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LOW LIFE CYCLE COST DESIGN STUDY FOR PARATRANSIT VEHICLES

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FINAL REPORT

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16. Abstract

This report describes how the original prototype of the AMF Paratransit vehicle was redesigned to achieve low life cycle cost for projected low volume production rates. Cost estimates were prepared for the major elements of life cycle costing including manufacturing, maintenance and repair costs. It was concluded that a paratransit vehicle, with all of the special features of this design, could be acquired, and utilized over its extended service life at a net cost to the operator that would be less than that of a conventional taxi-cab.

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PREFACE

This final report summarizes the work performed on the Low Life Cycle Cost Paratransit Vehicle contract. The program was structured to provide a design of a vehicle suitable for taxi paratransit usage, optimized for low life cycle cost to the end user.

The program was conducted by ASL Engineering, Inc. under contract DOT-TSC-1351 with the Transportation Systems Center (TSC) of Cambridge, Massachusetts for the Urban Mass Transportation Administration. Technical management of the contract was provided by Mr. J. Kakatsakis and Mr. J. Picardi.

The opinions and findings expressed in this report are those of the authors and not necessarily those of the Government.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

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

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

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SECTION 1
INTRODUCTION

This report summarizes the results of a program to redesign the original AMF paratransit vehicle in order to reduce its life cycle cost. This effort is in response to the growing recognition that purchase price or first cost of a vehicle is not a true measure of the cost of ownership. Other factors, such as costs for operation, and for repair and maintenance over the useful life of a vehicle must also be included.

1.1 BACKGROUND

The original paratransit vehicle was designed to be built as a prototype - a single unit. As a result the design was structured so that a minimum investment in tooling and maximum reliance on hand fabrication of body and structure would economically produce the desired prototype. Further, a number of advanced and unique features were incorporated that represented radical departures from concentional automotive practice for this type of vehicle. These included a steam engine, a floor of composite aluminum honeycomb structure, and body panels of aluminum in some areas.

After initial delivery to the government the vehicle was later modified by substitution of a gasoline engine for the steam plant. It was then subjected to an evaluation test program by Dynamic Science, Inc. Phoenix, Arizona, directed toward obtaining performance data on two prototypes (AMF and Dutcher) as compared to a baseline vehicle (Chevrolte Nova). The program consisted of five separate test series: 1) Ride Comfort and Quality, 2) Acceleration and Interior Measurements, 3) Handling, 4) Fuel Economy, and 5) Noise. The results are contained in a five-volume technical report.

The AMF vehicle, along with various other prototype paratransit vehicles, has been seen in a number of exhibitions and meetings around the country. At a number of these showings oral and written comments have been solicited from attendees, particularly operators and users of taxicabs and other paratransit.

A detailed evaluation and analysis of the AMF and other prototype paratransit vehicles shown at the Museum of Modern Art in New York City from June 17 to September 6, 1976 is found in Reference (1). This review is primarily in terms of human factors requirements for accommodation of both passengers and driver, and particularly of elderly and handicapped passengers.

1.2 OBJECTIVES

As stated in the contract, the objectives of the low life cycle cost (LLCC) design study were:

1. To review the current designs.
2. To identify and characterize features that impact the life cycle cost for taxi applications.
3. To design a ride-sharing paratransit vehicle primarily for the taxi application.
4. To consider volume production, use of readily available commercial component/parts, to reduce initial cost.
5. To consider maintainability, reliability, safety and other important features to assure wide acceptance in paratransit and related use.

1.3 METHOD OF APPROACH

The redesign of the prototype paratransit vehicle was accomplished primarily using analytical techniques, with some reliance on experience with automotive industry practices and standards. The general approach was to review the initial design and test results from the Dynamic Science test program, then to assess the functions, cost, maintainability, repairability, safety, and operational considerations of the entire vehicle. A study of factors impacting the life cycle costs of this paratransit vehicle was then performed, considering parameters such as weight, performance, fuel economy, capital costs, repair costs, durability, manufacturing and tooling costs, etc.

(1) "Assessment of Passenger and Driver Accommodations in Prototype Paratransit Vehicles" J.P. Jankovich, et al. DOT Transportation Systems Center, on file.

Sources used for guidance in the preliminary vehicle design optimization effort included:

1. Taxi industry
2. User groups, including handicapped and elderly.
3. Automobile industry
4. Human factors analysts

Overall the configuration and performance requirements were established by a set of design requirements and goals specified by the contracting agency.

The original AMF prototype PTV, with one change, formed the baseline and point of departure for the present program. The configuration and layout of that vehicle is shown in Figures 1-1 and 1-2 and its specifications are contained in Table 1-1. The principal change was the substitution of an Audi 100, 4-cylinder gasoline engine for the steam power plant of the original design.

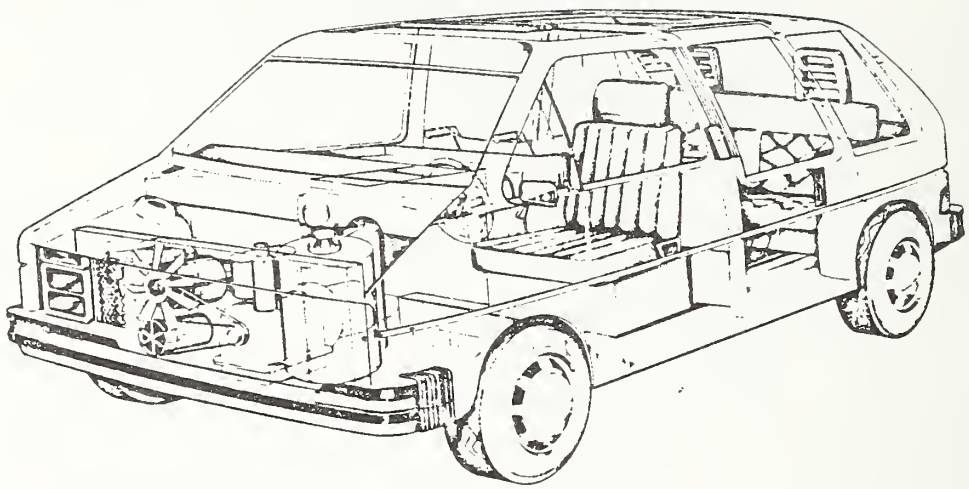

Figure 1-1. 3/4 Front Cutaway View of PTV

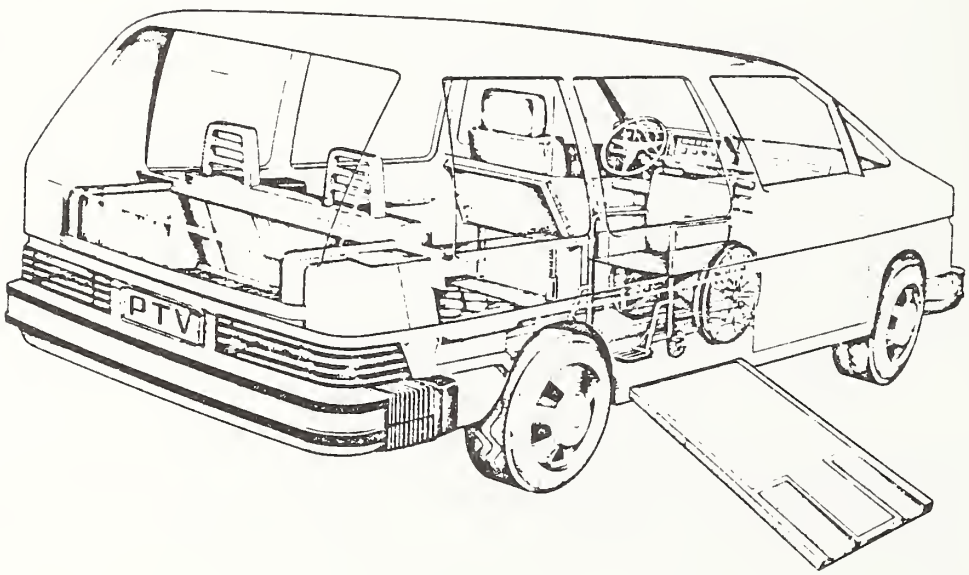

Figure 1-2. 3/4 Rear Cutaway View of PTV

Table 1-1. Specifications for the AMF Paratransit Vehicle

GENERAL	
Curb weight, lb	3355
Wt. Distribution (front, rear)	2045#/1310#
(front,rear %)	61/39
Wheelbase, inches	108
Track, front, rear	64/62.5
Overall length, inches	182.8
Width	72
Height	70
Ground clearance, inches	6.5
Overhang, front, rear	35.5/39.3
Fuel capacity, U.S. gallon	15
ENGINE*	
Type	2-cyl. steam uniflow single acting
Manufacturer	Carter Enterp.
Bore x stroke, inches	2.5 x 3.0
Displacement, cu.in.	30
Expansion ratio	10 to 1
Bhp @ rpm	105 @ 5500 (gross)
Torque @ rpm	100 ft-lbs @ 5500 rpm
Type fuel required	Multi-fuel
Emission control	Evaporative
DRIVETRAIN	
Transaxle	3-speed automatic
Manufacturer	VW/Audi
Gear ratios: 3rd (1.0)	3.73
2nd (1.59)	5.93
1st (2.65)	9.88
Final drive ratio	3.73
Torque converter ratio	2.2 : 1

*Later replaced by 4-cylinder Audi gasoline engine.

CHASSIS & BODY	
Layout	Front engine, front drive
Body/frame	Unit steel/alum with AMF composite floor
Brake type (from 75 Audi 100LS)	11.0 inch diameter disc front, 7.9 inch drum rear, swept area + 280 in^2
Wheels	Steel disc, 14 x 5-1/2
Tires	ER 78-14
Steering type	Rack & pinion
Turning circle, ft	35.0
Front suspension	Unequal-length A-arms, coil springs, tube shocks
Rear suspension	Solid axle w/T/arms & transverse locating rod & coil springs & tube shocks
ACCOMMODATION	
Seating capacity	5 plus driver
Seat width, inches	
Driver	25
Supplemental	22.4
Primary	2 x 20.75
Handicapped primary	30.5
Head Room (H63), in.	
Driver	42
Wheelchair passen.	40
Supplemental	45
Primary passenger	45
Passenger Protection	Specially design padded seats & interior padding, Type 2 seat belts

SECTION 2
PRELIMINARY DESIGN REVIEW

2.1 INTRODUCTION

This section presents the results of the preliminary prototype design review that was conducted in order to identify areas where cost-effective changes might be made. This is followed by a study of the parameters that most directly affect life cycle costs of a taxi used in paratransit applications.

2.2 PRELIMINARY RESULTS OF PROTOTYPE PERFORMANCE EVALUATION

A meeting was held with Dynamic Science, the independent test contractor who was conducting performance tests and evaluation of the AMF prototype PTV. The major items commented on in the test review meeting included: a) the need for increased road or ground clearance, and b) a mild objection to the noise levels in the driver compartment and wheelchair area caused by the fuel pump plus airborne noise levels transmitted from the engine compartment through the dash panel area. Both problems were considered to be easily solved.

Dimensional measurements on the prototype vehicle indicated the static trim height was 1.38 inches lower than design specification. The reason for this low trim height is not known and could have been the result of build errors or suspension spring sag problems. At the curb load condition the vehicle is actually sitting in the vehicle design load trim height.

Relocation of the fuel cell to the underfloor behind rear axle location and fuel pump relocation to rear wheelhouse area should eliminate the front compartment noise problem. There also was an inadequate amount of insulation between the engine compartment and the passenger compartment area. Additional sound barrier sealants and materials will be specified and the cost of this noise isolation package will be included in the LLCC design study.

2.3 PRELIMINARY REVIEW OF PROTOTYPE DESIGN

A thorough review of the original design was performed, with major emphasis on identifying areas that could be improved. A summary of the findings is presented.

Body Group

The body skin and structure should be redesigned to permit construction by conventional tooling, assembly, and material selection techniques for low volume production of van type vehicles.

The windshield angle should be changed to allow a conventional door opening and hinging technique which utilizes hardware that is in production and available with minimal tooling investments. This change is functional as well, improving frontal visibility, reducing solar heat gain and permiting use of Ford modified instrument panel and defrosting ducts.

The rear back light should be changed from a vertical recessed design to an angled almost flush design to permit lower investment in tooling by eliminating deep drawn exterior body panels with difficult assembly, welding and body finishing requirements.

A new roof drip rail attachment technique would reduce body finishing requirements by permitting attachment of the roof to the main body with a coach type joint. The drip rail would also allow an acceptable means of attaching optional roof construction materials such as reinforced fiberglass to the metal main body without expensive trim moldings and fixturing tools.

Powertrain Revisions

The Audi 100 LS engine and transmission assembly should be mounted in the Audi position relative to front wheels and front structure. This change would eliminate the necessity of unique, highly cantilevered engine mounting brackets, reduce the front end structure revisions, and eliminate a new axle half shaft assembly. Carburetion and fuel supply should be similar to the production Audi to eliminate the necessity of expensive cellular fuel cell components utilized

in the original design program and eliminate the objectionable passenger compartment noise levels generated by the fuel pump. The fuel tank should be moved from the front compartment and relocated behind the rear axle. The fuel pump could be relocated to the rear wheel well similar to the Audi design location. Evaporative emission hardware and vapor recovery systems would be included in the final system design for compliance to all fuel system integrity and emission requirements in effect at date of build.

Chassis Revisions

A change in wheelbase is needed as a direct result of increasing wheelchair passenger compartment capacity from one to two passengers and upgrading the rear suspension and brake package to a 2400 lb minimum GAWR. The rear suspension design change to reduce the passenger compartment intrusion of rear springs and increase the rear seat width to a three passenger accommodation yields an added benefit in revision of the rear axle, suspension and brake hardware to correct a marginal condition that existed in the prototype. Brake system modifications are required to insure compliance to safety standards and several candidates of shelf item hardware are available. An Oldsmobile Toronado suspension system does not appear to be cost effective in this application and the extensive changes required to the brake and wheel areas have dropped this candidate from consideration. Control arms, bushings and mounting brackets from the Toronado might be integrated into the design, however, and this possibility will be explored.

Front suspension and steering revisions should reduce the number of modifications that were necessary to package the hardware in the prototype vehicle for clearance to the steam engine.

The steering column, clutch and brake controls should also be slightly relocated, again, primarily to reduce rework requirements.

Handicapped Package Revisions

The electric ramp feature installed on the prototype vehicle would require an extensive design and test program to bring the product to a level of acceptable reliability and maintenance cost. The system developed was extremely difficult to service and adjust to function properly. The storable manually installed ramp is proposed as an alternative.

The wheelchair restraint mechanism could be cost reduced by redesign to a manual actuation mode rather than electric as in the prototype vehicle. Repair and maintenance cost would thereby be lowered with a manual system. However, overall satisfaction expressed by those handicapped people who evaluated the design indicates that the simple power-operated system should be retained.

Sliding Doors

The prototype sliding doors did not include exterior door handles or an easy means for opening the doors from the passenger compartment. This should be corrected by utilization of existing production hardware providing a manual override to the electric operation.

To reduce life cycle costs for the majority of users the left side sliding door should not be standard equipment but only be offered as a plus cost option. An electric sliding door will be retained to provide an easy to operate reliable door system.

2.4 LIFE CYCLE COSTING

As originally developed and applied by the Department of Defense some 10 years ago, life cycle costing was an analytic approach applied to weapons system procurement. This came about in growing recognition of the fact that acquisition, or first cost was only a part, and often the least part, of the total cost of ownership. Costs to operate, support, and maintain complex military systems over their service life frequently dwarf the initial cost.

UMTA has previously shown interest in applying LCC to the Transbus Program (Reference 2). That study showed:

"Evaluation of practices of bus operators and manufacturers indicates that they are in a position to agree mutually upon an evaluation process dependent upon: (1) maintenance cost data, (2) design-related maintenance elements, (3) fuel and tire costs, (4) useful life of a bus for evaluation purposes, and (5) initial bus purchase price.

"Inasmuch as the follow-on costs considered in the evaluation of bus bids exceed the cost of the bus itself, the life cycle costing approach highlights the follow-on costs. Of paramount importance is the flexibility to introduce design improvements that can result in savings during the life of the bus."

A somewhat similar but more detailed study (Reference 3) of life cycle costing as applied to police patrol cars was made for the Law Enforcement Assistance Administration of the Department of Justice in 1974. This study identified 17 critical cost elements in three major categories, as follows:

First or Acquisition Costs:

1. Preparation of specifications, testing, and other procurement-related costs.
2. Purchase price of the vehicle, including delivery costs and factory accessories.
3. Add-on equipment cost.
4. Equipping/modification labor cost.
5. Lease or purchase cost of tools, equipment, and facilities which may have to be used in connection with the vehicle acquisition.

(2) "Life Cycle Costing for Current Rohr, AM General Buses, and General Motors RTS-II Bus". H.R. Kain, et al, Report No. UMTA-VA-06-0039-76-1 dated July 9, 1976.

(3) "The Police Patrol Car: Economic Efficiency in Acquisition, Operation and Disposition". R.T. Ruegg, National Bureau of Standards, June 1976 PB 257-466.

Operation Costs:

6. Gas, oil, and tires.
7. Preventive maintenance program - parts and labor.
8. Other repairs - parts and labor.
9. Accident costs not covered by insurance.
10. Cost of maintaining spare-parts inventory.
11. Incidental expenses (parking, storage, washing).
12. Insurance (net of recovery).
13. Down-time costs — scheduled and unscheduled.
14. Other shop and administrative overhead.

End Costs:

15. Final reconditioning cost.
16. Selling expenses.
17. Resale or salvage value of the vehicle (a negative cost).

The foregoing cost elements were then further classified in another way, being divided into fixed costs and variable costs in accordance with the following breakdown:

Fixed Costs

(Those that do not vary with the mileage or age of the vehicle.)

1. Overhead - including costs of procurement, inventory control, cost accounting systems, depreciation of facilities and equipment, selling expenses, supporting systems, and general management.
2. Insurance.
3. Equipping, modification, and reconditioning costs.
4. Incidental Expenses - parking, storage, washing.

Variable Costs

(Those that do vary with the mileage or age of the vehicle.)

1. Depreciation.
2. Running Expenses.
   a. Those costs which accrue directly with mileage: gas, oil, tires, scheduled maintenance.
   b. Those costs whose probability of occurrence increases with mileage.
      - Repair cost due to failure of vehicle components. (Although not exactly predictable, studies suggest a higher failure rate initially, due to manufacturing defects; a lower rate during the "middle life", and a rising rate at higher mileage as the car begins to wear out).
      - Accident repair cost.

For the taxi paratransit vehicle, the variable costs are of major interest because they are the ones that can be most influenced by the designer and manufacturer of the vehicle. On the other hand fixed costs are mostly dependent on others, including fleet operators, regulatory agencies and insurance companies. An extreme example is the current cost of $48,000 for a medallion or license to operate a taxicab in New York City. Insurance is another cost over which the vehicle designer has little control because premiums are determined largely by factors such as geographical location and previous claims experience, but not to any appreciable extent by vehicle characteristics and to only a small degree by accident repair costs. Most of the other fixed costs such as overhead, parking, storage, and washing are determined principally by the mode of operation and management of the fleet operator and therefore beyond the control of the vehicle designer/manufacturer.

2.5 POTENTIAL DESIGN CHANGES

The initial design review identified a number of areas in which design changes could help achieve program objectives. These are discussed briefly in the following subsections and summarized in the final subsection.

Powertrain Group

In general the engine, transmission and final drive units will remain the same as installed in the prototype vehicle. The engine and drivetrain hardware will be upgraded to include all revisions made by Audi for the 1977 model year. Both nationwide and California-only emission packages will be available to place the higher cost burden on California vehicles only for meeting more stringent emission control standards.

The prototype vehicle front compartment, front structure width was 7.0 inches wider than the production Audi to accommodate the Carter steam engine installation and required extensive rework to the Audi front end structure, engine mounting hardware, axle drive shafts and rack and pinion steering linkages. The engine location was approximately 3.00 inches further displaced from the vehicle longitudinal centerline than the production Audi. These revisions are no longer required.

The LLCC version will incorporated the production Audi front structure width, engine location, suspension location, engine cooling system and location, battery box and location, catalytic converter and location and basic engine electrical components and location. Design revisions will be limited to structural integration to the new body structure, front tread increase from 57.00 inch (Audi) to 60.00 inch by decreasing the wheel offset, and relocation of driver control systems to accommodate the change in driver location.

Design revision investigations will include the following items for possible upgrading to accommodate taxi fleet usage either as standard equipment or as an option.

- Heavy duty cooling system
- Heavy duty battery and alternator
- Transmission oil coolers

Chassis Group

Front Suspension - The front tread will be 60.00 inches, which is 3.00 inches wider than the production Audi 100 and 4.00 inches less than the Paratransit prototype. This tread was selected as requiring no relocation of front suspension components and being compatible with the 63.5 inch rear track derived from the Toronado rear suspension hardware utilization. The track increase will be accomplished by a wheel change and wheel offset reduction from 1.875 (Audi) to a conventional .50 inch (typical U.S.). The wheel mounting bolt pattern will be changed from a 4 bolt, 4.25 inch diameter B.C. to a 5 bolt, 4.50 inch diameter BC pattern to accommodate standard U.S. manufactured 14 x 5.5 JJ x .5 offset wheel and rim assemblies.

This bolt circle pattern change can best be accomplished by the front hub and disc machining supplier to Audi; however, it may also be reworked on existing production hardware by local machining sources for low volume build programs.

The paratransit prototype was fabricated with considerable alterations in the Audi structure width and the 7.00 inch tread increase being accomplished entirely on the left hand side of the suspension resulting in unsymmetrical axle shafts and reworked steering linkage tie rods.

Steering - Power rack and pinion steering will be standard equipment on the Paratransit vehicle. The Audi 100 LS hardware will be utilized with revisions limited to those required to relocate the steering column assembly, relative to the gear and linkage assembly, to be compatible with the driver seating position. The steering gear and column assembly location will be different from the Paratransit prototype due to the front track difference and the attempt to reduce investment levels by minimizing rework of production components. Since the front GAWR on the Paratransit vehicle is the same as the production Audi, no upgrading of the steering gear and linkage assembly is deemed necessary. The power steering rack and pinion gear and overall steering ratios will remain unchanged from the production Audi. Front suspension and steering linkage geometries will also be the same as the Audi.

