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A SURVEY OF RAILROAD INDUSTRY PERCEPTIONS REGARDING NEEDED LOCOMOTIVE CAB DESIGN IMPROVEMENTS

by

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16. Abstract

This survey was initiated by the Federal Railroad Adminitration (FRA) as part of objective to improve locomotive cab safety. The need for and definition of the survey was generated by the Locomotive Control Compartment Committee (LCCC) in its advisory role to the FRA, and executed by R & R Research, Inc. through a task order subcontractor with Battelle. The objective was to design, execute and analyze a survey of perceptions of the railroad industry to future design improvements in locomotive cabs. With the help of the Association of American Railroads (AAR) and union leaders on the LCCC, 65 rail management and union participants were personally interviewed using a structured interview guide. The partipants represented eight railroads, the Brotherhood of Locomotive Engineers and United Transportation Union. The range of participant positions included vice president of operations, chief mechanical officer, engineering and operations staff, road foreman of engines, union leadership and practicing locomotive engineers.

The interviews, which averaged about 60 minutes, sought both interest in areas of future locomotive cab designs, and specific ideas for improvement. In addition to open-ended questions on the need for design improvements, participants were asked to rate the priority for design improvements embracing four general areas: a) crashworthiness, b) crew comfort, c) train handling aids, and d) cab layout and crew workstation design.

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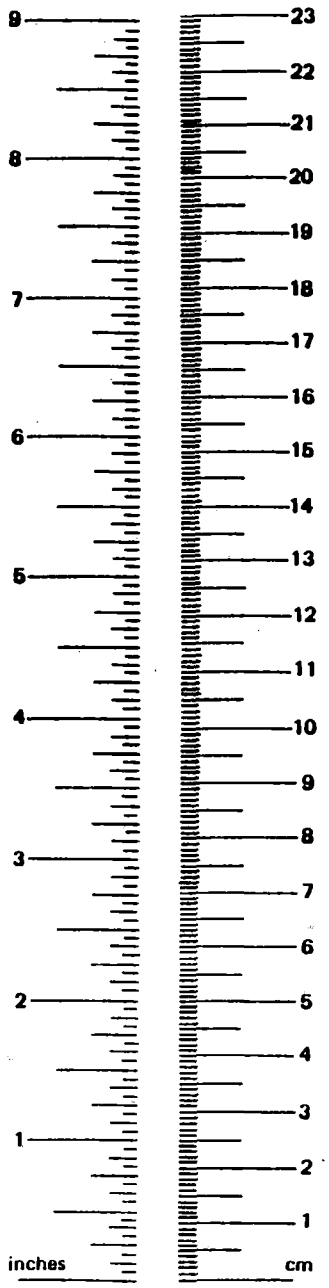
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

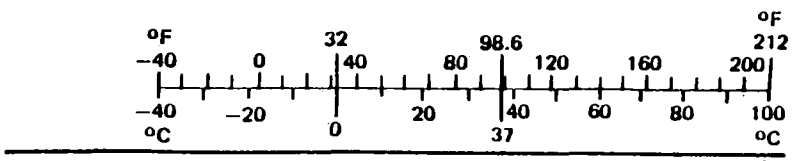
Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286, Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

This survey was initiated by the Federal Railroad Administration (FRA) as part of the objective to improve locomotive cab safety. The need for and the definition of the survey was generated by the Locomotive Control Compartment Committee (LCCC) in its advisory role to the FRA. The survey was executed through a task order to Battelle Memorial Institute, with R & R Research, Inc. as the subcontractor. The objective was to design, execute and analyze a survey of perceptions of the railroad industry to future design improvements in locomotive cabs. With the help of the Association of American Railroads (AAR), and union leaders on the LCCC, 65 rail management and union participants were personally interviewed using a structured interview guide. The participants represented eight railroads and the Brotherhood of Locomotive Engineers and United Transportation Union. The range of participant positions included vice president of operations, chief mechanical officer, engineering and operations staff, road foreman of engines, union leadership and practicing locomotive engineers.

The interviews, which averaged about 60 minutes, sought both interest in areas of future locomotive designs, and specific ideas for improvement. In addition to open-ended questions on the need for design improvements, participants were asked to rate the priority for design improvements embracing four general areas: a) crashworthiness, e.g., strengthen collision posts, b) crew comfort, e.g., improved seat design, c) train handling aids, e.g., Advanced Train Control System (ATCS), and d) cab layout and crew workstation design, e.g., control stand redesign and enhanced outside visibility. The respondents were articulate, knowledgeable and did not need prompting for ideas for locomotive cab improvements.

Some of the highlights include:

* Over the four design areas, the 65 participants generated 708 responses covering 96 different design improvements.

* Both union and management respondents offered more design improvements in the areas of crew comfort, cab layout and workstation design than the areas of crashworthiness and train handling.

* In the area of crashworthiness, the most frequently mentioned improvements were cab interior delethalization and doors for egress.

* In the area of crew comfort, noise reduction and better seats were most mentioned.

* In the area of train handling aids, ATCS was most frequently mentioned.

* In the area of cab layout and crew workstation design, console layout of controls and enhanced visibility to the outside were most mentioned.

* When 23 selected design improvements were given priority ratings by the participants, console control stands, ATCS, cab layout, seat design, ease of systems maintenance, noise reduction and climate control were given the highest rating.

* For the 23 selected design improvements, management and labor showed close agreement on priority ratings for 13 improvements and no agreement on only three design improvements (roll bars, stronger collision posts and better event recorders).

* All of the participants responded positively on the potential of new technology to improve future cab design with ATCS being mentioned with the highest frequency as an example of how new technology could be utilized.

* Over half of the respondents were familiar with ergonomic principles and 15% cited its application to seat design.

* When forced to select only one design improvement, the 65 respondents elected 24 different improvements with about the same emphasis on crew comfort, train handling and workstation design suggestions.

In general, the industry is positive towards future design improvements and, in fact, significant change in current locomotive purchases reflect this. New units have anticlimbers (six out of eight railroads), console design and air conditioning.

While there is concurrence on the need for specific design changes, differences exist between labor and management on how these changes should be implemented. Rail management proposed use of AAR standards and company policy, while labor participants opted for federal regulations.

ACKNOWLEDGEMENTS

This report represents the effort of many individuals. The Locomotive Control Compartment Committee provided the framework for the genesis of the survey. Cliff Gannett of the Federal Railroad Administration initiated the project and provided helpful comments in the design of the survey instrument.

Special thanks are due Tom Hackney, a consultant to the Association of American Railroads, for establishing contact with the eight major railroads, accompanying the interviewers on many of the interviews and helping to design the survey. Dr. Rich Klimoski, our survey consultant, provided the expertise to help build a professional interview guide and also helped in data interpretation.

John Riddle not only brought his 40 years of railroad experience to the project, but also was one of the three interviewers for the study.

Scott Freeman and Toni Strand exercised computer data entry, performed the analyses and assisted in report preparation. Norma Wallace patiently typed this report.

T. H. Rockwell
S. M. Kiger

I. INTRODUCTION AND SURVEY OBJECTIVES

A. Introduction

In the years 1981-85, a total of 540 rear-end and head-on collisions occurred in the U.S. railroad system, incurring 36 deaths, 815 injuries and damages of 67 million dollars. In addition, there were 1600 injuries and 23 deaths of crew members from derailments and grade crossing accidents during this same period. Statistics of this kind have led regulators, suppliers, rail management and unions to examine the role of locomotive design in both preventing accidents and minimizing the injury results given a crash.

Proposals have been made to, 1) increase crew comfort and thus minimize fatigue as a cause of accidents, 2) provide train handling aids to create alert crews and provide information to avoid accidents, and 3) improve the crashworthiness of locomotives in the event of crashes. In the latter case, the National Space Technology Laboratories examined collision data over a 19-year period and issued crashworthiness recommendations which included:

1. Coupler alignment
2. Top shelf couplers
3. Emergency escape routes
4. Delethalization of cab interior surfaces
5. Strengthened collision posts
6. Thicker and wider short hoods

The rail industry is already beginning to evolve designs which address some of these safety issues. Anticlimbers are a regular feature on new locomotives for six major railroads. Some railroads specify stronger collision posts; two provide air conditioning systems. Advanced Train Control Systems and Advanced Railroad Electronic Systems represent technology to provide the engineer with information to avoid accidents and to control train speed in the event the engineer is not alert.

The introduction of the Canadian National locomotive with its console-type cab has increased cab floor space, improved forward visibility and provided a thicker, wider short hood for impact protection.

With many changes now in place, which offer opportunities for safer operation and at the same time raise some concerns about crew workloads, federal authorities see the need for standardization of appropriate designs which could insure increased safety in all locomotive cabs.

Pursuant to achieving standardization, it is necessary to estimate the level of interest in the rail industry towards changes in locomotive design, and to find those specific design changes which are perceived as needed in the industry. This, then, was the genesis for this survey.

Safety issues are inherent either directly or indirectly in cab design. Locomotive structures directly affect crashworthiness and the safety of cab occupants. Indirectly, cab environment, e.g., climate control, noise reduction, good seat designs and vibration dampening, affect safety as they contribute to comfortable, alert and attentive crew members.

Train handling related changes such as alerting devices, train control systems, improved braking, improved communication and system monitoring devices can contribute to operational safety. Cab layout and crew workstation design changes, including improved visibility, control accessibility and display legibility, are clearly safety related.

Despite safety benefits achieved by design changes over the past decades, there are still unique opportunities for safety enhancement today. These are created by virtue of new electronic and computer technology, ergonomics, and the knowledge of structural changes needed from collision investigation and analysis.

Each design change is dictated by perceived safety cost-benefit considerations of rail management and the unions. In some instances, rail management and unions have worked closely in examining the feasibility of various proposed cab design improvements, e.g., the "clean cab" project of the 1970's.

The Federal Railroad Administration (FRA) has been evaluating the need for specific safety improvements in the locomotive cab for some time. The alternatives being examined range from voluntary industry standardization of safety improvements to possible regulatory action. In order to determine what design changes are needed, the FRA had to ascertain the level of interest in cab design change and the priority of specific changes as perceived by rail management and unions.

The Locomotive Control Compartment Committee (LCCC) recommended initiating the survey to be described in detail below. The LCCC, with participation from the rail unions, rail management, National Transportation Safety Board (NTSB) and FRA, developed a request for proposal which set forth items to be included in a survey. R & R Research, Inc., a sub-contractor to Battelle Memorial Institute, was selected to plan, develop, conduct and evaluate a survey of rail management and union leadership to ascertain the need for locomotive design changes.

B. Survey Objectives and Scope

B-1. Objectives

As stated in the contract work plan, the thrust behind the survey was to ascertain if there was sufficient interest in locomotive cab safety and crashworthiness design to justify the development of new cab design standards and, if so, which improvements were most desired and why. Because in depth information was required, i.e., reasons behind perceived design needs, "personal interview" techniques were used as opposed to mail or telephone surveys. This will be discussed in more detail later in Chapter II.

Thus, the contract objectives were to "develop, conduct and evaluate a survey of major U.S. railroads and labor unions using a structured personal interview guide to ascertain what specific locomotive design improvements are most needed in the future."

The focus was on road freight locomotives involving at least three crew members. This decision is consistent with current trends to eliminate the caboose and bring the conductor into the lead unit. It also is consistent with current railroad investments in road service rather than yard service. Improvements were characterized as those required "beyond existing design." Later, this stipulation will be discussed in terms of changes already taking place in new locomotive purchase specifications.

B-2. Scope

The scope of the survey as suggested by the LCCC involved such issues as:

1. Structural protection (crashworthiness)
2. Entrances and exits to cab
3. Windows and visibility
4. Cab size
5. Lighting
6. Climate control
7. Control stand redesign
8. Seating
9. Cab layout
10. Communications
11. Noise reduction

It will be seen later that many other issues were brought out from the subsequent interviews, such as cab surface delethalization (e.g., rounding of sharp corners), sanitation, instrument lighting, ease of maintenance, etc.

Four categories were used to organize the 96 design issues brought up in the interviews. These were:

1. Structural and crashworthiness
2. Crew comfort
3. Train handling
4. Cab layout and workstation design

In addition, special emphasis was placed on participant reaction to the opportunities for cab improvements offered by new electronic and computer technology and workplace ergonomics. A good example of the application of current technology is the "advanced train control system," ATCS.

The scope of the study might also be viewed in terms of five thematic questions.

1. How receptive is the rail industry to locomotive cab design change?

2. What areas of redesign need to be addressed?

3. What specific design improvements are needed in the areas of:

   a) Crashworthiness?
   b) Crew comfort?
   c) Train handling?
   d) Cab layout and workstation design?

4. What are the unique opportunities for cab design improvements as offered by new electronic technology and ergonomics?

5. What specific design improvements are called for <u>now</u> and how should they be implemented?

C. Organization of the Report

Chapter II describes the survey methodology employed. Chapter III describes survey participants. Chapter IV details the results of the responses to the survey questions. Chapter V summarizes and interprets the survey responses, and Chapter VI discusses the application of the survey results for cab mockups and full mission simulation experiments.

II. SURVEY DEVELOPMENT

The development of the survey instrument involved the following steps:

1. From the survey objectives, literature review (See Appendix A), discussion with LCCC members and with the guidance of the project's survey consultant, a draft survey (personal interview guide) was developed.

2. The survey was then pretested on ten participants who were knowledgeable in train operations, maintenance, design, and locomotive handling. Following the interviews, items of the survey were debriefed to test for language, clarity, content inclusiveness and interviewer technique. Tapes of the interview or direct observation of interviews were reviewed by the survey consultant to aid in training of the three interviewers who were to be used in the actual study.

3. The survey was revised based on #2 above.

4. The survey instrument was then approved by the LCCC (with recommended changes).

5. Prospective participants were identified and contacted by letter through the Association of American Railroads (AAR) for the major railroads and through labor members of the LCCC for the Brotherhood of Locomotive Engineers (BLE) and the United Transportation Union (UTU).

6. Complete transcripts were made from early interviews and were reviewed to insure quality and consistency among the interviewers.

Perceptions about the need for locomotive design change reflected in the leadership of union and management are major forces for change. The sampling strategy used in this survey emphasized personal, in-depth interviews with this leadership in order to allow probing for the reasons behind the responses. This strategy was selected over a larger sample size using mail or telephone survey methods. The average interview time was about sixty minutes over the 65 participants in the study.

The response rate, i.e., the percentage of those contacted who agreed to be interviewed, was over 95% which is very high in survey research and indicates the interest of the respondents in the topic. The personal interview approach enabled the interviewers to develop a rapport with the respondents. This rapport also resulted in agreement by all respondents to have the interview taped for subsequent data analysis purposes. That the leadership in the rail industry would devote an hour to the interview confirms the depth of interest in the topic area.

The final interview guide is shown in Appendix B-1. Note that for most content areas, the initial question asked by the interviewer sought unaided responses from the participant. Later, as the content area was delineated through exhibits shown to the participant, so called "prompted responses" were elicited (See Appendix B-2). It will be shown later that the participants needed little prompting for idea generation.

The first question was a critical one, because it attempted to solicit general areas for locomotive redesign. Typically, the participants offered specific design improvements which could be reclassified into one of the four major content areas, namely:

1. Crashworthiness
2. Crew comfort
3. Train handling
4. Cab layout and workstation design

Responses generated in the survey were spread across four design areas, as shown in code sheets used in the analysis (See Appendix B-3). The survey not only elicited needed design improvements, it also asked the participants to assess the priority of specific design suggestions in future locomotive design efforts, such as roll bars, ATCS, etc. A four-point scale enabled priorities to be quantified to permit calculation of two measures:

1. The average priority value assigned to the proposed suggestion
2. The amount of agreement, as measured by the variability of the priority ratings for a given design improvement

A few items were introduced into the survey as interview validity checks. For example, it is well accepted by union and management that the potable water problem has been solved with the introduction of bottled water. Thus, a question which asked for the priority of "design change in water systems beyond present design" yielded a low priority value, as expected.

The general content of the interview first involved the specification for areas of needed design, followed by questions in each of the four major areas. These questions provided frequency of mention data and assessment of priority data.

Next, questions on new technology and ergonomics were introduced. Participants were then shown two exhibits, 6 and 6a, to allow personal judgement about the need for design implementation and the best method of implementation for ten candidate design improvements. Comments on forces which enhance or inhibit change were also collected.

The last question dealt with the one design improvement needed, if only one were possible. In general, the responses to the survey instrument were enthusiastic and well thought out.

Because of last-minute scheduling problems, two respondents were interviewed by phone. Their responses were not different from others in their class.

III. SURVEY PARTICIPANTS

To generate cooperation from the eight major railroads, R & R Research drafted a letter for the AAR to send to its member railroads soliciting their cooperation. This was followed up by personal contact with each railroad by Mr. Tom Hackney, a consultant to the AAR and former Vice President and Chief Operating Officer of Amtrak. In this way, R & R Research was able to include, for each railroad, the vice president of operations, or assistant vice president, chief mechanical officer (CMO), chief of road foremen, as well as other leaders in rail management that have a role in specification of future locomotives.

Working through the union representative on the LCCC, R & R Research was able to make contact with UTU and BLE union representatives in Cleveland and Columbus, Ohio, to solicit their help in arranging interviews. During a meeting of BLE officials from throughout the nation in Cleveland, Ohio, on September 7, 1988, R & R Research was able to interview 12 union leaders of the BLE ranging from general chairman to chairman of the state legislative board. Most of these BLE officials were active in engine service. The UTU members interviewed were mostly engineers operating in Ohio. The total sample was 65 participants - 21 union and 44 rail management.

The seven major freight railroads plus Amtrak are included in the 44 railroad participants. Amtrak was included by virtue of its use of diesel-electric power in cross-country runs. The average length of service in the rail industry for the management participants was 22 years. Over a third had active engineer service in their background.

For the union members, their average railroad experience was 29 years with 21 years in engine service. Sixty percent of the union participants were currently active in engine service, while the remainder were in full-time administrative positions. The participants are classified by job title below.

Railroad Participants

Vice President Operations, Asst. Vice President Operations	6
VP Mechanical, Chief Mechanical Officer (CMO), Asst. CMO	7
Operations Department Staff	8
Mechanical Department Staff	15
Chief Road Foremen & Road Foreman	8
Total	44

Union Participants

Active Engineer Service	13
Union Administration	8
Total	21

The number of railroad management participants by company is shown below.

Amtrak	6
Burlington Northern	8
Conrail	6
CSX	5
Norfolk Southern	4
Santa Fe	5
Southern Pacific	4
Union Pacific	6
Total	44

In general, the participants were a good representation of management and unions; they were highly knowledgeable about locomotive operation, were articulate and had a sincere interest in improving locomotive design. Their wide experience was reflected in their ability to describe the historical evolution of changes in locomotive design. As will be seen later, many of the railroads were already immersed in changes in locomotive designs. Four railroads had already initiated orders for new locomotives which had a console-type of cab design.

IV. SURVEY RESULTS

The results of this survey will, in general, follow the five thematic questions presented in Chapter I. Data will involve both frequency of mention of specific design suggestions and priority ratings of selected design suggestions presented in exhibits to the participants.

