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Development of an Intervention Program to Encourage Shoulder Harness Use and Aircraft Retrofit in General Aviation Aircraft: Phases I and II

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EXECUTIVE SUMMARY

The safety record of general aviation is a matter of concern for the Federal Aviation Administration (FAA). In an attempt to improve this record, the FAA continually examines ways to reduce the number of injuries and fatalities in general aviation accidents. Investigators have recognized for years that many injuries and fatalities could be prevented through better occupant protection, including the use of personnel restraint systems. This project describes a program directed at maximizing the use and consequent benefits of restraint systems in general aviation aircraft.

The Federal Aviation Administration in 1977 amended the Federal Aviation Regulations (FAR) to require that shoulder harnesses be installed for each front seat in every small civil airplane manufactured after July 1978. The amendment required that crewmembers keep the shoulder harness fastened during take-off and landing unless such use would interfere with a crewmember's duties. In 1986, the amendments were extended to include shoulder harnesses for rear seat occupants as well. These amendments do not require retrofit of shoulder harness assemblies to general aviation aircraft manufactured before July 1978.

The National Transportation Safety Board (NTSB) in 1985 reviewed the safety record of light aircraft over a ten-year period. Based on studies of many accidents, the NTSB estimated that the shoulder harness was available in only 40 percent of these accident-involved aircraft. Where the harness was available, only 40 percent of the crewmembers actually used it. The NTSB study concluded that many fatalities and serious injuries could have been prevented had shoulder harnesses been installed and used in all of the aircraft in these accidents. However, since many of the aircraft in the NTSB study were manufactured before the adoption of the shoulder harness FAR amendment, the real value of this amendment could not be determined.

Phase I of the present study considered the feasibility of developing an intervention program, based on a health education model, designed to increase use of existing shoulder harnesses and to encourage retrofit installations in general aviation aircraft not so equipped. The services of an expert panel with collective experience in health education, behavior modification, highway safety, and aviation research were used to systematically develop intervention procedures. Deliberations of the expert panel were supplemented by a limited field observational study of shoulder harness use and aircraft retrofit plus a review of the literature covering use of safety belts in transportation systems and procedures for increasing use. The expert panel identified a number of predisposing, reinforcing and enabling factors which can influence shoulder harness installation and use. In the limited field study both the observed installation rate (61 percent) and the use rate (76 percent) are higher than those reported in the 1985 NTSB study.

Phase II of the present study continued the quest for improved general aviation safety, with the following objectives:

1. **Obtain Shoulder Harness Installation and Use Rates.** Estimates of shoulder harness installation and use rates presented in the Phase I study were based on a limited number of observations and reflect practices existing in the Washington, DC metropolitan area. Since these results may be representative only of the Washington, DC area, data collection in the Phase II study was expanded to a nationwide basis. Based on number of active aircraft and total hours flown in general aviation, five states were selected for additional data collection. These states are California, Texas, Florida, Illinois, and Alaska.

2. **Develop a Shoulder Harness Intervention Program.** A proposed intervention program to be developed using results from the nationwide survey. Additional information concerning availability and cost of aircraft retrofit systems also to be obtained for inclusion.

Results

1. Based on the survey of five states and Washington, DC, the estimated national use rate for shoulder harness restraint systems at this time is 71.9 percent.

2. The installation rate for shoulder harness systems in all general aviation aircraft is estimated at 59.1 percent. This indicates that over 80,000 general aviation airplanes remain without shoulder harnesses.

3. The rate of retrofit of shoulder harnesses to older aircraft remains quite low. Principal reasons given by aviation personnel for this lack include cost, restrictiveness and fit, and quality.

4. Data concerning availability and cost of shoulder harness retrofit kits are not well publicized. Information concerning availability and cost of these kits is included in this report.

5. Materials to support a National Shoulder Harness Educational Intervention Program are presented. This proposed program is educational, with no additional regulatory action or enforcement envisioned. Educational materials consist of (1) a brochure suitable for a variety of audiences and, (2) a short videotape presentation suitable for use with larger groups of pilots and other aviation personnel. Delivery of the program would be accomplished principally through the services of Aviation Medical Examiners (AMEs). Since AMEs report to the Federal Air Surgeon, they represent a readily available channel for use in implementing this educational program.

6. An analysis of the effect of shoulder harness use indicates that, if the intervention program increases use rate nationally to 80 percent in 1995, general aviation would have 17 fewer fatalities. Many more injuries would be avoided and the cost savings would be considerable.

DEVELOPMENT OF AN INTERVENTION PROGRAM TO ENCOURAGE SHOULDER HARNESS USE AND AIRCRAFT RETROFIT IN GENERAL AVIATION PHASES I AND II

INTRODUCTION

General aviation plays an important role in maintaining a viable and efficient U.S. air transportation system. General aviation operations contribute significantly to national commerce and to the intercity movement of passengers. In addition, a recreational outlet is provided for thousands of pilots.

The statistics describing general aviation activity are impressive. Slightly more than 46 percent of the mileage flown in U.S. civil aviation and roughly 20 percent of the passenger volume can be credited to general aviation. These numbers are built on a variety of activities including business travel, short-haul intercity freight transportation, traffic surveillance, police work, hospital deliveries, and other missions. In all, general aviation serves as a useful complementary and supporting force for the commercial air carrier industry.

While general aviation provides many services as part of a national transportation system, its utility always has been tempered by its safety record. For a variety of reasons, the safety record of general aviation does not, and probably never will, approach that of the air carriers, which stand as the safest form of transportation available to the American public. For the most part, general aviation flight personnel do not have the same extensive and on-going training given to commercial crews. Some general aviation aircraft also may not be inspected and maintained as rigorously as those of the commercial carriers.

Finally, and this is the matter of most concern at the moment, some general aviation pilots do not seem to have the same prevailing concern for safety as found in the commercial air carrier community. The recent extensive analysis of general aviation accidents conducted by the AOPA Air Safety Foundation (1991) contains many descriptions of events where safety concerns were not paramount. Phrases such as "lack of weather briefing prior to flight" and "lack of completion of a thorough pre-flight inspection prior to departure" are found all too frequently in the AOPA report and illustrate the point.

The safety record of general aviation has been a matter of interest for the Federal Aviation Administration (FAA) and for aviation-oriented organizations, such as the Aircraft Owners and Pilots Association, The Experimental Aircraft Association, and the Flight Safety Foundation, for years. For a variety of reasons, certainly including the safety programs initiated by these different groups, the safety record of general aviation has improved slowly through the years, although at all times lagging behind that of commercial aviation. For example, in 1958, the year in which the Federal Aviation Administration was created, the fatal accident rate for general aviation was about three per 100,000 flight hours. Twelve years later, in 1970, this rate had dropped to slightly less than 2.5, a modest but worthwhile improvement. In any event, the fact that improvement did occur, which continues to this day, would seem to show at least a measure of safety sensitivity on the part of the general aviation community and some receptiveness to safety initiatives.

In studying the accidents occurring in general aviation over the years, investigators recognized that many injuries and fatalities could be prevented through better occupant protection, including the use of personal restraint systems. While seatbelts were installed in all general aviation aircraft, few had shoulder harnesses. The first shoulder harnesses in general aviation were offered by Beech Aircraft Corporation for some aircraft in 1951. However, since the demand for this equipment was not great, other manufacturers did not follow suit. Indeed, Beech itself soon dropped shoulder harnesses altogether and did so for a number of years.

In an attempt to reduce injuries and fatalities, the Federal Aviation Administration in 1977 amended Parts 23 and 91 of the Federal Aviation Regulations to require that shoulder harnesses be installed for each front seat in every small civil airplane manufactured after 18 July 1978. The amendment also requires that crewmembers keep the shoulder harness fastened during take-off and landing. However, fastening is not required if it interferes in the performance of a crewmember's duties. In 1986, the FAA amended Part 23 to require shoulder harnesses for all front and rear forward-facing seats in new aircraft with less than nine seats.

The 1977 action by the Federal Aviation Administration was a significant step forward in improving the safety of general aviation aircraft. By the FAA's estimate at that time, approximately 1,875 lives would be saved over a 25-year period by the shoulder harness amendment (*Federal Register*, 1977).

The 1977 and 1986 amendments to the Federal Aviation Regulations do not require retrofit of shoulder harness assemblies to general aviation aircraft manufactured before 1978. This means that the 1977 general aviation fleet of some 200,000 aircraft is exempt. Since then, all major manufacturers plus a few independent suppliers, have offered retrofit kits for these earlier aircraft. However, interest by the general aviation community in retrofitting these aircraft has been quite low. In addition, manufacturers themselves have not been vigorous in promoting the sale of retrofit kits. As a result, the rate of retrofit is modest at best.

Effectiveness of Shoulder Harness Mandate

The purposes of the 1977 amendments to the Federal Aviation Regulations were to make shoulder harnesses available in all post-1978 aircraft, to ensure that shoulder harnesses were used by crewmembers during take-off and landing, and to encourage retrofit of older aircraft. Have these amendments been successful? Safety studies of the National Transportation Safety Board (NTSB) shed some light on this question.

The National Transportation Safety Board, in a 1985 report, reviewed the safety record of light aircraft over the ten-year period of 1972 - 1981 (NTSB, 1985). For the most part, these years were prior to the FAR regulations mandating installation and use of should harnesses. During these years, 36,466 accidents occurred involving general aviation airplanes. Of the 73,596 occupants of these airplanes, more than 18,614 (25 percent) were killed or seriously injured.

The NTSB study next selected 535 accidents that occurred in 1982 for an indepth review of impact severity and as a basis for estimating the benefits of shoulder harnesses and energy-absorbing seats. NTSB investigators were able to determine that shoulder harnesses were installed in 40 percent of the aircraft involved in these accidents. For the 253 occupants where the shoulder harness was available and use could be determined, only 100 persons, or 40 percent, actually used the harness. Combining the availability rate (40 percent) and the use rate (40 percent) indicates that only 16 percent of these general aviation front-seat occupants were wearing shoulder harnesses at the time of the accident.

The data presented in the NTSB report indicate the shoulder harness amendment has met with only partial success, at least at that time. Many of the aircraft studied in the accident review were not equipped with shoulder harnesses and where they were available, use was low. The NTSB study concluded that many of the fatalities and serious injuries could have been prevented if occupants had been using shoulder harnesses and had been seated in energy-absorbing seats.

Another avenue for exploring the effectiveness of the shoulder harness mandate can be found in accident data collected since passage of the amendments. Table 1 presents these data for 1982 through 1991. The data show that total general aviation flight activity has remained relatively constant during these ten years. However, total accidents have steadily declined as well as the total number of fatalities. The safety record of general aviation is improving steadily.

While the data in Table 1 are encouraging in terms of fewer accidents, do they reflect a benefit from increased shoulder harness use? If shoulder harnesses have been used increasingly since 1982, the number of fatalities should decrease at a faster rate than the number of accidents. In other words, shoulder harnesses should provide more protection and chances of a fatality occurring in a given accident should

Table 1

Accident and Fatality Record for General Aviation Aircraft (1980 - 1989)

Year	Aircraft Hrs. Flown (000)	Total Accidents	Total Fatalities	Fatalities/ Accidents (%)
1982	32,095	3,233	1,187	36.7
1983	31,048	3,075	1,064	34.6
1984	31,510	3,011	1,039	34.5
1985	30,590	2,741	950	34.7
1986	29,317	2,580	965	37.4
1987	29,208	2,468	811	32.9
1988	29,633	2,363	781	33.1
1989	29,901	2,167	763	35.2
1990	30,886	2,187	745	34.1
1991	30,760	2,143	746	34.8

Source: *FAA Statistical Handbook of Aviation (CY 1991)*

decrease. The final column in Table 1 shows total fatalities as a percentage of total accidents. Note that this percentage is quite stable, falling within the general range of 33 to 37 percent over the ten years. These data do not reflect a growing benefit from increased shoulder harness use.

A final, and perhaps the most dramatic, way of assessing the impact of shoulder harness use on general aviation safety is through the anecdotal method. If personal reports show even one person saved from death or injury because he/she was wearing a shoulder harness, the shoulder harness amendments will be justified. Fortunately, there are many anecdotal reports in which the pilot walked away unhurt and attributes this to his/her use of a shoulder harness. Certainly, in the mind of such pilots, the decision to install and use a safety harness was an excellent one.

PHASE I PROJECT PROCEDURES AND FINDINGS

The purpose of this project was to examine the feasibility of developing an intervention program designed to increase use of existing shoulder harnesses and encourage their installation in general aviation aircraft not presently equipped with usable shoulder harnesses. The project was conducted in two phases. Phase I provides the basis for an effective educational intervention program. Phase II extends data collection to ensure proper national coverage for the intervention program

A number of complementary sources were used in Phase I in developing an intervention approach. These included organization of a knowledgeable expert panel, consideration of observational data from a limited field study, and adaptation of an educational health model directed toward injury reduction. The extant

scientific literature on use of shoulder harness restraints in general aviation was found to be limited; thus, the experience of the Expert Panel members with automobile safety restraint systems assumed considerable importance as an information resource. The integration of these information sources is described below.

Expert Panel

A six-person Expert Panel was convened to address project objectives. The panel provided expertise in the areas of behavioral psychology, health education, injury epidemiology, highway safety research, statistics and test development, aviation medicine and pathology, and general aviation demography. The collective experience of the panel served to identify relevant lessons from the automotive industry applicable to the aviation environment. The following areas were addressed by the Expert Panel:

1. Development of initial concepts for an intervention strategy.
2. Review of highway safety research findings and consideration of their relevance for a program in general aviation.
3. Development of a priority listing of factors which tend to encourage or discourage installation and use of shoulder harnesses.
4. Review of project procedures and the recommended intervention program.

The Expert Panel met on two occasions for two days each, supplemented by a mail review of materials. Results of the Expert Panel meetings are reflected throughout this report.