Brakes

Parking Brake - Audi 100 LS hand brake assembly, using a 1974 Datsun pickup cable assembly, will require mounting bracket design, cable routing and adjustment and interface to rear brake drum assemblies.

Front Wheel Disc Brakes - Same as Audi LS except possible lining material composition change for heavy duty fleet and taxi application. Final design proposal to be supplied by Teves. All components to be production Audi from wheel to chassis junction block. New brake lines from junction block to master cylinder required.

Master Cylinder and Brake Pedals - Production Audi hardware. New location requiring new mounting brackets. Audi brake pedal relocated with driver seating position to maintain pedal ratio and geometry.

Bumpers

Bumpers to be redesigned to minimum section height and relocated to meet FMVSS 215 pendulum test requirements for override and underride impact conditions. System must meet low corner 3 mph no damage requirements of FMVSS 215 which would result in overall increase of approximately 5.00 inches bringing the vehicle overall width up to approximately 77 inches at the bumper ends.

Energy absorbers will be production Delco units for cost and availability consideration replacing the modified Audi units on the prototype vehicle.

Fuel System

Fuel tank will be located under the floor behind the rear axle with fuel pump mounted in the vicinity of the rear wheel well. The right front passenger compartment area utilized for fuel cell location on the prototype vehicle will be used for luggage storage. Other fuel system components will be the same as the Audi 100 LS.

Cooling System

Same as Audi 100 LS. Heavy duty cooling requirements to be evaluated.

Exhaust System

Same as Audi 100 LS except for exhaust pipe routing. Considerable ground clearance problems were encountered on the prototype vehicle which will be corrected by utilizing the original Audi catalytic converter location and mounting plus increasing the design height ground clearance trim height approximately 1.5 inches.

Body Group

The prototype paratransit vehicle was constructed of preformed structural framing members and hand formed aluminum and steel skin panels. The floor was constructed of a structural aluminum honeycomb sandwich material with integral compartment for electric ramp storage. While this may be a reasonable economic approach for the construction of one or two vehicles, it is not feasible for a low volume, low life cycle cost production program.

The body design for the LLCC program will be a more conventional unitized, stamped sheet metal components configuration with maximum consideration for construction from low investment level tooling.

The windshield slope and location will be modified to reduce tunnel vision effect and allow utilization of a modified Ford Econoline instrument panel structure, windshield wiper, heater and defroster system.

The roof structure should be modified by addition of a drip rail for a lower cost attachment of roof to body side structure and also permit the plastic roof option.

Maximum utilization of production shelf item components for all areas of body hardware and trim are planned. Tail lamps, side marker lamps, headlights, rear view mirrors (inside and outside) will be production Ford, Chevrolet, or VW Rabbit components to minimize production investments. Door locks, hinges, and window regulator hardware will also be of production shelf item stock.

Handicapped Systems

The power actuated wheelchair ramp will be redesigned to be offered as an option only application for taxi usage. The hand installed, storable ramps designed by ASL will be offered as the base design system. The problems associated with the power actuated ramp included variable curb heights, wheelchair safety restraints (roll off), remote actuation (the driver may be enclosed in a protective compartment and not able to accurately observe and operate the power ramp from his seated location). Problems as well as the complicated mechanical hardware to actuate the ramp and the structural design limitations for stowing the ramp, were all factors leading to the decision to recommend a manually activated, remotely storable, wheelchair ramp system.

Sliding Doors

The cost of an operating, left hand electric sliding door can also not be justified except as a high cost specialty option. The occasional usefulness for left hand pick up on one-way streets is not considered to be cost effective. If the taxi fleet demand is high for such an application, a fixed hinge door might be much more cost effective in this application.

The electric door operation modes, mechanical hardware and occupant safety protection aspects must be considered for an overall system design evaluation. The system developed on the prototype is not considered cost efficient, operationally correct, or safe from an occupant protection viewpoint. The electric sliding door can only be considered as a convenient form of loading and unloading passengers with the driver remaining in his seated location. While this system may be convenient for the driver, it might encourage the driver to remain in his seat and not offer assistance to handicapped individuals. The lack of safety related limit stops in the door could also be dangerous to passengers, especially the wheelchair occupant in close proximity to the door jamb and lock.

The following design safety features will be incorporated into the electric door system.

1. Load limiting switches or clutches.
2. Internal and external manual override door actuating handles.
3. Electric operation switch located in B-post area to open and close door from the outside of the vehicle.
4. Secondary emergency exit from the occupant compartment area.

Taxi Fleet Systems, Options and Accessories

Cost effective changes can be accomplished in several areas of the Paratransit vehicle by making convenience items available as added cost options.

The sliding door on the right side of the vehicle will be offered as manually operated standard equipment; electric operation will be an added cost option. The electric power door system option will include a manual override safety feature allowing the door to be operated in the event of power or component hardware failure.

The left hand sliding door will be an added cost option and will also be available as power or manually operated. Both the left hand and right hand door systems will be equipped with interior manually operated door handles for easy access and operation by rear compartment occupants. Both doors will have a lock open feature incorporated in door hardware design.

The handicapped option package will include provisions for two wheelchairs and one set of storable wheelchair ramps. The wheelchair provisions will include a manually activated wheelchair restraint and retractable lap belts.

Air conditioning will be an added cost option. An improved design for driver and occupant compartment ventilation is required and functional vent windows will be added in the rear passenger compartment area. Floor level fresh air vents in the front compartment will take in air from the front grille area. Upper level air intake in the cowl areas directly below the windshield will supply heater, air conditioning, and upper level ventilation air. Flow-through air exits will be incorporated in the rear "D" post to complete the ventilation package. In the driver full partition option, separating the front and rear compartments, air ducts will be incorporated to supply the rear occupant compartment with flow-through air.

The very large greenhouse glass area on the Paratransit vehicle results in solar heat gain that is difficult to remove efficiently with commercial air conditioning units. Laminated glass panels with tinted mylar film laminate material could reduce solar heat gain by as much as 30%. The laminated tinted glass will be optional equipment for all glass areas. The windshield will be tinted lightly with a darker band along the upper edge. The cost/effectiveness factors of tempered versus laminated side glass will be studied.

Engine options should be investigated for fuel economy and performance factors. The ISUZU 4-cylinder diesel engine has been dropped from consideration due to packaging limitations and marginal improvements over the Audi engine. The prime candidates for cost effective engine alternatives include the U.S. produced Audi 4-cylinder engine used in the AMC Gremlin and the turbo-charged V.W. diesel engine used in the V.W. Rabbit.

The V.W./Audi automatic transmission will be standard equipment in the taxi vehicle application. The 4-speed Audi manual transmission can be offered as an added cost option and could be desirable in rural taxi applications such as airport to city taxi service or long haul taxi routes.

2.6 REVISED VEHICLE SPECIFICATIONS

As a result of the design review a revised set of vehicle system specifications was drawn up, together with a new product profile.

GENERAL SPECIFICATIONS

Engine and Powertrain	Forward mounted, transaxle, front wheel drive
Engine type	Audi 100 LS 4-cylinder in line overhead valves
Valves	Pushrods and rocker arms
Cylinder bore	3.31 in (84mm)
Piston stroke	3.32 in (84.4mm)
Displacement	114.2 cu in (1871 cc)
Compression ratio	8.0:1

Torque (SAE	104 ft lbs @ 3200
Horsepower (SAE	95 @ 5500
Fuel supply	CIS fuel injection
Fuel pump	Electric, remote mounted
Engine lubrication system	Full pressure rotary pump
Cooling System	Water cooled
Radiator capacity	8 quarts
Fan and shroud	Electric, thermocouple controlled, remote mounted
Fuel capacity	15 gallons useable minimum
Engine oil capacity	8.5 pints
Transmission	Audi 100 LS 3-speed automatic transaxle
Final drive	Transaxle with integral ring gear, piston and differential
Output shafts	Splined axle shafts suspended with RZEPPA constant velocity outboard. Joint & pot type slip inboard joint.
Electrical System	12 volt negative ground
Battery	12.6 volt 55 amp/hr rating
Alternator	14 volt 55 amp output with integral regulator
Ignition	Capacitance discharge with control box and ignition coil
Suspension & Steering	
Front suspension	Independent wishbone with coil spring/shock mounted on upper control arm. Live spindle, integral knuckle pin/hub carrier with dual race ball bearings, ball joint knuckle attachment, rubber bushed wishbone, upper and lower control arms. Linkage type stabilizer bar.
Rear suspension	Four link control arm, solid axle, coil spring, fixed spindle with automatic load leveling air spring shock absorbers. Control arms, rubber bushed at body and axle attachments. Sway stabilizer bar attached to lower control arms for roll rate and roll couple control.
Steering system	Rear mounted rack and pinion power steering gear and linkage

Body	Stamped steel unitized frame and body construction. Extruded aluminum energy absorbing bumper systems.
Seating capacity	6-7 passengers.
Seating arrangement	Driver plus two rear facing wheelchair passengers plus three forward facing rear seat passenters, or, RH wheelchair accommodation includes a fixed fold-down rear facing jump seat. LH wheelchair location will accommodate a fold-up storable two passenger jump seat, stored in trunk when not in use.
Occupant Restraint Systems	
Driver	Class II lap and retractable shoulder belt
RH Wheelchair	Class II lap belt plus retractable wheelchair restraint belts. (Fold-down jump seat option utilizes same lap belt)
LH Wheelchair	Class II lap belt plus retractable wheelchair restraint belts. (Fold-up Storable jump seat has one additional lap belt.)
Rear Seat Occupants	Three Class II lap belts plus pull down short stop padded chest restraint.

Vehicle Height

Overall height (unload)	73.0
Overall height (loaded)	71.25
Ground clearance (engine) front suspension)	6.25
Ground clearance (body)	7.00
Ground clearance (rear susp)	6.25
Floor height (unloaded)	12.75 (max.)
Floor height (loaded)	11.00 (min.)
Bumper ℄ to ground-curb height (front/rear)	18.00/19.00
Bumper section height	5.0
Maximum stepheight from 7.00 curb	5.75
Maximum stepheight from street	12.75
Storage compartment lift over height - maximum	25.0

Vehicle Width

Overall width	72.00
Front track	61.00
Rear track	63.58
Driver "y" coordinate	16.00
Steering wheel "y" coordinate	-15.00
RH wheelchair "y" coordinate	17.00
LH wheelchair "y" coordinate	-17.00
Rear seat occupant "y" coord	20.0, 0.0, -20.0
RH jump seat "y" coordinate	17.00
LH jump seat "y" coordinate	-21.38, -1.38
℄ of engine "y" coordinate	.62
℄ diff. "y" coordinate	0.0

Vehicle Length

Wheelbase	112.00
Front Overhang	36.00
Rear Overhang	36.50
Overall length	184.50
Front wheel "x" coordinate	0.0
Driver "x" coordinate	43.5
RH wheelchair "x" coordinate	58.5
LH wheelchair "x" coordinate	74,5
Rear seat passenger's "x" coordinate	115.0

Paratransit Weight Distribution

Configuration "A1" 112.00 wheelbase 72.00 OAW 6 passengers *

	Distribution	Total	Front	Rear
Curb-weight	54/46	3000	1620	1380
+ driver	54/46	3150	1712	1438
+ RH wheelchair passenger	54/46	3300	1784	1516
+ LH wheelchair passenger	53/47	3450	1836	1614
+ 3 rear seat passengers	47/53	3900	1824	2076
G.V.W.		3900	1824	2076
G.A.W.R.		4284	1984	2300

hp/lb = .028

Configuration "A2" 112.00 wheelbase 72.00 OAW 7 passengers *

	Distribution	Total	Front	Rear
Curb-weight	54/46	3000	1620	1380
+ driver	54/46	3150	1712	1438
+ RH wheelchair passenger	54/46	3300	1784	1515
+ 2 passengers jump seat	52/48	3600	1888	1712
+ 3 passengers rear seat	46/54	4050	1875	2175
G.V.W		4050	1875	2175
G.A.W.R		4384	1984	2400

hp/lb = .027

*Including driver

The only difference between Configurations A-1 and A-2 is occupancy, i.e., in A-1 the jump seat is folded up to allow a second wheelchair, while in the A-2 the jump seat is occupied by two passengers. The A-2 condition is shown in Figures 2-1 and 2-2.

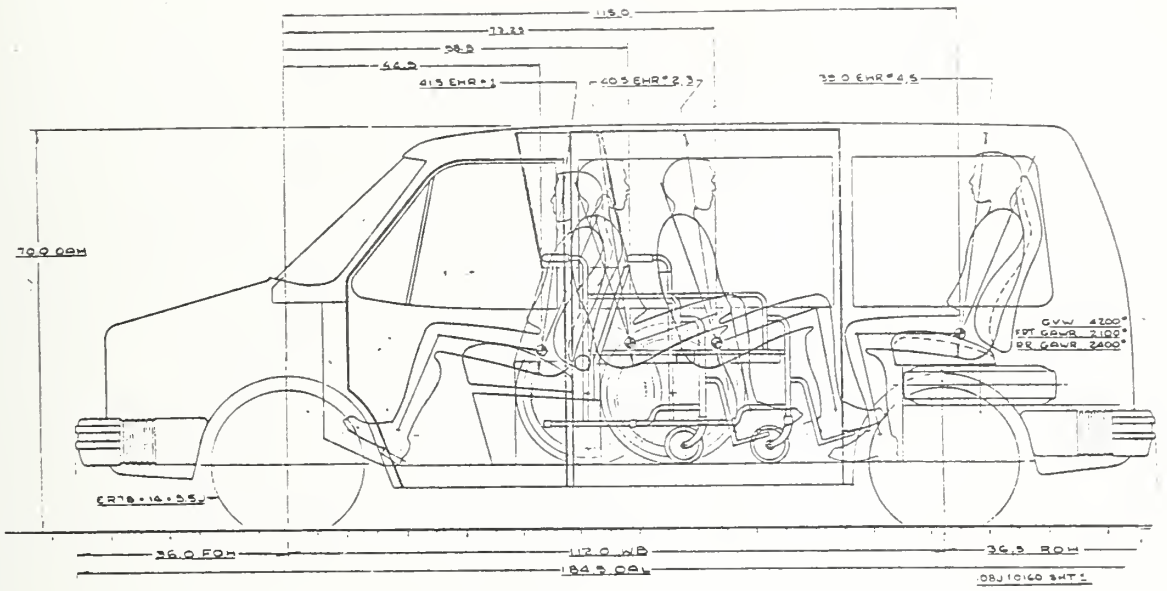

Figure 2-1. Side View, Configuration A-2

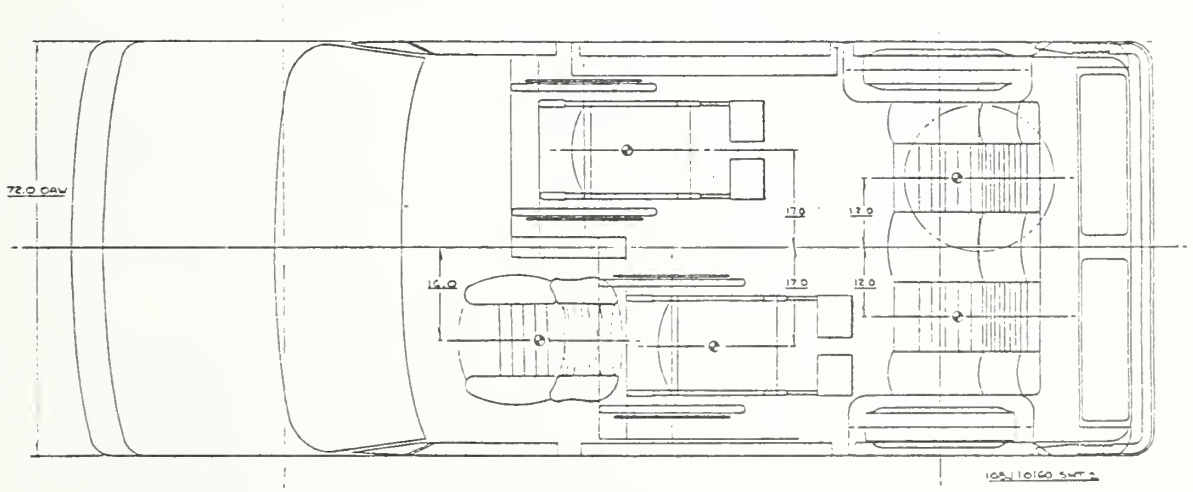

Figure 2-2. Plan View, Configuration A-2

SECTION 3
SYSTEM AND COMPONENT ASSESSMENT

Following the general appraisal of design changes that appeared necessary or desirable in the PTV, the study proceeded to more detailed studies and investigations. In some cases it was determined that further changes would be advantageous or required by the availability status of certain hardware. Wherever possible systems and components were selected from proven hardware in passenger car and multi-usage van type vehicles or else designed new for specific heavy-duty taxi fleet usage with major considerations for improving operation, reliability, maintainability and reduced life cycle costs.

Particular attention, in the selection of vehicle systems and components was directed to responding to the International Taxi Association's comments and suggestions included in their Evaluation of Paratransit Prototype Vehicles, and also the Assessment of Passenger and Driver Accommodations report from the U.S. Department of Transportation.

SYSTEM ASSESSMENT

At the preliminary design review a study was made of the implications of certain changes as they would affect life cycle cost and other program-related goals. As the study progressed these were updated and refined, and are shown in Table 3-1, Design Change Rationale. Discussion of the major points of this rationale follows.

Prior Shortcomings

The vehicle attitude trim heights and ground clearance problems experienced in the prototype test program have been addressed and corrected in the LLCC design study program. The noise and function problems associated with the fuel tank and electric fuel pump have been corrected by incorporation of production Audi components and locations (removed from passenger compartment). There also was an

Table 3-1. Design Change Rationale

DESIGN CHANGES / LOW LIFE CYCLE COST IMPLICATIONS	REDUCED INVESTMENT	REDUCED UNIT COST	REDUCED OPERATING COST	REDUCED MAINTENANCE COST	FUNCTIONAL	COST/EFFECTIVENESS	RELIABILITY/ PERFORMANCE	MANUFACTURING/ ASSEMBLY
Styling Revisions								
Front Sheetmetal, Hood, Fenders & Grille	x			x	x	x		
Bumper Sections		x		x	x	x		
Roof Drip Rail	x	x		x		x		x
Door Cut Lines	x	x				x		x
Rear Deck Hatch	x				x			x
Rocker Panel Design	x			x	x			x
Powertrain Revisions								
Engine Transmission Mounting	x	x		x	x			
Accelerator Controls		x			x			
Exhaust System		x		x	x		x	
Transmission Oil Coolers				x				
Chassis Revisions								
Wheel Offset	x	x		x		x		
Steering System	x	x		x	x	x	x	
Brake System				x	x		x	
Energy Absorbing Bumper Systems	x	x		x	x	x		
Body Revisions								
Body Construction	x	x		x	x	x		x
Body Structure	x	x		x	x	x	x	x
Roof Construction	x	x		x	x	x		x
Seats and Interior Trim	x	x		x	x	x		
Instrument Panel and Controls	x	x		x	x	x		
HVAC	x	x		x	x	x	x	
Door Locks, Hinges and Regulators	x	x		x	x	x	x	
Glass Weatherstrips and Seals	x	x		x	x		x	
Sliding Door Hardware	x	x		x	x	x	x	
Handicapped Package Revisions								
Wheelchair Ramp	x	x	x	x	x	x	x	
Left Hand Sliding Door Option	x	x		x		x		
Taxi Fleet Options & Accessories								
Air Conditioning	x	x		x		x		
Driver Compartment Enclosure	x	x				x		
Driver Protection Package	x	x				x		
Tinted Glass			x		x		x	
Engine Options			x		x	x	x	

inadequate amount of insulation between the engine compartment and the passenger compartment area. Additional sound barrier sealants and materials will be specified and the cost of this noise isolation package will be included in the LLCC design study.

The fuel economy tests indicate the Audi 4-cylinder powerplant when loaded to a 3600 pound vehicle inertia weight, will not meet the original design requirements for paratransit vehicle and that the selected engine option, the VW diesel, will not meet the original acceleration requirements. This hardware is, in our opinion, the best currently commercially available and we have chosen to design around these powerplants until such time as fuel economy improvements and future front wheel drive engine transmission combinations are available in a power to weight ratio range closer to the upper limit of the paratransit specifications.

Body Group

The primary reason for redesign of the body skin and structure is to permit construction by conventional tooling, assembly and material selection techniques for low volume production of van type vehicles.

The windshield angle change allows a conventional door opening and hinging technique which utilizes hardware that is in production and available with minimal tooling investments. This change is functional as well, improving engine compartment accessibility for service repair and maintenance.

The engine compartment hood utilizes production Ford van hinges and latching mechanisms, is easily removable for compartment access and vertical engine removal. The radiator, grille and front baffle crossmembers are bolt-on construction providing easy removal for engine service or removal.

The front quarter panels (fenders) are also of bolt-on construction allowing easy removal and replacement for accident repair or increased front suspension and brake overhaul access.

The roof drip rail attachment technique reduces body finishing requirements by permitting attachment of the roof to the main body with a coach type joint. The drip rail also allows an acceptable means of attaching optional roof construction materials such as reinforced fiberglass to the metal main body without expensive trim moldings and fixturing tools.

The prototype sliding doors did not include exterior door handles or an easy means for opening the doors from the passenger compartment. This will be corrected on the LLCC design program with utilization of existing production hardware providing a manual override to the electric operation. The addition of exterior door handles and manual override system can be considered cost effective and necessary from a product liability viewpoint.

To reduce life cycle costs for the majority of users the left side sliding door will not be standard equipment but will be offered as a plus cost option.

Electric sliding doors will be retained to provide an easy to operate reliable door system.

