METHODOLOGY FOR EVALUATION OF RAILROAD TECHNOLOGY RESEARCH PROJECTS

PROJECT MEMORANDUM

George J. Skaliotis
James L. Poage
John B. Hopkins
Stephen A. Cultrera

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U.S. DEPARTMENT OF TRANSPORTATION
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U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
TRANSPORTATION SYSTEMS CENTER
OPERATIONS AND MANAGEMENT SYSTEMS BRANCH
CAMBRIDGE, MA 02142

PREFACE

This Project Memorandum reports on a study being conducted by the Transportation Systems Center (TSC) under PPA RR-140 for the Office of Research and Development, Federal Railroad Administration (FRA), to aid in shaping and directing the FRA research and development program.

The report describes a methodology developed to evaluate railroad research projects. The methodology provides for a structured and consistent evaluation of projects. Benefits and costs of research are considered as well as technical risks and implementation considerations.

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SUMMARY

This Project Memorandum presents a methodology for evaluating railroad research projects. The methodology includes consideration of industry and societal benefits, with special attention given to technical risks, implementation considerations, and policy concerns. Application of the methodology to evaluate railroad research projects will provide a source of guidance and justification to support research planning by the Federal Railroad Administration, Office of Research and Development (FRA/ORD).

Formulation of the methodology began by identifying considerations which are most important in evaluating potential for a research project to be completed successfully, to be implemented successfully, and to have a beneficial societal impact. Eight project evaluation measures were defined for this purpose and are listed below.

A. Affected Area (e.g., safety)

B. Magnitude of Affected Area (e.g., fatalities per year)

C. Potential Impact on Area Through R&D in General (e.g., 30 percent reduction in fatalities)

D. Effect of Specific Research Project in Achieving Potential R&D Impact (e.g., specific R&D project represents 10 percent of potential R&D impact)

E. Likelihood of Research Success (e.g., 75 percent probability of successful outcome of all activities in R&D project under consideration)

F. Economy of Research Effort (e.g., $500,000 for R&D project under consideration)

G. Ease of Implementation (e.g., $1,000,000,000 over 10 years for implementation of project results)

H. FRA Needs and Commitments (e.g., Congressional interest and need of FRA Office of Safety for project results).

Two additional composite evaluation measures were selected to provide an overall indication of project quality. They are:

I. Research Cost-Effectiveness Rating

J. Overall Project Rating.

These ten measures, when applied to a set of 96 data elements that characterize research projects, establish the basis for project evaluation. The 96 data elements have been organized into a structured framework in a data base management system. Algorithms have been developed, using the 96 data elements, to calculate project evaluation measure scoring information of direct value in determining the quality of a project. Three reports are computer-generated for that purpose. They are:

A) Summary Project Evaluation Report.

B) Intermediate Project Evaluation Report

C) Detailed Project Description Report

These reports provide project data and scoring information that will be of value for FRA/ORD planning activities.

The work completed in this study provides a structured, unified methodology for evaluation of FRA/ORD research projects. It does not provide an absolute basis for measurement of project quality or for resource allocation due to need for inclusion of policy considerations that are beyond the scope of this study. Updating or modification of policy-related and other data elements by knowledgeable FRA/ORD managers is an important part of the evaluation process. To facilitate this process, all calculations included in the methodology are made by a computer data base management system and all output

reports are computer generated. This feature provides a useful tool for FRA/ORD management to improve assumptions related to any project with rapid and accurate redetermination of output scoring reports.

Methdology descriptions in this report use the FRA/ORD Coupling Optimization Project as an example to demonstrate application of the analysis methods involved. A Summary Project Evaluation Report for this project is shown below to provide a quantitative illustration of one methodology output and also to provide an example of the level of detail achieved in the study.

SUMMARY PROJECT EVALUATION REPORT

PROJECT NAME: COUPLING OPTIMIZATION

PROJECT EVALUATION MEASURES	SCORES
A. AFFECTED AREA	
A.1 Safety	X
A.2 Cost	X
A.3 Energy Efficiency	
A.4 Environment	
A.5 Quality of Service	X
B. MAGNITUDE OF AFFECTED AREA	
SAFETY	2
COST	5
C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL	
SAFETY	5
COST	3
D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT	2
E. LIKELIHOOD OF RESEARCH SUCCESS	4
F. ECONOMY OF RESEARCH EFFORT	5
G. EASE OF IMPLEMENTATION	1
H. FRA NEEDS OR COMMITMENTS	3
I. RESEARCH COST-EFFECTIVENESS RATING	
SAFETY	4
COST	5
J. OVERALL PROJECT RATING	
SAFETY	3
COST	4

The table shows the Coupling Optimization Project to have a high overall project score for cost impacts of research and a moderate overall project score for safety impact of research.

1. INTRODUCTION

This report presents a structured and consistent method for evaluating railroad research projects. The method includes an evaluation of potential industry and societal benefits with attention also given to technical risks and implementation considerations. Application of the method to evaluate projects provides a fundamental source of guidance and justification to support research planning by the Federal Railroad Administration, Office of Research and Development (FRA/ORD).

Establishment of a method to evaluate research projects and aid FRA research planning requires a structured and consistent way of considering a wide range of project related information. Order must be imposed on an array of strengths, weaknesses, constraints, and opportunities which apply to each project. The primary intent in this work is to reduce project characteristics to a manageable set that is amenable to quantitative evaluation.

In addition to an evaluation of potential benefits, technical risks, and implementation considerations, the establishment of priorities for research needs and allocation of resources among projects by the FRA Office of Research and Development is based on factors affecting FRA policy. Congressional mandates, industry and institutional factors, and internal DOT requirements are examples of FRA policy factors. The methodology presented in this report provides a mechanism for including these policy considerations in evaluating FRA/ORD research projects.

The approach presented in this report has been applied to 18 FRA/ORD research projects. The results of the evaluation of these projects are documented in two Project Memorandums "Analysis and Characteristics of Railroad Technology Projects: Project Assessments," April 1980, and "Analysis and Characteristics of Railroad Technology Projects: Project Assessments, Part II," December 1980.

The remainder of this section presents a more detailed description of those issues and requirements which are basic to the formulation of a practical and meaningful method for evaluating research projects.

1.1 RESEARCH IMPACTS

Development of a method to evaluate research projects should be sensitive to the fact that the research phase of a product cycle is only one step in a process which leads to the adoption of a new product by the railroad industry. This overall process can generally be characterized as shown in Figure 1-1 below.

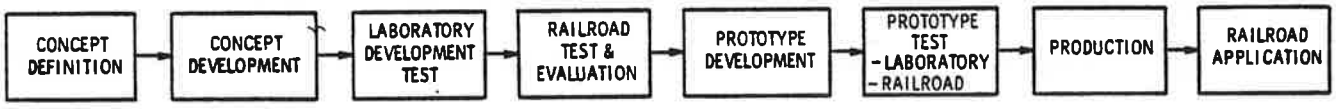

FIGURE 1-1. NEW PRODUCT RESEARCH AND IMPLEMENTATION PROCESS

Where the research phase specifically ends in the initial part of this process is project dependent. Some research projects are completed after development test and others much later in the product development cycle. Successful implementation of research results depends on success in all stages of this process. Thus, evaluation of all stages of the process must be an important consideration in development of research evaluation methodology.

Potential benefits and costs are major considerations in characterization and evaluation of a research project. However, there are several key ways in which evaluation of research projects differ from traditional benefit-cost analysis where the ratio of total benefit over total cost is the end result. The research phase of a product cycle is only part of a sequence of events leading to the ultimate utilization of a product by the railroads. Thus, a method for evaluating research projects must provide an assessment of the leverage of the research phase in the final utilization and impact of project results.

One problem associated with the rigorous application of benefit-cost analysis to the evaluation of research projects is determination of the degree to which final benefits (i.e., beneficial impacts from utilization of the end product) are attributable primarily to the research phase. In one sense, many of the final benefits can be traced back to the research phase. However, it is also necessary to recognize that there are other vital parts of the process resulting in the final benefit. For example, it may be necessary for the railroads to purchase a product or pay the costs incurred by a new operation. Thus, the final benefits cannot be attributed solely to the research phase. A benefit-cost ratio which reflects only research costs and final benefits is an

inadequate tool to assess research projects since it includes only one part of the costs.

Traditional cost-benefit techniques compare the total benefits to the total costs. The total cost would include cost of the railroads' procuring and operating the new project, as well as the research costs. Usually, research costs are very small compared to the cost of procurement and operation of the final product, so that the research costs have very limited effect on this particular benefit-cost ratio. While taking the ratio of total benefits to total costs may give an overall indication of efficiency for implementing a new product, it does not portray the leverage of research funds.

The general approach described in this paper will involve separate and explicit identification of the several components of "research cost-effectiveness." Through the use of a set of appropriately chosen measures relating to the sequence of events leading from research to implementation (see Figure 1-1), the potential research leverage becomes visible and then assessed, thereby contributing to the ranking of research projects. The degree to which these measures lend themselves to a quantitative form will vary from project to project.

1.2 QUANTITATIVE VS. QUALITATIVE MEASURES OF RESEARCH IMPACT

The nature of many research projects makes the development of appropriate quantitative measures difficult. If some benefits or costs can be only approximately predicted, then reporting these predictions to two or three significant figures conveys a false sense of precision. Also, many factors relating to the ultimate successful completion and implementation of research

are qualitative in nature, such as technical risks in completing research and implementation considerations regarding compatibility with existing equipment or industry consensus for interchange of equipment. The project evaluation methodology must accommodate the more qualitative along with the quantitative measures describing projects, and this study is careful to include consideration of these differences.

Although the nature of research projects often precludes the use of rigorous quantification for benefit-cost analysis, consideration of the beneficial impact and cost of a project remain important to the decision-maker. As a result, the methodology described in this report utilizes a "research cost-effectiveness" measure rather than the term "benefit-cost ratio." The implication of this choice is that an estimate of a "high" cost-effectiveness reflects a partially quantitative, partially judgmental finding and suggests that if a rigorous benefit-cost ratio could be calculated, it would also be high. In addition, explicit measures relating to the more qualitative aspects of technical risks in performing research and of implementation considerations are incorporated in the methodology. These measures incorporate the more qualitative aspects of research projects in the project evaluation information provided to a decision-maker. Detail on the measures is presented in Sections 2 and 3.

1.3 SELECTION OF PROJECT EVALUATION MEASURES

The evaluation of research projects can easily become too detailed, such that broad and substantive conclusions are not readily apparent. On the other hand, sufficient detail is needed to support research planning decisions. To strike a satisfactory balance between an excess of detail on one hand, or

inadequate substance on the other, it is necessary to focus on the ultimate purpose of the analysis and on the needs of the expected users.

Ideally, the project evaluation methodology would provide the decision maker with a single number for each project to specify its net attractiveness as a research activity. However, the projects to be ranked are diverse in nature and content. The ranking of projects, in fact, depends upon a variety of separate factors or dimensions which must be weighted by the decision-maker. At the same time, the characterization and choices presented must be reduced to the minimal comprehensive set if the analysis is to be of real value. Thus, the form of presentation of results is seen to be as important as the analysis itself if the evaluation results are truly to aid the FRA research planning process. By itself, a detailed description of each project would be of limited usefulness in comparisons with other projects. However, a score sheet containing merely a single entry for each of several measures would not provide sufficient depth to assure credibility, to support choices among projects, and to allow the decision-maker to change essential detail to more adequately reflect his understanding of a particular project.

In the methodology developed in this study, the problem described above is resolved by displaying results at three levels of detail, beginning with a Summary Project Evaluation Report containing a table of estimated quantitative values for a small number of comprehensive measures for all research projects. This allows direct comparisons of the essential characteristics and impacts of all projects under consideration. Policy-based factors added by FRA where designated in the methodology are part of a procedure subsequently used to generate single numerical rankings or scores for each project. In the

Intermediate Project Evaluation Report, the measures from the summary table are subdivided, with each general measure broken into separate quantitative components. Finally, the Detailed Project Description Report provides specific numerical data and narrative discussion of individual research projects to complete the impact analysis. This overall structure is described in detail in Section 2.

1.4 DISCUSSION OF REPORT CONTENT

This introductory section has discussed a number of issues relating to the type of research project evaluation methodology that will be an aid in research planning. A number of considerations concerning the difficulties in applying traditional benefit-cost analysis to research project analysis have been described. The remainder of the report presents the method developed. Section 2 describes the project evaluation measures used in the method. Section 3 develops the evaluation procedure. The method for calculation of quantitative values for the measures is explained in Section 4.

2. PROJECT EVALUATION MEASURES

The previous chapter discussed a number of reasons why traditional benefit-cost analysis does not provide adequate information for evaluating research projects. In particular, the research phase is only one part of a sequence of events leading from research on a product to implementation of research results (see Figure 1-1). It was also shown in Section 1 that the evaluation of research projects is a mix of quantitative and qualitative processes. These factors have influenced the choice of project evaluation measures which were selected to provide a research planner with information required to help shape and direct a research program and justify its content. The project evaluation measures used in this study are shown in Figure 2-1.

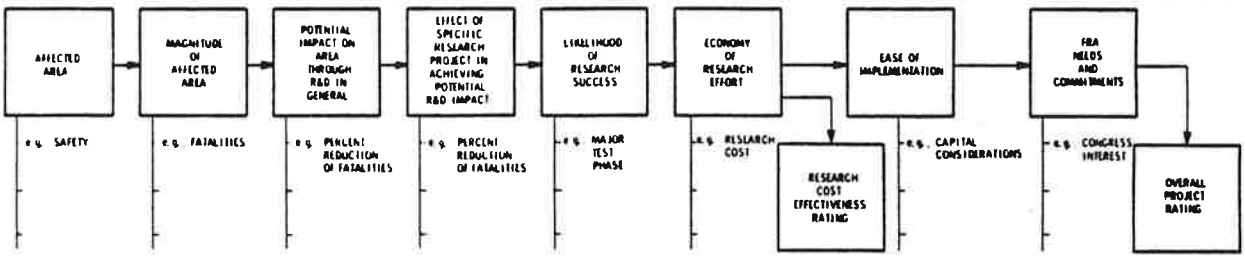

FIGURE 2-1. FLOW DIAGRAM OF PROJECT EVALUATION MEASURES

2.1 DEFINITION OF PROJECT EVALUATION MEASURES

Each project evaluation measure used in the study is listed in Table 2-1 below with examples of the type of information provided by each measure.

TABLE 2-1. PROJECT EVALUATION MEASURE

A. Affected Area (e.g., safety)

B. Magnitude of Affected Area (e.g., fatalities per year)

C. Potential Impact on Area Through R&D in General (e.g., 30 percent reduction in fatalities)

D. Effect of Specific Research Project in Achieving Potential R&D Impact (e.g., specific R&D project represents 10 percent of total possible R&D impact)

E. Likelihood of Research Success (e.g., 75 percent probability of successful outcome of all activities in R&D project under consideration)

F. Economy of Research Effort (e.g., $500,000 for R&D project under consideration)

G. Ease of Implementation (e.g., $1,000,000,000 over 10 years for implementation of project results)

H. FRA Needs and Commitments (e.g., Congressional interest and desire by FRA Office of Safety for project results).

In addition, two composite project evaluation measures are used:

I. Research Cost-Effectiveness Rating

J. Overall Project Rating.

Each project evaluation measure is described in the subsections which follow.

2.1.1 Affected Area

This measure describes the principal facet of railroading which is expected to be directly and substantially affected by the research project under consideration. The five major facets of railroading used in the study are:

TABLE 2-2. FACETS OF RAILROADING INCLUDED IN AFFECTED AREA MEASURE

A. Safety
B. Cost
C. Energy Efficiency
D. Environment
E. Quality of Service

More than one of the facets of railroading listed above may be identified if appropriate for a given project.

2.1.2 Magnitude of Affected Area

This measure describes the size of the area of railroading to which the research may be relevant and is expressed both in terms of casualties (i.e., fatalities and injuries) and in terms of dollar costs (i.e., property damage, operating costs, and other costs). If the Magnitude of Affected Area is small, it suggests that even a very successful research effort cannot have a large impact on the overall performance of the national rail transportation system, since only a small portion of the system costs or safety is affected. This measure, thus, gives an indication of the degree to which the research is focused on an area central to railroading. The Magnitude of Affected Area measure does not convey any information concerning the potential impact of the research project. This aspect of the evaluation process is addressed in the next two measures.

