RETURN TO L. WATSON

R-355U

DEVELOP THE GROUNDWORK AND
PREPARE THE BACKUP INFORMATION
NECESSARY FOR THE ESTABLISHMENT
OF A BUS TRIP DATA BANK

FINAL REPORT

OCTOBER 14, 1980

Prepared for:

U. S. DEPARTMENT OF TRANSPORTATION
Transportation Systems Center
Kendall Square
Cambridge, Massachusetts 02142

DYNAMICS RESEARCH CORPORATION

Contract Number: DTRS-57-80-C-00007

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PREFACE

This document is the final report of the contract to "Develop the Groundwork and Prepare the Backup Information Necessary for the Establishment of a Bus TRIP Data Bank" (hereafter referred to as Bus TRIP). The purpose of this report is to summarize all the activities of the Bus TRIP contract. This effort was performed by Dynamics Research Corporation (DRC) under Contract Number DTRS-57-80-C-00007 for the U.S. Department of Transportation, Transportation Systems Center (TSC). The contract for Bus TRIP was conducted from December 1979, to October, 1980. For more detailed information on the four tasks performed under this contract the reader is referred to References 1, 2, 3, and 4.

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LIST OF ABBREVIATIONS

ADB	Advanced Design Bus
AMG	American Motors General
APTA	American Public Transit Association
BREL	Bus Reliability Equipment List
EDB	Experimental Data Bank
FLX	Grumman Flxible
GMC	General Motors Corporation
GPL	Generic Parts List
GPN	Generic Part Number
MAN	Maschininfabrik Augsburn Nuremburg
MGPL	Master Generic Parts List
MREL	Master Reliability Equipment List
NLC	New Look Conventional
RRV	Rapid Rail Vehicle
TRIP	Transit Reliability Information Program
TSC	Transportation Systems Center
UMTA	Urban Mass Transportation Administration

SECTION 1 - INTRODUCTION

1.1 PROGRAM PURPOSE

Decreasing reliability and availability of new buses has been a significant concern of the bus transit industry. A comprehensive approach to reliability monitoring and assessment to benefit the industry was indicated. These assessments would help management in making decisions concerning the maintenance, operation, and purchasing of equipment. To support this objective a contract was awarded for the purpose of preparing the background information for developing a data bank for bus transit vehicles.

The purpose of this report is to summarize the activities of the Bus TRIP contract. This report describes the results of each task and provides an indication of the requirements to develop a data bank for buses. Each task undertaken represented an effort to achieve a specific objective defined within the Bus TRIP contract. Being distinct, the results of each task have been presented on an individual basis. This report also describes the historical development of the contract to acquaint readers with the evolution of Bus TRIP.

Figure 1 presents an overview of the approach used in the Bus TRIP contract. It identifies each task and shows their interrelationship.

1.2 PROGRAM BACKGROUND

Transit Reliability Information Program (TRIP) is a government initiated program to assist the transit industry in satisfying its needs for rapid rail transit vehicle reliability information. TRIP will provide this assistance through the implementation and operation of a national reliability data bank. The data collected will be disseminated to the transit operating industry, equipment suppliers, and federal agencies to assist in recognizing reliability problems, improving maintenance operations, and thereby reducing maintenance costs. In September 1978, DRC was awarded a contract to implement TRIP for Rapid Rail Vehicles (RRV). This contract (RRV TRIP) has two major phases:

