Chapter 3: Expert Information Interview Evaluation

Objective
It was the objective of the expert evaluation process to retrieve information from experts in the field of wheelchair operation and rehabilitation sciences which may be useful in future design iterations of the PAU. Evaluation of data collected concerning the current prototype helped to determine unforeseen safety considerations, aesthetic shortcomings, and technical design problems. Technical issues addressed included user-interface difficulties and performance capabilities. The information collected on these topics and other areas introduced by the experts will be integrated into the next generation of design alterations.

The purpose of the evaluation was to step back from the development effort and invite objective critique of the design before it has reached a stage of mass production and user operation. The term objective in this case refers to perspectives which are not directly involved in the development of the power assist device. Actual expert input was in the form of subjective opinion.

Plan of Attack
The first step in the evaluation process was to identify the type of expertise required for an adequate panel. Next, individuals were selected for the expert panel to cover the outlined expertise requirements. Once the parameters for the panel were established, a method to obtain input from the experts was chosen. A series of established methods for retrieving expert opinion were reviewed for applicability to the wheelchair PAU evaluation. It was then determined what measurement instruments were available in conjunction with the chosen information collection method. Again, those measurement instruments which were the most appropriate for the PAU evaluation were selected.

Next, specific questions and measurement tools for the evaluation were developed. An outline of the information collection procedures was developed including a method to brief the experts on the new PAU.

Expert Panel Selection
The panel of experts was assembled with the intention of providing a wide range of perspectives. Panel members were selected to offer this array of perspectives and included two wheelchair operators, three rehabilitation counselors, two rehabilitation engineers, and a professional assistant to a wheelchair operator.

Rehabilitation counselors are responsible for advising wheelchair operators concerning their assistive equipment. These duties include investigating and purchasing wheelchair equipment such as PAUs. Rehabilitation engineers serve as consultants in the rehabilitation field and this work includes the design and implementation of devices and environments for wheelchair users. In addition, one of the experts was employed for several years as a bus driver and aide for the disabled bus service in Blacksburg, Virginia.
Expert Opinion Capture Technique

There are several established scientific methods for collecting and evaluating information from a group of experts. Each method varies in terms of procedures, results, and types of advantages and disadvantages. Eight different methods were reviewed for applicability to the PAU evaluation. The methods included interviews, questionnaires, committees, conferences, brainstorming, the Nominal Group Process, the Delphi technique, the Shang Inquiry, the Estimate-Feedback-Talk-Estimate technique, and the Policy Specification Technique Using Realistic Environments (POSTURE).

The conclusion of the review of opinion capture techniques was that an interview process was the most appropriate method for the expert evaluation of the new PAU. An interview implies a verbal presentation of the question and a verbal response. This method has the following advantages over the others reviewed:

-- It does not require that the experts meet at a common place and time. This is important because traveling is extremely difficult for the wheelchair operators and the scheduling would be complicated with so many participants involved. Additionally, methods requiring group meetings introduce negative group dynamics such as bandwagon effects, lack of anonymity, and pressure to conform. Though several of the group techniques reviewed compensated for these problems, their purpose did not match the purpose of the evaluation.

-- Questions which may be misinterpreted can be clarified by the interviewer.

-- The participant can be motivated by the interviewer with positive responses.

-- Speaking is a more natural form of communication than writing.

-- Areas of interest not covered in the predetermined questions (introduced by the expert) can be explored further by the interviewer.

Development of Interview Questions

Structuring questions to be used in an information collection session involved careful consideration of several points. The following questions were posed to assure adequate question composition (Meister, 1986).

**What degree of control will be used when structuring the questions?**

Questions can be extremely open-ended such as "Now that you have seen the apparatus, what do think about it?" The other end of the spectrum includes questions with a limited set of multiple choice answers. The degree of control for each question lies at some point along this continuum. It is suggested that subject matter experts be given freedom to partially control the interview (Meister, 1986). In this case, questions were designed to introduce an area where the expert's opinion is wanted, while leaving the question open-ended enough to allow a creative response.

