

Patrol Car Passenger Compartment Design and the Prevention of Low Back Pain



ÉTUDES ET RECHERCHES

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January 1991 R-049

RAPPORT



IRSST
Institut de recherche
en santé et en sécurité

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Patrol Car Passenger Compartment Design and the Prevention of Low Back Pain

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This study was financed by the IRSST. The conclusions and recommendations are those of the authors.

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1st Quarter 1991.

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PREFACE

The consideration of human factors in studies in occupational health and safety is not an absolute nor an easy process in research. Consequently, this report on patrol car design is welcomed. It is aimed specifically at the public from which it has originated. It is, in conjunction with the research project, a definite step forward in the field of applied research, even if it does not totally conform to scientific conventions.

The participative process uses the abilities of the subjects, and this research has used them to advantage. There is more, however. Within the general framework of studies on work organization considered from a social, ergonomic and technical perspective, other procedures will be added. We therefore have not finished evaluating the scientific impact of the results obtained. This is because, from start to finish, it is scientific research being carried out to understand a phenomenon, not by concentrating on a handle or a button, or ultimately an injury, but rather by recognizing that it is difficult to study human beings in an occupational context without a prior rigorous understanding of the person as a whole.

For having done this and done it successfully, I congratulate the authors as well as all the participants, and I hope that the greatest possible use is made of their research.

Serge Bouchard
Director,
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1. BACKGROUND

Studies relating to police officers carried out at the Institut de recherche en santé et en sécurité du travail (IRSST - Quebec Occupational Health and Safety Research Institute) are the result of requests made to joint occupational health and safety associations (associations paritaires en santé et en sécurité du travail - Affaires Provinciales (APSSAP) and Affaires Municipales (APSAM)). In November 1985, the IRSST studied all occupational injuries that were the subject of compensation to police officers by the CSST. The report covered a number of problems about the validity of the data, and as a result, the reliability of the conclusions that could be drawn from the CSST statistics. From the standpoint of statistics as well as the phenomenon itself, the final report (Berthelette and Gervais, 1986) considered it premature to orient new research towards the arrangement of the patrol car driver's work station, and recommended that the health risks in this occupational sector be identified.

This recommendation was the origin of two studies on the subject. The first was carried out for APSAM by Arsenault, Dolan and Van Ameringen (1987) from M.D.S. Inc. The second was a joint study by Hôpital St-Luc's community health department and the APSSAP, carried out by Tougas, Gratton, Loranger and Tremblay (1990). The two studies were based on a questionnaire presented to a statistically representative sample with control groups.

In January 1988, the joint associations submitted a new request to the IRSST. We agreed to bring together all the groups involved in the dossier. A consultative committee¹ was formed, consisting of representatives of the employers (Sûreté du Québec, Municipal Services, Association of Chiefs of Police), representatives of the unions (Fédération des policiers du Québec, Fraternité des policiers de la Communauté urbaine de Montréal, Association des policiers provinciaux du Québec), of two joint sector-based associations, and researchers.

¹ Committee members listed in the Appendix.

Since 1985, and despite the results of the two previous studies, the request from the police has not changed. It still involves back pain which they link to the characteristics of the patrol car in general, and mainly to the seat.

In the spring of 1988, the IRSST agreed to carry out a short exploratory study dealing specifically with low back pain and its possible relationship to patrol car seats. It provided the opportunity to document our file, develop links between the IRSST and police departments, and to develop a climate of trust.

The results of this study led the IRSST research team and the members of the Consultative Committee to submit the specifications for a second project entitled: "Patrol Car Passenger Compartment Design and the Prevention of Low Back Pain".

2. PROJECT RATIONALE

2.1 Introduction

The study by Arsenault, Dolan and Van Ameringen (op. cit.) divides the source of problems related to police work into four parts, namely job content, technical organization of the work, the work context, and human resources management. In the technical organization of the work, the firm pinpointed 3 main problems: the car seats, the number of administrative forms, and the communications equipment. Furthermore, technical organization headed the list of problems identified by this study. The researchers in fact linked poor technical organization to numerous occupational health problems: back pain, depression, excessive workload, stress, and a significant decrease in motivation.

The main objective of the IRSST's exploratory study (op.cit.) was to document the dossier on low back pain in the police environment. This work concluded that:

1. Police officers do not have an acceptable sitting position from the standpoint of stability and posture. It also revealed that seat deterioration with use has a negative impact on its ability to provide appropriate seating. This inability of seats to provide proper support clearly increases the police officers' risk of suffering from back pain and disability. Furthermore, police patrol officers, as do many other workers, have to wear a certain amount of equipment at the waist which is necessary for their job. This equipment and its weight distribution around the waist must be taken into consideration in the rationale on low back pain.
2. The concerns of police patrol officers go far beyond back pain. Policemen and policewomen report stressful situations during discussions on low back pain, patrol car layout, the organization of work schedules, and the consumption of medication (analgesics, stimulants, and sleeping pills).

3. Low back pain related to police patrol work is the result of a context that is based at the same time on the passenger compartment, the equipment worn at the waist, job content, and work organization. However, it was impossible to evaluate the relative importance of each of these aspects.
4. Police officers take into account and try to establish relationships between 4 aspects of their work experience: a physical health problem (back pain), specific psychosocial situations, the patrol car and work organization.
5. Because of the government's actual purchasing policies and market availabilities, it is impossible to have a passenger compartment that meets the needs of police patrol officers.

The recently published results of the study by Tougas, Gratton, Bélanger and Tremblay (op. cit.) suggest that working conditions could explain the excessive musculoskeletal problems suffered by police patrol officers, and that preventive measures will have to be implemented. These measures include the vehicle's passenger compartment, work organization, and purchasing policies.

These conclusions led us to propose the study "Patrol Car Passenger Compartment Design and the Prevention of Low Back Pain".

2.2 Risk factors in low back pain related to police work

The specific risk factors in low back pain related to police work are not known. However, the existing literature allows us to conclude that certain general risk factors apply just as easily to police officers as to the general population. Hence, in the case of the sciatica, the following risk factors have been listed: smoking, driving of a vehicle, back injuries (Heliövaara, 1988), back pain in general: lifting heavy loads, vibration, uncomfortable postures (Frymoyer, 1983, and Troup, 1984).

Police patrol officers' work includes several elements that are found in the previous list. Simply driving the vehicle has several constraints, some of which are well identified and others hypothetical. This all leads us to believe that vibration, physical inactivity, sudden movements, as well as seat and patrol car characteristics are important factors in the appearance of back pain.

From the standpoint of personal characteristics, police officers' risk factors should not differ from those of the general population.

Furthermore, there are an increasing number of indications that psychosociological factors play a role in the appearance of back pain (Frymoyer et al., 1985). These factors, which include work organization and job satisfaction, at least play a modifying role which affects an individual's perception and experience of back pain.

2.3 Prevention of back pain

There is very little documentation on the prevention of back pain in police officers. The most common method seems to be the improvement in physical condition. This is the aim of several "back schools". Cady (1979) linked back pain in fire fighters to poor physical condition. In a more recent study, Cady (1985) has shown that physical conditioning decreases the probability of back pain in the participants with the best results.

An improvement in physical condition is considered, and justly so, to counteract the physical inactivity involved in the driving of a vehicle, and consequently, focuses on one of the risk factors for back pain in police officers.

Furthermore, some studies on stress and its management include elements that can be linked to low back pain and its prevention (Hurrell et al, 1982, Anon, 1975).

The present trend in the prevention of low back pain emphasizes the involvement and participation of the people in question (Ebeltoft, 1985). In actual fact, in the police environment generally, a lack of participation has been identified as a major source of stress (Hurrell et al, 1982).

2.4 Prevention and participative ergonomics

An increasing number of studies have shown that an improvement in working conditions plays a significant role in the reduction of back pain (Snook, 1989). Very little research has established a direct link between the frequency of back pain and the process of improving working conditions through participative methods. However, modern trends in the prevention of back pain stress the necessity for active participation of the people concerned. In addition, the results of passive methods show that they are not very effective. Furthermore, some studies link the improving of working conditions to muscular pain (Ebeltoft, 1985), as well as the possibility of reacting to unpleasant

work situations (autonomy) to the frequency of back pain. In other words, the less autonomy a worker has, the higher the frequency of back pain.

3. PROJECT OBJECTIVES

Taking into account the request from the police milieu, the results of previous studies and the present trend in prevention, a participative project was carried out on the prevention of low back pain in the police environment by improving patrol car design. This project had the following objectives:

1. To establish specifications for a patrol car passenger compartment that is better adapted to police work from the standpoint of the prevention of low back pain.
2. To develop our knowledge on the various aspects of low back pain that can be related to the content of the police officer's job. This knowledge will help document prevention programs that are better adapted to the culture and actual organization of police departments.

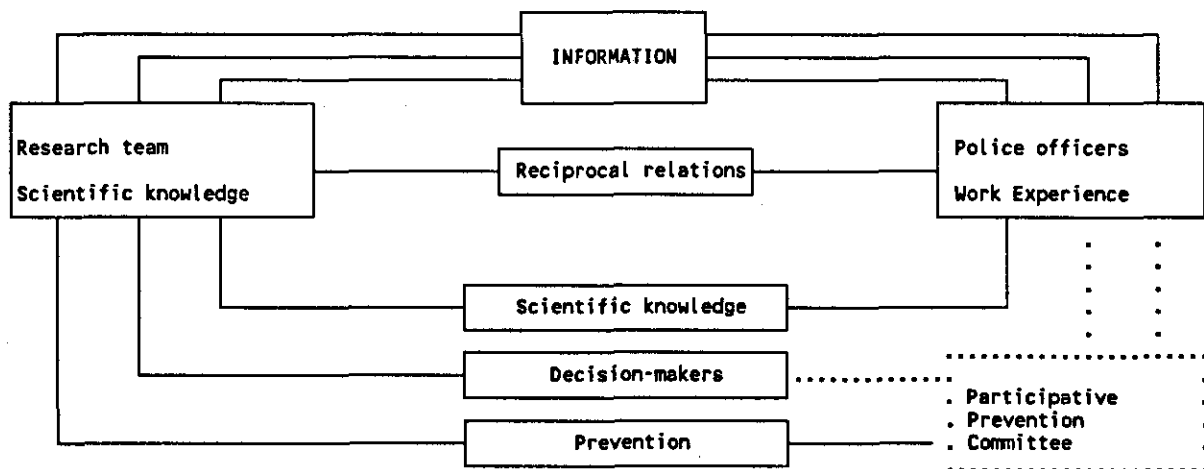
To achieve these two objectives, and given the project's participative character, the research team established a communication model which is presented in the following chapter dealing with methodology.

4. METHODOLOGY

4.1 Participative approach

The participative approach allows the value of the knowledge drawn from daily work experience to be recognized; this knowledge is that of the workers. In practice, this means that an attempt must be made to reduce the structural distance between the workers and the research team, to then ensure the transfer of knowledge to the decision-makers (Chanlat, 1985). To do this, an effective communications network must be established at all levels and the workers provided with tools that allow them to express their ideas. The participative approach is in fact a communication model. This communication model is presented in a diagram:

FIGURE 4.1
PARTICIPATIVE APPROACH



The active and psychological commitment of workers is demonstrated through their participation in the development of solutions. This commitment originates in the relationships that the workers develop with the research team, relationships based on trust and mutual respect.

The relations between the research team and the workers are based on the principle of reciprocity. Under no circumstances is there a confrontation between the knowledge of anyone or any group and that of anyone else or any other group. Policewomen and policemen must themselves test the result of an idea. In other words, they propose, develop a model, test, readjust, etc.

A participative approach in the workplace requires the support of employers and union representatives. This support is a prerequisite in order that the changes proposed during the process can be translated into reality. The active presence of decision-makers within the consultative committee at all stages of the participative process (developing specifications, selecting participants, and monitoring the project) allows managers as well as union representatives to have access to privileged information coming directly from the workers. However, since this information is transmitted by the research team, a plenary session was planned in which the workers would themselves present their production to the committee members, to colleagues, and to other participants (automobile industry, public administration, and health service).

The exchanges between the participants, the research team and the consultative committee allow a better understanding of the work context and the issues in prevention. They also allow intervention priorities that are better adapted to the culture of police departments and to police work to be determined. We should state that these exchanges could be expressed through the creation of a permanent participative committee for prevention represented by a dotted line on the diagram.

The project's technical organization is presented in detail in the following subsections.

4.2 Selection of participants

A group of 32 policemen and policewomen participated for three months in a project whose aim was to produce a patrol car design. The participants, selected by the health service and by the managers of police department units, were employed by municipal police forces in the Montreal region or by

the Sûreté du Québec (the provincial police force). They had to have at least 5 years' experience in police work.

At the researchers' request, half of the police officers selected were to have a history of low back pain. The others were to be subjectively healthy and without a significant history of low back pain. This latter category included three pregnant policewomen. Two participants withdrew from the project before the end for reasons unrelated to the project.

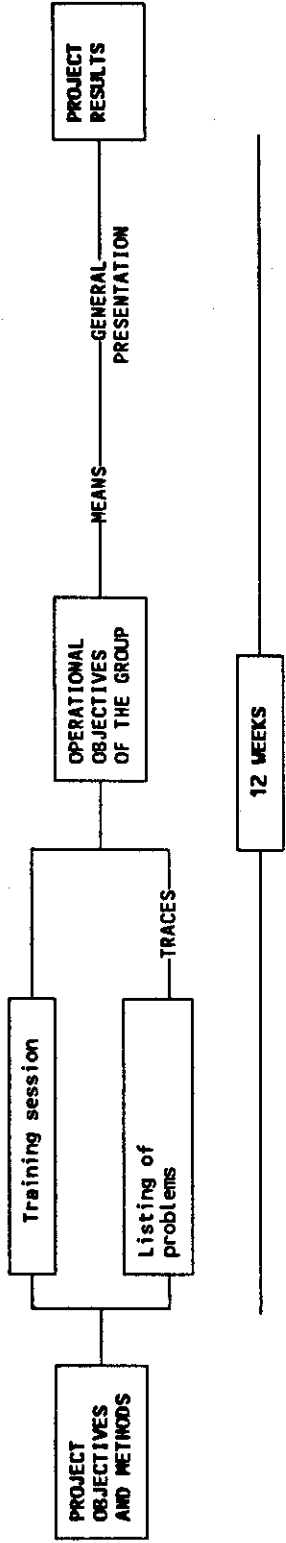
The participants were divided into six working groups, three of which consisted of police officers with low back pain, two contained policemen without low back pain, and one was composed of policewomen who did not suffer from low back pain (two of the five were pregnant). These teams were created by the participants themselves on the basis of whether or not they considered themselves as suffering from back problems.

4.3 The sessions

The participative design project is illustrated in a diagram on the following page and covered a period of twelve weeks. The first meeting took place during a plenary session in which employer and union representatives and all participants were present. The project objectives and the principles of the participative work were then presented, and the sub-groups formed.

4.3.1 Training program

At the same time, the research team established a training program presented in plenary sessions. This program included: the musculoskeletal apparatus (1.5 hrs), the biomechanics of the sitting position (3 hrs), automobile mechanics (3 hrs), standardization (3 hrs), and health and nutrition (1.5 hrs).



4.3.2 Means of concretization

By analyzing and ranking the problems and by holding training sessions, each group was able to define its own objectives in terms of finding solutions. The research team provided the participants with different means: access to a designer and an engineer, video production equipment, and graphics support for producing drawings and models. In addition to these technical means was a series of tools for gaining knowledge: consultation, plant visits, self-confrontation, and the systematic observation of the equipment used by police officers. The decision was made within each group regarding the means and techniques to use. The members of the research team served as resource persons, thus allowing the objectives defined in each of the groups to be reached.

A public presentation by the participants of each group's production, planned for the end of the 12-week period, stimulated creativity so that concrete solutions could be produced.

4.3.3 Trace analysis

The first working-group sessions clarified project objectives and identified problems. The trace method (Karnas, 1987; Ombredane and Faverge, 1955) was adapted to a participative approach and proposed to the participants as follows: "systematically note everything that you use in your work in the patrol car". A memory test was carried out on objects used daily. The participants had to make a systematic inventory during one work shift. They were given a form to assist them in their note-taking. At the following session, the group leader asked each member of the group to name the first point on his or her "work trace" list, to indicate its frequency of use, and to associate a value on a scale of 1 to 5 with it, expressing the importance of the "feeling of constraint" associated with the use of this component. The group leader then wrote this information on a flip chart and carried out the same exercise with the second participant in the group. Thus, each participant in turn had to mention a part of the vehicle, an object or some equipment used in his or her work. All the other members of the group could add additional information or nuances. Once the list was completed, the group leader proceeded through consensus to rank the list of components using an intervention priority criterion established by the participants.