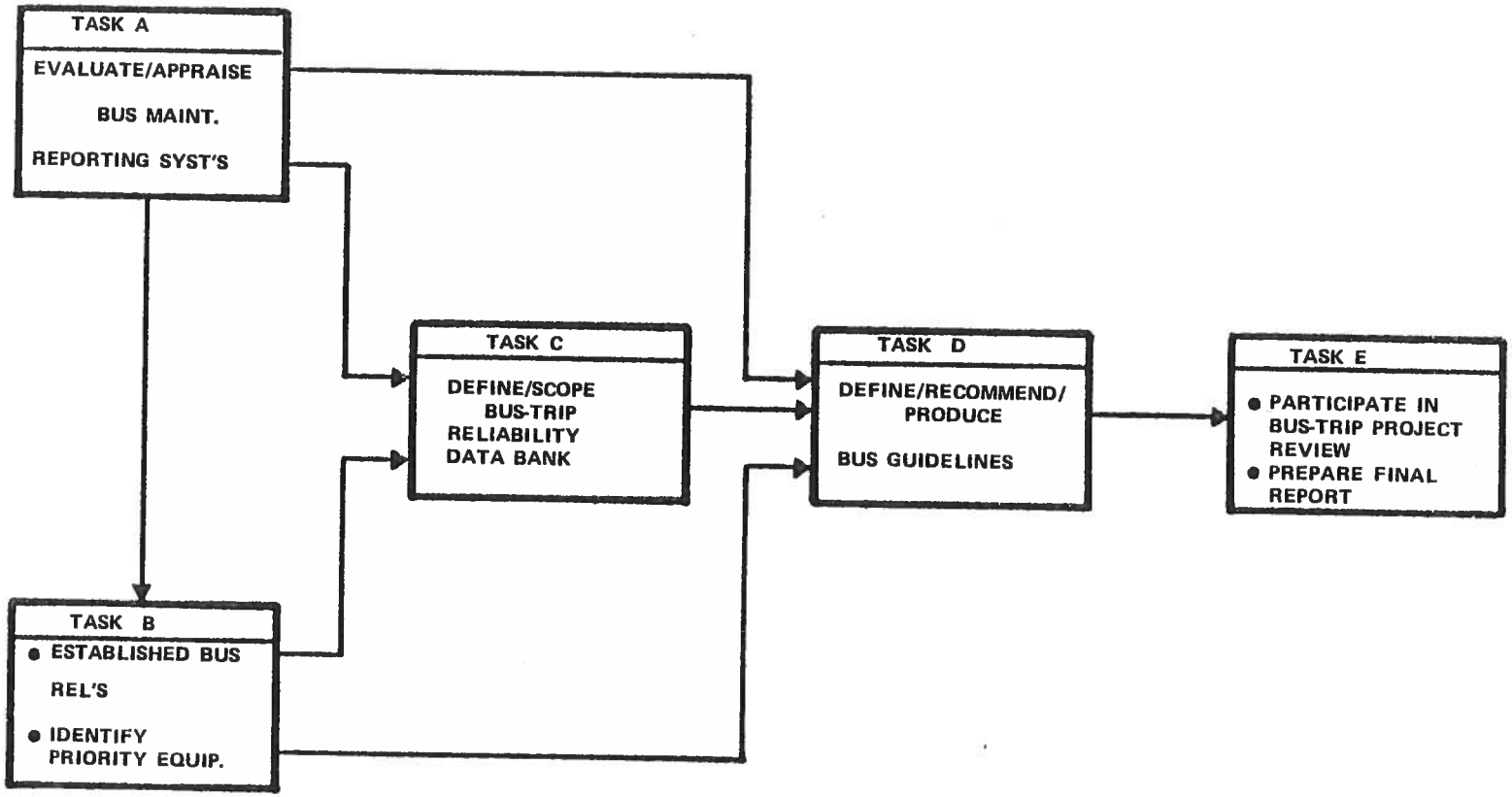


Figure 1
Bus - Trip Technical Approach
Overview

Phase I

- Define, document and present the RRV TRIP data bank requirements and configuration.

- Establish and operate the TRIP experimental data bank.

Phase II

- Assist and support the establishment of a full scale TRIP data bank.

At present, Phase I of RRV TRIP is in operation with an experimental data bank receiving data from five properties, covering the brake, door, and propulsion systems on 1300 RRVs.

Bus TRIP, an outgrowth of RRV TRIP, designed to accommodate bus transit vehicles was awarded to DRC in December 1979. The purpose of this contract (Bus TRIP) was to prepare the backup information necessary for establishing a bus reliability data bank. Bus TRIP was designed to use the present TRIP structure and experience in collecting and processing RRV information. Bus TRIP will be developed in a

manner similar to RRV TRIP and will utilize the same data bank configuration and general equipment breakdown structure where possible. The output generated from the bus reliability data bank will be disseminated to the bus transit industry, in the same way that RRV TRIP information is distributed to the rail transit industry. To carry out the program, the Bus TRIP contract was divided into five tasks, as follows:

Task A Appraise and evaluate incident and maintenance reporting systems used by bus transit systems in the USA.

Task B Establish a bus reliability equipment list.

Task C Define and scope the reliability data bank required by Bus TRIP.

Task D Define, recommend, and produce guidelines for the implementation and operation of Bus TRIP.

Task E Participate in and contribute to a Bus TRIP project review and prepare the Bus TRIP final report.

In addition to an appraisal of bus transit systems, government agencies and bus manufacturers were contacted to obtain information on bus standards and specifications. Ultimately, Bus TRIP data bank outputs will be used as inputs to such specifications and standards.

1.3 PROGRAM CONCLUSIONS

There is a strong requirement for a common, standard data bank such as Bus TRIP.

There is an interest in the industry to modernize and improve their data base.

Most data collected in the industry is subjective, complex, varied and tailored to each property's needs.

Technical data on modifications and improvements is not necessarily made available to the industry.

There is a trend towards accomodating and using reliability data.