Field Observational Study

During meetings of the Expert Panel, the research reports reviewed indicated little available information concerning current use rates for shoulder harnesses and for aircraft retrofit installations. At the first meeting, the Expert Panel concluded that a limited field study would be useful in providing current information about use rates and also in obtaining information concerning the context in which an intervention program could be introduced. Accordingly, a field study was conducted in which observations of shoulder harness installations and use of shoulder harnesses by general aviation pilots was conducted at five airports in the Washington, DC metropolitan area. Following this, aircraft manufacturers were contacted concerning cost of retrofit kits, maintenance time required to complete an installation, and approximate number of kits sold in a recent period.

A summary of the field observations is shown in Table 2. Both the observed installation rate (61 percent) and the use rate (76 percent) are higher than those reported in the 1985 NTSB study. This is as expected since the 1978 regulations regarding shoulder harness installation and use had been in effect long

Table 2

Installation and Use Rates Observed in General Aviation Aircraft in Washington, D.C., Area

Installations	
Number of aircraft observed	422
Shoulder harness installations	257
Percentage of aircraft with shoulder harnesses	61%
Use	
Number of crewmembers observed	173
Observed shoulder harness use	132
Percentage of use	76%

enough to have had some influence on behavior. However, the observed percentages still indicate shoulder harness installation and use to be a problem.

Key findings from the limited field study include:

1. Shoulder harness use rate was 76 percent for the 173 crewmembers observed. However, this estimate is based on a small number of observations and may not be representative of all general aviation.
2. Shoulder harness installations were found in 61 percent of the 442 aircraft observed. The same caution applies to this data item.
3. By report of maintenance personnel, the rate of retrofit of older aircraft is quite low.
4. Costs for retrofit are somewhat lower than believed initially. Some aircraft can have retrofit installations for both front seats for between $400 - $700.

Literature Review

A literature review was prepared to ensure that the recommended intervention program was based on knowledge gained from earlier research in aviation and in other transportation fields. The objective of the literature review was to cover those topics and those research programs of greatest relevance for project objectives. No attempt was made to document the complete history, including all research activities, in the field of transportation restraint systems. The literature review is presented as Appendix A.

Health Education Model

Structure for the procedural development of an intervention program for shoulder harnesses was obtained through use of a model adapted from the field of health education. This model, developed by Andersen (1968), and elaborated by Green et al. (1980) describes an orderly process for the preparation of a health education plan. It has the acronym PRECEDE, for "predisposing, reinforcing, and enabling causes in educational diagnosis and evaluation." Green et al state the value of the model is "to draw attention to the necessity of asking what behavior precedes each health benefit and what causes precede each health behavior that must be addressed in a health education plan." This model has been used effectively in a variety of settings.

The principal elements in the health education model are shown in Figure 1. In applying this model, one works from the right side back toward the left. This directs initial attention to desired outcome and causes one to systematically examine the actions that must occur in order to achieve the outcome.

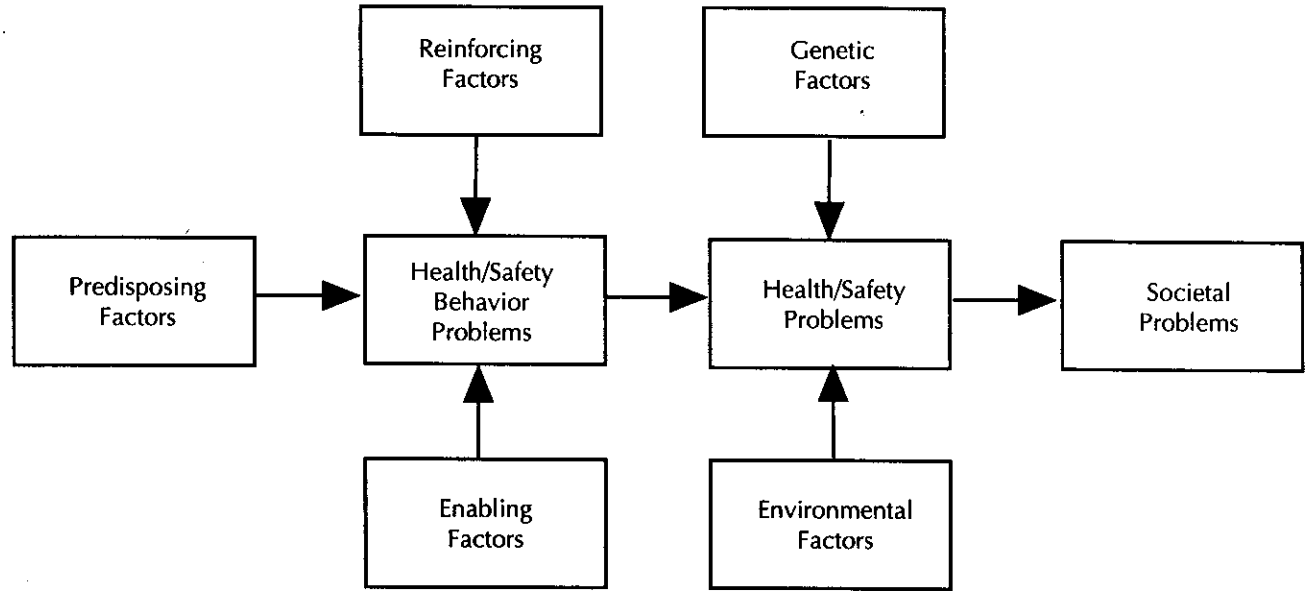

Figure 1. Conceptual Model Illustrating Factors Influencing Health/Safety Behavior Adapted from Green et al. (1980).

Societal problems, in the context of shoulder harness use, are the unnecessary loss of life, serious injury, and monetary costs resulting from failure to use shoulder harness restraint systems. Health/safety problems are seen in the percentage of crewmembers using shoulder harnesses and the current rate of retrofit of older aircraft. The health/safety behavior problems are the specific crewmember behaviors underlying the less-than-desired shoulder harness use and aircraft retrofit. These are the behaviors which must be influenced by a successful intervention plan.

The Predisposing, Reinforcing, and Enabling Factors represent the focal point for development of an intervention strategy. These are the factors to be manipulated in a program to produce the desired behavior. Predisposing factors include the values, attitudes, and beliefs of an individual. Reinforcing factors include variables such as incentives, instructor comments, reminder stickers, etc. Enabling factors are those which facilitate the behavior, such as ease of connecting the harness, comfort of the crewmember, and freedom of movement when the harness is in use. Any given health behavior may be seen as a function of the collective influence of these three factors.

The principal task of the Expert Panel and project personnel was to identify a number of predisposing, reinforcing, and enabling factors relevant to issues of shoulder harness use. These factors then were prioritized in terms of importance to the desired behaviors and in terms of relative ease of change. A systematic decision-making strategy, in this case a modified Delphi procedure, was used to achieve a priority listing. The resulting list of factors formed the basis for the recommended intervention program.

Identification of Target Groups

The first order of business for the Expert Panel was the identification of target groups (i.e., specific occupational or activity groups involved in or related to general aviation) which might be targeted for various features of an intervention program. The Expert Panel gave priority ratings of High, Medium, and Low to some 28 primary and secondary target groups. Ratings were made in terms of the contribution judged possible for each group to safety in general aviation. The initial list for rating included groups ranging from aircraft owners to airplane refuelers. From this list, eight target groups were selected and are shown in Table 3. These represent groups for which three or more members of the Expert Panel gave a priority rating of "High."

The Expert Panel felt that the fact that such clear-cut target groups could be identified within the general aviation community had implications for the development of an effective intervention program. The Panel noted that, as a rule, subgroups will have differential motivation and value systems and will, in all likelihood, respond in different ways to a common

Table 3

Target Groups Selected as Candidates for Intervention Procedures

	Emphasis	
	Use	Retrofit
Aircraft owners	X	X
Aircraft manufacturers		X
Student pilots	X	
Experienced pilots	X	
Rental operations	X	
Insurance companies		X
Flight examiners/instructors	X	
Aviation magazines/periodicals	X	X

intervention program. One must consider tailoring the intervention program as appropriate to each of the subgroups affected.

Listing of Desired Behaviors

The next task was to develop a listing of desired behaviors for each of the eight target groups. In order to keep the project within manageable levels, the project team decided to list behaviors at a macro level, such as "Use shoulder harness," rather than at the level of individual actions, such as "Reach for shoulder harness" and "Hook shoulder harness." The Expert Panel and project personnel worked together in developing the list of desired behaviors presented in Table 4.

Priority Listing for Factors Influencing Desired Behaviors

A major step in the implementation of the model presented in Figure 1 is the development of a list of predisposing, reinforcing, and enabling factors believed to influence in any way the safety behaviors identified in the previous step. In pursuing this, the following definitions were used:

Predisposing Factors - Those factors (knowledge, beliefs, values, attitudes) that increase or decrease the likelihood of an individual performing the desired behavior.

Table 4

Priority Listing of Desired Behaviorsfor Each Target Group

TARGET GROUP	DESIRED BEHAVIOR
I. Aircraft Owners	1. Use shoulder harness 2. Encourage passenger use of shoulder harness 3. Retrofit aircraft with shoulder harnesses
II. Aircraft/Equipment Manufacturers	1. Encourage retrofit of aircraft not equipped
III. Student Pilots	1. Use shoulder harness
IV. Experienced Pilots	1. Use shoulder harness 2. Encourage shoulder harness use by other pilots/passengers
V. Rental Operations	1. Encourage/require use by all pilots
VI. Insurance Companies	1. Encourage shoulder harness use by all pilots 2. Encourage retrofit of older aircraft
VII. Flight Examiners/Instructors	1. Encourage/require shoulder harness use by all pilots
VIII. Aviation Magazines/Periodicals	1. Encourage shoulder harness use by all pilots 2. Encourage retrofit of older aircraft

Reinforcing Factors - Those factors that serve to expedite and support the desired safety behavior or to reinforce the behavior itself (i.e., response consequences). These include such diverse items as incentives, rewards, reminders/placards, guides/signs, and examples set by other crewmembers.

Enabling Factors - Those factors that allow or facilitate the desired behavior. These include items such as ease of use, availability of the equipment, and the crewmember's personal skill.

Table 5

Example of Targeted Intervention Priority Summary Worksheet
Target Group I: Aircraft Owners

Behavior 1: Use Shoulder Harness

IMPORTANCE	EASE OF CHANGE	PREDISPOSING FACTORS	PRIORITY
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR *
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operations	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA *
		REINFORCING FACTORS	
2.8	2.8	a. Services of flight instructors/examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		ENABLING FACTORS	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

* NR = Not recommended; NA = Not applicable

An exhaustive list of possible factors was developed. These factors then were rated in terms of importance and ease of change by the Expert Panel. The factors were judged on a High - Low scale of importance and on an Easy - Difficult scale for ease of change.

Factors selected for further consideration were those which achieved an average score of better than 2.0 on the "Importance" scale in which "High" equaled three (3) and "Low" equaled one (1). Fifteen factors were selected in this manner and are shown in Table 5 together with their ratings for "Importance" and "Ease of Change." As judged by the Expert Panel, these are the most important factors which may serve to encourage or discourage the installation and use of shoulder harnesses.

Targeted Intervention Priorities

Each facilitating factor next was given a High - Low priority rating by project personnel as that factor relates to <u>one target group</u> (i.e., aircraft owners) and <u>one desired behavior</u> (i.e., use shoulder harness). Table 5, an example of this process, shows the target group and behavior as headings, with priority ratings on the right.

Priority assignments were based on a number of factors:

1. Discussions and judgments by the Expert Panel during the two meetings.
2. Information obtained during the literature search and the field observational study.
3. Importance and ease of change ratings. (Note that these ratings were used primarily for the initial selection of factors, not for establishing priority ratings.)

Priority levels are defined as:

<u>High</u> - Use of this factor is considered essential in the development of an effective intervention procedure.

<u>Low</u> - This factor is relevant but for a number of reasons (lesser importance, difficult to change, cost, feasibility, etc.) is not recommended for real consideration. If the factor can be worked into some intervention procedure without great effort, however, it might be considered.

<u>Not Recommended (NR)</u> - Any effort to pursue use of this factor in an intervention program is not considered worthwhile.

<u>Not Applicable (NA)</u> - This factor is not considered relevant for this target group and this behavior.

*NR = Not recommended; NA = Not applicable

(All Priority Worksheets are presented in Appendix D)

Recommended Intervention Procedures

Each factor rated as "High" in priority was next described as it would constitute an element in an intervention program for that target group and that behavior. For example, Table 5 shows high priority for "Services of flight instructors/examiners" and "Signs/posters/placards." The inset paragraph below illustrates the manner in which these two factors would apply to the group "Aircraft owners" and the behavior "Use shoulder harness."

Target Group I: Aircraft Owners
Behavior 1. Use Shoulder Harness

<u>Recommended Intervention Procedure</u>

The intervention procedure recommended for this behavior should consist of the following:

1. <u>Services of Flight Instructors/Examiners</u>. The Federal Aviation Administration should direct flight instructors and flight examiners to ensure that the shoulder harness restraint system is secured during periods of flight instruction and during the Biennial Flight Review. During the review, instructors should advise pilots that failure to secure the shoulder harness is illegal and constitutes poor safety behavior and could contribute to an unsatisfactory check ride. The FAA should provide all flight instructors, through normal communication channels, educational information concerning safety benefits of shoulder harness use which should, in turn, be passed on to pilot trainees.
2. <u>Aircraft Placard</u>. The Federal Aviation Administration should encourage all aircraft owners to place on the panel of each aircraft a direct

message such as a small placard reading "Use of the Seatbelt and Shoulder Harness is Required for all Crewmembers Occupying Front Seats During Takeoff and Landing."

Appendix D presents all materials on which recommended intervention procedures were based for each target group and for each behavior. A general description of each factor also is provided.

PHASE II PROJECT PROCEDURES AND FINDINGS

The findings of the first phase of this project, in particular those of the field observational study, were based on one limited geographical region and thus might or might not be representative of the entire country. Therefore, Phase II was initiated with the goals of collecting shoulder harness use data on a nationwide basis and exploring in greater depth the reasons underlying conformity or lack of conformity with the FAR shoulder harness amendments.