2.1.3 Potential Impact on Area through R&D in General

This measure evaluates the maximum possible improvement in the affected area after completion and implementation of all possible research. Some aspects of railroad technology and operations are far more sensitive than others to innovation based on new technology, data, or understanding. This measure is very much a function of how the Magnitude of Affected Area is

defined and care is taken in the study to assure consistency with the Magnitude of Affected Area measure.

2.1.4 Effect of Specific Research Project in Achieving the Potential R&D Impact

The preceding measure (Potential Impact on Affected Area Through R&D in General) characterized the basic sensitivity of the affected area to research in general by evaluating the maximum possible improvement in the Affected Area after completion and implementation of all possible research. This measure (Effect of Specific Research Project in Achieving the Potential R&D Impact) indicates the degree to which the specific project under consideration is expected to contribute to achieving the theoretically possible impact. This rating depends on the manner in which the magnitude of the affected area was initially described and on the definition of the project. The rating for this measure is based on an assumption that the research will be performed successfully, with all objectives met, and that no substantive obstacles to implementation will be encountered. A low rating for the Effect of Specific Research measure implies either that the particular project is relevant to only a small portion of the affected area, or that much additional research must be carried out before the potential impact can be achieved. For example, if the affected area had been defined as the very large area of freight car brake systems, but the particular project involved only brake-shoe materials, or if the project in question had as its only objective the gathering of data concerning current brake related costs, it would receive a relatively low score in this measure.

2.1.5 Likelihood of Research Success

This measure indicates the probability that the desired research objectives will be fully met. A low score may imply either that the goal is likely

to be achieved only partially, or that there is a substantial chance that no useful result will be obtained. Some factors which might influence this measure include requirements for special or revenue testing, availability of data, and need for an advance in the state-of-the-art. This measure is not based on technical analysis of the details of project performance. The evaluation process for this measure assumes effective and competent conduct of the research.

2.1.6 Economy of Research Effort

This measure primarily reflects direct FRA research cost. Care is taken that the costs considered are only those associated with the specific project as defined in both the preceding and subsequent measures. In keeping with the focus of the entire methodology on FRA concerns, only Government costs are included. In some cases, there may also be large industry costs for research which are not shown here.

2.1.7 Ease of Implementation

Ultimately, research only has value if its results are somehow implemented. In technology and railroad operations, there exist many obstacles to change. This measure indicates the likelihood that the research, if successful, will be put into widespread use. A low rating here would mean large impediments to the implementation of results. One example of this would be that the implementation period is so lengthy that the present value of the benefit will be very small.

2.1.8 FRA Needs or Commitments

This measure shows the degree to which prior Congressional interest, investment, industry agreements, needs of other agencies, or other factors provide a predisposition to perform a specific research project above and beyond direct benefits and general agency objectives of improved safety, economics, etc. Thus, a research activity mandated by Congress or which the Administrator had promised to another agency would receive a high rating. Input by FRA to this measure is provided for in the methodology and is particularly important since only FRA can properly assess the degree of commitment associated with factors of this nature.

2.1.9 Research Cost-Effectiveness Rating

This is the first of two composite project rating measures. It is a composite score determined from five of the Summary measures:

1) Magnitude of Affected Area
2) Potential Impact on Area Through R&D in General
3) Effect of Specific Research Project in Achieving Potential R&D Impact,
4) Likelihood of Research Success
5) Economy of Research Effort

The Research Cost-Effectiveness Rating expresses the "leverage" of the FRA research project, and serves primarily as a relative indicator to assist comparing projects. The algorithm used to establish this rating is developed in Section 4.

2.1.10 Overall Project Rating

The Overall Project Rating extends the Research Cost-Effectiveness Rating to account for two additional measures:

1) Ease of Implementation

2) FRA Needs or Commitments

The FRA Needs or Commitments measure contains only factors which might enhance motivations to perform a research project, and, thus, can only bring about an increase in the Overall Project Rating compared to the Research Cost-Effectiveness Rating. The Ease of Implementation considers potential obstacles and thereby decreases the final score. The Overall Project Rating, as well as the Cost-Effectiveness Rating, is meant to be useful as an aid in comparison of projects. As such it is only correctly used as a relative measure and not as an absolute measure of quality of any individual project.

2.2 RATINGS FOR PROJECT EVALUATION MEASURES

The project evaluation measures listed in Section 2.1 are both quantitative and qualitative in nature. For example, Magnitude of Affected Area is toward the quantitative end of the evaluation spectrum while Likelihood of Research Success is more a qualitative evaluation measure. To accommodate these characteristics in the ten project evaluation measures, each measure is rated on a scale from 1 to 5. A score of 5 in any particular project evaluation measure represents the most desirable rating and a score of 1 the least desirable. The range of 1 to 5 was chosen to allow a reasonable spread of ratings among various projects.

Development of the 1 to 5 rating scores for the ten project evaluation measures is described in Sections 3 and 4.

3. PROJECT EVALUATION METHODOLOGY

This section of the report introduces methodology developed to evaluate FRA Office of Research and Development (FRA/ORD) railroad research projects. A process flow diagram (see Figure 3-1) has been used in this section of the report to provide a visual presentation of each step in the methodology. Subsequent parts of this section describe the methodology and each of the steps used to develop project evaluation ratings and output information useful to FRA/ORD decision-makers.

3.1 DESCRIPTION OF THE METHODOLOGY

The methodology developed in this study is a series of steps which evaluate railroad research projects. Figure 3-1 shows this project evaluation structure. The flow chart in the figure is arranged so that steps in the evaluation methodology flow in order from left to right. The three major outputs of this methodological process are shown along the bottom of the chart. They consist of:

A) a Detailed Project Description Report

B) an Intermediate Project Evaluation Report

C) a Summary Project Evaluation Report.

These three reports are the methodology outputs the FRA/ORD decision-maker will find most useful for research planning.

There are five major steps in the process as shown in Figure 3-1. They are:

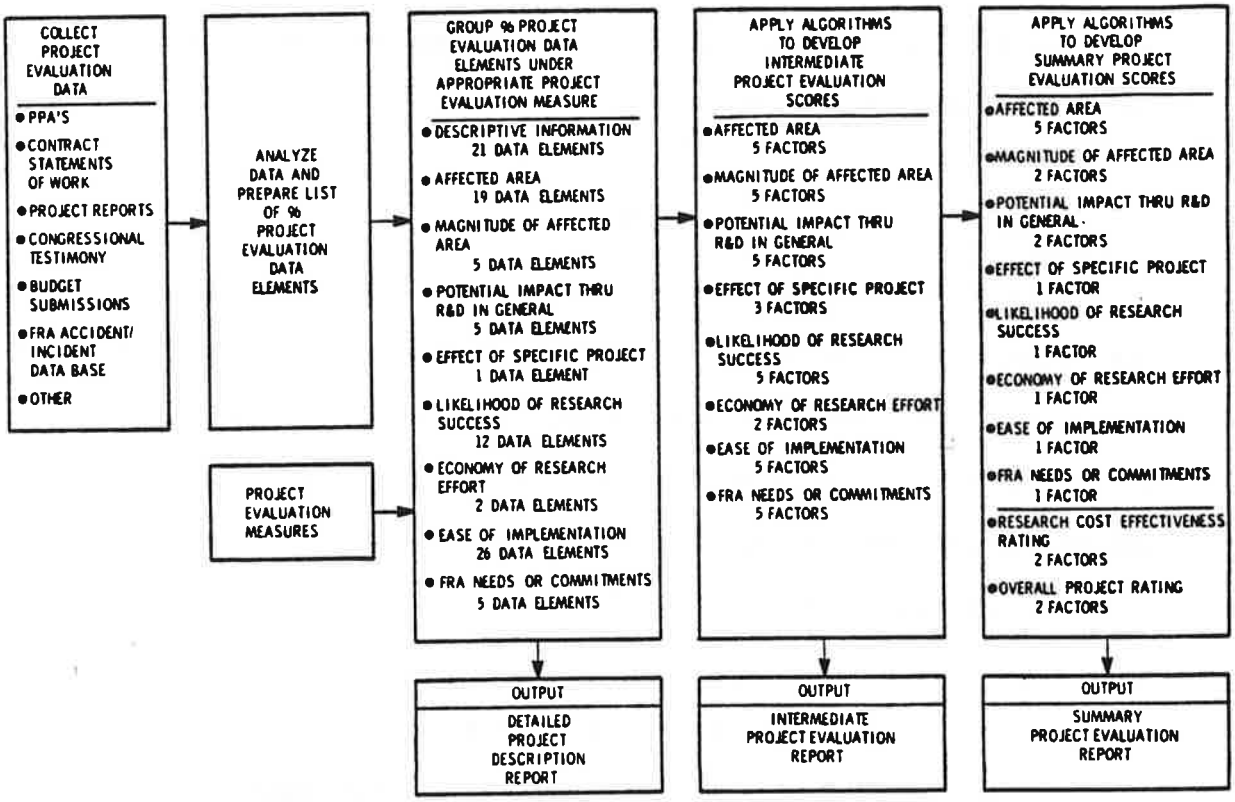

FIGURE 3-1. PROJECT EVALUATION STRUCTURE

A) Collect project evaluation data

B) Analyze project evaluation data and prepare a list of 96 data elements

C) Group project evaluation data elements under appropriate project evaluation measures

D) Apply algorithms to develop intermediate project evaluation scores

E) Apply algorithms to develop summary project evaluation scores.

The methodology has been computer implemented using a data base management system developed for this application. Once the project information has been collected and analyzed, all subsequent outputs of the process are automatically computer generated. This procedure assures consistent treatment of project evaluation data as well as convenient handling of the large amounts of data involved. The data base management system also facilitates calculating the algorithms which, if manually treated, would be cumbersome at best and subject to error. Also, changes can be made in the data used and weighting factors applied without requiring large amounts of time to evaluate new results. This feature is felt to have major value for FRA/ORD managers in responding to requests for project justification and other project information inquiries from DOT, the Administration, Congress, or other sources.

As defined in Section 2 of this report, there are eight project evaluation measures which serve as the focus for defining and reporting project quality. These evaluation measures are listed below with examples to illustrate each measure.

A. Affected Area (e.g., safety)

B. Magnitude of Affected Area (e.g., fatalities per year)

C. Potential Impact on Area Through R&D in General (e.g., 30 percent reduction in fatalities)

D. Effect of Specific Research Project in Achieving Potential R&D Impact (e.g., specific R&D project represents 10 percent of total possible R&D impact)

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H. FRA Needs or Commitments (e.g., Congressional interest and desire by FRA Office of Safety for project results).

In addition, two composite project evaluation measures are used:

I. Research Cost-Effectiveness Rating

J. Overall Project Rating.

It will be useful to consider these project evaluation measures sequentially. Each measure evaluates one aspect of a project starting in the beginning research stage with affected area and moving through the implementation of research results. As the flow chart in Figure 3-1 shows, these measures are used for project rating purposes in each of three evaluation steps:

A. Group 96 project evaluation data elements under appropriate project evaluation measure.

B. Apply algorithms to develop intermediate project evaluation scores.

C. Apply algorithms to develop summary project evaluation scores.

Each of the evaluation steps provides a different level of detail for use as needed by the FRA/ORD decision-maker.

Throughout the report, application of the research project evaluation methodology will be demonstrated using the same example. The example used, coupling optimization, is an actual FRA/ORD research project. This single consistent example is used to provide the reader with a frame of reference for application of the different steps in the methodology. Also, the potential user will have a concrete sample representing a beginning to end application of the methodology to use as a pattern for application on other projects. The following sections describe each step in the Figure 3-1 flow chart.

3.2 COLLECTION OF PROJECT EVALUATION DATA

The first step in the methodology developed for evaluation of FRA/ORD projects involves the collection, organization, and analysis of relevant information pertaining to a project. The methodology goes beyond traditional benefit-cost analysis techniques in that a diverse range of information sources and types are considered. Information often exists which, while not precisely quantifiable for benefit/cost analysis, is vital for project evaluation. For example, FRA may have an external requirement from Congress or commitments to industry to work within a project area. Consideration of this information, even though it is difficult to quantify, is vital in evaluating a project. Information of this nature is sought out, collected and integrated into the research project quantitative evaluation process in the methodology developed under this study.

Some of the sources of information used to provide data for project evaluation include:

Contract Statements of Work - These are agreements between an outside contractor and the Government which represent R&D work in progress.

Project Reports - These are the various project deliverables produced by either the Government or external contractors which represent completed stages of research projects. Many times these reports provide specific detailed technical information which is used as the basis for determining the effect the specific research project has in accomplishing overall FRA goals in a research area.

Budget Submissions - Justifications and budget information contained in previews and budget submissions to Congress provide a useful source of both qualitative and quantitative project information.

Congressional Testimony - Testimony at Congressional hearings provide an amplification of FRA policy as well as an indication of Congressional priorities.

FRA/ORD Planning Documents - These are internal FRA memoranda and other documents which indicate policy and other project information.

FRA Accident/Incident Reporting System - This is the railroad accident reporting system maintained by the FRA. It provides useful information about accident damages and casualties. This information helps to determine the magnitude of the problem which any specific research project addresses.

Railroad Industry Data - This type of data is typified by the Association of American Railroad's (AAR) Yearbook of Railroad Facts. This data describes general railroad industry performance and is also useful to help determine the magnitude of specific problem areas to be addressed by research.

Project Plan Agreements - These are statements of work between the FRA and the Transportation Systems Center (TSC). They provide cost and program content for some of FRA's research work in progress.

In the coupler project example, the following sources of information were used to collect project evaluation information.

- FRA Accident/Incident Data Base

- Contractor Report - Petracek, S.J.; A.E. Moon, R.L. Kiang, and M.W. Siddigee; Railroad Classification Yard Technology; Stanford Research Institute; prepared for U.S. Department of Transportation; June 1977.

- Industry Report - Association of American Railroads (AAR); Yearbook of Railroad Facts; 1979 Edition; Washington, D.C.

- Industry Report - Advanced Coupling Concepts Program Phase 1-1/2 Report Including General Economic Model, AAR Technical Center, Chicago, IL, November 1, 1977.

- Contract Statements of Work

- Budget Submissions

- Project Plan Agreements

- FRA/ORD Planning Documents.

3.3 ANALYZE DATA AND PREPARE LIST OF 96 PROJECT EVALUATION DATA ELEMENTS

Once collected, project evaluation data must be assembled into a useful form. Some of the data must be combined, judgements must be made based on qualitative information, and a number of calculations are necessary to prepare data in the necessary format for use in other parts of the evaluation process. An example is the need to combine from several sources, such as individual but related contracts, project research costs to provide an overall research cost for the project. One of the judgements to be made is a determination of the effect a specific research project will have in achieving the total possible research impact in an area. This is accomplished by examining statements of work and existing project reports. Finally, an example of calculations which may be necessary is typified by determination of the magnitude of an affected area which the research addresses. Here, calculations would be made from data provided by the FRA Accident/Incident Data Base and from the industry data provided by the AAR Yearbook of Railroad Facts. Specific examples will be provided in Section 4 of this report where each individual project evaluation data element is discussed.

There are 96 project evaluation data elements that have been selected to form a consistent basis for evaluation of all FRA/ORD projects. All project evaluation data elements are listed in Table 3-1. Application of this step of the methodology is simplified by use of a project evaluation data element summary form (Basic Project Information Form) shown in Appendix A. This form is designed and coded for easy recording of the 96 data elements for each project to be evaluated.

The information on this form also provides the data basis for a computer data base management system which is used to implement the methodology. The process which follows this step in the methodology is computerized so that implementation of the methodology is consistent and automatic. The computer exercises a number of algorithms to provide necessary project evaluation information.

The computer is used in this process as a facilitator. It assures accuracy in the calculation of otherwise unwieldy algorithms. All project output evaluation reports are produced at high speed on a consistent basis. This allows for confident comparison of projects. Also, certain subsets of information are readily available for more detailed analysis of one or several selected projects should the decision-maker have need for additional detailed information. Thus, use of the computer also allows greater flexibility in the evaluation of research projects.

The remainder of this section describes project evaluation reports that are produced by the computerized methodology.