Powertrain Revisions

The Audi 100 LS engine and transmission assembly will be mounted in the Audi position relative to front wheels and front structure. This change eliminates the necessity of unique, highly cantilevered engine mounting brackets, reduces the front end structure revisions, and eliminates a new axle half-shaft assembly. Carburetion and fuel supply will be the same as the production Audi, will eliminate the necessity of expensive cellular fuel cell components utilized in the original design program and eliminate the objectionable passenger compartment noise levels generated by the fuel pump. The fuel tank has been moved from the front compartment and relocated behind the rear axle. The fuel pump has been relocated to the rear wheel well similar to the Audi design location. Evaporative emission hardware and vapor recovery systems will be production Audi hardware and will be in compliance to all fuel system integrity and emission requirements in effect at date of build. The fuel economy summary table in Figure 3-2 compares the base vehicle engine with the optional diesel powerplants considered as viable cost effective fuel efficient alternatives in the Paratransit vehicle.

Table 3-2. LLCC PTV Fuel Economy

SUMMARY PARAMETER		ENGINE OPTIONS Audi 100 Gas	VW Turbo Diesel	VW Nat. Asp. Diesel
Fuel Economy (mpg)				
Constant Speed	20 mph	22.5	39.6	34.0
	30 mph	27.9	39.9	39.7
	40 mph	27.4	36.3	36.6
	50 mph	24.5	31.8	31.5
	60 mph	21.7	26.9	26.7
"Urban" Cycle ***		15.5	24.3	23.5*
"Suburban" Cycle ***		21.6	27.7	27.9*
Acceleration (sec.)**				
	0-30 mph	5	6.4	9.5
	0-55 mph	13.2	18.6	29.6

*Could not follow portions of these cycles.

**Optimistic - does not include delays for initial throttle lag and shifts. 3,600 pound vehicle weight.

***Per Dynamic Science test specifications, based on SAE J1082.

Chassis Revisions

The change in wheelbase is a direct result of increasing wheelchair passenger compartment capacity from one to two passengers and upgrading the rear suspension to a 2400 lb minimum GAWR. The rear suspension design change to reduce the passenger compartment intrusion of rear springs and increase the rear seat width to a three passenger accommodation was an added benefit in revision of the rear axle and suspension hardware to correct a marginal condition that existed in the prototype.

The cost of developing a totally new brake hardware package for the paratransit vehicle would be in excess of 5 million dollars and selection of the current production Audi power disc/drum hardware as the best alternative in existing shelf hardware, meeting current brake system standards and service-repair availability requirements, is the present best way to meet the low life cycle cost objectives of the paratransit program. The cost/effectiveness of the brake system hardware will be greatly influenced by the number of vehicles in operation, the operational environment, frequency of repair and other factors the sum of which is unknown at this time. A fleet of vehicles, as an example, in service in the San Francisco area may require brake system maintenance and lining replacement every 10,000 miles or twenty to thirty life cycle overhauls which greatly increases the frequency of repairs and the operational costs.

The general recommendations of the ITA study indicates that a four wheel disc brake system with 11" to 12" diameter rotors and 15 inch 5 bolt wheels and tires are desirable for the taxi application. This hardware is not commercially available or compatible with the powerplant, suspension and steering components, vehicle dimensional packaging limitations, or reduced weight and fuel economy requirements of the program.

The current production Cadillac Eldorado, Olds Toronado hardware was considered as being close to the ITA recommendations but the cost of integrating this hardware to the PTV design package, the additional power loadings and packaging clearance provisions are not considered to be worth the potential reduction in system repair and replacement requirements. The basic vehicle

braking performance for either system can be considered as equal with a potential lining life increase for the larger brake hardware. Rear wheel disc brakes are not considered cost effective or performance improvement oriented and the overall design and development of a new 4 wheel power disc brake package for the paratransit vehicle is considered beyond the scope and requirements of the LLCC program.

Front suspension and steering changes are primarily to reduce the number of revisions that were necessary to package the hardware in the prototype vehicle for clearance to the steam engine.

The steering column, clutch and brake controls have been slightly relocated again, primarily to reduce the rework requirements.

The rear suspension design is based on the current Audi hardware with new rear axle stamping, coil springs mounted on the axle, and automatic load leveling shock absorbers for load compensation and vehicle attitude-suspension travel control.

Handicapped Package Revisions

The electric ramp feature installed on the prototype vehicle would require an extensive design and test program to bring the product to a level of acceptable reliability and maintenance cost. The system developed was extremely difficult to service and adjust to function properly. The storable manually installed ramps proposed by ASL as an alternative to the electrically self-storing ramp will have a considerable impact on reducing the life cycle cost of the vehicle. In the systems and component assessment of the prototype installed ramp design it was very easy to rationalize the manual system as a cost-effective change based on the difficulties encountered in structural design, hardware costs and actual repair and adjustments required to make the system operational on the prototype.

The wheelchair restraint mechanism can be cost reduced by redesign to a manual actuation mode rather than electric as in the prototype vehicle. The repair and maintenance cost will be lowered with the manual system and an

overall reduction in life cycle costs is projected. However, overall satisfaction expressed by these handicapped people who have evaluated the design has led us to conclude that the simple power operated system should be retained.

Provision for a second rear facing wheelchair located directly behind the driver has been explored and the following conclusions drawn:

- Physical package space is available for a wheelchair and occupant in this position.
- Maneuverability into this position can be achieved by either attendant assistance or by wheelchair occupants having upper torso and arm control operating the wheelchair with their hands.
- Power assisted wheelchairs and wheelchair occupants having difficulty in maneuvering control would have considerable difficulty reaching this location because of the precise maneuvers involved.
- The addition of this feature would have very minimal impact on life cycle cost and be primarily in the additional initial cost of the wheelchair restraint system.
- This system is a viable option alternative but the need for a second wheelchair location is unknown and therefore will be considered as an added cost option only that will have no effect on life cycle costs and therefore not be included in the cost study.

These items are not considered as having a significant impact on the life cycle costs and will not be included in this study. The standard yellow with black trim paint treatment utilized on the prototype vehicle will be considered in the manufacturing cost estimate. A standard vehicle color for all fleet applications would be cost effective and allow priming and painting of replacement panels and sheet metal assemblies at the point of manufacture. Attaching flange weld areas would be masked and touched up with primer after assembly.

Interior seats and trim panels will be vinyl covered for ease of cleaning. Floor mats of rubber construction are specified again for ease of cleaning.

SECTION 4
REPAIR AND MAINTENANCE ASSESSMENT

4.1 INTRODUCTION

This section contains the results of Task 4, Repair and Maintenance Assessment, of the Low Life Cycle Cost Design Study for Paratransit Vehicle Program. There is assembled here all of the available data on repair and maintenance of taxicabs and kindred vehicles, together with manufacturers' recommendations for specific vehicle subsystems.

4.2 OBJECTIVE

The primary objective here is to critically review the vehicle design with regard to maintainability, recognizing that costs for repair and maintenance constitute a significant portion of life cycle costs. The frequency and duration of periods when a vehicle must be withdrawn from revenue-producing service in order to make repairs, also impact the cost-of-ownership.

4.3 DEFINITION OF PROBLEM

The current redesign effort is intended to produce a ride-sharing paratransit vehicle to be used in taxi applications. The operational environment and other factors that can significantly affect useful service life and maintenance costs, have not been specified. The range of variations in taxi utilization is illustrated by the following examples from a review of the literature. Reference (4) indicates the average annual mileage of all taxicabs in the U.S. was slightly more than 51,000 miles in 1973. Reference (5) states that fleet taxis in New York City, typically used in two 8-10 hour shifts daily, will travel 60,000 to 80,000 miles per year. In a more recent

(4) International Taxicab Association, "Fact Sheet on Taxicab Operations in the United States", 1973.

(5) "The Taxicab: A Design Challenge and Industry Testbed", Automotive Engineering, October 1973.

study, Reference (6), the New York City Taxi and Limousine Commission determined that fleet taxis averaged 75,000-85,000 miles per year while owner-drivers, who drive only one shift, averaged 45,000. Apparently at the upper extreme are figures cited in Reference (7) of 100,000 vehicle miles in urban areas and 70,000 miles per year in many suburban and rural areas. A value of 75,000 miles for urban use and 50,000 for suburban appear to be reasonable and representative figures.

A similar variation occurs in the length of service life reported for taxi applications, as shown below:

		Ref. (5)	Ref. (6)
Urban	Checker Fleet	2-3 years	2 years
	Other Fleet	1-2 years	2 years
	Owner-Driver	-	3-5 years

The above are not necessarily the total useful lives of the vehicles, but reflect factors such as depreciation rates, resale values, and fleet replacement timing.

In Reference (7) the ITA expressed a desire for a paratransit vehicle designed for sufficient serviceability and maintainability to have an expectation of remaining in use for a five-to-ten year amortization period. This implies a level of durability not even approached in ordinary passenger cars which are rated in Reference (8) as good for 100,000 miles over a 10-year lifespan in use in suburban-based operation.

In recent years automakers have shown increasing interest in improving the durability of their products. In 1973 Porsche announced a program to develop technology to build a car that would last 20 years, using a body

(6) "Urban Design and Usage Factors of Paratransit Vehicles and Facilities" R. Adams and G. Hildebrand, Pratt Institute, UMTA Report NY11-0011, 1976.

(7) "Evaluation of Paratransit Prototype Vehicles", International Taxicab Association, May 1977, UMTA Contract IL-06-0037, R.V. Gallagher, J. Davidson.

(8) "Cost of Owning and Operating an Automobile, 1976", DOT FHWA, L.L. Liston, C.A. Aiken.

made principally of aluminum. It is currently guaranteeing its zinc-coated steel bodies against corrosion for six years. Fiat and Peugeot-Citroen are also actively engaged in similar research, Reference (9). U.S. manufacturers have also taken steps to improve the corrosion resistance of their car bodies, particularly the bottom half and the underbody. This is being done by application of a variety of protective measures including wax sprays and zinc coatings.

Besides corrosion there are a number of other factors that work to shorten the life of an automobile. These include:

a. Fatigue. This is the weakening and ultimate failure of parts that are subjected to alternating, cyclic loading.
b. Wear. Loss of material due to motion and friction between rubbing surfaces.
c. Deterioration. Breakdown of physical properties caused by exposure to heat, light, moisture, aging, chemical attack, etc.
d. Overload. Structural failure or misalignment caused by overstressing.
e. Accident damage. Effects of collision with another vehicle or object.

The effects of these factors are mitigated or compensated for in three ways:

1. Adequate design and manufacturing quality control.
2. Preventive maintenance.
3. Corrective maintenance/repair.

The design phase is crucial in determining the costs that will be associated with repair and maintenance during a vehicle's operating lifetime. The designer should make intelligent tradeoffs and knowledgeable choices, balancing an item's original cost against its reliability (Mean Time Between Failures) and maintainability (Mean Time to Repair). Where the installed

(9) "The Drive to Build a Long-Life Automobile", Business Week, August 29, 1977.

component cannot be made easily accessible for removal and replacement, it should be specified for long life. Likewise good design can reduce the amount of scheduled or preventive maintenance by such means as lengthening intervals between oil changes, tune-ups, etc. While much has been done by manufacturers along these lines, especially in the past five years, even more is possible.

With respect to fatigue and overload, one auto manufacturer designs, builds, and tests a heavy-duty frame for its taxi package. This frame is required to survive a laboratory test equivalent to 9,000 miles of high-speed travel over cobblestones and 9,000 over potholes.

This same manufacturer has also made strenuous efforts to reduce the amount of preventive maintenance required by:

a. Lengthening the interval between oil changes, brake checks, wheel bearing lubrication and other servicing items. Examples are doubling the intervals between oil changes and lengthening period between tune-ups from 12,000 miles to 30,000.

b. Making the scheduled services for checks and adjustments simpler and quicker to perform.

In the matter of corrective maintenance another manufacturer rates its vehicles according to a serviceability index. This index contains weighted criteria for the various factors involved in making unscheduled repairs including time required, mechanic skill level, cost of repair parts and special tool requirements. The serviceability index number derived from this analysis is then compared with index numbers of other similar vehicles.

4.4 TECHNICAL APPROACH

There exist a number of ways by which a repair and maintenance analysis can be accomplished. These include statistical experience; time, motion and cost analysis; and comparative maintainability analysis. The approach used here is a combination of elements from all three of the above.

It was originally thought that it would be possible to obtain detailed statistical data on repair and maintenance from three or four large urban taxi fleet companies and from the manufacturer of the major chassis subsystems of the PTV. None of these sources cooperated, for reasons of proprietary data and competition. As a result, secondary sources were consulted, including:

1. Local taxicab fleet operator.
2. U.S. auto manufacturer's warranty experience on police patrol cars.
3. California Highway Patrol maintenance experience.
4. Records of other law enforcement agencies.
5. General Services Administration.

As might be expected the data from these diverse sources was at various levels of detail for various time frames, and not wholly consistent.

From the viewpoint of size the U.S. government is the largest vehicle fleet operator, having almost 340,000 of all types in 1975, of which some 65,000 were classified as sedans (Reference 10). Average annual mileage of sedans in this fleet is just over 12,000, although several small agencies registered 19,000 and 25,000 miles. Repair and maintenance costs are broken out by sedan size as follows in cents/mile:

(10) General Services Administration, Federal Supply Service, "Federal Motor Vehicle Fleet Report for FY 75", July 1976.

	Compact	Intermediate	Standard
Materials and Labor	3.81	5.56	5.30
Contract Services	0.36	0.79	1.35
Depreciation	3.22	2.58	3.00
Accident Repairs	0.13	0.10	0.12
Indirect	1.98	1.57	2.20
TOTAL	9.50	10.72	11.76

From the foregoing the ratio of accident repair costs to total direct repair and maintenance costs is calculated to be:

Compact sedans	3%
Intermediate sedans	1.6%
Standard sedans	1.8%

Law enforcement vehicles are in many ways analagous to taxicab fleets in terms of geographical deployment, annual mileage averages, and intensity of usage, particularly for urban police forces. A breakdown of warranty costs for one U.S. auto manufacturer for one year (1973) for its Law Enforcement Vehicles (LEV) is shown in Table 4-1. Experience of the Los Angeles Police Department, which emphasizes high levels of maintenance for its fleet, contrasts markedly with the national LEV average and is even appreciably less than overall commercial and fleet averages. This emphasizes dramatically the effect that planned, thorough maintenance can have on costs.

Table 4-1. Warranty Repair Costs

GROUP	L.A.P.D.	All Other LEV	All Other Fleet & Demestic
Engine	$ 8.70	$ 56.48	$ 8.17
Front Suspension-Steering	1.82	20.74	5.80
Brakes and Wheels	2.35	19.83	6.20
Electrical	2.74	18.12	9.59
Automatic Transmission	10.80	10.76	3.52
Fuel and Exhaust	3.37	9.05	4.77
Heater & Air Conditioner	4.98	8.45	4.80
Rear Axle & Prop Shaft	7.65	6.79	3.41
Cooling	2.12	4.65	2.04
Subtotal	$44.53	$154.87	$48.30
All Other	7.91	16.93	28.93
TOTAL	$52.44	$171.80	$77.23

The foregoing were further broken down to show the most expensive items, as follows in Table 4-2.

Table 4-2. High Cost Warranty Items

Description	L.A.P.D.	All Other LEV
Engine, Short	$ 3.82	$ 25.96
Pitman Arm - Special Prog	.18	9.53
Carburetor	.13	5.17
Intake Valve	.62	5.57
Drum Brake Shoe Set	.27	4.73
A/C Compressor	2.61	3.83
Piston Ring Set	-	3.96
Parking Brake to Rr. Wheels Cable Assy.	.26	3.22
Spark Plug	.19	3.07
Front End Alignment	.26	2.93
Rear Axle Ring Gear Set	3.03	2.38
Piston	.29	1.75
Water Pump	.71	2.21
Cylinder Head	.55	2.04
Alternator	.42	2.10
Cylinder Block	-	.76
Front Suspension Lower Control Arm Strut Rod	-	2.06
Paint and Metal Finish	1.08	1.77
Battery	.07	1.80
Chassis Wire Harness	.38	1.71
Body Water Leaks	-	1.71
15 inch Wheels - Special Prog.	-	1.61
Starting Motor	.20	1.53
Door Glass Frame/Channel/Stop Adj.	.57	1.36
Hub and Drum	.06	1.51
Automatic Transmission Case	4.11	.93
Alternator Voltage Regulator	.10	1.43
Automatic Transmission Converter	1.38	1.25
A/C Compressor Drive Clutch Assembly	.10	1.38
Automatic Transmission Oil Pump	.05	1.15
Front Wheel Disc Brake Shoe Set	-	1.17
Cylinder Head Gasket	.41	1.05
Automatic Transmission Assembly	.68	1.08
P.B. Master Cylinder Assembly	.18	1.08
Subtotal	$22.89	$104.79
All Other	29.55	62.01
TOTAL	$52.44	$171.80

While the foregoing reflects experience during only the first part of the vehicle's service life, some data is also available on late periods. The influence of driving patterns and environments on the maintenance costs is illustrated in Table 4-3, as presented in Reference (11). Table 4-4 presents cost data averaged from a sample of more than 1,100 patrol cars operated in 29 cities Reference (11) data originally furnished by Mainstem, Inc., Princeton, N.J.

Table 4-3. The Effect of Different Driving Environments and Vehicle Usage Rates on Maintenance Costs

Large City Police Department	Miles per Gallon of Gasoline	Maintenance Cost (Labor & Parts & Tires) Cents per Mile
Congested Traffic District (a)	7.65	4.7
Open Driving (Suburban) District (b)	8.78	2.6
High Car Utilization District (c)	8.70	3.7

(a) Averages are for three samples of twenty-three vehicles each, driven in three congested downtown city areas. Vehicles in these districts accumulate mileage at a slower rate than the department average, but corresponding engine hours are higher than average.

(b) Averages are for two samples of twenty-eight vehicles each, driven in two suburban districts characterized by relatively low population density and rural driving conditions. Vehicles in these districts accumulate mileage at a higher rate than the department average, but associated engine hours tend lower than average and stop and starts are fewer.

(c) Averages are for a sample of twenty-five vehicles operated in a high crime community. Driving conditions are not particularly severe, but the need for constant patrol results in higher than average utilization of cars in this district.

(11) "The Police Patrol Car: Economic Efficiency in Acquisition, Operation and Disposition", R.T. Ruegg, NBS June 1976, PB-257-466

Table 4-4. Maintenance Cost for a Sample of City Patrol Cars by Type of Expenditure and Mileage Interval of Occurrence (in cents/mile)

Type of Service	MILEAGE INTERVAL 0 to 10,000	10,000 to 20,000	20,000 to 30,000	30,000 to 40,000	40,000 to 50,000	50,000 to 60,000	60,000 and over
Instrument gauge	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Axle, front, nondriven	0.01	0.01	0.01		0.01	0.01	0.01
Brakes - major repair	0.07	0.13	0.29	0.27	0.27	0.29	0.31
Brakes - minor repair	0.02	0.04	0.06	0.03	0.05	0.06	0.04
Frame	0.01	0.01	0.01	0.01	0.01	0.02	0.04
Steering	0.05	0.05	0.07	0.09	0.12	0.10	0.19
Suspension	0.07	0.08	0.13	0.12	0.15	0.15	0.16
Wheel, rims, hubs, bearings	0.02	0.02	0.03	0.03	0.04	0.04	0.03
Axle drive, rear	0.01	0.01	0.02	0.01	0.01	0.01	0.05
Drive shafts			0.01	0.01	0.01	0.02	0.04
Transmission - major repair	0.06	0.06	0.10	0.13	0.13	0.31	0.34
Transmission - minor repair	0.02	0.04	0.03	0.07	0.06	0.05	0.08
Charge system	0.07	0.11	0.17	0.16	0.16	0.14	0.21
Cranking & battery system	0.08	0.10	0.14	0.17	0.18	0.19	0.21
Ignition	0.12	0.20	0.23	0.27	0.30	0.32	0.30
Lighting	0.14	0.09	0.11	0.13	0.12	0.11	0.12
Air intake			0.01	0.01	0.01	0.01	0.01
Cooling	0.05	0.05	0.09	0.01	0.15	0.14	0.17
Exhaust	0.06	0.05	0.06	0.08	0.08	0.10	0.09
Fuel	0.03	0.05	0.06	0.09	0.10	0.10	0.11
Power - major repair	0.03	0.06	0.22	0.22	0.27	0.25	0.41
Power - minor repair	0.08	0.13	0.18	0.18	0.16	0.22	0.15
Lubrication	0.04	0.03	0.03	0.03	0.04	0.04	0.01
Preventive maintenance	0.41	0.37	0.34	0.29	0.32	0.32	0.35
Accessories & expendible items	0.21	0.10	0.11	0.11	0.12	0.13	0.15
Radio equipment	0.04	0.02	0.01	0.02	0.01	0.03	0.04
Air conditioning/heating/vent	0.05	0.07	0.08	0.11	0.14	0.15	0.11
Cab/sheet metal	0.05	0.08	0.05	0.04	0.05	0.05	0.05
Tires	0.41	0.44	0.51	0.58	0.59	0.55	0.50
Body and door	0.15	0.18	0.19	0.16	0.30	0.18	0.16
Clean and paint	0.07	0.07	0.05	0.01	0.01	0.02	0.03
Towing and other	0.01	0.09	0.08	0.09	0.09	0.11	0.12
Mounted systems	0.01	0.01	0.01	0.01	0.01	0.01	0.02

The California Highway Patrol operates a fleet of 1,965 patrol cars, largely Monacos and Coronets, 1975-77 models that average over 55,000 miles per year each, with fuel consumption of 8.63 mpg. Maintenance and repair costs are 3.02 cents/mile and include the following types of high-cost items caused by extreme operating temperatures:

Exhaust valves and heads
Underhood belts, hoses, wires, gaskets, seals
Exhaust manifolds, flange gaskets, pipes
Power steering unit and pump
Starter motor and starter drive

The most frequently failing components are:

Valve cover gaskets (heat)
Exhaust pipes (heat)
Brake master cylinder (heat)
Power steering hose (heat)
Air conditioner clutch (hard use)
U-Joints (heat from catalysts)
Starter-starter drive (hard use)

A comparison of private auto and taxi costs is presented in Table 4-5, wherein it can be noted that maintenance costs for the two classes are not far different.

Table 4-5. Cost Comparison Auto vs Taxi

Cost Component	Cents per Mile	
	1976 Standard Size Automobile[1]	1975 Taxi[2]
Vehicle Depreciation	4.9	2.5
Operating Costs		
Maintenance (labor, parts, tires)	4.2	4.5
Fuel and oil	4.2	5.7
Insurance	1.7	3.6
Taxes and license	0.7	
Garage, parking, tools	2.2	
Other		5.2
Subtotal	13.0	19.0
Drivers, helpers	0.0	21.0
Total Operating	13.0	40.0
Vehicle Depreciation + Operating Costs	17.9	42.5

(1) Federal Highway Administration, "Cost of Owning and Operating an Automobile 1976".