Open-ended questions permit the subject to introduce a unique response. This type of question allows the subject to explain his/her answer and offers a good format for identifying new ideas.
What level of formality should be observed in the procedures and wording?
Formality can be controlled by the wording of the questions, the setting in which the information exchange takes place, and by the dress and the level of authority and control exhibited by the information collector. Since the objective of the interview was to obtain innovative and uninhibited responses from the panel members, it was not appropriate to present an extremely formal setting. Formality is based on ritual and following a set of rules, which tends to curb creative endeavors.

An excessively informal setting may also have some negative effects. For instance, sloppy clothing and carelessly worded questions can give the impression that the interview is not to be taken seriously. It was appropriate in this case to provide a semi-formal setting where the panel member felt comfortable. The demonstration and interview were carefully organized and presented in a friendly, but businesslike manner.

Is there any ambiguity in the question?
There are several areas where a question can be confusing to the recipient and make perfect sense to the originator. One problem area is the use of terms which may have different meanings to people with different backgrounds. Another situation to avoid is the use of compound statements in the question. For example, the question "Have you worked with any spinal cord injured patients within the past month, and if so, were any of them power wheelchair operators?" A response of "yes" to this question cannot be interpreted without understanding which part of the question is applicable.

Adding information to assist in comprehension of a question is not always helpful. If the expert is knowledgeable in the particular area in question, added knowledge for explanation tends to create confusion (Porter, Roper, Mason, Rossini, and Banks, 1991). Therefore, information presented to the expert in the questions was minimized. However, responses were developed to accommodate clarification questions from the experts which did not fully understand the question.

Is the question structured in a manner that will bias the respondent?
A leading question will produce results biased in a particular direction. This is an additional reason why minimal information was presented to the experts in the questions. Statements which may bias the question, such as examples, were provided only when necessary for clarification purposes.

Interview Questions

When it is necessary to compare and contrast the responses from different participants, it is suggested by Meister (1986) that each participant is asked the same questions in the same order. The interviewer followed the same format with each expert and attempted to present all questions in the same order to be certain that each topic was addressed. In the course of conversation, however, several participants introduced areas of interest out of the listed order and in some cases, expanded in a particular direction. This was encouraged and the interviewer followed up new avenues with questions which pertained to the explored area.
The generic questions were designed to serve as an introduction to an area of thought, not as a limit of the discussion. In cases when a participant strayed from conversation which was beneficial to the project, the interviewer used the predetermined questions to bring the topic back on track. The interview questions are listed in the order of presentation with corresponding answers provided by the experts in Appendix F: Expert Interview Questions and Responses.

Interview/Demonstration Procedures

Briefing the Expert on the Power Add-On Unit
Options for introduction methods to the new PAU included providing descriptive literature, a demonstration videotape, a one-on-one demonstration with the wheelchair and attachment, leaving the expert with the wheelchair and attachment for independent observation, or any combination of these methods. Due to the complicated nature of the design to be reviewed, it was necessary to have it present during the evaluation for reference purposes. The device was also too complicated to rely on literature or a videotape to explain its characteristics. Therefore, the most appropriate method to brief the expert was to present a one-on-one demonstration with the wheelchair and attachment.

Demonstration/Interview
The first portion of the interview consisted of providing instructions to the expert. This included describing the purpose and procedure of the interview process and obtaining written permission to participate from the panel member. Following instructions, a demonstration of the power attachment provided a means for the expert to become familiar with the PAU. Finally, the questions were presented to the expert in the interview situation.

Instructions. Prior to the interview, all participants were introduced to the topic of the project by personal or phone contact. Each expert understood that they were participating in a project for the Human Factors Engineering Center which is a part of the Industrial and Systems Engineering Department at Virginia Tech. They were told that the center had built an engineering model of a device which temporarily converts a manually driven wheelchair into a power-driven wheelchair. It was further explained that the interviewer is a Ph.D. student in the department and is working on the wheelchair project in partial fulfillment of the degree requirements. In this conversation, a date, location, and time was established for the demonstration and interview to take place. The locations were determined by the participant in order to minimize traveling difficulties.