TABLE 3-1. LIST OF 96 PROJECT DATA ELEMENTS

DESCRIPTIVE INFORMATION
- Program
- Project Title
- Project Number
- Subprogram

TYPE OF PROJECT
- concept development
- assessment/feasibility study
- data/information survey
- hardware/pre-prototype
- development or expansion of a research facility
- testing or evaluation
- operational/application guidelines
- performance specs
- demonstration
- requirements study

IMPORTANCE OF RESULTS FOR:
- industry decisions/use
- FRA safety/regulatory
- FRA Federal assistance
- NEC/AMTRAK decisions
- DOT decisions/actions
- other Federal or state agency
- FRA reserach activities

AFFECTED AREA

AFFECTED AREA
- safety
- cost
- energy efficiency
- environment
- quality of service

AFFECTED SUBAREA
- freight service
- passenger service
- employee safety
- rail-highway crossings
- hazardous materials
- track
- rolling stock
- operations
- maintenance
- classification yards
- equipment
- human factors
- facilities
- locomotives

MAGNITUDE OF AFFECTED AREA
- annual fatalities
- annual injuries
- property damage
- operating cost
- other costs

POTENTIAL IMPACT ON AREA THRU R&D IN GENERAL
- % of fatalities
- % of injuries
- % of property damage
- % of operating costs
- % of other costs

EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT
- % effect

LIKELIHOOD OF RESEARCH SUCCESS
- detailed info/cooperation from industry organization
- detailed info/cooperation from specific RR/supplier
- consensus or coordinated government & industry action
- use of major DOT test facility
- use of other (non-DOT) test facility
- significant revenue service testing or RR trial use
- testing or raising significant liability issues
- use of skill/capabilities not readily available
- data not readily available
- extension beyond state-of-art technology or knowledge
- integration of numerous elements
- dependence on other research

ECONOMY OF RESEARCH
- cost
- duration

EASE OF IMPLEMENTATION
- industry wide capital required
- estimated implementation time

TRANSITION PROCESS REQUIRES:
- industry consensus
- industry-wide equipment/system compatibility
- industry-wide data/information exchange
- major demonstration phase
- industry acceptance testing
- development of new suppliers/supply capability
- Federal safety regulation
- conflict with industry trends
- industry hardware development effort
- significant expenditures by government agency

IMPLEMENTATION WILL SIGNIFICANTLY CHANGE:
- rolling stock and equipment
- facilities
- train operations
- practices and procedures
- industry standards
- inter-railroad cooperation
- safety regulations
- economic regulation
- environmental regulations
- locomotives
- maintenance procedures

IMPLEMENTATION WILL SIGNIFICANTLY AFFECT LABOR:
- reduction of labor force
- skill mix
- work rules

FRA NEEDS OR COMMITMENTS
- Congressional interest or requirement
- agreement with industry or explicit industry interest
- specific DOT/FRA objective or responsibility
- needs of other Government agencies
- prior funding

3.4 GROUP 96 PROJECT EVALUATION DATA ELEMENTS UNDER APPROPRIATE PROJECT EVALUATION MEASURES

The Detailed Project Description Report (see Figure 3-1) is an organized computer printout of all project evaluation data elements grouped under appropriate project evaluation measures. It is the computer prepared counterpart of the Basic Project Information Form (see Appendix A). It provides the 96 project evaluation data elements in a more definitive computer-generated format. The purpose of the Detailed Project Description Report is to provide detailed project information listed under appropriate measures in a computer-generated format that can be used for development of the Intermediate and Summary Project Evaluation Reports. These reports are described in subsequent steps of the project evaluation methodology.

Figure 3-2 shows a Detailed Project Description Report which has been developed by the computer data base management system for the coupler project.

3.5 APPLY ALGORITHMS TO DEVELOP INTERMEDIATE PROJECT EVALUATION SCORES

The Intermediate Project Evaluation Report (see Figure 3-1) provides the decision-maker with project evaluation scores for a variety of factors useful in evaluating the quality of a research project. Project evaluation scores range from 1 to 5 in value. A 5 is always the best score and a 1 is always the least attractive score. The scoring system was developed to facilitate the comparison of projects. A consistent range of 1 to 5 scores for all factors associated with the project evaluation methodology frees the user from a need to remember the relative values of many different measures. Rather, the unitless 1 to 5 score evaluates each project in a uniform and consistent

DETAILED PROJECT DESCRIPTION REPORT

PROJECT # 117
TITLE: COUPLING OPTIMIZATION

PART 1. DESCRIPTIVE INFORMATION

PROGRAM: TRACK, EQUIPMENT AND PERSONNEL SAFETY
SUB PROGRAM: EQUIPMENT SAFETY

MAJOR FOCUS OF PROJECT:
Concept Development
Assessment/Feasibility Study

RELEVANCE OF ULTIMATE RESULTS:
MAJOR
FRA Research Activities
MODERATE
Industry Decisions/Use
MINOR
FRA Safety/Regulatory

PART 2. DETAILED PROJECT SUMMARY

SECTION A. AFFECTED AREAS:

AFFECTED AREAS:
MAJOR EFFECT
Safety
Cost
MODERATE EFFECT
Quality of Service

AFFECTED SUB-AREAS:
MAJOR EFFECT
Freight Service
Employee Safety
Rolling Stock
MODERATE EFFECT
Hazardous Materials

SECTION B. MAGNITUDE OF AFFECTED AREA:

Fatalities	5	(Annual)
Injuries	2500	(Annual)
Property Damage	$ 140M	(Present Value Over 20 Years)
Operating Costs	$19600M	(Present Value Over 20 Years)
Other Costs	$ 0M	(Present Value Over 20 Years)

SECTION C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL:

Fatalities	50 %
Injuries	50 %
Property Damage	9 %
Operating Costs	6 %
Other Costs	0 %

SECTION D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT:

Effect of Specific Research Project in Achieving Potential R & D Impact 4 %

SECTION E. LIKELIHOOD OF RESEARCH SUCCESS:

Requirements that Could Impede Performance:
MAJOR
MODERATE
Detailed Information and/or Cooperation from Industry Organizations
Detailed Information and/or Cooperation from Specific Railroads or Suppliers

SECTION F. ECONOMY OF RESEARCH EFFORT:

Research Cost	$ 200K
Research Duration	3 years

SECTION G. EASE OF IMPLEMENTATION:

CAPITAL REQUIRED (Industry-wide): $ 700M

ESTIMATED IMPLEMENTATION TIME: 20 years

TRANSITION PROCESS REQUIREMENTS:
MAJOR
Industry Consensus
Industry-wide Equipment/System Compatibility
Major Demonstration Phase
Industry Acceptance Testing
MODERATE
Federal Safety Regulation
Industry Hardware Development Effort

IMPLEMENTATION WILL AFFECT CHANGES IN:
MAJOR
Rolling Stock and Equipment
MODERATE
Practices and Procedures
Industry Standards
Safety Regulations

IMPLEMENTATION CHANGES AFFECTING POTENTIAL LABOR ACCEPTABILITY:
MAJOR
MODERATE
Reduction of Labor Force
Work Rules

SECTION H. FRA NEEDS OR COMMITMENTS:

Congressional Interest:	Very Small
Agreement with Industry:	Moderate
Needed by DOT / FRA:	Very Small
Important to Other Govt.Agency:	Very Small
Prior Funding:	Very Small
$ Amount:	$ 100K

FIGURE 3-2. DETAILED PROJECT DESCRIPTION REPORT

way. An algorithm is developed and used to calculate each project evaluation score. The algorithm is a formula that combines several data elements into a single score.

At the Detailed Project Description Report step in the project evaluation process, a single project evaluation measure may be associated with as many as 26 separate data elements (see Figure 3-1). The use of scores in the Intermediate Project Evaluation Report allows for combining data elements into groups, or factors, with five factors associated with each project evaluation measure. The purpose of the Intermediate Project Evaluation Report is to provide a useful amount of detail to show the basis for the Summary Project Evaluation Report to be developed in a subsequent step in the methodology.

Figure 3-3 shows an Intermediate Project Evaluation Report completed for the coupler project. As the example shows, this Report has the capability for displaying up to eight projects on the same page. This multiple project display allows comparison of project characteristics simultaneously for a number of projects.

3.6 APPLY ALGORITHMS TO DEVELOP SUMMARY PROJECT EVALUATION SCORES

The purpose of the Summary Project Evaluation Report is to provide a single score for each project evaluation measure. This is done to allow comparison of the important aspects of projects. Safety and cost scores are separately listed in this report. The safety score includes fatalities and injuries. The cost score includes property damage, operating cost, and other costs.

INTERMEDIATE PROJECT EVALUATION REPORT

PROJECT EVALUATION MEASURES	PROJECT NAME: PROJECT NUMBER:	COUPLER (117)	PROJ #2	PROJ #3	PROJ #4	PROJ #5	PROJ #6	PROJ #7	PROJ
		PROJECT EVALUATION SCORES							
A. AFFECTED AREAS									
A.1 Safety		X							
A.2 Cost		X							
A.3 Energy Efficiency									
A.4 Environment									
A.5 Quality of Service		X							
B. MAGNITUDE OF AFFECTED AREA									
B.1 Fatalities		1							
B.2 Injuries		4							
B.3 Property Damage		2							
B.4 Operating Costs		5							
B.5 Other Costs		1							
C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL									
C.1 Fatalities		5							
C.2 Injuries		5							
C.3 Property Damage		3							
C.4 Operating Costs		3							
C.5 Other Costs		1							
D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT									
D.1 Effect of Specific Project in Achieving Potential R&D Impact		2							
E. LIKELIHOOD OF RESEARCH SUCCESS									
Independence from Factors Affecting Success:									
E.1 Industry Participation		4							
E.2 Major Test Phase		5							
E.3 Special Resources		5							
E.4 Major Technical Advance		5							
E.5 Other Factors		5							
F. ECONOMY OF RESEARCH EFFORT									
F.1 Research Cost		5							
* Research Duration		2							
G. EASE OF IMPLEMENTATION									
G.1 Capital Considerations		2							
G.2 Implementation Speed		1							
G.3 Transition Process Simplicity		2							
G.4 Compat.w.Existing Equip & Ops		3							
G.5 Potential Labor Acceptability		4							
H. FRA NEEDS OR COMMITMENTS									
H.1 Congressional Interest		1							
H.2 Agreement with Industry		3							
H.3 DOT / FRA Requirement		1							
H.4 Needed by Other Agency		1							
H.5 Major Prior Funding		1							

* NOT INCLUDED IN SUMMARY CALCULATIONS

COUPLER COUPLING OPTIMIZATION

FIGURE 3-3. INTERMEDIATE PROJECT EVALUATION REPORT

In addition to the eight project evaluation measures which are carried through all reports, two additional composite project evaluation measures are developed in the Summary Project Evaluation Report. They are:

1) Research Cost-Effectiveness
2) Overall Project Rating.

Figure 3-4 shows a sample of the Summary Project Evaluation Report which has been completed for the coupler project. This report can display up to eight projects on one page.

As is apparent from Figure 3-4, the Summary Project Evaluation Report provides a convenient means for evaluating a large number of projects using project evaluation measures which describe quality of projects from early research through implementation. When more detail is required to amplify any individual summary project evaluation measure, the Intermediate Project Evaluation Report and the Detailed Project Description Report can be used.

In review, this section has introduced the methodology developed to describe and evaluate FRA research projects. A flow chart describing this process has been presented and steps in the process have been explained. Detailed algorithms used in the methodology will be presented in the next section.

SUMMARY PROJECT EVALUATION REPORT

PROJECT EVALUATION MEASURES	PROJECT NAME: / PROJECT NUMBER:	PROJECT EVALUATION SCORES							
		COUPLER (117)	PROJ #2	PROJ #3	PROJ #4	PROJ #5	PROJ #6	PROJ #7	PROJ #8
A. AFFECTED AREA									
A.1 Safety		X							
A.2 Cost		X							
A.3 Energy Efficiency									
A.4 Environment									
A.5 Quality of Service		X							
B. MAGNITUDE OF AFFECTED AREA									
SAFETY		2							
COST		5							
C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL									
SAFETY		5							
COST		3							
D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT		2							
E. LIKELIHOOD OF RESEARCH SUCCESS		4							
F. ECONOMY OF RESEARCH EFFORT		5							
G. EASE OF IMPLEMENTATION		1							
H. FRA NEEDS OR COMMITMENTS		3							
I. RESEARCH COST-EFFECTIVENESS RATING									
SAFETY		4							
COST		5							
J. OVERALL PROJECT RATING									
SAFETY		3							
COST		4							

COUPLER = COUPLING OPTIMIZATION

FIGURE 3-4. SUMMARY PROJECT EVALUATION REPORT

4. PROJECT EVALUATION RATING ALGORITHMS

Section 3 has reviewed the general methodology developed for evaluating railroad research projects. Evaluation results are presented in three different levels of detail as shown in Figure 3-1:

A) Summary Project Evaluation Report

B) Intermediate Project Evaluation Report

C) Summary Project Evaluation Report

The first two reports present 1 to 5 rating scales for the project evaluation measures, while the last report presents detailed information on the project. This section describes the procedures used to complete these reports.

4.1 RATING SCORES FOR PROJECT EVALUATION MEASURES

The project evaluation measures were identified in Section 2 as follows:

A. Affected Area (e.g., safety)

B. Magnitude of Affected Area (e.g., fatalities per year)

C. Potential Impact on Area Through R&D in General (e.g., 30 percent reduction in fatalities)

D. Effect of Specific Research Project in Achieving Potential R&D Impact (e.g., specific R&D project represents 10 percent of total possible R&D impact)

E. Likelihood of Research Success (e.g., 75 percent probability of successful outcome of all activities in R&D project under consideration)

F. Economy of Research Effort (e.g., $500,000 for R&D project under consideration)

G. Ease of Implementation (e.g., $1,000,000,000 over 10 years for implementation of project results)

H. FRA Needs and Commitments (e.g., Congressional interest and desire by FRA Office of Safety for project results).

I. Research Cost-Effectiveness Rating

J. Overall Project Rating.

In the Summary Project Evaluation Report, a 1 to 5 score is given for each measure. In the Intermediate Project Evaluation Report, several factors within each measure are rated with a 1 to 5 score, and in the Detailed Project Description Report, project data elements are organized under appropriate measures.

The 1 to 5 scoring in the Summary and Intermediate Project Evaluation Reports is achieved by using algorithms to combine project data elements provided in the Detailed Project Description Report. The ranges of values for the 1 to 5 rating scores in the Summary Project Evaluation Report are listed in Table 4-1. The ranges for the rating scores at the Intermediate Project Evaluation Report are contained in Table 4-2. The specific algorithms describing calculations performed to determine the rating score for each measure are presented in Section 4.3.

4.2 COUPLING OPTIMIZATION PROJECT EXAMPLE

An example using the FRA/ORD Coupling Optimization Project is utilized to illustrate application of the methodology. Descriptive data and information for an advanced coupler is analyzed, and rating scores calculated.