This section of the report is based in large measure on a national survey designed to support the following end products:

1. Determine the rate of shoulder harness installation and use on a national basis.
2. Collect information concerning motivational and other variables that might affect the decision of airmen to install and use shoulder harnesses.
3. Collect information on situational variables that might affect decisions concerning retrofit of older aircraft.
4. Collect information that might indicate useful features to include in a shoulder harness educational campaign.

Data Collection Procedures

The selection of data collection sites was done using procedures designed to maximize the ability to generalize results to the entire country. A decision was made to supplement the data from the Washington, DC Metropolitan Area, collected during the Phase I effort, through observations made at five additional locations. These locations were to be widely separated throughout the United States. Specific criteria considered in the selection of observation locations were (1) number of active general aviation aircraft and (2) total annual hours flown at each location, in this case a state. Table 6 presents these two variables with states listed in descending order. On the basis of these statistics, it was decided that observations to ensure national coverage should be conducted in California, Texas, Florida, Alaska, Illinois, and Washington, DC Area (previously collected).

Table 6

General Aviation Active Aircraft and Total Hours Flown by State in Which Based

STATE	ACTIVE AIRCRAFT	HOURS FLOWN
California	29,261	4,142,598
Texas	16,206	2,586,169
Florida	12,336	2,237,371
Illinois	6,543	912,313
Alaska	6,616	995,338

Source: *General Aviation Activity and Avionics Survey,* FAA, 1991 date.

Table 7

Observations of Shoulder Harness Installations

LOCATION	OBSERVATIONS	INSTALLATIONS	RATE
Florida	323	239	74.0%
Texas	395	257	65.1%
Illinois	308	183	59.4%
California	587	254	43.3%
Alaska	441	273	61.9%
Washington, DC	422	257	60.9%
TOTAL	2476	1,463	59.1%

Chi-square (installations) = 98.36, df = 5, $p < .01$

The initial goal was to obtain a minimum of 200, and hopefully 300, observations per site, recognizing that weather conditions would have considerable influence. In fact, this was the case. Poor weather, particularly in Florida and Illinois, tended to restrict observations, especially of shoulder harness use during take-off or landing. The final number of observations achieved, however, is considered adequate for project purposes. Table 7 shows number of observations made at the six sites, indicating that 2,476 useful observations were made of shoulder harness installations.

Shoulder Harness Installations

Observations of shoulder harness installations were made during a walk through of the tie-down ramps at each of the airports of interest. All observations were made with the approval of the Airport Manager. If an installation could not be observed due to interior window coverings, that airplane was not included in the sample. Results of observations for the six regions are presented in Table 7.

The results in Table 7 show a range of installation rates varying from 43 percent to 74 percent. The national installation rate is estimated at 59.1 percent. In order to determine the significance of regional differences, a chi-square test was made of the installations to assess homogeneity of cell entries. The obtained chi-square was significant ($p < .01$), indicating this not to be a homogeneous group. An inspection of the contributions to chi-square shows that Florida and California contribute disproportionately. Florida deviates from the group in the positive direction (more installations than expected) and California deviates in the negative direction (fewer installations than expected).

Shoulder Harness Retrofit Installations. The FAR amendments requiring shoulder harness installations in general aviation aircraft pertain only to airplanes built after 18 July 1978. While no requirement exists for shoulder harness installations in aircraft manufactured earlier, the existence of the shoulder harness FAR's, if nothing else, would indicate retrofit to be a good idea. Part of the data collection included discussions with maintenance managers concerning the number of shoulder harness retrofits installed in the past five years. Table 8 presents responses from the different regions. These results show that there are only 231 reported retrofits for the thousands of eligible older aircraft. Almost all of these are from Alaska, with the bulk based on conversations with five separate maintenance managers at one major general aviation airport.

Shoulder Harness Use

Observations of shoulder harness use were made through binoculars from viewing positions as close as feasible to the take-off and landing area of the active runway at each airport. An entry would be made only if the observer believed that he/she could make a definitive judgment concerning the use or non-use of the shoulder harness. In some instances, a decision could be made for only one of the two crewmembers in the front seat of an aircraft. In all, 1,522 observations of shoulder harness use were obtained. Results of these observations are presented in Table 9.

Results in Table 9 show a range of use rates between 62 and 83 percent. Again, a chi-square test shows these cell entries not to be homogeneous. Florida again deviates in the positive direction with a use rate slightly over 83 percent. Both California and Illinois deviate in the negative direction with use rates slightly above 60 percent. Based on these regional observations, the use rate for the entire United States is estimated at 71.9 percent.

Table 8

Responses Concerning Retrofit of Shoulder Harnesses in Older Aircraft

LOCATION	NUMBER
Florida	0
Texas	3
Illinois	12
California	0
Alaska	207
Washington, DC	9
TOTAL	231

Discussions Regarding Shoulder Harness Installation and Use

As part of the visits to different locations to obtain information on shoulder harness installations and use, informal discussions were held with pilots, airport managers, and maintenance managers. These

Table 9

Observations of Shoulder Harness Use

LOCATION	OBSERVATIONS	OBSERVED USE	USE RATE
Florida	172	143	83.1%
Texas	329	251	76.3%
Illinois	181	112	61.9%
California	426	267	62.7%
Alaska	241	190	78.8%
Washington, DC	173	132	76.3%
TOTAL	1,522	1,095	71.9%

Chi-square (use) = 48.27, df = 5, $p < .01$

Table 10

Number of Discussions with Aviation Personnel

LOCATION	PILOTS	AIRPORT MANAGERS	MAINTENANCE MANAGERS
Florida	26	1	1
Texas	16	2	3
Illinois	50	4	4
California	25	4	2
Alaska	11	1	8
Washington, DC	26	5	4
TOTAL	154	17	22

conversations were held as personnel happened to be available. The number of discussions conducted with each of the three personnel groups is shown in Table 10. Tabulations of the information obtained during these interviews is presented in full in Appendix B. No interview form or questionaire was used for these discussions.

An interpretation of the data presented in Appendix B must be done with caution. The aviation personnel knew that a research team was working under the auspices of the Federal Aviation Administration. In addition, one generally finds that in loosely structured interviews of this type, the information provided may be what the subject feels the interviewer wants to hear. Finally, it is well known in survey research that reported behavior may not match observed behavior.

The most valuable information found in the airport interviews most likely is in the responses to questions concerning problems that these persons had with shoulder harnesses. Information concerning the extent to which retrofits had been done and the cost of these retrofits also is valuable. Finally, suggestions made concerning ways to encourage shoulder harness use can help in structuring an educational program. All of this information is presented in Appendix B.

FACTORS AFFECTING SHOULDER HARNESS USE

Shoulder Harness Installations

The latest data available from the Federal Aviation Administration (FAA) indicate that in 1991 the active general aviation fleet included approximately 175,000 fixed-wing, piston-powered airplanes. Data collected during the present study with coverage of six separate regions of the United States lead to the estimate that, on a nationwide basis, 59 percent of this fleet is equipped with a shoulder harness installation and 41 percent is not. This translates into approximately 72,000 airplanes without shoulder harnesses.

The 59 percent shoulder harness installation rate found in the present study is higher than the 40 percent rate found in the 1985 investigation of general aviation accidents made by the National Transportation Safety Board (NTSB). The increase in installations can be explained on two bases. First, all general aviation aircraft manufactured since 1978 must have shoulder harness installations. Second, there appears to be an increasing safety awareness in general aviation as reflected in the continuing decline

in the general aviation accident rate. This enhanced safety awareness could also lead to efforts to install shoulder harnesses. While the improved shoulder harness installation rate is encouraging, the fact remains that approximately 40 percent of the general aviation fleet is not so equipped. Were all these airplanes to be retrofit with shoulder harnesses, one could expect a significant benefit in terms of reduced injuries and fatalities in the 2,000 or more general aviation accidents that continue to occur each year.

Shoulder Harness Use

The data on observed shoulder harness use collected in this study indicate a national use rate of about 72 percent. This is good and is better than that found in the NTSB study of 1985. However, the fact that 28 percent of flights still are made without using shoulder harnesses would indicate that, based on slightly more than 30 million flight hours made by general aviation in 1991, over 8 million hours of flight are made at this time with occupants not wearing a shoulder harness. A significant reduction in these hours of flight while not protected by a shoulder harness would be worthwhile.

The shoulder harness use rate of 72 percent is higher than the 59 percent installation rate. This apparent discrepancy can be attributed in part to the fact that newer aircraft, all of which have shoulder harnesses, probably are flown more than are older aircraft. Also, considerable flying is done by flight schools, which typically have newer aircraft and require that student pilots use shoulder harnesses during flight training.

Shoulder Harness Retrofits

While many thousands of general aviation aircraft are candidates for a shoulder harness retrofit installation, the number of installations actually made is very low. Some maintenance managers at general aviation airports cannot recall having made a single installation during the past five years. For others, the number of installations is less than ten over this same period.

The only evidence of noticeable activity regarding shoulder harness installations is found in small specialty shops. One such shop, which makes shoulder harness kits for a variety of Cessna aircraft, estimates it has sold approximately 1,000 of these kits in the past several years. Even at this rate, however, many years will pass before older general aviation aircraft all have shoulder harnesses. The rate of retrofit is the weakest element in the entire general aviation shoulder harness picture.

Reasons for Slow Rate of Retrofit

Discussions were held with pilots in an attempt to determine the reasons for the slow rate at which the older general aviation fleet is being retrofit with shoulder harnesses. Most pilots agree, at least in terms of verbal response, that use of a shoulder harness provides a crewmember significant protection from death or injury. In this case, why do they not immediately have shoulder harnesses installed in their aircraft? A review of responses suggests three possible reasons for low retrofit rates. These reasons are:

1. **Difficulty in obtaining information.**
   a. **No central data source.** A pilot interested in a retrofit can proceed in one of three ways. He/she can (1) purchase a shoulder harness kit from the aircraft manufacturer, (2) purchase a kit from an independent supplier, or (3) assemble the necessary components himself. Since the installation necessarily involves a modification to the aircraft structure, approval by the FAA is required. The actual installation must be made, or approved, by a licensed maintenance technician.

Considerable guidance and information is required to steer a pilot through the steps listed above. Unfortunately, there is no central data source from which a pilot can get detailed information concerning specific procedures to follow, a list of suppliers, and the approximate cost for the materials and installation. If a pilot deals directly with the manufacturer of his aircraft, the problem is solved to some extent. The manufacturer can provide much information and also is likely to have the necessary FAA installation approval. However, if a pilot is looking for an inertia reel system, for example, the manufacturer may offer only a fixed restraint system. In this case, the pilot must go elsewhere.

If a manufacturer no longer is in business, a pilot must rely on his own resourcefulness to determine the best way to approach the matter and where to locate a supplier for a shoulder harness suitable for his airplane. For example, the owner of a 1948 Ercoupe would be hard pressed to know who to call to inquire concerning shoulder harness retrofit.

There is a need for a central source of information on procedures and suppliers for shoulder harness restraint systems. If, on the basis of a single telephone inquiry, a pilot could get all necessary information for a retrofit, the retrofit process certainly would be expedited. Organizations with an expressed interest in general aviation safety, such as the Air Safety Foundation of the Aircraft Owners and Pilots Association, the Experimental Aircraft Association, and the Flight Safety Foundation, might be likely candidates to maintain a data base of shoulder harness information. A nominal fee for an inquiry, with mailed data printout, could support operation of the data base.

b. **Manufacturer emphasis.** A number of telephone calls were made to aircraft manufacturers during this project to request information concerning the availability, cost, etc. of shoulder harness systems for their airplanes. In all cases, the manufacturer's employees were courteous, friendly, and quite cooperative. However, these discussions made it plain that the sale of shoulder harness systems is not a major activity for their sales departments. Information concerning shoulder harnesses in many instances is not readily available. Also, supply generally is restricted to fixed harnesses. Inertia reel systems are not usually offered. In all, manufacturers do not seem prepared to have a pre-packaged unit on its way to a customer in the next mail.

Reasons for the apparent lack of emphasis given by manufacturers to shoulder harness retrofits are understandable. First, demand for shoulder harness systems has been very low. Under these conditions, it is expensive for a manufacturer to maintain any significant inventory of shoulder harnesses. Second, a campaign to interest pilots in shoulder harnesses calls attention to the possibility of an accident. Manufacturers quite naturally would prefer to direct attention to transportation assets such as speed, useful load, comfort, and similar positive product attributes. Third, manufacturers compete in the shoulder harness arena with small specialty shops that have obtained an STC for an installation and can provide a complete system, with detailed instructions, at a modest cost.

The situation with manufacturers probably would improve with increased demand. Considering that many thousands of airplanes are candidates for retrofit, increased demand should result in improved procedures as well as a measure of competition between manufacturers and independent suppliers. The result should be a more responsive marketing picture.

In all, lack of information concerning the availability of retrofit shoulder harness assemblies contributes to low installation rates. This situation points to the desirability of an information program, directed by the FAA, to emphasize the need and to provide clear directions for pilots on ways to obtain and install shoulder harness systems.

2. Perceptions of Shoulder Harnesses

Pilots verbally acknowledge the benefits of using shoulder harnesses. Results of interviews show that most pilots feel that shoulder harness use provides either "total" or "a lot" of protection. Why then would they fly without a harness?

The answer seems to lie in the way current shoulder harness installations are viewed. When pilots were questioned concerning problems identified with shoulder harness use, the most common responses were classed into categories titled "Restrictive," "Discomfort," and "Poor Engineering." There apparently is some basis for these comments. Pilots need to reach for more controls on the instrument panel than is the case with automobile drivers. The shoulder harness, particularly if it is not of the inertia reel type, can be restrictive. Even so, most manufacturers offer shoulder harness installation kits of the fixed-length type. The only way to achieve full movement is to unfasten the harness. Indeed, some instructors note that they do not wear the harness during take-off so they can immediately reach controls on the pilot's side should circumstances warrant.