Development of a Bus data bank indicates that there is a major difference in configuration from the RRV data bank.

There is a larger quantity of hard-copy data to be expected from bus transit properties which will make the input process more costly and difficult than in the RRV bank.

More storage is required in the computer to accomodate the larger number of dynamic data types and variability expected from the properties than for RRV TRIP.

The addition of generic vendor codes file will add to the cost and processing time of the data bank.

1.4 PROGRAM RECOMMENDATIONS

Bus TRIP should follow the same basic approach used previously in RRV TRIP in processing hard-copy data.

An effort should be made to correlate spares with repairs/replacement parts.

Initially, a limited number of components should be monitored in the bank to provide experience and identify problems.

Since most data input will be hard-copy, careful consideration should be given to the cost, time and resources necessary to implement Bus TRIP.

There is a need to develop a maintenance manual that will instruct maintenance engineers in fault detection and analysis on bus equipment.

A Bus TRIP Experimental Data Bank (EDB) should be implemented separately from the RRV TRIP data bank.

The Generic Part Number (GPN) format for Bus TRIP should conform more closely with bus equipment than the existing RRV TRIP GPN.

Data submitted to the data bank should be monitored throughout all stages of processing.

SECTION 2 - TASK A

U.S. Transit Properties

Bus Maintenance Reporting Systems

2.1 TASK A PURPOSE

The objective of Task A, the initial activity of the Bus TRIP contract, was to appraise and evaluate the incident and maintenance reporting systems used by bus transit systems in the USA. The basis for the evaluation was the information collected from a sample of bus properties considered as potential participants for a small-scale experimental data bank.

Information collected from these properties was summarized to categorize the various data characteristics collected during the visits. Five categories were defined for data presentation: reference; bus equipment breakdown; maintenance practices; data collection system; and reports.

2.2 TASK A APPROACH

In order to collect the necessary information, three data sources were investigated: bus properties, bus manufacturers, and government/other groups.

The ten bus properties selected and the selection criteria are listed in Table 1. The criteria covered size, location, climate and terrain to insure that a representative sample of properties was obtained.

Two bus manufacturers were visited: General Motors Truck and Coach Division and Grumman Flxible. APTA and UMTA were also investigated as additional sources of data.

2.3 TASK A CONCLUSIONS

Figure 2 provides a summary of the fleet composition at the properties that were visited. Figure 3 provides a data system summary of the selected bus properties.

Table 1

Selected Properties and Criteria

Property	Size	Location	Climate	Terrain
Atlanta, GA	Medium	South-East	Mild Winter Hot, humid Summer	Small Hills
Baltimore, MD	Large	East	Fair Winter Hot, humid Summer	Small Hills
Chicago, IL	Large	North Central	Fair Summer Cold, windy Winter	Level
Columbus, OH	Small	North Central	Hot Summer Cold Winter	Level
Detroit, MI	Small	North Central	Cold Winter Fair Summer	Level
Houston, TX	Medium	South Central	Mild Winter Hot, humid Summer	Level
Los Angeles, CA	Large	South-west	Very mild Winter Dry hot Summer	Level and hilly areas
Providence, RI	Small	North-east	Cold Winter Mild Summer	Small Hills
San Antonio, TX	Small	South Central	Mild Winter Dry, hot Summer	Flat plains
Seattle, WA	Medium	North-west	Cool Summer Wet, cold Winter	Hilly

FLEET COMPOSITION AT PROPERTIES VISITED								
BUS TYPE / PROPERTY	ADB		N L C			ARTIC		
	GMC	FLX	GMC	FLX	AMG	AMG/ MAN	OTHER	TOTAL FLEET
ATLANTA		134	572	125		10		841
BALTIMORE	60		723	245			10	1038
CHICAGO			1944	456		20		2420
COLUMBUS			273					273
DETROIT	123		208					331
HOUSTON	151	325	302				112	890
LOS ANGELES		230	1150	1147	200	30	60	2817
PROVIDENCE	77		163					240
SAN ANTONIO	121		252				57	430
SEATTLE			251	99	224	151	200	925
TOTALS	532	689	5838	2072	424	211	439	10,205

Figure 2. Fleet Composition at Properties Visited

DATA SYSTEM SUMMARY

	ATLANTA	BALTIMORE	CHICAGO	COLUMBUS	DETROIT	HOUSTON	LOS ANGELES	PROVIDENCE	SAN ANTONIO	SEATTLE
EQUIPMENT CODING SYSTEM USED	N	Y	Y	Y	N	Y	Y	N	N	Y
DATA COLLECTION SYSTEM	M	M	A	M	M	M	A&M	M	M	A&M
INVENTORY SYSTEM	A	M	A&M	M	A	A	A	M	M	A
MAINTENANCE REPORTING	FREQ. N/A	Monthly & Annual	None	N/A	Weekly & Monthly	Daily	N/A	N/A	N/A	Daily & Monthly