Impacts of a new coupler system with automatic coupling features will lessen the need for employees to work in hazardous situations on and around cars and will allow for faster coupling in yard operations. Possible prop-

TABLE 4-1. DETERMINATION OF RATINGS FOR MEASURES IN THE SUMMARY LEVEL

MEASURE	RANGE		RATING
	SAFETY MEASURE	COST MEASURE	
A. Affected Area	affected area indicated by		X
B. Magnitude of Affected Area (Present Value)	0-10	LE $.1B	1
	11-35	.11B - .3B	2
	36-100	.31B - 1B	3
	101-300	1.01B - 3B	4
	GT 300	GT 3B	5
C. Potential Impact on Area through R&D in General	LT 2%	LT 2%	1
	2% - 4%	2% - 4%	2
	5% - 9%	5% - 9%	3
	10% - 24%	10% - 24%	4
	GT 24%	GT 24%	5
D. Effect of Specific Project in Achieving Potential R&D Impact	LT 2%		1
	2% - 4%		2
	5% - 9%		3
	10% - 24%		4
	GT 24%		5
E. Likelihood of Research Success	LT 10%		1
	10% - 24%		2
	24% - 49%		3
	50% - 79%		4
	GT 79%		5
F. Economy of Research Effort	GE $5M		1
	3M - 4.9M		2
	1.5M - 2.9M		3
	.5M - 1.4M		4
	LT .5M		5
G. Ease of Implementation, H. FRA Needs or Commitments	very small		1
	small		2
	moderate		3
	large		4
	very large		5
I. Research Cost-Effectiveness, J. Overall Project Rating, Calculated as Ratios	LT $.1X10^{-7}$	LT .1	1
	$.1-.99x10^{-7}$	.1 - .99	2
	$1-9.9x10^{-7}$	1 - 9.9	3
	$10-99x10^{-7}$	10 - 99	4
	GE $100x10^{-7}$	GE 100	5

Note: LT = less than
GT = greater than
LE = less than or equal to
GE = greater than or equal to

TABLE 4-2. DETERMINATION OF RATINGS FOR MEASURES IN THE INTERMEDIATE LEVEL

A. Affected Area		affected area indicated by X				
B. Magnitude of Affected Area		B.1 Fatality	B.2 Injury	B.3 Property Damage	B.4 Operating Costs	B.5 Other Costs
	1.	0-10	0-100	LE $.1B	LE $.1B	LE $.1B
	2.	11-35	101-300	.11B-.3B	.11B-.3B	.11B-.3B
	3.	36-100	301-1000	.31B-1B	.31B-1B	.31B-1B
	4.	101-300	1001-3000	1.01B-3B	1.01B-3B	1.01B-3B
	5.	GT 300	GT 3000	GT 3B	GT 3B	GT 3B
C. Potential Impact on Area Thru R&D in General		C.1 Fatality	C.2 Injury	C.3 Property Damage	C.4 Operating Costs	C.5 Other Costs
	1.	LT 2%	LT 2%	LT 2%	LT 2%	LT 2%
	2.	2%-5%	2%-5%	2%-5%	2%-5%	2%-5%
	3.	6%-10%	6%-10%	6%-10%	6%-10%	6%-10%
	4.	11%-25%	11%-25%	11%-25%	11%-25%	11%-25%
	5.	GT 25%	GT 25%	GT 25%	GT 25%	GT 25%
D. Effect of Specific Research Project in Achieving Potential R&D Impact		D.1 Effect of Project	D.2 Role of R&D Sequence	D.3 Project Role in Sequence		
	1.	LT 2%	very small	very small		
	2.	2%-4%	small	small		
	3.	5%-9%	moderate	moderate		
	4.	10%-24%	large	large		
	5.	GT 24%	very large	very large		
E. Likelihood of Research Success		E.1 Industry Participation	E.2 Major Test Phase	E.3 Special Resources	E.4 Technology Advance	E.5 Other Factors
	1.	LT 10%	LT 10%	LT 10%	LT 10%	LT 10%
	2.	10% - 24%	10% - 24%	10% - 24%	10% - 24%	10% - 24%
	3.	24% - 49%	24% - 49%	24% - 49%	24% - 49%	24% - 49%
	4.	50% - 79%	50% - 79%	50% - 79%	50% - 79%	50% - 79%
	5.	GT 79%	GT 79%	GT 79%	GT 79%	GT 79%
F. Economy of Research Effort		F.1 Cost	F.2 Duration			
	1.	GE $5M	GT 4yrs			
	2.	3M-4.9M	3 yrs			
	3.	1.5M-2.9M	2 yrs			
	4.	.5M-1.4M	1 yr			
	5.	LT .5M	LT 1 yr			
G. Ease of Implementation		G.1 Capital	G.2 Speed	G.3 Simplicity	G.4 Compatibility	G.5 Labor Acceptability
	1.	GE $1B	GT 15 yrs	very small	very small	very small
	2.	300M-.9B	11-15 yrs	small	small	small
	3.	100M-299M	7-10 yrs	moderate	moderate	moderate
	4.	30M-99M	3-6 yrs	large	large	large
	5.	LT 30M	LT 3 yrs	very large	very large	very large
H. FRA Needs or Commitments		H.1 Congress	H.2 Industry	H.3 DOT/FRA	H.4 Othr Agncy	H.5 Prior Fund
	1.	very small	very small	very small	very small	LT $300K
	2.	small	small	small	small	300K-.9M
	3.	moderate	moderate	moderate	moderate	1M-2.9M
	4.	large	large	large	large	3M-9.9M
	5.	very large	very large	very large	very large	GE 10M

Note: LT = less than
GT = greater than
LE = less than or equal to
GE = greater than or equal to

erties of a new coupler include automated or improved basic coupling, an automatic angle cock, automatic hump uncoupling, automatic bleed, and greater gathering range. It is assumed that a new coupler system will be phased into the fleet and, therefore, must be compatible with existing couplers.

The current FRA research project activity on couplers (Coupling Optimization Project) is a study of benefit-cost considerations for coupler design features.

4.3 ALGORITHMS FOR CALCULATING PROJECT EVALUATION MEASURES

This section presents detailed steps used for calculating 1 to 5 scores for each project evaluation measure. The overall methodology was illustrated in Figure 3-1. In the following discussion, an application of the methodology to establish scores for each project evaluation measure is presented in a separate subsection. For each measure, the format to present the evaluation procedure is as follows:

1. Describe data and analysis required to complete the Basic Project Information Form (see Appendix A).
2. Present pertinent content of the Detailed Project Description Report.
3. Explain procedures used to determine 1 to 5 rating scores for factors in the Intermediate Project Evaluation Report.
4. Explain procedures used to determine 1 to 5 rating scores for the Summary Project Evaluation Report measures.

The Coupling Optimization Project example is used to illustrate the procedures. Details of the calculations are explained in this section; however, a computer program has been written to simplify the calculations necessary for

preparation of the Detailed Project Description Report, Intermediate Project Evaluation Report, and Summary Project Evaluation Report.

The first part of the Basic Project Information Form requests descriptive information about the project which is not used in the analysis of the project evaluation measures. Table 4-3 presents this part of the form.

TABLE 4-3. BASIC PROJECT INFORMATION FORM - DESCRIPTIVE INFORMATION

Project Number 117

Project Title Coupling Optimization

Program Track, Equipment and Personnel Safety

Subprogram Equipment Safety

Type of Project

x	(1) concept development
x	(2) assessment/feasibility stuch
	(3) data/information survey
	(4) hardware/pre-prototype
	(5) development or expansion of a research facility
	(6) testing and evaluation
	(7) operational/application guidelines
	(8) performance specs
	(9) demonstration
	(10) requirements study

Importance of Results for:

not applicable	small	moderate	large	
		x		(1) Industry decisions/use
	x			(2) FRA safety/regulatory
x				(3) FRA Federal assistance
x				(4) NEC/Amtrak decisions
x				(5) DOT decisions/actions
x				(6) Other Federal or state agency
			x	(7) FRA research activities

The information in Table 4-3 is for the Coupler Optimization Project example.

Algorithms used to determine project evaluation measures are now explained in the following subsections.

4.3.1 Affected Area

This is the only project evaluation measure where text information is presented rather than a calculation of 1 to 5 scores. The Affected Area describes the general area of railroading which will be impacted by implementation of project results.

Basic Project Information Form

Five Affected Areas are listed in the Basic Project Information Form. In addition, 14 subareas are shown to provide more detailed aspects of the areas which are affected. These affected areas and subareas are listed in Table 4-4 which illustrates the Affected Area section of the Basic Project Information form.

TABLE 4-4. BASIC PROJECT INFORMATION FORM - AFFECTED AREAS

A. AFFECTED AREA

Affected Areas

no effect	moderate	major	
		X	(1) Safety
		X	(2) Cost
X			(3) Energy Efficiency
X			(4) Environment
	X		(5) Quality of Service
			(6) _____

Affected Subareas

no effect	moderate	major	
		X	(1) Freight Service
X			(2) Passenger Service
		X	(3) Employee Safety
X			(4) Grade Crossings
	X		(5) Hazardous Materials
X			(6) Track
X		X	(7) Rolling Stock
			(8) Operations
X			(9) Maintenance
X			(10) Classification Yards
X			(11) Equipment
X			(12) Human Factors
X			(13) Facilities
X			(14) Locomotives
			(15) _____

Each of the five areas and 14 subareas are assigned either "major," "moderate," or "no effect" according to the degree to which the areas are affected by the project.

Table 4-4 shows the Basic Project Information Form as it was completed for the Coupling Optimization Project. For the evaluation of a different project, a different set of entries would be checked. The information in the Affected Area project evaluation measure is descriptive, and the analysis required is to determine the areas of railroading which would be affected by the research project. For the coupler example, reduced hazard for employees engaged directly in coupling tasks would result. Faster coupling will have an impact on yard operations, and, hence, a decrease in costs for yard switching labor and for car utilization. Quality of service would receive a moderate impact from decreased transportation time due to the faster yard operations.

Detailed Project Description Report

The information entered in the Basic Project Description Form in Figure 4-4 is listed for the user in the Detailed Description Report. The part of the Detailed Project Description Report which is provided for Affected Area is shown in Table 4-5 using the Coupling Optimization Project as an example.

TABLE 4-5. DETAILED PROJECT DESCRIPTION REPORT - AFFECTED AREA

```
SECTION A.  AFFECTED AREAS:
---------------------------
  AFFECTED AREAS:
     MAJOR EFFECT
      Safety
      Cost
     MODERATE EFFECT
      Quality of Service

  AFFECTED SUB-AREAS:
     MAJOR EFFECT
      Freight Service
      Employee Safety
      Rolling Stock
     MODERATE EFFECT
      Hazardous Materials
```

Only those items which were indicated in Table 4-4 as being affected in a major or moderate way are listed in the Detailed Description Report to simplify the table content.

Intermediate Project Evaluation Report

Since the Affected Area project evaluation measure is a text entry, no calculations are involved to determine project evaluation scores. Rather, the Intermediate Project Evaluation Report lists only the affected area data elements (the top part of Table 4-5) and not the subareas. Areas affected in either a major or moderate way are indicated by an "X." An Intermediate Project Evaluation Report is shown in Table 4-6 with the Coupling Optimization Project used as an example.

TABLE 4-6. INTERMEDIATE PROJECT EVALUATION REPORT - AFFECTED AREAS

MEASURE	SCORE
A. AFFECTED AREAS	
A.1 Safety	X
A.2 Cost	X
A.3 Energy Efficiency	
A.4 Environment	
A.5 Quality of Service	X

Summary Project Evaluation Report

For the Affected Area project evaluation measure, the same information table is contained in the Summary Project Evaluation Report as in the Intermediate Project Evaluation Report. This information is shown in Table 4-7, again with the coupler project as an example.

TABLE 4-7. SUMMARY PROJECT EVALUATION REPORT - AFFECTED AREAS

MEASURE	SCORE
A. AFFECTED AREA	
A.1 Safety	X
A.2 Cost	X
A.3 Energy Efficiency	
A.4 Environment	
A.5 Quality of Service	X

4.3.2 Magnitude of Affected Area

The purpose of this measure is to display the magnitude of the problem area to which the project is relevant. The Magnitude of Affected Area is presented for safety and cost-related data elements.

Basic Project Information Form

The part of the Basic Project Information Form for Magnitude of Affected Area is shown in Table 4-8.

TABLE 4-8. BASIC PROJECT INFORMATION FORM - MAGNITUDE OF AFFECTED AREA

B. MAGNITUDE OF AFFECTED AREA

_____ Fatalities (annual)
_____ Injuries (annual)
_____ Property Damage (20-yr discounted present worth in $ millions)
_____ Operating Cost (20-yr discounted present worth in $ millions)
_____ Other Costs (20-yr discounted present worth in $ millions)

The information requested for safety is number of annual fatalities and number of annual injuries; information required for cost is amount of property damage, operating costs, and a general category of other costs. The costs are the present value of costs discounted over a 20-year period.

The analyses required for the coupler example to provide the numbers requested in Table 4-8 are to determine the number of fatalities and injuries from coupler related causes, the property damage in coupler related accidents, and the yard switching costs. In terms of safety, there were five fatalities and approximately 2,500 injuries related to coupler causes reported to FRA in 1978 (Ref. 1). These values of annual fatalities and injuries are entered in the Basic Project Information Form as shown in Table 4-9.

TABLE 4-9. BASIC PROJECT INFORMATION FORM FOR COUPLER PROJECT - MAGNITUDE OF AFFECTED AREA

B. MAGNITUDE OF AFFECTED AREA

5	Fatalities (annual)
2500	Injuries (annual)
$130	Property Damage (20-yr discounted present worth in $ millions)
$19,600	Operating Cost (20-yr discounted present worth in $ millions)
0	Other Costs (20-yr discounted present worth in $ millions)

The cost of property damage from coupler-related accidents was $15 million in 1978 (property damage reported to FRA has been doubled to account for loss to lading and cost of clearing the wreck, Refs. 1 and 2). Labor expenses for yard engineers, yard conductors and foremen, and other yard trainmen was estimated to be $1,076 million in 1973 (Ref. 4). Converted to 1978 dollars using conversion factors in reference 5, the yard switching labor expenses are $1,700 million. This is the size of yard labor costs upon which a new coupler could have an impact. Using a value for a car-day of $12 (1978 dollars) and the total car-days spent in yards of 242,929,780 in 1973 (Ref. 4), the annual cost of time cars spend in yards is estimated to be $2,915 million (1978 dollars). However, only 20.8% of the time cars spend in yards was estimated to be related to coupler related activities (e.g., switching, inspection, train preparation). Thus, $600 million (20.8% of $2,915 million) is the cost esti-

mate of the time cars spend in yards during activities in which couplers play a part.

The 20-year present value of the costs are calculated. The present value of the property damage is $130 million (1978 dollars), and of operating costs (yard labor and car utilization costs) is $19,600 million (1978 dollars). These values are shown in Table 4-9.

Detailed Project Description Report

The information which was supplied to the Basic Project Information Form is listed for the user in the Detailed Project Description Report. This part of the report pertaining to Magnitude of Affected Area is shown in Table 4-10.

TABLE 4-10. DETAILED PROJECT DESCRIPTION REPORT - MAGNITUDE OF PROJECT AREA

SECTION B. MAGNITUDE OF AFFECTED AREA:

Fatalities	5	(Annual)
Injuries	2500	(Annual)
Property Damage	$ 130M	(Present Value Over 20 Years)
Operating Costs	$19600M	(Present Value Over 20 Years)
Other Costs	$ 0M	(Present Value Over 20 Years)

The values shown in this table are for the coupler project example and were calculated in the discussion above.

Intermediate Project Evaluation Report

Table 4-11 lists the format of the Magnitude of Area portion of the Intermediate Project Evaluation Report.

TABLE 4-11. INTERMEDIATE PROJECT EVALUATION REPORT - MAGNITUDE OF AFFECTED AREA

MEASURE	SCORE
B. MAGNITUDE OF AFFECTED AREA	
B.1 Fatalities	
B.2 Injuries	
B.3 Property Damage	
B.4 Operating Costs	
B.5 Other Costs	

To complete this report, 1 to 5 scores for the magnitude of fatalities, injuries, property damage, operating costs, and other costs are determined. As mentioned previously, a score of 1 always represents the least desirable score for research and a score of 5 is always the most desirable. Thus, for Magnitude of Affected Area, a 5 represents the largest range of casualty loss or dollar costs which most need research on possible improvements.

The number of fatalities and injuries and amount of property damage, operating costs and other costs from the Detailed Project Description Report (see Table 4-10) are assigned a 1 to 5 score according to the range in which they fall in Table 4-12.

TABLE 4-12. RATING SCORES FOR INTERMEDIATE PROJECT EVALUATION REPORT - MAGNITUDE OF AFFECTED AREA

Score	Fatalities	Injuries	Property Damage, Operating Costs, Other Costs
1	0-10	0-100	LE $.1B
2	11-35	101-300	.11B-.3B
3	36-100	301-1000	.31B-1.0B
4	101-300	1001-3000	1.01B-3.0B
5	GT 300	GT 3000	GT 3.0B

The values for converting the casualties and costs listed in the Detailed Project Description Report into 1 to 5 scores were selected after examining several years of FRA Accident/Incident Reports so that the scores for the various FRA projects would span the full range of 1 to 5.