4.4 Analysis of production

During the working sessions, the participants proposed solutions to the problems identified through the various means of concretization made available to them. The results of the trace analysis, completed using the information noted during the work sessions, were compared to the results observable in the productions (drawings, mock-ups, technical data sheets and videos) and to the complementary information gathered during the final presentation by the teams.

- The synthesis of this information is presented first in relation to each of the groups by taking into account the proposal's origin and context of execution. Subsequently, the productions were analyzed around themes that were defined a posteriori, with all groups combined. These themes were: 1) the seat and the driver's work station, 2) clerical tasks, 3) the communications system, and 4) the equipment and its organization.

The concrete solutions (drawings, data sheets, mock-ups) were characterized in relation to the recommendations and guidelines normally found in design manuals (Diffrient, N. et al, 1979, 1981, and Woodson, W.E., 1981). The advantages and disadvantages of each proposed solution are listed, as well as some implications should the solution ever be implemented.

Trace analysis, the training program, the means of concretization, and analysis of production primarily involve the project's first objective.

4.5 Session analysis

Note-taking during the work sessions and during individual semi-structured interviews was recommended. Group dynamics during work sessions is an important aspect to consider and to note because it allows the participants to confront and nuance their knowledge together as a group. The climate of confidence between the researchers, the participants and the patrol officers determines the quality of the information gathered. Particular attention was paid to determine whether the dialogue on back pain was modified during the work sessions.

4.6 Individual interviews and analysis of dialogue

After the teamwork period, the police officers suffering from back pain agreed to participate in an individual semi-structured interview focusing on 2 themes: 1) their participative experience at the IRSST, and 2) the impact of their state of health on their work and their quality of life in a police department. We chose the most suitable day and time and a familiar context that promoted dialogue. The elements of the discourse were grouped into three categories defined a priori: the evaluation of the participative process, the patrol car and work organization, and back pain.

4.7 Questionnaire on back pain

As part of their functional evaluation, the policemen and policewomen answered two questionnaires on their perspective of the underlying causes and mechanisms of back pain. The questionnaires included closed-ended and open-ended questions.

One of the open-ended questions asked the policemen and policewomen to draw a spine. The drawings were evaluated and coded by a physician in such a way as to analyze the general organization of their knowledge (instead of the quantity and quality of the details). The drawings were then presented in a random order to an evaluator external to the research.

The participants completed a questionnaire at the beginning of the project and another at the end. The questionnaire presented at the end of the project included questions relating to their participative work experience at the IRSST. The aim of the two questionnaires, one at the beginning of the project and the other at the end, was to check the participants' knowledge and level of learning during the project.

4.8 Functional examinations

In total, 26 police officers were examined, 14 of whom suffered from low back pain and 12 did not. For various reasons, 5 policemen and policewomen (three pregnant women and two cases unrelated to the project) refused the examination or were eliminated from the analysis.

The examination was conducted by three physiotherapists with specialized skills in evaluating vertebral functions. Inter-observer reliability tests were conducted on three subjects prior to commencing the project to ensure interpretational consistency between examiners for each of the tests included. In addition, during the pre-project evaluation sessions, three subjects were tested by all examiners (split half cross-over) to ensure that the consistency was persistent. Great care was taken to evaluate control subjects with the same standards as the ones applied to those with back problems.

The primary objective of the evaluation was to classify the subjects clinically. The examination included an anamnesis of the subjective symptoms (history, pain and functional limitations), followed by an evaluation of active and passive movements. Observations of posture, and neurological and iliosacral tests completed the examination. The functional tests included flexibility, strength and endurance of the muscles linked to back pain. In total, 108 qualitative or quantitative observations and tests were recorded during the examination.

From the 108 tests comprising the clinical examinations, 4 categories were established *a posteriori*: 1) normal; 2) minor postural or functional problems; 3) somewhat serious problems related to an intervertebral disk or to iliosacral articulations; 4) serious and disabling problems with neurological symptoms, instability in articulation or limited vertebral movements with signs of inflammation. Although the small number of participants does not allow extrapolation from these data, the latter allowed us to check our classification of subjects with and without low back pain.

By grouping the 8 most significant tests (Lasèque tests, lumbar-sacral flexion and extension, two hamstring flexibility tests, three accessory movement tests), Figure 4.3 was developed to illustrate the significant differences between those subjects with low back pain and those without. Figure 4.3 represents the summary of these 8 functional tests on 26 police officers during the first examination. Each radius represents one test, and the length of the radius indicates the degree of abnormality. A healthy subject is represented by a point at the centre of the circle. Even if the difference between the subjects without low back pain (circles 1 to 12) and those with low back pain (circles 13 to 26) is clear, one notes that healthy subjects have some abnormalities, and that subjects with low back pain have a variety of injuries. Lastly, note that the results are from only one examination and that a follow-up might have produced a more complete picture.

In addition to the validation of the sample, the data essentially served as a reference point to support or invalidate the patrol officers' discourse on their back pain. In addition, it could serve as a basis for a broader study on the etiology of low back pain.

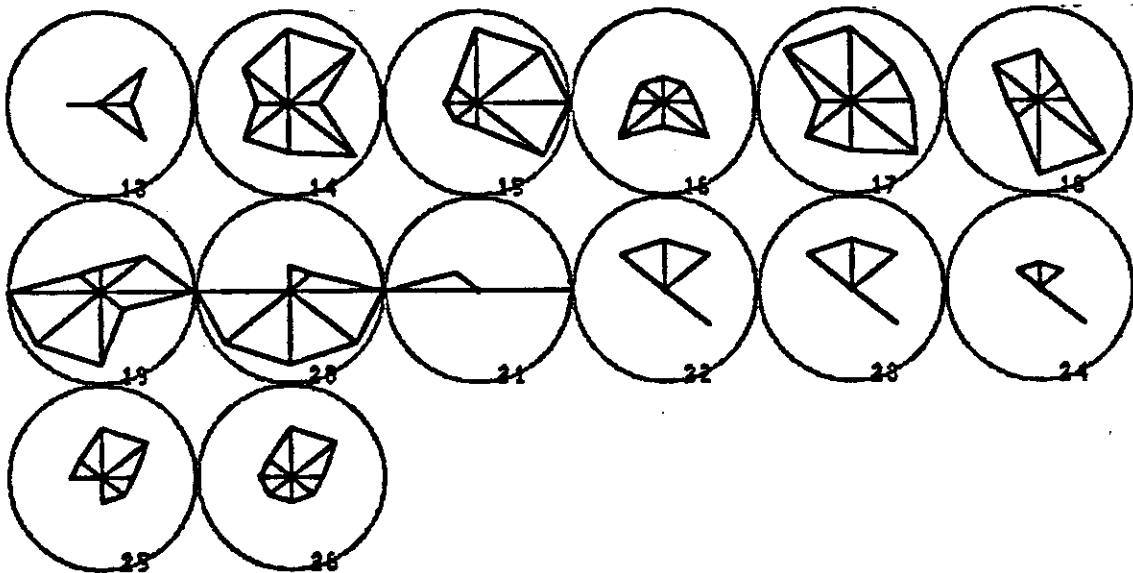
Details concerning the tests as well as the bibliographical references are available at the CORD Laboratory².

Analysis of the sessions and the production, individual interviews and the analysis of the discourse, the questionnaire and the functional examinations involve the project's second objective: developing our knowledge about the different aspects of low back pain which can be related to the content of the police officer's task.

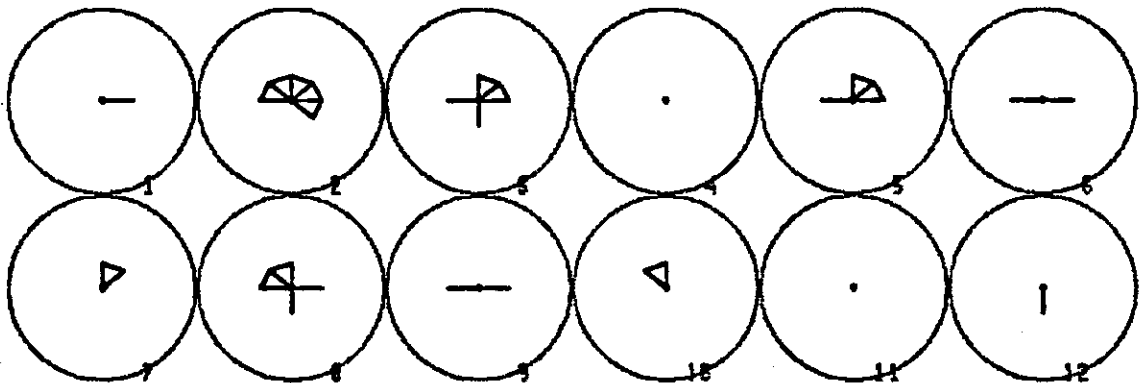
² CORD Laboratory, Mary-Ann Dalzell, 5545 St. Jacques West, Montreal, Quebec, Canada H4A 2E3 (483-1213).

FIGURE 4.3
RESULTS OF THE 8 FUNCTIONAL TESTS
ON POLICE OFFICERS WITH AND WITHOUT LOW BACK PAIN

WITH LOW BACK PAIN



WITHOUT LOW BACK PAIN



5. PARTICIPATIVE PROCESS

Analysis of the participative process deserves attention in order to understand the impact and the limitations of the means and the methods used in this project.

We should immediately point out that the participative process that was begun within the context of this project is different from traditional approaches because the work sessions took place on IRSST premises. As a result, the workers were removed from their daily work environment.

In the industrial context, the participative process has been used to achieve several goals. K. Noro (1990), in his analysis of several cases where the participative process was applied in a Japanese context, emphasizes some of them: efficient use of the workers, improvement in the movement of information, and consideration of the workers' viewpoint.

In a Western context, emphasis has instead been placed on social aspects and the improvement of working conditions (De Keyser, 1980).

Our study falls within the context of occupational health and safety related to the improvement of working conditions.

General evaluation of techniques

Cotton et al (1988) compiled 400 articles dealing with participation, 91 of which were selected as a basis for classification into 6 categories:

1. Participation in the decision-making process on working conditions.
2. Participation in a consultative process.
3. Short-term participation.
4. Informal participation.
5. Participation of workers in company profits.
6. Participation through union representatives or others.

Taking into account this classification, our study falls into the first category even if the duration of the participative approach is rather close to "short-term participation".

Training of the research team members played an important role in the session dynamics. In fact, analytical frameworks specific to each discipline were implicit due to the presence of these professionals on the team, hence the importance of clearly defining the composition of the multidisciplinary team.

The session dynamics depended to a great extent on the methodological choices and the goals that were set by the research team. These methodological choices are not neutral, even within the framework of a participative project whose basic assumption is control by the workers of the largest number of factors in the session dynamics. By their presence, the research team members had an impact from the very beginning on the way the problems were dealt with and the form in which the solutions were presented.

The objectives of the research guided, among other things, the choice of participants. The latter, even if they were chosen by managers from municipal and provincial police departments, had to first respect the division between those with low back pain and those without, and second, provide the training of at least one female team. The people who made up our sample thus corresponded to a wide range of percentiles, mainly due to the presence of women, thus orienting the layout suggestions (particularly for the seat) towards the need for multiple adjustments which would allow everyone to be accommodated.

Some authors (Leppanen, 1990) have stressed the usefulness of training as a means of participation. In the project, the training sessions' content and method were determined in advance by the team of researchers, and the sessions played a certain role in establishing the objectives of the groups. Even if the results of the questionnaires show that the participants felt they were useful, we believe it would have been preferable to define the objectives on the basis of the needs of the working teams.

A participative project therefore requires an effective and flexible framework that allows adaptation to the needs expressed by the workers during the process (O'Brien et al. 1987).

The dynamics in each of the working groups was based to a large extent on the leadership or lack of leadership of one or more members of the team. The rather frequent absenteeism of certain members played a significant role in the teams' levels of motivation.

The dynamics between the groups was marked by healthy competition which stimulated creativity and the production of results.

The IRSST had a wide range of educational tools as well as resources: video equipment, drawing tools, mock-ups, samples of seats and cushions brought by the participants or supplied by the IRSST. The participants were not restricted to 1 or 2 means of representation, but care had to be

taken to provide tools that could be used by the participants themselves. For this reason, the idea of using a CAD (computer aided design) system was rejected because it adds a level of difficulty by forcing the subject to picture himself in space using a 2-dimensional model drawn on a screen.

The choice of one tool over another by the working group depended on the leadership demonstrated and on the capabilities of the participants. However, the tools are not neutral. For example, a video is very effective in identifying and demonstrating problems but does not allow an object to be created. However, a full-size mock-up allows the model of a piece of equipment to be presented and tested and provides an overall perspective of the solutions, but the mock-up is not very effective in evaluating all the actual problems in the patrol car. Data sheets and drawings allow the organizational constraints to be pinpointed, as well as more precise specifications to be given for a particular piece of equipment.

Regarding work analysis, the most common pedagogical tool is a training program adapted to the situation. For example, Montreuil et al. (1986) used the context of training on physiologic and postural factors to enable workers to analyze their work. Work analysis is an essential element of the participative process. In the project, trace analysis was used because it is well suited for observing work in a patrol car.

Evaluation of scientific contributions

In general, the results of this research lead us to consider the work environment as a systemic environment whose characteristics vary with the organization. It is a living environment where social relationships are sometimes very dense and very complex such as in a rehabilitation centre, a hospital or a police department. It is a rather hazardous living environment which produces pleasure and suffering, and where there are such things as accidents and illnesses. Seen from such a broad perspective, the study of work environments demands a diversity of analysis and synthesis.

Does this mean that it is better to study men and women at work from the standpoint of several disciplines? We believe so. A multidisciplinary approach introduces added complexity to the definition of the problems and to the interpretation of the results. In the study of human factors, this leads us to conclude that we are closer to reality.

The aspects in this multidisciplinary approach are to be defined for each project. In general, they should represent four large areas of human existence:

1. The worker's somatic history which is in the form of an accident or an occupational illness. It directly involves medical science and the related sciences, biology, toxicology, ergonomics, and biomechanics.
2. Personal psychosocial history which originates in the work environment. It mainly involves psychology, the study of psychosomatic illnesses, and ethnopsychology.
3. The physical and ecological environment of the workplace. Understanding this environment involves a large number of disciplines including environmental sciences (i.e., air quality control), engineering, ergonomics and design.
4. The company's sociocultural environment. This environment is understood through sociology, anthropology and economics.

In general, these four fields should be considered as reciprocal in the sense that they interact with each other. The problems related to the study of occupational health and safety often result from the fact that one approach is favored over the others, or that it is impossible to fit the study of one aspect into all the knowledge about a work environment.

Let's briefly look at the general principles that allowed researchers from different disciplines to work together in carrying out the project:

1. Sharing and complementariness: Acquiring a broader and more complex understanding of a work environment through the sharing of various resources such as those described above.
2. Returning to the individual: Promoting approaches that respect people's physical and mental integrity.
3. Collective representations: The knowledge gained from professional experience is recognized as being a significant aspect which serves in defining the rationale and in orienting the proposed solutions.
4. Valorizing the discretionary activity of the workers in taking charge of prevention. The researcher tries to minimize his position of authority to promote collaboration, which is made easier through teamwork involving researchers and workers. In practice, an appropriate level of communication must be established, and participants must be provided with the tools that allow them to express their ideas.

In the case of back pain in police patrol officers, we used anthropology, biomechanics, ergonomics, design, engineering and orthopedics.

Study of the musculoskeletal apparatus

From the standpoint of a scientific analysis of the etiology of low back pain, the choice of participants in this study did not allow a statistically representative body of data to be produced. Among other things, "low back pain" is a very broad category and does not allow a pathology to be isolated and an in-depth study to be carried out on it. However, from the standpoint of a study of the musculoskeletal apparatus, the research framework allowed the rationale of back pain to go beyond the strictly orthopedic aspect and to include external factors which can affect the development of low back pain.

Ergonomics

The number of participative projects in ergonomics is increasing from year to year. They are based on a theoretical assumption in which the participation of workers in the development of solutions

to their problems can be a way of reducing the physical or psychosocial stress expressed, in this case, by back pain.