Upon arrival at the demonstration and interview site, the following procedures were followed:

1) It was explained that it should take approximately 20 minutes to demonstrate the PAU.
2) The panel member was then reminded that questions would be asked following the demonstration to obtain feedback about the device.
3) It was then explained that it should not take more than two hours of time total.
4) The panel member was then instructed to please feel free to ask questions as the PAU is demonstrated.
5) It was then explained that the purpose of the interview was to retrieve input from experts that could identify problems and promote new avenues of thought along the design process.
6) The panel member was then asked to read over the release form and sign it if they wished to continue. A copy of the informed consent form is included in Appendix G: Expert Interview Informed Consent Form.

Demonstration. The following steps in the demonstration are listed in order of presentation:
1) Explain that the premise of the design is to add drive wheels which are electrically powered to the wheelchair.
2) Show the battery with the battery box and explain how it is wired to the motor.
3) Explain that the battery sling which holds the battery, remains on the wheelchair when the battery is removed and can fold with the wheelchair.
4) Demonstrate how the tiller column with the steering handle at the top rotates.
5) Describe the connection between the outer column tube, the horizontal crossbars, and the wheelchair frame.
6) Explain the three different column positions: power-drive, manual-drive, and transfer, and demonstrate how to adjust between the positions.
7) Transfer into the wheelchair and readjust to the power-drive position.
8) Discuss the on/off, forward/reverse switch and the finger actuated speed control.
9) Demonstrate maneuvering including moving forward and reverse and turning.
10) Readjust the column to the transfer position.
11) Transfer out of the wheelchair.
12) Explain the ideal power assist scenario: a wheelchair operator can independently transfer to and from a personal automobile with the power drive/steer attachment.
13) Remove the tiller column and crossbars to demonstrate how it slides off of the wheelchair.
14) Explain that the securing blocks for the horizontal crossbars remain on the chair when the device is removed (the wheelchair can still be folded without obstruction).
15) Place the PAU back on the wheelchair in the transfer position.
16) Invite the panel member to transfer into the wheelchair and operate the PAU.
17) Explain several of the major advantages the new device has over other similar products.
   -- Only one battery is required for operation as opposed to two batteries. It is suggested that the operator purchase two batteries and leave one charging while the other is in use.
   -- A six wheel stance is maintained during operation for stability.
   -- Most moving parts are located under the seat and behind the footrests.

The expert was then presented with the series of interview questions.

Recording the Collected Data
Options for recording responses included the expert writing down responses to questions, the information collector writing down responses to questions, tape recording responses, and videotaping responses. In this case, videotaping did not
provide a practical solution. The camera is complicated to set up and monitor and may have served to distract the panel member. There was also no obvious advantage to producing a visual record of the comments.

Important concepts may have been missed if all recording was left up to the responder. Relying on a tape recorder to maintain all records could also have resulted in missed ideas. Words spoken away from the microphone may not have been loud enough to interpret or technical problems with the recorder could have interrupted the demonstration and interview. Therefore, the interviewer was responsible for collecting information with a paper and pen and a tape recorder was utilized to record the interview and demonstration as a backup measure. When the expert's remarks were not understandable, the interviewer asked the responder to repeat the words.

Pretesting
The demonstration and interview procedures were pretested with expert number one to determine if any of the questions were confusing, biasing, or did not provide the intended results. The pretesting session also provided an estimate of the time required to complete the information collection session and a practice opportunity for the interviewer. Data collected during the pretesting session were found to be useful and were therefore included in the results of the evaluation.

Results and Data Analysis

The data from the interviews were analyzed for innovative ideas, identification of design deficiencies, and determination of avenues which may serve to improve current deficiencies.

Meister (1986) recommends a set of questions the data analyst can use to refine the data collected in an informational interview. They are:

-- Are there any irrelevant statements that should be ignored?
-- What are the more important ("more revealing") statements?
-- Was the respondent's report complete, detailed and understandable in contrast to being sparse and uncommunicative?
-- What did the respondent mean by particular statements?
-- How consistent was the respondent?
-- Is there any way of determining the accuracy/validity of the response?

These questions were referenced during refinement of the data collected in the expert interviews.