A = AUTOMATED
M = MANUAL
N = NO
Y = YES
N/A = NOT AVAILABLE

Figure 3. Data System Summary

The evaluation of candidate bus properties provided significant insight into the maintenance reporting systems employed by the bus transit industry. The results of this study showed that there is a definite requirement for a common, standard data bank such as Bus TRIP to assist in the decision making process at all levels. The bus transit industry currently collects an abundance of data, complex in nature, from a variety of data sources, subjective and tailored to each property's needs.

The properties recognize that a disparity in data exists and they have expressed an interest in modernizing and improving their data base. Most properties are planning to automate their data systems and there is a trend towards accommodating and using reliability data. This trend is encouraging since it will facilitate the collection of meaningful maintenance data and should enhance Bus TRIP data bank operation and use.

In summary, conclusions resulting from the Task A investigation are as follows:

- There is little similarity in data collection systems.

- Little reliability analysis is performed on what data is collected.

- The "coach history" is the primary method of recording data.

- Information on property-equipment improvements and modifications is not necessarily made available to the industry.

- Little trend analysis or forecasting of future equipment performance is performed.

2.4 TASK A RECOMMENDATIONS

The evidence shows that there is a need for a Bus TRIP data bank. The development of the Bus TRIP data bank would be a strong factor in the improved operation of the bus transit industry. First, it is recommended that a "generic" approach be adopted in order to identify equipment and maintenance actions. Second, it is recommended that initially a limited number of components be monitored and processed through the data bank to gain experience in a manner similar to RRV TRIP. Following the evaluation of this initial step, the data bank can be expanded to provide greater coverage.

Consistent with the development of the data bank, Bus TRIP should be organized to provide a variety of data reports to satisfy the needs of the bus transit industry. These areas might include the following:

- Fleet utilization and inspections
- Fleet unscheduled maintenance
- Fleet fuel and oil consumption
- Fleet road calls
- Component road calls
- Vendor performance

In addition, the data bank should be capable of accepting data requests to produce special reports as requested and have the ability to accommodate, process, and publish reliability type data indicators which will serve to measure equipment performance.

SECTION 3 - TASK B

Bus TRIP Reliability Equipment Lists

3.1 TASK B PURPOSE

The purpose of Task B was to establish the Bus Reliability Equipment Lists (BREL). This task deals with the transformation of source material into equipment lists relating to the five most numerous bus models that are or will be found in operation throughout the USA:

- General Motors Corporation (GMC) Advance Design Bus (ADB)
- Grumman Flxible (FLX) ADB
- GMC New Look Conventional (NLC)
- FLX NLC
- AMG/MAN Articulated

From these lists, a master generic parts list (MGPL) representing a comprehensive list of all the components contained in these buses is generated.

3.2 TASK B APPROACH

First, bus parts catalogs, and operation and maintenance manuals for the five bus models were reviewed in order to develop a functional hierarchy of bus equipment. Figure 4 shows the resulting bus equipment categories and their RRV counterparts.

Within each equipment category (for each bus model), components to be monitored in the data were identified by means of a uniform system, called the Generic Part Number (GPN). The format of the GPN is shown in Figure 5. Also, in order to identify the bus property that will be submitting data on these buses, a generic serial numbering (GSN) scheme will be employed, as shown in Figure 6.

3.3 TASK B RESULTS

The following lists were created:

1. Generic Parts List (GPL) - a list of all GPN's identified by a GSN, and associated manufacturer's and property part identification. An example of a GPL is shown in Figure 7.

BUS VS RRV EQUIPMENT CATEGORIES

BO	TRANSIT BUS	AO	RAPID RAIL VEHICLE
BA	DOORS AND DOOR CONTROLS	AA	DOORS AND DOOR CONTROLS
BB	AIR COMFORT SYSTEM	AB	AIR COMFORT SYSTEM
BC	COMMUNICATIONS EQUIPMENT	AC	COMMUNICATIONS EQUIPMENT
BD	ELECTRICAL SYSTEM	AD	AUXILIARY ELECTRICAL SYSTEM
BE	ENGINE SYSTEM	AE	PROPULSION SYSTEM
BF	BRAKE SYSTEM	AF	FRICTION BRAKE SYSTEM
BH	AUTOMATIC VEHICLE MONITORING	AH	ATO/ATC
BJ	SUSPENSION, STEERING, AND TIRES	AJ	TRUCK AND SUSPENSION
BK	DRIVE TRAIN	AK	COUPLERS AND DRAFT GEAR
BL	FUEL SUPPLY SYSTEM	AL	POWER COLLECTION EQUIPMENT
BM	BODY AND STRUCTURES	AM	CAR BODY AND STRUCTURES
BN	SAFETY EQUIPMENT		
BP	FARE COLLECTION		