A frequent complaint by pilots is that shoulder harnesses are poorly engineered. One installation, frequently used, employes a plastic grommet on the attachment fitting to ensure a good fit. The friction between the metal on the harness attachment and the grommet keeps the fit relatively tight and does not allow easy movement at the fitting. However, over a number of flights, the plastic will tend to wear away resulting in a metal-to-metal fitting. When this happens, the friction is gone and the metal clasp of the shoulder harness frequently comes loose. After this has happened a number of times, pilots tend simply not to secure the harness in the first place.

3. Cost

Another concern of pilots is with the cost of shoulder harness retrofits. Cost estimates range from several hundred dollars to several thousand dollars per airplane. In general, however, a good estimate is that it should cost $1500 or less to equip the two front seats of a single-engine airplane with FAA-approved, inertia reel shoulder harnesses. In some instances, and with some airplanes, the cost can be much higher.

Information collected during this project on availability and cost of shoulder harness retrofit kits is presented in Appendix C.

Regional Differences

The data collected in the six different regions of the country, when examined statistically, show significant differences among regions both for shoulder harness installation rate and use rate. As can be seen in Table 11, for both installation and use, the state of Florida scored higher than other states. Correspondingly, California was lower than most other regions both in installations and use. For use, California was approximately the same as Illinois. Specific bases for these differences, which appear to be genuine, are not clear at this time.

One reason for the good showing of the state of Alaska in shoulder harness use may be found in the type of flying conducted there. Alaska has mountainous regions and low-level flight through these regions can experience heavy turbulence. For this reason, pilots there report that the shoulder harness is used to control the effects of turbulence as much as to protect against the possibility of an accident. As one pilot phrased it, "If you don't wear a shoulder harness and fly in the state of Alaska, you will get exactly what you deserve."

While the reasons underlying regional differences may be obscure, these differences do serve to indicate where special attention should be given in the imple-

Table 11

Comparison of Installation and Use Rates by Region

REGION	INSTALLATION RATE	USE RATE
Florida	74.0	83.1
Texas	65.1	76.3
Illinois	59.4	61.9
California	43.3	62.7
Alaska	61.9	78.8
Washington, DC	60.9	76.3
U.S. estimate	59.1%	71.9%

mentation of any national intervention program to improve shoulder harness installation and use rates. These regional differences also indicate a need for careful coordination with FAA personnel in the different FAA regions who might be responsible for implementation of parts of a national intervention program.

General Factors

One factor possible affecting regional differences in shoulder harness installation rates is that the separate FAA regions do not have identical approaches to the cost and procedural complexity of obtaining a Supplemental Type Certificate (STC) if a pilot wishes to design and install his own shoulder harness retrofit. Where the procedure is rapid and the cost not high, there apparently is a corresponding increase in the rate of retrofits. The development of a standardized approach to this issue through the different FAA regions would be beneficial.

The best answer may be to encourage pilots seeking retrofit kits to deal either with the original manufacturer of the airplane or with independent suppliers who make retrofit kits. These sources will have an STC and hence there will be no need for the pilot to obtain one.

The End Product: A National Educational Program

The principal end product of this study is a proposal for an educational program to increase shoulder harness installation and use rates. The proposed Shoulder Harness Educational Intervention Program is described in the next section. The objectives of the recommended program are to (a) improve the current use rate of shoulder harness restraint systems by aircraft crewmembers and (b) encourage the retrofit of older aircraft not equipped with shoulder harnesses.

Potential Benefits. A calculation of the benefits to be achieved through introduction of a shoulder harness intervention program suggests this program could achieve a significant annual reduction in general aviation fatalities. The analysis presented in Appendix E indicates that in 1995 some 17 fatalities would be prevented if the educational program raised the shoulder harness use rate from 70 to 80 percent. This improvement in shoulder harness use appears achievable, especially since the proposed program uses one-on-one delivery of program materials from Aviation Medical Examiners (AMEs) to pilots and crew-members. Previous research (Geller et al., 1987) has shown this type of intervention to be an effective procedure for influencing behavior of a targeted audience.

The 17 fewer fatalities attributable to the shoulder harness intervention program would be accompanied by a considerable reduction in serious and/or moderate injuries, particularly those to the head and face. The national savings in medical and legal costs would be impressive, certainly in the millions of dollars each year. If the national shoulder harness educational intervention program is successful, as anticipated, it will make a notable contribution to safety in general aviation.

A PROPOSED SHOULDER HARNESS EDUCATIONAL INTERVENTION PROGRAM

The objectives of the recommended shoulder harness intervention program are (a) to increase the current use rate of shoulder harness restraint systems by aircraft crewmembers and (b) to encourage the retrofit of older aircraft not equipped with shoulder harnesses.

A related objective is to ensure that the educational program is cost effective. This can be done by drawing on available resources in aviation wherever possible. Where mechanisms now exist for delivering messages to aviation personnel, these mechanisms should be used. Program administration can be made cost effective by working with in-place groups within the aviation community, such as Aviation Medical Examiners (AMEs) or owner associations.

These objectives, while presenting overall direction for the program, are broad and do not provide specific goals. Establishing an effective program requires that such goals be listed. The following goals are recommended:

1. The use rate for shoulder harnesses should be increased from its present rate of just over 70 percent to 80 percent.

2. The rate of installation for shoulder harness restraint systems in general aviation aircraft should be increased from 59 percent to 75 percent, or greater if possible. Retrofit of older aircraft probably represents the area of greatest pay-off in an intervention program. A properly constructed educational program will produce a measure of improvement in use for pilots who simply do not use available shoulder harnesses. Until the program is conducted, however, it is only possible to speculate concerning the extent of any increase in use by such pilots. On the other hand, if an aircraft is retrofit with shoulder harnesses, it is very likely that the pilot and other crewmembers who fly with him will use the shoulder harnesses. If a pilot is not completely convinced of the value of shoulder harnesses, he will not bear the expense of retrofit.

The recommended shoulder harness intervention program is entirely one of education. No consideration is given to changes in the Federal Aviation Regulations or to enforcement. Any increase in shoulder harness use should come as a voluntary change on the part of general aviation pilots and owners.

An effective learning process should accomplish the following:

1. **Create awareness of the importance of shoulder harness use.** As noted, most pilots are well aware, at least at the verbal level, of the value of shoulder harness use. Therefore, an intervention program must do more than simply inform flight personnel that shoulder harnesses are good things to use. "Awareness" must be more comprehensive and include specific information concerning risks of non-use and levels of protection to be gained through use.
2. **Provide motivation for change.** Awareness alone is not enough. The simple provision of safety information seldom is effective in changing behavior. In a program to increase the use of safety belts in automobiles, Robertson et al (1972) presented safety messages to selected viewers over cable television for a number of months. Following this, safety belt use by this group was compared with drivers in control groups not exposed to the safety messages. Results showed the campaign had no effect whatsoever on safety belt use.

   The learning process must be structured to provide intrinsic motivation. Procedures to accomplish this are discussed in the next section.
3. **Offer guidance for change.** If behavioral change is to occur, the process will be aided if specific guidance is offered concerning the change. This is particularly important if the immediate objective is to increase the rate of shoulder harness retrofit installations. The educational program should describe, in appropriate detail, the specific steps a pilot must go through if he wishes to install shoulder harnesses. Simply urging him to do so is not enough.

Three features of safety and health educational programs have been shown to foster behavior change. These are:

1. **Useful information.** Green (1980) notes that, while some contend that knowledge has little impact on the outcome of health education programs, there is evidence that the association between knowledge and health is more than a philosophic one. Green cites research showing that lower death rates for a variety of diseases are significantly associated with increased years of schooling. While this effect cannot be attributed entirely to an accumulation of knowledge, Green suggests that knowledge more than likely makes some of the difference. It improves decision-making ability and others skills required for effective living in a complex world.

   Information to support decision making and other skills must, by definition, be useful. A safety program which relies on platitudes, such as "A safe pilot uses his shoulder harness" is not likely to change behavior. Information concerning specific risks and specific benefits can be used by a pilot in his decision making and is more likely to result in the desired changes in behavior.
2. **Personalized approach.** From studies in the health sciences, it appears that a key factor in the degree of change in health behavior is the extent to which the appeal to change is personalized (Robertson, 1975). The message should

[illegible]ected toward the individual and his world. [illegible]n the present instance, the message should talk [illegible]t general aviation pilots and general avia[illegible]aircraft. Since much of this program will [illegible]with shoulder harness retrofit, illustrations [illegible]ould use aircraft built before 1978.

[illegible]delivery of the safety message, as well as the [illegible]ssage itself, should be personalized. Geller [illegible]Nimmer (1985) state that the credibility of [illegible]intervention is enhanced and, more impor[illegible]ly, the probability of program maintenance [illegible]increased by having indigenous personnel [illegible]liver the behavior change strategy. With this [illegible]idance, individuals within the aviation com[illegible]unity should be used to conduct the educa[illegible]ional program. Flight instructors and Aviation [illegible]edical Examiners would meet this require[illegible]ment.

[illegible]mall groups. Education directed toward be[illegible]avior change is more effective in small rather [illegible]han large groups (Geller and Nimmer, 1985). [illegible]mall groups encourage active involvement of [illegible]articipants. Displaying safety slogans or lec[illegible]turing to passive audiences is not as effective as [illegible]an approach which produces interactive discus[illegible]sions. Geller cites an educational principle that "Tell them and they will forget — demonstrate [illegible]and they will remember — involve them and [illegible]they will understand."

[illegible]The smallest of the small groups is represented [illegible]by one-on-one instruction. The delivery of the [illegible]safety message and materials by a flight instruc[illegible]tor or by an Aviation Medical Examiner should [illegible]result in interaction and should promote behavior change on the part of the pilot.

Assessment. A safety intervention program should be structured so that a meaningful evaluation can be conducted at the completion of the program. Green et al (1980) describe three levels at which the assessment of an intervention program can be made. These are (1) in terms of process, (2) in terms of impact, and (3) in terms of outcome. In a process evaluation, interest is in the extent to which the intervention program meets professional standards for the design and conduct of such a program. An impact evaluation, in turn, focuses on the effect of the program on the learner, i.e. do pilots know more about reasons for shoulder harness use and for the retrofit of aircraft? At the third level of evaluation, that of outcome, interest is in whether the program meets its stated goals.

Primary attention for the recommended shoulder harness intervention program should be on outcome, the third level of evaluation. Success of the program should be judged in terms of the extent to which the behavior of general aviation crewmembers changes. Is the observed rate of shoulder harness use increased to 80 percent? Is there a significant increase in the retrofit rate for older aircraft?

Implementation

The best chance for success of the shoulder harness educational program will be through use of multiple channels for delivery of the safety message. For each channel, presentation techniques known to enhance message effectiveness should be employed. To the extent possible, the person to whom the message is directed should be involved in the educational process. Green et al. (1980) emphasize this need and state that "The evidence that the durability of cognitive and behavioral changes is proportional to the degree of active rather than passive participation of the learner is overwhelming."

Specifics for FAA development and management of the proposed program require careful consideration. The program has several aspects which would involve different components of the FAA including the Federal Air Surgeon, Flight Standards Service, Aircraft Certification Service, and Air Traffic Services. Development of this program would require creation of a group of representatives of these organizations with appropriate management to define program details and responsibilities. Approaches to this process are under consideration in the Office of Aviation Medicine.

Aviation Medical Examiners (AMEs). The primary path for implementing the educational intervention program could be through use of Aviation Medical Examiners (AMEs). AMEs consist of about 5,700 private physicians who annually perform over 490,000 required medical examinations of flight personnel seeking FAA certification. Since Aviation Medical Examiners report to the Federal Air Surgeon,

they represent a readily available channel for use in implementing the shoulder harness educational program and for delivering appropriate educational materials. Inasmuch as the maximum time between certification renewal examinations for general aviation pilots is 24 months, the safety message can be delivered to the entire general aviation community within this period.

The interaction between the Aviation Medical Examiner and the pilot is the key to the anticipated success of this approach. Geller and his associates (1987) found that interactive educational programs achieve greater success than passive programs. This, of course, is consistent with the conclusions of Green and coworkers noted earlier. When an individual interacts in some manner with the bearer of the safety message, the message is more likely to be successful. Geller found in his work that simple exposure to billboards or poster slogans was not as effective in encouraging automobile seatbelt use as was interactive discussion between drivers and safety educators. In the present campaign, each AME can deliver the safety message, with supporting materials, personally and then discuss these with the pilot. This should give maximum impact to the message.

The safety program can be introduced to Aviation Medical Examiners during the course of AME seminars given by FAA personnel a number of times each year at different locations throughout the country. For example, more than 20 AME seminars are scheduled throughout the United States during fiscal year 1994. During these meetings, each AME can be given a detailed set of instructions to use during a certification examination at the point where the safety brochure is distributed. These instructions should include the following:

1. Discuss the fact that safe flight behavior is simply one additional aspect of a safe and healthy lifestyle. Remaining healthy and flying safely are, in many respects, one and the same.
2. Review the latest statistics (to be provided) on injuries and fatalities in general aviation. Emphasize that these numbers would be lower if every pilot used shoulder harnesses at all times.
3. Give the pilot the brochure and ask him to read it carefully.
4. Ask if the pilot owns an airplane and, if so, is it equipped with shoulder harnesses.
5. If the pilot owns an airplane without shoulder harnesses, ask if he plans to do a retrofit. If the answer is yes, emphasize the importance of doing it soon.
6. Conclude this part of the discussion by asking if there are any questions. (Note: The AME must be provided information on retrofit procedures in order to answer questions on this topic.) Emphasize that while shoulder harnesses are not as exciting as new radios, they are equally important. When a pilot needs a shoulder harness, he ***really*** needs a shoulder harness.

Aircraft Owner Associations. Another channel for consideration in an educational program is use of associations formed primarily by owners of specific types of general aviation aircraft. The roster of associations and clubs maintained by the Aircraft Owners and Pilots Association (AOPA) lists at least 40 of these owner associations. Membership in many is impressive. For example, the Mooney Aircraft Pilots Association currently has over 4,000 members. The American Bonanza Society represents more than 9,000 owners of Bonanza, Baron, and Travel Air aircraft.