Data analysis has produced a set of ideas which identify possible design deficiencies, suggest avenues to improve some of the possible deficiencies, and introduce unique concepts concerning the design. The ideas listed from the experts have been compiled here into a report of their suggestions for future design changes and testing. These are summarized under the categories to which they are related. Results of this evaluation are compared to findings of the PAU performance and usability evaluations in a later section.
Attachment and Detachment Procedures
Because strength and dexterity are required to attach and detach the PAU, there was some concern for the varying finger and hand capability levels of different users. This was expressed by most of the experts in different ways. Two experts suggested that an assistant may need to attach/detach the device. Others offered ideas for improving the PAU release mechanisms on the crossbars (finger grips) such as:

-- Applying a locking mechanism to the finger grips so that both hands can then be used to align and place the PAU. After placement, the lock can be released to secure the PAU.

-- Designing a release mechanism which can be operated by one hand and would not require finger dexterity. One option presented included a U-shaped handle (in place of the finger grips) which could be pulled. Figure 9 is an illustration of the investigator’s interpretation of the idea.

![PAU crossbar](image1)

Figure 9. U-shaped release mechanism replacement suggestion.

The expert further suggested that this type of simple release mechanism might be applicable to the plugs as well. A second idea presented by the expert involved a two-bar grip where one bar remains stationary as the second pulls closer to the first when gripped by the hand (both bars would fit inside the squeezing hand). The investigator’s interpretation of this option is illustrated in Figure 10.

![PAU crossbar](image2)

Figure 10. Two-bar grip release mechanism replacement suggestion.

The actual location of the finger grips to the right side of the column (from the operator’s perspective sitting in the wheelchair) was considered good by one expert who pointed out that this location is closest to the driver’s side seat of a car. One observation by the investigator here is that all components should consider the car transfer scenario more closely. For instance, the plug for the column section is located far from the driver’s seat position.
Another concern introduced with the attachment and detachment procedures is the requirement to turn the wheelchair around in order to place the battery. It was suggested that it would be better to have small batteries in the front of the wheelchair so that it would not have to be turned around. This type of arrangement would strongly limit battery size to the available space under the front section of the wheelchair. The majority of this space is currently allocated to permit motion of the PAU through the different column positions.

Transfer with the PAU Attached
Most of the experts expressed a concern with the column extending out in front of the wheelchair during transfer. The reasons for concern vary and include the following:

-- When transferring to and from an automobile, the column will interfere with the car door. Also, there will be less room to place both legs between the car and the column (before the leg is lifted over the column).

-- Many wheelchair users have trouble maintaining balance. Activities which involve shifting weight, such as lifting one leg over the column during transfer, may jeopardize the balance of the operator.

-- Although the majority of experts anticipated that most users would be capable of lifting a leg over the column, one expert wheelchair user was not able to do so. She identified the column as "a big obstacle." In order to transfer her into the wheelchair to use the PAU, she suggested first placing the column section on the ground. While seated in the wheelchair, she then wheeled over top of the column section, and an assistant lifted it behind her lower legs into position on the wheelchair. This sequence for attachment did work, but was quite awkward.

Two suggestions were offered for alleviating the extended column problem. The first idea was to design a telescoping column section which could collapse into itself when clearance is required. The second suggestion was to design the column in two sections which could be separated. The upper part of the column could unplug from the lower section which would remain on the wheelchair. The expert indicated that this type of arrangement is currently used in airplane control sticks which can be removed from the floor of the cockpit. Options for this design feature may also be retrieved by investigating the removable steering wheel mechanisms utilized in some racing cars.

Switching Between Transfer, Manual-Drive, and Power-Drive Positions
Several different types of concerns were introduced with respect to switching between column positions. Placement of the top crossbar release mechanism was described as "difficult" (to actuate) because the user must bend over and move his/her leg. It was suggested that the release mechanism could be placed on the column in a higher position. This would alleviate the requirements to bend over, and to move the leg. The investigator notes here that these movement requirements also introduce the possibility of loss of balance.

One expert considered the requirement to rotate the column when moving to and from the transfer position as a possible problem (the column must be turned 180 degrees while shifting positions to avoid interference between the drive wheels and the ground). It was suggested that forgetting to rotate the column may be a problem with some users.
In addition, several experts recommended altering the location of the battery to avoid interference with the drive wheels. In the current position, the column rotates forward until the drive wheels come to rest against the battery box. The possible advantage to moving the battery, as suggested, is that the column may come to rest in a lower position. While this may minimize difficulties involving lifting the leg over the column, the investigator notes that it is possible a lower location will require the operator to reach farther forward to grab the column. These possibilities should be considered if design efforts are made to change the location of the battery.