Figure 4. Bus Vs RRV Equipment Categories

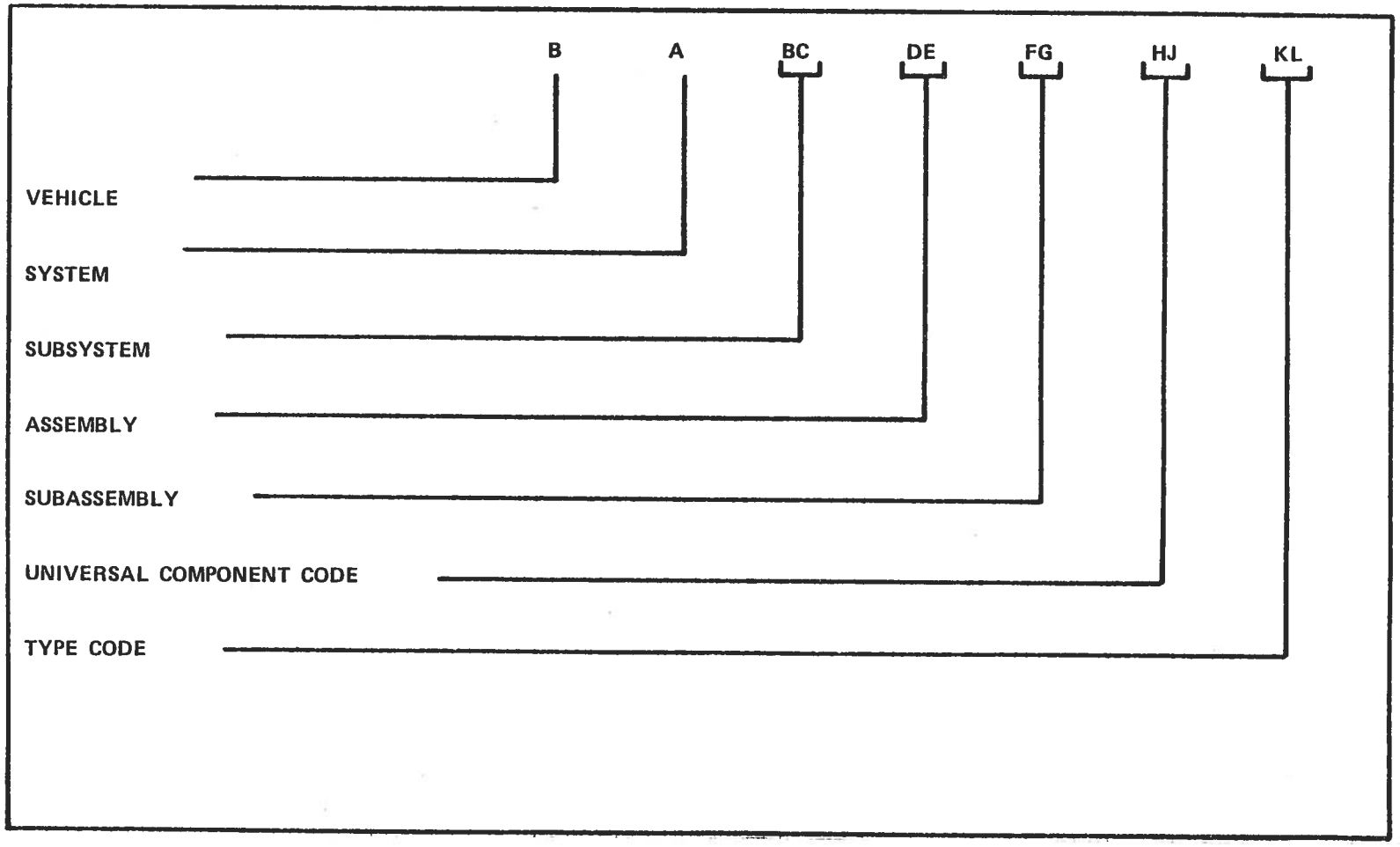
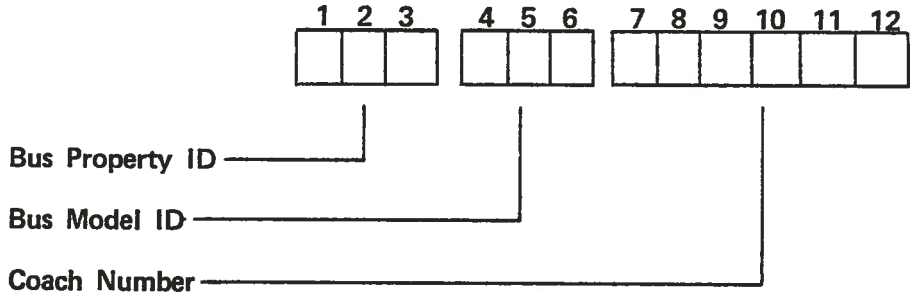


Figure 5. Bus TRIP Generic Part Number Format.