A. Difference in Prompted vs. Unprompted Responses

Each of the first five questions asked for needed design improvements both before and after an exhibit was presented to the participant. The exhibits (See Appendix B-2) were used primarily for purposes of eliciting priority ratings. They could also trigger additional suggestions from the participant for that area of inquiry. The data support the notion that the participants needed little prompting from the exhibits. Most of their ideas (78%) in a given design area were offered before the exhibits were presented to them. Based on this finding, all suggestions, either pre- or post-exhibit, were combined for subsequent analysis.

B. "How Receptive is the Rail Industry to Needed Changes in the Design of Locomotive Cabs?"

B-1. Suggested Improvements

The answer to this question came from two sources:

1. The number of design suggestions offered in response to question #1, "In thinking about future locomotive design, what do you believe to be the problem areas that really must be addressed?"

2. The total number of responses and the number of unique suggestions offered by the participants across the survey.

Design suggestions were usually made by participants to answer the first survey question, rather than areas of design. Using the coding scheme in Appendix B-3, one can translate the design ideas into the appropriate area categories. Four general areas were adopted in line with the exhibits as illustrated in the codes below:

200 series -	crashworthiness, e.g., 201 = anticlimbers
300 series -	crew comfort, e.g., 301 = temperature control
400 or 4800 series -	train handling, e.g., 405 = ATCS
500 series -	cab layout and crew workstation design, e.g., 513 = console layouts

For the 65 participants, 281 responses were offered in answer to the first question, an average of over four suggestions per participant. The responses embraced 60 different design ideas, covering the four basic areas of design classification, with 16% associated with crashworthiness, 34% with crew comfort, 11% with train handling aids, and 39% for cab layout and crew workstation design.

Union and rail management differences are reflected in Table IV-1. This table shows that there is little difference between labor and management in terms of response to areas of needed improvement. The differences are not statistically significant. Clearly, both groups see a need to make design changes in cab layout and workstation design and in crew comfort improvements.

TABLE IV-1

AREAS OF DESIGN NEEDS

Response to Survey Question #1

"What Areas Need to Be Addressed Now?"

Response to the Design Area	Rail Management	Union	Total
Crashworthiness	16%	15%	16%
Crew Comfort	32%	38%	34%
Train Handling Aids	13%	9%	11%
Cab Layout and Crew Workstation Design	39%	38%	39%
Total Responses (Percent)	157 (100%)	124 (100%)	281 (100%)

Note: Percent (%) refers to the percentage of all responses provided by management (union) related to designated design area.

The participants were receptive, and indeed motivated, to seek specific changes in future locomotive design. Figure IV-1 details the frequency of mention of specific design improvements. Only improvements with more than nine mentions are shown. Note console design (code 513), seat improvement (code 316), and climate control (code 301) received the highest frequency of mention. There were little differences in relative emphasis between management and labor. The following quote illustrates the responsiveness of the participants.

> *"The locomotives that are out there right now are at least 25 years behind technology. I can't think of very much with them that is right. We went out and in three hours finalized plans for our new design coming out next year."*

The areas of greatest need for change appear to be the 500 series codes, i.e., cab layout and crew workstation design. For the railroad company participants, this finding may reflect the fact that some railroads are already ordering new cabs with radical changes in crew workstations, e.g., console designs.

As a further index of the positive response to change, Figure IV-2 depicts those areas of design suggestions mentioned most often in response to the four design area questions in the survey. The 65 participants offered 427 design improvements covering 96 separate topics - 23 in crashworthiness, 18 in crew comfort features, 31 in train handling and 24 in cab layout and workstation design.

B-2. Priority Ratings of Candidate Areas for Redesign

Table IV-2 depicts the results when the areas of design in Exhibit 1 were presented to the participants for rating the priority for redesign. Ratings are presented for the four areas and include responses by union, management, and the combination of union and management.

One highlight of Table IV-2 is the fact that all areas received an average moderate priority or greater (greater than 3.0 on a 4-point scale). Fifty-eight percent of all participants placed cab layout and workstation design in the top priority category, while 41% placed crashworthiness in the top priority.

The low standard deviation* of ratings on cab layout and workstation design reflects a consensus of participants on this issue. It is, in fact, the lowest in the survey. The higher standard deviation for crashworthiness reflects a lack of agreement among participants. This is particularly true when one examines union and management differences in these priority ratings. The union rated crashworthiness its highest in average priority (3.6) while the railroad management gave it a priority of 2.9. There were little differences in priority assignment between management and labor for the other three areas. In general, union participants were more concerned with comfort and crashworthiness because of their direct relationship to engineer safety and well-being.

The rating data supports the frequency of mention data earlier. Those areas most frequently mentioned, e.g., crew comfort and cab layout and workstation design, also had higher priority ratings.

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* Standard deviation is a statistical calculation to represent the variability of ratings that make up an average. This is referred to as "Std Dev" in the tables.

Code Key

207 = Delethalization of surfaces
301 = Temperature control
302 = Noise reduction
316 = Seat design
501 = Design for housekeeping
502 = Cab layout
503 = Visibility
513 = Desk-type console
514 = Control for bi-directional movement

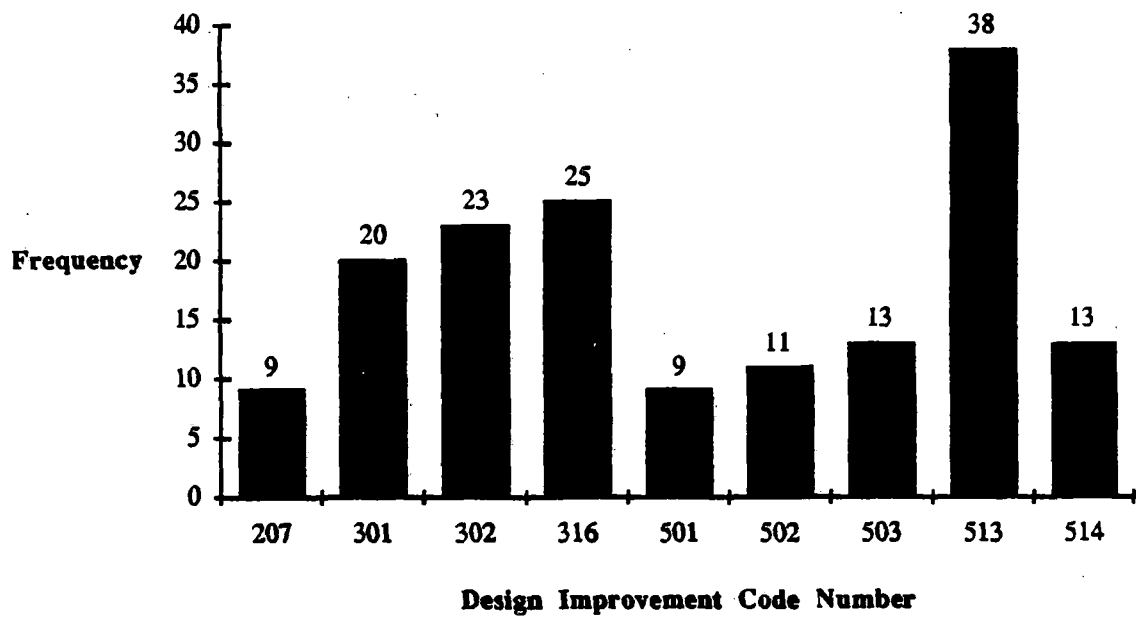

Figure IV-1. Specific design improvements offered in response to Question 1: "What areas need to be addressed?" (Nine or more mentions.)

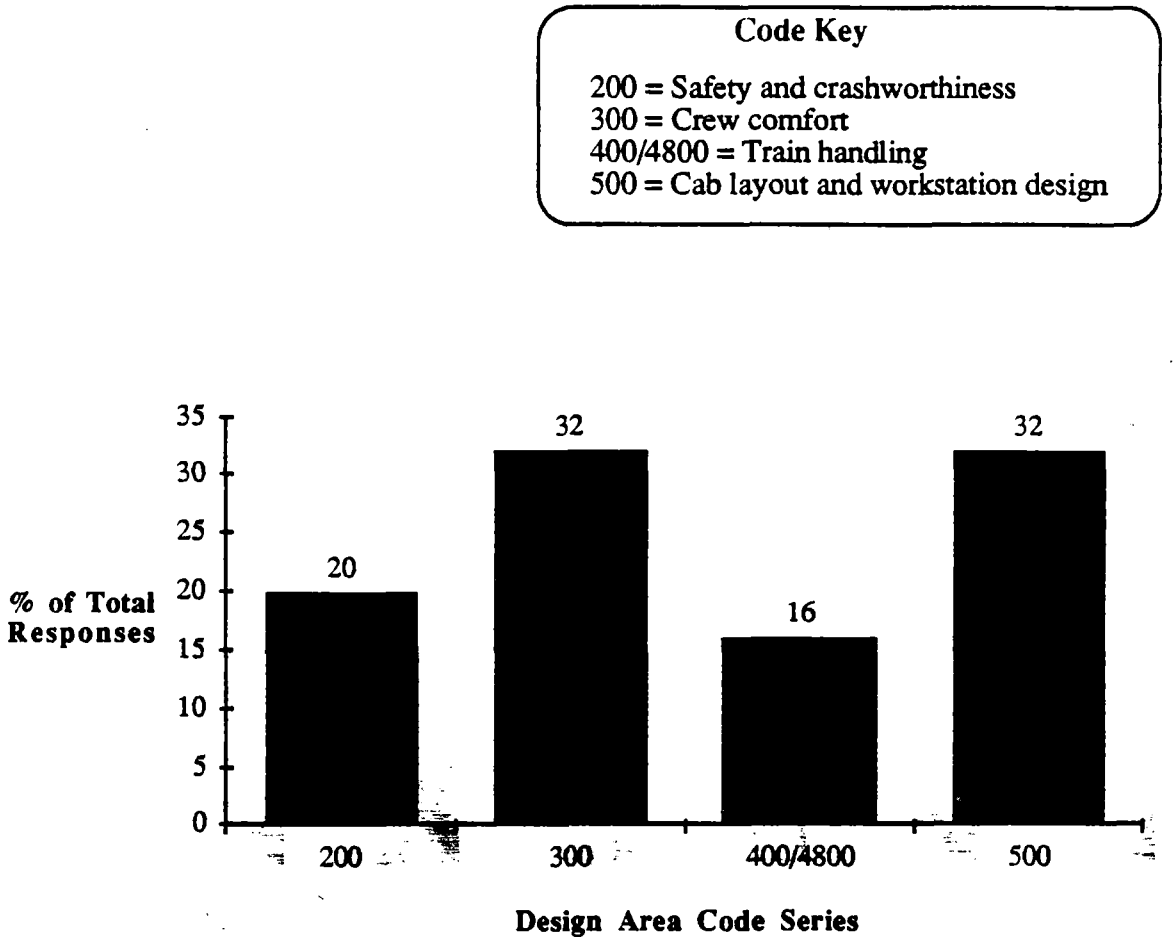

Figure IV-2. Categorization of responses to the questions by the four design areas.

TABLE IV-2

PRIORITY ASSIGNMENTS

TO THE FOUR DESIGN IMPROVEMENT AREAS

Design Improvement Area		Priority (In % of Participants) Don't Know	No	Low	Mod	Top	Avg*	Std Dev
Crashworthiness	Mgmt.	4	7	26	30	33	2.9	1.0
	Union	15	0	5	20	60	3.6	.6
	Total	8	5	19	27	41	3.1	.9
Crew Comfort	Mgmt.	0	2	7	37	54	3.4	.7
	Union	0	0	10	35	55	3.5	.7
	Total	0	2	8	36	54	3.4	.7
Train Handling Aids	Mgmt.	2	0	16	26	56	3.4	.8
	Union	0	10	25	25	40	3.0	1.1
	Total	2	3	19	25	51	3.3	.9
Cab Layout and Crew Workstation	Mgmt.	2	0	5	29	64	3.6	.6
	Union	0	0	0	55	45	3.2	.5
	Total	2	0	3	37	58	3.5	.5

* Average based on a 4-point scale, No = 1, Low = 2, Mod = 3, Top = 4, using 44 management respondents and 21 union respondents.

C. "What Specific Locomotive Design Improvements are Needed in Crashworthiness?"

In introducing crashworthiness to the participants, the interviewer defined crashworthiness as "protective structures to minimize injury from rollovers, collisions at grade crossings and low speed impact with other trains." The participant was asked to consider improvements "beyond present design."

C-1. Frequency of Mention Data

Figure IV-3 shows the overall response by the participants. Only categories with five percent of the total responses are shown. Note that code 207, delethalization of controls and work surfaces, and code 208, door design for egress, received the largest number of responses. Code 207 was mentioned by 25% of the participants, and code 208 by 20%.

Overall, there were 100 responses with over 23 different suggested design improvements for the 65 participants. Clearly, there was little consensus for design change in this area. This result meant less than two design ideas per participant and a tendency to have only a few responses per design idea. The stated reasons behind the ideas were clearly safety-based. Some of the diverse comments from the participants are presented below.

"I guess one of the first things is some type of collision posts - reinforced structure that doesn't have to take away from the aesthetic value of the locomotive, but that it would provide adequate protection, and if nothing else (if you want to call it), peace of mind. When I talk with our men and our local chairman too, that is a major concern of theirs. With the different styles of locomotives, there is a different comfort level or confidence level."

"I never particularly appreciated having the door in the front on the freight locomotive to go out that way. I like the idea of doors, at least one on each side. I would not want to have less than that. As far as doors that would allow a person to go back into the engine room, I tend to prefer to have two. Personally, I would like to have two because if there is a reason to want to vacate that cab, I would like to be given as many escape routes as possible."

"I personally feel that a locomotive cab is a very, very, very safe place to be in a road crossing accident and I don't care if it's with steel trucks, concrete trucks, you name it. It's a very safe place to be but there's always room for improvement. I think with the wide cab, just that in itself done properly is an improvement."

"The locomotives that are out there right now, they'll take a good smack. You don't design planes to crash into each other, and you don't design trains to crash into each other. It's not supposed to happen. Occasionally, it does, but the proven design of both manufacturers now, I think, will take a reasonable smack. I'm not saying that it is a low priority or no priority, I am simply saying what exists now is adequate."

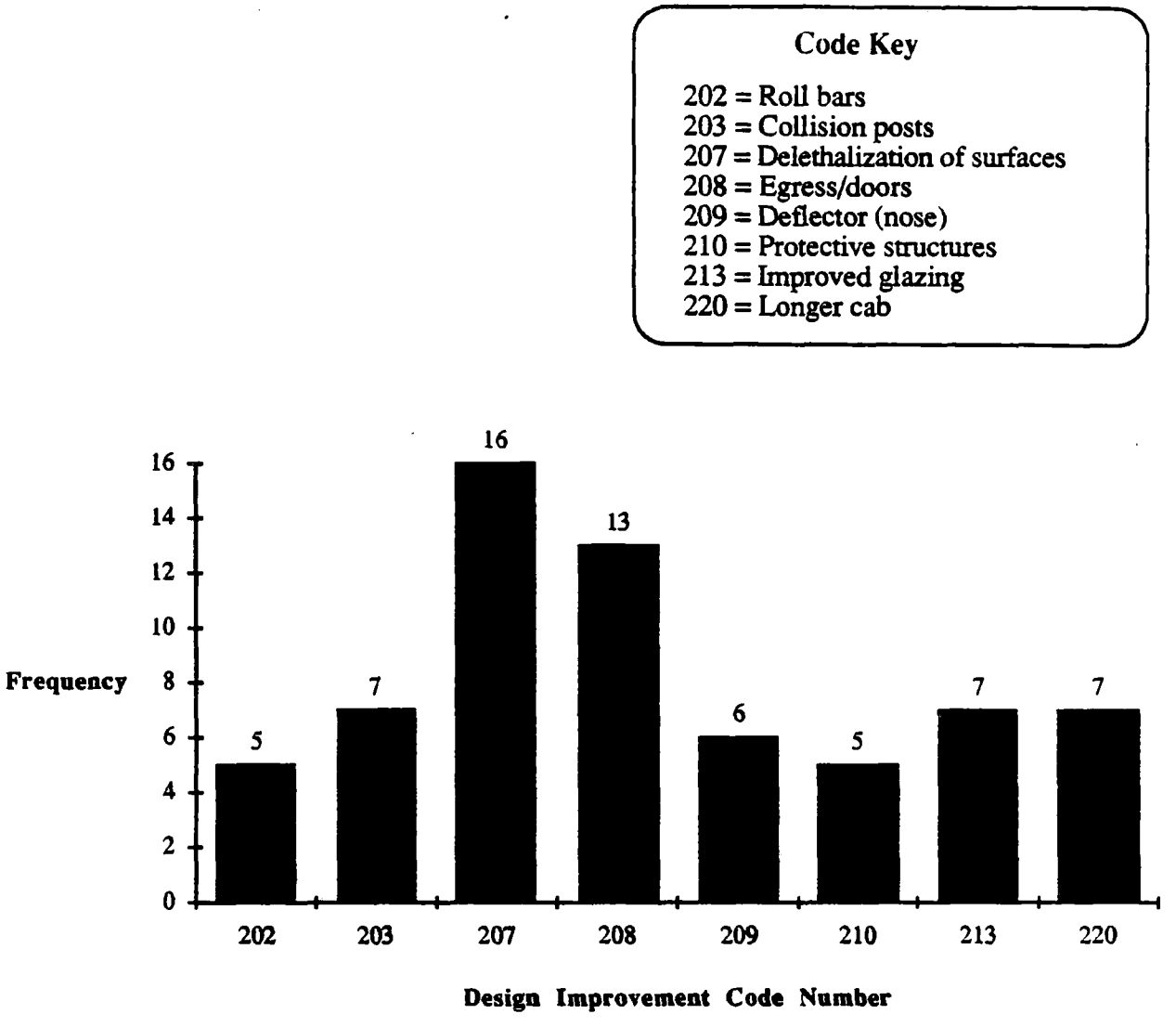

Figure IV-3. Frequency of mention data for crashworthiness design improvement. (Greater than five percent of all responses.)

C-2. Priority Ratings of Specific Crashworthiness Design Improvements

Participants were asked to rate the priority for five design improvements in this area. These were:

1. Anticlimber (1-1/2")
2. Roll bars (support a loaded hopper)
3. Collision posts (support 500,000 lbs.)
4 Full width and thicker (3/8") short hood
5. Shelf couplers

Table IV-3 depicts the priority ratings for all participants, and tabulations of the union and management separately. Anticlimbers are within "present design" for some railroads and, hence, received a low rating from railroad management participants. Clearly, the data understates the importance of anticlimbers to the management.

The average priority ratings are quite different between management and union participants. For all design improvements except shelf couplers, the union gave an average rating of 3.5 vs. 2.5 to 2.9 for management. The high standard deviation reflects lack of agreement among participants for these design improvements. Note the difference in ratings for roll bars between management and labor.