The position of the ergonomist, the designer, and the engineer is delicate because they must act at two levels simultaneously. First, they must choose and transmit available technical knowledge without presenting a position of authority, but rather by promoting and stimulating creativity. This is the educator's difficult position. Second, they must collect data on the task's technical content which allows them to evaluate the production of the groups.

Anthropology

Overall, this approach requires that the researcher take into consideration a discourse that is organized around an occupational illness or accident. The illness or the injury becomes the favored path of communication for illustrating a global context. In fact, the characteristics of a worker's social relationships within the company will emerge from a dialogue on the why, the how and the consequences. The discourse as a whole will reveal the rules and the quality of the social relationships within the work environment. The participatory group context allows the possibility of combining critical information on job content. The training of a multidisciplinary team therefore allows data to be compiled on a variety of aspects that have a role to play in the effective prevention of back pain.

6. PARTICIPATIVE DESIGN OF THE PATROL CAR

The description of the design process as planned by the participants in this project can be dealt with in several ways. This section of the report deals with three.

First, since each of the six working groups has its own profile due to its composition, dynamics, and the characteristics of its members, the design exercise is presented on the basis of the approach and the priorities of each of the groups. This same description is then dealt with again in relation to the themes whose formulation is based on a regrouping of the problems (associated with one or more solutions) established *a posteriori* by the research team. These groupings take into account the intervention priority given to each work trace identified, as well as the relationships between certain problems as explained by the analysis of the dialogue on these problems. What emerges from all of the groups is a consensus on the problems and the proposed solutions.

From the standpoint of police work, both these problems and solutions are, in relation to the patrol car (ergonomic aspect), a reconstitution of the tasks carried out at this work station, and an analysis of the proposed solutions. These three ways of dealing with the participative design of the patrol car are discussed at the end of the chapter.

6.1 Approach and priorities by working group

To design a patrol car passenger compartment that is suitable for police work is one of the main objectives of the project. This section presents the approach and the results of the working groups. Each of the teams developed an original perception of the problems and solutions which deserves to be presented individually. Trace analysis, and an analysis of the working sessions and the production of each team have been grouped in a composite table:

Patrol car passenger compartment design
and the prevention of low back pain

IRSST - RA-049

Research report

FIGURE 6.0
Synthesis of the activities by working group

Team	Without back pain			With back pain		
	1	2	3	1a	2a	3a
Number of members	5	6	4	5	6	4
General approach	- problems dealt with individually - analytical	- problem analysis - global	- passenger compartment layout	- passenger compartment layout - global	- design of a seat	- passenger compartment layout - storage space
Means of expression	- data sheets	- video	- mock-up	- mock-up - drawings	- seat prototype	- drawings - mock-up
Problem prioritization	- seat - clerical tasks - equipment	- clerical tasks - seat and drivers's work station	- drivers's work station and seat - clerical tasks	- seat and driver's work station	- seat and driver's work station - clerical tasks	- seat
Orientations of solutions	- comfort - safety - quality of professional life	- space management - comfort - safety	- space management - comfort - safety	- space management - safety	- developing a seat adapted to the work	- prevention - safety - comfort

GROUP 1 (Without low back pain)

The team was composed exclusively of policewomen. Two of them carried out their profession in large municipalities, two in small municipalities, and one with the Sûreté du Québec. Their general approach to the patrol car passenger compartment could be qualified as individual in the sense that the problems were dealt with systematically one after the other. It was also very analytical in the sense that each detail was considered in the analysis of the problems as well as in the proposal of solutions. The production was oriented towards finding solutions. These characteristics are reflected in their means of expression, which consisted essentially of the production of a series of 12 technical data sheets on the following subjects: the front seats of the vehicle, a retractable writing surface on the passenger side, a work light, a storage compartment between the front seats, the layout and

location of the communication system and the emergency controls, the layout and location of the computer, the location of the spotlight, the protective screen, the location of the 12-gauge shotgun, and guidelines on the installation of the other equipment (radar, AM-FM radio, window and door controls), guidelines on the equipment carried on one's person, and lastly, reflection on health and working conditions. An example of these data sheets is presented on the following page (Figure 6.1).

Regarding the priorities established using the trace method, one notes, in order of importance, concerns about the seat, all the clerical tasks, and the equipment (the equipment found in the patrol car as well as that worn on one's person). The seat is, in their approach, separate from the driver's work station and is dealt with in terms of the adjustments necessary to conform to individual body structure. Apart from these adjustment problems, they stressed the necessity for proper maintenance. The proposed solutions are realistic in the sense that the effort to find solutions was oriented towards an existing seat which could meet their criteria. From their perspective, the seat and back problems are intimately related. For them, a good seat would correct the majority of back problems. The other components of the driver's work station involve a technical approach in which the tools are examined one by one. Their evaluation is oriented towards finding minimum comfort and safety standards.

Sensitive to the clerical tasks to be performed in the patrol car, the members of this team looked for solutions oriented towards the prevention of poor posture in writing or in putting away accessories. They identified a causal relationship between these poor postures and low back pain.

The solutions proposed for the communications equipment (walkie-talkie and computer) stress the necessity for compact equipment to save space, but also to prevent low back pain during transportation. Radio communication is dealt with in relation to safety in the sense that it must be rapid and efficient.

Figure 6.1 - Example of a technical data sheet produced by Group 1

Patrol Car Design

Useful Object Data Sheet

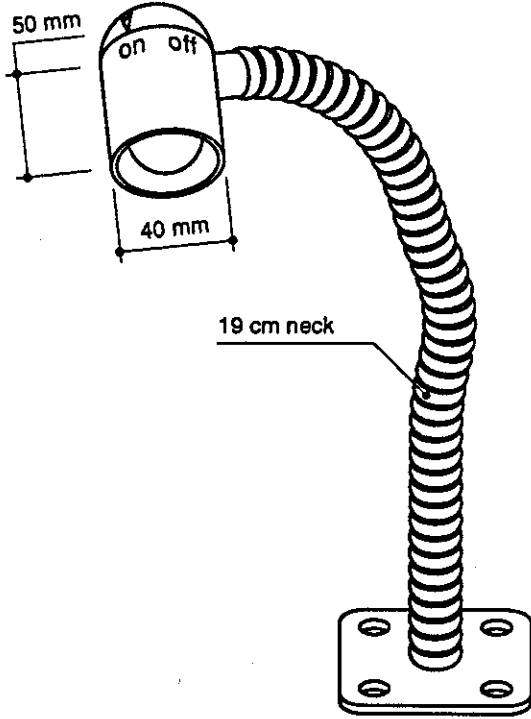
Work light


Characteristics :

- Uniform cylindrical shape
- Enclosed switch
- Directional light
- Halogen lamp
- 19 cm neck
- Flexible neck
- 40 mm circumference
- 50 mm depth of the lamp
- Installation at centre of dashboard

Research Group 1

Data sheet no. 03





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Another concern of this group's members is the equipment and its arrangement. Also discussed in great detail were factors related to work organization, as well as health and safety.

Improving the comfort of patrol car occupants and the quality of their professional life is seen as a preventive measure not only for low back pain, but also for all of the unpleasant work situations related to police work.

GROUP 2 (Without low back pain)

In this team, four policemen were from the Sûreté du Québec, and two others work in small municipalities. Their general approach to the patrol car was oriented towards an overall problem analysis. The use of video as a means of expression allowed self-confrontation and detailed reflection. The team produced a 25-minute video illustrating the main problems encountered by police officers in their work in the patrol car. The thematic framework of the film was:

- . The trunk;
- . The seat: entering and exiting the vehicle, the safety belt, blind spots, the sun visor, armrests, seat backs and headrests, as well as adjustments;
- . The dashboard: mirror adjustment, unlocking of doors and trunk, the location of the radio and the receiver, the heating and ventilation system, controls for special equipment, the AM-FM radio, air-conditioning, installation of the 12-gauge shotgun, and the tilting steering wheel;
- . Interior lighting: individual lighting and the dome light, as well as report writing;
- . Torsion: accessibility of the rear seat, unlocking of doors, opening of windows, transportation of equipment, and poor sitting positions;

- . **Equipment:** police emergency kit, radar, briefcases, 12-gauge shotgun, bullet-proof vest, flashlight, nightsticks, bicycle supports, spotlight, directional arrows.

- . **Conclusion:** comments on driving, recommended equipment, better organization of the dashboard accessories, the poor quality of seats, interior space, reduction in torsion, performance and comfort: finding the ideal car.

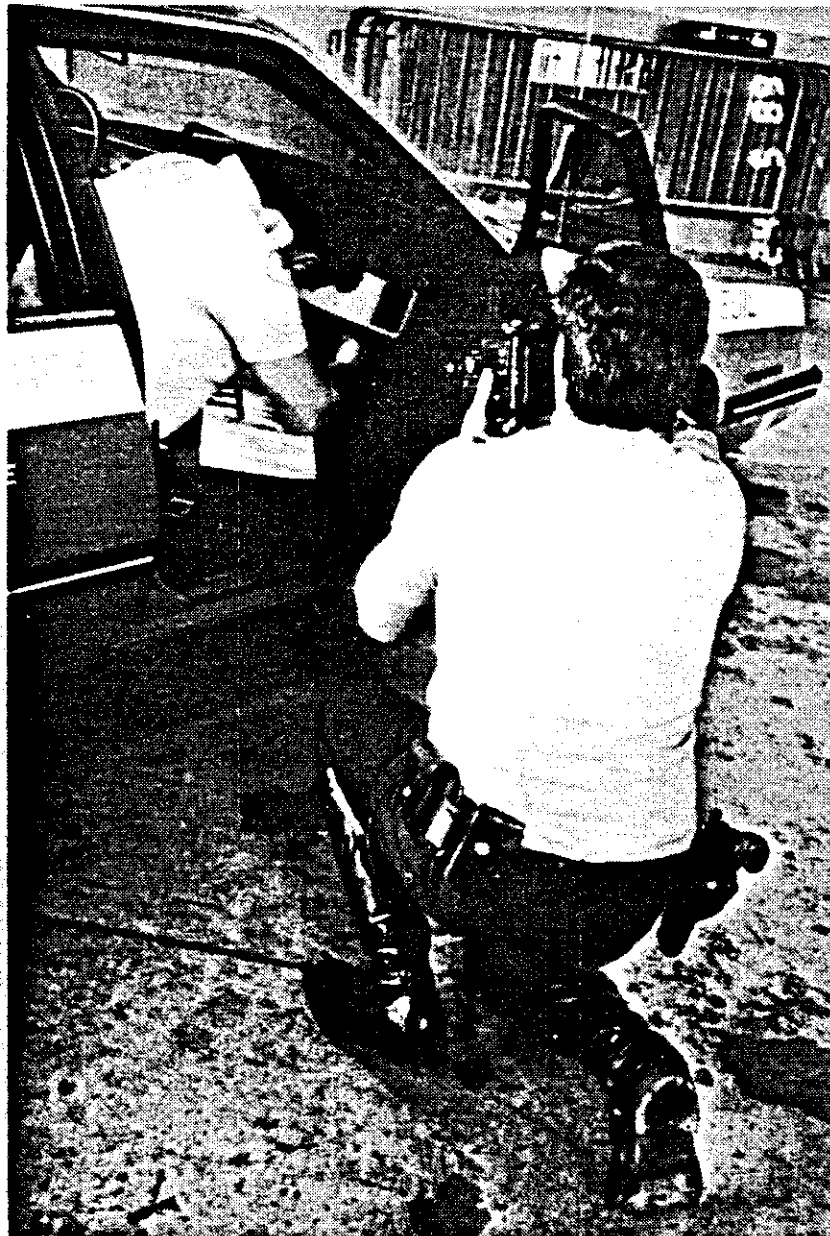
The major titles of sections in the film were chosen on the basis of different parts of the vehicle, and the subtitles refer to the results of work trace analysis.

In contrast to the other teams, the seat and the driver's work station were ranked second in preoccupations after clerical tasks. The seat is analyzed as an integral part of the driver's work station, and the problems identified mainly involve deficient adjustments. Since this team contained members without low back pain, it had difficulty seeing a relationship between back pain and the sitting position. In their opinion, low back pain could only be caused by torsion from a sudden movement during an impact (therefore from an injury), or be the result of a repetitive movement carried out under poor conditions. A proper arrangement of a driver's work station and a workplace allowing clerical tasks to be performed under comfortable postural conditions are the main aspects in the proposed solutions. Poor posture for carrying, and the risks caused by inappropriate storage space for briefcases and for the equipment necessary for police work are also identified as being potentially responsible for low back pain.

The communications equipment and other equipment are also analyzed in terms of the space inside the patrol car. After the analysis, they concluded that in general, the inside layout of existing patrol cars is deficient from several standpoints: the equipment is poorly integrated; the space is not rationally organized, that is, it is not the subject of minimally functional and safe standardization. Support for the 12-gauge shotgun is continuously used as an example of risk in the event of impact.

The use of video as an analytical and demonstration tool has in general oriented the group's reflection towards an analysis of the existing situation in patrol cars that are now in service in police forces. The solutions to the observed problems are oriented towards spatial organization and the concept of comfort. Storage spaces must be safe, compact, and functional, allowing the police officers to carry out their tasks without risk to health, which includes the risk of low back pain.

FIGURE 6.2
PHOTOGRAPH OF THE VIDEO TEAM
RESEARCH GROUP NO. 2



GROUP 3 (Without low back pain)

This team was composed of three policemen and one policewoman. Two of them worked in large municipalities, one in a small municipality, and the other with the Sûreté du Québec. The passenger compartment layout was a priority for them and the construction of a full-sized mock-up of the front part of the passenger compartment of a patrol car fulfilled this priority. Observing the final result, one notes that the often-expressed need for space appears in the mock-up which is sober and functional.

Trace ranking was clearly oriented towards the driver's work station, with the seat integrated into it and not a priority in itself. The main problems identified regarding the seat involved the adjustments. The global approach did not really relate to back problems, but stressed comfort, space management and safety. The solutions considered were always realistic: care was taken to explore existing equipment and to try to integrate it to meet the objectives.

Clerical tasks were considered as a not very likely to cause back pain. Nevertheless, it was observed that the layout of the actual patrol car in no way met the minimum requirements for carrying out these tasks since it is crowded and the space not well planned.

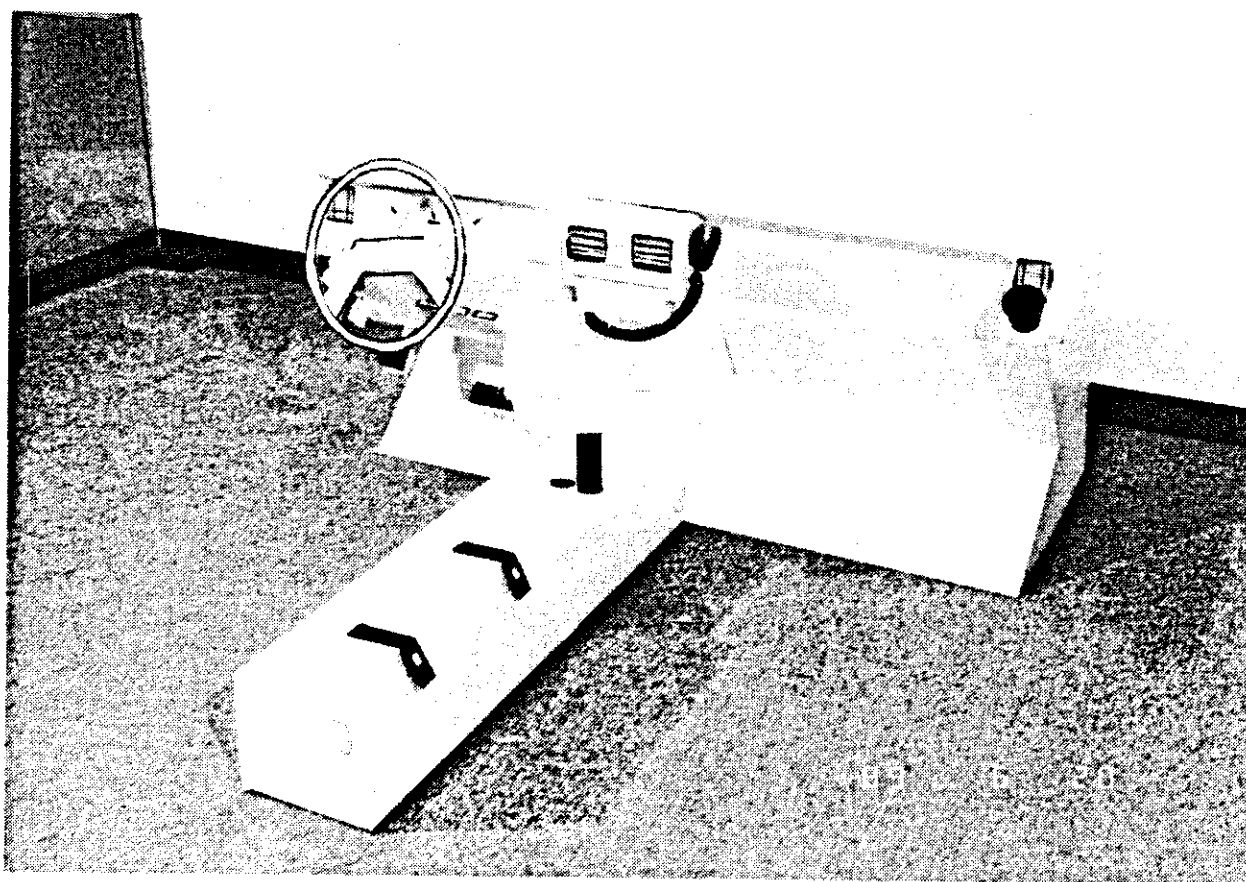
Very sensitive to space management, the members of this team dealt with communications in terms of equipment accessibility. Grouping the equipment and controls together in a central space allows unhindered movement. By eliminating rather random layouts, which are often dangerous in the event of impact, occupant safety is improved.