Bus Model

Bus Model		Bus TRIP I.D.
GMC ADB	–	A
GMC NLC	–	B
FLX ADB	–	C
FLX NLC	–	D
AMG/MAN	–	E

Figure 6
Generic Serial Number, (GSN)

BUS TRIP GENERIC PARTS LIST
EXAMPLE EQUIPMENT BREAKDOWN

BF00	0000	0000	.	BRAKE AND AIR SUPPLY SYSTEMS
BFAA	0000	0000	. .	MASTER BRAKE CYLINDER ASSEMBLY AND BRAKE COMPONENTS
BFAA	AA00	0000	. . .	BRAKE PEDAL ASSEMBLY
BFAA	AB00	0000	. . .	MOUNTING PIN ASSEMBLY
BFAA	AC00	0000	. . .	PLATE
BFAA	AD00	0000	. . .	BUSHING
BFAA	AE00	0000	. . .	LINKAGE ASSEMBLY
BFAA	AF00	0000	. . .	HOUSING ASSEMBLY
BFAA	AFAA	0000	. . . .	DIAPHRAGM
BFAA	AFAB	0000	. . . .	PISTON
BFAA	AFAC	0000	. . . .	SPRING
BFAA	AFAD	0000	. . . .	PISTON ROD GUIDE
BFAA	AFAE	0000	. . . .	BOOT
BFAA	AFAF	0000	. . . .	STOP LIGHT PRESSURE SWITCH
BFAB	0000	0000	. .	TRISTOP BRAKE CYLINDER ASSEMBLY

Figure 7. Bus Trip Generic Parts List Example
Equipment Breakdown

- GPN - a 12-character code used as an identification for components from different bus models which perform similar functions.

- GSN - a 7-character code which identifies the bus property, vehicle type, and bus number and is used in conjunction with the GPN.

2. Master Generic Parts List (MGPL) - a list of all unique GPNs (obtained by combining all of the GPLs).

SECTION 4 - TASK C

Bus TRIP Reliability Data Bank Requirements

4.1 TASK C PURPOSE

The purpose of Task C was to define and scope the reliability data bank required by Bus TRIP. This definition included:

- Evaluating data bank characteristics, including
  - Configuration
  - Input
  - Processing and Storage
  - Output

- Determining the compatibility between Bus TRIP and RRV TRIP,

- Estimating the size of (full-scale) data bank and associated costs of operation,

- Determining the applicability of RRV EDB to buses.

4.2 TASK C APPROACH

The following areas were addressed for data bank definition and scoping:

- Characterization of Input Data

  Based on the information collected in Task A relating to various types of transit bus reference, operating, maintenance, and repair data, the requirements of the data bank were defined in order to address:

  - Data types and content,
  - Data frequency and format, and
  - Differences between Bus and Rapid Rail Vehicle (RRV) input data.

- Definition of Output Requirements

  Based on the Task A investigation of maintenance reporting systems used at transit bus properties, the output reporting requirements for the data bank were defined for:

  - Report form and content and
  - Report frequency and distribution

- Bus TRIP Data Bank Configuration

  Based on the definition of input data characteristics and output reporting requirements, the use of information obtained in Task 2 - RRV TRIP concerning the operation of the RRV TRIP data bank, the Bus Reliability Equipment List (BREL), developed in Task B of this program, the general configuration and operating requirements for the full-scale Bus TRIP data bank were defined for:

  - Data submission,
  - Data preparation and processing,
  - Data verification,
  - Data organization and storage,
  - Data retrieval and analysis, and
  - Data reporting.

- Bus Experimental Data Bank (BEDB) Configuration

  Based on the full-scale Bus TRIP data bank configuration definition and the RRV TRIP Experimental Data Bank (EDB) currently in

operation, the configuration shown in Figure 8 and operating methods for the Bus TRIP Experimental Data Bank (BEDB) were defined to test the final Bus TRIP Data Bank Configuration for:

- Data submission,
- Hard-copy data preparation and entry,
- Computer-readable input data translation and extraction,
- Data reformatting and cross-referencing,
- Data editing and error correction,
- Data storage,
- Equipment identification requirements,
- Data retrieval and analysis, and
- Data reporting.