Among design improvements, the wider and thicker short hood received the highest percent of responses in the top priority. Three design improvements - anticlimbers, collision posts and wider, thicker hoods - received an average of 3.0 or greater from all participants. This suggests an overall rating of moderate priority with about 40% of the participants assigning "top priority" for anticlimbers, stronger collision posts and wider, thicker short hoods.

D. "What Specific Design Improvements are Needed in the Area of Crew Comfort (Beyond Current Design)?"

Crew comfort is defined as "systems to make crew members comfortable during 8-10 hours of duty."

D-1. Frequency of Mention Data

Figure IV-4 shows the results of this question. The 65 participants offered 128 responses covering 18 specific design improvements. Two design improvements - code 316, seat design and adjustment, and code 301, climate control - received the highest frequency of responses, 37 and 24 respectively. The third most cited design suggestion was noise reduction, although, at this point, this response was more of a symptom needing to be addressed than a specific solution.

Interestingly, these three ideas were the top three for both management and labor, although a greater percent of union participants suggested the three design improvements.

TABLE IV-3

PRIORITY RATINGS OF SELECTED CRASHWORTHINESS IMPROVEMENTS

Design Improvement		Priority (In % of Participants) Don't Know	No	Low	Mod	Top	Avg*	Std Dev
Anticlimbers	Mgmt.	9	7	30	19	35	2.9	1.0
	Union	20	0	10	25	45	3.4	.7
	Total	13	5	24	20	38	3.1	.9
Roll Bars	Mgmt	11	14	33	30	12	2.5	.9
	Union	25	0	10	15	50	3.5	.7
	Total	16	10	25	25	24	2.8	.9
Strengthened Collision Posts	Mgmt.	5	9	23	32	30	2.8	1.0
	Union	10	0	5	20	65	3.6	.6
	Total	6	6	18	29	41	3.1	.9
Thicker & Wider Hoods	Mgmt.	7	11	26	23	33	2.8	1.1
	Union	5	5	5	20	65	3.5	.8
	Total	6	10	19	22	43	3.0	1.0
Shelf Couplers	Mgmt.	19	16	23	26	16	2.5	1.0
	Union	23	18	18	6	35	2.8	1.3
	Total	20	16	22	20	22	2.6	1.1

* Average based on a 4-point scale, No = 1, Low = 2, Mod = 3, Top = 4, using 44 management respondents and 21 union respondents.

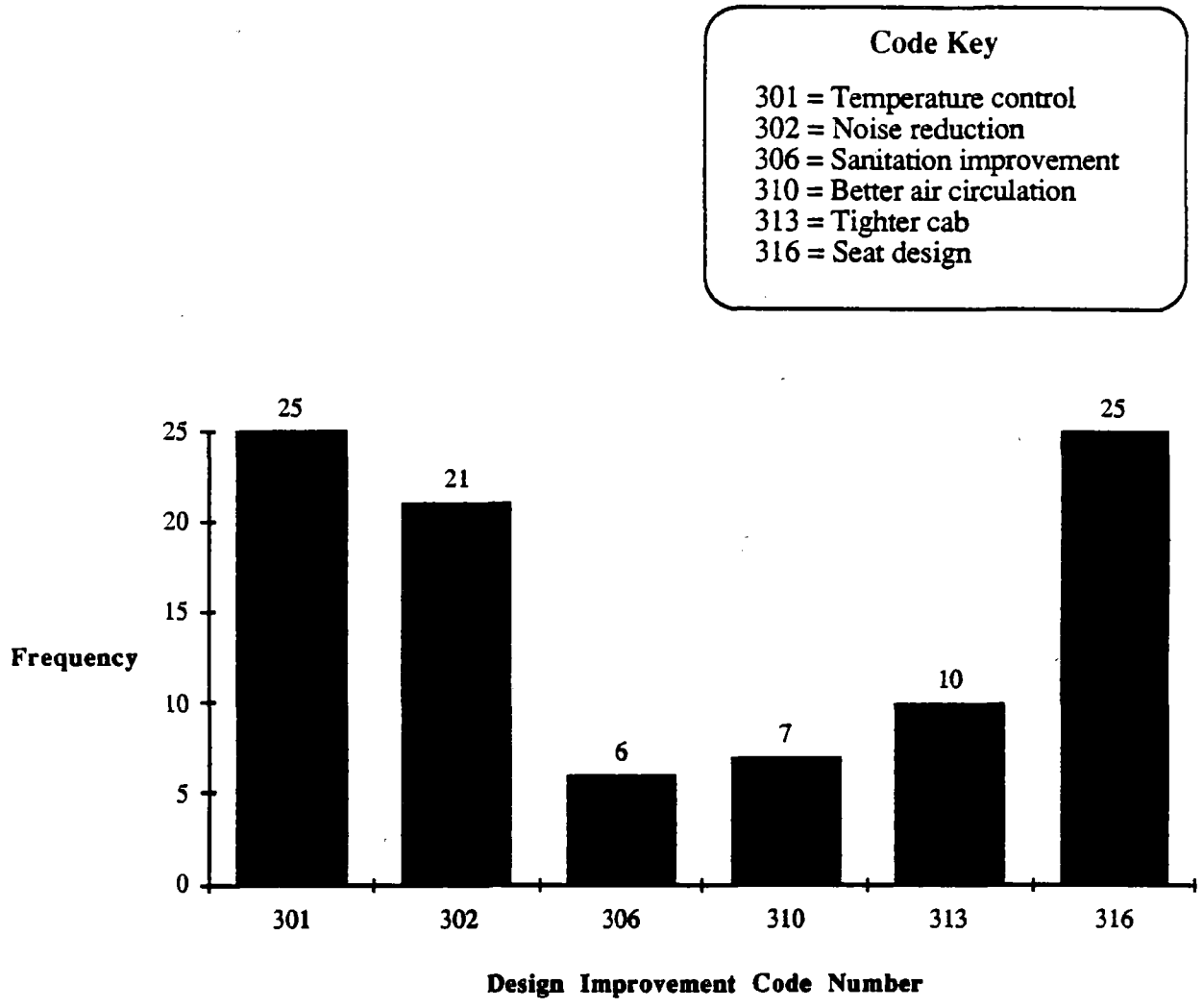

Figure IV-4. Frequency of mention data for crew comfort design improvement. (Greater than five percent of all responses.)

The stated reasons behind the proposed design improvements were, obviously, crew comfort, but this was often translated into "more alert crews and, hence, fewer accidents" and reduction in progressive cumulative trauma claims, e.g., "chronic low back problems." Some illustrative comments were:

"As far as air conditioning goes, that is something rather new and most of our men that don't have it in the desert areas and the extreme hot areas really do need it. When you say air conditioning, I would think in terms of perhaps tinted windows or something that would also help repel the sunlight that comes through. A lot of our people will reduce themselves to putting paper up to cut down on direct rays and they will tell me that there is a noticeable difference in the temperature in the cab."

"The other thing is the noise levels, and we have put in our specification. I think it was an 82 dB max and we are going to go lower than that. We recently had a unit sent out so they could test and retrofit the cab with a floating floor, and various insulating materials. I didn't get the results of that. It only happened a week and a half ago. We are very active in looking to quiet that cab down. We've moved horns. Again, for the new cab, we had the new spec of 82 dB and they did a lot of nice things, and the cab is nice and quiet. Now we are getting complaints because the crews don't think the horn is loud enough, because if the window is closed they can't hear it. It's as loud as it always was, but they can't hear it so they're reporting a weak horn."

"The cab will have to be designed in conjunction with the locomotive to minimize the entry of the diesel emissions. I think that will become important. Also, we need to design to maximize their ability to prevent such things as battery emissions that routinely come off batteries from entering the cab. I've been involved in two significant claims related to that area of battery misting. So I'm particularly sensitive to airborne things going into the cab. I can see that becoming a costly issue to the railroad."

"They have already overdone the noise control because we have some real problems with some of our [xyz's]. We can't hear torpedoes. Temperature control, we don't operate in the desert. It's not an office out there. It's not an office environment, and it isn't supposed to be. Frankly, I would have to give that a low priority."

"The air quality in our cabs is not all that bad. It's not an office-type environment, but it was never meant to be and never will."

"As with any person in this modern, late '80's here, we all ask each other, "How do people exist without air conditioning?" The kind of money we are paying these people to run these trains - they obviously have a pretty good lifestyle - it's kind of putting them back into the dark ages getting into a cab at 115 degrees and expect them to be productive on a 10 or 12-hour run."

D-2. Priority Ratings of Specific Design Improvements

Participants were asked to rate the priority for redesign of six proposed design improvements. These were:

1. Climate control
2. Noise reduction (insulation)
3. Vibration isolation
4. Improved seat design (and adjustment)
5. Improved water quality
6. Improved sanitation

Table IV-4 depicts the results of these ratings. Seat design, noise reduction and temperature control were all given high ratings with an average rating for all participants of greater than 3.4 (on a 4-point scale). As might be expected, union ratings were slightly higher for these three ideas than management, but these differences were not statistically significant. This data suggests a remarkable consensus on these three crew comfort ideas.

Water quality received a very low rating, and this was anticipated in the design of the survey. With the use of bottled water, nearly all union and management participants consider the water quality acceptable and, hence, no high ratings for redesign "beyond present design."

Vibration isolation received uniform but relatively low ratings across the top three rating categories for both management and labor, suggesting that the need for this improvement was not perceived by the respondents. Sanitation ratings appear to be determined as much by maintenance practices as by design, and this may account for the high standard deviation of ratings.

E. "What Specific Design Improvements are Needed in the Area of Train Handling Aids (Beyond Current Design)?"

For this question, train handling aids were defined as "systems to promote improvements in speed control, authority enforcement and control of slack."

E-1. Frequency of Mention Data

Figure IV-5 depicts the specific design improvements proposed by the participants in the area of train handling. It should be noted that the 4800 codes are train handling ideas requiring specific application of new electronic technology. This was done to capture specific responses to question six later, asking for specific application of electronic technology and computers.

TABLE IV-4

PRIORITY RATING FOR SELECTED CREW COMFORT IMPROVEMENTS

Design Improvement		Priority (In % of Participants) Don't Know	No	Low	Mod	Top	Avg*	Std Dev
Temperature (Climate) Control	Mgmt.	0	5	14	39	42	3.2	.8
	Union	0	0	0	20	80	3.8	.4
	Total	0	3	10	33	54	3.4	.8
Noise Reduction	Mgmt.	5	7	7	18	63	3.4	.9
	Union	0	0	5	30	65	3.6	.6
	Total	3	5	6	22	64	3.5	.8
Vibration Isolation	Mgmt.	7	9	28	28	28	2.8	.9
	Union	10	10	30	20	30	2.8	1.1
	Total	8	9	29	25	29	2.8	1.0
Seat Design	Mgmt.	0	7	14	19	60	3.3	.9
	Union	0	0	5	35	60	3.6	.6
	Total	0	5	11	24	60	3.4	.9
Water Quality	Mgmt.	0	37	35	16	12	2.0	1.0
	Union	0	40	30	10	20	2.1	1.2
	Total	0	38	34	14	14	2.0	1.1
Sanitation	Mgmt.	0	3	18	51	27	3.0	.8
	Union	0	5	10	45	40	3.2	.8
	Total	0	3	16	49	32	3.1	.8

* Average based on a 4-point scale, No = 1, Low = 2, Mod = 3, Top = 4, using 44 management respondents and 21 union respondents.

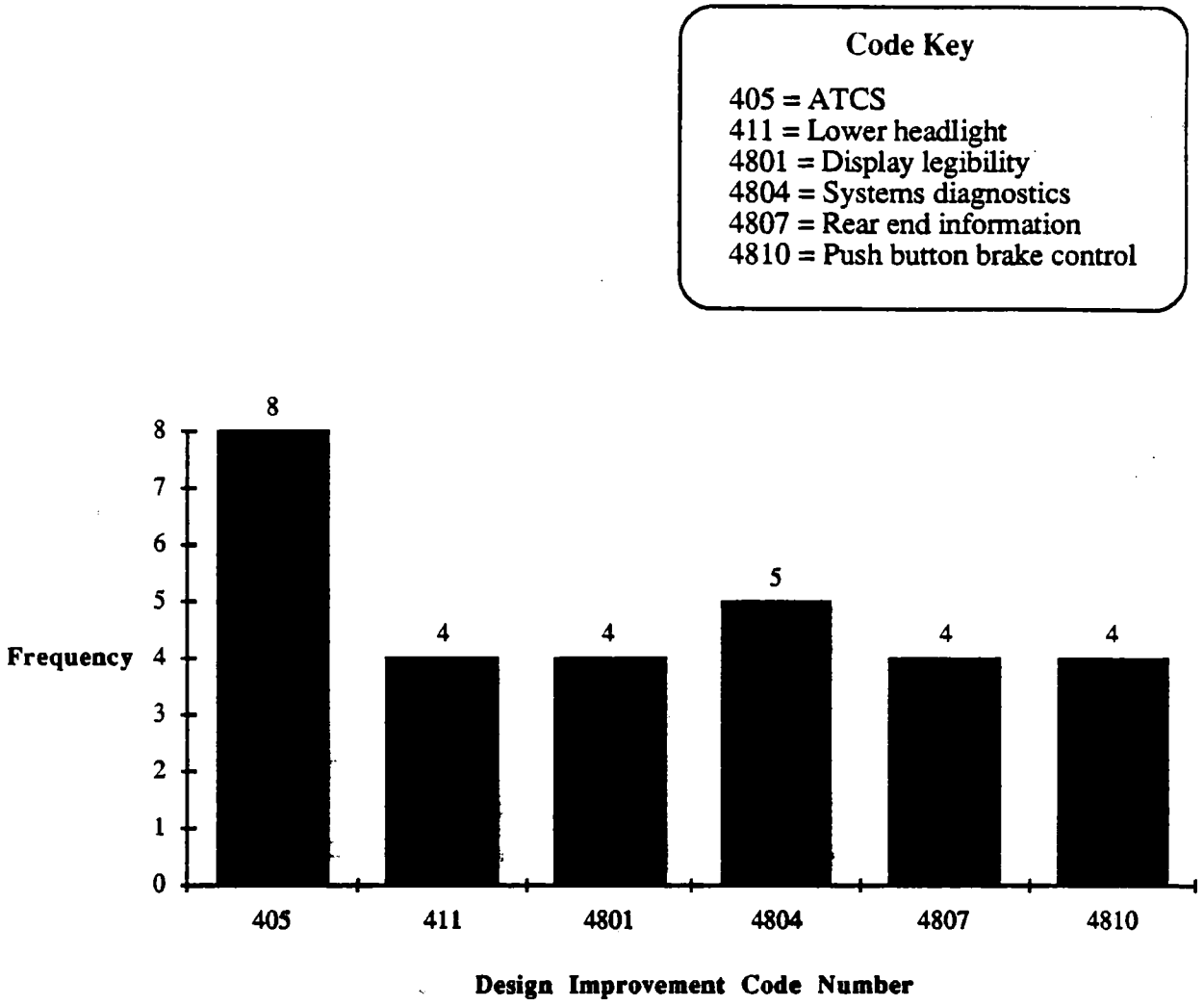

Figure IV-5. Frequency of mention data for train handling design improvements. (Greater than five percent of all responses.)

From Figure IV-5 it is clear that there are no dominant suggestions. ATCS, the Advanced Train Control System, received the highest frequency of mention, but this represented only eight of the 65 participants. In total, there were only 81 responses proposed by the 65 participants covering 31 different improvements, suggesting that this area had minimal response over a large number of suggestions. The stated reasons for the ideas proposed involved better train handling, ease of operation and safety. Despite the limited responses, much discussion was generated, particularly with regard to ATCS and alerters. Some of the excerpts from this area are shown below.

"As far as electronically transmitting information such as train orders or bulletin orders or speed restrictions, I think that is a tremendous improvement and as far as the graphic displays up there go, some people (older generation railroaders) might stop at this because they are going to say an engineer is supposed to know whether he is going uphill or downhill. But in real bad weather, a display like this might be extremely helpful for the engineer to be able to track on this screen where he is, because he can't see where he is out the window. I would put that as a top priority."

"The first thing that comes to mind is some of our trains that we operate where we will pick up in 400 miles, ... 70 or 80 train orders and I know it is unbelievable if the man were to operate alone, we would never be able to handle that. What I would like to see , if we had computers, would be something that from the headquarters or the dispatching point, they could put in whatever information they want, but the computer would line it up in such a way that we know what track the man is on, we know what direction he is going, and I don't give him two tons of things that he is not even going to come into contact with. Prioritize these things so that he could, perhaps if nothing else, get the speed restrictions in the order that he is going to encounter them, given the direction of travel."

"I have a strong opinion about alerters. I think that alerters are meant to be a substitute for an alert brain. And I don't think there is a substitute for an alert brain. I think an alert brain, and I think the numbers will bear me out, they are a function of good regimentation or discipline. Negative ways to get people to be alert have been proven to be extremely effective. They have produced some significant results. I think the attitude another black box or another magic box is going to make things better is an illusion. I think alerters cost money, they take maintenance time which is not available in sufficient quantities now. The results that they produce are minimal, if not counter-productive, because they do create a lot of irritation. Some designs do."

"Event recorders - put at top priority. We are doing 100 this year and 90 more next year. As much as I hate to put them on, because they are a pain to maintain, in accident investigation, it's good. You have to have it. But even in train handling problems, stall burn motors, you have two play-back machines that play them back. Again, that is a top priority."

E-2. Priority Ratings of Specific Design Improvements

Participants were asked to rate the priority for redesign of six proposed design improvements. These were:

1. Improved monitoring devices and reset controls
2. Dual speed displays, radios and speakers
3. Advanced event and speed trace recorders
4. Advanced alerting systems
5. ATCS
6. Reliable radios

Table IV-5 depicts the results of these ratings for all participants and for union and management separately.

Since these improvements are related to effective train handling, it was thought that management would rate these ideas higher. However, overall average ratings show the union average ratings to be higher than management in three of six design improvements. ATCS clearly received the highest priority ratings from both participant groups, and overall, there was a high level of consensus (standard deviation of 0.7) among management participants for this idea. Union participants were less in agreement, although 65% gave it a top priority.

Responses to dual radio, speedometers and speakers usually evoked splits in responses. Almost all agreed that more and smaller radio speakers would improve communication and reduce cab noise. Some union members expressed concern about radio reception quality. Little support for dual radios was given.

The response to advanced event recorders showed a wide split between labor and management. The former looks at recorders as tools to find blame in engineers for accidents. Management views recorders as potential training aids. In any case, the difference between labor and management in ratings for this idea was the greatest found in the survey, tied only with roll bars in the crashworthiness area.

Advanced alerting systems showed a lack of consensus and overall a low priority for design improvement. Much of the reason for this stemmed from a perceived lack of reliable systems, the distraction effect and the fact that being alert is part of the engineer's job as noted by the following perceptions.