Even if it was difficult to arrive at a consensus on the equipment and its arrangement due to the diversity of equipment used by the various police forces, a priority was established around safety. At all costs, mobile components were to be avoided, with installations integrated into the passenger compartment that are safe in the event of impact.

In fact, two possibilities were considered: find a compact and safe location for the equipment, or eliminate it from the passenger compartment.

Space management, comfort and safety were the major concerns in this working group.

FIGURE 6.3
PHOTOGRAPH OF THE MOCK-UP
RESEARCH GROUP NO. 3



GROUP 1a (With low back pain)

This team was composed of three policemen who work in small municipalities, another policeman from a large municipality, and a policewoman from the Sûreté du Québec. The seat and driver's work station were their major concern, but several elements in the passenger compartment as a whole and even the general configuration of the vehicle were dealt with. Many drawings and a full-sized mock-up of the front seat area served as means of expression in finding solutions (illustrations on following page).

The seat was considered as being an integral part of the entire driver's work station; it became the starting point. First they had to find, from among existing seats, a model that could be used as a base and to which the necessary changes would be added without compromising comfort and safety. Then, it meant building a passenger compartment around this seat. They felt there was a strong link between back pain and the lack of a good seat as well as poor management of space inside the passenger compartment. The solutions were oriented around this rationale, and include a general redesign of the seat and the space inside the passenger compartment. A good seat, good suspension and increasing the living space at the front of the vehicle would, in their opinion, correct back problems.

Even if clerical tasks were not a priority for this team, the need for good lighting was expressed. The communications equipment was focused on, due to its direct relationship with space management and interference with the driving of the vehicle. The problems involving radio communications, the walkie-talkie and the computer were dealt with in detail, and this resulted in solutions clearly oriented towards improved space management. They proposed installing a central console containing the controls for the various communication systems and the computer. In the central console, they planned for storage space for documents, forms and other equipment.

The equipment necessary for police work was also dealt with in a detailed way and in relation to the torsion that can result from a poor layout. Once a consensus had been arrived at, the solutions

led to the development of basic principles that take into account both human anatomy and space management.

Many of these solutions are achieved through the development of a console.

In summary, this team organized the passenger compartment around the seat. It was a global approach despite the specific attention to details. The need for space inside the passenger compartment to hold the police officers and equipment safely and preventively oriented this team's members towards models of vehicles that are closer to vans than automobiles.

FIGURE 6.4
PHOTOGRAPH OF THE MOCK-UP
RESEARCH GROUP 1 a)



GROUP 2a (With low back pain)

This team was composed solely of policemen and was well distributed with respect to origin, because it included two representatives from each category of police department. Work trace analysis indicated a strong polarization towards the seat and the driver's work station, and second, towards clerical tasks. Very early, the group directed its action towards the design of a seat adapted to police work, and the decision was made to concentrate all efforts on producing a drawing and constructing a seat mock-up. With the help of a manufacturer³, they produced a full-sized functional prototype of the seat from their drawings.

The rationale concerning the seat and the driver's work station was oriented towards a solution to back pain. The fact that police officers have to work in a sitting position for a prolonged period was identified as the major problem. According to them, a seat whose components are adjustable, provides proper posture, and which is adapted to police work, would correct back problems. In addition, the seat must be solid and contribute to occupant safety.

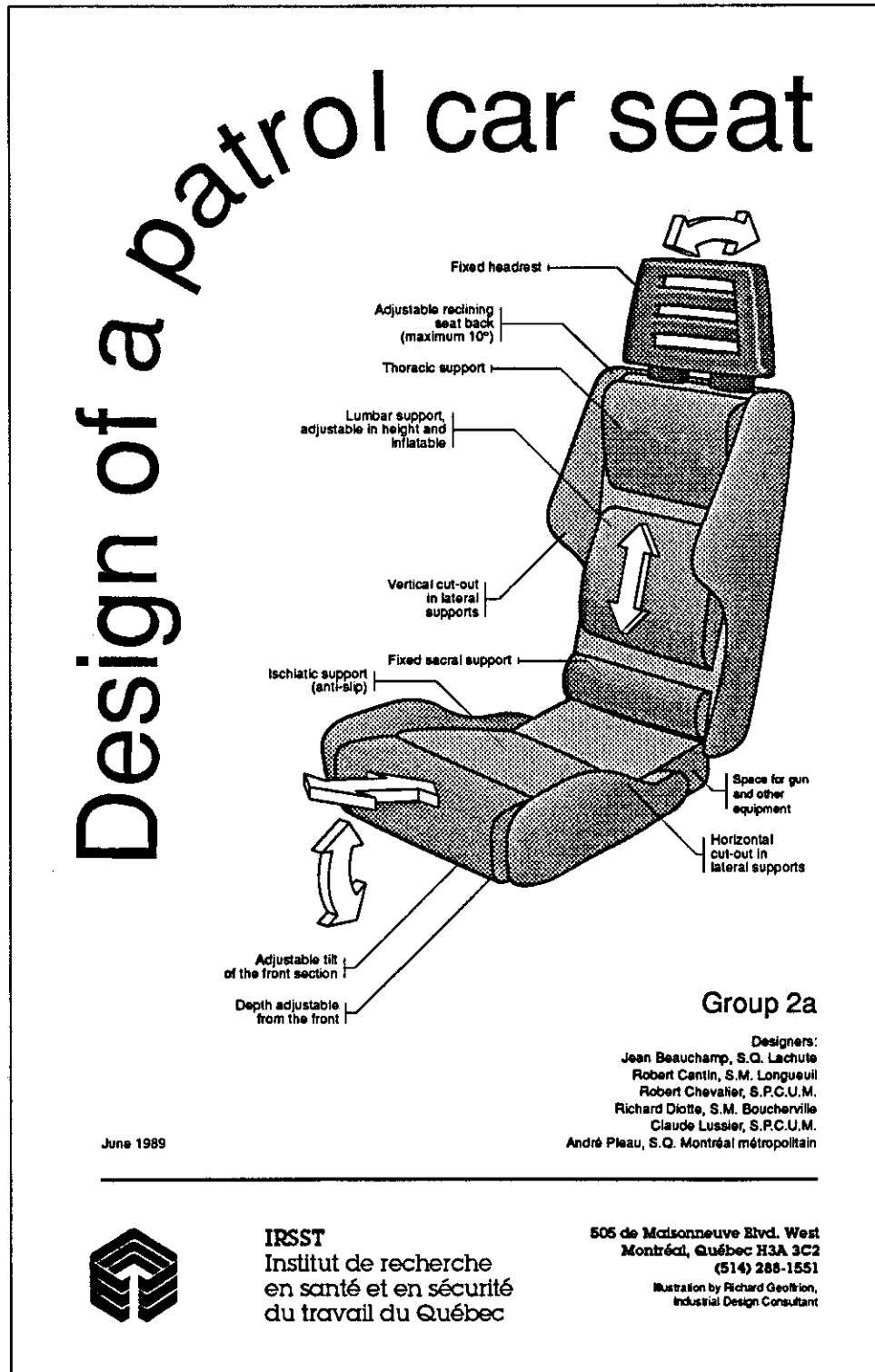
Since their efforts were oriented voluntarily towards seat design, there was only marginal discussion about problems and solutions relating to clerical tasks, communications systems and equipment.

They were mainly concerned about the torsion resulting from use of the equipment (equipment integrated into the vehicle and that necessary for police work in a restricted space). Even if it is only the subject of a rough sketch, the solution is again achieved through the development of a central console accessible to the two police officers.

³ Daniel Laviolette, owner of "Les ateliers Van Richelieu inc." in Sorel.

In brief, back pain was the focus of their discussions, and the solution consisted of a good seat and improved spatial organization.

Figure 6.5 - Diagram of a patrol car seat adapted to police work, produced by Group 2a



GROUP 3a (With low back pain)

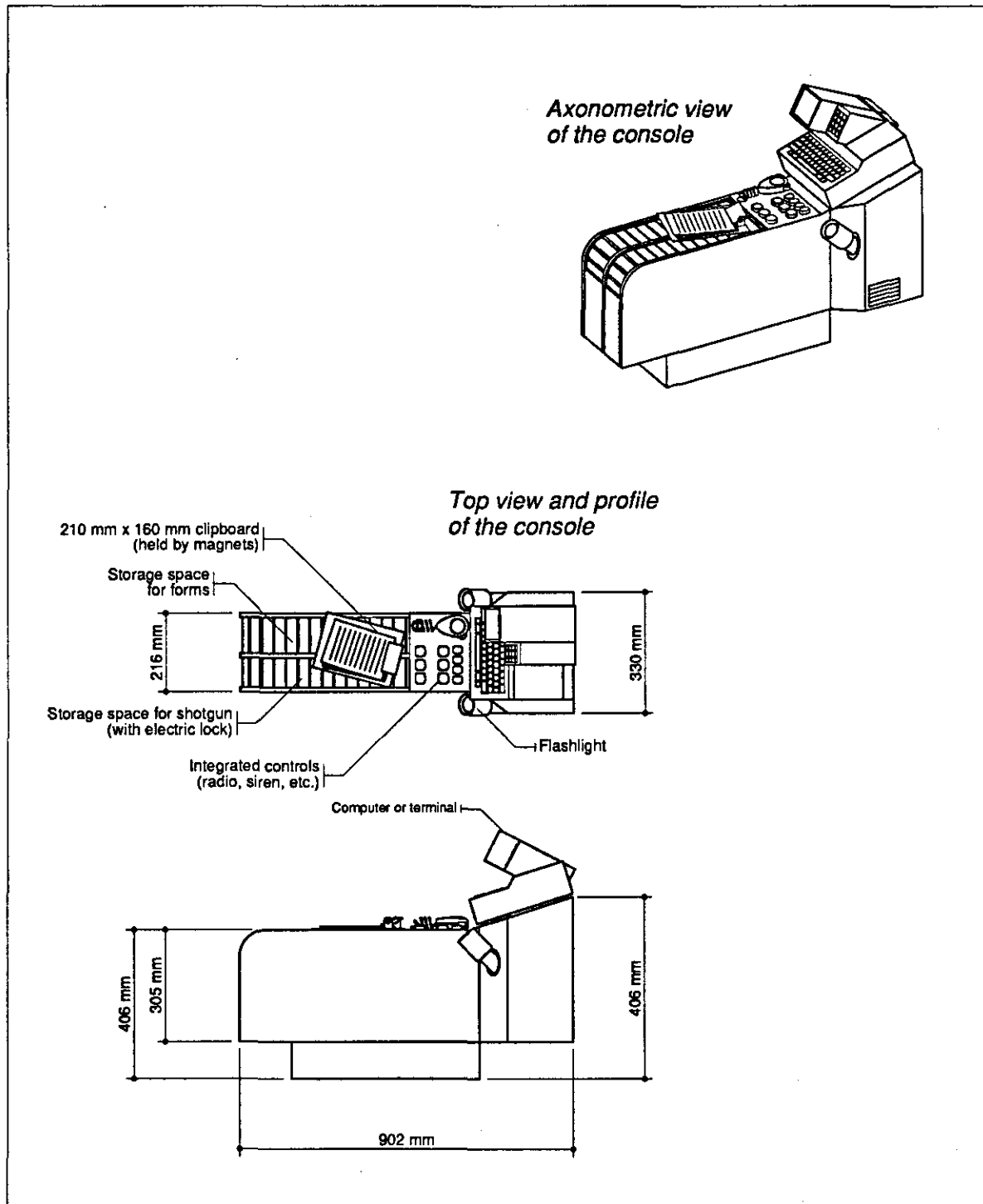
Two members from small municipalities' police forces, one member from a large municipality, and one member from the Sûreté du Québec made up this team. The seat was their first concern in work trace analysis, while all other components had no particular order of distribution. The result of their reflection is expressed in the form of drawings and a mock-up in which the central console dominates.

The seat was only one of many elements in the driver's work station because, very early, back problems were identified as being caused by a deficient general layout of the passenger compartment, which forced police officers to continually be subjected to torsion in carrying out their work. Since police officers must do a large part of their work in the patrol car, reflection focused on a vehicle design that took into account this reality. Prevention and safety were guides in finding solutions. Very realistic regarding the cost and possibility of having their solutions implemented over the short term, they verified that their arrangement proposals could be integrated into vehicles actually in service in the different police forces.

Problems relating to clerical tasks were linked to the poor postures resulting from lighting that is poorly adapted to report writing. The problem is solved through the installation of map lamps whose light can be directed towards the driver and the partner. The equipment for clerical tasks is organized in a central console.

The components that make up the communications systems were studied separately and the solution involves better management of the space, whose major component would be the central console. Since the patrol car is used as a shelter in the event of difficulty, as a mobile police station, and increasing as a data processing centre, a central console with a rational arrangement of the communications equipment and controls would reduce torsion and would provide greater safety for the patrol officers.

Figure 6.6 - Diagram of the mock-up produced by Group 3a



The equipment and its arrangement were dealt with in relation to the front part of the passenger compartment. Realistic and simple solutions were developed to achieve a preventive arrangement in relation to torsion as well as one that is safe in the event of impact.

In general, problems were dealt with in a global manner in relation to the various tasks to be carried out by policemen in the vehicle. Prevention, safety, and a certain occupant comfort associated with simple and realistic solutions over the short term, summarize this team's approach.

6.2 Consensus of all groups on the problems and proposed solutions

The aim of this chapter is to present the consensus of all or most of the participants regarding the 4 main themes defined a posteriori: the seat and the driver's work station, clerical tasks, communications, and the equipment.

6.2.1 The seat and the driver's work station

The seat

The problems identified regarding seats that are actually used in patrol cars involve adjustments, quality and design, maintenance, and layout.

The lack of adjustments for height and seat back angle is deplored. It is difficult to move the seat forward and backwards due to broken mechanisms, rusted rails, extended rails which result in too great a tilt of the entire seat towards the rear, poor alignment of the rails, or the presence of the protective screen.

Actual seats are not adapted in quality and design to police work. Reference is made to such things as the equipment worn at the waist and to the lack of reinforcement in the seat back. The poor quality of the materials used for padding and the structure of the seats lead to permanent deformation of the seat pan and back. The poor quality of the materials used in the mechanisms at

the base of the seats promotes rusting and limits adjustments. The off-centering of the seat in relation to the steering wheel forces the driver to maintain an uncomfortable position. The seat back, and as a result the headrest, are too low. The divided bench limits access to the rear seat. The lack of suspension at the base of the seat and the lack of adjustable orthopedic supports on the seat pan and back are considered unfortunate. Lastly, the use of vinyl or imitation leather for seat coverings is considered as uncomfortable.

Delayed and inadequate maintenance of the seats increases the discomfort. In addition, it is noted that the seat-padding repair used causes bulging of the seat pan, which limits the distance between the head and the roof and between the steering wheel and the seat.

The results of these problems are at three levels. First, they cause back pain or even aggravate existing low back pain. Second, they cause material damage because any techniques are used (lever, piece of wood, physical force) to adjust the seat. Third, they force the policemen and policewomen to make adaptations that are more or less successful: poor posture at the wheel, improvised lumbar supports using a piece of rolled-up clothing or a cushion. Lastly, a telephone book, a cushion, or sitting on one's left leg make up for a lack of height adjustment.