4.3 TASK C CONCLUSIONS

The following conclusions resulted from the Task C effort:

- Differences in the nature of the input data and output requirements will require modifications to the RRV TRIP EDB software, as it exists, in order to implement a Bus TRIP EDB. These differences include:

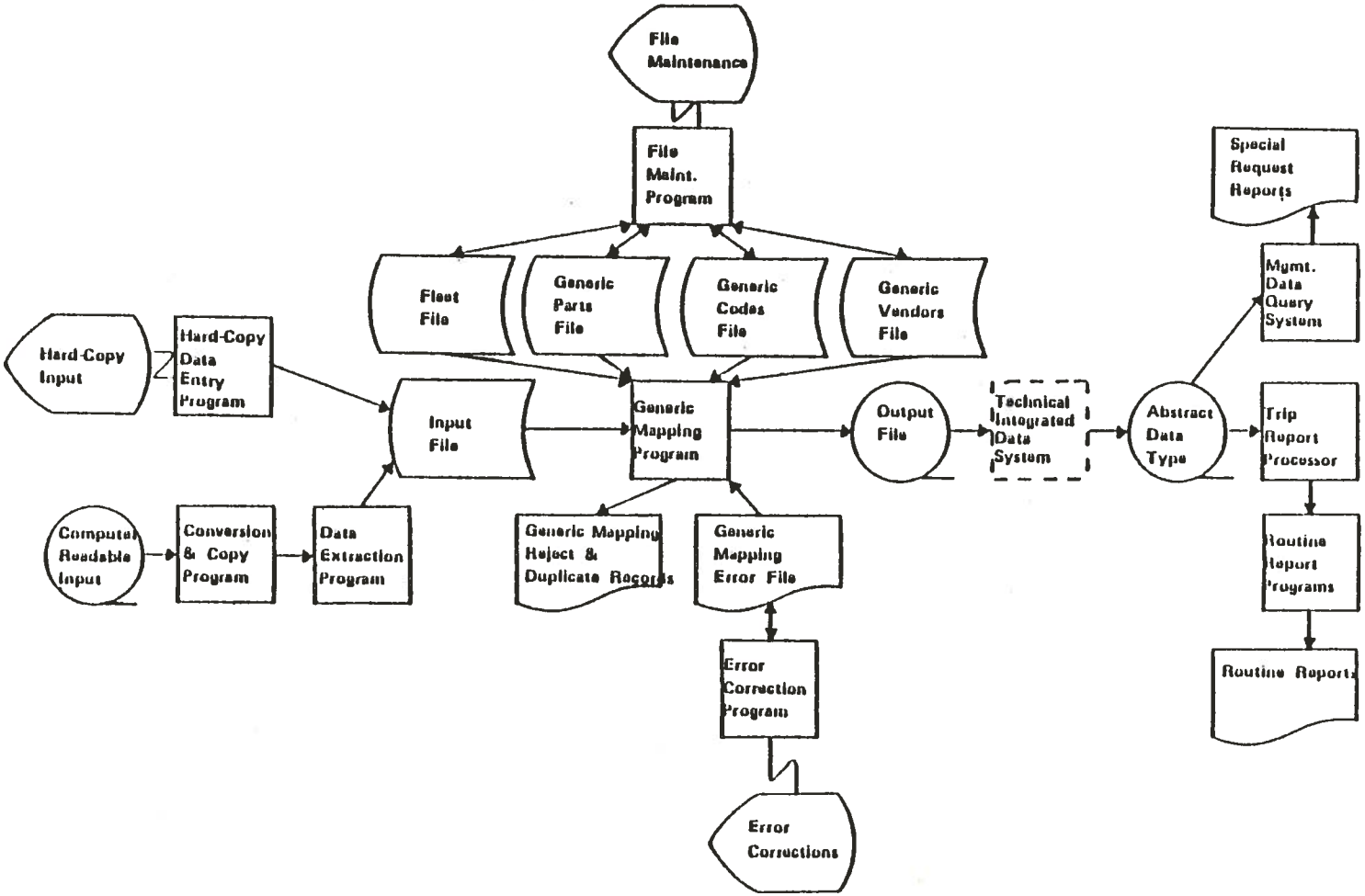


Figure 8. Simplified Bus TRIP EDB system flow diagram.

- Differences in reference data (no power or track information, no train consist data, and different equipment categories).
- Differences in dynamic data, including additional data types: consumables, road calls/incidents, and vendor information.
- Different GPN format
- Different output requirements
- Larger data bank size

- The large volume of hard-copy input data will make the input process more difficult and costly than has been experienced in the RRV TRIP EDB. This large quantity of hard-copy input data will require additional data entry personnel, as well as additional time to prepare, verify, and enter this data.