Aircraft owner associations are quite active. Most publish a monthly newsletter, generally as a multipage, full-color journal; conduct safety seminars; and have one or more meetings through the year. Some offer pilot training programs and service clinic inspections of your airplane. The theme of all is to provide a forum for the exchange of owner experiences and to promote safety in use of member-owned aircraft.

A number of owner associations were contacted during this project. Among these were:

- American Bonanza Society
- Cessna Owner Organization
- Cessna Pilots Association
- Cherokee Pilots Association
- Ercoupe Owners Association
- Flying Apache Association
- Luscombe Association
- Mooney Aircraft Pilots Association
- Piper Owners Society
- Short Wing Piper Club
- Twin Bonanza Association

scheduled to run for five years. For each six-month period, two topics are emphasized, one in flight operations and one in maintenance. The following operational topics have been conducted or are scheduled:

July - December 1992:	Navigation Update
January - June 1993:	Communications
July - December 1993:	Aeromedical Factors
January - June 1994:	Fuel Management
July - December 1994:	Decision Making

The Shoulder Harness Educational Program is appropriate for inclusion in the "Decision Making" seminar.

Flight Instruction. Flight instructors can be quite valuable in a safety program since they serve as role models for pilots during training. During initial and advanced training, flight instructors should emphasize the requirement for use of the shoulder harness and should strongly recommend shoulder harness retrofit if the aircraft being used is not so equipped. During the Biennial Flight Review, failure to secure the shoulder harness prior to take-off could contribute to an unsatisfactory review in precisely the same manner as would loss of 400 feet during a 360 degree turn.

Program Materials

Two educational materials should be developed in final form before implementation of a shoulder harness educational intervention program. These materials are:

1. A brochure describing the requirement for shoulder harness systems and the increased safety afforded by their use. This brochure will present the case for shoulder harness use factually rather than through elaborate graphics. An overview of safety statistics showing benefits of using shoulder harness restraint systems will be included. The brochure also will include a discussion of aircraft retrofit procedures, including kit availability and approximate cost. Procedures for acquiring additional information will be given.
2. A short videotape presentation describing the shoulder harness intervention program and what it is attempting to accomplish. The videotape will be approximately five to seven minutes in length. It will be prepared in a form suitable for showing to larger groups of pilots and other aviation personnel as a means of introducing the program. The video also should serve to engender positive attitudes toward program participation.

The following sections describe rules for preparation and show materials for inclusion in each of these educational materials.

Brochure. A shoulder harness brochure for wide distribution should have three qualities. First, it must be factual. The advantages of using shoulder harnesses should be stressed and should be supported by statistical evidence describing the protection afforded against injury and possible death. Second, the brochure should be short. If the brochure is to be successful, the message must be delivered in a few short minutes of reading. Third, the brochure should be done attractively and prepared in a readable style and format.

The brochure should include information on protection afforded by shoulder harnesses in reducing fatal and serious injuries and should also include details on how one can accomplish should harness retrofits on their airplanes. This latter section should describe the necessary FAA requirements for this process.

Videotape Presentation. A videotape presentation can be used in situations where the safety message cannot be delivered personally. In safety seminars with large groups, for example, the videotape might be used during the introduction of a speaker discussing safety in general aviation. Speakers should be encouraged to invite discussion of the message of the video in order to obtain the same benefits as found with interactive one-on-one sessions.

The impact of a videotape presentation would be enhanced through use of an opening scene showing a person well known in general aviation entering a small airplane, "hooking up," and making the case for use of shoulder harnesses.

The video presentation should include the following sequences:

1. A view of a good shoulder harness installation in a modern airplane. All positive aspects of shoulder harness installation and use should be illustrated. The shoulder harness should be carefully coordinated with other interior materials and

should be installed in such a manner as to cause least interference with front or back seat passenger movement. This first scene also might illustrate the ease with which a shoulder harness can be donned or removed as desired.

2. A view of an older aircraft not equipped with shoulder harnesses. The discussion here would acknowledge the fact that about 40 percent of the general aviation fleet still is not equipped with these restraint systems.
3. Footage from the CAMI impact test facility showing results on anthropomorphic dummies not wearing shoulder harnesses during simulated impacts.
4. Information concerning procedures to be followed in order to have a shoulder harness system installed in an older aircraft.
5. A scene showing a pilot and crewmember preparing for flight and buckling their seatbelt and shoulder harness. Emphasis should be placed on the requirement for this as a pre-flight checklist item, calling attention to the fact that buckling up is as important as any other item on the checklist.
6. A final scene showing the airplane taking off.

Program Evaluation

Within a period after initiation of the program, in the order of two years, an evaluation of the success of the shoulder harness educational intervention program should be done. There are certain aspects to this evaluation program, as follows:

1. The primary objective of an evaluation program is to answer two questions. Did shoulder harness use increase? Was there an increase in rate of retrofit of older aircraft?
2. Some interviews with pilots could be used very beneficially to determine the particular features of the intervention program which affected either their use rate or their decision to retrofit.

These questions could be answered by a statistical field study similar to that which produced the data for this report.

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APPENDIX A

AN HISTORICAL REVIEW OF RESEARCH REGARDING SEAT BELT/SHOULDER HARNESS USAGE IN TRANSPORTATION SYSTEMS

The requirement for lap belts in early aircraft was not a matter for scientific enquiry — the need was obvious. Abrupt stops during less-than-perfect landings, turbulent air, and an occasional period of inverted flight clearly defined the need. The lap belt thus became a standard item in civilian and military airplanes almost immediately.

The matter of shoulder harness restraint systems was, and still is, quite another matter. Prior to any systematic testing, the common belief was that if a pilot's shoulders were restrained in a crash and the head was not supported, cervical fracture could be expected. Not until the mid-1930's was work done to demonstrate otherwise (Engle and Lott, 1979). Lieutenant Colonel Malcolm Grow, a Medical Officer in the Army Air Corps had visited an aircraft accident scene and noted blood on the instrument panels of both the front and rear cockpits. The crewmembers had died of skull fractures, but without other injuries. Grow requested that Harry Armstrong, another Air Corps Medical Officer, study the problem.

Armstrong used a suspended airplane seat which could be dropped a few feet, and stopped abruptly, to investigate the problem. Using himself as a subject and an early acceleration meter to measure the force, Armstrong gradually increased the drop distance. His results, constituting perhaps the earliest work in human acceleration tolerance, were surprising (Armstrong, 1939).

Using a lap belt only, Armstrong found that a sudden deceleration of eight G's or more caused the body to jack-knife forward with such force that had the head struck any object, as would have occurred in an airplane, the skull would probably have been fractured. However, when he was restrained with a shoulder harness, Armstrong found he could readily tolerate decelerations of up to 15 G's without body displacement and without any significant discomfort. The tests were terminated at this point because the accelerometer would not measure any higher force. However, Armstrong estimated that crewmembers could survive decelerations of between 30 and 50 G's provided the shoulder harness and aircraft seat remained in place. He also speculated that use of a shoulder type safety belt would save most of the 42 percent of Air Corps aircraft accident victims being killed at that time through trauma to the head and face only.

The benefits of occupant restraint systems in aircraft did not lead soon to their introduction into automobiles. Campbell and Campbell (1986), in their review of early automobile restraint systems, note that lap belts rarely were used before the mid-1950's. At that time, the Ford Motor Company introduced two front seat lap belts as an option. Further acceptance of seatbelts as automotive equipment was slow until 1964, when an increasing number of states passed laws requiring installation of two front seat lap belts in new passenger automobiles. In 1966, U.S. automobile manufacturers adopted a policy of equipping all new cars with lap belts in both the two front and the two rear seats.

By the 1960's, with motor vehicle deaths beginning to exceed 50,000 per year, the Federal Government undertook an active role to reduce the highway toll. The National Highway Safety Bureau of the Department of Transportation issued regulations requiring lap and shoulder belts in the two front outboard positions of new vehicles, beginning with 1968 models.

Even after lap belts were installed in vehicles, use rate was low. In 1978, by which time most vehicles in active use had lap belts, only 13 percent of front seat occupants used the belts (Department of Transportation, 1986). By 1984, this rate had increased to only 14.3 percent, a negligible change.

During the 1970's and early 80's, the need for programs to increase use of seat belts became quite clear. Simple provision of the belts was not enough to achieve the anticipated safety benefits. Large scale programs to encourage or to mandate use of seat belts would be required. Here, the United States lagged far behind other countries. For example, Australia instituted seat belt laws in 1970 and Japan followed in

1971. Over 30 other countries followed immediately or within several years. In the United States, the first official action came with the passage of an adult restraint law by the State of New York in 1984.

In all countries, efforts to increase seat belt use have followed two complementary paths which include (a) programs to encourage increased seat belt use on a voluntary basis and (b) legislative activities to mandate use of seat belts. The following sections review milestones within these two efforts.

Programs to Encourage Use of Seat Belts and Shoulder Harnesses

Programs to encourage use of restraint systems inevitably follow some theme. There is an hypothesis as to what will work and this becomes the central theme of the program. Later efforts draw on those themes with the best record and present a blend in an attempt to achieve increased success. The principal themes underlying most programs to enhance seat belt use are:

Educational Programs. Programs to modify behavior must first describe the desired behavior. What is it you want? Logically, this should be followed by some explanation of the benefits to be derived. How will this help me? In attempting to encourage use of restraint systems, the first message is easily presented - drivers should use seat belts/shoulder harnesses at all times. The second message, that describing benefits, appears equally straightforward - seat belts save lives. This educational message should be a simple matter to implement and, if presented properly, should produce the desired behavior. The logic of this has led to many educational programs designed to insure that seat belts are used. Results of these programs show the educational imperative to be a more complex issue than it might appear.

In a large-scale program prior to passage of a seat belt law, Great Britain was able to increase safety belt use from 12 to 26 percent with a six-week television and print campaign (Streff and Geller, 1986). Subsequent educational efforts increased British safety belt use to 35 percent, at significant cost, however. This program, which runs every year for about six weeks, is extensive and expensive. The average television viewer sees one of the safety messages eight to nine times during the six-week period. Cost, including newspaper advertisements and radio announcements, comes to some $2.5 million per year. When the British mandatory-use seat belt law was passed in 1983, belt use rate increased to between 90 and 95 percent. Streff and Geller suggest that these surprising results may be attributed to the unusual effectiveness of the media campaign. In any event, the success achieved in Great Britain stands as a benchmark. Other programs have not been as successful.

A controlled study of the effectiveness of a television educational campaign was conducted by Robertson et al. (1972). A set of television messages was derived based on a study of factors associated with observed safety belt use. These messages were shown on one cable of a dual cable television system for nine months. For one month prior and throughout the campaign drivers were observed as to safety belt use and compared with matched drivers in control groups who were not exposed to the safety messages. Results showed the campaign had no effect whatsoever on safety belt use.

The results achieved by the Robertson team are similar to those found by other investigators. The Committee on Trauma Research of the National Research Council and the Institute of Medicine in its report "Injury in America" states that "Neither safety-education campaigns nor driver-education programs have been shown by scientific evaluation to justify the faith and large budgets accorded them." This report notes that many injuries result not from lack of knowledge but rather from failure to apply what is known.

Campbell et al. (1984) summarized results of educational efforts to increase seat belt use. These programs have included television spots, pamphlets, news stories, as well as special packaged programs developed for specific interest groups. The authors note that while campaigns can modify attitudes toward belts and even increase one's stated intentions of using them, such programs have not, by themselves, been shown to have much effect on use rates.

There are several useful conclusions to be drawn from attempts to develop educational programs to support seat belt use. These include:

• Educational programs alone seldom are very effective. They can, however, be used quite beneficially to support other kinds of seat belt enhancement programs.

• Educational messages should be personalized to have any success (Robertson, 1975). If a specific target group can be identified, the message should address this group.

• Interactive educational programs achieve greatest success (Geller et al., 1987). Successful programs to encourage seat belt use have more active involvement of participants than do less successful interventions. Exposure to billboards or poster slogans is not as effective as interactive discussions with the group being encouraged.

Incentives and Inducements

The use of incentives to motivate automobile drivers to use seat belts has been explored in a variety of settings in recent years. The rewards employed have been immediate or delayed, direct or indirect, and offered in a variety of settings (communities, universities, corporations, Federal facilities, schools, etc.). Rewards include such items as cash, gift certificates, lottery tickets, food coupons, tickets to sports events, and others. Geller (1984) reviewed 28 incentive-based programs and summarized outcomes and issues. Rationale and procedures for such programs also were discussed. Some of the important points made by Geller include:

• Incentives can be used successfully as motivating agents. In all programs, an increase in use of the seat belt/shoulder harness was observed during the period of the incentive program. In many instances use rate more than doubled.

• The requisite size of rewards has not been established. While reinforcement theory indicates the higher the perceived value of the reward the greater should be the increase in seat belt use, attempts to demonstrate this have been complicated by the fact that rewards often are offered on some probability basis. Geller also notes that there is research in social psychology which suggests that incentive value should not exceed that necessary to motivate initial behavior change. Unless other motivating factors come into play, a behavior change based on reward size only will cease when the reward is removed.

• An observed increase in seat belt/shoulder harness use, when incentives are employed, almost invariably is directly proportional to the percentage of belt use prior to incentives. If baseline use is three percent, improvement through incentives probably will increase only to five to ten percent. However, if baseline use is 25 percent, one might expect an increase to 50 or 60 percent.

• Different groups respond differently to incentive programs. As a rule, white collar workers respond better to incentives than do blue collar workers. Similarly, white drivers respond better than blacks and, with a smaller difference, females respond better than males.

• Incentives may be offered on an individual or a group basis. Each approach has proven successful, although there are no systematic comparisons of relative effectiveness of group versus individual incentive plans.

• Incentive programs can be administered on a community-wide basis. Geller notes that community-wide programs thus far have been successful in reaching and influencing a large number of drivers, but the program has not been without a great deal of human effort and substantial financial expenditures. A particular challenge is to ensure that a community-wide program will be lasting and its effects permanent.