The solutions proposed are based on four major principles: a comfortable, preventive, sturdy seat that is adapted to the equipment. According to the police officers, a comfortable seat is easy to move frontwards and backwards, adjusts in height, has a rather high and reclinable back, allows proper posture, and provides good support for the head. A preventive seat can be adjusted to change position in order to avoid ankylosis and to provide proper support at the buttocks and back; it should also have good suspension for shock absorption. A sturdy seat is composed of firm padding material, a nondeformable support, and durable fabric. Lastly, a seat adapted to police work should provide room for the equipment worn at the waist.

The driver's work station

The driver's work station includes a large number of components such as the safety belt, the steering wheel, the rearview mirrors, the brakes and accelerator, the armrest, the selector lever, and the sun visor. A consensus on the problems and proposed solutions was difficult to obtain for these components.

The dialogue on the necessity of wearing a seat belt clearly illustrates this ambivalence. For some, it represents an indispensable safety feature in driving an automobile, while for others it is an element of insecurity in police work because it is an impediment in emergencies. However, all agree that an effective safety belt should contribute to stability on curves and in braking, and should have an accessible anchoring mechanism which can be rapidly released in emergency situations.

The steering wheel should be adjustable and provide sufficient clearance to allow easy entry to, and exit from the vehicle with the equipment worn on one's person. Rearview mirrors whose electrical controls are accessible to the driver are desired. Given that the actual sun visor hinders visibility for tall people, participants suggest that the windshield be tinted at the top. Some consensus directly involves the layout. For example, when a piece of equipment is installed, the brake and accelerator pedals must be clear of other mechanisms and wiring. Finally, it is recommended that the selector lever be properly maintained because play can develop in the mechanisms, thus making it more difficult to read the speed selected.

6.2.2 Clerical tasks

The problems related to writing in the vehicle mainly involve transportation and storage of the objects necessary for clerical tasks. The task itself is discussed, and this discussion focuses on factors that are based on work organization.

The weight and the number of objects necessary for writing tasks (briefcase, report case, forms) are the major constraints associated with transportation from the police station to the vehicle. These

articles are in addition to the other equipment required for police work. Storage of these objects in the vehicle also poses several problems. They are mobile in the passenger compartment and compromise the safety of the occupants during impact or sudden braking. The briefcases on the rear seat are unstable and can fall during emergency braking. Storing briefcases on the back seat causes extension and torsion which are a risk factor for back injury. This problem becomes even more serious if there is a protective screen, which seriously limits access to the equipment arranged on the back seat. Briefcases on the back seat take up space necessary for certain police tasks: interrogating witnesses, transporting prisoners, transporting persons in distress, etc. Having to stop and leave the vehicle in order to retrieve briefcases from the back seat is not a practical nor effective solution. Lastly, due to the lack of storage space for the different forms and notes, the top of the dashboard has to be used for filing, thus blocking ventilation ducts.

Concerning the "writing" function, the lack of support for writing and inadequate lighting are mentioned. The dome light causes blinding and is considered as inappropriate for writing. Furthermore, it compromises the safety of the police officers during night work should it come on automatically when a door is opened. A flashlight held by the chin is used to provide proper lighting.

The steering wheel, the armrests, the briefcase and even the knees are used as a support for the report case. The lack of support and inadequate lighting result in poor postures and are risk factors for back pain.

In brief, patrol officers note that the patrol car passenger compartment does not fulfill its office function. In addition, material on the back seat has to be moved to the front seat or to the trunk to create the space necessary for transporting or interrogating people.

The proposed solutions take into account that clerical tasks are performed in the patrol car. It is hoped that this office patrol car will be preventive, safe and functional. A preventive and functional

layout implies a console or a box between the two seats for storage, directional lights, and a writing surface to eliminate much of the poor posture and torsion. From the standpoint of safety, storage space eliminates mobile objects from the vehicle, making it safer in the event of impact. This new equipment should be designed in shape and position to reduce injuries. A good lighting system should not disturb the driver, nor cause blinding.

6.2.3 Communications systems

The communications system includes a transceiver, a microphone or telephone, a walkie-talkie and a computer. The frequent use of the transceiver and its microphone or telephone results in constraints which, although minor, become very bothersome for patrol officers. Inadequate control of the volume and tone, the need to turn the ignition key to use the equipment, and the code calling card which contains too much information, are examples. Also emphasized was the problem of the location of this equipment. Located outside the dashboard, it constitutes a risk of injury during impact and hinders movement. It also interferes with the selection lever and the controls.

The main constraints associated with the walkie-talkie involve the need to remove it and replace it when entering and exiting the vehicle, its volume and weight which are considered too great, its lack of power, and again, inadequate control of the volume and tone.

The computer, which is planned for general use over the short term, is already causing some reflection, particularly regarding its space requirement, possible interference with driving, the use of a keyboard, as well as the difficulty of noting information coming from the computer. The dangers of the visual display terminal are also being considered.

One of the principles guiding the proposed solutions is to avoid crowding through space management. The equipment must be compact and integrated into the dashboard or installed in a central console. The walkie-talkie, equipped with a detachable microphone, should be of a weight and volume to allow continuous wear.

Moreover, nothing should interfere with driving. The different controls for the communications equipment should be grouped together, made uniform, and be easily accessible. During computer installation in vehicles, the screen and the keyboard should be located in an appropriate position so that visibility is maximized, the angle formed between the hand and the keyboard is comfortable, and the equipment is accessible by both the driver and the partner. A means of collecting the information appearing on the screen should be planned; some of the participants suggested a small printer, while others would be happy with a judiciously placed notepad on a central console. These suggestions are prospective ones because few screens in use were available. Lastly, all agree in stressing that equipment must be installed to prevent any risk of accidents during impact, and that for the safety of police officers, communications must be rapid and efficient.

In brief, the communications equipment involves a problem with space. Solutions are arrived at through proper management of the space available in the passenger compartment.

6.2.4 The equipment and its organization

The list of equipment that was examined by the participants during the work sessions is impressive. For purposes of the analysis, we have divided it into three categories. First, there is the mobile equipment necessary for police work: the support and the 12-gauge shotgun, flashlights, nightstick, spotlight, and radar. Second is the equipment integrated into the vehicle: the emergency controls, the air conditioning and heating, the protective screen or window, windows and handles, locks, the AM-FM radio, the bicycle support, spare tire, ashtrays, speedometer, the motor's power, traction, the gas tank, doors, trunk, glove compartment, clock, mats, directional arrows, headlights, suspension, the steering column and the rear seat. Third is the equipment worn on one's person: clothes, bulletproof vest, and the various equipment worn at the waist.

For several of these components, a consensus was difficult, given the diversity of the equipment from the various police forces and the regulations in force. Nevertheless, one notes that the major concerns focus on the mobile equipment, mainly the support and the 12-gauge shotgun. The

secondary concerns involve the equipment attached to the car and the equipment worn on the person. The problems are considered from the standpoint of transportation, storage and use. The arrangement and storage of the equipment inside the passenger compartment involve safety in the event of a sudden stop or impact, and harmful movements (torsion).

The support for the 12-gauge shotgun is considered as dangerous and unsafe because it is poorly located and bulky. Most of the participants want to retain the 12-gauge shotgun particularly due to its dissuasive impact and the feeling of security that it offers, but most want to eliminate the support. Various solutions were proposed but no consensus emerged for its storage, either inside or outside the passenger compartment. It is suggested that the storage spaces for the flashlights, nightsticks and the spotlight be located where the equipment could be securely attached and be easily accessible. The participants feel that the radar should be attached to the vehicle, which would require a certain uniformity in the equipment and would eliminate its transportation.

The solutions relating to emergency controls are based on principles focusing on a rational layout (grouping) and on accessibility. Unsafe makeshift work is to be avoided. The protective screen or window was the subject of many team discussions; it is considered as providing additional security during the transportation of prisoners, but its installation should allow proper aeration and provide sufficient space for proper adjustment of the seat. There was a consensus on window controls and door locks; it is recommended that the mechanisms be electric and accessible to the two patrol officers. Another consensus involved the AM-FM radio. Several police officers bring their own radios either for entertainment during the night and for keeping them awake, or simply because it is thought to be "good for morale". It is another mobile and dangerous component in the event of impact. It is therefore recommended that it be installed permanently in the dashboard or in a central console. The other components were not the subject of a consensus, because they were not discussed sufficiently or because they were too specific to one police force or to one police application (as for example, the permanent bicycle support which is useful only in small municipalities).

Clothes (cap, coat, snowmobile suit for the Sûreté du Québec, bulletproof vest, etc.) must be comfortable and safe; storage space must be provided. For equipment worn at the waist, the participants ask that information be circulated about a balanced distribution of weight around the waist. Furthermore, they ask that a choice of equipment be made available which at the same time respects the standards in effect in each of the police forces.

It was therefore mainly principles that emerged from the solutions proposed by the participants regarding the equipment, rather than solutions based on consensus.

6.3 Analysis of police work in the patrol car

We should remember here that within the framework of this project, participants themselves proceeded with a first analysis of the work, using a method taught to them which had been adapted to the participative context. The exercise was focused on their work in the patrol car, and not on all police work. This method allowed two types of results to be generated. The first was an ordered list of more or less constraining technical objects related to police work in a patrol car passenger compartment, while the second was information on the organizational, environmental, and sometimes social context in which each of these objects is used. Once these two types of information had been collected, the work could be described from an ergonomic perspective.

6.3.1 Types of tasks carried out in a patrol car

The driving task is usually subdivided into primary tasks (guiding of the vehicle and maintaining visibility), secondary tasks (collecting of peripheral information and adjustment of comfort), and tertiary tasks, which are carried out when the vehicle is stopped (e.g., seat adjustment). A similar classification is possible with tasks that are more specifically related to police work in the patrol car.

The driving of the vehicle must be considered an integral part of police work. Most of the components necessary for driving a vehicle are all normally found in patrol cars, seeing that it is a conventional vehicle more or less adapted to police work. Some thirty can be listed, to which must be added those necessary for police work (most are found among the work traces identified by the participants). In all, police work in a patrol car, including driving, requires 57 distinct elements (controls, objects, dials, ...) which must be properly arranged in the passenger compartment. This number might not include certain specific elements which were not present in the sample observed.

The primary driving task includes the guiding of the vehicle and requires good visibility at all times. It is based on central vision and direct, rapid and unequivocal accessibility of the controls: the accelerator and the brake, the ignition, the controls for defrosting the rear window and front windshield, the front windshield wiper, the windshield washer, the controls for the front headlights, the turn signal controls, the horn, the selector lever, the steering wheel, the safety belt, and lastly the seat (the vehicle component with which contact is the most prolonged). The primary tasks in patrol car work identified during the project are: releasing the 12-gauge shotgun, operating the controls for the flashing lights, flashers, siren, horn siren, the roof lights, adjusting the steering wheel, the communications channel, the microphone or telephone, as well as the frequent entering and exiting from the vehicle.

Next are a series of secondary driving tasks which can be associated with peripheral vision and with directly-accessible controls, but which require neither major flexion nor extension. They include access to the cigarette lighter, the heating and air conditioning controls, the vehicle's emergency flashers, the air vents (intensity and direction), the AM-FM radio, the right and left window controls, the inside rearview mirror adjustment as well as that for the outside right and left rearview mirrors, and the door locks. The secondary tasks in police work can include controlling the dome light and the dashboard light, reading documents, and research using the communications computer.

Lastly, the tertiary tasks are carried out in the vehicle or in relation to it, but normally when it is stationary. Tertiary driving tasks include adjusting the seat, locking-releasing of the parking brake, and using the ashtray. The tertiary tasks in police work in the vehicle are: writing; reading; hood opening; trunk opening; handling the report case, the spotlight, the briefcase, radar, the flashlight, and the 12-gauge shotgun and its support. If this task classification seems restrictive, it is nevertheless coherent with all aspects of patrol car-related police work, as dealt with in the two previous sections.

6.3.2 Analysis of the solutions proposed in the drawings and mock-ups

All the elements mentioned in the previous section do not have the same weighting in terms of intervention priority and their relationship with low back pain, and all have not been reproduced in drawings or mock-ups by the working teams. The objective of this section is to show that the proposed solutions by the participants are primarily "ergonomic", in addition to being sound and achievable overall. What is meant by "ergonomic" is any solution that takes into account human characteristics and which facilitates or improves the work to be done. The comment "overall" is important because one solution taken alone could be judged unfavorably if taken out of context or from the system in which it is normally integrated. It is also important to note that there is no single solution, but that a generalization of all the proposed solutions orients the intervention for the problems raised. Lastly, this section dwelled to a greater extent on the "fabricated" or "drawn" productions of the working groups, since the oral expression of these same solutions (and of others) was largely covered in the two first sections of this chapter.

The 44 distinct solution elements compiled are presented in Appendix II. The columns in the table identify, from left to right: the group from which the solution originates as well as the medium favored by this group (data sheet, mock-up or illustration); the production element; the advantages and disadvantages (which can be ergonomic, technical or others); and lastly, the implications relating to their implementation in patrol cars. These solution elements are presented according to the same categories as those in section 6.2. The "Seat and driver's work station" category shows

three different solutions for patrol car seats, including one design developed as a functional prototype, which incorporates several elements specific to police work: lateral support to avoid muscular work by the back during rapid driving but which does not add additional work on entering/exiting the vehicle; increased ranges of adjustment, including that for lumbar curvature, in order to take into account a wide range of users; large open space on the side of the seat back to avoid pressure from the service revolver and the walkie-talkie; and lastly, increased support at the shoulders and in the sacral region. The interventions related to emergency controls are all oriented towards relocation into primary access zones, although some of the solutions do not allow two-officer patrols inside the same vehicle.

The improvement in "Clerical tasks" requires the creation of storage spaces for the writing board and the briefcase, the installation of suitable directional lights that light the work surface without producing postural constraints, as well as the installation of a small retractable table to facilitate writing inside the vehicle.

The solution to the "Communications system" problems is achieved by integrating control boxes into the dashboard and by installing attachment systems for the microphone, so that they are accessible by the two occupants of the patrol car. Also planned is a space dedicated to the walkie-talkie which can at the same time be used as a charging station for the batteries for this equipment. Three of the four proposals involving the communication computers have them installed on a pivot at the centre of the console, while the fourth solution was to recess it in the centre of the dashboard, nearer the primary field of vision.

Lastly, "Equipment and organization" includes some twenty solutions for organizing various objects, including different ways of storing the 12-gauge shotgun, the flashlights, as well as the permanent installation of the radar and the safety screens, promoting air flow within the vehicle. It can be seen that the proposed solutions are realistic while remaining innovative.

Furthermore, several of the solutions expressed in the mock-ups and drawings overlap proposals made by two American researchers in a study on patrol cars in Michigan (Clark and Ludwig, 1970, Ludwig, 1971). The authors' recommendations to manufacturers and decision-makers include a front passenger compartment "package" that contains two "scientifically" designed seats, and a central console to be used as storage space for small equipment. In concluding, we should point out that the challenge in designing a patrol car passenger compartment rests in the fact that the same space must simultaneously be used for driving the vehicle and for police work, with these two functions partially overlapping, but without interfering with each other.

6.4 Dialogue on the patrol car, the task and work organization

The essential part of the participants' creative activity was oriented towards a partial rearrangement of the actual passenger compartment while taking into account the daily objects used in police work, except for one group which extended its reflection to the total rearrangement of a vehicle. These reconfigurations were first supported by anthropometric considerations whose objective was to accommodate the largest possible range of users right from the first stage of design by maximizing the range of seat adjustments. This approach is more flexible than an a priori construction based on an "average" individual or a "95th percentile". For example, all the recommended seats have three advantages in that they properly support the police officer, allow access to the essential components for the work without excessive bending or torsion, and take into account the equipment worn at the waist.

Seats with different characteristics (suspension, supports, adjustment, clearance, ...) were therefore the focus around which the participants recreated their work environment. The designs common to almost all groups are:

- emphasis on the seat, to different degrees, either using existing equipment or going as far as major redesign;

- the presence of a console, redeveloped to hold a computer and/or to produce specific storage space (shotgun, briefcase, report case, etc.); these redevelopments sometimes involve minor reorganization of the work;
- the presence of a computer in the passenger compartment, even if most of the participants had little practical experience with this type of equipment in police work;
- functional rearrangement of the most frequently used controls into easily accessible zones;
- making the clerical tasks carried out in the vehicle easier.