> *"What we did in the navy to keep people busy, or keep them alert, or keep them busy, was to give them things to do. If you gave the people things to do, real things to do like measuring things, taking readings, anticipating things, making calculations, typing in things to a little keyboard so it prints back at a dispatcher's office. If you keep people busy doing meaningful things, they'll be more alert. I think there is a lot to be said for that and I think that integrates well into the ATCS."*

> *"Again, we are using the [xyz] system which we have developed. It's tied into just about all the controls on the stand so that the guy who is normally moving ... the engineers... about the only thing they have said about it was that we ought to have one on the other side of the cab for the brakeman to keep him awake. I think the existing system, what's available on the market today, I think the [xyz] system is adequate. I would have to say no priority on any future development in that area."*

TABLE IV-5

PRIORITY RATING FOR SELECTED TRAIN HANDLING AIDS

Design Improvement		Priority (In % of Participants) Don't Know	No	Low	Mod	Top	Avg*	Std Dev
Engine Monitoring Devices	Mgmt.	16	7	26	21	30	2.9	1.0
	Union	10	10	15	30	35	3.0	1.0
	Total	14	8	22	24	32	2.9	1.0
Dual Speedometer, Radio	Mgmt.	0	7	10	29	54	3.3	.9
	Union	0	10	20	35	35	2.9	.9
	Total	0	8	13	31	48	3.2	.9
Advanced Event Recorders	Mgmt.	0	2	16	28	54	3.3	.8
	Union	0	30	30	20	20	2.3	1.1
	Total	0	11	21	25	43	3.0	1.0
Advanced Alerters	Mgmt.	0	16	33	21	30	2.7	1.1
	Union	0	20	20	10	50	2.9	1.3
	Total	0	17	29	17	37	2.7	1.1
ATCS	Mgmt.	12	0	9	23	56	3.5	.7
	Union	5	10	10	10	65	3.4	1.1
	Total	9	3	10	19	59	3.5	.8
Reliable Radios	Mgmt.	14	24	12	21	29	2.7	1.2
	Union	5	15	5	10	65	3.3	1.2
	Total	11	21	10	18	40	2.8	1.2

* Average based on a 4-point scale, No = 1, Low = 2, Mod = 3, Top = 4, using 44 management respondents and 21 union respondents.

Despite the fact that the interviewer emphasized that for these improvements, one had to assume system reliability and adequate crew training, many of the participants refused to accept these preconditions. This might also account for the low degree of consensus found within the participating groups.

F. "What Specific Design Improvements are Needed in the Area of Cab Layout and Crew Workstation Design (Beyond Current Design)?"

For this question, cab layout and workstation design was defined as "design of interior cab features to promote effective performance of the crew."

F-1. Frequency of Mention Data

Figure IV-6 depicts the major design suggestions offered. Only those getting five percent of the total responses are included. There were 118 responses by the 65 participants covering 24 specific design suggestions. These statistics should be considered in light of the response in Exhibit 1 which showed the greatest participant interest to be in this area.

Note in Figure IV-6 that code 513 - console-type cabs - received almost twice the responses of any other item. Both management and union saw the need to redesign the control stand.

Part of this response may stem from the fact that several railroads are now introducing the EMD SD-60M into service. This locomotive features a console or desk arrangement for controls and displays. Interestingly enough, although the union group is one-half the management group size, it accounted for as many mentions.

For this topic, the next most frequently mentioned design improvement was code 503 - enhanced outside visibility. Again, the response rate for the union group was twice that of management.

The stated reasons behind the proposed design suggestions included safety, crew comfort, and better train handling. Some of the participant comments included:

> *"We have fuel savers, we have [xyz] alerters, we have fuel gauges and what we're doing now is we're sticking a piece here, sticking a piece there, second speed indicator for the conductor or brakeman so he knows how fast we're going. It's got to the point that there is no place to logically stack the stuff and it's time for a redesign."*

> *"Unfortunately, when you find that the best way to enhance visibility you are usually giving something else away. So when you are trading off safety for visibility you have to stick with safety. So I would say that enhanced visibility would be a relatively low priority."*

> *"To be able to put the vital sources of information, such as the air gauges, the amp meter or the load meter, depending upon what you want to call that, and also the speedometer in a very convenient location that's not only there, but it is not going to detract from the man's or woman's ability to look out the windshield at the same time. Now sometimes with gauges now on the side, to read them you must*

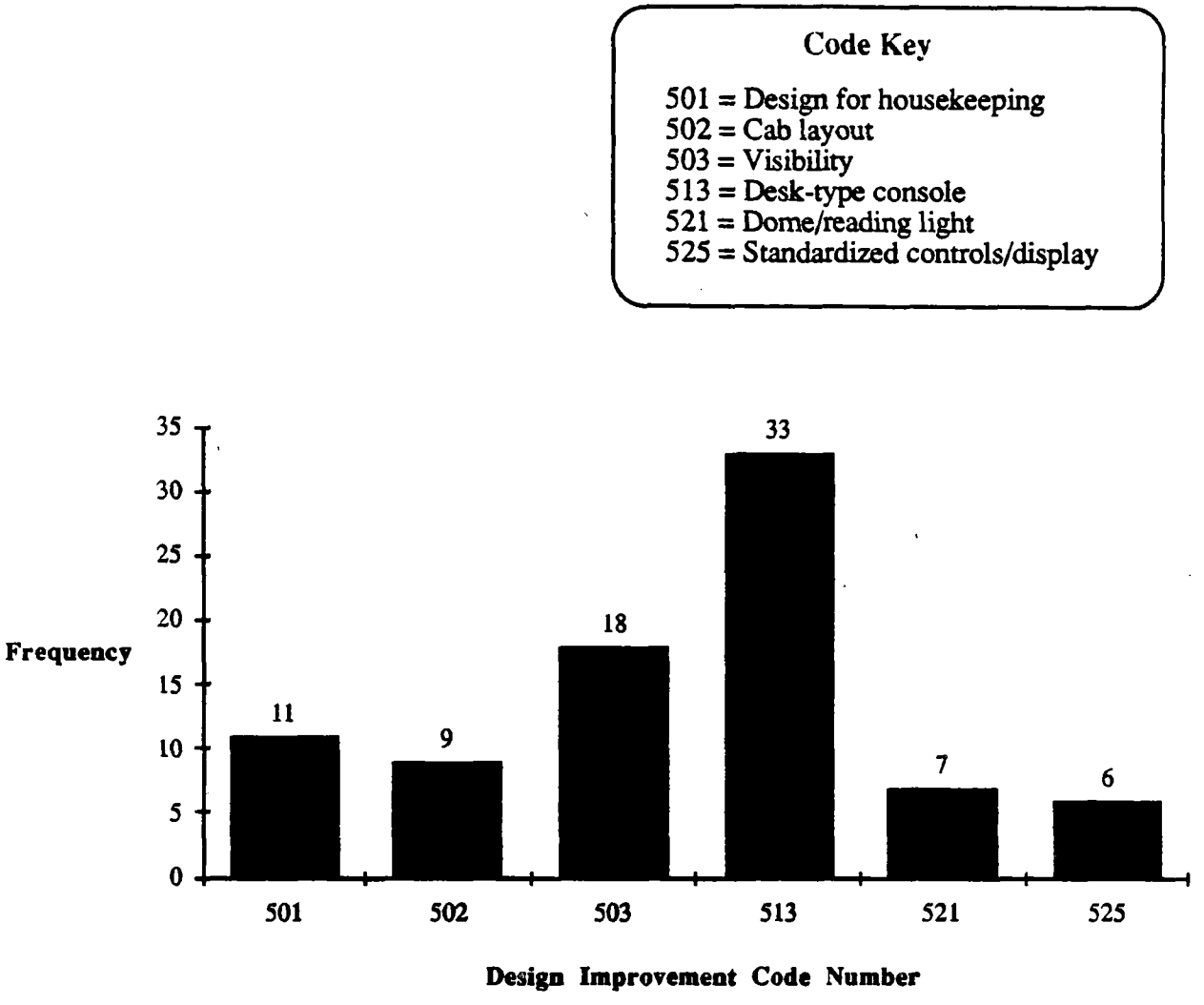

Figure IV-6. Frequency of mention data for cab layout and crew workstation design improvement. (Greater than five percent of all responses.)

turn your head away from the forward direction. On some of our diesels, we actually have a speedometer that is mounted up above the windshield and we get complaints from our engineers where it is constant raising of the head, and a soreness in the neck even, after a long trip."

F-2. Priority Ratings of Specific Design Improvements

Participants were asked to rate the priority for six proposed design improvements. These were:

1. Interior lighting and glare control
2. Improved cab layout
3. Enhanced visibility
4. Improved doors for normal and emergency use
5. Control stand redesign
6. Cab systems ease of maintenance

Table IV-6 summarizes the ratings for these six proposed improvements for all participants and for management and labor groups separately.

Except for "doors" where there was some difference in union and management ratings, these areas of design improvements received the highest ratings and had the greatest consensus between management and labor.

A look at the area of control stand redesign shows an average of 3.7 for ratings for both management and labor, and little disagreement within each group. That both groups are receptive to change in this area supports decisions by management to purchase the EMD SD-60M. While the data does not show it, there is some disagreement on whether control stand redesign calls for a console-desk arrangement or a redesigned island type control stand. As indicated by a respondent who represents his railroad's concern:

"The biggest problem I see that we have with the rest of the industry is we have got to have a bi-directional locomotive. We don't have turning facilities. We don't have hostlers. We can't afford the loss in productivity of a uni-directional locomotive."

There was also a consensus on the need for cab layout changes, including a wide range of ideas such as seat placement, workstations for the conductor, arrangement to improve housekeeping and greater headroom. This is illustrated by the following:

"Linoleum could be properly cleaned. I think that would have some benefits. Some kind of a trash hole would be a good idea. I'm not sure what the best way to design it, but get rid of the trash in the cab. It is a perpetual problem with people hanging clipboards on the back of the control stand, electric cabinets, bags and tape bags and all that. If someone would put a hole somewhere where you could throw the trash down like a laundry chute and all the garbage would go down there, it would give the crew a little more space. "

Other interesting results include the unions' concern for ease of maintenance, and the general concern for visibility and interior lighting.

TABLE IV-6

PRIORITY RATINGS FOR SELECTED CAB LAYOUT AND WORKSTATION DESIGN IMPROVEMENTS

Design Improvement		Priority (In % of Participants) Don't Know	No	Low	Mod	Top	Avg*	Std Dev
Lighting and Glare Control	Mgmt.	0	2	20	33	45	3.2	.8
	Union	0	5	10	40	45	3.3	.9
	Total	0	3	16	36	45	3.2	.8
Cab Layout	Mgmt.	2	2	8	19	69	3.6	.7
	Union	5	5	5	20	65	3.5	.8
	Total	3	3	7	19	68	3.6	.8
Enhanced Visibility	Mgmt.	0	7	21	31	41	3.1	.9
	Union	0	5	25	15	55	3.2	1.0
	Total	0	7	23	25	45	3.1	.9
Improved Doors	Mgmt.	0	10	38	24	28	2.7	1.0
	Union	0	10	5	30	55	3.3	.9
	Total	0	10	28	25	37	2.9	1.0
Control Stand	Mgmt.	0	2	3	16	79	3.7	.6
	Union	0	5	0	20	75	3.7	.7
	Total	0	2	2	18	78	3.7	.7
System Maintenance	Mgmt.	16	0	12	18	54	3.5	.7
	Union	35	0	15	25	25	3.2	.8
	Total	22	0	13	21	44	3.4	.8

* Average based on a 4-point scale, No = 1, Low = 2, Mod = 3, Top = 4, using 44 management respondents and 21 union respondents.

G. New Technology Application - "Do You Believe that New Technology (Computers, Electronics) Offers the Potential for Improved Locomotive Design?"

The general response to this question was positive, which suggests the industry sees the need to take advantage of new technology. The reasons for the few negative responses were centered around the concern for maintainability and reliability. The unions were concerned about whether training of engineers to use the technology properly would be done. A few union participants were concerned that the fascination with technology would lead to the introduction of "black boxes" which would do little for their performance at the expense of alternative crashworthiness and crew comfort changes. Some of the comments to the questions include:

> *"There are probably more things that he could see. One problem he has is there are many, many manufacturers making many devices so you have control stands in some cases with a multitude of magic boxes sitting on it -- fuel saver boxes, special speed indicators, odometers, telemetry devices, etc. I think if someone could come up with a CRT that essentially sits there and displays all these things, then you can ... it would be quickly a display [that] you can take all the electronics that make the display happen and place them somewhere else besides on top of the control stand. There are benefits in terms of visibility there, as well as giving him access to a lot of different stuff."*

> *"I think with the advent of CRTs, he can be looking ahead and he can be doing more planning. With more preparation, it will make the job safer and to make you a better engineer. Right now it is all 'seat of the pants,' you're in a reaction mode. We want to make this more of a proactive job."*

Examples of specific technology applications are shown in Figure IV-7. Ninety-five percent of the responses emphasize train handling applications with the highest frequency of mention associated with microprocessors for system diagnostics, ATCS and CRT's for planning purposes. There were 66 responses covering 24 different applications of new technology.

When asked, "Was ATCS important in future locomotive design," the response was positive. Seventy percent of the union participants and 93% of the management participants affirmed the importance of ATCS in future design.

H. Response to Ergonomic Questions

Participants were first asked whether they understood the term "ergonomics." Sixty-eight percent of the management participants and 19% of the union participants understood the term. Given that background, it was surprising to see the diversity of response to the question of "needed ergonomics in future cabs." Overall, the 65 participants offered 60 responses covering 23 ergonomic improvements. Those who did recognize the contribution of ergonomics were ready to specify several potential applications. Those included by order of frequency of mention:

1. Improved seat design (15%)
2. Display legibility (12%)
3. Digital displays (8%)
4. Advanced alerting system (8%)
5. Cab layout and control stand redesign (8%)

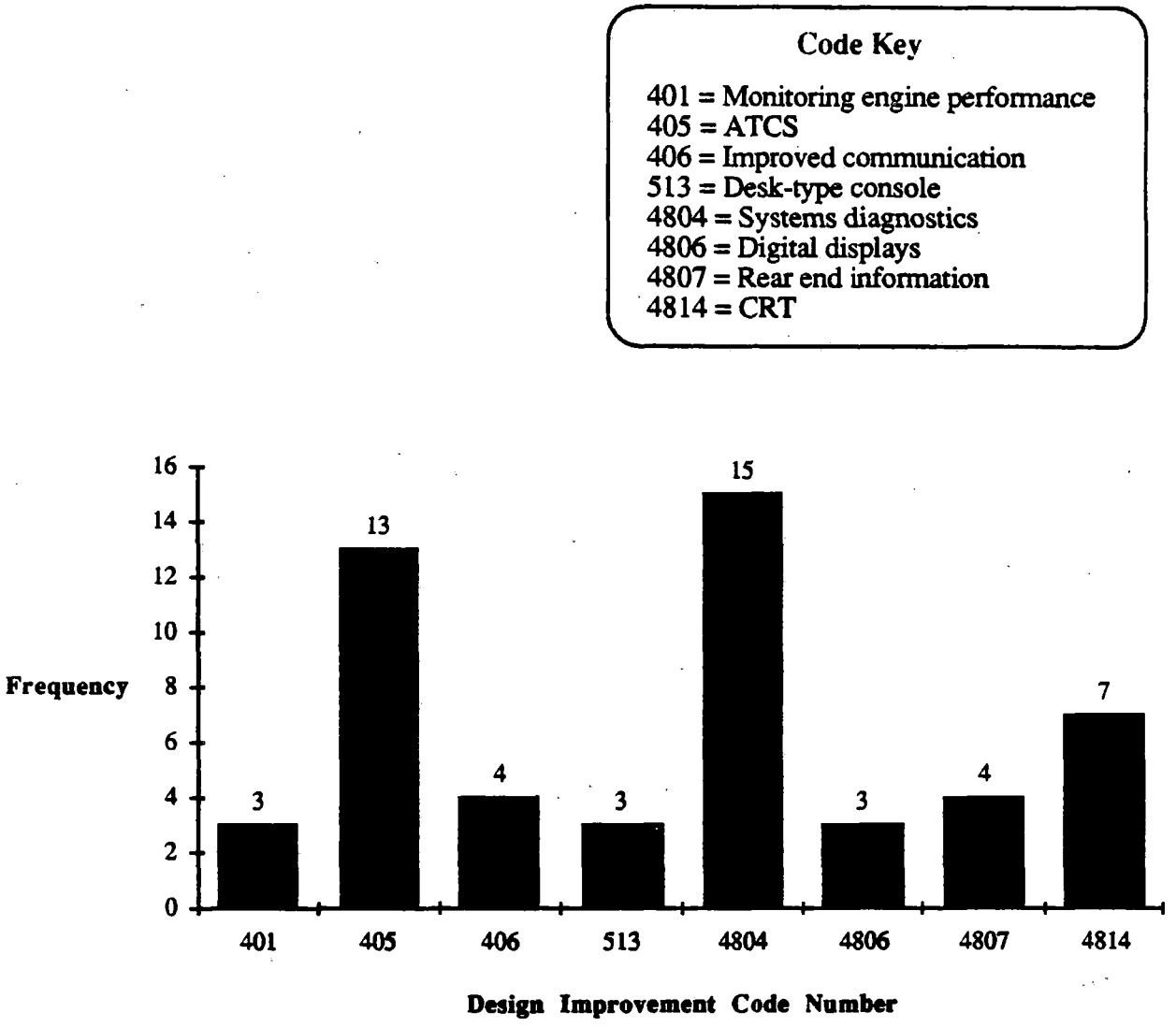

Figure IV-7. Suggested design improvements from new technology. (Greater than five percent of all responses.)

One participant raised a concern that ergonomics was not properly addressed in the new console designs now being introduced. Other comments included:

"I just have the feeling that so much of the present cab design is an afterthought. It isn't by design if you understand what I am trying to say. It is as if once it reaches the shop floor, it was left up to the whims of the people who install... well, we will put it up here or we will locate it here. It gives me a feeling of lack of design, lack of purpose, lack of thought. So I am very happy that you are doing what you are doing, getting out in the field and talking to people who... it just appears to me that people who have designed them and built them never rode in a cab."

"When you talk about displays, I agree that there is a tremendous advantage in being able to have the information displayed legibly and we have the conditions that in the daylight, the bright sunlight depending on how the instruments are designed, they may not be as legible and then when you go from bright sunlight into your tunnels or you are working at night and the instruments are lit up. A good example might be that, I have seen airplane cockpits where the way the instruments were laid out, they are laid out in a very useful way and you train people that instruments are always going to be in the same spots, so they can then set up a pattern of reading them in a logical order."

"Obviously, you've got to pay attention to ergonomics with that stuff. And, by God, it's time we do that, too. We're paying our people more than the airlines pay their people, and someone has to pay attention to it."

I. "If You Could Have Only One Design Improvement for New Locomotives, What Would You Want?"

The range of responses to this question embraced a wide variety of topics treated earlier. Thirteen percent opted for ATCS, 11% for noise reduction and 10% for console-type cab layout. Because of the diversity of responses, i.e., 24 different design improvements, it was decided to summarize the "one choice" responses by the general design areas as discussed with responses to Exhibit 1. When this is done (Figure IV-8), it can be seen that crew comfort features received the most responses, although there was no statistical difference among the top three areas, e.g., crew comfort, train handling and cab layout and crew workstation design. There were some surprises, such as some union choices in the area of train handling, especially the choice of ATCS over all other proposed design improvements. It is clear that ATCS is perceived by the respondents to offer safety and train handling benefits in the future.