One idea presented involved pivoting on the top crossbar instead of the lower crossbar. The advantages or disadvantages of such a configuration can be investigated as part of the next generation of design alterations.

**Maneuvering in Power Mode**
Five of the experts operated the PAU in power mode on the wheelchair. Observations by the investigator and comments by the experts have identified several areas which may need to be addressed in future design changes. One expert commented that too much effort was required to turn the unit when it was not moving. He suggested a handle configuration which would offer more leverage such as a two handle steering system. This is the type of handle built into the Roll-Aid power add-on unit where both hands have a place to grip and maneuver. It was observed that a different expert grabbed the column with the non-steering hand for security while driving. The expert also commented that the handle was "nice to hold on to" while operating the unit.

Initially, one expert attempted to steer the PAU by rotating only the handle. With training, this did not continue to be a problem. Another expert commented that she felt like pulling back on the handle to put on a brake. In addition, the expert commented that the wheelchair jumps when it is triggered. This quick take-off caught her by surprise.

Another possible design deficiency mentioned is the requirement to move the steering handle in the opposite direction of the intended turn. One expert pointed out that this activity goes against intuition, but mentioned that it may be a successfully trained behavior.

**Environmental Considerations.** When questioned about traveling in different situations with the PAU, the experts developed a few considerations. First, approach to tables in restaurants may be troublesome due to the table center post and the forward leaning position of the PAU column. Second, wheelchair vans and busses often have unique obstacles such as small curbs and requirements to lock the wheelchair down. Users may need to instruct transportation personnel not to secure tie downs to the PAU itself. Third, it was questioned if the friction between the drive wheels and ground would still be adequate under circumstances such as wet pavement or smooth ramps. It was also suggested that the unit should be tested driving over sidewalks and going down ramps which can introduce unique problems. Finally, it was noted that the orientation of the drive wheels preclude two ramp vehicle entry systems in power mode.
Operating Controls
A variety of comments were received concerning the controls for operating the PAU. With regard to the forward/reverse operating switch, one expert mentioned that the switch should be marked to indicate which position corresponds to which direction. Another expert suggested matching the mental image of forward and reverse by placing a rocker control switch on top of the handle. This could be oriented with the forward location toward the front and the reverse location toward the rear. A third expert found the positions easy to remember because "Right is reverse; two R's."

The investigator observed a wheelchair user maneuvering the PAU and wheelchair within a house. The tight quarters required that the unit shift constantly from forward to reverse and back. This continual need to switch between the two positions was not anticipated and perhaps a more convenient switch would be appropriate.

Another control suggestion included the possibility of utilizing the palms of the hands as opposed to the finger for controlling the device. One expert with weak hands used both hands to operate the unit and appeared to put forth a good effort to pull the finger trigger. The idea of developing a joystick control was introduced as well. This type of arrangement can be considered but would greatly increase the complexity of the product. Joystick controls require that the steering be accomplished via a motor and the motor controls must be programmed for joystick use.

It appeared to some of the experts that the controls as they are eliminate quadriplegic consumers. This was also anticipated by the design team, but surprisingly, one quadriplegic expert was able to maneuver the PAU and wheelchair quite well. The expert actuated the trigger by pressing it against the medial side of the second metacarpal. For balance, he was required to place his nonsteering hand on top of the handle. In this position it was difficult to observe the angle of the steering arm, but operation of the wheelchair was controlled. If the intended consumer of the PAU is to include quadriplegic wheelchair users, a different set of controls will need to be implemented.

PAU Appearance
All of the experts except for one were quite pleased with the aesthetic qualities of the PAU. Comments included the following:

-- "Very polished. Great."
-- "Good."
-- "... attractive. Very integrated with the chair."
-- "It's so small there's no problem; it doesn't stand out."

The one negative comment stated that the PAU "looks mechanical, a lot of straight lines." It was suggested that the grip can be more rounded and contoured. Additional suggestions included trying to match the colors of wheelchairs, and possibly using reflective tape to improve visibility. The expert pointed out that electric wheelchairs are often driven in the road where visibility is important.