The production drawings and photographs illustrate the proposed solutions. However, to better understand how these various solutions can be integrated into the passenger compartment and to better visualize the unit, we asked the designer from the research team to create three passenger compartment models incorporating certain elements of the participants' productions (pp. 71-79). Note that these are representations of concepts and that these illustrations are not final solutions because they have never been validated. However, they give a very good idea of possible passenger compartments. The three passenger compartment models all include seats adapted to police work, a central console, emergency controls grouped together, directional lighting, and storage spaces specific for the work tools.

Figure 6.7 shows the first passenger compartment model, incorporating a semi-recessed terminal, a lockable compartment for the 12-gauge shotgun (inclined towards the front), and emergency and telecommunications controls grouped together at the centre of the console. Supports for the portable telecommunications system and for the flashlights are integrated into the back part of the console, thus requiring the use of a protective screen. This passenger compartment's lighting (not illustrated) is provided by directional dome lights. Figure 6.8 shows a passenger compartment without a terminal or 12-gauge shotgun, but equipped with a retractable table (in the central compartment, in place of the 12-gauge shotgun) to make writing tasks easier. Lighting comes from a gooseneck lamp installed on the dashboard. In the absence of a computer, the flashlights and the portable communications system can be relocated to the front of the console. Lastly, Figure 6.9 shows a

passenger compartment with a terminal mounted on the console, thus freeing the central part of the dashboard for a communications system. The inside of the console is used for storage. The emergency controls (flashing lights, flashers and siren) are relocated onto the steering wheel (Figure 6.10) which brings them closer to the drivers's central line of vision but makes them inaccessible to the other officer.

From the ergonomic standpoint, the arrangement of the components must allow police patrol officers to carry out their various tasks rapidly and efficiently without postural or other constraints. The safety of police equipment installed after the vehicle is purchased is also important (Figure 6.11). The guidelines in passenger compartment development are: the proper positioning of the components in relation to the type of vision (central or peripheral) required for their use, particularly in emergencies; the grouping of frequently-used components according to an access or sequence priority; access to these components without postural constraints (within reach), and the presence of feedback. These guidelines must take into account the users' anthropometric dimensions, which vary according to the seasonal clothing worn. Lastly, particular attention must be paid to the reading and writing tasks in a vehicle in relation to posture and lighting, as well as to the use of car computers, since the scientific literature to date contains little data on these last two situations.

There was no consensus on choosing a car or a van. The impasse seems related to the fact that the organization of police work in the patrol car has requirements which exceed the limitations inherent in a car or van. However, there is consensus on their representation of this vehicle which is much more than a patrol car. For them it is a patrol car, office, communications centre, and shelter. It therefore encompasses a range of requirements, symbols, and representations.

For all people involved, whether police department managers, manufacturers, or designers, it is desirable that the report be considered an important source of useful information in patrol car design. The police patrolmen and patrolwomen have done their work seriously and with originality.

The proposed solutions reflect this attitude and deserve to be used as models for concrete applications.

However, it is important to point out to those who will be involved in the purchase or manufacture of these future products that the information from this document's proposed solutions can be used at several levels. We propose four:

The first level involves direct use of the solutions proposed by the police officers, either individually or combined, to develop functional models. This first level in result interpretation is for participants who wish to implement the proposed solutions rapidly. From this perspective, the following precautions must be taken:

- Ensuring that the product is safe;
- Testing the new product on a small scale;
- Collecting the users' comments and making the necessary corrections.

This approach is appropriate for a manager of a small police department who has direct contact with the workers.

The second level consists of verifying in what way the proposed solutions correct the problems identified by the police officers before producing functional models. This second level of result interpretation applies to a manufacturer who is specialized in certain areas and who wants to put a new product on the market which could interest police departments and is adaptable to an existing vehicle (a console which can be installed in American cars, for example). Since the manufacturer has no daily contact with police work, he might be interested in our study. It can help the designer relate the product to be designed to the problems to be solved. However, this document's content is not the result of a market study. In choosing this approach, the manufacturer must take care in: identifying the market, product safety, and manufacturing a prototype.

At the third level, a designer mandated by an entrepreneur considers the solutions proposed in this report as an illustration of the problems that the police officers live daily. The products resulting from this approach are not necessarily similar to those suggested by the police officers who participated in this research. By examining the proposed solutions as the expression of problems, and by combining the results of his analysis with the problems directly raised by the police officers, the designer could arrive at original solutions. This creative process will eventually lead to products that directly solve a major problem identified, while indirectly correcting a series of other problems.

The fourth level analysis is similar to the third, but the solutions do not bear exclusively on one object or one department, but include administrative reforms which more generally affect work organization. In fact, at this level it is remembered that each time a product is successfully introduced, it must be related to work organization.

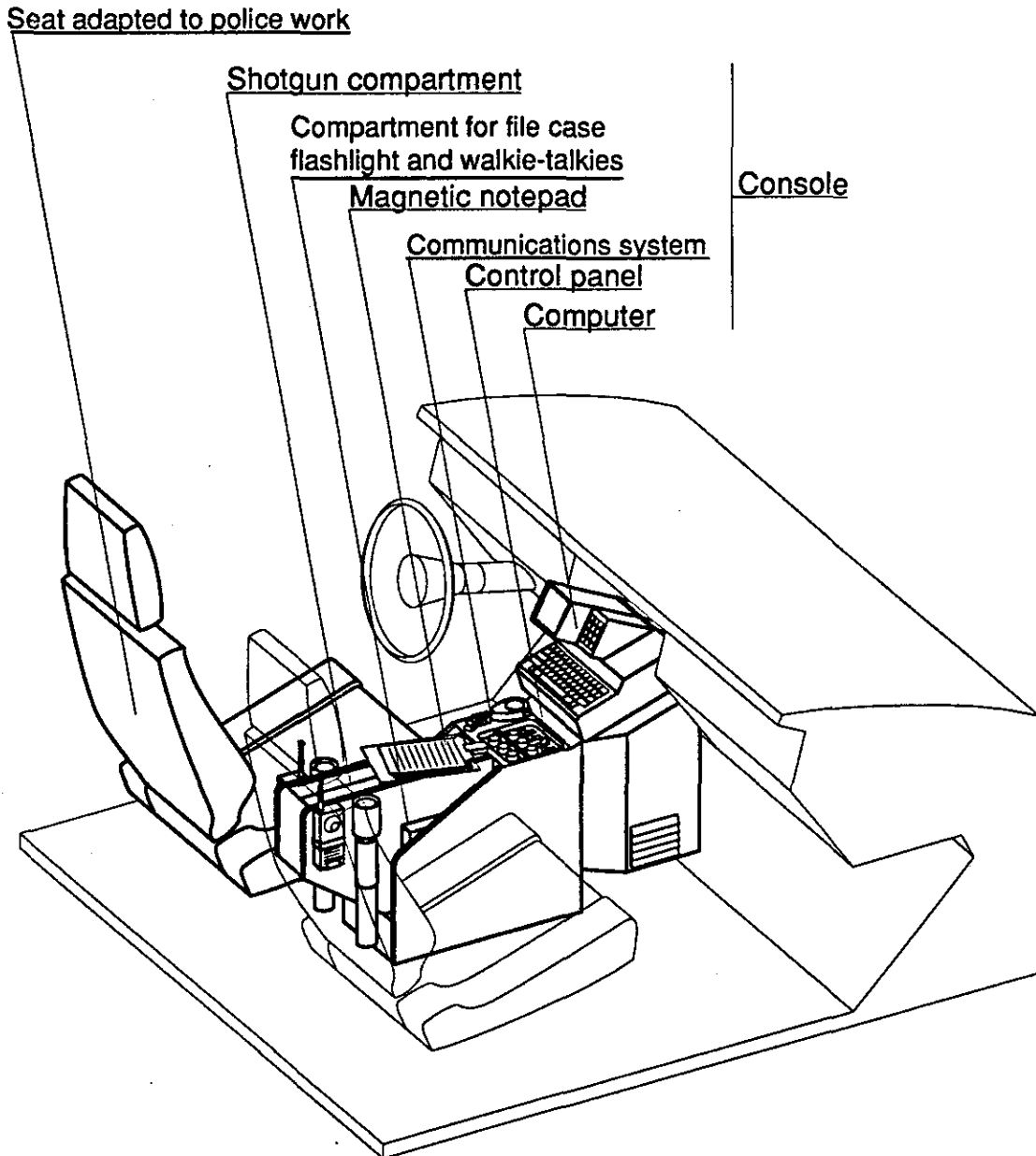


Figure 6.7 - Passenger compartment model 1, incorporating a communications computer recessed into the dashboard, a lockable compartment for the 12-gauge shotgun (inclined towards the front), and emergency and telecommunications controls grouped at the centre of the console. Supports for the portable telecommunications system and for the flashlights are integrated into the back part of the console, involving the use of a protective screen. Lighting (not illustrated) is provided by directional dome lights. Note that this is a representation of concepts and that this illustration is not a final solution because it has never been validated.

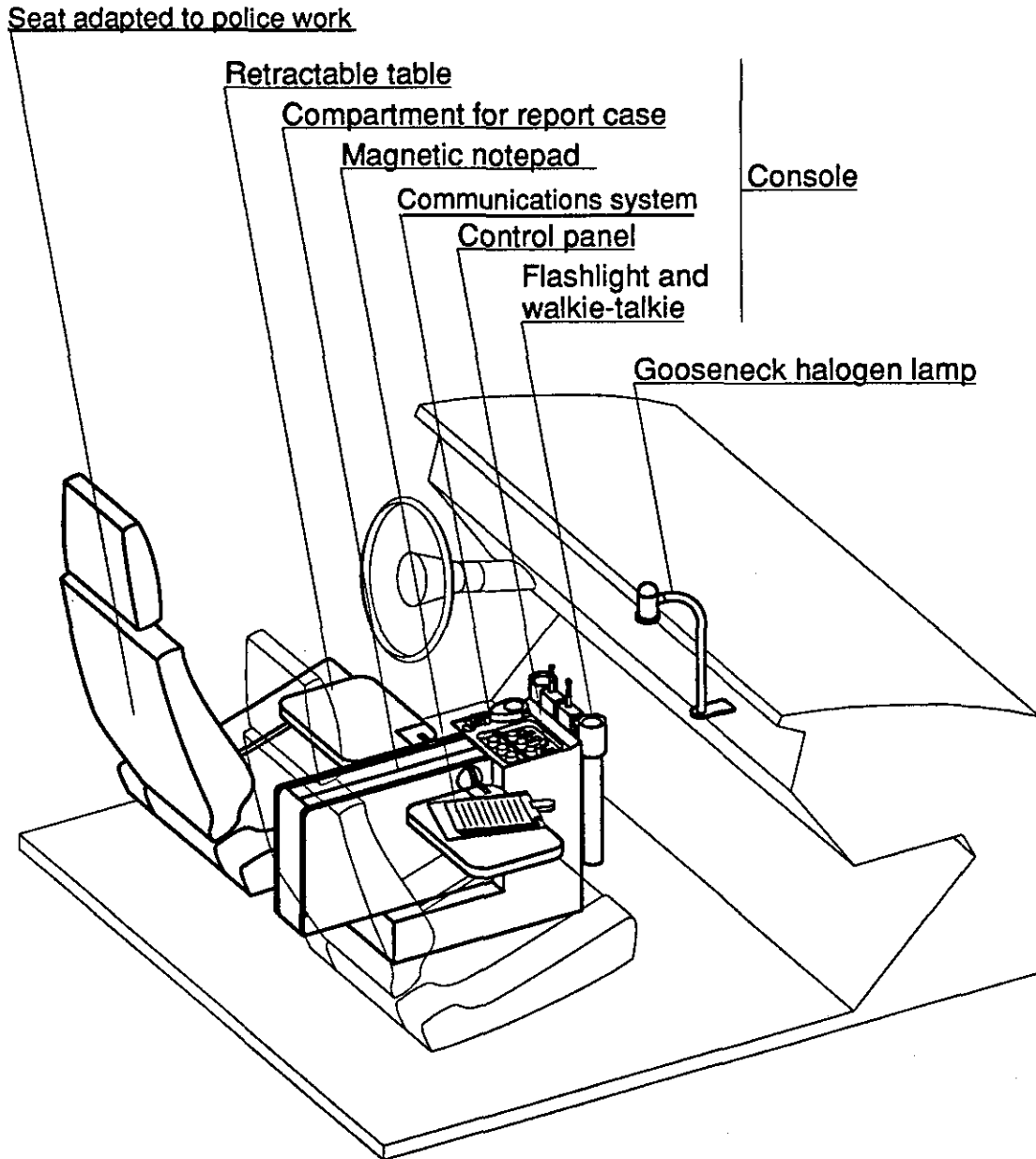


Figure 6.8 - Passenger compartment model 2, illustrating a passenger compartment without communications computer nor 12-gauge shotgun, but equipped with a retractable table (in the central compartment, in place of the 12-gauge shotgun) to make writing tasks easier. For obvious safety reasons, this table must only be used when the vehicle is stopped. Lighting is from a gooseneck lamp installed on the dashboard. In the absence of a computer, the flashlights and the portable communications system can be relocated to the front of the console. Note that this is a representation of concepts and that this illustration is not a final solution because it has never been validated.

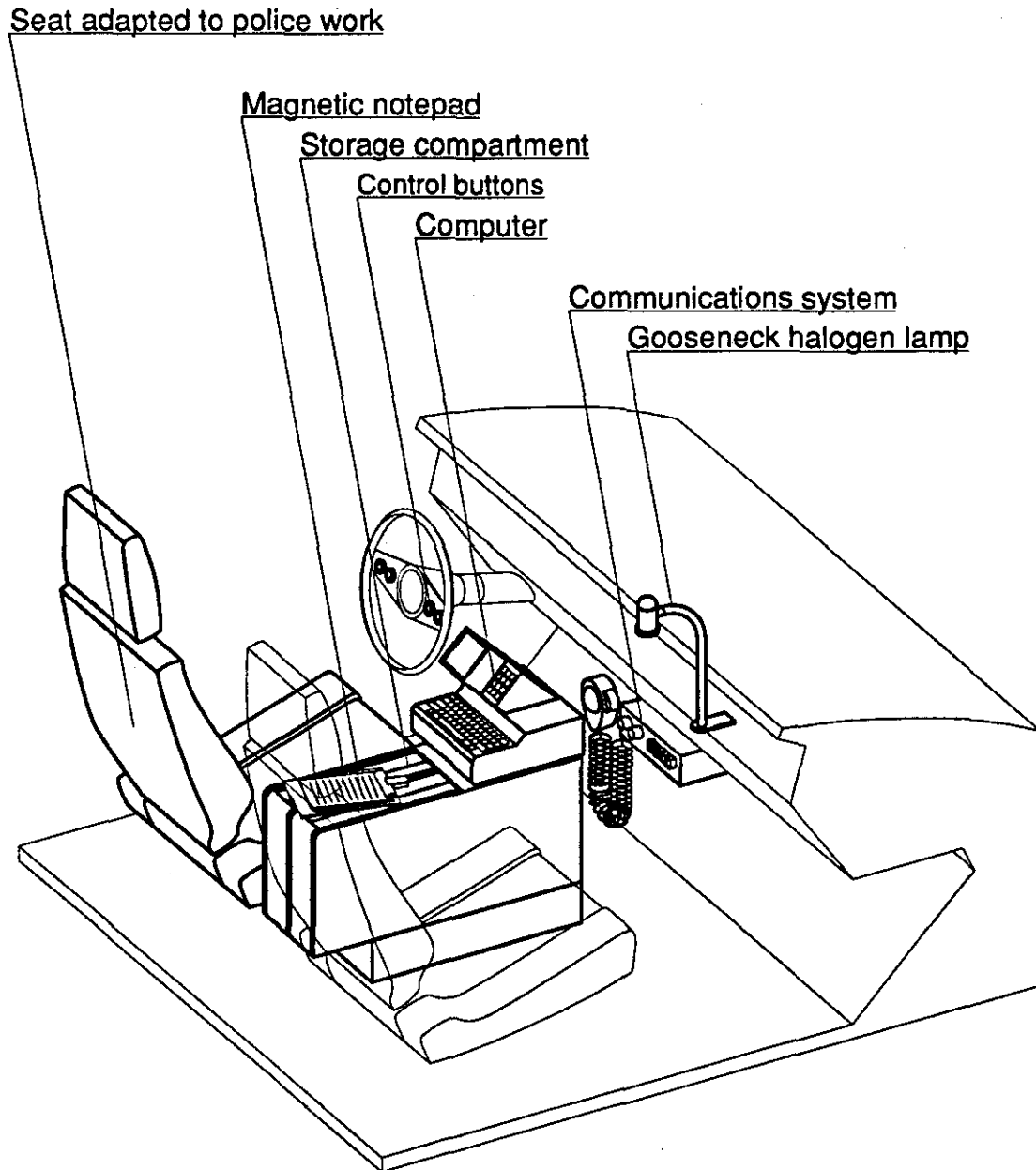


Figure 6.9 - Passenger compartment model 3, illustrating a passenger compartment with a communications computer mounted on the console, thus freeing the central part of the dashboard for a radio communications system. The inside of the console is used for storage. Note that this is a representation of concepts and that this illustration is not a final solution because it has never been validated.