(2) Glassman, M.L., "Operational Issues for Paratransit - Operators Prospective". Paper presented at Transportation Research Board's Paratransit Workshop. (November 9-12, 1975).

4.5 ANALYSIS

As previously pointed out, maintenance can be divided into three distinct parts.

1. Preventive maintenance, or scheduled servicing.
2. Corrective maintenance; repair or replacement of failed or malfunctioning parts or systems.
3. Accident repairs.

Each of these will be treated in turn.

Preventive Maintenance

Almost all of this relates to chassis systems which comprise all of the operating systems and running gear. Each manufacturer publishes a recommended list of services to be performed at scheduled intervals, based on accumulated mileage or elapsed time.

The recommended schedule for the Audi 100LS from which the PTV chassis is derived, consists of the following:

A. Every 7,500 miles or 6 months:

Change engine oil, tune up engine

B. Every 15,000 miles or 12 months, the following:

Vehicle Maintenance

1. Oil change
2. Complete lubrication
3. Automatic Transmission: Check ATF level.
4. Automatic Transmission, final drive: Check oil level, add if necessary
5. Brake system: Check for damage and leaks.
6. Brake linings and pads: Check thickness.
7. Brake fluid: Check level, add if necessary.
8. Tires, incl. spare wheel: Check for wear and damage, check and correct pressure.
9. Brakes: Check, adjust if necessary.
10. Brake pressure regulator: Check visually.
11. Front axle: Check dust seals on ball joints and dust seals on tie rod ends, check tie rods.
12. Steering: Check play

13. Boots on steering system and drive shafts: Check for damage.
14. Electrical system: Check operation of all lights, horn emergency flasher, turn signals and rear window defogger. Adjust headlights if necessary.
15. Windshield wiper/washer system: Check operation and fluid level, add if necessary.
16. Battery: Check electrolyte level.
17. Safety belt warning light, buzzer and ignition/steering lock: Check.
18. Interior lights and instrument lights: Check.
19. Warning lights for alternator, oil pressure and brakes: Check.
20. Door hinges: Lubricate.
21. Power steering: Check fluid level.

During Road Test

Check efficiency of braking, kickdown, steering, heating and ventilation systems.

After Road Test

1. Engine idle and idle CO: Check, adjust if necessary.
2. Cylinder head cover: Check for leaks.

Emission Control Maintenance

1. Engine: Change oil. Replace oil filter
2. V-belt: Check tension and condition
3. Cooling system: Check coolant level, add if necessary.
4. Valves: Adjust clearance and replace cover gasket.
5. Compression: Check
6. Spark plugs: Replace
7. Ignition distributor: Replace ignition points. Adjust dwell angle and timing.
   Visually check ignition wires, distributor cap and rotor, replace if necessary.
8. Fuel filter: Replace.
9. EGR system: Check, reset EGR mileage counter.
10. Crankcase ventilation hoses: Check visually.
11. Exhaust system: Check for damage.
12. Fuel tank lines, connections and evaporative control system: Check visually.
13. Air Cleaner: Clean filter element

C. Every 30,000 miles or 2 years:

Vehicle Maintenance

1. Automatic Transmission: Change ATF (includes removal and installation of transmission fluid pan).
2. Air cleaner: Replace filter element.
3. Brakes: Replace brake fluid.

Corrective Maintenance

The nature and frequency of corrective maintenance depend on a number of variables, including driver characteristics, weather and climate, type of road surfaces driven over, and cumulative total mileage and age of the vehicle. The fastest wearing items are tires and brakes, followed generally by those chassis items exposed to the most severe operating conditions such as spark plugs, distributor points, shock absorbers, etc.

The following list of corrective maintenance items is taken from a current chassis flat rate manual for Audi models and is believed to represent most of the high-cost and high frequency items.

Maintenance Action	Manhours
Muffler, R&R - Front	1.1
- Rear	.8
Alternator, R&R	.6
Starter, R&R	.8
Valve grind (complete)	7.4
Engine overhaul	19.7
Flush cooling system	.7
Radiator hoses, R&R - Upper	.3
- Lower	.5
Water pump, R&R	1.0
Brakes, O/H complete	5.5
Wheel bearings, repack	.4
Master cylinder, R&R	1.0
Front end alignment	1.8
Ball joints, R&R, upper & lower	3.6
Shock absorbers, R&R, - front	1.8
- rear	.8
Rear wheel alignment	.6
Battery, R&R	.5
Headlamp, R&R	.4
Wiper blades	.4

NOTE: R&R = Remove and replace with new parts.
O/H = Overhaul

The cost for labor is highly variable; recent quotes are in the range of $12-15 per hour. For parts the situation is even worse. A local authorized Audi dealer's service parts manager pointed out the difficulty, with the following example for identical replacement water pump:

Factory catalog price	$72
Direct Importer price	$14
Dealer's charge to customer	$28

A recent article in Automotive Industries (9/1/77) noted that a new car can be purchased for $4,438 new, versus $19,979 when bought piece by piece.

Accident Damage

Body parts are most frequently involved in collision damage, particularly sheet metal panels. In a study of 89,060 crash repair estimates submitted to four insurance companies in 1971-72 (Reference 12) it was found that the parts most frequencly damaged were fenders and quarter panels, followed closely by bumpers, one or both, the latter being involved in 60% of all crashes. Cost data on crash repairs has been accumulated by the Insurance Institute for Highway Safety using two different approaches. The first method analyzes loss payments by insurance companies for collision coverages they write.

The second approach involves crash testing of cars by the Institute under controlled conditions and appraisal of costs to repair the resulting damage. Results of the first type of data are of interest here.

The most recent loss payment summary (Reference 13) shows an overall average payment per vehicle per year of about $62. Since 40% of the claimants had $50 deductible coverage and the other 60% had $100 deductible, the average total cost of repairs was 62+80 = $142. For an assumed 12,000 miles per year of driving, this yields an accident repair cost rate of 1.18 cents/mile. This is somewhat higher than the comparable figures of 0.67 cents/mile derived from data in Reference 6 for Checker taxis in New York City, and .10-.13 for GSA.

(12) Status Report, Insurance Institute for Highway Safety, October 31, 1972.
(13) Status Report, IIHS, January 10, 1977.

4.6 CONCLUSIONS

Analysis of the previously accumulated cost data, adjusted to 1977 labor and material cost levels, yielded the following results:

Average taxi maintenance cost = 5.1 cents/mile

This figure includes preventive and corrective maintenance as well as accident damage repairs. These three categories break down as follows:

		¢/mile
Preventive Maintenance	27%	1.38
Corrective Maintenance	66%	3.37
Accident Repairs	7%	.35
	100%	5.10

For the PTV a check was made for the current estimated cost of preventive maintenance using the manufacturer's recommended servicing schedule. This gave a result of 1.4 cents per mile, which is very close to the average PM cost of 1.38 obtained for all taxis.

Selected corrective maintenance items for the PTV were also costed and gave good correspondence with updated costs for similar items obtained from Table 4-4.

No similar check was possible for accident repairs, but since their cost is such a small part of the total (7% or less) any normal variation would have only a small effect on the overall figure.

It therefore appears reasonable to use a figure of 5.1 cents per mile for PTV maintenance over its service life.

SECTION 5
FINAL DESIGN DATA

Following the assessments of the original design in general and then in particular, a final selection of an optimum design based on low life cycle costs was accomplished. In order to delineate the design in sufficient detail to enable subsequent estimation of manufacturing, and repair and maintenance costs, a design data package was prepared, reviewed and submitted.

5.1 DESIGN DATA PACKAGE

This package consisted of three parts:

1. A Bill of Materials, with a Group Index. The Index is shown in Table 5-1 and a sample page from the Bill of Materials is presented in Figure 5-1. Complete listing is in Appendix A.
2. A set of drawings, together with an applicable drawing list. The list itemizes 50 drawings of the prototype design that still apply, and 18 new drawings that set forth design revisions. The list is shown in Table 5-2, and five of the revised LLCC drawings are presented in Figures 5-2 through 5-6.*
3. A stress analysis of the structural members of the vehicle is found in Appendix A.

5.2 FINAL DESIGN REVIEW

Highlights of modifications and revisions were pointed out during the final design review. Among items covered were the following.

Configuration

- Wheelbase - increased by 4" to 112".
- Front treadwidth - reduced to 57".
- Rear seat - widened by 5", permitting three full seats. Moved back 2" providing better wheelchair access.
- Hatchback - reshaped to enlarge luggage area.
- Fuel tank - relocated behind rear axle.

*The complete set of drawings is not a part of this report.

Table 5-1. Bill of Materials Group Index

Group	
1.	Engine and Transmission Assembly and Mounting
1.a	Engine Assembly
1.b	Engine Fixed Parts
1.c	Engine Camshaft and Valves
1.d	Engine Crankshaft and Pistons
1.e	Engine Oil Pump
1.f	Engine Manifolds and Air Cleaner
1.g	Engine Fuel Injection System
1.h	Engine Cooling-Radiator Hoses and Connections
1.i	Engine Electrical System
1.j	Transmission Assembly and Starter
2.	Front Axle, Hubs, Bearings, Shafts and Joints
3.	Brakes - Vacuum Assisted Power Disc/Drum
4.	Front Suspension
5.	Rear Suspension
6.	Wheels, Tires and Jacks
7.	Heating Ventilation and Air Conditioning
8.	Body and Chassis Electrical System
9.	Exhaust System
10.	Body
10.a	Body Front Door Assemblies
10.b	Sliding Door Assembly
10.c	Rear Hatch Assembly
10.d	Hood, Latch and Hinges, w/s Wipers and Linkage
10.e	Instrument Panel Assembly
10.f	Seats and Interior Trim
10.g	Lamps, Mirrors and Reflective Devices
10.h	Underbody Floor and Structure
10.i	Body Side Structure, Roof Headers and Bows
10.j	Body Exterior Sheet Metal and Roof
10.k	Body Exterior Trim
10.l	Body Glazing, Seals and Weatherstrips
11.	Energy Absorbing Bumper Assemblies
12.	Seat Belts, Occupant Restraints and Paratransit Devices
13.	Vehicle Identification, Manuals, Decals and Stickers
14.	Paints, Fuels, Lubricants and Sealants

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10b-1	44-08-2	Door assembly - sliding RH mounted	1					
2		-2	44-08-2	Door assembly - sliding RH glazed	1					
3		10160-10b-4	44-08-2	Glass - RH sliding door	1	*				
4		-005	44-08-5	Lock assembly - sliding door	1					
5		-006	44-08-5	Handle - sliding door outer	1					
6		-007	44-08-5	Handle - sliding door inner	1					
7		-008	44-08-5	Tumbler and key assembly - door lock	1					
8		-009	44-08-6	Latch assembly - sliding door rear	1					
9		-010	44-08-5,6,7	Attaching hardware - lock and latch	AR					
10										
11		10160-10b-3	108J10160	Panel assembly - sliding door RH	1					
12		-003	108J10160	Panel - sliding door outer RH	1					
13		-004	108J10160	Panel - sliding door inner RH	1					
14										
15		-011	44-08-2	Reinf - door inner hinge assembly mounting	1					
16		-002		Weatherstrip - sliding door window	1					
17		-012	44-08-9	Weatherstrip - sliding door seal	1					247A14
18		-013		Adhesive - weatherstrip	AR					
19										
20		-014	44-08-9	Plug - paint drain rectangular	1					24766
21		-015	44-08-9	Plug - paint drain round	2					247A90
22		-016	44-08-9	Plug - paint drain lower	3					379286
23										
24		-017	44-08-4	Lower guide assembly - sliding door RH	1	**				268A26
25		-018	44-08-4	Screw - lower guide mounting	3					379238
26										
27		-019	44-08-4	Bracket - body side upper guide RH	1	**				25036
28		-020	44-08-4	Roller assembly - guide bracket	1					25028
29		-021	44-08-4	Nut - roller mounting	1					376838
30		-022	44-08-4	Screw - bracket mounting	3					374371

*

REVISIONS

GROUP: 10b Sliding door

ISSUED

Ref 1975 Ford Truck Shop Manual

*assigned in glzaing group
**parts to be modified per 108R7514

Figure 5-1. Sample Parts List Page

PROJECT NO.

SHEET NO. 1

Table 5-2. Drawing List

PARATRANSIT VEHICLE DRAWINGS - PROTOTYPE DESIGN

1.	R108 7500	PV and SV Lower
2.	R108 7501	PV and SV Upper
3.	R108 7502	FV and RV Upper and Lower
4.	R108 7503	"B" Pillar Structure
5.	D108 7504	Front Door Handle, Striker & Latch
6.	D108 7505	Front Door Hinge
7.	D108 7506	Front Door
8.	D108 7507	Front Wheelhouse and "A" Pillar
9.	R108 7508	Hood Inner Panel
10.	R108 7509	Windshield "A" Pillar and Header
11.	R108 7510	Right Front Door
12.	R108 7511	Window Molding Section
13.	R108 7512	Mercedes Tailight Inst.
14.	R108 7513A-D	Body Rear Structure and Hatch
15.	R108 7514	Sliding Door
16.	R108 7515	Roof Inner Structure
17.	R108 7516	"B" Post Structure
18.	R108 7517	Right Hand Fender and Hatch Inner
19.	R108 7518	"A" Pillar & Instrument Panel Const.
20.	R108 7519	Headlamp and Directional Signal
21.	R108 7520	Windshield Division Bar
22.	R108 7521	Bulkhead and "B" Pillar Const.
23.	R108 7522	Door Header, Cross Brace & Inner Structure
24.	R108 7523	Glass Molding
25.	R108 7524	License Plate Mounting
26.	R108 7525	Headliner Const.
27.	R108 7526	Side Marker Lights
28.	R108 7527	W/W Mech. & Geom.
29.	108E 10000	Air Conditioning Instrument
30.	108J 10013	Heating and AC Instruments
31.	108E 10014	Floor Structure - AHC
32.	108J 10015	Front Suspension
33.	108J 10025	Rear Suspension
34.	108J 10033	Brake Pedal and Linkage
35.	108C 10044	Steering Gear Modification
36.	108C 10045	Rear End U-Body Structure
37.	108J 10112	"B" & "C" Post Base Plate
38.	108J 10113	Transaxle Installation
39.	108J 10114	Cowl and M/Cyl. Inst.
40.	108C 10120	Trailing Arm Modification
41.	108D 10121	Rear Axle-Tread Increase
42.	108J 10123	Steering Column and Pedals Inst.
43.	108J 10124	Parking Brake
44.	108J 10130	Idler Installation
45.	108J 10131	Trans Selector Controls

46.	108J 10132	Front E/A Bumper
47.	108J 10133	Rear E/A Bumper
48.	108J 10134	A/C Modification
49.	108J 10135	Bumper Bar Construction
50.	108J 10137	Fuel Cell Installation

PARATRANSIT VEHICLE DRAWINGS - LLCC REVISIONS

1.	108J 10160 Sht 1	1/8 Scale Seating Arrangement - Side View
2.	108J 10160 Sht 2	1/8 Scale Seating Arrangement - Plan View
3.	108J 10160 Sht 3	Full Scale Side View
4.	108J 10160 Sht 4	1/4 Scale Front View
5.	108J 10160 Sht 5	1/4 Scale Side View
6.	108J 10160 Sht 6	1/4 Scale Rear View
7.	108J 10160 Sht 7	1/4 Scale Plan View
8.	108J 10160 Sht 8	Exploded View - Doors, Hatches & Fenders
9.	108J 10160 Sht 9	Exploded View - Rear Compartment Seats & Trim
10.	108J 10160 Sht 10	Exploded View - Body Side and Roof Structure
11.	108J 10160 Sht 11	Exploded View - Underbody Structure
12.	108J 10160 Sht 12	Exploded View - Front Compartment Seats & Trim
13.	10160-6-3	Ramp Assembly - Wheelchair Loading
14.	10160-6-012	Ramp Extrusion Section
15.	108J 10160 LWB	138.00 WB PTV Side View Seating
16.	108J 10160 LWB	138.00 WB PTV Plan View Seating
17.	108J 10160 Sht 13	1/8 Scale Seating Arrangement - Rear View
18.	108J 10160 LWB	138.00 WB Mod Ford PTV Side View Seating