The number of casualties and amount of costs for the Coupling Optimization Project example are listed in Table 4-10. By comparing the 5 fatalities for the coupler project to the ranges of fatalities in Table 4-12, a score of 1 is assigned for fatalities. Similarly, a score of 4 is assigned to the 2,500 injuries, a 2 to the $130 million property damage, a 5 to the $19,600 million operating costs, and a 1 to the negligible other costs. The completed Intermediate Project Evaluation Report for the Coupler Project is shown in Table 4-13.

TABLE 4-13. INTERMEDIATE PROJECT EVALUATION REPORT FOR COUPLER PROJECT - MAGNITUDE OF AFFECTED AREA

MEASURE	SCORE
B. MAGNITUDE OF AFFECTED AREA	
B.1 Fatalities	1
B.2 Injuries	4
B.3 Property Damage	2
B.4 Operating Costs	5
B.5 Other Costs	1

Summary Project Evaluation Report

The Summary Project Evaluation Report condenses the safety and cost information into two summary scores. One score is for safety which combines injuries and fatalities, and the other is for costs which combines property damage, operating costs, and other costs. The format of the Summary Project Evaluation Report is shown in Table 4-14.

TABLE 4-14. SUMMARY PROJECT EVALUATION REPORT - MAGNITUDE OF AFFECTED AREA

	MEASURE	SCORE
B.	MAGNITUDE OF AFFECTED AREA	
	SAFETY	
	COST	

The 1 to 5 rating scores for safety and cost are required to complete this table.

The Summary Project Evaluation Report safety score is calculated from the following formula:

magnitude of casualties = (no. fatalities) + (no. of injuries/100)

The number of fatalities and injuries are taken from the Detailed Project Description Report (see Table 4-10). The fractional magnitude of casualty is rounded upward to the next integer value. The 1 to 5 numerical score is then determined by comparing magnitude of casualty to the casualty conversion table listed in Table 4-15.

TABLE 4-15. RATING SCORES FOR SUMMARY PROJECT EVALUATION REPORT - MAGNITUDE OF AFFECTED AREA

Score	Safety (Magnitude of Casualties)	Cost (Magnitude of Costs)
1	0-10	LE $.1B
2	11-35	.11B - .3B
3	36-100	.31B - 1.0B
4	101-300	1.01B - 3.0B
5	GT 300	GT 3.0B

Since the casualty conversion chart in Table 4-15 is the same as the fatality conversion chart in Table 4-12, the combined casualty score is never lower than the score for fatalities alone. A large number of injuries will have the effect of raising the fatality score to a more severe level. The procedure for combining fatalities and injuries was based on an examination of the relative numbers of fatalities and injuries reported over the past several years.

The Summary Project Evaluation Report cost score is computed by first adding together the three cost components of property damage, operating costs, and other costs as shown in the following equation.

magnitude of cost = (property damage) + (operating costs) + (other costs)

This total magnitude of costs is converted into a 1 to 5 score using the cost conversion table in Table 4-15, which is the same as the cost conversion table in Table 4-12. This, in effect, says that the separate cost effects are cumulative and sum to a larger total cost problem.

For the Coupling Optimization Project example, the number of fatalities and injuries and amounts of property damage, operating costs, and other costs contained in the Detailed Project Description Report are shown in Table 4-10. The magnitude of casualty is calculated by the following formula.

magnitude of casualties for couplers = (5 fatalities) +
(2500 injuries/100) = 30

Comparing the magnitude of casualties value of 30 to Table 4-15 results in a score of 2 assigned to safety in the Summary Project Evaluation Report. The magnitude of cost for couplers is calculated similarly.

magnitude of cost = ($130M property damage) + ($19,600M operating cost) + ($0 other costs) = $19,730M

Using Table 4-15, a score of 5 is assigned to cost in the Summary Project Evaluation Report for couplers. The Magnitude of Affected Area portion of the Summary Project Evaluation Report for the coupler project listing these scores is shown in Table 4-16.

TABLE 4-16. SUMMARY PROJECT EVALUATION REPORT FOR COUPLER PROJECT - MAGNITUDE OF AFFECTED AREA

	MEASURE	SCORE
B.	MAGNITUDE OF AFFECTED AREA	
	SAFETY	2
	COST	5

4.3.3 Potential Impact on Area Through R&D in General

The Potential Impact on Area Through R&D in General represents the percentage of the affected areas which can be improved through all possible research activity. The data elements in this measure area are identical to those of the previous measure: fatalities, injuries, property damage, operating costs, and other costs.

Basic Project Information Form

The information required to complete the Basic Project Information Form on Potential Impact on Area Through R&D in General are the percentage impacts on fatalities, injuries, property damage, operating costs, and other costs possible by all research in general. This required information is shown in Table 4-17.

TABLE 4-17. BASIC PROJECT INFORMATION FORM - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

____% of Fatalities in Magnitude of Affected Area
____% of Injuries in Magnitude of Affected Area
____% of Property Damage in Magnitude of Affected Area
____% of Operating Costs in Magnitude of Affected Area
____% of Other Costs in Magnitude of Affected Area

In the analysis of each project, the percentages of the values listed in the Magnitude of Affected Area which are impacted by the results of research on fatalities, casualties, property damage, operating costs and other costs are determined separately. For example, individual cause and occurrence codes for casualties in the FRA Accident/Incident data base are examined to estimate the extent to which casualties could be reduced by research. Similarly, cost data are investigated to determine impacts on various elements of cost, such as maintenance, inspection, or fuel costs. These analysis results, expressed as percentage impacts, are entered in the Basic Project Information Form shown in Table 4-17.

For the Coupling Optimization Project example, the percentage impact on injuries and fatalities was estimated by examining the number of casualties listed in the individual occurrence codes reported to FRA for casualties

during coupling and uncoupling, including air hoses. The result of this investigation was an estimate of 50 percent of the coupler related casualties could be prevented by a new coupler. These values are entered in the Basic Project Information Form as shown in Table 4-18.

TABLE 4-18. BASIC PROJECT INFORMATION FORM FOR COUPLER PROJECT - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

50 % of Fatalities in Magnitude of Affected Area
50 % of Injuries in Magnitude of Affected Area
9 % of Property Damage in Magnitude of Affected Area
6 % of Operating Costs in Magnitude of Affected Area
0 % of Other Costs in Magnitude of Affected Area

Most of the property damage for coupler related accidents is for broken or defective coupler parts rather than mismatched couplers during coupling. It is estimated that a new coupling system would reduce coupler related property damage by 25 percent. Twenty-five percent of the annual $15 million in coupler related property damage determined in Section 4.3.2 is $3.8 million. A 20-year phase-in period for a new coupler system is assumed, which implies that 5 percent of the fleet receives new couplers each year. The present value of the property damage savings while adding 5 percent of the impact each year is $12 million. This is present value over 20 years using a 10 percent discount rate. $12 million is 9 percent of the $130 million present value of amount of property damage listed in Table 4-10. This value of 9 percent impact on property damage has been entered in Table 4-18.

The estimate of the impact of a new coupler on labor costs is based on the number of cars processed through yards annually and an estimated savings of 5 minutes of labor each time a car passes through a yard. The number of daily

switching operations is taken to be 910,000 (Ref. 4), and a labor cost of $9.93 per hour (1978 dollars) is estimated from values given in Reference 5. The estimated savings for labor with a new coupling system is, then, $275 million annually once the coupler system is completely implemented.

It was determined in Section 4.3.2 that the value of the car time involved in yard switching activities in which couplers play a part was $600 million. It is estimated that an advanced coupler system could reduce the car time involved in switching, and hence the $600 million, by 25 percent once the coupler system was completely implemented. (A reduction of 25 percent of the time cars spend related to switching represents approximately a 5 percent reduction of the total time cars spend in yards. Since an average car spends approximately 20 hours for each processing through a yard (Ref. 6), the assumption is equivalent to a one-hour decrease in yard time.) A 25 percent reduction of $600 million is $150 million.

The sum of the $275 million yard labor savings and $150 million car time savings is a $375 million savings in operating costs. The coupler system is, however, assumed to be implemented over a 20-year period. The 20-year present value of the operating cost savings with 5 percent of the impact added each year is $1,200 million. $1,200 million is 6 percent of the present value of the $19,600 million in coupler related operating costs listed in Table 4-10. The value of 6 percent impact on coupler related operating costs has been entered in Table 4-18. There were $0 other costs listed in Table 4-10 for couplers, and, thus, 0 percent is entered in Table 4-18 for impact on other costs.

Detailed Project Description Report

The information completed in the Basic Project Information form is listed for the user in the Detailed Project Description Report. Table 4-19 shows the part of this report pertaining to Potential Impact on Area Through R&D in General.

TABLE 4-19. DETAILED PROJECT DESCRIPTION REPORT - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

SECTION C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL:	
Fatalities	50 %
Injuries	50 %
Property Damage	9 %
Operating Costs	6 %
Other Costs	0 %

The values in the table are for the Coupling Optimization Project example. These values were listed in Table 4-18.

Intermediate Project Evaluation Report

The format of the Potential Impact on Area Through R&D in General part of the Intermediate Project Evaluation Report is shown in Table 4-20.

TABLE 4-20. INTERMEDIATE PROJECT EVALUATION REPORT - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

	MEASURE	SCORE
C.	POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL	
C.1	Fatalities	
C.2	Injuries	
C.3	Property Damage	
C.4	Operating Costs	
C.5	Other Costs	

The 5 values of percent impact on fatalities, injuries, property damage, operating cost and other costs listed in the Detailed Project Description Report

(see Table 4-19) are converted to 1 to 5 rating scores and entered in Table 4-20. The percentages are assigned scores according to Table 4-21.

TABLE 4-21. RATING SCORES FOR INTERMEDIATE PROJECT EVALUATION REPORT - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

Score	% Potential Impact
1	LT 2%
2	2% - 4%
3	5% - 9%
4	10% - 24%
5	GT 24%

The scores for the percentages were selected such that the various FRA research projects would display a full range of the 1 to 5 values.

In the Coupling Optimization Project example, the impact percentages listed in Table 4-19 are 50 percent for fatalities, 50 percent for injuries, 9 percent for property damage, 6 percent for operating costs, and 0 percent for other costs. Using Table 4-21, these values are converted to scores of 5 for fatalities, 5 for injuries, 3 for property damage, 3 for operating costs, and 1 for other costs. The completed Intermediate Project Evaluation Report for couplers is shown in Table 4-22.

TABLE 4-22. INTERMEDIATE PROJECT EVALUATION REPORT FOR COUPLER PROJECT - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

MEASURE	SCORE
C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL	
C.1 Fatalities	5
C.2 Injuries	5
C.3 Property Damage	3
C.4 Operating Costs	3
C.5 Other Costs	1

Summary Project Evaluation Report

The format of the Summary Report is shown in Table 4-23.

TABLE 4-23. SUMMARY PROJECT EVALUATION REPORT - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

	MEASURE	SCORE
C.	POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL	
	SAFETY	
	COST	

The Summary Project Evaluation Report summarizes the Intermediate Project Evaluation Report data elements into two composite 1 to 5 scores: one for safety and one for costs. The safety Summary score represents a weighted average percent impact whereby the percent impact for fatalities is weighted 100 times that of injuries. This is consistent with the comparison of fatalities and injuries in the Magnitude of Affected Area. The formula for calculating the safety percentage impact is:

$$\text{Safety Percentage} = \frac{(\%\ \text{fat. impact} \times \text{no. fat.} \times 100) + (\%\ \text{inj. impact} \times \text{no. inj.})}{([\text{no. fatalities} \times 100] + \text{no. injuries})}$$

The values of number fatalities and injuries and percent impacts on fatalities and injuries are listed in the Detailed Project Evaluation Reports (see Table 4-10 for number of casualties and Table 4-19 for percent impacts). The resulting weighted average casualty percentage is converted to a 1 to 5 score using Table 4-24.

TABLE 4-24. RATING SCORES FOR SUMMARY PROJECT EVALUATION REPORT - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

Score	% Potential Impact
1	LT 2%
2	2% - 4%
3	5% - 9%
4	10% - 24%
5	GT 24%

The Summary Project Evaluation Report cost score represents a weighted average percent impact of all of the cost data elements. The percentages are weighted by the dollar amounts within each data element as follows:

$$\text{Cost Percentage} = \frac{(\%\text{impact x prop dam})+(\%\text{ impact x op costs})+(\%\text{impact x other costs})}{(\text{prop dam + operating costs + other costs})}$$

This resulting weighted average cost percentage is also converted to a 1 to 5 score using Table 4-24 presented above.

The values of the percent impacts for the Coupler Project example are listed in Table 4-19, and the magnitudes of areas are listed in Table 4-10. These values are used in the above formulae to calculate the summary casualty percentage and cost percentage.

$$\text{Safety Percentage} = \frac{[(50\%) \text{ x } (5 \text{ fat.}) \text{ x } 100] + [(50\% \text{ inj.}) \text{ x } (2500 \text{ inj.})]}{(5 \text{ fat. x } 100 + 2500 \text{ inj.})} = 50\%$$

$$\text{Cost Percentage} = \frac{[(9\%) \text{ x } (\$130\text{M})] + [(6\%) \text{ x } (\$19{,}600\text{M})]}{(\$130\text{M} + \$19{,}600\text{M})} = 6\%$$

Using Table 4-24, the 50% safety percentage is assigned a score of 5 and the 6% cost percentage is assigned a score of 3. These scores are listed in the Summary Project Evaluation Report for couplers as shown in Table 4-25.

TABLE 4-25. SUMMARY PROJECT EVALUATION REPORT FOR COUPLER PROJECT - POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL

MEASURE	SCORE
C. POTENTIAL IMPACT ON AREA THROUGH R&D IN GENERAL	5
SAFETY	3
COST	

4.3.4 Effect of Specific Research Project in Achieving Potential R&D Impact

This measure area carries the concept of the previous two measures down to the specific, current research project. It evaluates the degree to which the specific research under consideration will contribute to the potential impact from R&D in general.

Basic Project Information Form

The information required for the Basic Project Information Form is shown in Table 4-26.

TABLE 4-26. BASIC PROJECT INFORMATION FORM - EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

____% Effect of Specific Research Project in Achieving Potential R&D Impact

The completion of this form requires an estimate of the percent of all research included in Potential Impact on Area Through R&D in General (see Section 4.3.3) which would be accomplished by the specific R&D project being evaluated. For example, if the research was on brakes and the specific

project was on brake shoes, a value of 10 percent might be assigned to the effect of the specific project on completing research on brakes in general. In this case, the specific research subject (i.e., brake shoes) is only one of several possible research topics affecting brakes. Another influence on this project evaluation measure is that the specific project may address only part of the sequence of research that needs to be performed on the subject. For example, a concept definition study on brake system improvements might be assigned 5 percent since this is only a small part of the research steps required to complete research on brakes.

The current research on the Coupling Optimization Project is intended primarily to clarify benefit-cost considerations. While an important step in the research effort on couplers, this specific project represents only a small portion of the total research and development which will be necessary to result in an implementable advanced coupler. The effect of the specific Coupling Optimization Project is estimated to be 4 percent. The Basic Project Information Form completed for the Coupling Optimization Project on the effect of the specific project is shown in Table 4-27.

TABLE 4-27. BASIC PROJECT INFORMATION FORM FOR COUPLER PROJECT - EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

__4__ % Effect of Specific Research Project in Achieving Potential R&D Impact

Detailed Project Description Report

The single data element of percent effect of the specific project is presented in the Detailed Project Description Report as is shown in Table 4-28.

TABLE 4-28. DETAILED PROJECT DESCRIPTION REPORT - EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

SECTION D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT:	
Effect of Specific Research Project in Achieving Potential R & D Impact	4 %

This table shows the percentage determined for the Coupling Optimization Project example in the preceding discussion.

Intermediate Project Evaluation Report

The Intemediate Project Evaluation Report format is shown in Table 4-29.

TABLE 4-29. INTERMEDIATE PROJECT EVALUATION REPORT - EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

	MEASURE	SCORE
D.	EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT	
D.1	Effect of Specific Project in Achieving Potential R&D Impact	

This report is completed by converting the percent effect of the specific project to a 1 to 5 score. Table 4-30 presents the rating scores assigned to various ranges of percent effects.