J. Responses to Implementation of Candidate Design Improvements

In order to go one step beyond rating the priorities of given design suggestions, ten specific cab improvements were introduced to solicit whether they deserved implementation now and if so, the best mechanism to achieve implementation. These questions emphasized the comparison of crashworthiness items compared to crew comfort, train handling and cab layout design improvements. See Exhibits 6 and 6-A in Appendix B-2.

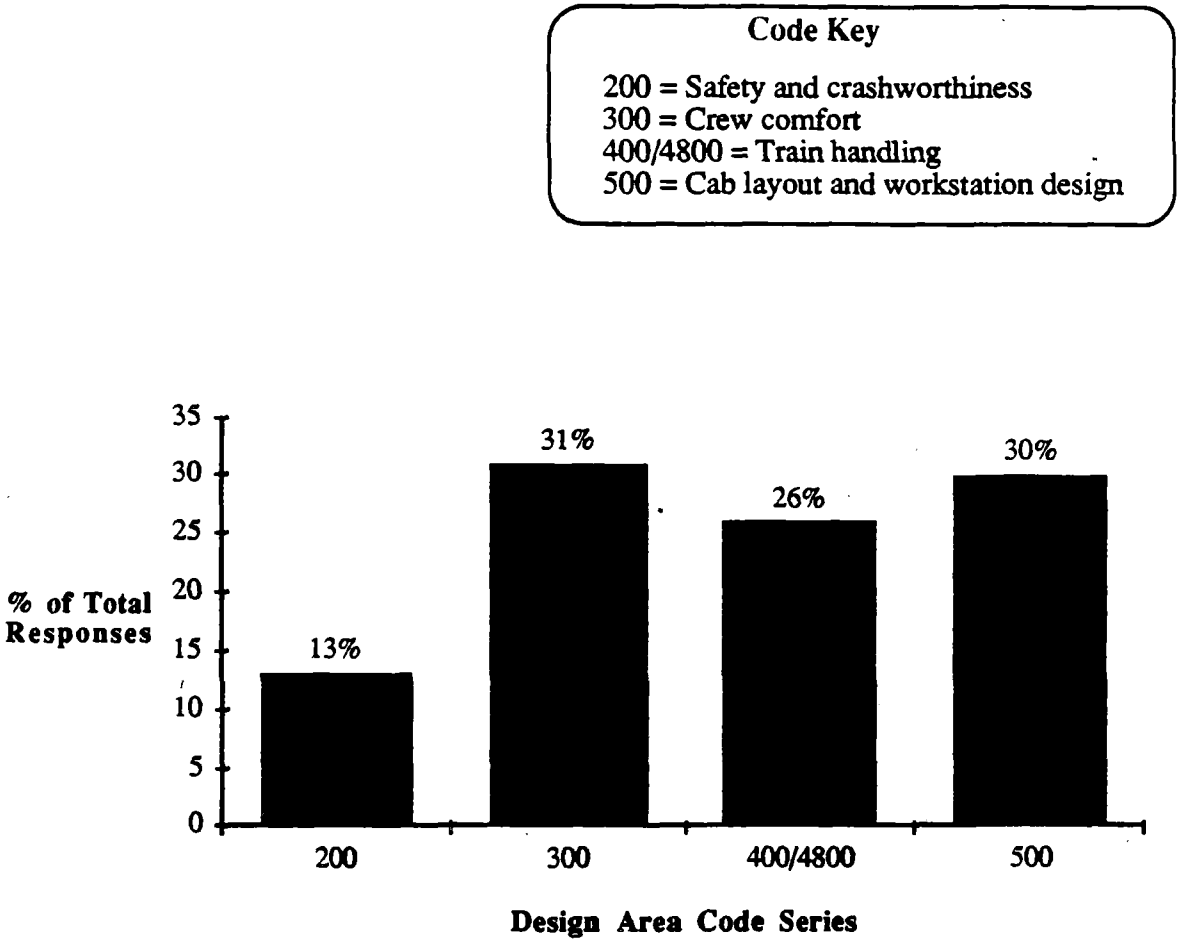

Figure IV-8. Responses to the question: "If you could only have one design improvement?" (Categorized into areas.)

Table IV-7 summarizes the response to this line of questioning. Considering only those responses which called for "implementation now" or "warrants serious consideration," it can be seen that over 85% of the management participants selected event recorders, cab visibility, noise reduction and ATCS. Correspondingly, the union selected cab visibility, vibration isolation, noise reduction, and collision posts. Note the greater interest by management for implementation of advanced event recorders and ATCS. The union favors thicker and wider short hoods, roll bars and collision posts. These results demonstrate the union emphasis on crashworthiness and management interest in train handling.

If response to the improvement was "implement now" or "warrants serious consideration," the participant was then asked the best way to implement such improvements, i.e., by Federal Regulation, AAR Standards, Company Policy or other. These data are shown in Table IV-8.

Of no surprise is the reluctance of management to use federal regulation as the means to implement new designs, preferring AAR standards, or in the case of ATCS, event recorders and alerters, the use of company policy. The union tends to rely on federal regulations to implement change.

This question should be viewed with some caution, because the choice for or against federal regulation would depend on the respondents' perception of the nature of the regulation. For example, management might accept performance standards, but not design standards. The difference here might be illustrated by the following example. A noise performance standard would require the maximum noise level in the cab to be less than 88 dB(A). Management would be free to ascertain the best way to meet the standard. A design standard would specify that 1/2" sound absorption material of given specification be placed on specific surfaces to effect noise reduction.

When participants were asked what forces tend to encourage design change, there were a wide variety of responses with three providing the largest number of responses. These were:

1. Organized labor (a management perception)
2. Accidents and their social impact
3. Government regulation

For forces inhibiting change, cost was the dominant response for both management and labor.

TABLE IV-7

THE NEED TO IMPLEMENT GIVEN IMPROVEMENTS

		% Now	% Serious Consideration	% Some Consideration	% No	% Don't Know
Anti-climbers	Mgmt.	29	38	0	28	5
	Union	55	15	0	10	20
	Total	37	31	0	22	10
ATCS	Mgmt.	19	67	0	5	9
	Union	35	40	0	20	5
	Total	24	58	0	10	8
Roll Bars	Mgmt.	12	33	2	37	16
	Union	55	25	0	5	15
	Total	25	30	2	27	16
Collision Posts	Mgmt.	32	47	0	21	0
	Union	55	45	0	0	0
	Total	39	47	0	14	0
Noise Reduction	Mgmt.	58	33	0	7	2
	Union	80	20	0	0	0
	Total	65	8	0	5	2
Wider & Thicker Hoods	Mgmt.	21	36	0	36	7
	Union	55	25	0	10	10
	Total	32	32	0	28	8
Shelf Couplers	Mgmt.	23	26	5	30	16
	Union	35	20	0	5	40
	Total	27	24	3	22	24
Cab Visibility	Mgmt.	28	58	0	12	2
	Union	45	45	0	10	0
	Total	33	54	0	11	2
Alerters	Mgmt.	37	35	0	28	0
	Union	50	25	0	20	5
	Total	41	32	0	25	2
Event Recorders	Mgmt.	51	42	0	7	0
	Union	40	35	0	25	0
	Total	47	40	0	13	0

TABLE IV-8

PREFERRED MECHANISMS TO IMPLEMENT NEEDED CHANGE

		% Fed	% AAR	% Co. Policy	% AAR or Co.	% Don't Know	% Not Req'd	% No Resp
	Mgmt.	12	58	12	2	2	0	14
Anti-	Union	50	20	5	0	0	0	25
Climbers	Total	24	46	10	2	2	0	16
	Mgmt.	7	28	47	2	7	0	9
ATCS	Union	35	15	5	0	0	0	45
	Total	16	24	33	2	5	0	20
	Mgmt.	14	47	12	2	2	9	14
Roll Bars	Union	55	10	5	0	0	0	30
	Total	24	35	10	2	2	6	21
	Mgmt.	12	67	7	2	0	0	12
Collision	Union	60	10	5	0	0	0	25
Posts	Total	27	49	6	2	0	0	16
	Mgmt.	21	47	12	2	5	2	11
Noise	Union	70	20	5	0	0	0	5
Reduction	Total	37	38	10	2	3	2	8
Wider &	Mgmt.	5	49	23	2	2	5	14
Thicker	Union	45	30	5	5	0	0	15
Hoods	Total	17	43	17	3	2	3	15
	Mgmt.	7	49	16	2	5	2	19
Shelf	Union	45	5	5	0	0	0	45
Couplers	Total	19	35	13	2	3	2	26
	Mgmt.	7	58	19	2	2	2	10
Cab	Union	50	25	5	0	0	0	20
Visibility	Total	21	48	14	2	2	2	11
	Mgmt.	16	26	40	2	0	2	14
Alerters	Union	45	10	15	0	0	0	30
	Total	25	21	32	2	0	2	18
	Mgmt.	19	23	47	2	0	5	4
Event	Union	45	10	10	0	0	5	30
Recorders	Total	27	19	35	2	0	2	15

V. SUMMARY AND CONCLUSIONS

This survey has demonstrated that the rail industry has a keen sense of the need for change in future locomotive design. The 65 participants included a cross section of rail management leaders representing operations departments, engineering departments, and road foremen of engines. Union leaders and current engineers on the job were both represented. The range of jobs, from company vice presidents to operating engineers insured that the responses were representative of both decision makers and users of locomotives. Indeed, 33% of the management and 100% of the union participants had experience in engine service.

A. Frequency of Response

Table V-1 presents the responses to the seven key questions of the survey. These data are a measure of the interest and knowledge about this subject of needed design changes in future locomotives. The 65 participants in the survey generated 838 responses covering over 124* different design suggestions. These 124 suggestions came from six questions on crashworthiness, crew comfort, train handling, cab layout and crew workstation design, new technology and ergonomics. The responses were heaviest in crew comfort issues and cab layout and workstation design areas. It was noteworthy that there was little union/management difference in the response for four areas of design change.

Improvements for crashworthiness generated 100 responses across 23 design suggestions with a delethalization of interior surfaces, and doors for egress having the largest relative frequency. Similar data is shown for the other three design areas.

Console layout designs elicited the most responses. Seat redesign, noise control and ATCS were also highly mentioned.

B. Priority Ratings of Selected Improvements

Twenty-three selected design improvements across the four areas were offered for priority ratings within Exhibits 2-5. The summary of these data is reflected in Table V-2. Only the percentage of respondents who placed this item in the top priority and the average rating and standard deviation of ratings are shown. These data are drawn from earlier Tables IV-3 through IV-6.

The four improvements receiving the most top priority votes were control stand redesign, cab layout, noise reduction and seat design. In terms of average rating, the same result occurs, except ATCS replaces seat design for the top four.

These design improvements also have lower rating standard deviations which suggest the highest consensus among raters.

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* Since the same design improvement could be suggested in more than one question, the total number of unique improvements is not the arithmetic sum of the data in Table V-1.

TABLE V-1

FREQUENCY OF MENTION SUMMARY FOR SURVEY QUESTIONS

Topic	Number of Responses	Number of Specific Design Improvements	Dominant Frequency of Mention Responses
General (Areas) of Design	281	60	Crew Comfort Cab Layout
Crashworthiness Design Improvements	100	23	Doors/Egress Delethalization
Crew Comfort Improvements	128	18	Seat Design Noise Reduction
Train Handling Design Improvement	81	31	ATCS
Cab Layout and Crew Workstation Design Improvements	118	24	Cab Layout Outside Visibility
New Technology	66	23	System Diagnostics ATCS
Ergonomics	64	25	Seat Design Display Legibility

TABLE V-2

SUMMARY OF PRIORITY RATINGS FOR 23 PROPOSED IMPROVEMENTS

Proposed Design Improvement	% Rated Top Priority	Average* Rating	Rating Standard Deviation
Control Stand	78	3.7	.7
Cab Layout	68	3.6	.8
Noise Reduction	64	3.5	.8
Seat Design	60	3.4	.9
ATCS	59	3.5	.8
Climate Control	54	3.4	.8
Dual Speedometer/ Radio/Speaker	48	3.2	.9
Lighting/Glare Control	45	3.2	.8
Enhanced Visibility	45	3.1	.9
Systems Maintenance	44	3.4	.8
Advanced Event Recorders	43	3.0	1.0
Wider/Thicker Short Hood	43	3.0	1.0
Stronger Collision Posts	41	3.1	.9
Reliable Radios	40	2.8	1.2
Anticlimbers	38	3.1	.9
Improved Doors	37	2.9	1.0
Advanced Alerters	37	2.7	1.1
Improved Sanitation	32	3.1	.8
Engine Monitoring/ Reset Controls	32	2.9	1.0
Vibration Isolation	29	2.8	1.0
Roll Bars	24	2.8	.9
Shelf Couplers	22	2.6	1.1
Water Quality	14	2.0	1.1

* Based on a 4-point scale.

C. Union-Management Comparisons

Table V-3 depicts those improvements in which union-management had close, some and little agreement. The criterion used was the statistical difference in the average scores of rated improvement ideas. If the rating difference was 0.3 or less, it was considered a close agreement. No agreement reflected greater than 0.7 in mean ratings differences. The range between these two difference values (i.e., 0.3 to 0.7) represents some agreement.

It should be noted that of the 23 selected design improvements, 13 showed close agreement between management and labor, and only three showed no agreement. Interestingly enough, two of these were in the crashworthiness area.

Union-management comparisons are also reflected on implementation need, and strategies for change. Only cab visibility and noise reduction showed a close union-management agreement on the need for implementation. Understandably, the union sees federal regulation as the key for promoting change, while management prefers AAR standards and company policy to implement change.

Other statistical tests were performed on the priority data. No difference was found between union leadership and engineers actively operating trains. Staff positions within a railroad indicated little difference, suggesting a basic company philosophy. Some differences between railroads were found, especially in the area of cab layout and crew workstation design. This reflected the need for one railroad to have bi-directional control of locomotives.

D. Some Cautions on Data Interpretation

Since all questions posed in the survey had the qualifier, "beyond current design," certain design improvements were given low priority ratings because good design was already in place. Six of the eight railroads now specify anticlimbers on new locomotive shipments. Hence, if this qualifier were not present, anticlimber ratings would be much higher. Similarly, for most participants, the water quality problem appeared solved and, hence, little need was expressed for redesign.

Some design items led to controversy not only between participants, but also within participant groups by virtue of past experience with the design concept. Advanced alerters typify this problem. Many participants believed there was no need to alert crews. This was essentially a statement of principle, i.e., crews ought to be alert. Others saw the need to scrap old ineffective devices, e.g., deadman pedal, "touch type" systems, and automatic train control and develop new alerters. Others argued that the most sophisticated system available today can actually distract the engineer from key decision making. Clearly, this topic is far from resolved today.

The conflict between console-type control station designs and bi-directional movement poses a dilemma for standardization of controls for new locomotive specifications. Consideration of alternative designs to the console might have merit if fly-by-wire control miniaturization is possible, i.e., use of small portable control boxes.

TABLE V-3

UNION-MANAGEMENT DIFFERENCES IN PRIORITY RATINGS FOR 23 PROPOSED DESIGN IMPROVEMENTS

Close Agreement (13)	Some Agreement (7)	No Agreement (3)
Shelf Couplers	Temperature Control	Roll Bars
Vibration Isolation	Noise Reduction	Collision Posts
Seat Design	Dual Displays,Radios	Event Recorders
Water Quality	Anticlimbers	
Sanitation Facilities	Wide Hoods	
ATCS	Reliable Radios	
Cab Layout	Doors	
Enhanced Visibility		
Control Stand Redesign		
Engine Monitoring		
Advanced Alerting		
Lighting & Glare Control		
Ease of Systems Maintenance		

E. Needed Research and Education

Clearly, statements on lack of agreement on the efficacy of such items as alerters, ATCS, air conditioning and ergonomics in crew workstation layout suggests both education and research needs.

Short courses and workshops in cab ergonomics, ATCS design, and approach to practical alerting systems would offer opportunities to define system objectives and parameters.

Some research on ATCS effects on engineer performance is now in place. Clearly, crews must be shown the potential for workload reduction from such systems. Basic research on task-related alerters is still needed. The application of ergonomic principles is especially needed now with the introduction of the new console-style cab designs.

VI. IMPLICATIONS OF THE SURVEY TO MOCKUP DESIGNS AND EVALUATIVE STUDIES

This survey is only a beginning step in the promotion of needed and effective changes in locomotive design. Once a need for a change in a design area has been identified it then becomes necessary to evaluate candidate designs. These evaluations can involve the use of static mockups or full mission train operation simulators. For example, mockups can be used to evaluate doors, stairs, cab layouts, visibility, and control stand redesign issues. The effects of train handling aids and whether they will lead to reduced workload, increased alertness and overall acceptance by train crews can be examined by actual train operation in simulators.

These issues suggest two areas of follow up in the evolution of improved cab design given the needs and interests found in this survey, i.e., static mockups and full mission simulation of proposed train handling, crew comfort and display-control proposals.

A. Mockups

Mockups can serve a useful purpose in evaluating spatial configuration of proposed designs. If the spatial arrangements can be made flexible, i.e., be moved, it is possible to have subjects (locomotive engineers) rate alternative layouts. It must be noted that for some issues (e.g., candidate seat designs), long term sitting is required to avoid the "car showroom effect." Moreover, the location of some equipment (e.g., cab heaters), can materially affect seat postural fatigue if these are used as footrests. Life cycle tests are needed for seat adjustment features.

Mockups then can be used to evaluate:

1. Design and location of stairs
2. Design and location of doors, latches, handles
3. Design of alternative seats
4. Design of seat adjustment
5. Allocation of cab space to seats, controls, displays, sanitation facilities, etc.
6. Housekeeping proposals and location of special equipment, e.g., fire extinguishers
7. Demonstration of delethalized cab surfaces
8. Maintenance access
9. Movement within cab and egress in emergencies
10. Legibility and functional reach evaluations of console designs

Mockups should not be perceived as merely design examples to examine. Well-designed rating procedures, specific environmental conditions, order of presentation and functional use of mockup items must be considered. Moreover, anthropometric effects (sizes and shapes of users) must be controlled to represent the population of cab crew members.

B. Full Mission Simulation

Train operation simulation is an effective way to evaluate the impact of design improvements on train performance and crew comfort perceptions. Care must be exercised to avoid introducing too many changes at one time and also trying to evaluate the effect of any one improvement. Simulation can be used to evaluate the following:

1. Crew Comfort Design Proposals

   a. Noise and temperature control and their effects on train handling and perceived measures of comfort
   b. Cab visibility and performance
   c. Radio speaker design and location
   d. Seat design and perceived psychological and physiological measures of comfort over extended hours of use

2. Train Handling Design Proposals

   a. ATCS - various versions, e.g., text vs. graphics, amount of information, etc.
   b. Digital displays
   c. Advanced alerters
   d. System diagnostic aids
   e. New electronic devices in general

3. Crew Workstation Design Proposals

   a. Console designs and their long-term effect on performance and crew fatigue
   b. Seat locations
   c. Conductor workstations
   d. CRT's for planning
   e. Equipment diagnostic and engineer performance warning systems

The above represent a few of the applications of simulators for evaluative purposes. Given careful experimental design, such simulations can be useful in ascertaining the full impact of design improvements and lead to better and standardized design configurations.