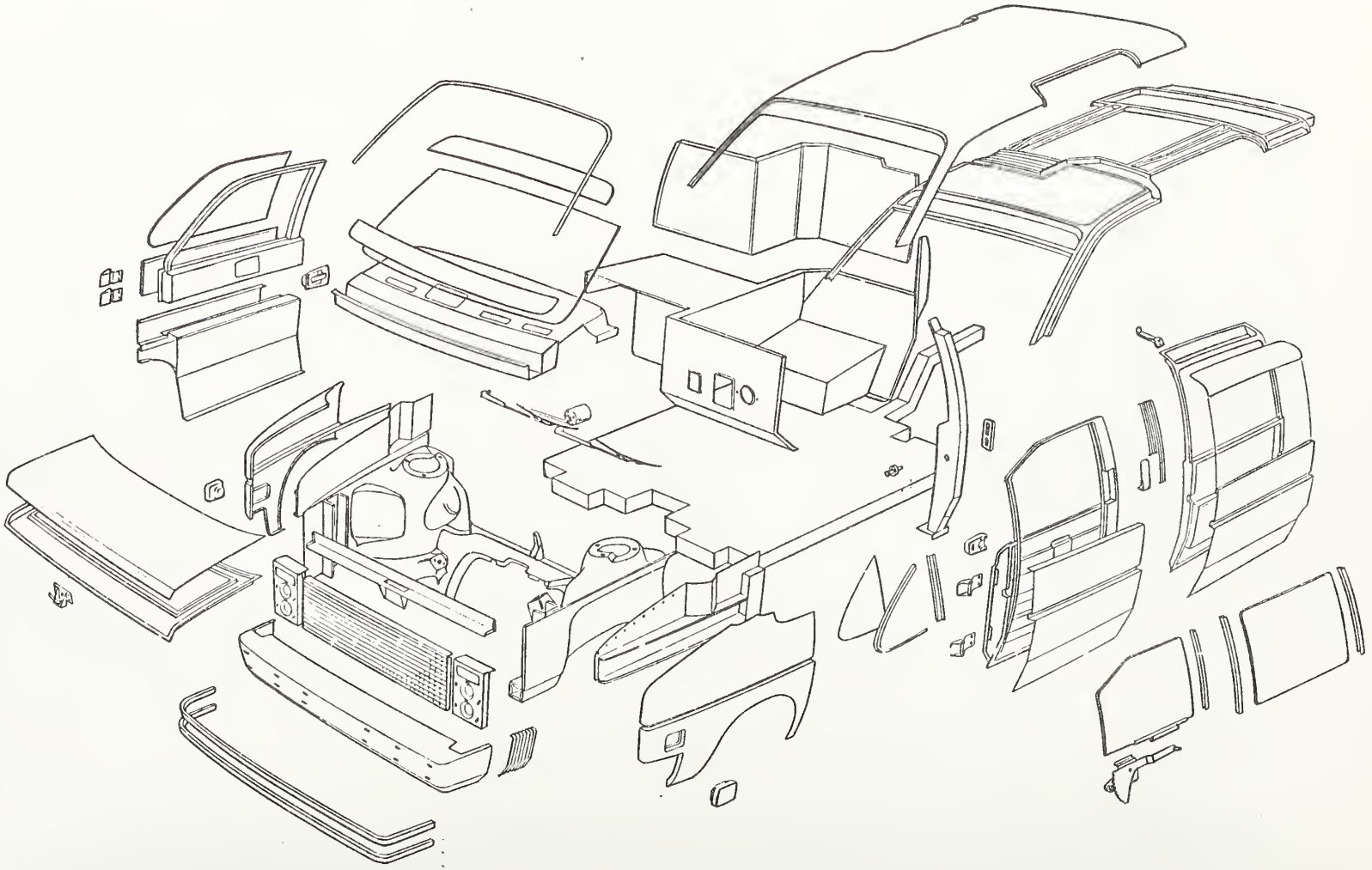

Figure 5-2. Master Assembly

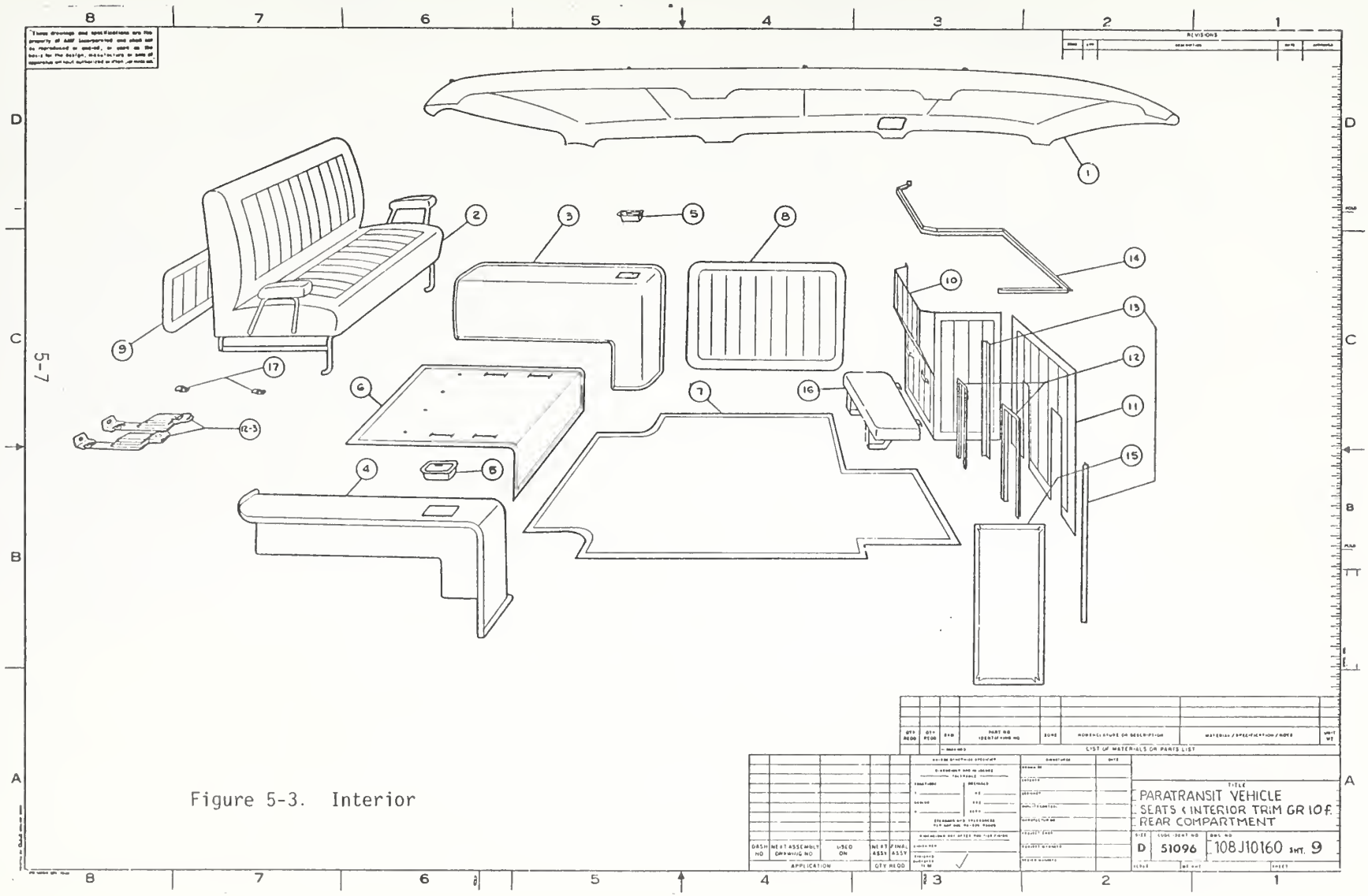

Figure 5-3. Interior

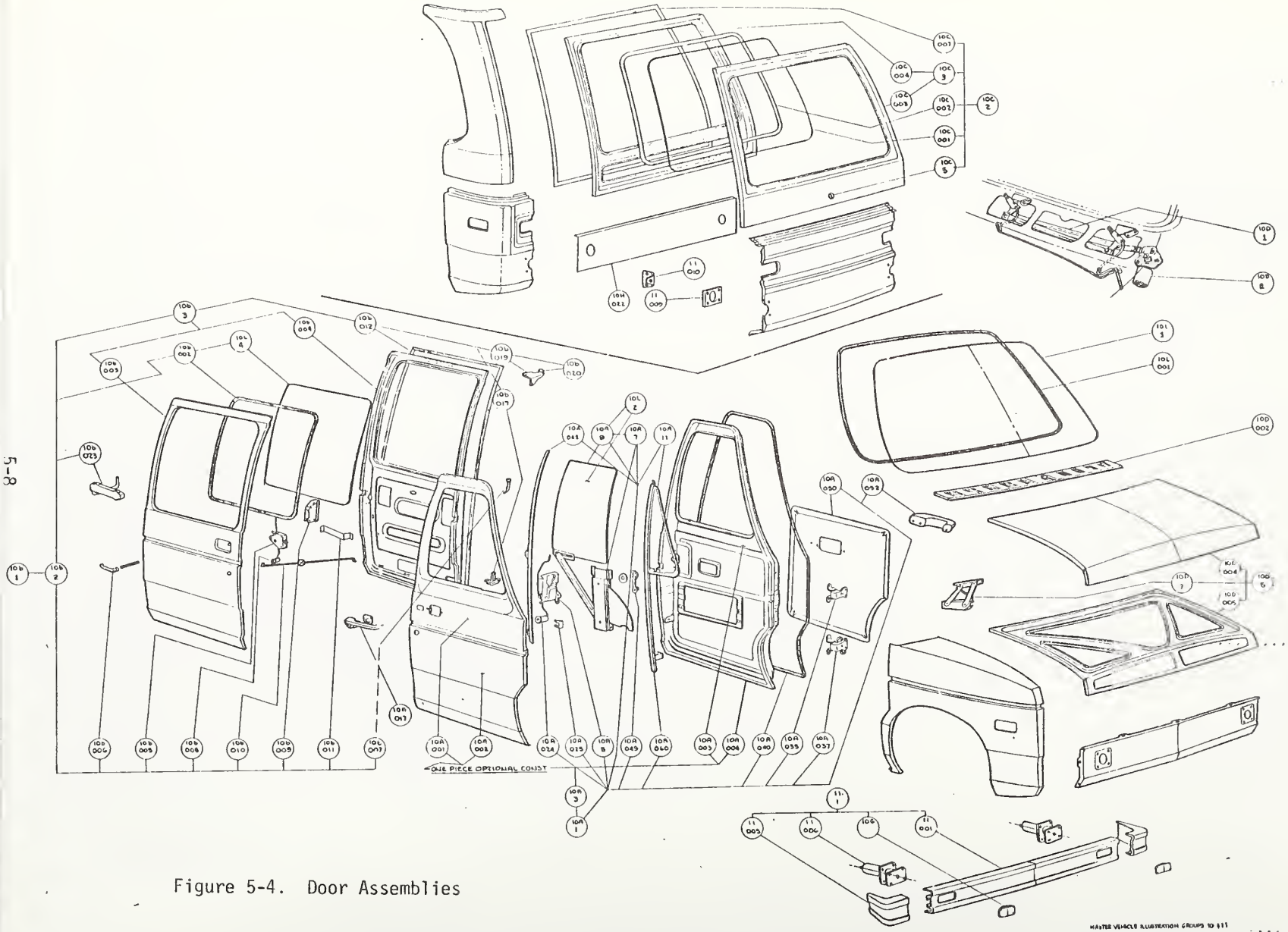

Figure 5-4. Door Assemblies

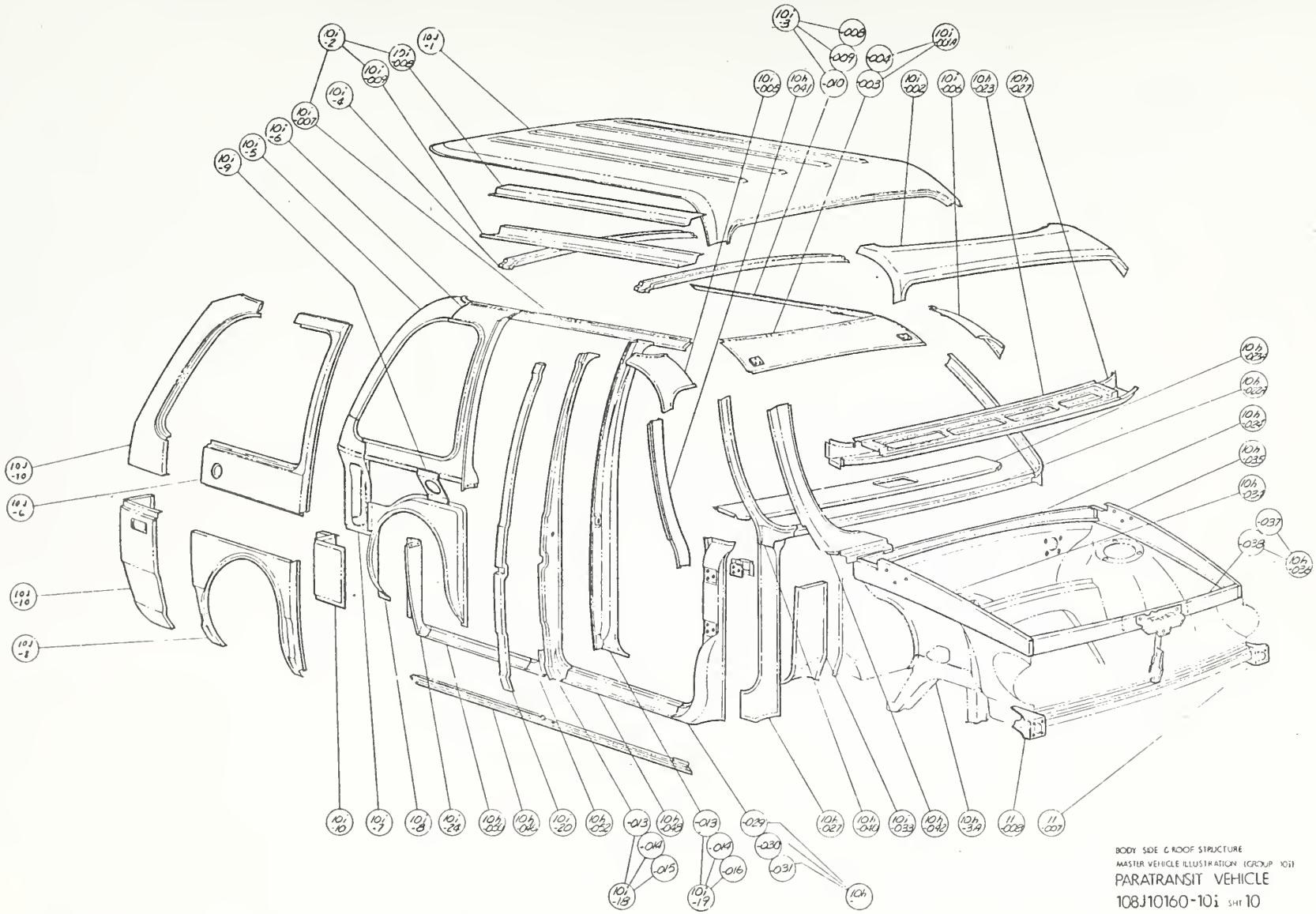

Figure 5-5. Body Side and Roof

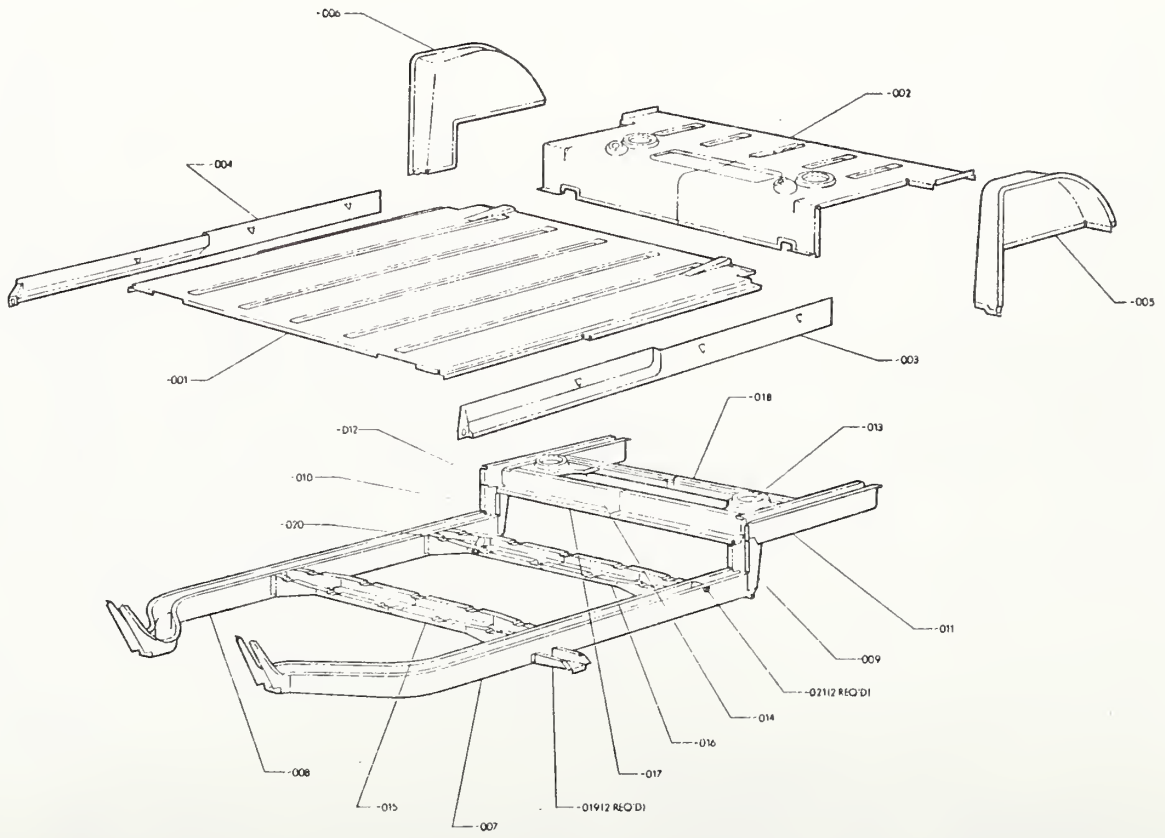

Figure 5-6. Underbody

10161-10h-2 STRUCTURE ASSY-UNDERBODY REAR
MASTER VEHICLE ILLUSTRATION (GROUP 10h)
PARATRANSIT VEHICLE
108-10160-10h SHT. 11

Main Frame

- Honeycomb composite structure replaced by conventional formed steel.
- Conservative structural analysis indicates only minor strengthening needed.

Body

- Windshield angle changes.
- Front doors now modified stock.
- Left rear door now optional.
- Body panels now lighter in weight.
- Less expensive headlights, tail lights specified.

Other

- Powered ramp replaced by two portable channels.
- Air conditioning made an option.
- Bullet resistant partition now optional.
- Air load levelers in rear suspension assure horizontal trim at all loads.
- Rear suspension relocated.

Weight

A comparison of original and revised vehicle weights is shown in Table 5-3.

Table 5-3. PTV Weight Summary

COMPONENT	ORIGINAL WEIGHT (LBS)	REVISED WEIGHT
Front Suspension	182	170
Rear Suspension	105	98
Wheels & Tires (4)	152	152
Main Structure	518	393
Body	736	736
Engine	352	352
Transaxle	150	150
Fuel System	40	35
Steering System	48	46
Wheelchair Ramp System	42	12
Wheelchair Restraints	18	18
Driver Compartment	172	130
Passenger Compartment	48	48
Seats (Driver, Rear)	96	96
Heater System	33	33
Air Conditioning System	72	0
Miscellaneous	418	413
Subtotal	3,182	2,882
Contingency Provision	118	118
TOTAL	3,300	3,000

SECTION 6
MANUFACTURING COST ESTIMATES

The manufacturing cost estimates for one vehicle in both production volumes is based on current price structures and represent the first year's estimated costs beginning production in 1978. Subsequent years costs would be expected to increase at or near the level of inflation.

6.1 ESTIMATING PROCEDURES

Cost Categories

1. Direct Labor.
2. Overhead
3. Materials
4. Rental/Amortization of Tooling
5. Warranty Repairs

6.2 PRODUCTION PLANNING

6.2.1 Body-in-White

This portion of the production planning and estimating covers the processes by which the sheet metal components of the body are formed and assembled. These procedures are divided into three phases:

Phase I	Tooling and Fixtures
Phase II	Component Build
Phase III	Body-in-White Assembly

6.2.2 Tools and Fixtures

This phase provides for the build of:

a. Plastic/wood patterns of components.
b. Three piece draw dies, punches and dies of outer surface and structural body components.
c. Sub-assembly fixtures.

d. Plug gages

e. Final assembly fixture

Based on engineering and design data provided, this phase will create the three dimensional patterns necessary to make zinc alloy form tools. These plastic and wood patterns will be utilized throughout the program serving as the "Master" for design and build checks. Also, in the event of future design change, they provide immediate capability to produce vacuum-formed plastic design check panels.

The tooling approach planned would utilize three piece draw dies in forming the outer body surface. This approach will insure a high degree of quality as well as consistency from panel to panel as regards panel configuration and fit.

The balance of the required tooling for structural components will utilize either a three-piece draw die or punch and die dependent upon the finalized design. Large panels will be utilized where possible to not only satisfy structural requirements but provide for a feasible production method applicable to the build of 100 or 5,000 units per year.

In order to provide the capability to produce body-in-white assemblies economically, it is not only necessary to have production component tooling but assembly fixturing as well. General timing and labor content establish the requirement for build of the following.

6.2.3 Sub-assembly Fixtures

These fixtures would provide the ability to assemble with the required dimensional accuracy relating to surface, perimeter lines and attachment points items such as:

- Doors
- Hatch
- Hood
- Underbody

6.2.4 Plug Gages

These gages are utilized to establish opening requirements for the final assembly and include:

- Windshield
- Doors
- Hatch
- Hood

6.2.5 Final Assembly Fixture

This "Master" assembly fixture will accept the sub-assemblies and balance of surface and structural components. It will locate and maintain throughout final assembly all critical dimensions including attachment points for suspension, steering, drivetrain, etc. The fixture will be located on a full-size surface plate during assembly to further ensure dimensional accuracy.

6.2.6 Phase II - Component Fabrication

The body components, both surface and structural, will consist of stampings made from the zinc alloy form tooling previously built. Generally, flanging will be an integral part of the parent panels and will be formed in the stamping operation. Stampings will be hand-trimmed, punched and detailed in preparation for assembly.

This procedure provides for the tooling and build of the components essentially established in the current vehicle build and parts list with the exception of Audi front structure (engine/suspension) which will be a modified part.

6.2.7 Phase III - Sub-Assembly and Final Body Assembly

Having formed and detailed the stamped components, they will then be checked for proper fit and function. Utilizing the sub-assembly fixtures, the various components will be assembled and welded into finished units. Sub-assembly of doors, hood, deck lid, front structure and rear structure will be accomplished prior to being fed into final body assembly.

Upon acceptance they will be assembled in sequence into the #1 body-in-white. This initial assembly will undergo a thorough review and design check throughout its build to ensure that it is dimensionally correct and that subsequent builds can be accomplished as planned.

6.2.8 Final Vehicle Assembly

The basis used for estimating the cost of final vehicle assembly was the division of this sequence into four parts, detailing the assembly procedure by keying it to the parts list, identifying the tooling required, and estabishing manning requirements for each stage of the production line. The four parts of this sequence are:

1. Attach doors and hood, paint body
2. Dress engine (subassembly line)
3. Trim body
4. Final vehicle assembly

6.2.9 Spares Requirements

Spare body parts requirements may be handled at the time of production. These crash repair parts could be manufactured and stored with a protective coating at a cost of approximately 25 percent more than original unit cost. Another approach is to hold all tooling in storage at a cost of approximately five hundred dollars per month, utilizing them annually to stamp out a yearly supply of needed parts.

6.3 COSTS

6.3.1 Direct Labor

Three categories of direct labor are projected with estimated rates as follows:

		100/year		5,000/year	
	Rate	Hours	$	Hours	$
Component fabrication	$5.50	720	$ 3,960	222	$1,221
Sub and final body assembly	$5.75	660	3,795	90	517
Vehicle assembly	$6.25	360	2,250	28.4	178
Total Hours & Direct Labor per vehicle		1,740	$10,005	304.4	$1,916

6.3.2 Overhead

Overhead costs would include supervisory personnel as well as the standard overhead cost elements. For both production levels, the rate is estimated at 100%.

6.3.3 Materials

Materials are divided into three classes:

	100 per year	5,000 per year
1. Purchased parts - stock	$4,260	$2,669
2. Modified purchased parts	753	470
3. Manufactured parts	871	629
Total per vehicle	$5,884	$3,768

Refer to Schedule A for material and parts list.

Cost data for the first two was obtained from manufacturers and source suppliers, and adjusted for quantity order discounts and for modification costs where necessary. Manufactured parts were separately estimated by Metal Specialists, Inc. based on different sets of tooling and fixturing for each of the two production rates, and the labor requirements.

Vehicle subassembly and final assembly costs were based on a detailed appraisal of the process requirements appropriate to each of the two different production rates, and the tooling, fixturing and labor needed for each. As will be explained further, an area of uncertainty exists as the to size of investment in tooling that a manufacturer would make for relatively low volume production.

A complete Bill of Materials is contained in Appendix A-1.

SCHEDULE A

BILL OF MATERIALS

		Group Number	100 Per Year	5,000 Per Year
Purchased Parts				
Engine		1	$ 910	$ 569
Cooling		1h	109	68
Engine Electrical		1i	198	124
Transmission		1j	1,315	822
Front Axle, Hubs		2	377	235
Brakes		3	272	170
Suspension F&R	(a)	4-5	487	305
Wheels, Tires, Jack		6	202	126
Heating, Ventilating		7	65	41
Sliding Door		10b	112	70
Lamps, Mirrors		10g	59	43
Bumpers		11	90	56
Miscellaneous		12,13,14	64	40
Total Purchased Parts			$4,260	$2,669
Modidifed Parts				
Intake, Exhaust, Fuel	(a)	9	282	176
Body Electrical		8	218	136
Front Doors	(a)	10a	120	75
Instrument Panel	(a)	10e	133	83
Total Modified Parts			$ 753	$ 470
Manufactured Parts				
Wipers, Washer		10d	42	26
Seats, Trim		10f	245	153
Glazing, Seals		10L	358	224
Body Steel			226	226
Total Manufactured Parts			$ 871	$ 629
TOTAL PARTS			$5,884	$3,768

Note: Costs for items marked (a) were derived from manufacturer's retail parts catalogs and factored for quantity purchase but not for inflation. All other items were direct vendor quotes or estimates on quantity shown.

Purchased Parts were priced on a basis factored from the retail prices appearing in the respective automobile manufacturer's parts catalogs. These are retail prices reflecting successive mark-ups made by dealers, area and zone distributors. A number of studies made by insurance companies show that the initial cost to automobile manufacturers for parts and components is 15-18% of that shown in their retail catalog. Cost to dealers for single replacement parts is 62-65% of retail. The factors used for this program were 30% and 48% of retail for the 5000 and 100 per year production rates respectively. Since these costs are approximately twice and three times the manufacturer's high-volume purchase costs, they are considered to be conservative.

It should be noted that no attempt was made to include taxes since these are variable by political jurisdiction.

6.4 TOOLING AND FIXTURES

	100 per year	5,000 per year
Phase I		
Form Tools	$386,600	$4,600,000
Assembly Fixtures	169,700	892,500
Body Paint Equipment	30,000	87,800
Engine Dress	4,600	9,800
Body Trim	3,600	15,200
Final Assembly	10,900	26,300
Total Tooling	$605,400	$5,631,600
Amortized over 10 years	$605	$113

It should be recognized that the above is a "point" estimate that does not reflect the variations and uncertainties that would exist in a real world situation where an actual commitment to manufacture exists. For example, there is considerable scope for tradeoff between increased investment in tooling and reduction in direct labor hours, with some optimum balance, dependent on production rate and duration, at which overall cost per unit is minimized.