• All incentive programs show a significant decline in safety belt use after incentives are removed. In most cases, however, follow-up use levels remain higher than the pre-incentive baseline levels.

One incentive program that depicts the difficulty in reward selection for incentive programs is that offered by a national insurance company several years ago (Robertson, 1984). The company offered increased compensation payments for clients injured or killed in a motor vehicle crash while using a seat belt. After the program was initiated, observations of belt use showed no difference between drivers offered the insurance incentive and drivers insured by other companies. This study showed that use of an economic incentive remote both in time and probability (i.e. increased compensation by insurance in the event of a crash) was not successful in improving seat belt use rate.

Epidemiological Investigations

An epidemiological approach to issues of public health policy involves as one aspect an identification of those groups considered to be "at risk." The prevention of injuries and fatalities due to automobile accidents is a matter for public health action, just as is the prevention of communicable disease spread. One of the first steps is to identify those persons or groups most likely to be affected. A second step is to identify risk factors associated with the behavior or event of concern (Tolsma, 1984).

Goldbaum et al. (1986) present results of a nationwide telephone survey of behavioral risk factors associated with use and non-use of automobile seat belts. Over 22,000 respondents were surveyed in all states. Data were acquired before any states had mandatory seat belt use laws. Survey data indicate that:

1. Ethnic background (Black, Hispanic, White) was a determinant of compliance in use of seat belts, with Hispanics reporting the highest use rate.
2. Use of seat belts increases with increasing age up to a point. This trend is greatest for white drivers.
3. Use of seat belts increases markedly with increased education. This trend was found for every ethnic group.

One should recognize that the above findings are based on a telephone survey and that self-reported belt use may differ considerably from use rates noted through direct observation.

Health Behaviors and Attitudes

Use of seat belts can be considered as one in a number of health behaviors (exercise, nutrition, etc.) which individuals may or may not follow. If these behaviors appear to form a health complex, and use of seat belts is one item within the complex, new opportunities to encourage seat belt use are presented. Strategies could be developed which advocate seat belt use as an integral part of an overall approach to health. Here the emphasis is one of health rather than one of damage control, as is the case with most seat belt safety messages.

Merrill and Sleet (1984) examined use of seat belts as part of a health promotion program in a large corporation. Results presented a better picture of health for users of seat belts. Such drivers were found to have better smoking, nutrition, exercise, and alcohol consumption habits than were found for non-users of seat belts. In addition, fewer users than non-users tended to be overweight.

Results of the above study suggest that employees who have good health habits also tend to fasten their safety belts. This in turn suggests that programs to encourage safety belt use might benefit through describing safety belt use as part of a broader health complex. Again, however, an interpretation of these findings must recognize that the data were obtained through a questionnaire survey and not through direct observation of behavior. The authors acknowledge that "safety belt use is known to be somewhat exaggerated in self-reported data."

Reminders (Signs, Posters, Placards)

In programs to encourage use of seat belts, signs and posters generally are but one part of a larger educational effort involving perhaps use of television, personal messages, pamphlets, and other devices. Therefore, one has difficulty in determining the role, if any, that signs and posters played in effecting the desired behavioral change. However, Streff and Geller (1986) note that for behavior change messages to be most effective, they should occur in close proximity to the desired target behavior. On this basis, signs and posters displayed at some point away from an automobile would probably have little impact on seat belt use.

Thyer and Geller (1987) investigated use of a vehicle dashboard sticker that read "Safety Belt Use Required in This Vehicle" as a stand-alone measure to increase use. This technique certainly meets the requirement for the message to be in close proximity to the behavior. Results showed that safety belt use increased by over 100 percent, resulting in approximately 70 percent belt wearing by front-seat passengers. In most cases, passengers buckled their safety belts without questioning the driver. Driver prompts were used on only 19 percent of the occasions when

the passenger buckled up. The authors conclude that this study demonstrates the remarkable effectiveness of a simple environmental intervention that could be readily integrated with other behavior change approaches to safety belt promotion.

Programs to Mandate Safety Belt Use

Legislation for Automobile Transportation. Provision of seat belts in automobiles slowly followed the example set in aviation, with early efforts being voluntary on the part of manufacturers. In the late 1960's, the Federal government began regulatory efforts to increase the installation of safety belts. By the 1970's, however, injury and fatality statistics made it abundantly clear that simple provision of safety belts was not enough. Use rate was extremely low, with most observations yielding rates well below 15 percent. Momentum began to build toward two programs: (1) those using educational efforts to encourage safety belt use and (2) those employing legislation to mandate safety belt use. Initially, greater attention was given to the first of these - use of educational activities.

Attempts to educate and encourage drivers to use safety belts clearly showed that, while such programs could produce notable increases in use, rate of use invariably began to drift downward when the education program or the incentive program ceased. In the early 1980's, greater consideration was given to legislation to mandate use of safety belts. Indeed, a number of other countries already had adopted such legislation and recorded impressive increases in usage rates (Campbell and Campbell, 1986).

The first state to mandate safety belt use was New York, which adopted an adult restraint law in 1984. At the present time, 46 states plus the District of Columbia have seat belt laws in effect. One of these 46 states passed a safety belt law which is now suspended. A vote is expected in June 1994.

When safety belt laws become effective, there is a substantial increase in belt use which may double or even triple pre-law rates. Campbell et al. (1987) list all states having belt laws and show usage levels: (1) just prior to the law, (2) the highest usage on record, and (3) the most recent usage. By their calculations, the population-weighted usage rate at that time was 48 percent. Thus, only about one-half of drivers and passengers required by law to use safety belts actually do so.

Campbell et al. (1987) present data showing a clear increase in safety belt usage as belt laws are enforced more strictly. At this time, there are three levels of enforcement, with variation in each. These are:

1. **Primary Enforcement.** Eight states have policies in which the officer may stop a motorist solely because of a belt law violation.
2. **Secondary Enforcement.** Twelve states issue a belt law violation only if the motorist has been stopped for another offense.
3. **Warning Tickets.** Five states issue warning tickets only. In some instances, however, this represents a phase toward later full enforcement.

The data of Campbell et al. show that primary enforcement, depending on how vigorously it is pursued, can produce usage rates approaching 70 percent. Secondary enforcement, on the other hand, results in rates averaging around 40 percent. For states which only issue warnings, average usage rate drops to slightly over 30 percent. Clearly, enforcement is required if safety belt laws are to be effective.

Legislation for General Aviation. Seat belts have been installed in aircraft virtually since day one. Shoulder harnesses, however, are another matter. The first shoulder harnesses in general aviation were offered by Beech Aircraft Corporation for some aircraft in 1951. Since there was no great demand for this equipment by pilots, other manufacturers were slow to follow and, indeed, Beech dropped shoulder harnesses altogether for a number of years (Aviation Consumer, 1985).

In an attempt to reduce injuries and fatalities in general aviation, the Federal Aviation Administration in 1977 amended Parts 23 and 91 of the Federal Aviation Regulations to require that shoulder harnesses be installed for each front seat in every small civil airplane manufactured after 18 July 1978. Further, the Regulations require that crewmembers keep the shoulder harness fastened during take-off and landing. This regulatory action was a significant step

forward and undoubtedly contributed to aviation safety. By the FAA's estimate at that time, approximately 1,875 lives would be saved over a 25-year period by the shoulder harness amendment (*Federal Register*, 1977).

Only recently have shoulder harnesses begun to be available for rear seat passengers in small aircraft. The General Aviation Manufacturers Association, an organization including virtually all manufacturers of such aircraft, agreed that, starting 1 January 1985, all new aircraft would include shoulder harnesses for both cockpit positions and for all other forward-facing cabin seats (*Aviation Consumer*, 1985).

In 1986, the FAA amended Part 23 of the Federal Aviation Regulations to require shoulder harnesses for all front and rear forward-facing seats in new aircraft with less than nine seats. Seats facing sideward must show equivalent protection.

The 1977 and 1986 amendments to the Federal Aviation Regulations make no mention of retrofit of shoulder harness assemblies to general aviation aircraft manufactured before 1978. Since then, all major manufacturers plus a few independent suppliers have offered retrofit kits for these earlier aircraft. However, interest in retrofit of the pre-1978 general aviation aircraft fleet has been quite low.

APPENDIX B
PERSPECTIVES OF AVIATION PERSONNEL

Part 1. General Aviation Pilots

Sex of pilots interviewed:

SEX	FL	TX	IL	CA	AK	DC Area	Total
M	24	15	49	23	11	24	146
F	2	1	1	2	0	2	8
	26	16	50	25	11	26	154

Age ranges of pilots interviewed:

AGE RANGE	FL	TX	IL	CA	AK	DC Area	Total
Under 30	9	5	11	2	1	6	34
31-40	6	6	6	7	4	5	34
41-50	4	4	9	10	3	6	36
51-60	3	1	12	3	3	8	30
61-70	3	0	4	2	0	1	10
71+	0	0	7	1	0	0	8
	25*	16	49*	25	11	26	152

*Age range unknown for two pilots (one in Florida and one in Illinois).

Type of license held by pilots interviewed:

LICENSE TYPE	FL	TX	IL	CA	AK	DC Area	TOTAL
Student	3	1	4	0	1	3	12
Private	10	7	32	20	5	12	86
Commercial	10	7	9	1	4	10	41
ATP	3	1	5	4	1	1	15
	26	16	50	25	11	26	154

Aircraft Flown Most in Past Two Years

A/C Type	FL	TX	IL	CA	AK	DC Area	Total
Single, fixed gear	18	10	39	16	5	23	111
Single, retractable gear	6	6	6	4	4	2	28
Twin	2	0	4	4	1	0	11
Unknown	0	0	1	1	1	1	4
	26	16	50	25	11	26	154

Pilot Classification

CLASSIFICATION	FL	TX	IL	CA	AK	DC Area	Total
A/C Owner	12	5	28	15	6	15	81
A/C Renter	6	5	8	4	2	4	29
Club Member	0	0	2	1	0	0	3
Flight Instructor	8	6	12	5	3	7	41
	26	16	50	25	11	26	154

Question: When shoulder harness is available, what percentage of the time do you use it?

% USED	FL	TX	IL	CA	AK	DC Area	Total
0			7	1	1	1	10
10			2	1			3
20	1			1			2
30		1	1	1			3
40							
50	2		3	1			6
60	1		1				2
70			1			1	2
80		1		3		2	6
90			2			1	3
100	22	14	29	17	10	20	112
Unknown			4			1	5
	26	16	50	25	11	26	154

Question: When you use the shoulder harness, do you use it for: (1) take-off only; (2) landing only; (3) take-off and landing; or (4) entire flight?

PORTION OF FLIGHT	FL	TX	IL	CA	AK	DC Area	Total
Take-Off		1					1
Landing						1	1
Take-Off & Landing	7	3	4	3		3	20
Entire Flight	19	12	33	20	10	21	115
Unknown			13	2	1	1	17
	26	16	50	25	11	26	154

Question: To what extent do you think use of a shoulder harness reduces your chance of injury or death in an airplane accident?

RESPONSE	FL	TX	IL	CA	AK	DC Area	Total
Totally	3	3	5	5	5	7	28
A Lot	15	11	24	10	6	14	80
Some	6		11	10		3	30
Not Much	1	2				1	8
None			3			1	4
Don't Know	1		3				4
	26	16	50	25	11	26	154

Question: What problems, if any, have you identified with shoulder harness use (i.e. discomfort, etc.)?

FLORIDA

	Number
Restrictive	8
Discomfort	6
Poor Engineering	7
No Problems ("None")	5
	26

TEXAS

Restrictive	6
Discomfort	4
Poor Engineering	4
No Problems ("None")	2
	16

ILLINOIS

Restrictive	11
Discomfort	10
Poor Engineering	13
Too Costly	6
No Problems ("None")	7
No Comment	3
	50

CALIFORNIA

Restrictive	8
Discomfort	4
Poor Engineering	4
Too Costly/Unsure of Benefit	3
No Problems ("None")	3
No Comment	3
	25

ALASKA

	Number
Restrictive	3
Discomfort	2
No Problems ("None")	6
	11

WASHINGTON, DC AREA

Restrictive	8
Discomfort	8
Poor Engineering	4
No Problems ("None")	6
	26

SUMMARY

Restrictive	44
Discomfort	34
Poor Engineering	32
Cost	9
No Problems ("None")	29
No Comment	6
	154

Question: Have you ever had a shoulder harness installed (retrofit) in an aircraft?

RESPONSE	FL	TX	IL	CA	AK	DC Area	Total
No	25	14	43	24	8	22	136
Yes	1	2	6	1	3	3	16
No Answer			1			1	2
	26	16	50	25	11	26	154

If yes, what was the cost?

COST ($)	FL	TX	IL	CA	AK	DC Area	Total
Min	2400	4000	5*		250	50	5*
Mean	2400	4000	201.67		525	109.33	838.30
Max	2400	4000	500		800	200	4000

* $5 "minimum" was from interviewee who bought shoulder harness from "junkyard" dealer and installed it himself.

Question: Assuming limited resources and comparable cost, would you be more likely to purchase:

	FL	TX	IL	CA	AK	DC	Total
Shoulder Harness Retrofit Kit	4	6	19	7	7	7	50
Electronics Equipment	8	5	11	10	2	8	44
Flight Instruments	10	2	5	1		9	27
Engine/Fuel Management Equipment	3	1		1		1	6
No Answer	1	2	15	6	2	1	27
							154

General Aviation Pilots' Comments Regarding Shoulder Harnesses in Aircraft

Number

1. **Poorly engineered** ---------- 26

"Current harnesses have cheap design/poorly engineered."
"Lap belt should be separate from shoulder harness."
"Compared to automobiles, airplane harnesses are outdated."
"Installed in older Cessna; bolt provided was too small."
"Need inertia reels instead of type in aircraft now . . . make them more functional."

2. **Too costly** ---------- 15

"Retrofit requirements impossibly expensive."
"Need help from FAA in obtaining on-time approval for 337. Very costly."
"Purchase and repair too expensive."
"Too expensive - You should be allowed to design your own as long as mounting is approved."

