computers located at the offices of DDOT.

Call logs from the HANSEN system will be exported into the NAVCOM software which, in turn, will send each complaint/call for service to the appropriate service unit. In principle, the NAVCOM software is intended to convey all service calls to the point of service with minimal delay. All calls will be time-stamped and dated on the sending and receiving ends. The service manager/supervisor would then be able to dispatch and monitor service vehicle using the installed NAVCOM GTS, and should be able to know when the vehicle

arrives at the appropriate location to execute the service and when the service is completed.

The service manager would then be able to determine whether the task has been completed and provide response information in minimum time back to sender. The NAVCOM software is supposed to generate a report on the status of requested services.

Evaluation Plan: Up to Ten (10) officials at DDOT will be surveyed to determine whether the NAVCOM software integration with the HANSEN system functions as outlined above. They will be given a series of questions which will determine the reliability and effectiveness of the functions and capability of this integration. A scale of 1 (ineffective) to 3 (very effective) will be used to measure the effectiveness of the integration.

Data Collection: The questions presented in Tables 10 and 11 will be used to determine the effectiveness and reliability, respectively, of NAVCOM's integration software. NAVCOM's integration software (with the HANSEN system) will be evaluated on the basis of the timeliness of providing information on the status of tasks performed or those to be performed. As shown in Table 11, each task will be performed five times to measure the reliability of the system.

Analysis: A simple percentage of the ratings will be computed.

Criteria: For NAVCOM's integration with the HANSEN system to be deemed effective, at least 80% rating of "very effective" should be obtained **in** the questionnaire presented in Table 16. In addition, an overall percentage of at least 85% of "Yes" should be obtained in the survey presented in Table 11 for the system to be denied reliable.

FINAL REPORT

A final report, detailing the work performed by NAVCOM together with the evaluation of each work performed would be developed. The reliability of NAVCOM's systems will be reported while outlining other findings of the evaluation and suggesting future work in this area for DC DPW. Contents obtained from users in the evaluation will also be incorporated in the report.

APPENDIX A

Table 1: Evaluation NAVCOM Equipment and Software

EQUIPMENT	EXPECTED SPECIFICATION	IS EQUIPMENT IN COMPLIANCE?	
		YES	NO
1. Server • Hardware	Intel Pentium III		
• Operating System	Microsoft Windows 2000		
• Disk Space	36 GB		
• Total RAM	512MB		
• Model	Dell PE 4000		
• Processor Card	1GHz with 256K		
• Floppy Disk Drive	1.44 MB, 3.5" Floppy		
• Network Standard	Ethernet		
2. G.T.S. (In Vehicle) • Display	8 lines 20 characters backlit LCD		
• Keyboard	10 keys		
• Storage	12 MB		
• Power	12v/24v		
• Communication	Modem-120 kit baud rate		
3. Software NAVCOM Software			

Table 2: Training Evaluation questionnaire

	1 (Ineffective)	2 (Somewhat Effective)	3 (Very Effective)
1 How would you rate explanations given by NAVCOM about the functions and capabilities of its system?			
2 How would you rate responses or answers to your questions during your training?			
3. How would you rate the effectiveness of the training provided in relation to your use and operation of the NAVCOM system?			
4. How would you rate your familiarity with the functions of the system from NAVCOM's training?			
5. Rate NAVCOM's training in terms of how you understood the operation of the system.			

Method of Data collection

(i) Five different messages will be sent from each vehicle
(ii) For each message sent, a confirmation of receipt at the Management Center will be sought
(iii) The date/time the message is sent in the vehicle will be noted
(iv) The date/time the message is received at the Management Center will be compared with that sent from the vehicle
(v) A "Yes" will be checked if the date/times are the same (or closely the same) Otherwise a "No" should be checked.

Table 3: Is the operator able to send messages to the Management Control Center using keypad?

VEHICLE NUMBER

#	1		2		3		4		5		6		7		8	
	YES	NO	YES	NO '	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
3																
4																
5																
TOTALS																
%																

VEHICLE NUMBER

#	9		10		11		12		13		14		15		16	
	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

Method of Data collection

(i) Five different messages will be sent from Management Control Center
(ii) For each message sent, a confirmation of receipt in the vehicle will be sought
(iii) The date/time the message is sent at the Management Center will be noted
(iv) The type of message received in the Vehicle will be compared with that sent from the Management Center
(v) A "Yes" will be checked if the date/times are the same (or closely the same) Otherwise a "No" should be checked.

Table 4: Is the operator able to receive messages from the Management Control Center?

VEHICLE NUMBER

	1		2		3		4		5		6		7		8	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

VEHICLE NUMBER

	9		10		11		12		13		14		15		16	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

Method of Data collection

(i) Five different messages sent from the sensor tracking software/facility
(ii)For each message sent, in the vehicle display unit will be sought
(iii) The type of message sent will be noted as well as the time it was sent
(iv) The type of message received in the Vehicle display unit will be compared with that sent through the sensor tracking facility
(v) A "Yes" will be checked if the messages are the same and the time of receipt is close to the time it was sent, otherwise a "No should be checked.