APPENDIX A

LITERATURE REVIEW AND BIBLIOGRAPHY

A literature review was conducted using the On-Line Computer Search system at The Ohio State University. Also the Transportation Research Information Service (TRIS) database was accessed.

In terms of crashworthiness, much of the important work in this area was completed in the late 70's, the most comprehensive study being from the Boeing Vertol Company which designed a locomotive cab capable of deflecting overriding vehicles upward, resisting secondary impact, and providing a survivable area for the crew.

Task analyses have been performed on the engineer's working environment and many cab designs have been based on the results. Design principles dealing with the fields of structure, visibility, environment, anthropometrics, controls and instrumentation have been developed. A number of studies have suggested the basic characteristics of an optimum cab layout. Human factors studies have described the design for the cab of the future, as well as modifying existing designs. However, it appears that much of this information is unknown to or disregarded by locomotive manufacturers. Another factor responsible for the lack of ergonomically designed cabs may be the resistance to change by the industry itself, and the cost incurred by design changes.

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APPENDIX B-1

SURVEY PROTOCOL

R & R Research, Inc. Interview Protocol

I. Introductions

I'm _____, representing _____, and this is _____, representing_____.
[Develop any rapport you deem necessary to melt any ice.]

II. Lead In

"I want to thank you for taking the time to participate in this survey. Although you have some idea of why we are here, let me recap our mission. We wish to get your perceptions regarding possibilities and priorities for locomotive redesign. We are talking to a group of people like yourself who are knowledgeable about the industry. In doing this, we hope to get some new insights about locomotive design and design improvements.
"To obtain your views, I will be asking a series of prepared questions, using this interview form to guide our discussion. It will help keep me "on track" and reduce the likelihood that I'll forget something. So, I'll be referring to it from time to time. I hope it doesn't distract you.

"I might say that the form was developed by our project staff with the help of the LCCC (Locomotive Control Compartment Committee). [Elaborate on composition.] We found that by using it, our session will take about 40 minutes. However, if you have a lot to tell me, or if we overlook something important that you particularly want to discuss, we can take longer if you want."

"It is important to note that it is your own point of view that is important to us. We want to know what you think and how you feel about things. So you should realize that there are no right or wrong answers. To put it another way, your opinions are what counts. If anything, they are the "right" answers."

"Both your comments and your organization will be treated confidentially. Only our project team will have access to the detailed information that we gather. When we have finished interviewing officials from the other railroads, we will be preparing a summary report of our results. It is this summary which will be made available to participating groups. And even there, the information will be organized by job positions and not by a particular railroad."

Do you have any questions before we start? [Pause]
[Briefly answer questions that will involve respondent's willingness to participate, get back to those which can be addressed after the survey.]

"Because I don't write very fast and legibly, I would like to tape our session for future reference. Do you mind if I do this? [If there are no objections] Thanks."
[Answer questions; unobtrusively turn on recorder]
[If there are objections] "OK, I'll do my best without it."

III. General Questions Regarding Redesign Area

A1. "Let's focus on road freight locomotives of the future with 3-5 crew members in the cab. First off, in thinking about future locomotive design, what do you believe to be the problem areas that really must be addressed?

[Probe for clarity and your understanding] _____
[Ascertain the "why's" behind comments if possible]

A2. "Can you think of any other areas that need redesign or rethinking?"

[Probe for clarity and your understanding] _____

A3. "You have identified _____ and _____ as areas where redesign is needed. Let me share with you an exhibitthat we have prepared based on some preliminary information. Let's see how these compare."

[Show Exhibit 1]

[Point to and read each of the 4 areas and their illustrations]

"You'll note that _____ that you mentioned earlier would fall into this list."

[Compare and match up the nominations provided by the respondent to the four areas on the list. Link to list wherever possible.]

"Let me ask you to consider just the printed list for a moment. Please tell me how the areas would rate in priority from your point of view when it comes to needed locomotive redesign in the future? We realize that these areas or categories are not independent. Still we'd like your judgement on their priority for future design improvement. Assign each to a priority box. Note more than one area can be assigned to a box"

["Now, let's go back to the _____ area that you mentioned at the beginning. If you were to assign this area to the appropriate box, where would it be placed?" [If this area not encompassed in the form listed]]

IV. Specific Redesign Needs

"Great. This is useful information."

A. "Now let's get a little more specific. You have noted that one of the areas on our prepared list was "locomotive structure to enhance crashworthiness." I now want to solicit other specific design improvements needed within this area.

[Relate any previous unsolicited improvements which fall into this area.]

[Probe for clarity and understanding] _____
[Ascertain "why needed" if possible]

"Good. Now let me see how your ideas match up with some thoughts that our team has put together in this area."

[Show Exhibit 2]

"Let's compare your ideas to this list."

[Read list on Exhibit 2 for clarity; compare respondent's nominations to the list, integrating them in the list whenever possible. Use illustrations here.]

"After looking over this list of specific areas for redesign within the area of locomotive structures, I'd like you to tell me what priority for future design you would give each of these suggested improvements. Let's assign these improvements to the appropriate box."

B. [Repeat A for crew comfort features [Exhibit 3]]

C. [Repeat A for train handling [Exhibit 4] (Use illustrations)]

D. [Repeat A for cab layout and crew workstation design [Exhibit 5] (Use illustrations)]

V. Do you believe that new technology (for example, computers, electronics) offers the potential for improved locomotive design? (assumes associated maintenance and crew training)

[If positive, got to A; if negative, go to C]

A. "Could you give me an example." _____

B. "Any other design improvements possible from new technology?
_____

C. "We've referred to the proposed Advanced Train Control Systems (ATCS) earlier. This is a good example of new technology."

"How important is this system in future locomotive design?
[Skip if discussed earlier]
[Probe] _____

D. Some people have suggested that "ergonomics" could have a significant impact on locomotive design improvement. Are you familiar with this term? [If not, explain] - "designing displays and controls around the capabilities of the human operator." [Show illustrations]

E. Do you feel current locomotive design reflects good or poor ergonomics? [Seek examples] _____
In what areas are better ergonomic design needed? _____

VI. Before we get off of the topic, are there any other issues of locomotive redesign that you feel are important, but that we have failed to cover so far?" _____

VII. A. Exhibit 6 shows 10 specific recommended design improvements covered from prior interviews. For each of these, could you check on the form whether each warrants implementation.
[Have respondent check the appropriate box in exhibit 6 & 6a.]

B. Using Exhibit 6a, would you check the best way to implement those ideas which merit implementation.

C. For those you've indicated warrant implementation, are there forces which would promote or inhibit such implementation? _____

VIII. "If we assume a new locomotive today will cost about $1,500,000, what % of this amount do you think should be allocated to pay for the inclusion of ideas you endorsed in Exhibit #6?"_____

IX. In closing, if you could have only one of all the design improvements discussed earlier for the next locomotive model, which one would you choose? _____

X. Closing

"I have gotten a lot of insight from this interview. I particularly liked your ideas about _____. I want to thank you again for your time. By the way, when I get back to my office and review my notes, I may have need for a clarification or two. Could I give you a call? At what number? _____"

XI. Bio Sketch

APPENDIX B-2

SURVEY DATA LOG

Interviewee _____
Interviewer _____
Date_____

Data Log

A. Name of person interviewed _____
Title _____

B. Name of staff person conducting interview
_____

C. Name of other person(s) at interview
_____

D. Time of interview start _____

E. Time of interview completion _____

F. Date of interview _____

G. Location of interview _____

H. Was tape recorder used _____

I. Phone number of person interviewed for follow-up _____

J. Special notes: (interruptions, problems, etc.) _____
_____

XI. Biosketch

Length in current position _____

Length in the railroad industry _____

Engineer Service - Engr. Fireman - # years _____ when _____

Years in crew training and management _____

Years in developing purchasing specifications for locomotives _____

Other relevant background _____

Interviewee _____
Interviewer _____
Date _____

DEFINITIONS FOR EXHIBIT 1 DESIGN AREAS

(Use if necessary to clarify)

A.	Crashworthiness:	Protective structures to minimize injury from rollovers, collisions at grade crossings and low speed impact with other trains.
B.	Crew Comfort:	Systems to make crew members comfortable over an 8 - 10 hour tour of duty.
C.	Train Handling:	Systems to promote improvements in speed control, authority enforcement and control of slack.
D.	Cab Layout:	The design of interior cab features to promote effective performance of the crew.

Interviewee _____
Interviewer _____
Date _____

EXHIBIT 1

AREAS OF NEEDED LOCOMOTIVE REDESIGN BEYOND PRESENT DESIGN

	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority
A. Locomotive Structures for Crashworthiness					
B. Crew Comfort Features					
C. Train Handling					
D. Cab Layout & Crew Work Stations					
E. Other _____					
	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority

III. Areas Suggested in Open-Ended Probe

Pre-Exhibit _____
_____
_____
_____

Post Exhibit _____
_____
_____
_____

Interviewee _____
Interviewer _____
Date _____

EXHIBIT 2

NEEDED DESIGN IMPROVEMENTS WITHIN THE AREA OF LOCOMOTIVE STRUCTURE BEYOND PRESENT DESIGN FOR LOW SPEED IMPACT

	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority
A. Anticlimber (1-1/2")					
B. Roll Bars (Support loaded hopper car)					
C. Collision Posts (500,000 lbs. each)					
D. Full Width and Thicker (3/8") Short Hoods					
E. Shelf Couplers					
F. Other _____					
	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority

Design improvements suggested in open-ended probe

Pre-Exhibit _____
_____
_____
_____

Post Exhibit _____
_____
_____
_____

Interviewee _____
Interviewer _____
Date _____

EXHIBIT 3

NEEDED DESIGN IMPROVEMENTS WITHIN THE AREA OF CREW COMFORT BEYOND PRESENT DESIGN

	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority
A. Heating/Air Conditioning (Temperature Control)					
B. Noise Reduction (Through better insulation)					
C. Vibration Isolation of Cab					
D. Improved Seat Design					
E. Improved Water Quality					
F. Improved Sanitation Facilities					
G. Other _____					
	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority

Design improvements suggested in open-ended probe

Pre-Exhibit _____
_____
_____
_____

Post Exhibit _____
_____
_____
_____

Interviewee _____
Interviewer _____
Date _____

EXHIBIT 4

NEEDED DESIGN IMPROVEMENTS WITHIN THE AREA OF TRAIN HANDLING BEYOND PRESENT DESIGN

	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority
A. Improved Engine Monitoring Devices & Their Reset Controls					
B. Dual Speed Displays, Radios and Speakers					
C. Event and Speed Trace Recorders					
D. Advanced Alerting Systems					
E. Advanced Train Control Systems					
F. More Reliable Radios					
G. Other _____					
	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority

Design improvements suggested in open-ended probe

Pre-Exhibit _____
_____
_____
_____

Post Exhibit _____
_____
_____
_____

Interviewee _____
Interviewer _____
Date _____

EXHIBIT 5

NEEDED DESIGN IMPROVEMENTS WITHIN THE AREA OF
CAB LAYOUT AND CREW WORKSTATION DESIGN BEYOND CURRENT DESIGN

	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority
A. Interior Lighting & Instrument Glare Control					
B. Improved Cab Layout					
C. Enhanced Visibility (Outside)					
D. Doors for Normal Use and Emergencies					
E. Engineer Control Stand and Crew Workstations					
F. Ease of Cab Systems Maintenance					
G. Other _____					
	Don't Know	No Priority	Low Priority	Moderate Priority	Top Priority

Design improvements suggested in open-ended probe

Pre-Exhibit _____
_____
_____
_____

Post Exhibit _____
_____
_____
_____

Interviewee _____
Interviewer _____
Date _____

DATA FORM FOR V - IX

V. New technology (circle) Positive Negative

A. Examples _____

_____

B. _____

_____

C. ATCS - Yes No _____

_____

_____

D. Ergonomics - Familiar? Yes No

E. Current Design Reflection of Ergonomics

Positive Negative

_____

_____

_____

_____

_____

VI. Final Ideas _____

_____

VII. See Sheets

VIII. % of locomotive price allocated to ideas in Exhibit #6 _____

IX. One choice over all improvements _____

Interviewee _____
Interviewer _____
Date _____

EXHIBIT 6

IMPLEMENTATION RECOMMENDATIONS FOR CANDIDATE LOCOMOTIVE REDESIGN SUGGESTIONS

SUGGESTION	Warrants Implementation Now	Deserves Serious Consideration	Not Needed	Don't Know
A. Anticlimbers				
B. Advanced Train Control System				
C. Roll Bars				
D. Collision Posts				
E. Noise Reduction				
F. Wider and Thicker Short Hood				
G. Shelf Couplers				
H. Cab Outside Visibility				
I. Alerters				
J. Event Recorders				

Check appropriate box

Interviewee _____
Interviewer _____
Date _____

EXHIBIT 6a

IMPLEMENTATION STRATEGIES FOR LOCOMOTIVE REDESIGN SUGGESTIONS

SUGGESTION	Best Implemented By: Federal Regulation	AAR Standards	Company Policy	Other
A. Anticlimbers				
B. Advanced Train Control System				
C. Roll Bars				
D. Collision Posts				
E. Noise Reduction				
F. Wider and Thicker Short Hood				
G. Shelf Couplers				
H. Better Cab Visibility				
I. Alerters				
J. Event Recorders				

Check appropriate box

VIIC. Promoting Forces _____
_____

Inhibiting Forces _____
_____

Interviewee _____
Interviewer _____
Date _____

XI. Biosketch

Length in current position _____

Length in the railroad industry _____

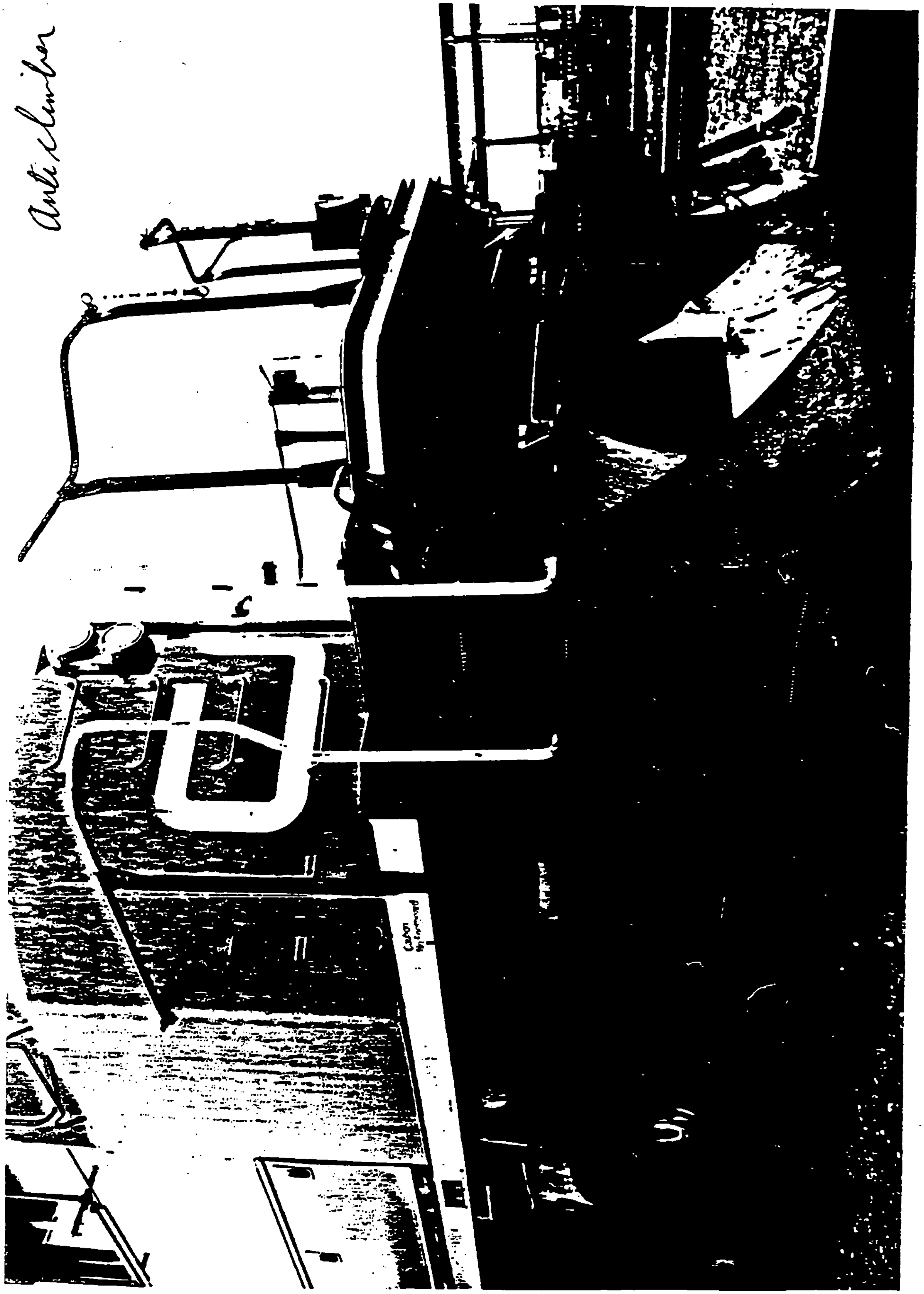
Engineer Service - Engr. Fireman - # years _____ when _____