3. **Too restrictive/inconvenient/uncomfortable** ------- 7

"Too restrictive; should be designed like automobile harnesses."
"If I can reach it, I use it; if I can't, I don't."
"Gets in the way more than it helps to restrain."

4. **Value/benefit not considered "proven"** ---------- 16

"So many other things more important than shoulder harness."
"Avionics keep you alive. Shoulder harness is "last shot.'"
"Don't think they are of much value except possibly during take-off and landing."
"May be needed after everything else fails."

5. **Should be mandated/required** ---------- 4

"FAR should be issued to have them installed in all aircraft."
"Should be basic equipment."
"Should be mandatory."
"Should be required."

6. **Valuable/"Worth It"** ---------- 27

"Been in three head-on auto accidents; firm believer in belts and harnesses."
"If harness is there, you should use it. You can't legislate common sense."

Part 2. Maintenance Managers

1. To what extent would shoulder harness use reduce injury or death in an accident?

RESPONSE	FL	TX	IL	CA	AK	DC Area	Total
Totally	--	--	1	--	2	--	3
A Lot	1	2	3	1	6	2	15
Some	--	1	--	1	--	1	3
Not Much	--	--	--	--	--	1	1
None	--	--	--	--	--	--	--
	1	3	4	2	8	4	22

2. How many shoulder harness retrofits done in past five years?

STATE	AIRPORT	NUMBER
Florida	Willow	0
Texas	Grand Prairie	0
	Addison	3
Illinois	DPA	2
	Clow	10
	3HA	0
California	Brackett	0
	El Monte	0
Alaska	Anchorage	12
	Merrill Field	195
DC Area	Bay Bridge	2
	College Park	2
	Leesburg	5
		231

3. Major problems encountered with shoulder harnesses

Number

Poor engineering ---------- 12

"Difficulty in Debonair; had to build hard points."

"Retract reel failures - shoulder harnesses falling out of door and being frayed. . ."

"Shoulder harness hangs out of or gets caught in door."

"Some Senecas (PA 34-200) came with inertial reel type harnesses that were defective - replacements were also defective."

"Need to 'beef up' airframe for attachment; upholstery and cosmetic work also required."

"If aircraft is not designed for retrofit, mods are required (remove existing structure to accommodate); Cessna is particularly difficult."

"170-type installation needs extra beefing."

Costly ---------- 1

"Cost and engineering."

No Problems ---------- 5

"No problem - all STC instruction."

"No damage seen in annuals, etc. No problem."

"No problem with kit."

4. Comments

Number

Costly ---------- 4

"Good idea. Prefer inertia reel, but too expensive."

"Pilots spend for radios."

"Too expensive; lousy systems."

"Valuable to have but too expensive."

Valuable ---------- 7

"Bodies recovered in crash(es) rarely had shoulder harnesses on."

"Invaluable. Would prevent serious bodily harm."

"Valuable accessory, especially during turbulence."

Poor Engineering ---------- 3

"Manufacturer's kit didn't fit . . ."

"Retrofit kits need improvement with attachment methods, especially Cessna."

"No uniformity — some are inertia reel, others are 'straps.'"

APPENDIX C

AVAILABILITY AND COST OF SHOULDER HARNESS RETROFIT KITS FOR PRE-1978 AIRCRAFT

Manufacturer: Beech Aircraft Corporation
Wichita, Kansas

Aircraft:

Beechcraft A23-19, 19A, M19A and B19, serials MB-1 through MB-520; B19 Sport 150, serials MB-521 through MB-905; 23, A23, A23A, B23 and C23, serials M-1 through M-1361; C23 Sundowner 180, serials M-1362 through M-1747; A23-24, serials MA-1 through MA-368; A24R, serials MC-2 through MC-95.

Cost/Installation:

Estimated man-hours to install shoulder harness kits on pilot and copilot seats on 19, 23 and 24 series airplanes = 17 hours; Debonair/Bonanza, Baron, Turbo-Baron or Travel Air airplanes = 24 hours; Duke series airplanes = 24 hours; Queen Air, King Air, Airliner and Super King Air series airplanes = 30 hours. (All estimates are for installation of shoulder harness kits on pilot and co-pilot seats).

Service Bulletin No. 2031 states that ". . . The kits may be ordered through BEECHCRAFT Aero or Aviation Centers or International Distributors and Dealers. The value of the kits will be advised on order."

Telephone: 512/896-6000

Manufacturer: Cessna Aircraft Company (a General Dynamics Company)
Wichita, Kansas

Aircraft:

Cessna Model Series 120, 140, 150, 170, 172, 175, 177, 180, 182, 185, 190, 195, 205, 206, 207, and 210.

Cost/Installation:

Estimated man-hours per seatbelt/shoulder harness is between 0.5 to 1.5. Installation time will vary depending on airlane model, serial number, seat location and interior configuration. Cost per kit ranges from $67 to $141, depending on aircraft model. All kits are metal connection type seat belt shoulder harness assemblies.

Single Engine Service Bulletin (SEB) 92-28 dated September 4, 1992, *Cessna Safety Enhancement Program,* provides a listing of aircraft model series, year, and serial numbers for which shoulder harness kits are available. It also provides a complete listing of part numbers and price so the reader can easily determine the appropriate part number and quantities required for retrofit.

Telephone: 316/941-6000.

Comments:

SEB 92-28 states that "The special below-cost price shown will remain in effect thru December 31, 1993. Thereafter, prices may increase to reflect cost increases to Cessna, but will remain specially priced to provide no profit to Cessna."

Manufacturer: B.A.S., Inc.
Eatonville, Washington 98328

Aircraft:

Cessna 170 through Cessna 210-F, Cardinals, and 190/195 model aircraft.

Cost/Installation:

Prices (per pair) range from $700 to $760 depending on aircraft model, headliner (i.e., cloth or plastic/foam), and color.

Manufacturer estimates installation time at about two hours for models 170 through 185; about three hours for a 205 through 210-F. Recommend adding an extra hour for a first time installation. Hard plastic headliners require an extra hour for trimming and fitting the dress cuff.
All kits shipped as a complete inertia reel shoulder harness restraint system, including lap belts and hardware and certification needed for installation. Money back guarantee if kit is returned unused/undamaged within 30 days of sale.
Comments:
Manufacturer estimates that, at this time, there are approximately 1,000 sets of these harnesses installed in 500 Cessna aircraft.
Telephone: 206/832-6566.

Manufacturer: Mooney Aircraft Corporation
Kerrville, Texas
Aircraft:
Mooney M-20A through 20J
Cost/Installation:
$370 per kit. Installation time estimated at approximately two hours for two front seats.
Comments:
Retrofit kits are in stock. Installation judged "simple." Service Letters and literature sent to dealers re retrofit kit availability, cost, etc.
Telephone: 512/896-6000

Manufacturer: Piper Aircraft Corporation
Vero Beach, Florida
Aircraft:
Piper Aircraft Corporation released Service Bulletin 896 (November 28, 1988) and Service Letter 953 (July 28, 1983) pertaining to shoulder harness installation.
Service Bulletin 896 lists 29 "Models Affected." All models listed are in the PA-28, 32, 34, 44, or 46 series. This Bulletin supersedes Service Letter 953 for the affected models outlined.
Service Letter 953 lists "Models Affected" as "All Piper Models."
Cost/Installation:
Service Letter 953: "Material requirements, installation complexity, and price will vary depending upon the series, model, serial number, and date of manufacture of the affected airplane."
Service Bulletin 896 does not address cost/installation.
Telephone: 407/567-4361

Manufacturer: Kosola and Associates, Inc.
Aeronautical Engineers
Albany, Georgia 31706
Aircraft:
Piper PA-24, PA-30, J-3, and PA-11 Series
Cost/Installation:
Individual strap and inertia reel models range in price from $240.00 to $400.00 depending on aircraft type. Front and rear seat shoulder harness retrofit kits available for most models.
All kits include: (1) reinforcing structure hardware; (2) shoulder strap; (3) inertia reel (where applicable); (4) lap belt; (5) complete installation instructions; and (6) FAA STC.

APPENDIX D

TARGETED INTERVENTION PROGRAM DEVELOPMENT

DESCRIPTION OF FACTORS INFLUENCING BEHAVIOR

Predisposing Factors

a. **Knowledge of Benefits** - All members of the aviation community should be informed concerning safety benefits derived through use of shoulder harness restraint systems. However, this factor should not be made the primary focus of an intervention program for all target groups for two reasons. First, results of the field study indicate that most aircraft owners/pilots/fixed-base operators are well informed at this time concerning these safety benefits. Second, research results from studies of highway safety indicate knowledge of safety benefits in and of itself does not result in an increased use of automobile restraint systems.

b. **Motivation** - The manipulation of an individual's motivational state, i.e. development of a positive attitude toward flight safety, does not offer great promise for increasing shoulder harness use. Experience in programs to increase automobile seat belt use indicates that attempts to piggyback on a general motivation/attitude toward safety are not successful. In addition, considering the general resistance of attitudes to change, it is unlikely that any significant change in existing attitudes toward flight safety could be effected without a much larger intervention program than that envisioned.

c. **Values** - The values of a pilot, as the term is used here, refers to a general belief or attitude that the pilot is directly responsible for his/her own safety and for that of the passengers. While such values obviously should be encouraged, they do not represent potential variables for an intervention program. Health-related values are often found to be in conflict with health behaviors. In addition, health practitioners have found that producing lasting change in a health value system can be quite difficult.

d. **Judgment** - Good judgment on the part of a pilot requires that the shoulder harness be used at least during the takeoff and landing phases of flight. The Federal Aviation Administration recently incorporated "Judgment Training" as part of its Back to Basics training seminars. While these seminars focus on judgment issues concerning pre-flight and in-flight decisions that directly impact flight safety, attention easily could also be given to shoulder harness use. While the extent to which this might improve use is debatable, the investment is nominal.

e. **Federal Mandate** - This factor pertains only to retrofit of aircraft. A Federal Aviation Regulation now requires aircraft crewmembers to fasten the shoulder harness during takeoffs and landings, unless so doing impedes required flight activities. A Federal mandate for retrofit of pre-1978 aircraft, while feasible, would be difficult to achieve. The process of developing new Federal Aviation Regulations is cumbersome and time consuming. Previous movement toward such a mandate has found little evidence of support within the Department of Transportation.

f. **Knowledge of Shoulder Harness Operation** - The use of a shoulder harness is quite simple, involving pulling a strap and hooking a metal catch. For persons who have used automobile seatbelt/shoulder harness systems, use of an aircraft system involves no learning at all. For this reason, significant effort directed toward teaching shoulder harness use appears unjustified.

g. **Adverse Experience** - Any attempt to reverse adverse experience in an intervention procedure implies a demonstration to pilots that shoulder harnesses are not restrictive and are not inconvenient. Such a demonstration would be costly and might not correspond with day-to-day experiences of the pilot.

h. **Greater Perceived Need for Other Flight Safety Equipment** - Results of the field observations of pilots indicate that less than 25 percent give preference to shoulder harness retrofit when considering purchase of new aircraft safety equipment. Electronics equipment and flight instruments which might directly improve safety of flight are considered more desirable

even though such equipment generally is much more expensive. "Perceived need" will be of value as a variable in an intervention program only if information is disseminated widely concerning the relatively low cost of aircraft retrofit. This information then should be supplemented by a discussion of the real safety benefits to be derived through shoulder harness use.

Reinforcing Factors

a. **Services of Flight Instructors/Examiners** - Use of the flight instructor/examiner community was judged to be both important and easy to change or implement. Flight instructors and examiners hold positions of authority. During periods of instruction or during Biennial Flight Reviews, these individuals can insure that trainees/ pilots wear their shoulder harnesses. They also can deliver a brief message concerning safety benefits of such use.

b. **Perception of Other Pilots Wearing a Shoulder Harness** - While seeing another pilot in an aircraft hooking the shoulder harness might motivate an individual to hook his own harness, any systematic program based on this factor would be difficult to implement. A safety message to pilots might note that their use would influence other pilots beneficially but the real thrust of the safety message should be that shoulder harness use might save one's own life.

c. **Signs/Posters/Placards** - Fixed-base operators should be encouraged to develop and use signs and posters which advise pilots to use shoulder harnesses, particularly since this is an easy activity to implement. On the other hand, since the viewing of the sign by a pilot and the desired response will be separated in time, there is no real expectation that signs and posters will be particularly effective as a primary educational mechanism. It has been demonstrated that messages presented in direct temporal contiguity with the desired behavioral response are more effective than messages aimed at a response at some later time.

d. **Enforcement of FAA Shoulder Harness Regulations** - Since 1978, each crewmember of a U.S. civil aircraft has been required to keep his shoulder harness fastened during takeoff and landing, provided the shoulder harness does not impede performance of required duties. Obviously, strict enforcement by the Federal Aviation Administration would improve compliance with this Regulation. However, an enforcement program would be most difficult to develop, and was so judged by the Expert Panel. The difficulty and expense of strict enforcement, which would require significant utilization of FAA personnel, appear to rule out enforcement as a feature in any intervention procedure.

Enabling Factors

a. **Availability of Shoulder Harness in Aircraft** - The availability of shoulder harnesses in an aircraft is an obvious requirement if shoulder harnesses are to be used. This issue is addressed in the behavior concerning retrofit of those aircraft not currently equipped with shoulder harness restraint systems.

b. **Comfort** - Comfort is a legitimate enabling factor but there seems little one can do about it inasmuch as the design of shoulder harness restraint systems is, for the most part, fixed at this time. It is possible, of course, that manufacturers of shoulder harness retrofit kits could be made aware of specific "comfort" issues existing with current designs.

c. **Ease of Use** - Ease of use is an important enabling factor but is one which will be difficult to address since the design of shoulder harnesses and retrofit kits has been completed. However, while the shoulder harness is more difficult to use in some aircraft than in others, in no cases is it so difficult to use that this variable becomes a major problem. With the most difficult systems, "ease of use" appears to be only a momentary inconvenience.