TABLE 4-30. RATING SCALES FOR INTERMEDIATE PROJECT EVALUATION REPORT - EFFECT OF SPECIFIC PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

Rating	% Effect
1	LT 2%
2	2%-4%
3	5%-9%
4	10%-24%
5	GT 24%

For the Coupling Optimization Project example, the 4 percent effect of specific project (see Table 4-23) is assigned a score of 2 by using Table 4-30. Thus, the completed Intermediate Project Evaluation Report for the coupler project is shown in Table 4-31.

TABLE 4-31. INTERMEDIATE PROJECT EVALUATION REPORT FOR COUPLER PROJECT - EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

	MEASURE	SCORE
D.	EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT	
D.1	Effect of Specific Project in Achieving Potential R&D Impact	2

Summary Project Evaluation Report

The same score for the effect of the specific project is contained in the Summary Project Evaluation Report as is in the Intermediate Project Evaluation Report. The format for the Summary Project Evaluation Report is shown in Table 4-32.

TABLE 4-32. SUMMARY PROJECT EVALUATION REPORT - EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

MEASURE	SCORE
D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT	

The score of 2 determined for the Coupling Optimization Project example is shown in Table 4-33.

TABLE 4-33. SUMMARY PROJECT EVALUATION REPORT FOR COUPLER PROJECT - EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT

MEASURE	SCORE
D. EFFECT OF SPECIFIC RESEARCH PROJECT IN ACHIEVING POTENTIAL R&D IMPACT	2

4.3.5 Likelihood of Research Success

This project evaluation measure provides an evaluation of the likelihood of research success by consideration of a variety of factors which affect a successful research outcome. The measure is concerned with the specific current research project as discussed in Section 4.3.4 rather than research in general on the topic. Twelve factors are involved in the determination of the likelihood of research success. These factors are listed in Table 4-34 which presents the Basic Project Information Form for Likelihood of Research Success.

TABLE 4-34. BASIC PROJECT INFORMATION FORM - LIKELIHOOD OF RESEARCH SUCCESS

E. LIKELIHOOD OF RESEARCH SUCCESS

Requirements which could impede performance of research project:

none	moderate	major	
___	___	___	1. detailed information and/or cooperation from industry organizations
___	___	___	2. detailed information and/or cooperation from specific railroads or suppliers
___	___	___	3. concensus or coordinated joint action by government and industry
___	___	___	4. use of major DOT test facility
___	___	___	5. use of other (non-DOT) test facility
___	___	___	6. significant revenue service testing or other railroad trial use
___	___	___	7. testing raises significant liability issues
___	___	___	8. use of skills and capabilities which are not readily available
___	___	___	9. data not readily available
___	___	___	10. extension beyond state-of-the-art technology or knowledge
___	___	___	11. integration of numerous elements
___	___	___	12. dependence on other research

In the completion of the form, each factor is marked as having a major, moderate, or none to indicate the effect the factor has on the likelihood of successful completion of the current research project. Each of the twelve factors can be viewed as a requirement for research, and thus, a possible impediment to research completion. The more of these factors marked moderate or major, the more difficult it is likely to be to fully complete the research project. The form is completed by qualitatively analyzing how each of these factors pertains to the particular project.

The current research effort on couplers involves a benefit-cost analysis of possible coupler concepts. For this type of research analysis, there is a moderate requirement for information and/or cooperation from industry organi-

zations and from specific railroads or suppliers (i.e., items 1 and 2 in Table 4-34). The completed Basic Project Information Form for the coupler project example is shown in Table 4-35.

TABLE 4-35. BASIC PROJECT INFORMATION FORM FOR COUPLER PROJECT - LIKELIHOOD OF RESEARCH SUCCESS

E. LIKELIHOOD OF RESEARCH SUCCESS

Requirements which could impede performance of research project:

none	moderate	major		
____	X	____	1.	detailed information and/or cooperation from industry organizations
____	X	____	2.	detailed information and/or cooperation from specific railroads or suppliers
X	____	____	3.	concensus or coordinated joint action by government and industry
X	____	____	4.	use of major DOT test facility
X	____	____	5.	use of other (non-DOT) test facility
X	____	____	6.	significant revenue service testing or other railroad trial use
____	____	____	7.	testing raises significant liability issues
X	____	____	8.	use of skills and capabilities which are not readily available
X	____	____	9.	data not readily available
____	____	____	10.	extension beyond state-of-the-art technology or knowledge
X	____	____	11.	integration of numerous elements
X	____	____	12.	dependence on other research
____	____	____		

Detailed Project Description Report

The factors affecting likelihood of research success which were marked on the Basic Project Information Form are displayed for the user in the Detailed Project Description Report. Only the factors marked moderate or major are listed to simplify this report. This report is illustrated in Table 4-36 using the coupler project as an example.

TABLE 4-36. DETAILED PROJECT DESCRIPTION REPORT - LIKELIHOOD OF RESEARCH SUCCESS

SECTION E. LIKELIHOOD OF RESEARCH SUCCESS:

Requirements that Could Impede Performance:
MAJOR
MODERATE
Detailed Information and/or Cooperation from Industry Organizations
Detailed Information and/or Cooperation from Specific Railroads or Suppliers

Intermediate Project Evaluation Report

The 12 factors relating to likelihood of research success listed in Table 4-34 are integrated into 5 general categories and assigned 1 to 5 rating scores for the Intermediate Project Evaluation Report. The format for this report is shown in Table 4-37.

TABLE 4-37. INTERMEDIATE PROJECT EVALUATION REPORT - LIKELIHOOD OF RESEARCH SUCCESS

MEASURE	SCORE
E. LIKELIHOOD OF RESEARCH SUCCESS	
Independence from Factors Affecting Success:	
E.1 Industry Participation	
E.2 Major Test Phase	
E.3 Special Resources	
E.4 Major Technical Advance	
E.5 Other Factors	

The process for determining the rating scores for each of the 5 data elements listed in Table 4-37 is shown in Figure 4-1.

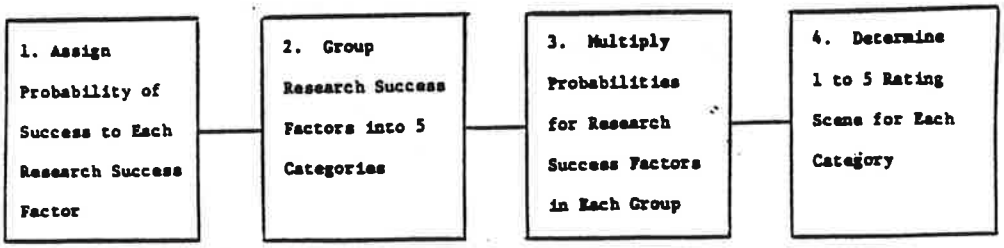

FIGURE 4-1. PROCEDURE FOR DETERMINING RATING SCORES FOR LIKELIHOOD OF RESEARCH SUCCESS

The procedure is described in detail below.

Step 1. Each of the twelve factors relating to likelihood of research success (see Table 4-34) is assigned a probability of success according to whether the factor was marked major, moderate, or none. The 12 factors are listed in Table 4-38 with the numbers in parentheses representing the probability assigned to each factor for a response of major, moderate, or none, respectively.

TABLE 4-38. PROBABILITIES FOR LIKELIHOOD OF RESEARCH SUCCESS FACTORS

	Probability (Major/ Moderate/None)	
1.	(.80/.90/1.0)	Detailed information and/or cooperation from industry organizations
2.	(.50/.75/1.0)	Detailed information and/or cooperation from specific railroads or suppliers
3.	(.50/.75/1.0)	Consensus or coordinated joint action by Government and industry
4.	(.80/.90/1.0)	Use of major DOT test facility
5.	(.80/.90/1.0)	Use of other (non-DOT) test facility
6.	(.80/.90/1.0)	Significant revenue service tests or other railroad trial use
7.	(.50/.75/1.0)	Testing raising significant liability issues
8.	(.50/.75/1.0)	Use of skills and capabilities which are not readily available
9.	(.80/.90/1.0)	Data not readily available
10.	(.50/.75/1.0)	Extension beyond state-of-the-art technology or knowledge
11.	(.80/.90/1.0)	Integration of numerous elements
12.	(.50/.75/1.0)	Dependence on other research

Step 2. The twelve factors are grouped into five categories as shown below in Table 4-39.

TABLE 4-39. CATEGORIES OF LIKELIHOOD OF RESEARCH SUCCESS FACTORS

Category	Factors Included
Industry participation	1,2,3
Major test phase	4,5,6,7
Special resources	8,9
Technology advance	10
All other factors	11,12

Step 3. The probabilities associated with the factors in each category are multiplied together to calculate a composite probability for each category. For example, if factors 1, 2, and 3 have probabilities of .80, .75, and 1.0 assigned, respectively, then the probability for Industry Participation is (.80) x (.75) x (1.0) = .60.

Step 4. The final step in the process is to convert these resulting probabilities into 1 to 5 scores. Table 4-40 shows the scores assigned to each category of likelihood of research success depending on the composite probability calculated in Step 3.

TABLE 4-40. RATING SCORES FOR LIKELIHOOD OF RESEARCH SUCCESS - INTERMEDIATE PROJECT EVALUATION REPORT

Score	Probability
1	.00 - .09
2	.10 - .24
3	.25 - .49
4	.50 - .79
5	GT .79

The example probability of .60 calculated in Step 3 would receive a score of 4.

For the coupler project example, two factors in Table 4-44 were marked moderate. The calculation of the 1 to 5 scores is explained below using the 4 steps shown in Figure 4-1.

Step 1. According to Table 4-38, the two factors marked moderate (1. detailed information and/or cooperation from industry organizations, and 2. detailed information and/or cooperation from specific railroads or suppliers) are assigned probabilities of .90 and .75, respectively.

Step 2. Both factors fall within the category Industry Participation in Table 4-39.

Step 3. The product of .90 and .75 is .675 for the category Industry Participation. All of the other categories have a probability of 1.0 since the other factors were marked "none" for the Coupling Optimization Project.

Step 4. A .675 for Industry participation is assigned a score of 4 according to Table 4-40, and the other categories are assigned 5 since their probability products are 1.0.

The completed scores for the Coupler Project example are shown in Table 4-41.

TABLE 4-41. INTERMEDIATE PROJECT EVALUATION REPORT FOR COUPLER PROJECT - LIKELIHOOD OF RESEARCH SUCCESS

MEASURE	SCORE
E. LIKELIHOOD OF RESEARCH SUCCESS	
Independence from Factors Affecting Success:	
E.1 Industry Participation	4
E.2 Major Test Phase	5
E.3 Special Resources	5
E.4 Major Technical Advance	5
E.5 Other Factors	5

Summary Project Evaluation Report

The Summary Project Evaluation Report format is shown in Table 4-42.

TABLE 4-42. SUMMARY PROJECT EVALUATION REPORT - LIKELIHOOD OF RESEARCH SUCCESS

MEASURE	SCORE
E. LIKELIHOOD OF RESEARCH SUCCESS	

A single 1 to 5 score is calculated by multiplying the probabilities determined for the 5 categories of research success in the Intermediate Project Evaluation Report. This probability is converted to a 1 to 5 score using Table 4-43.

TABLE 4-43. RATING SCORES FOR LIKELIHOOD OF RESEARCH SUCCESS - SUMMARY PROJECT EVALUATION REPORT

Score	Probability
1	.00 - .09
2	.10 - .24
3	.25 - .49
4	.50 - .79
5	GT .79

For the Coupling Optimization Project example, Industry Participation category had a probability of .675 and the other 4 categories probabilities of 1.0. The product of these is .675. By using Table 4-43, a score of 4 is assigned as shown in Table 4-44.

TABLE 4-44. SUMMARY PROJECT EVALUATION REPORT FOR COUPLER PROJECT - LIKELIHOOD OF RESEARCH SUCCESS

MEASURE	SCORE
E. LIKELIHOOD OF RESEARCH SUCCESS	4

4.3.6 Economy of Research Effort

This project evaluation measure provides information on the cost and duration of the research effort. In keeping with the scoring philosophy of a 5 representing the score most favorable for research, a high score represents a low cost or a short duration project. Accordingly, this evaluation measure is called economy of effort rather than magnitude of effort.

Basic Project Information Form

The information needed to complete the Basic Project Information Form for Economy of Research Effort is shown in Table 4-45.

TABLE 4-45. BASIC PROJECT INFORMATION FORM - ECONOMY OF RESEARCH EFFORT

F. ECONOMY OF RESEARCH EFFORT

$\_\_\_\_$ Cost ($ thousands)
____ Duration (years)

The estimation of the cost for the specific research project and the duration of the research project is required to fill in this form.

For the Coupling Optimization Project example, the cost of the current research related to benefit-cost analysis of possible coupler design improvements is approximately $200,000 with a project duration of approximately 3

years. The Basic Project Information Form for the coupler project example is shown in Table 4-46.

TABLE 4-46. BASIC PROJECT INFORMATION FORM FOR COUPLER PROJECT - ECONOMY OF RESEARCH EFFORT

F. ECONOMY OF RESEARCH EFFORT

$ 200 Cost ($ thousands)
3 Duration (years)

Detailed Project Description Report

In the Detailed Project Description Report, these two data elements are reported directly as dollar costs and time in years. Table 4-47 shows this portion of the Detailed Project Description Report.

TABLE 4-47. DETAILED PROJECT DESCRIPTION REPORT - ECONOMY OF RESEARCH EFFORT

SECTION F. ECONOMY OF RESEARCH EFFORT:

Research Cost	$ 200K
Research Duration	3 years

The information determined for the coupler project example is presented in this table.

Intermediate Project Evaluation Report

Table 4-48 shows the format for the Intermediate Project Evaluation Report for Economy of Research Effort.

TABLE 4-48. INTERMEDIATE PROJECT EVALUATION REPORT - ECONOMY OF RESEARCH EFFORT

MEASURE	SCORE
F. ECONOMY OF RESEARCH EFFORT	
F.1 Research Cost * Research Duration	

To complete the report, the numerical values of cost and duration of the research project are converted to a 1 to 5 score according to Table 4-49.

TABLE 4-49. RATING SCALES FOR INTERMEDIATE PROJECT EVALUATION REPORT - ECONOMY OF RESEARCH EFFORT

Rating	Cost ($millions)	Duration (years)
1	GE $5.0	GT 4
2	3.0 - 4.9	3
3	1.5 - 2.9	2
4	.5 - 1.4	1
5	LT .5	LT 1

The cost and duration for the current coupler research project were reported in Table 4-30 as $200,000 and 3 years. These values are converted to scores of 5 and 2, respectively, using Table 4-49. The completed Intermediate Project Evaluation Report for the Coupling Optimization Project example is shown in Table 4-50.

TABLE 4-50. INTERMEDIATE PROJECT EVALUATION REPORT FOR COUPLER PROJECT - ECONOMY OF RESEARCH EFFORT

MEASURE	SCORE
F. ECONOMY OF RESEARCH EFFORT	
F.1 Research Cost	5
* Research Duration	2

Summary Project Evaluation Report

In the Summary Project Evaluation Report, the score for the research cost is reported alone since the research cost is the most important consideration for the later calculation of a composite research cost-effectiveness rating for a project. The format for the Summary Project Evaluation Report is shown in Table 4-51.

TABLE 4-51. SUMMARY PROJECT EVALUATION REPORT - ECONOMY OF RESEARCH EFFORT

MEASURE	SCORE
F. ECONOMY OF RESEARCH EFFORT	

The same score for research cost reported in the Intermediate Project Evaluation Report (see Table 4-48) is shown in this table.

The research cost score of 5 determined for the Coupling Optimization Project example (see Table 4-50) is presented in Table 4-52.

TABLE 4-52. SUMMARY PROJECT EVALUATION REPORT FOR COUPLER PROJECT - ECONOMY OF RESEARCH EFFORT

MEASURE	SCORE
F. ECONOMY OF RESEARCH EFFORT	5

4.3.7 Ease of Implementation

The Ease of Implementation project evaluation measure evaluates both quantitative aspects of implementation (implementation cost and duration) and qualitative aspects (e.g., compatibility with existing equipment, industry consensus regarding interchange of new equipment, and employee sensitivity).

Basic Project Information Form

The ease of implementation is determined by considering: (1) 24 separate factors which address the qualitative considerations affecting the likelihood of research results being implemented; (2) the implementation cost; and (3) duration of the implementation process. The specific information required is listed in Table 4-53, the part of Basic Project Information Form for Ease of Implementation.