Years in crew training and management _____

Years in developing purchasing specifications for locomotives _____

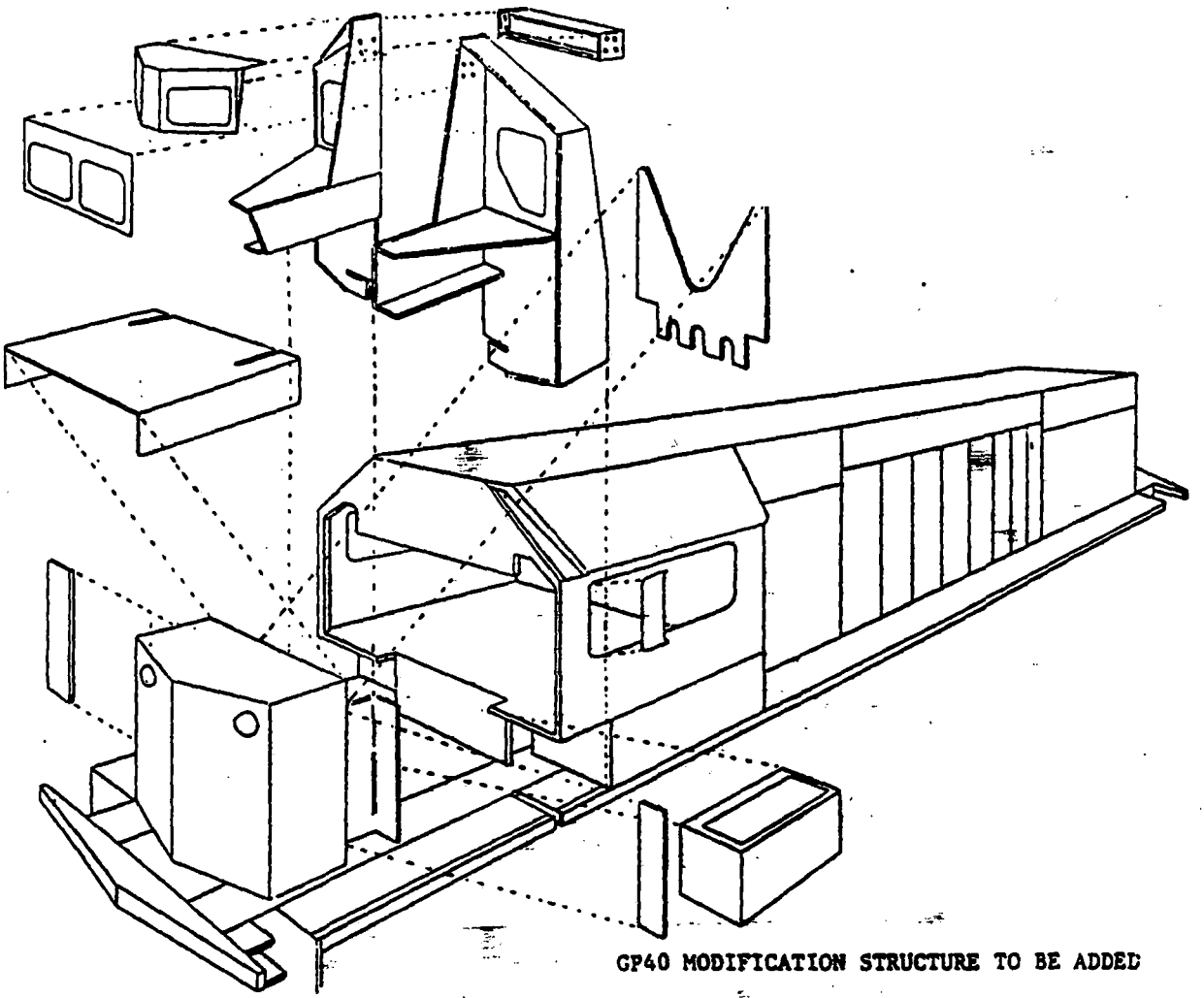
Other relevant background _____
_____

PHOTOGRAPHS USED TO PROMPT PARTICIPANTS DURING SURVEY

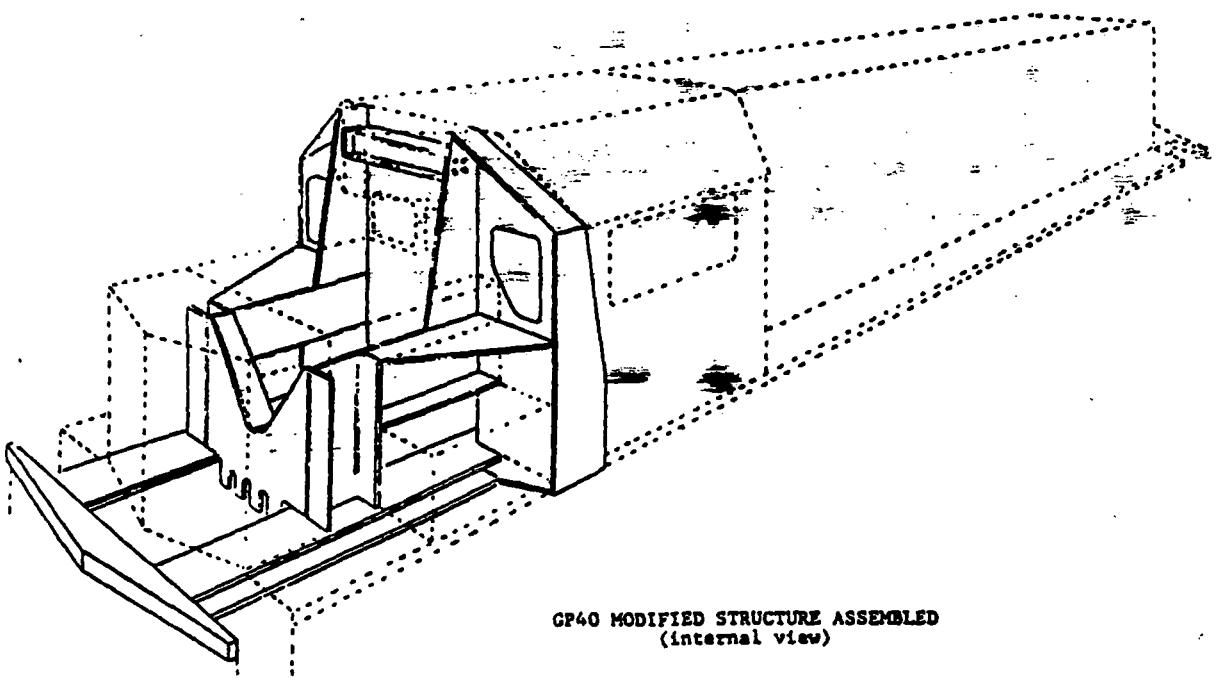


Anti climber

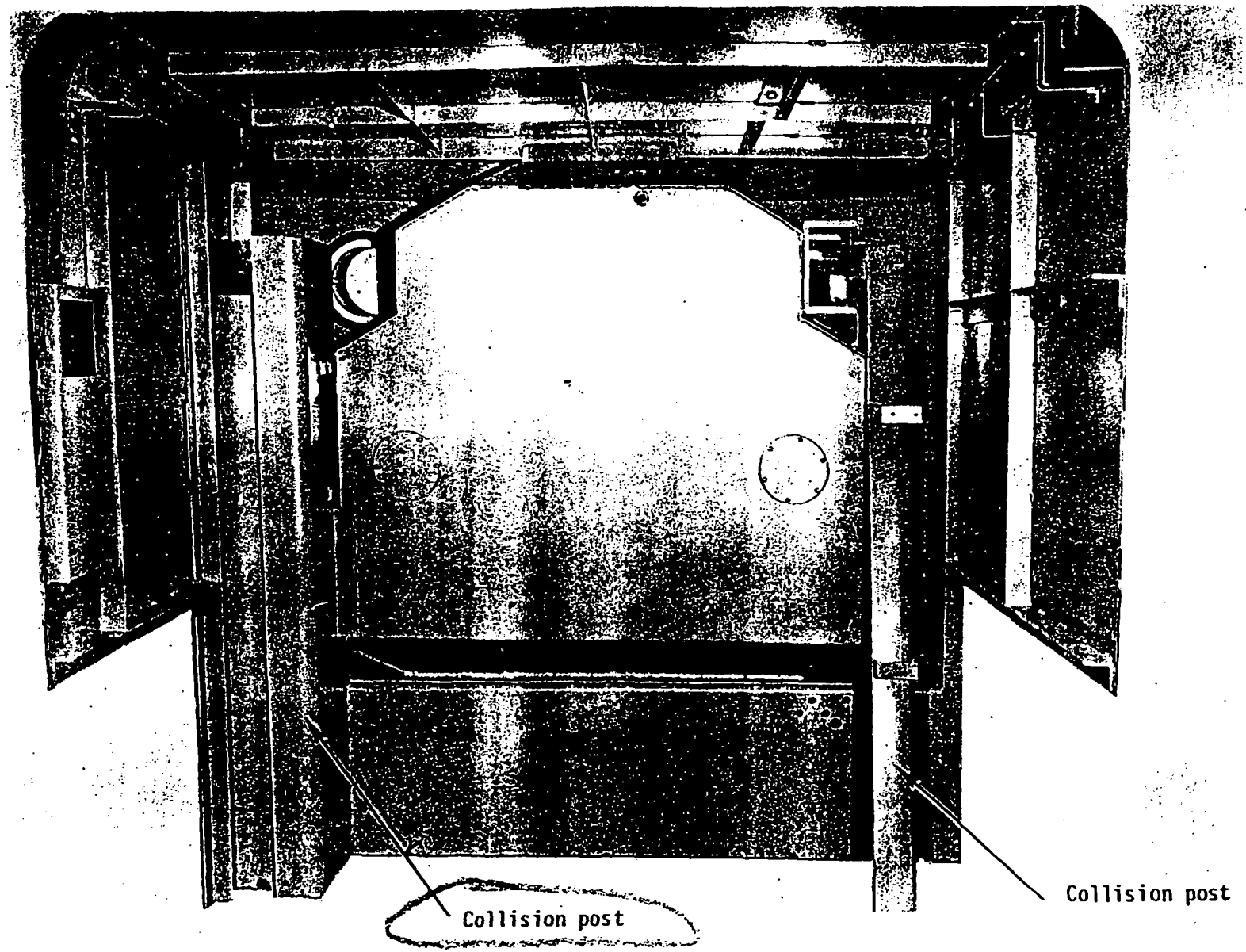
Illustration of
Roll Bar Concept



GP40 MODIFICATION STRUCTURE TO BE ADDED



GP40 MODIFIED STRUCTURE ASSEMBLED
(internal view)



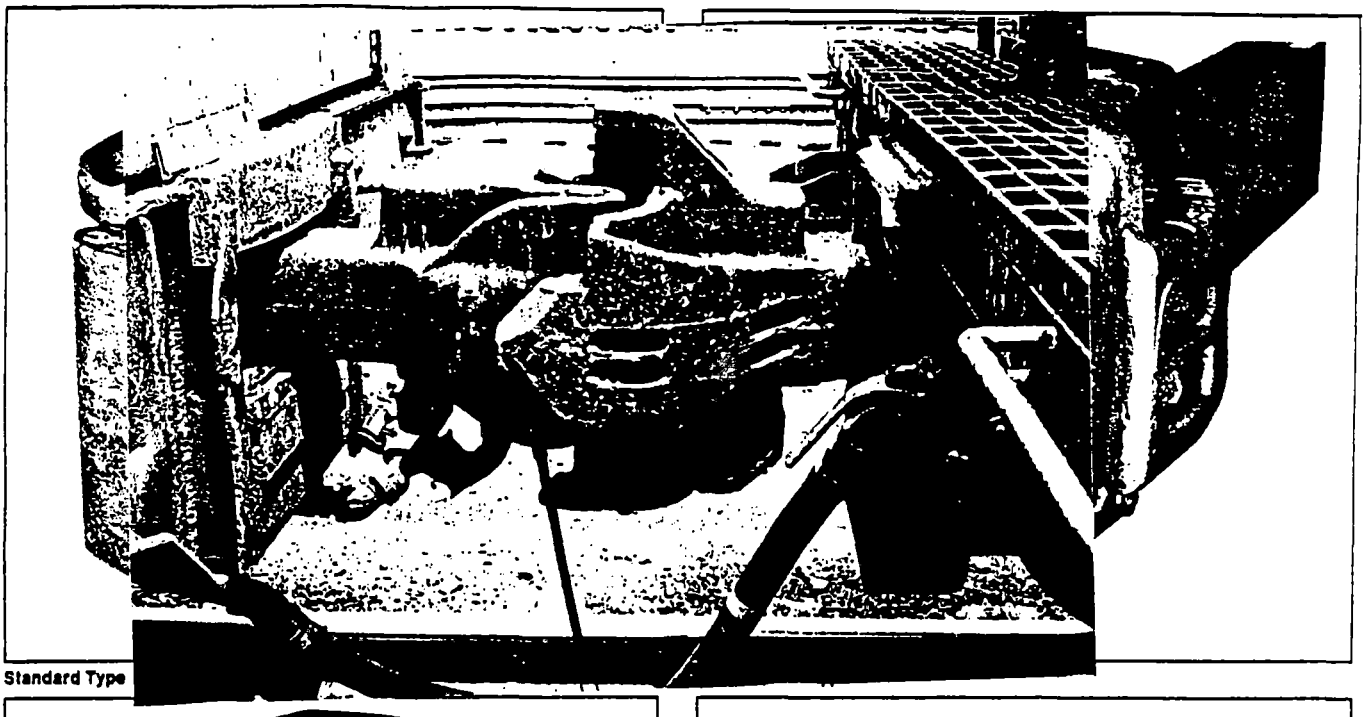
Inside view of the short hood of an EMD locomotive,

showing construction of collision posts

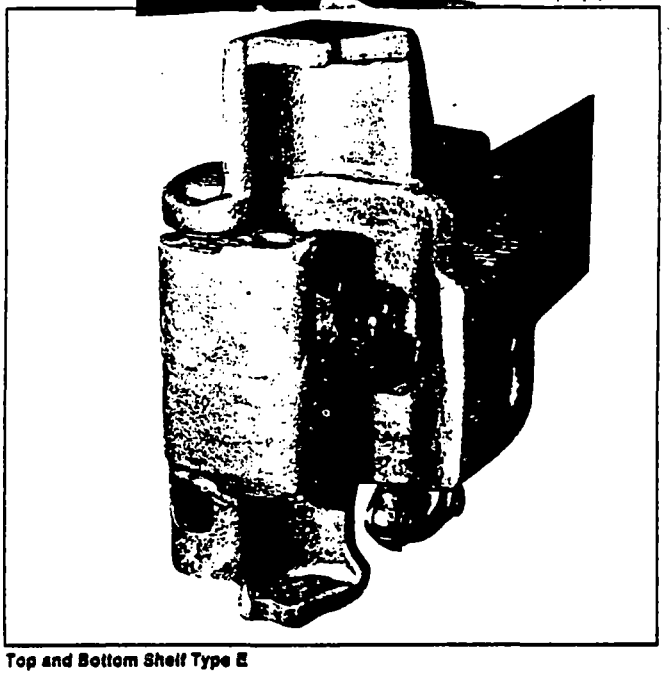

5362

Full Width Hood

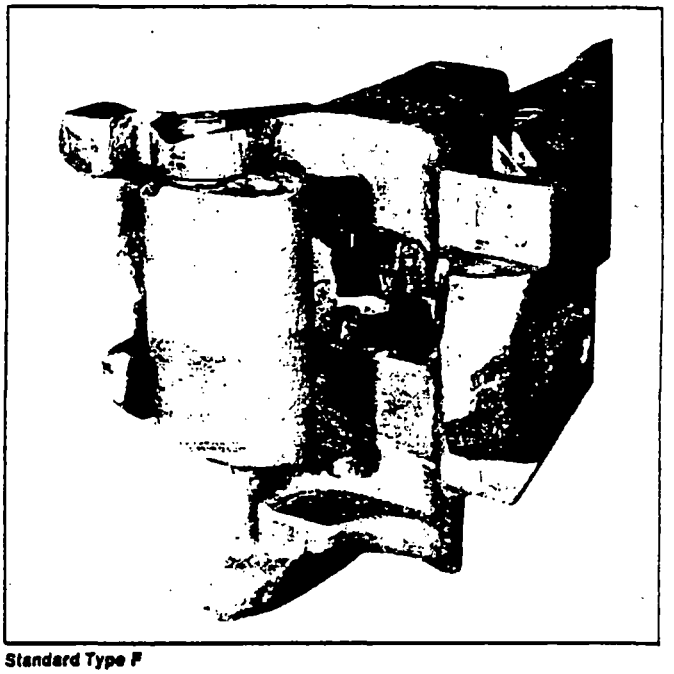
Couplers, Coupler Yokes & Parts



Standard Type



Top and Bottom Shelf Type E



Standard Type F

Strength. Resistance to impact and fatigue. Durability. Sure, dependable operation. Those are the features that have made McConway & Torley's freight car couplers leaders in the industry for over a century. And with its recently expanded plant facility, it has increased its production of those couplers by 66%.

McConway & Torley offers a full line of couplers, yokes, and parts in Types E, E/F, and F, including AAR Standards, Alternate Standards, Approved Specials, and D.O.T. Shelf Couplers. All castings are composed of "McConaloy", a specially formulated nickel-chromium-moly alloy, and the newly installed heat quenching and tempering processes provide additional steel grades with the toughness to meet and surpass the most stringent requirements: HTQ Grade C and HTE Grade E. For couplers and coupler parts with outstanding durability and superior service performance, always specify McConway & Torley.