One further idea presented was to create a playful version of the product by making it look like an airplane stick or a video game.
**Potential Consumers**
The experts listed several categories of potential consumers for the new PAU product. These groups of users include:

-- People with multiple sclerosis who tend to lose the ability to use one or both legs. The functional capability of this group of wheelchair operators varies tremendously from day-to-day and even within each day. One expert thought it common for people with multiple sclerosis to manually push a wheelchair to a location, and then become stranded because they are unable to push the wheelchair back.

-- Temporarily disabled persons that may wish to rent an inexpensive power unit.

-- Wheelchair users that do not have sufficient hand strength to push a wheelchair.

-- Those who need assistance going up and down grades.

-- Very overweight wheelchair users. Many cannot push their own weight.

-- Paraplegics and amputees.

-- Users of ultralightweight wheelchairs.

-- Wheelchair users who have hand problems from pushing their wheelchairs. Diabetics cannot afford the open cuts which often result from pushing a wheelchair.

**Advertising the PAU**
The experts had many suggestions for letting wheelchair consumers know that a new product is on the market. Their compiled suggestions are listed here.

-- Advertise in newsletters that are targeted for wheelchair users. They usually have both articles and advertisements.

-- Advertise in magazines such as "One Step Ahead," "Independent Living," and "Team Rehab."

-- Develop a demonstration, brochures and notices to be distributed at trade shows, support groups, centers for independent living, rehabilitation centers, the Veteran's Administration, and specialist's offices.

-- Internet.

-- Advertise through direct mail (little card advertisements).

**Estimated Retail Value**
The experts all indicated that the product would be a good alternative to what is currently available. Several offered estimates of what they would be willing to pay for the new PAU. The lowest estimate contributed was $500 to $700 with the comment that the numbers are based on outdated information. Other estimates in the middle range included $1000, and $1000 to $1500. Several of the rehabilitation counselors, who are often responsible for purchasing this type of equipment, estimated that they would be willing to pay $2500 for such a product. This included the estimate by the rehabilitation counselor who was located separately from the others.

**Further Suggestions**
All experts unanimously agreed that there were no features implemented in the design which are not necessary. Two experts did recommend a better cover for the wires associated with the motor; one that considers wear and avoidance of interference. Currently, the wires are housed in a plastic, nonretractable cover. Also, it was suggested that a holder be placed on the wheelchair for the plug at the back (plug for the battery box). The wire and associated plug currently swing freely when not in use.
Discussion

The expert interview evaluation found no major design flaws sufficient to require the design and construction of a new prototype prior to usability and performance testing. Evaluation recommendations including the testing of the PAU under different operation circumstances (wet, smooth surfaces, sidewalks, etc.) were incorporated into the design of the performance evaluation.

Concerns and suggestions introduced by the subject matter experts have been compared to results of the performance and usability evaluations in a later section. The compiled findings were then interpreted to produce a set of prioritized recommendations for design changes.

Evaluation Structure
The information gathered by the demonstration and interview process has offered perspectives on many aspects of the PAU design which were not anticipated by the PAU design team. This was the purpose of the subject matter expert consultation. The selection of experts determines the types of perspectives introduced to the design process and, in retrospect, this panel could be broadened to incorporate additional viewpoints. For instance, assistive equipment is generally prescribed by physical and occupational therapists. It would therefore be appropriate to include members of these professions in the expert panel. Also, assistive equipment distributors such as home health care representatives often see the advantages and disadvantages of equipment first-hand. This group may have also provided an interesting perspective on the new design. Experts from these fields were successfully included in the PAU evaluation expert panels developed by Gaal and Johnson (1993).

The actual demonstration and interview processes were quite successful in providing a good introduction of the product to the experts, and in soliciting insightful information. One interesting finding is that the attempt to present the structured interview questions in a particular order sometimes introduced a disruption to the flow of conversation. At times it seemed more appropriate to ask the question which most closely followed the most recent comments by the expert. It is recommended that this type of informational interview may produce more optimal results when questions are presented in the order that conversation deems appropriate. A checklist approach can be utilized, as opposed to a prescribed order of presentation.