Detailed tool and fixture requirements can be found in Appendix A.

This minimum cannot be closely determined until detailed manufacturing drawings, processes and plant equipment utilization have been definitized. Accordingly, the estimates presented here should be taken as likely values in a band of ± 15%.

6.5 WARRANTY REPAIRS

Warranty provisions parallel those currently in effect in the automotive industry and are estimated as follows:

100 per year	5,000 per year
$50	$50

6.6 TOTAL VEHICLE COST

The estimated total manufacturing cost is summarized as follows:

	100 per year	5,000 per year
Direct labor	$10,005	$1,916
Overhead 100%	10,005	1,916
Materials	5,884	3,768
Tooling	605	113
Start up and preproduction costs	2,150	46
Warranty Repairs	50	50
Cost	$28,699	$7,809

As pointed out earlier, it is quite conceivable that added investment in tooling, fixtures, and automated equipment could reduce these costs by as much as 15%. The low volume vehicle would then be costed at about $24,394 and the higher volume one at $6,638.

6.7 OPTIONS

The following optional equipment will be available and the estimated cost, installed, is as follows:

	100 per year	5,000 per year
Bullet resistant partition	$250	$160
Air-conditioning	360	225
Diesel engine	210	130

6.8 OTHER COSTS

Not included were certain pre-production costs such as development of manufacturing engineering drawings and specifications and build and test of pre-production prototype vehicles. Compliance testing for safety and environmental regulations constitutes another cost factor that would be treated as an annual increment because of its evolving and changing nature. These costs are estimated to add $2,150 to 100 per year vehicle and $46 to the 5,000 per year model.

SECTION 7
CONCLUSIONS AND RECOMMENDATIONS

The redesign and development work accomplished in this program demonstrates that a durable, economical paratransit vehicle can be built, with a relatively modest investment, at an estimated cost of $7,800. It is believed that this vehicle should be attractive to the paratransit industry, even at a premium, because of its functional superiority, longer life, and lower life cycle cost.

As was pointed out in Section 2.4 many of the elements of life cycle cost are completely beyond the control of the vehicle designer and manufacturer. The factors over which he does exercise a large degree of control include the following:

- Depreciation
- Fuel and oil consumption
- Maintenance and repairs

With a service life of 350,000 miles the PTV will have a depreciation of 2.2 cents per mile, about 20% less than the commercial taxi rate reported in Reference (2). Fuel economy of 15.5 miles per gallon for the urban cycle is about double that of conventional taxis. Maintenance and repairs for the PTV were estimated to be 5.1 cents per mile which is comparable to or less than the rate reported by the taxi industry (adjusted for inflation). Overall, therefore the PTV offers cost advantages in these categories for the prospective owners and operators.

It is suggested that further study, to develop a complete life cycle cost analysis may be desirable. Such a study would develop and quantify the other cost factors applicable to PTV ownership and operation and permit a direct, overall cost comparison with current taxicab costs. These factors include:

- Driver salaries
- Insurance
- Overhead
- Special taxi equipment
- Incidentals - storage, washing, etc.

A logical next step in the development of this type of paratransit service would be to build, test, and operate a small number of PTV's under realistic usage conditions. A pilot group of vehicles built to this design would furnish a preliminary basis for evaluating the performance and functional factors for which the vehicle design has been optimized. Careful monitoring of the fleet operator's maintenance and operating records and surveys of user reactions would then be tangible proof of the vehicle's suitability to its intended use.

A number of current developments in the automotive industry hold promise that the current LLCC PTV design could be further improved from the standpoint of performance and cost. Higher fuel costs, increasingly stringent government regulations on car fuel economy and exhaust emissions, and growing competition from imports, have all combined to drive U.S. automotive design in new directions. The results of these combined pressures are being evidenced in the following ways:

- Car size is shrinking
- Car weight is being reduced
- Engine power is being lowered
- More new materials are being used.

As these developments unfold they should be carefully reviewed for their relevance to PTV design and manufacturing improvements. It is recommended that a study be made of the applicability of this new technology to the low volume production of specialized vehicles such as paratransit taxi types.

SECTION 8
REFERENCES

1. "Assessment of Passenger and Driver Accommodations in Prototype Para-Transit Vehicles", J.P. Jankovich, et al. DOT Transportation Systems Center, on file.

2. "Life Cycle Costing for Current Rohr, AM General Buses, and General Motors RTS-II Bus". H.R. Kain, et al, Report No. UMTA-VA-06-0039-76-1, dated July 9, 1976.

3. "The Police Patrol Car: Economic Efficiency in Acquisition, Operation and Disposition". R.T. Reugg, National Bureau of Standards, June 1976, PB 257-466.

4. International Taxicab Association, "Fact Sheet on Taxicab Operations in the United States", 1973.

5. "The Taxicab: A Design Challenge and Industry Testbed", Automotive Engineering, October 1973.

6. "Urban Design and Usage Factors of Paratransit Vehicles and Facilities", R. Adams and G. Hildebrand, Pratt Institute, UMTA Report NY11-0011, 1976.

7. "Evaluation of Paratransit Prototype Vehicles", International Taxicab Association, May 1977, UMTA Contract IL-06-0037, R.V. Gallagher, J. Davidson.

8. "Cost of Owning and Operating an Automobile, 1976", DOT FHWA, L.L. Liston, C.A. Aiken.

9. "The Drive to Build a Long-Life Automobile", Business Week, August 29, 1977.

10. General Services Administration, Federal Supply Service, "Federal Motor Vehicle Fleet Report for FY 75", July 1976.

11. "The Police Patrol Car: Economic Efficiency in Acquisition, Operation and Disposition", R.T. Ruegg, NBS June 1976, PB-257-466.

12. Status Report, Insurance Institute for Highway Safety, October 31, 1972.

13. Status Report, Insurance Institute for Highway Safety, January 10, 1977.

BILL OF MATERIALS

GROUP INDEX

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-1A-1		Engine & Transmission Assembly - CP	1					77 Audi 100
2				4 cylinder, 3 speed automatic						
3				F.W.D., 1871 cc, CIS fuel injected						
4				dressed						
5		-001	55-23	Damper-engine front mount vibration	1					
6										
7		-002	55-23	Hardware-engine front mount attachment	1					
8										
9		-003	54-17	Mount-engine RH	1					
10										
11		-004	54-18	Mount-engine LH	1					
12		1A-2	54-16	Crossmember & mount assembly - transmission rear	1					
13		-005	54-16	Mount-transaxle rear	1					
14		-006	54-16	Crossmember-rear transmission mounting	1					
15		-007	52-11	Heat shield - RH engine mount	1					
16										
17		-008	54-16,17,18	Hardware-engine mounting	1					
18			52-11							
19		-009	53-14	Bracket - engine loading (shipped with engine)	1					
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1A Engine & Transmission

ISSUED

PROJECT NO.

SHEET NO. 1

A1-2

ASL ENGINEERING INC.

PROJECT NAME

DOT-TSC-1351

LAYOUT NO. 108J10160

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-1A-3		Engine Assembly - Dressed Less Transmission	1					77 Audi 100
2										
3										
4										
5		10160-1A-4	118-11	Altenator assembly - 14V 53 amp H.D.	1					
6		-011	118-11-37	Plate-Altenator mounting	1					
7		-012	118-11-34	Bracket-Altenator to engine	1					
8		-013	118-11-60	Ground wire-Altenator to engine	1					
9		-014	118-11-36	Bolt-Altenator bracket to engine	2					
10		-015	118-11-36	Washer-Altenator bracket to engine	2					
11		-016	118-11-46	Bolt-Altenator mounting plate to bracket	1					
12		-017	118-11-32	Sleeve-Altenator bushing	2					
13		-018	118-11-45	Bushing-Altenator mounting	2					
14		-019	118-11-49	Retainer-Altenator mounting bushing	2					
15		-020	118-11-47	Lockwasher						
16		-021	118-11-48	Nut						
17										
18		-022	118-11-44	Bracket-Altenator belt tension adj.	1					
19		-023	118-11-45	Bushing-Altenator mounting	1					
20		-024	118-11-32	Sleeve-Altenator bushing	1					
21		-025	118-11-52	Washer-flat	1					
22		-026	118-11-50	Lockwasher	1					
23		-027	118-11-51	Capscrew-tension adj.	1					
24		-028	118-11-53	Bolt-tension adj.	1					
25		-029	118-11-54	Washer-flat	1					
26		-030	118-11-55	Lockwasher	1					
27		-031	118-11-56	Nut-tension adj.	1					
28		-032	118-11-33	Belt-altenator to A/C comp.	1					
29										
30										

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1A Engine Assembly

ISSUED

PROJECT NO.

SHEET NO. 2

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1A-5	135-14	Pump & pulley assembly - water	1				
2		-033	135-14-e	Pump assembly - water	1				
3		-034	135-14-h	Pulley - water pump	1				
4		-035	135-14-i	Lockwasher - pulley att.	3				
5		-036	135-14-k	Bolt - pulley att.	3				
6		-037	135-14-d	Plate - water pump mounting	1				
7		-038	135-14-a	Bolt - short - water pump mounting	1				
8		-039	135-14-b	Bolt - long - water pump mounting	1				
9		-040	135-14-c	Lockwasher	2				
10		-041	135-14-f	Bolt - water pump to engine	3				
11		-042	135-14-g	Lockwasher - water pump to engine	3				
12		-043	135-14-1	Gasket - water pump to engine	1				
13									
14		-044	120-12	Belt - water pump and A/C comp.	1				
15									
16									
17		10160-1A-6	94-29,95-32	Pump & pulley assembly - air	1				
18		-045		Bracket - air pump to engine mounting	1				
19		-046		Attaching hardware - air pump	1				
20		-047	11-4	Idler assembly - air pump belt tension	1				
21									
22		-048	94-29,95-32	Manifold - air injection	1				
23		-049	94-29	Checkvalve - air pump					
24		-050	95-31	Valve - anti backfire					
25		-051	95-30	Filter - air pump					
26		-052	95-30	Hose - air cleaner to filter	1				
27		-053	95-30	Hose - air filter to air pump	1				
28		-054	94-29	Hose - air pump to check valve	1				
29		-055	94-29	Hose - air pump to backfire valve	1				
30		-056	94-29	Hose - backfire valve to intake manifold	1				

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1A Engine Assembly

ISSUED

PROJECT NO.

SHEET NO. 3

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1A-057	94-29	Hose - checkvalve to manifold	1				
2		-058		Clamp - air hose	AR				
3		-059		Attaching hardware - air injection manifold	AR				
4									
5		-060	93-25	Valve - EGR	1				
6		-061	93-25	Tube & connector assembly - EGR valve to filter	1				
7		-062	93-25	Filter - EGR	1				
8		-063	93-25,93-26	Tube assembly - filter to exhaust manifold	1				
9		-064	93-26	Line - EGR vacuum	1				
10									
11		10160-1A-8	120-12	Compressor & clutch assembly - air conditioner	1				
12		-065	ND	Bracket - AC compressor mounting	1				
13		-066	ND	Attaching hardware - AC compressor mounting	AR				
14									
15		-067	ND	Hose assembly - AC compressor to condenser	1				
16		-068	ND	Hose assembly - AC compressor to evaporator	1				
17									
18									
19		10160-1A-9	ND	Pump assembly - power steering	1				
20		-069	ND	Bracket - power steering pump mounting	1				
21		-070	ND	Attaching hardware - PS pump	1				
22		-071	ND	Hose assembly - power steering pressure	1				
23		-072	ND	Hose assembly - power steering pump return	1				
24									
25									
26		10160-1A-10		Engine Assembly - Audi 4 cylinder					
27									
28									
29									
30									

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REVISIONS

GROUP: 1A Engine Assembly

ISSUED

PROJECT NO.

SHEET NO. 4

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1B-073	57-26-1	Block cylinder	1				
2		-074	-2	Dowell Pin - engine block lower	AR				
3		-075	-3	Lockwasher	1				
4		-076	-4	Bolt - shaft seal	1				
5		-077	-5	Bolt - bearing cap	10				
6		-078	-5A	Cap - bearing	4				
7		-079	-5B	Cap - bearing rear	1				
8		-080	-6	Plug - engine block rear	1				
9		-081	-7	Seal - oil galerey	2				
10		-082	-8	Plug - oil galerey	2				
11		-083	-9	Seal - crankshaft rear	1				
12		-084	-10	Dowel Pin - engine block front	1				
13		-085	-11	Cover - timing gear	1				
14		-086	-12	Seal - crankshaft front	1				
15		-087	-13	Gasket - timing gear cover	1				
16		-088	-14	Washer - timing gear cover	7				
17		-089	-15	Bolt - timing gear cover	7				
18		-090	-16	Flange - cylinder hd water rear	1				
19		-091	-17	Gasket - cylinder hd water rear	1				
20		-092	-18	Washer - cylinder hd water flange	4				
21		-093	-19	Bolt - cylinder hd water flange	4				
22		-094	-20	Flange - cylinder hd water front	1				
23		-095	-21	Gasket - cylinder hd water front	1				
24		-096	-22	Cap - engine block core plug	AR				
25		-097	-23	Plug - cylinder head	1				
26		-098	-24	Seal - oil pan drain plug	1				
27		-099	-25	Plug - oil pan drain plug	1				
28		-100	-26	Head - cylinder	1				
29		-101	-27	Washer - cylinder head bolt	10				
30		-102	-28	Bolt - cylinder head	10				

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1B Engine Fixed Parts

ISSUED

PROJECT NO.

SHEET NO. 5

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1B-103	57-26-29	Gasket - cylinder head	1				
2		-104	-30	Stud - exhaust manifold	8				
3		-105	-31	Stud - intake manifold short	4				
4		-106	-32	Stud - intake manifold long	4				
5		-107	-33	Insert - valve guide	8				
6		-108	-34	Snap ring - valve guide insert	8				
7		-109	-35	Insert - intake valve seat	4				
8		-110	-36	Insert - exhaust valve seat	4				
9		-111	-37	Cover - cylinder head	1				
10		-112	-38	Gasket - cylinder head cover	1				
11		-113	-39	Cap - oil fill	1				
12		-114	-40	Stud - cylinder head cover	4				
13		-115	-41	Washer - cylinder head cover	4				
14		-116	-42	Nut - cylinder head cover	4				
15		-117	-43	Vent tube - cylinder head cover	1				
16		-118	-44	Clamp - vent tube hose	1				
17		-119	-48	Pan - engine oil	1				
18		-120	-49	Gasket set - engine oil pan	1				
19		-121	-50	Screw socket head oil pan short	14				
20		-122	-51	Screw - socket head oil pan front	3				
21		-123	-52	Washer - socket head oil pan front	2				
22		-124	-53	Screw - socket head oil pan rear	1				
23		-125	57-26-54	Screw - socket head oil pan long	1				
24									
25									
26									
27									
28									
29									
30									

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1B Engine Fixed Parts

ISSUED

PROJECT NO.

SHEET NO. 6

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		0160-1C-001	60-31-1	Camshaft - engine	1				
2		-002	-2	Sprocket - timing gear	1				
3		-003	-3	Chain assembly - timing	1				
4		-004	-4	Roll pin - camshaft timing gear	1				
5		-005	-5	Guide flange - camshaft timing gear	1				
6		-006	-6	Lockwasher - guide flange mounting	2				
7		-007	-7	Bolt - guide flange mounting	2				
8		-008	-8	Flat washer - sprocket mounting	1				
9		-009	-9	Bolt - sprocket mounting	1				
10		-010	-10	Guide - timing chain	1				
11		-011	-11	Tensioner - timing chain	1				
12		-012	-12	Lockplate - timing chain tensioner	1				
13		-013	-13	Plug - lockplate	1				
14		-014	-14	Lockplate - chain guide	1				
15		-015	-15	Bolt - lockplate mounting	2				
16		-016	-16	Bolt - tensioner mounting	1				
17		-017	-17	Tappet - valve	8				
18		-018	-18	Pushrod	8				
19		-019	-19	Guide - pushrod	8				
20		-020	-20	Plate - pushrod guide	8				
21		-021	-21	Rocker arm - valve pushrod	8				
22		-022	-22	Bolt - rocker arm stud	8				
23		-023	-23	Nut - rocker arm stud adj.	8				
24		-024	-24	Retainer - rocker arm	8				
25		-025	-25	Valve - intake	4				
26		-026	-26	Valve - exhaust	4				
27		-027	-27	Rotocap - exhaust valve	4				
28		-028	-28	Spring - valve outer	8				
29		-029	-29	Base - intake valve spring	4				
30		-030	-30	Spring - valve inner	8				

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1C Engine Camshaft

ISSUED

PROJECT NO. 7

SHEET NO.

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		0160-1C-031	60-31-31	Retainer - valve upper	8				
2		-032	-32	Poppet - valve spring retainer	8				
3		-033	-33	Seal - valve spring	8				
4									
5									
6									
7									
8									
9									
10									
11									
12									
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* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1C Engine Camshaft

ISSUED

PROJECT NO. 8

SHEET NO.

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1D-001	65-41-1	Crankshaft - engine	1				
2		-002	-2	Key - woodruff timing sprocket	1				
3		-003	-3	Sprocket - timing gear crank	1				
4		-004	-4	Pulley - crankshaft	1				
5		-005	-5	Nut - crankshaft pulley	1				
6		-006	-6	Flywheel	1				
7		-007	-7	Ring gear - starter	1				
8		-008	-8	Pin dowel	3				
9		-009	-9	Bolt - flywheel to crank	6				
10		-010	-10	Bushing - crank pilot needle	1				
11		-011	-11	Rod - connecting	4				
12		-012	-11A	Cap - connecting rod	4				
13		-013	-12	Bolt - connecting rod cap	8				
14		-014	-13	Nut - connecting rod cap	8				
15		-015	-14	Bushing - connecting rod	4				
16		-016	-14A	Wristpin - connecting rod	4				
17		-017	-15	Bearing - thrust upper	1				
18		-018	-16	Bearing - thrust lower	1				
19		-019	-17	Bearing - main upper	4				
20		-020	-18	Bearing - main lower	4				
21		-021	-19	Bearing - connecting rod half	8				
22		-022	-20	Piston	4				
23		-023	-21	Ring - piston upper	4				
24		-024	-22	Ring - piston center	4				
25		-025	65-41-23	Ring - piston oil scraper	4				
26		-026	65-41-24	Circlip - connecting rod wristpin	8				
27									
28									
29									
30									

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1D Engine Crankshaft

ISSUED

PROJECT NO.

SHEET NO. 9

A1-10

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1E-1	49-5-1	Pump assembly - engine oil	1				
2		-001	49-5-2	Body - oil pump upper	1				
3		-002	49-5-3	Shaft and gear - oil pump drive	1				
4		-003	49-5-4	Impeller - oil pump	1				
5		-004	48-6-B	Shaft and gear - oil pump lower	1				
6		-005	48-6-A	Housing - oil pump lower	1				
7		-006	48-6-C	Screen - oil pump housing	1				
8		-007	48-6-D	Circlip - oil pump screen	1				
9		-008	48-6-E	Bolt - oil pump lower housing	4				
10		-009	48-6-F	Washer - oil pump lower housing	4				
11		-010	49-5-12	Bushing - pump assembly mounting	1				
12		-011	49-5-13	Washer - pump assembly mounting	1				
13		-012	-14	Bolt - pump assembly mounting	1				
14		-013	-15	Tube assembly - oil pump pressure	1				
15		-014	-16	Gasket - pressure tube	2				
16		-015	-17	Lockplate - pre-sure tube	2				
17		-016	-18	Bolt - pressure tube mounting	4				
18		-017	-19	Valve - oil pressure relief	1				
19		-018	-20	Filter - engine oil	1				
20		-019	-21	Dipstick - oil level	1				
21		-020	-22	Seal - dipstick	1				
22		-021	-23	Seal - oil spray jet	1				
23		-022	-24	Adaptor - oil filter	1				
24									
25									
26									
27									
28									
29									
30									

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1E Engine Oil Pump

ISSUED

PROJECT NO.

SHEET NO. 10

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1F-001	90-21-15	Manifold - engine exhaust	1				
2		-002	-18	Shield - exhaust manifold heat	1				
3		-003	-19	Stud - heat shield	AR				
4		-004	-20	Washer - heat shield	AR				
5		-005	-21	Nut - heat shield	AR				
6		-006	-14	Gasket - exhaust manifold to engine	4				
7		-007	-16	Washer - exhaust manifold to engine	8				
8		-008	-17	Nut - exhaust manifold to engine	8				
9		-009	-22	Stud - exhaust manifold flange	6				
10		-010	-36	Manifold - engine intake	1				
11		-011	-37	Gasket - intake manifold to engine	4				
12		-012	-5	Washer - intake manifold to engine	8				
13		-013	-6	Nut - intake manifold to engine	8				
14		-014	-38	Bracket - Intake manifold support	1				
15		-015	-40	Lockwasher - support bracket to engine	1				
16		-016	-41	Bolt - support bracket to engine	1				
17		-017	-43	Bolt - Support bracket to manifold	1				
18		-018	-44	Flat washer - bracket to manifold	1				
19		-019	-45	Lockwasher - bracket to manifold	1				
20		-020	-46	Nut - bracket to manifold	1				
21		-021	-47	Gasket - carburator	1				
22		-022	-42	Stud - intake manifold to carburator	4				
23		-023	-1	Washer - manifold to carburator	4				
24		-024	-2	Nut - manifold to carburator	4				
25		-025	-3	Bracket - air cleaner - rear	1				
26		-026	-4	Bracket - air cleaner - front	1				
27		-027	-23	Air cleaner assembly	1				
28		-028	-24	Plug - air cleaner	1				
29		-029	-25	Cartridge - air cleaner	1				
30		-030	-26	Seal - air cleaner cover	1				

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1F - Engine Manifolds & Air Cleaner

ISSUED

PROJECT NO.