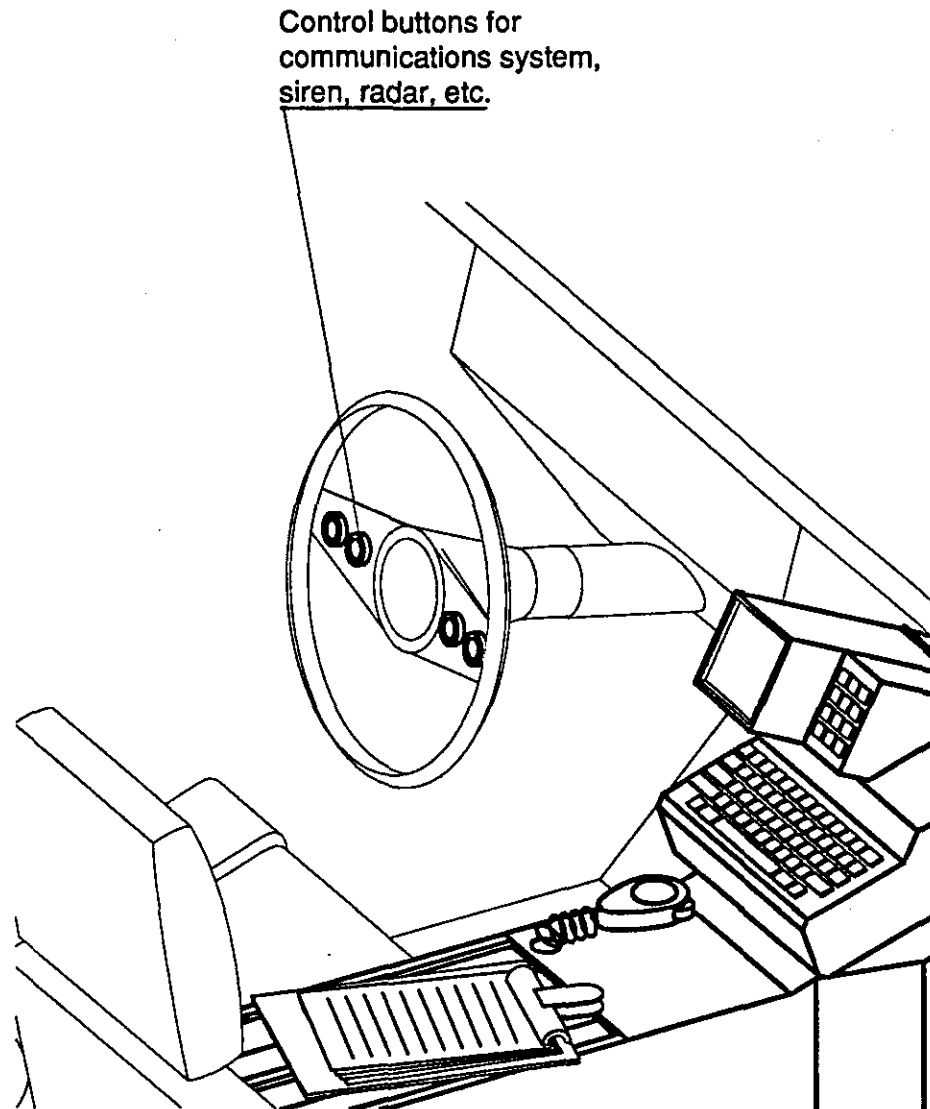


Figure 6.10 - Example of the relocation of emergency controls :flashing lights, flashers, and siren onto the steering wheel (enlargement of figure 6.8). This illustration is not a final solution because it has never been validated.

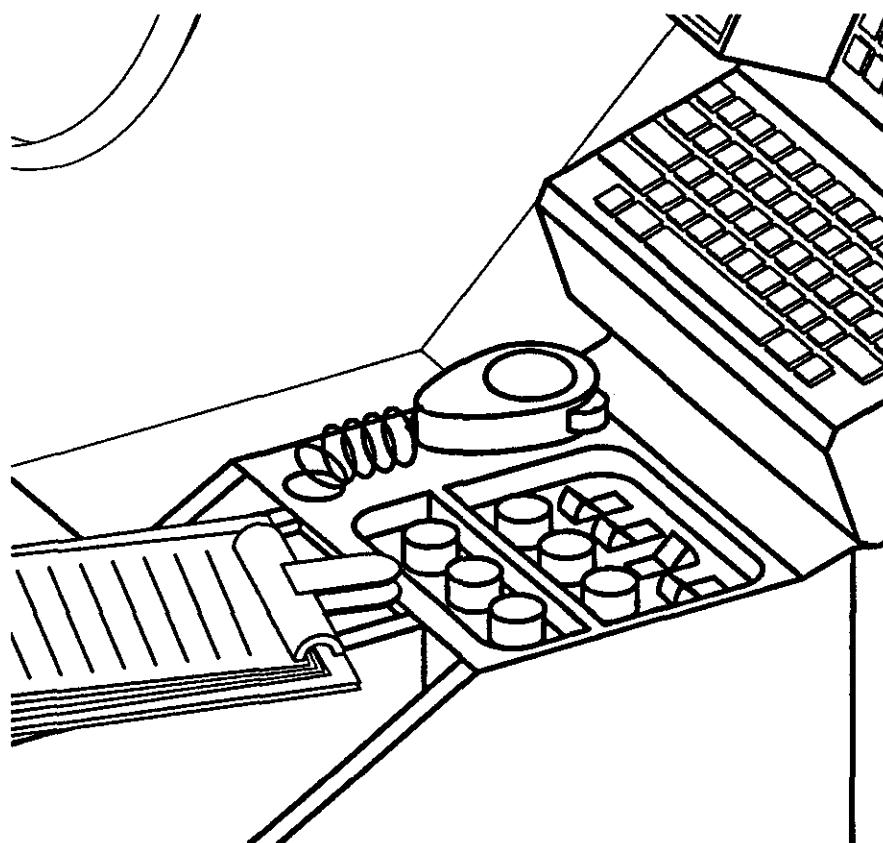


Figure 6.11 - Example of the safety of police equipment installed after vehicle purchase: the emergency controls are recessed and perimeter of the console is padded to avoid injuries in the event of impact. This illustration is not a final solution because it has never been validated.

7. THE PARTICIPATIVE PROCESS AND BACK PAIN

7.1 Analysis of interviews

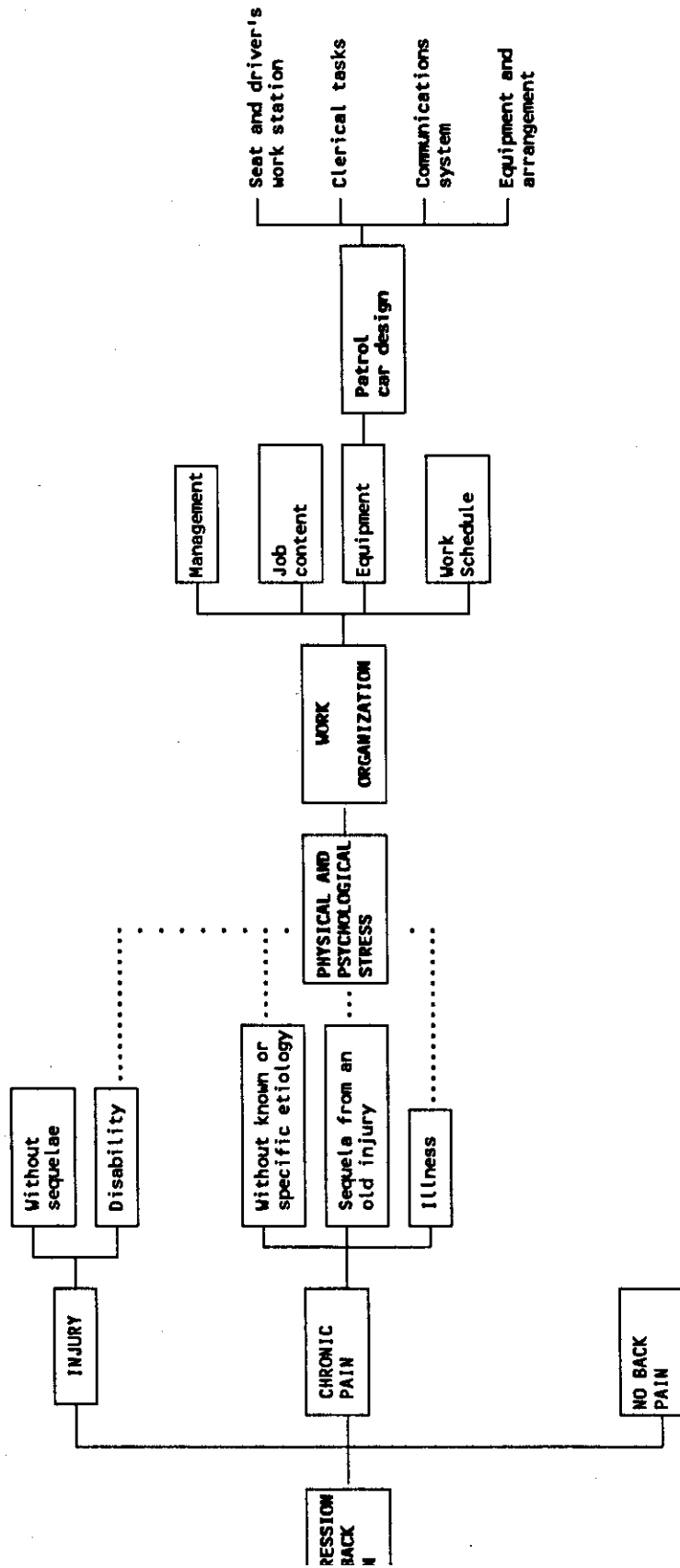
During the semi-structured interviews with police officers, two themes defined a priori were dealt with: 1) back pain, the patrol car and work organization; and 2) the evaluation of the participative process. The "back pain" category was subdivided a posteriori into 4 sub-categories: case histories and probable causes, medication and secondary effects, work relations, family relationships.

The interviews and the clinical examinations were carried out by two people who did not exchange information before combining the results. The aim of this approach was to establish whether or not there was consistency between the characteristics of the police officers' dialogue and the results of their clinical evaluation. For police officers who took part in the project, the characteristics of their discourse were consistent with the state of health of their backs.

All of the data was regrouped and presented using a diagram entitled "Development of the subjective discourse on back pain, the patrol car and work organization" (following page).

The analysis shows that policemen and policewomen talk about low back pain by using three concepts: back injury, chronic pain, and no low back pain. The concept of injury involves no ambiguity because the injury relates to a specific event in time. The outcome is clear: either there is no sequela, or the accident causes disability and results in assignment to another task.

FIGURE 7.1
DEVELOPMENT OF THE SUBJECTIVE DISCOURSE ON BACK PAIN,
THE PATROL CAR AND WORK ORGANIZATION



The expression of back pain through a dialogue on chronic pain brings out stereotypes. The comment "no one works at having back pain" made by a participant suffering from back pain clearly demonstrates the uncomfortable situation of the back pain sufferer as well as the defensive reaction to those who see the complainer or the faker behind the chronic pain.

In fact, many patrol officers who suffer from back pain never admit it. Some prefer to say nothing so as not to jeopardize their choice of career: the daily life of the patrol officer, a non-routine and in a sense unpredictable life, in the eventful reality of a large city or on the roads. Others remain quiet because they know the difficulties in proving to medical and administrative officials that their pain is real. These diagnosed difficulties were emphasized in the recent study by Spitzer on a "Scientific Approach to the Assessment and Treatment of Activity-Related Spinal Disorders" (1987). Spitzer also proceeded to validate the CSST file. The results of this validation reveal that:

36% of the cases of requests for compensation related to the anatomical region of the back and neck were poorly classified in the computerized files. This resulted in the exclusion of cases which truly originated in the back from back ailment diagnostics. (Spitzer, 1987:D7)

The different police departments manage these occupational health problems in their own way. Some do not plan for any reintegration or reassignment program for police officers suffering from low back pain. As one police officer stated: "With us, when you can no longer do patrol work, you're laid off". Other police departments have medical restriction programs which obviously have an impact on the perception that the patrol officer has of himself. Being on a medical restriction program and no longer wearing the uniform exclude the police officer from the patrol officers' social circle. Sitting behind a desk, without a uniform and without an intervention function, is seen by some as a demotion from a professional as well as from a social and family standpoint. These situations contribute to an increase in the number of unreported cases.

What then can make a policeman or policewoman admit to back pain? We received three answers: First, chronic pain that becomes evident during an acute attack; second, an experience in performing patrol work which led to psychological suffering which is expressed as low back pain (as one

patrolman stated, "There are some who can't stand the job anymore"); and third, wanting to have a long disability leave.

A comparison of the results of the interviews to those of the clinical examinations establishes a correlation between the seriousness of the back problems and the signs of psychosocial problems that appeared during interviews (Frymoyer, 1985; Pope, 1980). This does not mean that there are psychosocial problems every time there is back pain. It means that when an individual has significant back injuries and pain, there is a risk of such problems developing (Frymoyer, 1983), a concept which should be taken into account in the development of a prevention program (Troup, 1988). Some police officers stated that low back pain not only had an effect on their relationships with their colleagues, but also on their "character", as well as their social, family and sometimes sexual life. In addition, they are preoccupied by the secondary effects of the medication that they have to take (analgesics, anti-inflammatories, sleeping pills, etc.). Frymoyer (1988) confirms that there is a significant correlation between back pain and the secondary effects of the medication. Brown (1989) suggests including detoxification in any rehabilitation program for serious cases. Among the police officers' concerns, we retained: the effects on character and on the use of a firearm.

Whatever the dorsolumbar condition in question, all dialogue brings us back to a concept of physical and psychological stress related to work organization. Because of the project's framework, we were unable to clarify the nature of the relationships between low back pain and the stress involved in police work.

7.2 Analysis of interviews and the questionnaire involving participation

From the analyses of the interviews, we can say that police officer participation in the management of their occupational health problems is one avenue of intervention.

Furthermore, they emphasized during the interviews that they were benefitting from it. Two primary benefits and one secondary benefit were identified. The first primary benefit was the recognition of back problems by the employer, a peer group, and the IRSST. This recognition played a significant role in increasing the level of credibility of the police officers suffering from low back pain, and as a result, changed the perception that the participating police officers and their relatives have of back pain. The second primary benefit was a recognition of their knowledge gained from work experience. Knowledge from which others could benefit is not only valorizing for the individual but changes the perception of the general value of the knowledge that can be gained from work experience. The secondary benefit involved participants who went from rotating work shifts to day work during the project.

In addition, we had only positive comments about the communication model implemented for the project. From comments collected at the time of the semi-structured interviews and the compilation of answers to the questionnaire on back pain, we can state that the assessments of the participative process were generally positive. In fact, the responses to the structured questions about participation show that all participants (100%) found the information sessions useful, and that 83% (15) benefited from them in their daily work, particularly in relation to postures but to a lesser extent in relation to improvements in working conditions. Analysis of the responses to open-ended questions shows that peer support was good but that the opinion of superiors on the usefulness of the project was partly positive. The semi-structured interviews give more detail on the quality of the support by all coworkers. In fact, several police officers feel that their participation in the project produced feelings of jealousy towards them.

7.3 Prevention of back pain

Our second objective was to develop our knowledge on back pain. This second objective had two basic assumptions:

- That policemen and policewomen would become involved in a participative project whose purpose was to improve working conditions that cause back pain.
- That this involvement would also change the subjective representation and the attitude of the participants with respect to back pain.

The first assumption was important for us because involvement, according to the literature, can reduce stress and musculoskeletal symptoms.

From the results that were observable from the richness of the productions, and from the positive comments obtained during the interviews and the questionnaire (corroborated by generally low participant absenteeism), we can say that the involvement of the policemen and policewomen was real. However, the involvement and its effect on stress and musculoskeletal symptoms was not the subject of our research and remains to be studied.