Table 5: is the operator able to display data sent through the Sensor Tracking Facility?

VEHICLE NUMBER

	1		2		3		4		5		6		7		8	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

VEHICLE NUMBER

	9		10		11		12		13		14		15		16	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

Method of Data collection

(i) At five different times in each vehicle the position of the snow blade will be sought
(ii) At each time, using cellular (hands-free) phones, the evaluator will place a call to the vehicle operator to determine the operation mode of the vehicle
(iii) The answers will be checked with what NAVCOM's software is displaying at the Management Center
(iv) A "Yes" will be checked if the mode is the same as showing on NAVCOM's software (or closely so), otherwise a "No" should be checked.

Table 6a: Is the supervisor able to determine operation mode of vehicle (Snow plow blade Position)

VEHICLE NUMBER

	1		2		3		**4**		5		6		7		8	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																-
2																
3																
4																
5																
TOTALS																
%																

VEHICLE NUMBER

	9		10		11		12		13		14		15		16	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

Method of Data collection

(i) At five different times in each vehicle the position of the snow blade will be sought

(ii) At each time, using cellular (hands-free) phones, the evaluator will place a call to the vehicle operator to determine the operation mode of the vehicle

(iii) The answers will be checked with what NAVCOM's software is displaying at the Management Center

(iv) A "Yes" will be checked if the mode is the same as showing on NAVCOM's software (or closely so), otherwise a "No" should be checked.

Table 6b: Is the operator able to determine the operation Mode of vehicle? (Salt dispenser operation)

VEHICLE NUMBER

	1		2		3		4		5		6		7		8	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

VEHICLE NUMBER

	9		10		11		12		13		14		15		16	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES'	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

Method of Data collection

(i) At five different times, the status of operation (snow plowing/salting) will be sought

(ii) At each time, using cellular (hands-free) phones, the evaluator will place a call to the vehicle operator to determine the operation mode of the vehicle

(iii) The answers will be checked with what NAVCOM's software is displaying at the Management Center

(iv) A "Yes" will be checked if the mode is the same as showing on NAVCOM's software (or closely so), otherwise a "No" should be checked.

Table 7: Is NAVCOM's display software able to adequately show the status (in color) of operation of each vehicle on a map overlay?

VEHICLE NUMBER

	1		2		3		4		5		6		7		8	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

VEHICLE NUMBER

	9		10		11		12		13		14		15		16	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

Method of Data collection

(i) At five different times in each vehicle, the location will be sought

(ii) At each time, using cellular (hands-free) phones, the evaluator will place a call to the vehicle operator to determine the location of the vehicle

(iii) The answers will be checked with what NAVCOM's software is displaying at the Management Center

(iv) A "Yes" will be checked if the mode is the same as showing on NAVCOM's software (or closely so), otherwise a "No" should be checked.

Table 8: Does the **NAVCOM software display system adequately show the location of each vehicle?**

VEHICLE NUMBER

	1		2		3		4		5		6		7		8	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

VEHICLE NUMBER

	9		10		11		12		13		14		15		16	
#	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1																
2																
3																
4																
5																
TOTALS																
%																

Table 9: Summary of Tables 3 - 8

CAPABILITY	Average "YES"	Average "NO"
Is the operator able to send messages to the Management Control Center using keypad?		
Is the operator able to receive messages from the Management Control Center?		
Is the operator able to display data sent through the Sensor Tracking Facility?		
Is the supervisor able to determine operation mode of vehicle (Snow plow blade Position)?		
Is the operator able to determine the operation mode of vehicle? (Salt dispenser operation)		
Is NAVCOM's display software able to adequately show the status (in color) of operation of each vehicle on a map overlay?		
Does the NAVCOM software display system adequately show the location of each vehicle?		

Table 10: Integration Software Evaluation Questionnaire

QUESTIONS	1 (Ineffective)	2 (Somewhat Effective)	3 (Very Effective)
1. How would you rate NAVCOM's software capability of serving the defined needs?			
2. How would you rate NAVCOM's software user friendliness?			
3. Rate NAVCOM's integration software in terms of its functions.			
4. Rate the effectiveness of using NAVCOM's software with the HANSEN system to perform tasks at DDOT timely.			

TABLE 11: Evaluating the Reliability of NAVCOM's Integration

No of Times	Does the information sent from the HANSEN file properly register in NAVCOM's software?		Is information sent and showing in HANSEN file appear exactly the same in NAVCOM's software?		Does information logged in the HANSEN file and sent to NAVCOM software indicate equal logging times?		Does NAVCOM's software adequately show status of tasks performed and those to be performed?	
	YES	NO	YES	NO	YES	NO	YES	NO
I								
2								
3								
4								
5								
TOTALS								
PERCENTAGE								