SHEET NO. 11

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1F-031	90-21-27	Seal - air cleaner lower	1				
2		-032	-28	Cover - air cleaner	1				
3		-033	-29	Flatwasher - air cleaner mounting	2				
4		-034	-30	Lockwasher - air cleaner mounting	2				
5		-035	-31	Bolt - air cleaner mounting	2				
6		-036	-32	Hose - air cleaner to exhaust manifold	1				
7		-037	-33	Holder - air cleaner hose	1				
8		-038	-34	Clamp - air cleaner hose holder	1				
9		-039	-35	Clamp - air cleaner hose	1				
10									
11									
12									
13									
14									
15									
16									
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* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1F - Engine Manifold & Air Cleaner

ISSUED

PROJECT NO.

SHEET NO. 12

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1G-1	92-24	Housing Assembly - CIS fuel injection	1				
2		-001	92-24	Distributor Assembly - fuel	1				
3		-002	92-24	Valve - fuel injection	4				
4		-003	92-24	Fuel line - injection valve	4				
5		-004	92-24	Valve - cold start	1				
6		-005	92-24	Switch - thermo	1				
7		-006	92-24	Fuel line - cold start	1				
8		-007	92-24	Regulator - CIS pressure	1				
9		-008	92-24	Fuel line - regulator to distributor	1				
10		-009	92-24	Fuel line - regulator return	1				
11		-010	92-24	Fuel line - distributor to fuel tank	1				
12		-011	92-24	Fuel line - tank to pump	1				
13		-012	92-24	Pump - fuel electric	1				
14		-013	92-24	Fuel line - pump to accelerator	1				
15		-014	92-24	Accumulator - fuel	1				
16		-015	92-24	Fuel line - accumulator to filter	1				
17		-016	92-24	Filter - fuel	1				
18		-017	92-24	Fuel line - filter to distributor	1				
19									
20									
21		10160-1G-2	75-28	Pedal & linkage assembly - accelerator	1				
22				(see illustration for components)					
23									
24									
25									
26									
27									
28									
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* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1G - Engine Fuel Injection

ISSUED

PROJECT NO.

SHEET NO. 13

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		0160-1H-1	172-2 130-4	Radiator Assembly - engine cooling	1				
2		-001	130-4-1	Hose - radiator return	1				
3		-002	-2	Clamp - return hose	2				
4		-003	-3	Hose - water flange rear	1				
5		-004	-4	Clamp - water flange hose	2				
6		-005	-5	Hose - water flange to heater	1				
7		-006	-6	Clamp - heater hose	2				
8		-007	-7	Hose - radiator lower outlet	1				
9		-008	-8	Clamp - lower hose	2				
10		-009	-15	Pipe - lower hose T	1				
11		-010	-9	Hose - water pump inlet	1				
12		-011	-10	Clamp - inlet hose upper	1				
13		-012	-16	Clamp - inlet hose lower	1				
14		-013	-26	Hose - T pipe to thermo housing	1				
15		-014	-27	Clamp - T hose lower	1				
16		-015	-28	Clamp - T hose upper	1				
17		-016	-30	Housing - thermostat lower	1				
18		-017	-37	Bolt - thermo housing mounting	2				
19		-018	-35	Gasket - thermo housing mounting	1				
20		-019	-36	Washer - thermo housing mounting	2				
21		-020	-29	Thermostat	1				
22		-021	-31	Seal - thermo cap	1				
23		-022	-32	Cap - thermostat housing	1				
24		-023	-33	Washer - cap mounting	2				
25		-024	-34	Bolt - cap mounting	2				
26		-025	-23	Hose - thermo cap to engine	1				
27		-026	-24	Clamp - thermo hose to cap	1				
28		-027	-25	Clamp - thermo hose to engine	1				
29		-028	-14	Pipe coolant	1				
30		-029	-11	Hose - water pump to pipe	1				

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1H - Engine Cooling

ISSUED

PROJECT NO.

SHEET NO. 14

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1H-030	130-4-12	Clamp - pipe hose lower	1				
2		-031	130-4-13	Clamp - pipe hose upper	1				
3		-032	130-4-38	Cowl - radiator shroud	1				
4		-033	131-5	Attaching hardware - radiator shroud	AR				
5		-034	131-5	Fan and Motor Assembly - radiator electric	1				
6		-035	131-5	Attaching hardware - fan and motor	AR				
7		-036	130-4	Attaching hardware - radiator assembly	AR				
8		-037	130-4-54	Baffle - radiator left	1				
9		-038	130-4-55	Baffle - radiator right	1				
10		-039	130-4-56	Baffle - radiator upper	1				
11		-040	130-4	Attaching hardware radiator baffles	AR				
12		-041	128-2	Hose - radiator return	1				
13		-042	128-2	Clamp - radiator return hose	2				
14									
15									
16									
17									
18									
19									
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21									
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* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1H - Engine Cooling

ISSUED

PROJECT NO.

SHEET NO. 15

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-1J-001	115-7-1	Coil - ignition (cap disch system optional)	1				
2		-002	-2	Washer - coil wire	1				
3		-003	-3	Lockwasher - coil wire	1				
4		-004	-4	Nut coil wire	1				
5		-005	-24	Cable - coil to starter	1				
6		-006	-5	Resistor - coil	1				
7		-007	-6	Washer - resistor mounting	2				
8		-008	-7	Screw - resistor mounting	2				
9		-009	-8	Washer - coil mounting	1				
10		-010	-9	Screw - coil mounting	1				
11		-011	-18	Condensor - distributor ignition	1				
12		-012	-20	Clamp - distributor mounting	1				
13		-013	-21	Washer - distributor mounting	1				
14		-014	-22	Bolt - distributor mounting	1				
15		-015	-23	Seal - distributor mounting	1				
16		10160-1J-1	117-9,115-7-10	Distributor assembly - engine ignition	1				
17		-016	-11	Cap - distributor	1				
18		-017	-15	Dust cap - distributor	1				
19		-018	-12	Rotor Distributor	1				
20		-019	-13	Plate - contact breaker	1				
21		-020	-14	Spring - breaker plate	2				
22		-021	-16	Connector - rotor drive	1				
23		-022	-17	Valve - vacuum advance	1				
24		-023	-19	Plug - engine ignition	4				
25		-024	-25	Cable - sparkplug #1 cylinder	1				
26		-025	-26	Cable - sparkplug #2 & 3 cylinder	2				
27		-026	-27	Cable - sparkplug #4 cylinder	1				
28		-027	-28	Cable - coil to distributor	1				
29		-028	-29	Clip - sparkplug cable	1				
30		-029	-32	Holder - sparkplug cable	1				

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1J - Engine Electrical

ISSUED

PROJECT NO.

SHEET NO. 16

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108310160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD
1		0160-1J-030	115-7-30	Sleeve - spark plug cable	1				
2		-031	-31	Bracket - spark plug cable	1				
3		-032	-33	Lock Assembly - steering column ignition switch	1				
4		-033	-34	Switch - starter ignition	1				
5		-034	-35	Shear screw - lock mounting	2				
6		-035	-36	Clip - lock mounting	1				
7		-036	-37	Cylinder - lock	1				
8		-037	-38	Key - ignition	1				
9									
10		-038		Sending unit - oil pressure	1				
11									
12		-039		Sending unit - water temperature	1				
13									
14		0160-1J-2		Harness assembly - engine electic wiring	1				
15									
16									
17									
18									
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* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1J - Engine Electrical

ISSUED

PROJECT NO.

SHEET NO. 17

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160, 108J10131

PROJECT NAME: LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-1K-1	108-11	Transmission Assembly - CP 3 Speed Automatic	1					77 Audi 100
2		-001		Attaching Hardware - Trans Assy to Engine Assy	AR					
3		10160-1K-2	113-3-1	Starter Assembly - Engine Ignition	1					
4		-002	-38	Bolt - starter mounting	2					
5		-003	-39	Flatwasher - starter mounting	2					
6		-004	-40	Lockwasher - starter mounting	2					
7		-005	-41	Nut - starter mounting	2					
8		10160-8-002	112-5-A	Cable - starter to battery	1 *					
9		-006	112-5-A	Cable - starter to ignition starter lock	1					
10		-007	112-5-A	Attaching Hardware - starter cables	AR					
11										
12										
13		10160-1K-3		Kit - Transmission oil cooler complete	1					TPP Cooling
14										
15		10160-1K-4		Controls and Selector Assembly - Auto Trans						77 Audi 100
16										
17										
18										
19										
20										
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* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 1K - Transmission

ISSUED

*Assigned in Electrical Group

PROJECT NO.

SHEET NO. 18

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-2-001	159-14-1	Front Hub	2				
2		-002	159-14-2	Bearing - front wheel hub	4				
3		-003	-3	Spacer - wheel bearing outer	4				
4		-004	-4	Spacer - wheel bearing inner	2				
5		-005	-5	Ring - wheel bearing retainer	4				
6		-006	-6	Ciriclip - wheel bearing retainer	4				
7		-007	-7	Knuckle assembly - steering hub carrier LH	1				
8		-008	-7	Knuckle assembly - steering hub carrier RH	1				
9		10160-2-1	-8	Shaft & Joint assembly - axle drive LH	1				
10		10160-2-2	-8	Shaft & joint assembly - axle drive RH	1				
11		-009	-9	Boot - axle shaft inner	2				
12		-010	-10	Boot - axle shaft outer	2				
13		-011	-11	Washer - spring	4				
14		-012	-12	Clip - boot outer	2				
15		-013	-13	Clip - boot inner inside	2				
16		-014	-14	Clip - boot inner outside	2				
17		-015	-15	Ring - pressure	2				
18		-016	-16	Ring - snap	2				
19		-017	-21	Gasket - axle shaft seal	2				
20		-018	-22	Bolt - axle shaft att	8				
21		-019	159-14-23	Lockwasher - shaft att	8				
22									
23									
24									
25									
26									
27									
28									
29									
30									

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 2 Front axle

ISSUED

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

PROJECT NAME

LLCC PARATRANSIT VEHICLE

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160
108-J-10123
108-J-10124

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-3-1	143-7-1	Caliper Assembly - Front disc brake - LH	1					*
2		-001	-1A	Housing - caliper inner - LH	1					
3		-002	-1B	Housing - caliper outer - LH	1					
4		10160-3-2	143-7-1	Caliper Assembly - front disc brake - RH	1					*
5		-003	-1A	Housing - Caliper inner - RH	1					
6		-004	-1B	Housing - Caliper outer - RH	1					
7		-005	-2	Pad Assembly - disc brake heavy duty	4					
8		-006	-3	Seal	4					
9		-007	-4	Clamp ring	4					
10		-008	-5	Piston	4					
11		-009	-6	Cap - protective	4					
12		-010	-7	Pin - retaining	4					
13		-011	-8	Spring - cross	2					
14		-012	-9	Valve - disc brake bleeder	2					
15		-013	-10	Cap - dust bleeder valve	2					
16		-014	-11	Lock - caliper	4					
17		-015	-12	Cap screw - short	2					
18		-016	-13	Cap screw - long	2					
19		-017	-14	Lockwasher - caliper assembly	4					
20		-018	-15	Nut - caliper assembly	4					
21		-019	-16	Nut - caliper mounting	4					
22		-020	-17	Lockwasher - caliper mounting	4					
23		-021	-19	Dust shield - brake disc LH	1					
24		-022	143-7-19	Dust shield - brake disc RH	1					
25		-023		Attaching hardware - dust shield	AR					
26		-024		Brake Line - caliper to chassis	2					
27		-025		Connector - chassis	2					
28		-026		Bracket - chassis connector	2					
29										
30										

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 3 Brakes

ISSUED

* shown purchased as part of front suspension assembly

PROJECT NO.

SHEET NO. 1

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

PROJECT NAME LLCC PARATRANSIT VEHICLE

LAYOUT NO. 108-J-10160, 108-J-10123, 108-J-10124

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		108-A-10037	140-2	Booster & Master cylinder assembly - power brake	1					*
2		10037-3-001	141-3-2	Reservoir - power brake master cylinder	1					
3		-002	141-3-2	Cap - brake MC reservoir	1					
4		-003	140-2-B	Booster assembly - power brake vacuum	1					
5		-004	7501-MP	Bracket - booster mounting LH						*
6		-005	7501-MP	Bracket - booster mounting RH						*
7		-006	142-5	Bolt - booster mounting	2					
8		-007	142-5	Washer - booster mounting	2					
9		-008	142-5	Lockwasher - booster mounting	2					
10		-009	142-5	Nut - booster mounting	2					
11		-010	152-6	Pushrod and booster assembly - power brake	1					
12		-011	142-6-B	Pushrod - power brake	1					
13		-012	142-6-C	Clevis - power brake	1					
14		-013	142-6-A	Jambnut - power brake	1					
15		-014	142-6-B	Boot - power brake pushrod	1					
16		-015	142-6-B	Retainer - pushrod boot	1					
17		108-A-10035	141-3	Master cylinder assembly - power brake	1					
18		10035-3-016		Attaching hardware - brake MC	AR					
19		108-D-10033		Pedal, Pad & Pivot Assembly - power brake	1					*
20		10033-3-017		Pedal and bushing assembly - power brake	1					
21		108-A010155		Pad - power brake pedal	1					
22		10155-3-018		Attaching hardware - pad to ped	AR					
23		-019		Attaching hardware - pedal pivot						
24				to steering column support bracket	AR					
25		-020		Spring - brake pedal return	1					
26		10155-3-021	140-2-F	Switch assembly - brake stop light	1					*
27										
28										
29										
30										

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 3 Brakes

ISSUED

*New Part

**Audi 100LS Product items

PROJECT NO.

SHEET NO. 2

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

PROJECT NAME

LLCC PARATRANSIT VEHICLE

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108-J-10160
108-J-10123
108-J-10124

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		108-A-10036	150-26,108J	Brake lines, hoses, connections - power	AR					
2			10123	disc brake system CP						
3		10036-3-001		Valve - combination proportioning	1					*Tevis
4		-002		and metering						
5			150-26-6	Brake line - master cylinder to rear axle	1					**
6				connector						
7		10036-3-003		Attaching hardware - brake lines	AR					
8										
9		108-A-10034		Lever Assembly - parking brake	1					77 VW 411
10		108-A-10159		Cable assembly - parking brake	1					77 VW 411
11		108-J-10124		Attaching hardware - parking brake	AR					
12		108-J-10124-2		Bracket - angle	1					***
13		108-J-10124-3		Bracket - angle	1					***
14		108-J-10124-5		Plate - cap	1					***
15		No Drawing		Grommet - plate cap, 50 I.D.	1					
16		108-J-10124-10		Bolt	2					
17		108-J-10124-11		Nut	2					
18		108-J-10124-12		Flatwasher	2					
19		108-J-10124-13		Screw	1					
20		108-J-10124-14		Nut	1					
21		108-J-10124-15		Flatwasher	3					
22										
23		10160-3-4		Brake,spindle, hub & drum assembly - rear LH	1					****
24				(1977 Audi 100LS rear brake assy CP)						
25				wheel spindle, hub, drum						
26				bearings and backing plate						
27										
28		10160-3-5		Brake,Spindle, Hub & drum assembly - rear RH	1					****
29				(1977 Audi 100LS rear brake assy CP)						
30				wheel spindle, hub, drum, bearings & backing plate						

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 3 Brakes

ISSUED

*New part - Teves shelf item
**New part or Audi modified routing
***New part - Metal Specialists
****New assembly - Audi & Teves

All brake lines, fittings and tubing may be hand made and routed at final assembly.

PROJECT NO.

SHEET NO. 3

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PRDD.
1		10160-4-1	156-3,159-14	Suspension & axle shaft assembly - front CP with wheels, tires and brakes	1				
2									
3		10160-4-2		Suspension and axle shaft assembly - front RH	1				
4		10160-4-3		Suspension and axle shaft assembly - front LH	1				
5		10160-4-4	160-18-A	Arm assembly - front suspension upper control LH	1				
6		10160-4-5	160-18-A	Arm assembly - front suspension upper control RH	1				
7		-001	160-19-A	Arm and pivot shaft - front suspension upper	2				
8		-002	-B	Ball joint assembly - upper arm LH	1				
9		-003	-B	Ball joint assembly - upper arm RH	1				
10		-004	-C	Retaining ring - ball joint boot	2				
11		-005	-D	Washer - upper arm bushing	4				
12		-006	-E	Bushing - upper arm	4				
13		-007	-F	Nut - upper arm shaft	4				
14		-008	160-18-B	Bracket - upper arm mounting	4				
15		-009	-B	Lockwasher - upper arm mounting	8				
16		-010	-B	Bolt - upper arm mounting	8				
17		-011	157-10-F	Bolt - ball joint upper to strg. knuckle	2				
18									
19		10160-4-6	161-21	Arm assembly - front suspension lower control LH	1				
20		10160-4-7	161-21	Arm assembly - front suspension lower control RH	1				
21		-012	161-21-A	Arm and pivot shaft - lower control LH	1				
22		-013	161-21-A	Arm and pivot shaft - lower control RH	1				
23		-014	161-21-D	Ball joint assembly - lower arm LH	1				
24		-015	161-21-D	Ball joint assembly - lower arm RH	1				
25		-016	161-21-E	Bracket - lower arm ball joint	2				
26		-017	161-21-I	Attaching hardware - ball joint bracket	AR				
27		-018	161-21-F	Disc - spring lower ball joint	4				
28		-019	161-21-G	Nut - Ball joint to arm	2				
29									
30									

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 4 Front Suspension

ISSUED

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-4-020	161-21-H	Ring - ball joint retaining lower	2				
2		-021	161-21-B	Bushing - lower arm pivot front	2				
3		-022	161-21-C	Bushing - lower arm pivot rear	2				
4		-023	161-21	Washer - pivot bushing inner	4				
5		-024	161-21	Washer - pivot bushing outer	4				
6		-025	161-21	Nut - pivot shaft	4				
7		-026	161-21	Bracket - lower arm mounting front	2				
8		-027	161-21	Bracket - lower arm mounting rear	2				
9		-028	161-21	Bolt - lower arm bracket mounting	4				
10		-029	157-10-F	Bolt - lower ball joint to strg. knuckle	2				
11		10160-4-8	156-3-3	Bar assembly - front suspension stabilizer	1				
12		-030	156-3	Attaching hardware - stabilizer bar	AR				
13		-031		Disc - front axle brake	2				
14		-032		Attaching hardware - disc to hub	AR				
15		-033	157-12	Attaching hardware - hub to drive shaft	AR				
16									
17		-034	156-3-1	Spring - front suspension heavy duty	2				
18		-035	-2	Ring - spring seat	2				
19		-036	-9	Shock absorber assembly - front H.D.	2				
20		-037	-10	Retainer - spring seat lower	2				
21		-038	-11	Retainer - spring seat upper	2				
22		-039	-12	Washer - spring st. retainer lower	2				
23		-040	-13	Bumper - front suspension jounce	2				
24		-041	-14	Cup - jounce bumper	2				
25		-042	-15	Grommet - shock absorber mounting lower	2				
26		-043	-16	Grommet - shock absorber mounting upper	2				
27		-044	-17	Washer - shock absorber mounting upper	2				
28		-045	-18	Nut - shock absorber mounting upper	2				
29		-046	-18	Jamb nut - shock absorber mounting upper	2				
30									

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 4 Front Suspension

ISSUED

PROJECT NO.

SHEET NO. 2

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-4-047	156-3-19	Lockwasher - spring seat mounting	AR				
2		-048	156-3-20	Nut - spring seat mounting	AR				
3									
4									
5		10160-2-001	159-14-1	Front hub and bearing assembly	**				
6									
7		10160-2-1,2	159-14-8	Shaft and joint assembly - front axle LH & RH	**				
8									
9		10160-2-049	152-1	Gear Assembly, steering, rack & pinion CP	1				
10									
11		10160-2-050	162-3	Column & Steering Wheel Assembly, CP	1				
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

* Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 4 Front Suspension

ISSUED

**These parts assigned in Group 2

PROJECT NO.

SHEET NO. 3

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO DOT-TSC-1351

LAYOUT NO. 108J10160
108D10161

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-5-1	140-2	Suspension and Axle Assembly - rear complete	1					Audi 100 LS
2										
3		10160-5-1A	108D10161	Suspension and Axle Assembly - rear reworked	1					New
4										
5		10160-5-2		Axle assembly - rear suspension	1					New
6		10160-5-001		Attaching hardware - hub and drum to axle	AR					
7		10160-3-4		Hub - drim and brake assembly - rear complete LH	1*					Audi 100 LS
8		10160-3-5		Hub - drum and brake assembly - rear complete RH	1*					Audi 100 LS
9		10160-5-002		Rod assembly - rear suspension panhard	1					Audi 100 LS
10										
11		10160-5-003		Bushing - panhard rod	2					Audi 100 LS
12										
13		10160-5-004		Attaching hardware - panhard rod	AR					Audi 100 LS
14										
15		10160-5-005		Spring - rear suspension coil	2					New
16										
17		10160-5-006		Bumper - rear suspension jounce	2					AMC
18										
19		10160-5-3		Shock absorber assembly - load leveling	2					Delco
20										
21		10160-5-007		Attaching hardware - shock absorber	AR					Delco
22										
23		10160-5-008		Compressor - shock air electric	1					Delco
24										
25		10160-5-009		Bracket Assembly - shock load level	1					Delco
26										
27		10160-5-010		Attaching hardware - comp. to shock	AR					Delco
28										
29		10160-5-4		Arm and bushing assembly - rear suspension control	2					Audi 100 LA
30										

REVISIONS

GROUP: 5. Rear Suspension

ISSUED

*assigned in brake group

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-6-1		Wheel and tire assembly - DR78x14x5.0 steel belted rads	5					
2										
3										
4		-001		Wheel - 14x5.0x1.94 offset 4 bolt 4.25 bc	5					Audi 100 LS
5										
6		-002		Tire - DR78x14 steel belted radial	5					
7										
8										
9		10160-6-2		Jack assembly - bumper (AMC or equivalent)	1					
10		-003		Ratchet assembly - bumper jack	1					
11		-004		Post - bumper jack	1					
12		-005		Base plate - bumper jack	1					
13		-006		Face plate - bumper	1					
14		-007		Handle - bumper jack wrench	1					Audi or equiv
15										
16										
17		-008		Bracket - spare tire hold down	1					
18		-009		J-bolt - spare tire hold down bracket	1					
19		-010		Plate - J-bolt	1					
20		-011		Wingnut - spare tire hold down	1					
21										
22										
23										
24		10160-6-3		Ramp assembly - wheelchair loading	2					
25		-012		Ramp extrusion	2					
26		-013		Retainer bracket	2					
27										
28										
29										
30										

REVISIONS

GROUP: 6. Wheels, Tires, Jacks

ISSUED

PROJECT NO.