The second assumption was just as important for us because changes in perception and attitude can play an important role in the implementation of a prevention program.

To verify this second assumption, we explored several avenues. We must first note that the relationships between back pain and the daily life of the project were rather weak. In the course of the work sessions, the participants said very little spontaneously about back pain. Furthermore, during the participative process, the policemen and policewomen established no direct link between design and back pain, except in relation to the seat and the location of certain equipment. The design of the patrol car raised many other concerns involving the organization of police work in the passenger compartment.

From these interviews, it was seen that simple recognition of the existence of the problem which was the basis of a participative research project, probably changed the perception that the

participants had of back pain. In a few cases, it might even have allowed certain participants with low back pain to again be valued in their work environment.

Another avenue was provided by the analysis of the responses to the questionnaires. The two versions of the questionnaire on back pain were completed by 18 of the 33 participants. The results show that the participants were able to integrate a certain number of concepts about the back and about back pain into their active knowledge. The analysis of the drawings of the spine done by the participants in the questionnaires shows that not only did their anatomical knowledge improve, but also that this knowledge is generally better structured.

Most of the changes observed are related to the content of the information that the participants received during the project. The relationships between back pain, prevention, and the improvement in working conditions remained weak. The participants did not generally feel very strongly about self-management of back pain. However, the responses showed a great interest in questions of back pain, and in this respect, the participants' activity increased during the project.

7.3.1 Differences between participants with and without low back pain

We have already noted that the relationships between back pain and the daily life of the project were rather weak except regarding the seat and some equipment.

The analysis of the dialogue, trace analysis and the analysis of the responses to the questionnaires revealed that there is little difference between the groups.

Participant involvement in improving the patrol car passenger compartment left very little room in the end for expression on back pain.

7.3.2 Conclusion

The interpretation that can be given to the results involving the prevention of back pain can be summarized in three points:

- The assumption that participation influences the perception of back pain must be retained even if a relationship between participation and a change in perception cannot be clearly established in our study.
- To strengthen the positive impact of participation, reflection on the organization of working conditions must be closely related to the individual and to the daily work reality. The patrol car as an isolated organizational component of the police officer's work environment is too general and therefore too far removed from the overall reality of police work.
- These results lead us to believe that a prevention program for back pain in the police environment should be participative and based on a broad rationale that includes biomechanical and psychosocial aspects.

8. CONCLUSION

The use of a participative approach within the context of this research project as a means of exploring problems related to back pain in workers and as an incubator of solutions to improve working conditions (in this case involving the patrol car), allows us to draw certain conclusions.

In our opinion, some conditions are essential in carrying out such a process: the support of social partners related to police work, strong interest by the milieu, and means of communication adapted to the situation. By involving workers by giving them the opportunity to express themselves on their working tools, it is possible to explore working conditions, identify problems, and obtain proposals of solutions in a relatively rapid and efficient manner.

The fact that the patrol car was clearly identified as the main risk factor for back pain in the police milieu (mainly by means of an exploratory study) resulted in strong participant involvement in the project to design a passenger compartment that is better adapted to their work. The solutions proposed show that the participants knew how to channel knowledge gained from actual work experience, analyze it, and identify the main constraints. In most cases, the solutions proposed proved to be realistic, well based in the work reality, while at the same time being innovative.

The results show that back pain as an occupational health problem is sufficiently important to develop a basic dynamics for the participative process. However, very early in the project, there was a broadening of the initial rationale towards other aspects related to all the working conditions. The latter are therefore just as important in developing a prevention program. For prevention to be effective, we believe that the basis for the participative process must relate directly to the preoccupations of the milieu as well as to individual concerns.

9. RECOMMENDATIONS

In conformity with the inventory of the characteristics of police work in the patrol car, we recommend:

- a) that the work station concept be retained for defining the minimum parameters of a patrol car;
- b) that it be recognized that a poorly designed patrol car can have a negative impact on worker health and safety;
- c) that sustained and coordinated efforts be made to ensure that government purchasing policies take into account the parameters defined in the studies aiming to determine the characteristics of police work;
- d) that studies complementary to this one be carried out on work characteristics, going from basic equipment to the working environment in the organization;
- e) that the elements in the design of the patrol car defined in this study be retained as a model for a new patrol car design;
- f) that the results of the study be disseminated in French and in English and that follow-up be provided by the Consultative Committee.

In conformity with the results of the participative approach, we recommend:

- a) that all prevention programs be based on police officer participation in defining the problems and solutions that involve them;

- b) that a participative program in back pain prevention be developed on the basis of a broad rationale that includes biomechanical and psychosocial aspects.

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APPENDIX I

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APPENDIX II

Comprehensive table, by theme,
of the solutions proposed by the participants

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
I - Seat and driver's work station					
- Group 1 (data sheet)	- "Police seat" from RECARO	- Commercially available - Several characteristics specific to police work	- Purchase and installation of base, for installation in the vehicle	- none	- Adjustment depend on the type of base Can be transferred from vehicle to another
- Group 1A (illustration)	- VOLVO seat adapted to hydraulic suspension	- Commercially available	- Seat and hydraulic suspension requiring van type vehicle	- Requires adaptation of a hydraulic base to the seat	- Suspension adjustment remains critical that oscillations are not induced - Can be transferred from vehicle to another
- Group 2 (seat prototype)	- Patrol car seat	- Characteristics specific to police work	- Still at prototype stage	- none	- Can be transferred from vehicle to another
- Group 1 (data sheet)	- Emergency controls (flashing lights, siren, flashers, directional arrows) relocated onto the dashboard, on each side of the steering wheel	- Grouping of emergency controls into a primary zone - Controls equipped with operating indicator	- Usable by driver only	- none	- Rather easy to implement - Position should be standardized from one vehicle to another - Controls should meet automotive safety standards
- Group 1A (mock-up and illustration)	- Emergency controls (flashing lights, siren, flashers) relocated onto the centre back of the console	- Grouping of emergency controls - Controls usable by driver and partner	- Controls non-visible in the driving position - Absence of tactile indicators can result in mistaking the controls	- Requires console	- Can be corrected by partial redesign

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
- Group 3 (mock-up)	-Emergency controls (flashing lights, siren, flashers) relocated to the steering wheel	-Improvement in primary driving task in emergencies - Near the central field of vision	Usable by driver only	-Adaptation to police system requires partial re-design	-Study even further the sharing of tasks between driver and partner regarding the controls -Already used for radio and speed control by some manufacturers
- Group 3 (mock-up)	-Control for directional arrows relocated to the steering wheel	-idem	-idem	-idem	-Pertinence of this relocation is to be demonstrated because if these are not "primary task" controls, they unnecessarily clutter the steering wheel
- Group 3 (mock-up)	-Central console grouping emergency controls, controls for telecommunication system and microphone clip	-Accessible to driver and partner -Grouping of components important to the task	-Lack of tactile delimiters or identifiers; high density of controls can lead to confusion	-Requires console and separate seats -Install in safe manner to minimize risk of injury in event of impact	-Defect can be corrected by partial redesign -This solution could be standardized from one vehicle to another -Add passive protection to avoid accidental release

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
II - Clerical tasks					
- Group 1 (data sheet)	-Optional writing board for partner	-Posture stabilization during writing tasks	-none	-Place to store it when not in use	-Must be retractable to avoid injury the event of impact -Must be stable when used -Technology already exist some planes trains
- Group 1 (data sheet)	-Directional gooseneck lamp mounted on dashboard	-Illuminates working surface -Does not illuminate complete interior of vehicle - Allows better posture for writing tasks	-none	-none	-Install in a manner to minimize the of injury in of impact -Halogen (expensive, fragile)
- Group 1 (mock-up)	-Storage space for report cases in the console, bilateral	-Report cases secured in the vehicle	-none	-Requires console and appropriate seats	-none
- Group 1A (illustration)	-Directional dome light	-Appropriate lighting for reading/writing	-none	-none	-Location must be carefully chosen: must illuminate work surface and the police officer or the side of passenger compartment - Adjustable intensity to minimize eye adaptation period -Inspiration lighting in p

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
- Group 3 (mock-up)	-Storage space for report case in central console	-Report cases stored in the vehicle	-none	-Requires console and separate seats	-Easily achievable
- Group 3 (mock-up)	-Storage space for briefcase in central console	-The briefcase no longer on rear seat (torsion, impact)	-none	-Requires console and separate seats	-Depth can vary according to vehicle floor profile -This production nevertheless requires body torsion to remove briefcase from console
- Group 3A (mock-up)	-Sliding-door compartment for storing report case	-Report case stored in passenger compartment -Report case easily accessible by driver and partner	-none	-Requires one console with sliding doors	-Depth of compartment can vary according to vehicle floor profile

III - Communications system

- Group 1 (data sheet)	-Communications system integrated into dashboard, central section	-System accessible by driver and partner -Safe installation	-none	-Modify the dashboard	-none
		-Access within reach of driver and partner	-none	-Ease of installation depends on type and model of vehicle	-Install in safe manner to minimize risk of injury in the event of impact
- Group 1A (mock-up and illustration)	-Communications system installed permanently at the upper centre of the dashboard	-Access within reach of driver and partner	-none	-Ease of installation depends on type and model of vehicle	-Install in safe manner to minimize risk of injury in the event of impact

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
- Group 1A (mock-up)	-Space dedicated to walkie-talkie in the console	-Secured walkie-talkie	-none	-Requires appropriate console - Requires protective screen between front and rear compartment	-The slot could double as a charging station Plan for mechanism to hold walkie-talkie place in the event of impact
- Group 3 (mock-up)	-Clips for microphone located to the left and right of dashboard	-Located within reach of driver and partner	-none	-none	-Install in a manner to minimize risk of injury in the event of impact -Easy to achieve
- Group 1 (data sheet)	-Vehicle computer mounted on pivot at centre of console	-Pivots in order to be used by the driver or partner	-Computer limits access to air conditioning/heating controls	-Requires appropriate seats	-Some computers already installed in this manner The cognitive aspect of the use of vehicle computers is being studied
- Group 1A (mock-up and illustration)	-Vehicle lap-top computer mounted on pivot at centre of console	-Pivots in order to be used by the driver or partner	-Large area of dashboard not accessible when screen is in the high position	-none	-Some computers already installed in this manner The cognitive aspect of the use of vehicle computers is being studied
- Group 3 (mock-up)	-Vehicle computer mounted on pivot at centre of console	-Pivots in order to be used by the driver or partner	-Computer limits access to AM/FM radio and to air conditioning/heating controls	-none	-Some computers already installed in this manner The cognitive aspect of the use of vehicle computers is being studied

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
- Group 3A (mock-up)	-Pivoting vehicle computer mounted on the console, recessed in dashboard	-Locates screen in peripheral field of vision and closer to the central zone of vision - Accessible by driver and partner	-Requires console and separate seats	-Rather difficult to install: requires relocation of heating/air conditioning controls and AM/FM radio as well as creation of recessed area in the dashboard	-Type of installation could be limited to certain types of vehicles
- Group 1, 1A, 3, 3A (mock-ups, illustrations and data sheet)	-AM/FM radio installed permanently	-Avoid uninstalled portable AM/FM radios	-Can interfere with radio communications	-none	-There are systems available which cut off AM/FM radio during communications
IV - Equipment and organization					
- Group 1 (data sheet)	-Radar installed on attached support	-Radar securely mounted	-Takes time to install/remove	-none	-Install in safe manner to minimize risk of injury in the event of impact - A study of the radar task is to be done
- Group 1A (mock-up and illustration)	-Radar installed permanently in upper centre of dashboard	-Radar securely mounted	-Difficult installation and removal if equipment must change vehicles	-Requires console and appropriate dashboard	-Install in safe manner to minimize risk of injury in the event of impact - A study of the radar task is to be done

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
- Group 1 (data sheet)	-Rear vertical support for 12-gauge shotgun	-Shotgun outside field of vision - Shotgun not in trajectory in event of impact	-none	-Requires protective screen	-Shotgun bar can appear in rearview mirror
- Group 1 (data sheet)	-Horizontal compartment for 12-gauge shotgun attached to ceiling	-Shotgun outside field of vision - Shotgun not in trajectory in event of impact	-none	-none	-Pad the compartment Access system similar to the other installations
- Group 3A (mock-up)	-Lockable compartment with sliding doors for 12-gauge shotgun	-Shotgun in inclined position - Shotgun out of sight - Shotgun accessible by driver and partner	-none	-Requires console and separate seats	-Compartment depth can vary according to vehicle floor profile - Tests are necessary to evaluate shooting access time, particularly with winter gloves
- Group 1A (illustration)	-Rear vertical support for 12-gauge shotgun	-Shotgun outside field of vision - Shotgun not in trajectory in event of impact	-none	-Requires protective screen	-Shotgun bar can appear in rearview mirror
- Group 1 (data sheet)	-Space for storage and for flashlight support between the seats	-Flashlights secured in passenger compartment - Easy and rapid access - Storage for equipment and report case	-none	-Requires appropriate seats	-Shape of the compartment prevents injury in event of impact If there is a screen, install flashlights behind, in front otherwise
- Group 1A (mock-up)	-Space dedicated to flashlights behind the console	-Secured flashlights	-none	-Requires appropriate console -Requires protective screen between front and back seat	-Plan for mechanism to secure flashlights in event of impact

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
- Group 3 (mock-up)	-Storage for flashlights integrated into dashboard, passenger side	-Flashlights secured in passenger compartment - Easy and rapid access	-Accessible by partner only - Inconvenient in solo patrols	-Ease of installation depends on type and model of vehicle	-Stability in the event of impact has never been demonstrated - Already installed in vehicle where air conditioning has been eliminated
- Group 3A (mock-up)	-Storage for flashlights integrated into front part of console, driver's side and passenger side	-Flashlights secured in passenger compartment - Flashlights easily accessible	-none	-Installation depends on space available under the console - Depends also on length of flashlight -Involves installation of console and separate seats	-More detailed examination of the space requirements and the consequences in the event of impact is to be done
- Group 1A (mock-up)	-Space dedicated to storage at centre of console	-Storage for small objects and equipment	-none	-Requires appropriate console	-none
- Group 1A (mock-up and illustration)	-Refrigerated storage under console, side access	-Having refrigerated storage space	-none	-Requires appropriate console -Requires cooling system	-A true refrigeration system is possible, or use the vehicle's air conditioning if it exists -It is, however, one of the hottest areas of a vehicle (proximity to motor and transmission) -Study further the need for this device

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
- Group 3 (mock-up)	-Large storage space under dashboard, passenger side	-Allows storage of report cases and other thin objects -Provides more space for partner	-Difficulty to retrieve small objects from bottom	-Difficult to install considering the heating and defogging mechanism	-In event of impact, lower risk of injury in uncluttered passenger compartment
- Group 3 (mock-up)	-General storage space in central console	-Storage of small objects and equipment	-none	-none	-Could be shallower than expected depending on vehicle floor file
- Group 1 (data sheet)	-Safety screen between front and rear compartments with sliding window	-Protects patrol officers from actions by rear passengers	-Limits backward movement of front seat	-Limits installation of computer	-Several models already exist the market
- Group 1A (illustration)	-Safety screen between front and rear compartments, with electrically controlled sliding window	-Protects patrol officers from rear passengers -Operates with back torsion	-Limits backward movement of front seat	-Limits installation of computer - Makes air conditioning/heating of passenger compartment more difficult	-Use technology developed for limousines
- Group 3 (mock-up)	-Safety screen between front and rear compartments, with sliding window	-Protects patrol officers from actions by rear passengers	-Limits backward movement of front seat	-Limits installation of computer - Makes air conditioning/heating of passenger compartment more difficult	-Several models already exist the market

Group	Production Element	Advantages	Disadvantages	Implications	Remarks
- Group 3A (mock-up)	-5" x 7" notebook secured to the console	-Notebook secured in passenger com- partment - Notebook within reach	-none	-Requires a console	-Notebook moves to the rear when compartment door is moved -Notebook always useful because vehicle computers do not produce written copies
- Group 1 (data sheet)	-Relocation of the spotlight closer to the centre of the dashboard	-Leaves more room for partner	-none	-none	-The problem of wires on the floor must also be corrected
- Group 1A (mock-up and il- lustration)	-Side access doors on the console	-Facilitates in- stallation and maintenance of equipment in console (case, fuses, wires and connectors, ...)	-none	-none	-Particularly ad- vantageous for personnel assigned to installation and maintenance of equipment because it prevents poor posture