Target Group I: Aircraft Owners
Behavior 1: Use Shoulder Harness

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedure

The intervention procedure recommended for this behavior should consist of the following:

1. **Services of Flight Instructors/Examiners.** Flight instructors and flight examiners should ensure that the shoulder harness restraint system is hooked during periods of flight instruction and during the Biennial Flight Review. During the review, instructors should advise pilots that failure to hook the shoulder harness is illegal and constitutes poor safety behavior and could contribute to an unsatisfactory check ride. Flight instructors should have educational information concerning safety benefits of shoulder harness use, which should, in turn, be passed on to pilot trainees.

Target Group I: Aircraft Owners
Behavior 2: Encourage Passenger Use of Shoulder Harness

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High Low
2.2	1.5	b. Perception of other pilots wearing shoulder harness	
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedure

The intervention procedure recommended for this behavior should consist of the following:

1. **Values.** Every pilot in command of an aircraft should be well informed that he is fully responsible for the safety of each passenger in the aircraft. Any discussion of the responsibilities of "pilot in command" should make it quite clear that this extends beyond simply a successful takeoff and a successful landing. It is the **pilot's responsibility** to see that each passenger uses the shoulder harness if such is available.

2. **Perception of Other Pilots Wearing a Shoulder Harness.** The pilot in command of an aircraft is in a position of authority. Passengers will be more likely to use their shoulder harness if they simply observe the pilot fastening his. Literature to pilots should emphasize that their safety behavior sets the stage for the safety behavior of aircraft passengers.

3. **Availability of Shoulder Harness in Aircraft.** A case can be made, in literature distributed to pilots, that they have a moral and possibly a legal responsibility to retrofit their aircraft as a means of insuring maximum safety for passengers, if not for themselves. A pilot does not have the same freedom of choice regarding passenger safety as he does regarding his own safety. Emphasizing the pilot's responsibility for passenger safety could increase the rate of aircraft retrofit.

Target Group II: Aircraft/Equipment Manufacturers
Behavior 1: Encourage Retrofit of Aircraft Not Equipped

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedure

The intervention procedure recommended for this behavior should consist of the following:

1. **Availability of Shoulder Harnesses in Aircraft.** All records describing manufacture of aircraft prior to 1978 should be reviewed and, using these data, estimate the number of aircraft not equipped with shoulder harnesses at this time. Using these data, annual goals for retrofit could be established and monitored in cooperation with aircraft manufacturers. The responsibility of the aircraft/equipment manufacturer would be, if he has not already done so, to develop materials describing the ready availability of retrofit kits for specific aircraft (both front and rear seats), the cost for each kit, and the estimated installation hours required. This information should reach every owner/pilot operating a pre-1978 aircraft. Information regarding rear seat installations might also be distributed to all aircraft owners, regardless of the age of their aircraft.

Target Group III: Student Pilots
Behavior 1: Use Shoulder Harness

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedure

The intervention procedure recommended for this behavior should consist of the following:

1. **Knowledge of Benefits.** Student pilots may not be well informed concerning safety benefits derived through the use of shoulder harness restraint systems. It is most important that this information be imparted to them. The latest safety statistics relating to shoulder harnesses should be available to instructor pilots, flight inspectors, and fixed-base operators. This might then be transmitted to student pilots either by small safety brochures or by direct communication. While this safety information in itself would not insure full use of shoulder harnesses, it provides a sound basis for a larger intervention program to be used with student pilots.

2. **Services of Flight Instructors/Examiners.** Flight instructors and flight examiners have a particular responsibility with student pilots to ensure that the shoulder harness restraint system is hooked during all periods of flight instruction. This can be reinforced later during the biennial flight review and should be a regular part of instruction.

3. **Perception of Other Pilots Wearing a Shoulder Harness.** Instructor pilots are in a unique position of authority with student pilots. From the day of the first flight, the instructor pilot should provide an example by letting the student pilot observe that the shoulder harness is worn at all appropriate times.

Target Group IV: Experienced Pilots
Behavior 1: Use Shoulder Harness

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedure

The intervention procedure recommended for this behavior should consist of the following:

1. **Services of Flight Instructors/Examiners.** Flight instructors and flight examiners should ensure that the shoulder harness restraint system is hooked during periods of flight instruction and during the biennial flight review. During the review, instructors should advise pilots that failure to hook the shoulder harness constitutes poor safety behavior and could contribute to an unsatisfactory check ride. Flight instructors should have educational information concerning safety benefits of shoulder harness use, which should, in turn, be passed on to pilot trainees.

Target Group IV: Experienced Pilots
Behavior 2: Encourage Shoulder Harness Use by Other Pilots/Passengers

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedure

The intervention procedure recommended for this behavior should consist of the following:

1. **Values.** Every pilot in command of an aircraft should be reminded that he is fully responsible for the safety of each passenger in the aircraft. Any discussion of the responsibilities of "pilot in command" should make it quite clear that this extends beyond simply a successful takeoff and a successful landing. It is the **pilot's responsibility** to see that each passenger uses the shoulder harness if such is available.

2. **Perception of Other Pilots Wearing a Shoulder Harness.** The pilot in command of an aircraft is in a position of authority. Passengers will be more likely to use their shoulder harness if they simply observe the pilot fastening his. Literature to pilots should emphasize that their safety behavior sets the stage for the safety behavior of aircraft passengers.

Target Group V: Rental/Charter Operations; Fixed-Base Operators
Behavior 1: Encourage/Require Use of Shoulder Harness Use by all Pilots

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedure

The intervention procedure recommended for this behavior should consist of the following:

1. **Signs/Posters/Placards.** The owner of aircraft used in rental or charter operations, typically the fixed-base operator, should see that the checklist provided with each aircraft lists "Fasten seatbelt and shoulder harness" as a pre-takeoff procedure. The rental/charter agreement should require that pilots follow all checklist procedures.

2. **Enforcement of FAA Shoulder Harness Regulation.** Materials supplied by rental or charter operators could serve as a focal point for insuring that pilots know of the FAA shoulder harness regulation and that compliance is mandatory. The fixed-base operator, operating on a voluntary basis of course, nevertheless is the key element to promote compliance with the FAA regulation.

Target Group VI: Aviation Insurance Companies
Behavior 1: Encourage Shoulder Harness Use by Other Pilots/Passengers

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of should. harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors/examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedures

The intervention procedure recommended for this behavior should consist of the following:

1. **Knowledge of Benefits.** Aviation insurance companies have a vested interest in methods to enhance aviation safety and are a logical source of safety data concerning benefits derived through use of shoulder harness restraint systems. Such information, possibly included as a small message with insurance notices, could serve to maintain an alertness within the aviation community concerning shoulder harness use.

2. **Federal Mandate.** Materials supplied to each pilot by aviation insurance companies could note the Federal regulation requiring seatbelt and shoulder harness use during takeoff and landing. While decisions regarding coverage in the event a shoulder harness is not worn remain the prerogative of the insurance company, a reminder from the company concerning the Federal mandate should increase compliance.

Target Group VI: Aviation Insurance Companies
Behavior 2: Encourage Retrofit of Older Aircraft

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedures

The intervention procedure recommended for this behavior should consist of the following:

1. **Knowledge of Benefits.** Aviation insurance companies can play a useful role in disseminating information concerning the benefits to be achieved through use of shoulder harness restraint systems. Such information at least sets the stage for a consideration by pilots of retrofitting older aircraft not equipped at this time. This message would be even more meaningful if it were supplemented by a discussion of the availability of retrofit kits for the particular aircraft flown by the pilot receiving the message. This should include the address of the supplier, the cost of the kit, and the approximate installation hours required. The pilot then would know the exact effort and cost required on his part to achieve the safety benefits described initially.

Target Group VII: Flight Examiners/Instructors
Behavior 1: Encourage/Require Shoulder Harness Use by all Pilots

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedures

The intervention procedure recommended for this behavior should consist of the following:

1. **Knowledge of Benefits.** Flight examiners and instructors should regularly receive updated information and statistics concerning safety benefits derived through use of shoulder harness restraint systems. They then can draw on this information to justify the shoulder harness use they require of all pilots under instruction. The flight examiner/ instructor position is an excellent one to use to transmit information to the general pilot community.

2. **Perception of Other Pilots Wearing a Shoulder Harness.** Flight examiners and instructors are in strong positions of authority. Use of the shoulder harness by pilots will be more an automatic activity if they see the instructor pilot fastening his as a first activity upon being seated in the aircraft.

3. **Federal Mandate.** Flight examiners and instructors are one of the best sources of information concerning regulations regarding the aviation environment. Considerable time is spent in discussing Federal Aviation Regulations and procedures for complying. Therefore, flight examiners and instructors represent a logical medium for passing specific information to pilots concerning the shoulder harness regulation.

Target Group VIII: Aviation Magazines/Periodicals
Behavior 1: Encourage Shoulder Harness Use by all Pilots and Passengers

Importance	Ease of Change	Predisposing Factors	Priority
2.6	2.4	a. Knowledge of benefits	Low
2.6	1.4	b. Motivation	NR
2.2	1.8	c. Values	NR
3.0	1.0	d. Judgment	Low
2.2	1.3	e. Federal Mandate	Low
2.2	3.0	f. Knowledge of shoulder harness operation	Low
2.8	1.8	g. Adverse experience	NR
2.6	1.4	h. Greater perceived need for other equipment	NA
		Reinforcing Factors	
2.8	2.8	a. Service of flight instructors /examiners	High
2.2	1.5	b. Perception of other pilots wearing shoulder harness	Low
2.2	2.5	c. Signs/posters/ placards	Low
2.4	1.0	d. Enforcement of FAA shoulder harness regulation	NR
		Enabling Factors	
3.0	1.2	a. Availability of shoulder harness in aircraft	Low
2.6	1.6	b. Comfort	Low
2.4	1.6	c. Ease of use	Low

Recommended Intervention Procedures

The intervention procedure recommended for this behavior should consist of the following:

1. **Knowledge of Benefits.** Aviation magazines and periodicals represent an excellent means for disseminating summary information developed by the National Transportation Safety Board and the Federal Aviation Administration concerning safety benefits through use of shoulder harness restraint systems. Review articles could place these safety benefits in a perspective comparing them on a cost/benefits basis with other items of safety equipment. This would illustrate the relatively low cost for increasing the overall safety of flight operations.

In addition to general safety information, a review article in an aviation magazine might provide an interview with someone obviously saved from significant injury from use of a shoulder harness during an accident such as a runway overshoot. This type of anecdotal information would be a useful adjunct to the customary array of safety statistics.

APPENDIX E

POTENTIAL BENEFITS OF A NATIONAL SHOULDER HARNESS INTERVENTION PROGRAM

The Federal Aviation Administration (FAA) estimated, in 1977, that the new shoulder harness amendments to the Federal Aviation Regulations would save approximately 1,875 lives over a 25-year period (*Federal Register*, 1977). Undoubtedly, many lives have been saved. In 1980, some 1,239 persons died in general aviation accidents. By 1989, the number of general aviation fatalities had dropped to 763, a significant improvement. Was any part of this decrease in fatalities attributable to increased shoulder harness use? No one knows. We do know, however, that the improvement in the number of fatalities parallels the increased use of shoulder harnesses which, by our best estimates, increased from a rate of about 40 percent in 1984/85 to over 70 percent in 1991.

Were a shoulder harness intervention program, as described here, to be introduced, would this program contribute significantly to general aviation safety? Can we make any predictions as to the number of lives saved and injuries prevented? Fortunately, information exists which makes such predictions possible.

A prediction concerning shoulder harness benefits can be made through the following analysis:

1. The number of fatalities in 1989 was 763 with a general aviation accident rate of 7.25 per 100,000 aircraft hours.

2. The general aviation accident rate in 1995 is estimated at 4.5 accidents per 100,000 aircraft hours. This is the goal established by the AOPA Air Safety Foundation (1991) and, hopefully, it will be met. This 38 percent reduction in the current accident rate next can be applied to total fatalities, assuming fatalities decrease in direct relation to the decrease in accidents. This gives an estimate of 473 fatalities in 1995.

3. We assume that, without a shoulder harness intervention program, the current use rate of about 70 percent will remain.

4. The estimate of 1995 fatalities includes both survivable and non-survivable accidents. The 1985 NTSB study concludes that, under these conditions, use of shoulder harnesses reduces fatalities by about 20 percent. Therefore, those not using a shoulder harness contribute disproportionately to fatalities and the ratio of shoulder harness fatalities (70 percent) to non-shoulder harness fatalities (30 percent) must be adjusted accordingly.

5. The following calculations can be made:
   a. The 70/30 ratio for shoulder harness use, when applied to the 473 fatalities in 1991, gives an initial estimate of 142 fatalities for those not wearing a shoulder harness.
   b. The above number is adjusted to account for the imbalance described in step 4.
      X = Adjusted non-shoulder harness fatalities
      X - .2X = 142
      X = 178
      Y = Adjusted shoulder harness fatalities
      X + Y = 473
      Y = 295

6. A successful national shoulder harness intervention program should be able to raise the use rate, reflecting both increased use and additional retrofit installations, from the present 70 percent to 80 percent. Then, using an 80/20 ratio, the benefit of the intervention program can be calculated as follows:
   a. The contribution of shoulder harness users increases from 70 to 80 percent. The new contribution (Y_2) then becomes:
      $Y_1 = 295$
      $\frac{8}{7} Y_1 = Y_2$
      $Y_2 = 337$ (fatalities in crewmembers using shoulder harnesses)
   b. $X_1 = 178$
      $\frac{2}{3} X_1 = X_2$
      $X_2 = 119$ (fatalities in crewmembers not using shoulder harnesses)
   c. 337 (shoulder harness fatalities)
      +119 (non-shoulder harness fatalities)
      456 (total fatalities)
   d. 473 (fatals without intervention)
      - 456 (fatals with intervention)
      17 (total reduction in fatalities)

7. The above calculations indicate the national shoulder harness intervention program would result in 17 fewer fatalities in 1995. Similarly, many serious and moderate injuries also could be avoided.

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