TABLE 4-53. BASIC PROJECT INFORMATION FORM - EASE OF IMPLEMENTATION

G. EASE OF IMPLEMENTATION

$____ Industry-wide Capital Required ($ millions)
____ Estimated Implementation Time (years)

Transition Process Requires:

none	moderate	major	
____	____	____	1. Industry concensus
____	____	____	2. Industry-wide equipment/system compatibility
____	____	____	3. Industry-wide data/information exchange
____	____	____	4. Major demonstration phase
____	____	____	5. Industry acceptance testing
____	____	____	6. Development of new suppliers and/or supplier capabilities
____	____	____	7. Federal safety regulation
____	____	____	8. Conflict with industry trends
____	____	____	9. Industry hardware development effort
____	____	____	10. Significant expenditures by government agency

Implementation will result in significant changes in the following equipment and operations:

none	moderate	major	
____	____	____	1. Rolling stock equipment
____	____	____	2. Facilities
____	____	____	3. Train operations
____	____	____	4. Practices and procedures
____	____	____	5. Industry standards
____	____	____	6. Inter-railroad cooperation
____	____	____	7. Safety regulations
____	____	____	8. Economic regulations
____	____	____	9. Environmental regulations
____	____	____	10. Locomotives
____	____	____	11. Maintenance procedures

Implementation will result in the following changes affecting potential labor acceptability:

none	moderate	major	
____	____	____	1. Reduction of labor force
____	____	____	2. Skill mix
____	____	____	3. Work rules

The analysis of any particular research project would estimate the cost and duration of the implementation process as well as assign to each of the 24 implementation factors a response of major, moderate, or none according to the extent to which the factor pertains to the implementation process. The cost is expressed as the present value of the implementaton costs over the implementation duration period.

For the coupler project example, the incremental cost of a new coupler over the cost of existing couplers is estimated to be $1000 per car. A 20-year implementation period has been assumed with 5 percent of the fleet of 1.65 million cars (Ref. 5) being equipped each year. For a 10 percent discount rate, the present value of this implementation cost is $700 million. Industry consensus, industry-wide equipment compatibility, a major demonstration phase, and industry acceptance testing would be required for the transition process leading to implementation of a new coupler. Some changes in safety regulations would be necessary along with some modifications in labor operations since coupling would be more automatic and require less labor time. The completed Basic Project Information Form for the coupler project example is presented in Table 4-54.

TABLE 4-48. BASIC PROJECT INFORMATION FORM FOR COUPLER PROJECT - EASE OF IMPLEMENTATION

G. EASE OF IMPLEMENTATION

$ 700 Industry-wide Capital Required ($ millions)
20 Estimated Implementation Time (years)

Transition Process Requires:

none	moderate	major	
		X	1. Industry concensus
		X	2. Industry-wide equipment/system compatibility
X			3. Industry-wide data/information exchange
		X	4. Major demonstration phase
		X	5. Industry acceptance testing
X			6. Development of new suppliers and/or supplier capabilities
	X		7. Federal safety regulation
X			8. Conflict with industry trends
	X		9. Industry hardware development effort
X			10. Significant expenditures by government agency

Implementation will result in significant changes in the following equipment and operations:

none	moderate	major	
		X	1. Rolling stock equipment
X			2. Facilities
X			3. Train operations
	X		4. Practices and procedures
	X		5. Industry standards
X			6. Inter-railroad cooperation
	X		7. Safety regulations
X			8. Economic regulations
X			9. Environmental regulations
X			10. Locomotives
X			11. Maintenance procedures

Implementation will result in the following changes affecting potential labor acceptability:

none	moderate	major	
	X		1. Reduction of labor force
X			2. Skill mix
	X		3. Work rules

Detailed Project Description Report

The information contained in the Basic Project Information Form is displayed for the user in the Detailed Project Description Report as shown in Table 4-55.

TABLE 4-55. DETAILED PROJECT DESCRIPTION REPORT - EASE OF IMPLEMENTATION

```
SECTION G.  EASE OF IMPLEMENTATION:
-----------------------------------
   CAPITAL REQUIRED (Industry-wide):  $  700M

   ESTIMATED IMPLEMENTATION TIME:        20 years

   TRANSITION PROCESS REQUIREMENTS:
     MAJOR
      Industry Consensus
      Industry-wide Equipment/System Compatibility
      Major Demonstration Phase
      Industry Acceptance Testing
     MODERATE
      Federal Safety Regulation
      Industry Hardware Development Effort

   IMPLEMENTATION WILL AFFECT CHANGES IN:
     MAJOR
      Rolling Stock and Equipment
     MODERATE
      Practices and Procedures
      Industry Standards
      Safety Regulations

   IMPLEMENTATION CHANGES AFFECTING POTENTIAL LABOR ACCEPTABILITY:
     MAJOR
     MODERATE
      Reduction of Labor Force
      Work Rules
```

The table uses the coupler project as an example of the report content. Only implementation factors in the Basic Project Information Form marked major or moderate are listed to simplify the report content.

Intermediate Project Evaluation Report

The format of the Intermediate Project Evaluation Report is shown in Table 4-56.

TABLE 4-56. INTERMEDIATE PROJECT EVALUATION REPORT - EASE OF IMPLEMENTATION

MEASURE	SCORE
G. EASE OF IMPLEMENTATION	
G.1 Capital Considerations	
G.2 Implementation Speed	
G.3 Transition Process Simplicity	
G.4 Compat.w.Existing Equip & Ops	
G.5 Potential Labor Acceptability	

The rating scores for Capital Considerations and Implementation Speed are determined from look-up tables, and the scores for the other three data elements in Table 4-56 are determined by a procedure similar to that used in Likelihood of Research Success. The procedure is illustrated in Figure 4-2.

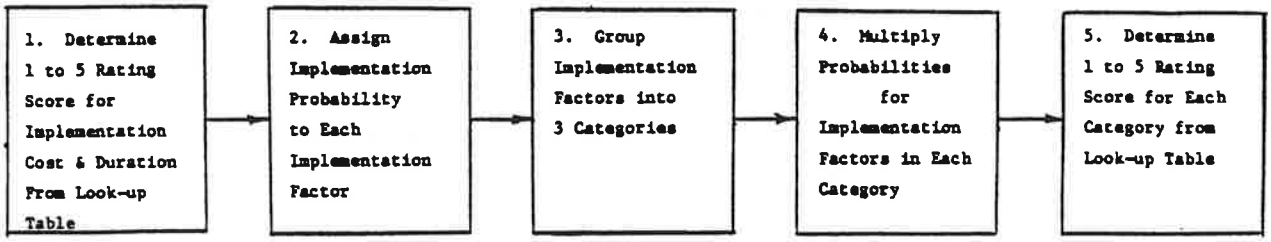

FIGURE 4-2. PROCEDURE FOR DETERMINING RATING SCORES FOR EASE OF IMPLEMENTATION

The steps for this procedure are explained in detail below.

Step 1. The implementation cost and duration from Table 4-55 are converted to 1 to 5 scores using the rating scores in Table 4-57.

TABLE 4-57. RATING SCORES FOR IMPLEMENTATION COST AND DURATION

Score	Implementation Cost	Implementation Duration
1	GE $1B	GT 15 years
2	300M - .9B	11 - 15 years
3	100M - 299M	7 - 10 years
4	30M - 99M	3 - 6 years
5	LT 30M	LT 3 years

Step 2. Each implementation factor with a major response (see Table 4-55) is assigned a probability of .75 and each implementation factor with a moderate response is assigned .90, except that the implementation factors concerned

with Potential Labor Acceptability are assigned .50 for major and .80 for moderate. If a factor was marked none, it is assigned 1.0.

Step 3. The implementation factors are grouped in the categories in which they are listed in Table 4-55. The labels of these categories for the Intermediate Project Evaluation Report are Transition Process Simplicity; Compatability with Existing Equipment and Operations, and Potential Labor Acceptability, respectively.

Step 4. For each of the 3 categories, the probabilities assigned to each factor are multiplied together to form a product probability for each category.

Step 5. The product probabilities for each of the 3 categories are converted to 1 to 5 scores by using the rating scores in Table 4-58.

TABLE 4-58. RATING SCORES FOR IMPLEMENTATION FACTORS

Score	Probability
1	LT .20
2	.20 - .39
3	.40 - .59
4	.60 - .79
5	GR .79

The scoring scheme in this procedure is consistent with the overall philosophy of a high score representing the conditions most favorable to a research project. In this case, a high score is associated with a low implementation cost, a short implementation duration, and the fewest potential implementation impediments.

The completion of this process for the Coupling Optimization Project example is presented below.

Step 1. The implementation cost and duration for a new coupler system were listed in Table 4-55 as $700 million and 20 years, respectively. Using Table 4-58, these are converted to scores of 2 and 1, respectively.

Step 2. Five implementation factors listed as major in Table 4-55 are assigned probabilities of .75 and 5 factors listed as moderate are assigned .90. In addition, 2 factors marked moderate under labor acceptability are assigned .80.

Step 3. Four factors marked major and 2 moderate in Table 4-55 are grouped into Transition Process Simplicity, 1 factor marked major and 3 moderate are grouped into Compatibility with Existing Equipment and Operations, and 2 factors marked moderate are grouped into Potential Labor Acceptability.

Step 4. The 4 probabilities for factors marked major and 2 for moderate are multiplied together to give a product probability of .26 for Transition Process Simplicity.

$$(.75) \times (.75) \times (.75) \times (.75) \times (.90) \times (.90) = .26$$

Similarly, the product probability for Compatibility with Existing Equipment and Operations is

$$(.75) \times (.90) \times (.90). \ (.90) = .55$$

and for Potential Employee Sensitivity,

$$(.80) \times (.80) = .64.$$

Step 5. Using Table 4-58, the product probabilities of .26, .55, and .64 are converted to rating scores of 2, 3, and 4, respectively.

The completed Intermediate Project Evaluation Report for the Coupling Optimization Project example is presented in Table 4-59.

TABLE 4-59. INTERMEDIATE PROJECT EVALUATION REPORT FOR COUPLER PROJECT - EASE OF IMPLEMENTATION

MEASURE	SCORE
G. EASE OF IMPLEMENTATION	
G.1 Capital Considerations	2
G.2 Implementation Speed	1
G.3 Transition Process Simplicity	2
G.4 Compat.w.Existing Equip & Ops	3
G.5 Potential Labor Acceptability	4

Summary Project Evaluation Report

The format of the Summary Project Evaluation Report for Ease of Implementation is shown in Table 4-60.

TABLE 4-60. SUMMARY PROJECT EVALUATION REPORT - EASE OF IMPLEMENTATION

MEASURE	SCORE
G. EASE OF IMPLEMENTATION	

The Summary Project Evaluation Report score is obtained in two steps. In the first step, a preliminary 1 to 5 score is obtained by combining the 3 categories of implementation factors related to potential implementation impediments. Then, this score is adjusted to account for the implementation cost and duration.

Step 1. An overall probability is obtained by multiplying the probabilities for the 3 categories of implementation factors determined in Step 4 for the Intermediate Project Evaluation Report. This has the effect of reducing the summary score as the number of impeding factors increases. This overall

fraction is then converted to a preliminary 1 to 5 score according to Table 4-61.

TABLE 4-61. RATING SCORES FOR SUMMARY REPORT - EASE OF IMPLEMENTATION

Preliminary Score	Overall Probability
1	LT .10
2	.10 - .29
3	.30 - .49
4	.50 - .69
5	GT .69

Step 2. This preliminary score is adjusted to account for implementation cost and speed in the following formula.

$$\text{Summary Level score} = X - [.25 \times (5-Y)] - [.1 \times (5-Z)]$$

round up to next highest integer. If less than 1, set equal to 1.

where X = preliminary score calculated in Step 1 above.

Y = Intermediate Project Evaluation Report score for implementation cost.

Z = Intermediate Project Evaluation Report score for implementation speed.

This formula has the effect of lowering the score based on the implementation factors when there is a high implementation cost and/or a long duration of implementation. However, the primary determination of the score is based on consideration of the 24 implementation factors. In the adjustment due to cost and duration, a high cost is given more weight in reducing the score over a high implementation duration.

The summary score for the Coupling Optimization Project example is calculated as follows.

Step 1. The probabilities of .26, .55, and .64 determined for the 3 categories of implementation (see Step 4 of coupler example in Intermediate Project Evaluation Report) are multiplied together.

$$(.25) \times (.55) \times (.64) = .09$$

Using Table 4-61, this is assigned a preliminary score of 1.

Step 2. The Intermediate Project Evaluation Report score was 2 for implementation cost and 1 for implementation speed (see Table 4-59). Using the formula presented above, the summary score is calculated

$$\text{Summary Report Score} = 1 - [.25 \times (5-2)] - [.1 \times (5-1)] = -.15$$

$$\text{Summary Report Score} = 1 \quad \text{since 1 is minimum score allowed.}$$

The completed Summary Project Evaluation Report for the coupler project example is shown in Table 4-62.

TABLE 4-62. SUMMARY PROJECT EVALUATION REPORT FOR COUPLER PROJECT - EASE OF IMPLEMENTATION

	MEASURE	SCORE
G.	EASE OF IMPLEMENTATION	1

4.3.8 FRA Needs or Commitments

This project evaluation measure assesses the importance of a research project in terms of policy considerations.

Basic Project Information Form

Five data elements are considered in determining importance of a project to FRA Needs and Commitments. These five data elements are listed in the Basic Project Information Form in Table 4-63.

TABLE 4-63. BASIC PROJECT INFORMATION FORM - FRA NEEDS AND COMMITMENTS

H. FRA NEEDS OR COMMITMENTS

The research meets explicit FRA objectives associated with:

very small	small	moderate	large	very large	
____	____	____	____	____	1. Congressional interest or requirement
____	____	____	____	____	2. Agreement with industry or explicit industry request
____	____	____	____	____	3. Specific DOT/FRA objective or responsibility
____	____	____	____	____	4. Needs of other Government agencies (which ones) _____
____	____	____	____	____	5. Prior Funding Amount $_____

very small	LT $300K
small	$300K - $9.9K
moderate	$1M - $2.9M
large	$3M - $9.9M
very large	GT or EQ $10M

Each of the 5 data elements is analyzed for its applicability to the specific research project and is marked very small, small, moderate, large, or very large to indicate the degree to which the data element applies. For prior funding amount, a look-up table is provided to convert the amount to a very small through very large rating.

Input by FRA on this project evaluation measure is particularly important since only FRA can properly assess the degree of commitment associated with such factors.

For the coupler project example, there is a moderate degree of agreement with industry to conduct such a research project which reflects work done in cooperation with the Association of American Railroads (AAR). The other data elements have been marked very small. The completed Basic Project Information Form for the coupler project is presented in Table 4-64.

TABLE 4-64. BASIC PROJECT INFORMATION FORM FOR COUPLER PROJECT - FRA NEEDS OR COMMITMENTS

H. FRA NEEDS OR COMMITMENTS

The research meets explicit FRA objectives associated with:

very small	small	moderate	large	very large	
X					1. Congressional interest or requirement
		X			2. Agreement with industry or explicit industry request
X					3. Specific DOT/FRA objective or responsibility
X					4. Needs of other Government agencies (which ones) _____
X					5. Prior Funding Amount $ 100K

very small LT $300K
small $300K - $9.9K
moderate $1M - $2.9M
large $3M - $9.9M
very large GT or EQ $10M

Detailed Project Description Report

The information contained in the Basic Project Information Form is listed for the user in the Detailed Project Description Report, as shown in Table 4-65.

TABLE 4-65. DETAILED PROJECT DESCRIPTION REPORT - FRA NEEDS AND COMMITMENTS

SECTION H. FRA NEEDS OR COMMITMENTS:

Congressional Interest:	Very Small
Agreement with Industry:	Moderate
Needed by DOT / FRA:	Very Small
Important to Other Govt.Agency:	Very Small
Prior Funding:	Very Small
* Amount: $ 100K	

The coupler project is used as an example for this report.

Intermediate Project Evaluation Report

The format for the Intermediate Project Evaluation Report is shown in Table 4-66.