- Vendor-specific reliability monitoring will add significantly to the usefulness of Bus TRIP.

4.4 TASK C RECOMMENDATIONS

- A Bus TRIP EDB separate from the RRV TRIP EDB should be implemented, due to differences in the nature of the input data and output requirements.

- While Bus TRIP will employ the same Generic Part Number (GPN) approach used in RRV TRIP, the specific make-up of the GPN will be changed to more closely coincide with bus equipment.

- Methods for logging input data as received should be developed due to the large quantity of anticipated hard-copy input data.

- Engineering evaluation should be performed on the data input to the data bank "along the way" from input to storage to output.

SECTION 5 - TASK D

Bus TRIP Participants Guideline

5.1 TASK D PURPOSE

The purpose of Task D was to define and prepare a guideline document for Bus TRIP users, describing the implementation and operation of Bus TRIP. The document produced in this task is a user's manual for transit property personnel interested in participating in Bus TRIP. It provides instructional guidelines for users voluntarily submitting data to Bus TRIP and describes reliability analysis techniques that could be used on the data available in Bus TRIP.

5.2 TASK D APPROACH

The user's manual, first, describes the operations of the data bank, along with the information needed by the participants supplying data to Bus TRIP.

Second, the guidelines illustrate the approach and development of the GPL's and MREL. The procedures for modifying the lists in order to add new or delete equipment is included.

Third, the guidelines describe practical approaches for applying reliability techniques that can be used to analyze the information available through the Bus TRIP data bank.

Table 2 is an abbreviated table of contents of this guidelines document.

Table 2
Task D Report
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SECTION 6 - TASK E

Project Review

6.1 PURPOSE

The object of Task E was to participate and contribute to a Bus TRIP project review. This review described and illustrated each task of the contract and the results achieved. The review also provided an overview of the total project and an opportunity to elaborate in detail on certain aspects of the program.

6.2 RESULTS

The Task E project review was presented to TSC personnel at the Transportation System Center in Cambridge, Mass. The review was presented in two parts, the first to provide an overall summary of the contract's major aspects and the second, a detailed description of each task within the contract.

Supporting the second part of the presentation was a handout identifying specific key points in each of the task's reports. These points were referenced to their locations in their respective reports so that a reader could

locate the material directly. Each task's presentation was followed by a question and answer period in which issues, ideas, problems, future operation, and other considerations were discussed. With each task presentation, twelve copies of that task report were given to TSC for their use. Additional comments concerning the overall contract implementation were made.

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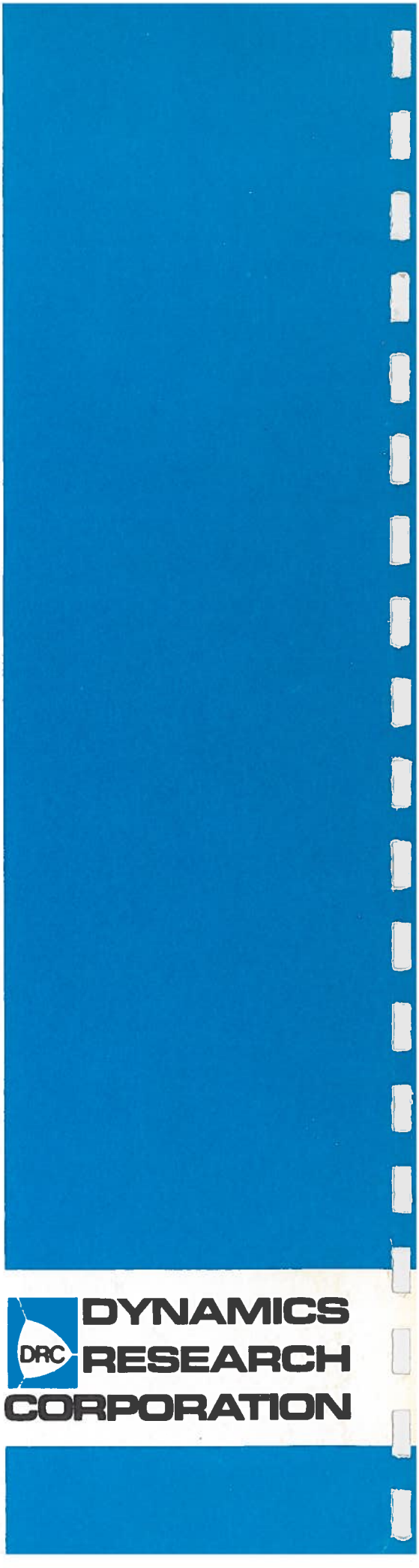
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