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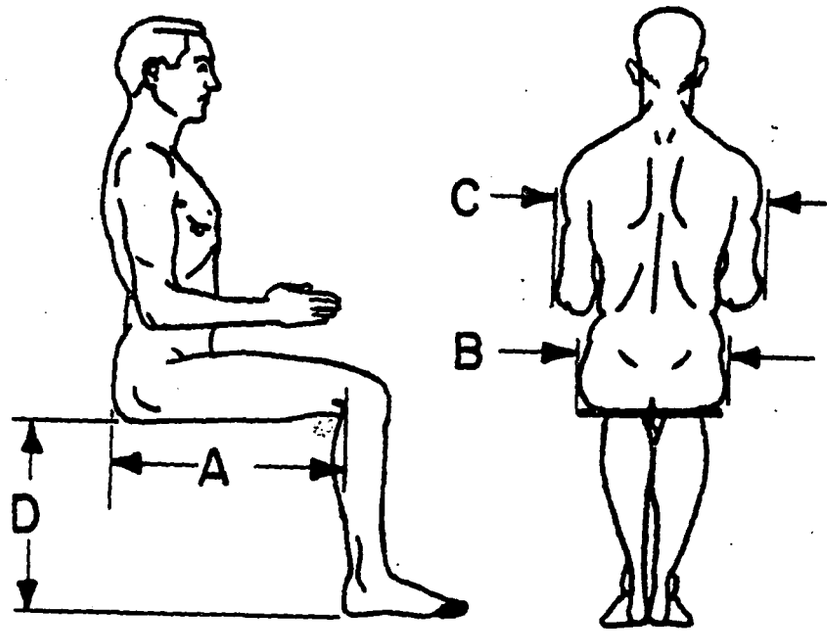
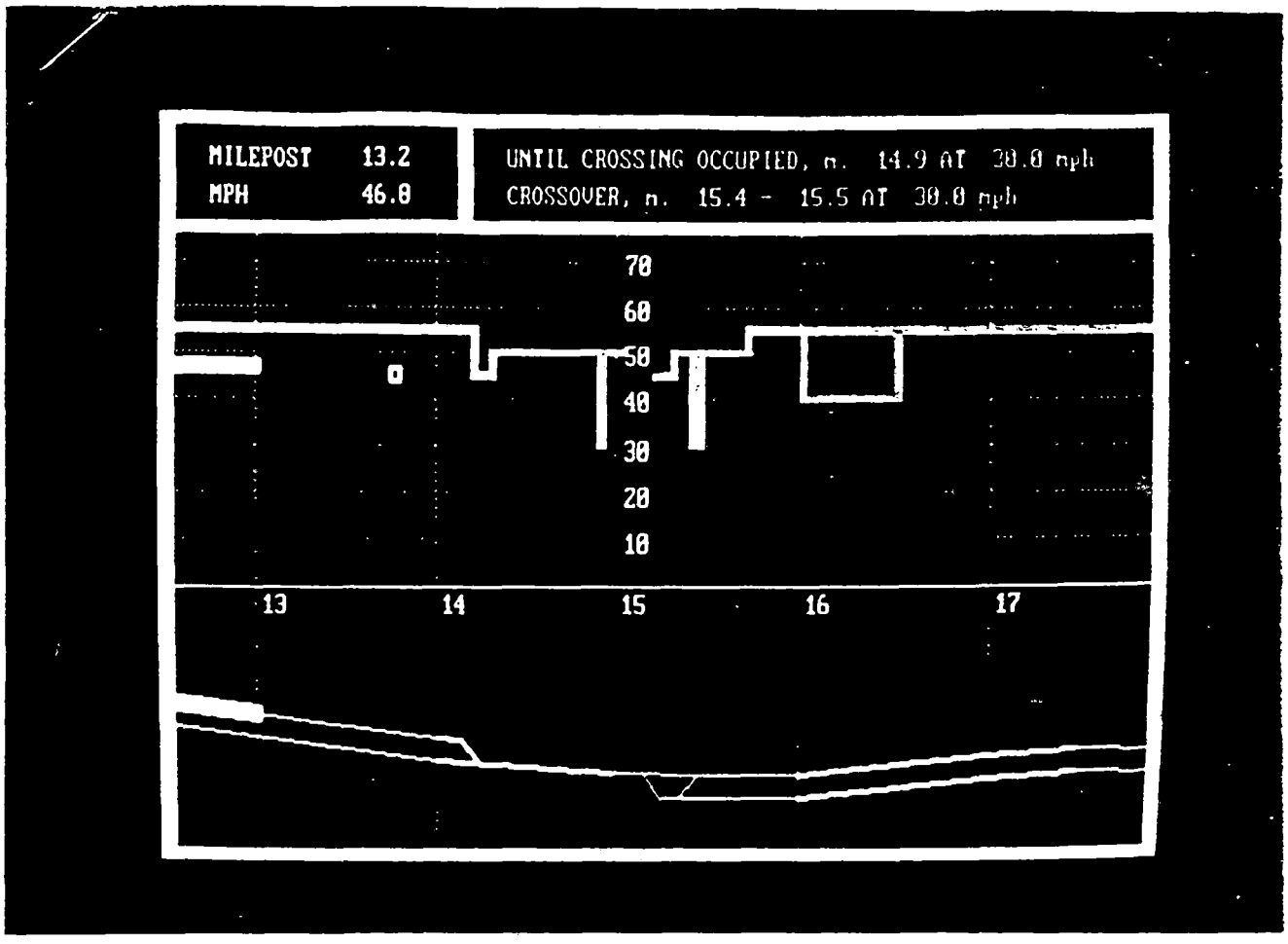
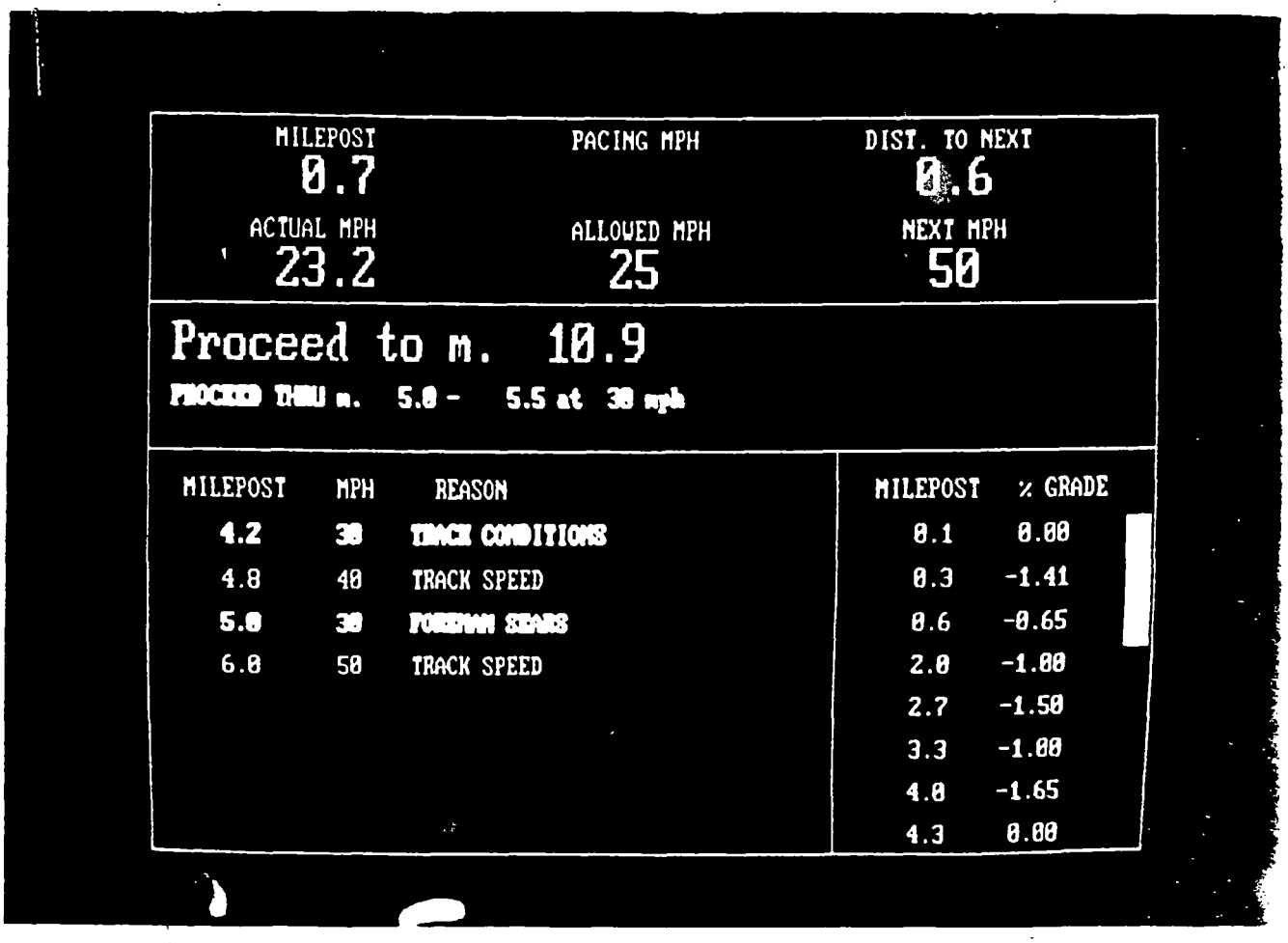
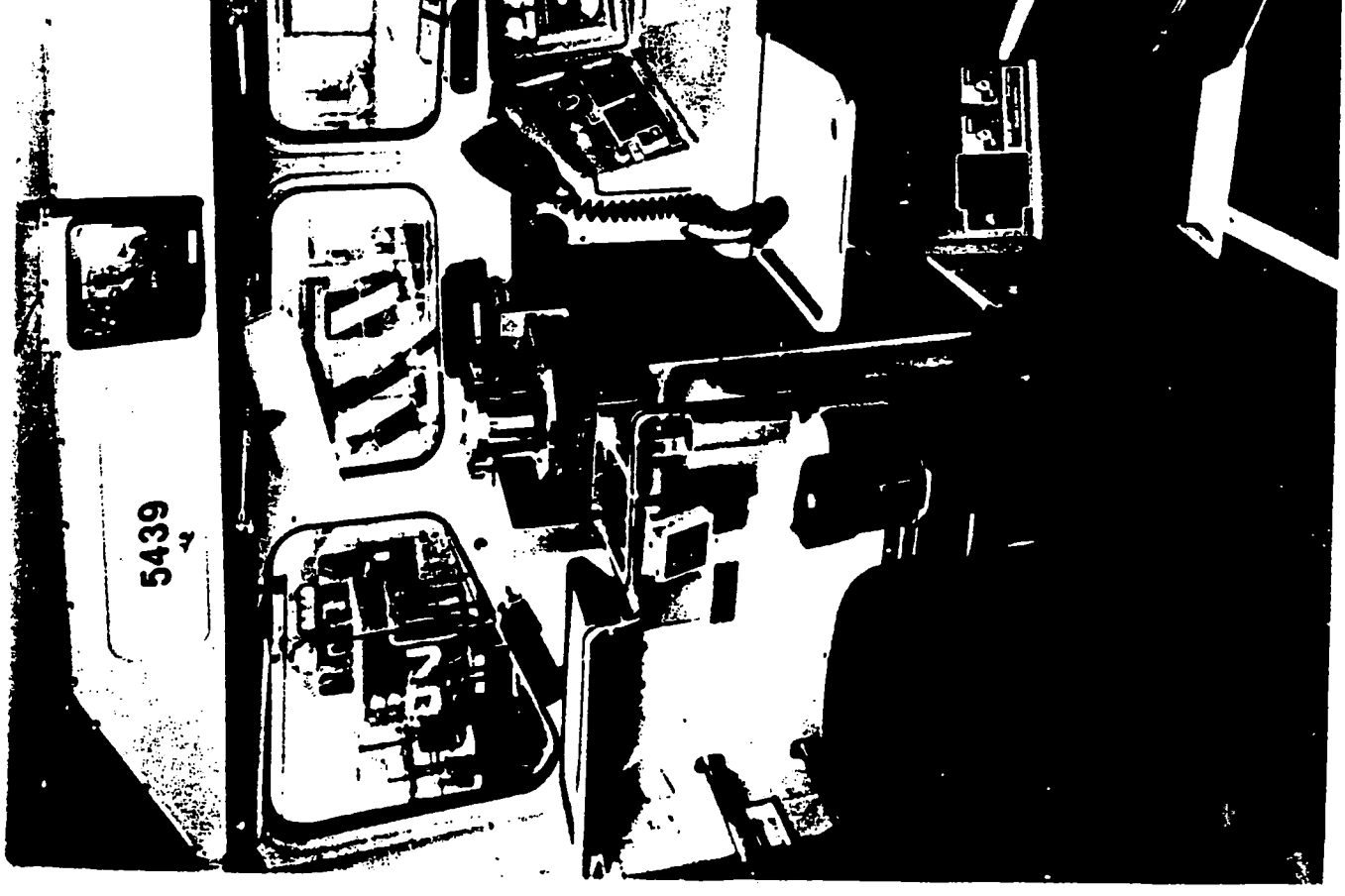


Anthropometric dimensions to be collected on locomotive engineers for good seat design


MILEPOST 13.2
MPH 46.0
UNTIL CROSSING OCCUPIED, m. 14.9 AT 30.0 mph
CROSSOVER, m. 15.4 - 15.5 AT 30.0 mph
70
60
50
40
30
20
10
13
14
15
16
17

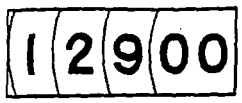

MILEPOST
0.7
PACING MPH
DIST. TO NEXT
0.6
ACTUAL MPH
23.2
ALLOWED MPH
25
NEXT MPH
50
Proceed to m. 10.9
PROCEED THRU m. 5.0 - 5.5 at 30 mph
MILEPOST MPH REASON
4.2 30 TRACK CONDITIONS
4.8 40 TRACK SPEED
5.0 30 FOREMAN SEARS
6.0 50 TRACK SPEED
MILEPOST % GRADE
0.1 0.00
0.3 -1.41
0.6 -0.65
2.0 -1.00
2.7 -1.50
3.3 -1.00
4.0 -1.65
4.3 0.00


5439

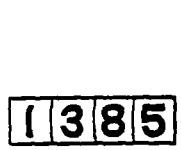

65MPH

DIGITAL DISPLAYS

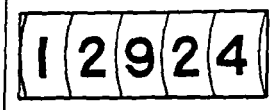
PREFERRED

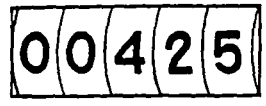


PREFERRED



POOR





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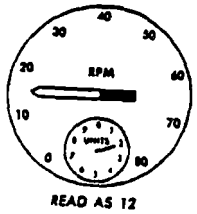
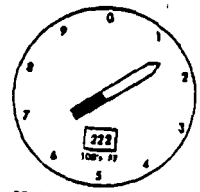
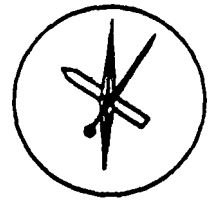


READ AS 12

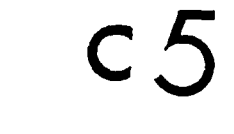


READ AS 22,215 FT.



POOR

NUMERALS, LETTERS, AND INDICES



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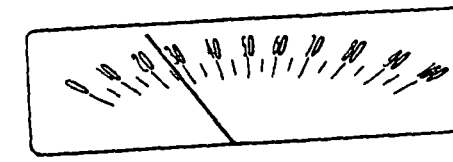

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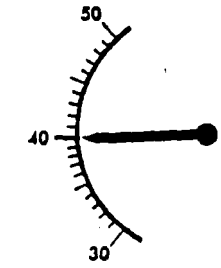
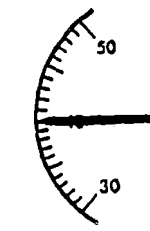


PREFERRED



POOR

GOOD POOR

APPENDIX B-3

IMPROVEMENT CODES AND CRITERION FOR RESPONSE CODING

Any design suggestions which involved structural changes for safety or crashworthiness purposes were coded in the 200 series.

Any design suggestions that related to crew/environmental comfort, e.g., temperature, noise and vibration control, meeting bodily needs (water and sanitation) or postural comfort (seat design and adjustment) were coded in the 300 series.

Any design improvement which would have a direct benefit to train handling was given a 400 series code. This would include cab instrumentation and controls.

The 4800 series were also directed towards train handling, but were mainly intended to answer question V about the role of electronic technology in design improvements.

The 500 series codes deal with design improvement specific to cab layout and workstation design which have multiple impact, i.e., can affect safety, comfort or train handling.

The 600 series includes a few miscellaneous items not easily embraced in the 200, 300, 400 or 500 series.

The 900 series were specific to Exhibit 6A on forces which inhibit or promote change.

Codes for Proposed Design Improvements*

Safety and Crash Worthiness

201-Anticlimbers
202-Roll Bars (Support loaded hopper)
203-Collision Posts
204-Full width and thicker short hoods
205-Modularized crew compartment
206-Derailment car bias
207-Delethalization of controls,furniture, other surfaces
208-Egress/Doors
209-Nose deflector
210-Protective structures
211-Sliding doors
212-Windows for egress
213-Improved glazing for safety
214-Standardized doors & walkway area
215-High short hood
216-Lower short hood (for better visibility)
217-Seat belts
218-Fireproof compartments
219-Thicker fuel tanks
220-Longer cab
222-Standardize height of loco main frame
223-Delethalize locomotive coupler
224-Better seat attachment to floor/wall
225-Thicker metal on cab sides
226-Non-slip floor surfaces
227-Strengthen the pilot
228-Better latches and door handles
229-Improved locomotive ladders

* Some codes used throughout the list are from preselection interviews.

Crew Comfort

301-Heating/Air Conditioning/Temperature Control
302-Noise reduction (insulation)
303-Vibration isolation
305-Water - improved quality
306-Sanitation improvement
307-Tinted windows-sun protection
308-Better refrigerators
309-Water and sanitation
310-Better heating air circulation
311-Radio headsets
312-Move brake pipe exhaust location
313-Tighter cab
314-Wash basins
316-Seat design and adjustment
317-Horn relocation/noise reduction
318-Noise reduction by engine mount.
319-Add luggage compartment
320-Window design for ease of use
322-Storage area (tools)
327-Sun visors (location, adjustment, size)

Train Handling

401-Monitoring engine performance and reset
402-Dual speed displays and speakers
403-Advanced event and speed trace recorders
404-Advanced alerting systems (tamper-free)
405-Advanced train control systems
406-Improved communication systems
407-Railstar
408-Cab signal systems
409-Standardized radios
411-Lower headlight for visibility
412-Multiple, less powerful speakers
415-In-cab display/results of automated way-side detectors (e.g.,hot box)
416-Use heads-up display instead of conventional gauges
417-More reliable speedometers
418-Organization device for train orders
419-Engineer dynamic brake cancel
421-Locotrol application
422-Audio taped dispatch orders
423-Engineer performance monitor
424-Controls for reverse operation
426-Sander redesign
428-Dual radios

Ergonomic & New Technology

4801-Display highlight/legibility
4802-Digital speedometer
4803-Bar graphs - traction motor
4804-Systems diagnostic microprocessors on console
4805-Digital air gauges
4806-Digital displays
4807-New information/rear end devices
4808-Project weather change
4809-Acceleration inform on demand
4810-Push button brake valves
4811-Tractive effort monitor - trailing units
4812-Combined speed, acceleration, distance indicator
4813-Ultrasonic motion alerter
4814-CRT for planning
4818-Auto pilot
4819-Buff and draft indicator
4821-Fuel gauge redesign
4822-Automated locomotive systems monitoring
4823-Electronics for power control

Cab Layout and Workstation

501-Design for housekeeping/trash system
502-Cab layout
503-Visibility (outside)
506-Ease of maintenance access
507-Mirrors
508-Conductor work station
509-Control miniaturization
510-Display lighting
511-Glare free displays
512-Better wipers
513-Desk type console
514-Portable controls for bi-directional movement
515-Draper taper - rear visibility
516-Wire-in-glass electric defrosters
521-Interior dome/reading lights
522-Lower horn control location
523-Lower speedometer location
524-Ditch lights
525-Standardized control/display locations
526-Develop a compact engineer compartment
527-More headroom in cab
532-Relocate radio for ease of access
534-Automatic switch for horn direction
536-Control stand warning light for back panel annunciator
540-Optimize seat locations in cab
542-Standardize control/display designs
543-Two-handed control operation

Miscellaneous

601-Drug and alcohol detectors
602-Reduce distraction by reducing crew size
603-Reliable motive power
604-Aerodynamics
605-Eliminate need for seat antenna
606-Improved engine control fans
607-Improved draft gear
608-Cab aesthetics

Forces (6A)

901-Cost
902-Organized labor
903-Government regulation
904-Train handling
905-Industry inertia
906-Opposition to change
907-Standardization
908-Company policy
909-Industry need (strong buyer demand)
910-Suppliers
911-Legal
912-Industry leadership
913-Need to retrofit current units
914-Elimination of caboose
915-Accidents
917-Crew size
918-Long design implementation cycle
919-Testing facilities are limited
921-Public Relations

Railroad
01-Amtrak
02-Conrail
03-Norfolk Southern
04-Santa Fe
05-Southern Pacific
06-Burlington Northern
07-CSX
08-Union Pacific
09-UTU
10-BLE

Priority
9-Don't Know
1-NO
2-Low
3-Moderate
4-Top

Job Title
1-VP/AVP Operations
2-Operations Staff
3-CMO/ACMO/VP Mechanical
4-Mechanical Staff
5-Union - Currently Operating
6-Union - Administrative
8-Road Foreman/General Road Foreman

Interviewer
1-THR
2-SMK
3-JR

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