TABLE 4-66. INTERMEDIATE PROJECT EVALUATION REPORT - FRA NEEDS AND COMMITMENTS

MEASURE	SCORE
H. FRA NEEDS OR COMMITMENTS	
H.1 Congressional Interest	
H.2 Agreement with Industry	
H.3 DOT / FRA Requirement	
H.4 Needed by Other Agency	
H.5 Major Prior Funding	

In the Intermediate Project Evaluation Report, each of the five data elements is assigned a 1 to 5 score according to Table 4-67.

TABLE 4-67. RATING SCORES FOR FRA NEEDS AND COMMITMENTS

Score	FRA Needs or Commitments
1	very small
2	small
3	moderate
4	large
5	very large

For the Coupling Optimization Project example, the one data element marked moderate, Agreement with Industry, is assigned a score of 3 by using Table 4-67. The other data elements are assigned scores of 1. The completed Intermediate Project Evaluation Report for the Coupling Optimization Project is shown in Table 4-68.

TABLE 4-68. INTERMEDIATE PROJECT EVALUATION REPORT FOR COUPLER PROJECT - FRA NEEDS OR COMMITMENTS

MEASURE	SCORE
H. FRA NEEDS OR COMMITMENTS	
H.1 Congressional Interest	1
H.2 Agreement with Industry	3
H.3 DOT / FRA Requirement	1
H.4 Needed by Other Agency	1
H.5 Major Prior Funding	1

Summary Project Evaluation Report

The format for the Summary Project Evaluation Report is presented in Table 4-69.

TABLE 4-69. SUMMARY PROJECT EVALUATION REPORT - FRA NEEDS OR COMMITMENTS

MEASURE	SCORE
H. FRA NEEDS OR COMMITMENTS	

A formula has been developed to combine all the 5 data element scores into a single score to complete this table.

$$\text{Summary Report Score} = \text{Highest Intermediate Report Score} + \frac{(\text{sum of remaining scores}) - 4}{2}$$

truncate fractions to next lowest integer

For example, if the scores for the 5 FRA Needs or Commitments data elements in the Intermediate Project Evaluation Report are 2, 3, 2, 1 and 1, respectively, the formula is:

$$\text{Summary Report Score} = 3 + \frac{(2 + 2 + 1 + 1) - 4}{2} = 4$$

The Summary Report score is based on a cumulative effect of the 5 Intermediate Report data element scores whereby several moderately important factors in the Intermediate Report can combine to form a higher Summary Report score. The Summary Report score is specifically designed so that it is never lower than the highest Intermediate Report score. If there are several moderate or high scores in the Intermediate Report, the Summary Report score is raised higher than the highest Intermediate Report score.

For the coupler project example, the 5 data element scores in the Intermediate Project Evaluation Report are 1, 3, 1, 1, and 1, respectively (see Table 4-68). Using the formula, the Summary Report score is determined.

$$\text{Summary Report Score} = 3 + \frac{(1 + 1 + 1 + 1) - 4}{2} = 3$$

The completed Summary Project Evaluation Report for the coupler project is shown in Table 4-70.

TABLE 4-70. SUMMARY PROJECT EVALUATION REPORT FOR COUPLER PROJECT - FRA NEEDS OR COMMITMENTS

MEASURE	SCORE
H. FRA NEEDS OR COMMITMENTS	3

4.3.9 Research Cost-Effectiveness

This project evaluation measure is the first of two composite project evaluation measures which are calculated by combining the previous project evaluation measures. The composite project evaluation measures are presented only in the Summary Project Evaluation Report.

Summary Project Evaluation Report

The format for the Summary Project Evaluation Report is shown in Table 4-71.

TABLE 4-71. SUMMARY PROJECT EVALUATION REPORT - RESEARCH COST-EFFECTIVENESS

	MEASURE	SCORE
I.	RESEARCH COST-EFFECTIVENESS RATING	
	SAFETY	
	COST	

To complete the table, 1 to 5 rating scores are determined separately for safety and cost. Safety includes fatalities and injuries. Cost includes property damage, operating costs, and other costs.

Research Cost-Effectiveness combines information from the project evaluation measures listed in Table 4-72.

TABLE 4-72. DETERMINATION OF RESEARCH COST-EFFECTIVENESS RATING

Evaluation Measure	Evaluation Measure Title	Source of Numerical Value	Safety Units	Cost Units
B	Magnitude of Affected Area	Calculation for Summary Report	Equiv. Fatalities	$
C	General R&D Impact Potential	Calculation for Summary Report	%	%
D	Specific Project Effect	Detailed Project Report	%	%
E	Likelihood of Research Success	Calculation for Summary Report	%	%
F	Economy of Research	Detailed Project Report	$	$

A ratio of the project's potential benefits divided by the research cost is calculated as follows.

$$\text{Ratio} = \frac{B \times C \times D \times E}{F}$$

Actual numerical values associated with the project evaluation measures rather than 1 to 5 scores are used to calculate the ratio. Table 4-72 lists the source of the numerical values. Three values come from numbers calculated during the determination of scores for the Summary Project Evaluation Report and two values are listed in the Detailed Project Description Report. Table 4-72 also shows the units of the numerical values used for the calculations. This calculation is performed separately for safety and costs. Table 4-73 is used to convert the ratios into 1 to 5 scores.

TABLE 4-73. RATING SCORES FOR RESEARCH COST-EFFECTIVENESS

Score	Safety Ratio	Cost Ratio
1	LT .1 x 10^{-7}	LT .1
2	.1 - .99 x 10^{-7}	.1 - .99
3	1 - 9.9 x 10^{-7}	1.0 - 9.9
4	10 - 99 x 10^{-7}	10 - 99
5	GE 100 x 10^{-7}	GE 100

For the Coupling Optimization Project example, Table 4-74 lists the numerical values determined in Summary Report calculations or listed in the Detailed Project Description Reports (sources are indicated in Table 4-72) which are used to calculate the Research Cost-Effectiveness.

TABLE 4-74. DETERMINATION OF RESEARCH COST-EFFECTIVENESS FOR COUPLER PROJECT

Evaluation Measure	Title	Safety Value	Cost Value
B	Magnitude of Affected Area	30	$19,730M
C	General R&D Impact Potential	50%	6%
D	Specific Project Effect	4%	4%
E	Likelihood of Research Success	68%	68%
F	Economy of Research	$200K	$200K

The safety and cost ratios are calculated as follows.

$$\text{Safety Ratio} = [(30) \times (.50) \times (.04) \times (.68)]/(\$200K) = 20 \times 10^{-7}$$

$$\text{Cost Ratio} = [(\$19,730M) \times (.06) \times (.04) \times (.68)]/(\$200K) = 161$$

The safety ratio of 20 x 10^{-7} and cost ratio of 161 are converted to scores of 4 and 5, respectively, using Table 4-73. The completed Summary Project Evaluation Report for the Coupling Optimization Project is presented in Table 4-75.

TABLE 4-75. SUMMARY PROJECT EVALUATION REPORT - RESEARCH COST-EFFECTIVENESS

	MEASURE	SCORE
I.	RESEARCH COST-EFFECTIVENESS RATING	
	SAFETY	4
	COST	5

4.3.10 Overall Project Rating

This last project evaluation measure is also only presented at the Summary Project Evaluation Report and extends the research cost-effectiveness measure to include Ease of Implementation and FRA Needs and Commitments.

Summary Project Evaluation Report

The format for the Summary Project Evaluation Report is contained in Table 4-76.

TABLE 4-76. SUMMARY PROJECT EVALUATION REPORT - OVERALL PROJECT RATING

	MEASURE	SCORE
J.	OVERALL PROJECT RATING	
	SAFETY	
	COST	

A separate 1 to 5 score is determined for safety and cost. The Overall Project Rating begins with the safety and cost research cost-effectiveness ratios calculated in Section 4.3.9 and adjusts them using the Summary Report scores for Ease of Implementation and FRA Needs or Commitments. An adjusted

ratio is calculated using the same following equation for both casualty and cost:

$$\text{Adjusted Ratio} = \text{Research cost-effectiveness ratio} \times (4^{(H-1)}/4^{(5-G)})$$

where: G = 1 to 5 score at Summary Level for Ease of Implementation

H = 1 to 5 score at Summary Level for FRA Needs or Commitments.

This equation has the effect of adjusting the overall project rating downward if the implementation process is difficult, and adjusting it upward if there is a strong FRA need or commitment to the project.

The adjusted ratios for safety and cost are converted to 1 to 5 scores using Table 4-77.

TABLE 4-77. RATING SCORES FOR OVERALL PROJECT RATING

Score	Adjusted Safety Ratio	Adjusted Cost Ratio
1	LT $.1 \times 10^{-7}$	LT .1
2	$.1 - .99 \times 10^{-7}$	.1 - .99
3	$1 - 9.9 \times 10^{-7}$	1.0 - 9.9
4	$10 - 99 \times 10^{-7}$	10 - 99
5	GE 100×10^{-7}	GE 100

For the coupler project example, the safety and cost research cost-effectiveness ratios calculated in Section 4.3.9 were 20×10^{-7} and 161, respectively. The Ease of Implementation Summary Report score was 1 (see Table 4-62), and FRA Needs and Commitments score was 3 (see Table 4-70). The formulae to calculate the adjusted ratios are

Adjusted Safety Ratio $= (20 \times 10^{-7}) \times (4^{(3-1)}/4^{(5-1)}) = (20 \times 10^{-7}) \times (16/256) = 1.25 \times 10^{-7}$

Adjusted Cost Ratio $= (161) \times (4^{(3-1)}/4^{(5-1)}) = (161) \times (16/256) = 10.1$

These ratios are converted to scores of 3 and 4, respectively, using Table 4-77. The completed Summary Project Evaluation Report for the Coupling Optimization Project is shown in Table 4-78.

TABLE 4-78. SUMMARY PROJECT EVALUATION REPORT FOR COUPLER PROJECT - OVERALL PROJECT RATING

	MEASURE	SCORE
J.	OVERALL PROJECT RATING	
	SAFETY	3
	COST	4

4.4 COMPUTER AID TO CALCULATE PROJECT EVALUATION MEASURES

The detailed algorithms used to calculate the project evaluation measures have been presented along with an example using the Coupler Optimization Project. The complete Detailed Project Description Report, Intermediate Project Evaluation Report, and the Summary Project Evaluation Report for the Coupling Optimization Project were shown in Figures 3-2, 3-3, and 3-4, respectively. As discussed in Section 3, the algorithms for these 3 reports have been implemented in a computer program. Thus, the user needs only to complete the Basic Project Information Form and enter this information into a computer data base. The calculation of 1 to 5 scores for the project evaluation measures and the printing of the 3 reports can then be done automatically by the computer.

5. CONCLUSIONS

This report has presented a methodology for consistent evaluation of FRA/ORD research projects. It provides evaluation data and scoring information for projects at three levels of detail in three computer-generated output reports.

A) Summary Project Evaluation Report

B) Intermediate Project Evaluation Report

C) Detailed Project Description Report

These reports can be used directly by FRA/ORD managers for their planning activities and for project justification and information needs in response to inquiries from Congress, the Administration, DOT management, and other agencies.

The methodology does not provide an absolute basis for measurement of project quality or resource allocation due to the need for inclusion of policy considerations that are beyond the scope of this study. Updating or modification of policy-related and other data elements by knowledgeable FRA/ORD managers is an important part of the evaluation process. To facilitate this process, all calculations included in the methodology are made by a computerized data base management system and all output reports are computer-generated. This feature provides a useful tool for FRA/ORD management to improve assumptions related to any project with rapid and accurate revision of output scoring reports.

Additional research that will be of significant help to FRA/ORD managers includes further development to add interactive elements to the computerized data base management system.

6. REFERENCES

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5. Yearbook of Railroad Facts, 1979 Edition, Association of American Railroads, Washington, D.C., December 1979.

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APPENDIX A

BASIC PROJECT INFORMATION FORM

BASIC PROJECT INFORMATION FORM

PART 1 - DESCRIPTIVE INFORMATION

Project Number _____

Project Title _____

Program _____

Subprogram _____

Type of Project

_____ (1) concept development
_____ (2) assessment/feasibility stuch
_____ (3) data/information survey
_____ (4) hardware/pre-prototype
_____ (5) development or expansion of a research facility
_____ (6) testing and evaluation
_____ (7) operational/application guidelines
_____ (8) performance specs
_____ (9) demonstration
_____ (10) requirements study

Importance of Results for:

not applicable	small	moderate	large	
_____	_____	_____	_____	(1) Industry decisions/use
_____	_____	_____	_____	(2) FRA safety/regulatory
_____	_____	_____	_____	(3) FRA Federal assistance
_____	_____	_____	_____	(4) NEC/Amtrak decisions
_____	_____	_____	_____	(5) DOT decisions/actions
_____	_____	_____	_____	(6) Other Federal or state agency
_____	_____	_____	_____	(7) FRA research activities

PART 2 - DETAILED PROJECT INFORMATION

A. AFFECTED AREA

Affected Areas

no effect	moderate	major		
____	____	____	(1)	Safety
____	____	____	(2)	Cost
____	____	____	(3)	Energy Efficiency
____	____	____	(4)	Environment
____	____	____	(5)	Quality of Service
____	____	____	(6)	_____

Affected Subareas

no effect	moderate	major		
____	____	____	(1)	Freight Service
____	____	____	(2)	Passenger Service
____	____	____	(3)	Employee Safety
____	____	____	(4)	Grade Crossings
____	____	____	(5)	Hazardous Materials
____	____	____	(6)	Track
____	____	____	(7)	Rolling Stock
____	____	____	(8)	Operations
____	____	____	(9)	Maintenance
____	____	____	(10)	Classification Yards
____	____	____	(11)	Equipment
____	____	____	(12)	Human Factors
____	____	____	(13)	Facilities
____	____	____	(14)	Locomotives
____	____	____	(15)	_____

B. MAGNITUDE OF AFFECTED AREA

_____ Fatalities (annual)
_____ Injuries (annual)
_____ Property Damage (20-yr discounted present worth in $ millions)
_____ Operating Cost (20-yr discounted present worth in $ millions)
_____ Other Costs (20-yr discounted present worth in $ millions)

G. EASE OF IMPLEMENTATION

$_____ Industry-wide Capital Required ($ millions)
_____ Estimated Implementation Time (years)

Transition Process Requires:

none	moderate	major		
_____	_____	_____	1.	Industry concensus
_____	_____	_____	2.	Industry-wide equipment/system compatibility
_____	_____	_____	3.	Industry-wide data/information exchange
_____	_____	_____	4.	Major demonstration phase
_____	_____	_____	5.	Industry acceptance testing
_____	_____	_____	6.	Development of new suppliers and/or supplier capabilities
_____	_____	_____	7.	Federal safety regulation
_____	_____	_____	8.	Conflict with industry trends
_____	_____	_____	9.	Industry hardware development effort
_____	_____	_____	10.	Significant expenditures by government agency

Implementation will result in significant changes in the following equipment and operations:

none	moderate	major		
_____	_____	_____	1.	Rolling stock equipment
_____	_____	_____	2.	Facilities
_____	_____	_____	3.	Train operations
_____	_____	_____	4.	Practices and procedures
_____	_____	_____	5.	Industry standards
_____	_____	_____	6.	Inter-railroad cooperation
_____	_____	_____	7.	Safety regulations
_____	_____	_____	8.	Economic regulations
_____	_____	_____	9.	Environmental regulations
_____	_____	_____	10.	Locomotives
_____	_____	_____	11.	Maintenance procedures

Implementation will result in the following changes affecting potential labor acceptability:

none	moderate	major		
_____	_____	_____	1.	Reduction of labor force
_____	_____	_____	2.	Skill mix
_____	_____	_____	3.	Work rules

H. FRA NEEDS OR COMMITMENTS

The research meets explicit FRA objectives associated with:

very small	small	moderate	large	very large	
____	____	____	____	____	1. Congressional interest or requirement
____	____	____	____	____	2. Agreement with industry or explicit industry request
____	____	____	____	____	3. Specific DOT/FRA objective or responsibility
____	____	____	____	____	4. Needs of other Government agencies (which ones) _____
____	____	____	____	____	5. Prior Funding Amount $_____

very small	LT $300K
small	$300K - $9.9K
moderate	$1M - $2.9M
large	$3M - $9.9M
very large	GT or EQ $10M