SHEET NO

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-7-1	108J10013	Heater and blower assembly - complete	1					GM Truck 610
2		7-001		Attaching hardware - heater assembly	AR					
3										
4										
5		10160-7-2	108J10013	Air conditioning assembly - hd complete kit	1	*				ARA-0507351
6		7-002		Attaching hardware - R/C assembly	AR					
7										
8										
9										
10		10160-1A-8	120-12	Compressor and clutch assembly - air conditioning	1	**				Audi 100 LS
11										
12		10160-1A-067		Hose assembly - compressor to condensor	1	**				ARA
13										
14		10160-1A-068		Hose assembly - compressor to evaporator	1	**				ARA
15										
16										
17										
18										
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REVISIONS

GROUP: 7. Heater & Air Conditioning

ISSUED

*less compressor

**assigned in engine group

PROJECT NO

SHEET NO 1

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO	Drawing * Reference	PART NAME	AMT REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-8-1		Battery - 12V 80 amp hr	1					
2										
3		10160-8-001		Cable - battery ground						
4		-002		Cable - battery to starter solenoid	1					
5		-003		Attaching hardware - battery cables	AR					
6										
7										
8		10160-10J-2		Harness Assembly - engine electrical	1	*				
9										
10		10160-8-2		Harness Assembly - front lamps front compartment	1					
11										
12		10160-8-3		Harness Assembly - body wiring rear lamps	1					
13										
14		10160-10b-4		Harness assembly - electric door	1	**				
15										
16		10160-8-4		Harness assembly - wheelchair restraint	1					
17										
18				Sending unit - fuel level	1					Audi 100 LS
19										
20				Pump assembly - fuel	1					
21				Attaching hardware - fuel pump	AR					
22										
23		10160-8-5	34-00-1	Harness Assembly - I.P. to dash	1					Ford Econ
24										
25										
26										
27										
28										
29										
30										

*1975 Ford Truck Shop Manual

REVISIONS

GROUP: 8. Body & Chassis Electrical

ISSUED

*assigned in engine group

**assigned in body group

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AMT REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-9-1	75-27	Exhaust system - complete as purchased	1					Audi 100 LS
2										
3		10160-9-1A		Exhaust system - complete reworked	1					
4										
5		10160-9-001	75-27-A	Manifold assembly - exhaust inlet pipe	1					Audi 100 LS
6		-002	75-27-a	Gasket - inlet pipe manifold	1					Audi 100 LS
7		-003	75-27-c	Hex nuts - inlet pipe to manifold	6					Audi 100 LS
8										
9		-004	75-27-B	Muffler & pipe assembly - primary	1					Audi 100 LS
10		-005	75-27-d	Attaching hardware - muffler to inlet	AR					Audi 100 LS
11										
12		-006	75-27-D	Muffler assembly - final	1					Audi 100 LS
13		-007	75-27-d	Attaching hardware - primary to final	AR					Audi 100 LS
14										
15		-008	75-27-C	Tail pipe	1					New
16		-009	75-27-d	Attaching hardware - tail pipe	AR					Audi 100 LS
17		-010	75-27-e	Strap assembly - tail pipe retaining	1					Audi 100 LS
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
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REVISIONS

GROUP: 9. Exhaust & Fuel System

ISSUED

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AMT REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-9-2	80-1	Fuel Tank Assembly - complete as purchased	1					77 Audi 100 LS
2		10160-9-3	80-1	Tank Assembly - fuel	1					
3		10160-9-011	80-1-2	Seal - tank drain plug	1					
4		10160-9-012	80-1-3	Plug - tank drain	1					
5		10160-9-013	80-1-4	Tube assembly - fuel tank vent	1					
6		10160-9-014	80-1-5	Connection - elbow hose	1					
7		10160-9-015	80-1-6	Hose - elbow	1					
8		10160-9-016	80-1-78	Clip - elbow hose	2					
9		10160-9-017	80-1-9	Hose - vent right	1					
10		10160-9-018	80-1-10	Hose - vent left	1					
11		10160-9-019	80-1-11	Retainer - fuel line	5					
12		10160-9-020	80-1-12	Sleeve - vent tube protection	2					
13		10160-9-021	80-1-13	Hose - vent tube to tank	1					
14		10160-9-022	80-1-14,15,16	Bolts, nuts and washers - fuel tank mounting	AR					
15		10160-9-023	80-1-17	Seal - fuel tank mounting	1					
16		10160-9-024	80-1-18	Fuel line	1	(Re-route as necessary)				
17		10160-9-025	80-1-19	Grommet - fuel line mounting	1					
18		10160-9-026	80-1-20,21	Hose - fuel line	2					
19		10160-9-027	80-1-22,3,4	Sleeve - fuel line protection	3					
20		10160-9-028	80-1-25	Separator - fuel vapor	1					
21		10160-9-029	80-1-26	Cap - fuel tank filler	1					
22		10160-9-039	80-1-27	Seal - filler cap	1					
23		10160-9-031	80-1-30	Canister - activated carbon	1					
24		10160-9-032	80-1-31,2,3	Screw, lockwasher & nut - canister mounting	AR					
25		10160-9-033	80-1-31	Container - expansion	1					
26		10160-9-034	80-1-37,8,42	Vent line	3					
27		10160-9-035	80-1-39	Vent hose	1					
28		10160-9-036	80-1-40,1	Clip	2					
29										
30										

*Clymer Publication A131 70-76 Audi 100 LS

REVISIONS

GROUP: 9. Exhaust & Fuel Systems

ISSUED

See also Group 1G

PROJECT NO

SHEET NO. 2

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

PROJECT NAME

LLCC PARATRANSIT VEHICLE

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-10-1	108J10160	Body Assembly - painted and trimed	1					Metal Spec.
2										
3		10160-10-2	108J10160	Body-in-white assembly - primed	1					Metal Spec.
4										
5		10160-10-3	108J10160	Body and structure assembly - bare metal	1					Metal Spec.
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
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28										
29										
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REVISIONS

GROUP: 10 Body Painted & Trimed

ISSUED

PROJECT NO

SHEET NO 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10A-1	10160 Sht 8	Door assembly - front complete, RH	1			N		
2			42-04-3							
3		10160-10A-2		Door Assembly - front complete, LH	1			N		
4										
5										
6		10160-10A-3		Door assembly - front RH	1			N		
7		-001		Panel - door outer upper RH	1			N		
8		-002		Panel - door outer lower RH	1			N		
9		-003		Panel - door inner upper RH	1			N		*
10		-004		Panel assembly - door inner lower RH	1			N		*
11		-005		Panel - front door inner lower RH	1			N		*
12		-006		Reinforce - front door hinge upper RH	1				X	
13		-007		Reinforce - front door hinge lower RH	1				X	
14		-008		Tapping plate - door hinge	2				X	
15										
16										
17		10160-10A-4		Door assembly - front LH	1			N		
18		-009		Panel - door outer upper LH	1			N		
19		-010		Panel - door outer lower LH	1			N		
20		-011		Panel - door inner upper LH	1			N		*
21		-012		Panel assembly - door inner lower LH	1			N		*
22		-013		Panel - front door inner lower LH	1			N		*
23		-014		Reinforce - front door hinge upper LH	1				X	
24		-015		Reinforce - front door hinge lower LH	1				X	
25		-016		Tapping plate - door hinge	2				X	
26										
27										
28										
29										
30										

* 1975 Ford Truck Shop Manual Sketch No.

REVISIONS

GROUP: 10A Body-Front Door

ISSUED

*Similar to Econoline except contour and flanging

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

PROJECT NAME

LLCC PARATRANSIT VEHICLE

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10A-5	*N1629-B	Latch assembly - front door RH	1	Econ			X	21812
2		10160-10A-6	*N1629-B	Latch assembly - front door LH	1	Econ			X	21813
3		-017	*N1629-B	Handle assembly - front door outside RH	1	Econ			X	22400
4		-018	*N1629-B	Handle assembly - front door outside LH	1	Econ			X	22400
5		-019	*N1629-B	Pad - door handle front	2	Econ			X	22428
6		-020	*N1629-B	Pad - door handle rear	2	Econ			X	22428
7		-021	*N1629-B	Nut - door handle attachment	4	Econ			X	55734-52
8		-022	*N1629-B	Rod- door outside handle to latch	2	Econ			X	22134
9		-023	*N1629-B	Retainer - latch rod	2	Econ			X	219A36
10		-024	*N1629-B	Lock cylinder & Ken set assembly - front door	2	Econ			X	
11		-025	*N1629-B	Retainer - lock cylinder	2	Econ			X	22023
12		-026	*N1629-B	Rod - lock cylinder to latch	2	Econ			X	22134
13		-027	R1781-A	Handle & trim cup assembly - front door inside	2	Econ			X	
14		-028	R1781-A	Attaching hardware - inside handle	AR	Econ			X	
15		-029	N1629-B	Attaching hardware - front latch assembly	AR	Econ			X	
16		-030	N1462-A	Rod - latch lock RH	1	Econ			X	21852
17		-031	N1462-A	Rod - latch lock LH	1	Econ			X	21853
18		-032	N1462-A	Push button - latch lock rod	2	Econ			X	21850
19		-033	N1462-A	Retainer - latch lock rod	2	Econ			X	219A36
20										
21		-034	N1625-B	Striker - front door latch	2	Econ			X	21982
22				(installed in "B" post)	2	Econ			X	
23										
24		-035	N1686-B	Hinge assembly - front door upper RH	1	Econ			X	22800
25		-036	N1686-B	Hinge assembly - front door upper LH	1	Econ			X	
26		-037	N1686-B	Hinge assembly - front door lower RH	1	Econ			X	22806
27		-038	N1686-B	Hinge assembly - front door lower LH	1	Econ			X	
28		-039	N1686-B	Bolt - door hinge att.	20	Econ			X	382623
29										
30										

* 1975 Ford Truck Shop Manual Sketch No.

REVISIONS

GROUP: 10a Body

ISSUED

PROJECT NO.

SHEET NO. 2

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10A-040	N2568-A	Weatherstrip assembly - front door RH	1	Econ			*	20530
2		-041	N2568-A	Weatherstrip assembly - front door LH	1	Econ			*	20530
3										
4		-042	N2568-A	Channel - glass run rear - RH	1	Econ			*	21548
5		-043	N2568-A	Channel - glass run rear - LH	1	Econ			*	21548
6		-044	N2568-A	Retainer - run channel RH	1	Econ			X	21532
7		-045	N2568-A	Retainer - run channel LH	1	Econ			X	21533
8		-046	N2568-A	Bracket - run retainer RH	1	Econ			X	21532
9		-047	N2568-A	Bracket - run retainer LH	1	Econ			X	21533
10										
11		10160-10A-7	N2568-A	Regulator assembly - front door glass RH	1	Econ			X	23200
12		10160-10A-8	N2568-A	Regulator assembly - front door glass LH	1	Econ			X	23201
13		-048	N2568-A	Attaching hardware - window regulator	AR	Econ			X	
14		-049		Handle - window regulator	2	Econ			X	26690
15										
16		-050	R1781-A	Panel - front door interior trim RH	1	Econ			*	23890
17		-051	R1781-A	Panel - front door interior trim LH	1	Econ			*	
18		-052	R1781-A	Armrest - front door RH	1	Econ			X	27540
19		-053	R1781-A	Armrest - front door LH	1	Econ			X	27541
20		-054	R1781-A	Screw - arm rest att.	6	Econ			X	55916
21		-055	R1781-A	Retainer - trim panel rear - RH	1	Econ			X	37A26
22		-056	R1781-A	Retainer - trim panel rear - LH	1	Econ			X	37A26
23		-057	R1781-A	Retainer - trim panel upper	2	Econ			X	37A26
24		-058	R1781-A	Screw - retainer att.	16	Econ			X	381969
25		-059	R1781-A	Screw - trim panel att.	16	Econ			X	381944
26										
27		10160-10A-9	N2568-A	Window assembly - front door RH	1	Econ		N		21410
28		10160-10A-10	N2568-A	Window assembly - front door LH	1	Econ		N		
29		-060	N2568-A	Channel - glass run front RH	1	Econ			X	
30		-061	N2568-A	Channel - glass run front LH	1	Econ			X	

* 1975 Ford Truck Shop Manual Sketch No.

REVISIONS

GROUP: 10a Body

ISSUED

*Production Rework

PROJECT NO.

SHEET NO. 3

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10A-11	N2568-A	Window assembly - front door vent RH	1	Econ			X	21402
2		10160-10A-12	N2568-A	Window assembly - front door vent LH	1	Econ			X	21403
3		-062	N2568-A	Attaching hardware - vent window	AR					
4		-063	N2568-A	Seal - vent window rubber RH	1					
5		-064	N2568-A	Seal - vent window rubber LH	1					
6		-065	N2568-A	Weatherstrip - front door glass belt	2					
7										
8										
9										
10										
11										
12										
13										
14										
15										
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* 1975 Ford Truck Shop Manual Sketch No.

REVISIONS

GROUP: 10a Body

ISSUED

PROJECT NO.

SHEET NO. 4

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10b-1	44-08-2	Door assembly - sliding RH mounted	1					
2		-2	44-08-2	Door assembly - sliding RH glazed	1					
3		10160-10b-4	44-08-2	Glass - RH sliding door	1	*				
4		-005	44-08-5	Lock assembly - sliding door	1					
5		-006	44-08-5	Handle - sliding door outer	1					
6		-007	44-08-5	Handle - sliding door inner	1					
7		-008	44-08-5	Tumbler and key assembly - door lock	1					
8		-009	44-08-6	Latch assembly - sliding door rear	1					
9		-010	44-08-5,6,7	Attaching hardware - lock and latch	AR					
10										
11		10160-10b-3	108J10160	Panel assembly - sliding door RH	1					
12		-003	108J10160	Panel - sliding door outer RH	1					
13		-004	108J10160	Panel - sliding door inner RH	1					
14										
15		-011	44-08-2	Reinf - door inner hinge assembly mounting	1					
16		-002		Weatherstrip - sliding door window	1					
17		-012	44-08-9	Weatherstrip - sliding door seal	1					247A14
18		-013		Adhesive - weatherstrip	AR					
19										
20		-014	44-08-9	Plug - paint drain rectangular	1					24766
21		-015	44-08-9	Plug - paint drain round	2					247A90
22		-016	44-08-9	Plug - paint drain lower	3					379286
23										
24		-017	44-08-4	Lower guide assembly - sliding door RH	1	**				268A26
25		-018	44-08-4	Screw - lower guide mounting	3					379238
26										
27		-019	44-08-4	Bracket - body side upper guide RH	1	**				25036
28		-020	44-08-4	Roller assembly - guide bracket	1					25028
29		-021	44-08-4	Nut - roller mounting	1					376838
30		-022	44-08-4	Screw - bracket mounting	3					374371

*

REVISIONS

GROUP: 10b Sliding door

ISSUED

Ref 1975 Ford Truck Shop Manual

*assigned in glzaing group
**parts to be modified per 108R7514

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10b-1-023	44-08-07	Hinge assembly - sliding door rear RH	1	*				26800
2		-024	44-08-7	Screw - hinge assembly mounting	4					57032
3										
4										
5										
6										
7		10160-10b-4	108R7514	Kit - sliding door electric operation - complete	1					
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
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28										
29										
30										

* REVISIONS

GROUP: 10b Sliding Door

ISSUED

*parts to be modified per 108R7514

PROJECT NO.

SHEET NO. 2

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.		PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD
1		10160-10c-1		Hatch assembly - rear deck mounted	1				
2		10160-10c-2		Hatch assembly - rear deck glazed	1				
3		-001		Glass - rear hatch	1				
4		-002		Weatherstrip - rear hatch glass	1				
5									
6									
7		10160-10c-3		Panel assembly - rear hatch	1				
8		-003		Panel - rear hatch outer	1				
9		-004		Panel - rear hatch inner	1				
10									
11		10160-10f-9		Panel - rear hatch trim	1	*			
12		-006		Screw and washer assembly - trim panel	8				
13									
14		-007		Weather strip - rear hatch seal	1				
15		-008		Adhesive - weatherstrip	AR				
16									
17		-009		Hinge assembly - rear hatch	2				
18		-010		Bolt - rear hatch hinge mounting	12				
19		-011		Nut - rear hatch hinge mounting	12				
20		-012		Lockwasher - rear hatch hinge mounting	12				
21									
22		10160-10c-4		Cylinder assembly - rear hatch gas	1				
23		-014		Attaching hardware - gas cylinder	AR				
24									
25		10160-10c-5		Latch, lock and key assembly - rear hatch	1				
26		-015		Attaching hardware - rear latch	AR				
27									
28									
29									
30									

REVISIONS

GROUP: 10c Rear hatch

ISSUED

*assigned in trip group

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10d-1		Linkage assembly - windshield wiper	1					Ford
2		10160-10d-2		Motor assembly - windshield wiper	1					Econoline
3		10160-10d-3		Blade assembly - windshield wiper	2					"
4		-001		Attaching hardware - windshield wiper	AR					
5										
6		-002		Cover - plenum chamber air intake	1					
7		-003		Screw - plenum cover attaching striker	AR					
8										
9		10160-10d-4		Hood, striker and hinge assembly - engine compartment	1					
10										
11		10160-10d-5		Hood assembly - engine compartment						
12		-004		Panel - hood outer						
13		-005		Panel - hood inner reinf.						
14										
15										
16		10160-10d-6	44-31-3	Hinge assembly - hood LH						16801Econo
17		10160-10d-7	44-31-3	Hinge assembly - hood RH						16801Econo
18										
19		-006	44-31-3	Screw - hinge attachment	4					57141
20										
21		-007	44-31-3	Bumper - hood	2					16C604
22		-008	44-31-3	Screw - hood bumper attachment	4					
23										
24		-009	44-31-3	Striker assembly - hood latch	1					Econoline
25		-010	44-31-3	Striker - hood latch	1					Econoline
26		-011	44-31-3	Spring - hood latch	1					Econoline
27		-012	44-31-3	Screw - striker attachment	3					Econoline
28										
29		10160-10d-8	44-31-3	Latch assembly - hood	1					16700
30		-013	44-31-3	Screw and washer - hood latch mounting	2					57040

* REVISIONS

GROUP: 10d Hood and wipers

ISSUED

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-10e-1	33-00-1	Instrument Panel, cluster & gauges assembly - CP	1					Ford Econo
2										
3		10160-10e-1A		Instrument Panel, cluster & gauges assembly - reworked	1					Met Spec.
4										
5		10160-10e-001		Pad assembly - instrument panel (shortened 8.00)	1					Met Spec.
6										
7		10160-10e-002		End cap - instrument panel pad assembly	1					New
8										
9		10160-10e-003		Mounting hardware - instrument panel	AR					Ford Econo
10										
11		10160-10h-023A	10i Sht 10	Panel - Instrumental panel defroster duct	1*					Met Spec.
12				(new - same as Econ except length)						
13										
14		10160-8-5	34-02	Wiring harness - instrument panel to dash						Ford Econo
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

*1975 Ford Truck Shop Manual

REVISIONS

GROUP: 10e Instrument Panel

ISSUED

*assigned in Group 10h

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-10f-1	108J10160-6	Headlining Assembly - roof	1					
2										
3		10160-10f-2		Seat assembly - rear bench 3 passenger	1					77 Chev van
4										
5		10160-10f-3		Trim moulding - rear wheelhouse arm rest LH	1					
6										
7		10160-10f-4		Trim moulding - rear wheelhouse arm rest RH	1					
8										
9		10160-10f-5		Recepticle - cigar ash	2					
10										
11		10160-10f-6		Mat - rear floor rubber	1					
12										
13		10160-12-3		Belt assembly - lap	6	*				
14										
15		10160-10f-7		Mat - center floor rubber	1					
16										
17		10160-10f-8		Panel - trim sliding door & center side	2					
18										
19		10160-10f-9		Panel - trim rear hatch	1					
20										
21		10160-10f-10		Panel - trim driver bulkhead	1					
22										
23		10160-10f-11		Panel - trim wheelchair bulkhead	1					
24										
25		10160-10f-12		Moulding - wheel recess	2					
26										
27		10160-10f-13		Moulding - corner	2					
28										
29		10160-10f-14		Moulding - bulkhead cap	1					
30										

REVISIONS

GROUP: 10f. Seats & Interior Trim

ISSUED

*assigned in belt group

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-10f-15		Panel trim - wheelchair side	1					
2										
3		10160-10f-16		Seat assembly - driver bulkhead jump	1					
4										
5		10160-10f-17		Attaching hardware - rear bench seat	AR					
6										
7		10160-10f-18		Attaching hardware - trim panels and mouldings	AR					
8										
9		10160-10f-19		Glue - vinyl trim	AR					
10										
11		10160-10f-20		Seat, track & adjuster assembly - driver	1					77 Chev van
12										
13		10160-10f-21		Attaching hardware - driver's seat	AR					77 Chev van
14										
15		10160-10-2		Belt and retractor assembly - driver	1	*				
16										
17		10160-12-1		Restraint assembly - wheelchair	1	*				
18										
19		10160-10a-051		Panel - trim front door LH	1	**				
20										
21		10160-10a-050		Panel - trim front door RH	1	**				
22										
23		10160-10f-22		Visor assembly - sun LH	1					
24										
25		10160-10f-23		Carpet - driver floor	1					
26										
27										
28										
29										
30										

REVISIONS

GROUP: 10f. Seats & trim

ISSUED

*assigned in belt group

**assigned in door group

PROJECT NO.

SHEET NO. 2

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-10g-1	108J10160-4	Headlamp, bezel & mounting can assembly - CP RH	1					76 Chev van
2		10160-10g-2		Headlamp, bezel & mounting assembly - CP LH	1					76 Chev van
3										
4		10160-10g-3	108J10160-6	Taillamp assembly - rear stop & directional signal RH	1					76 Chev vega
5		10160-10g-4		Taillamp assembly - rear stop & dir. signal LH	1					76 Chev vega
6										
7		10160-10g-5	108J10160-6	Lamp assembly - license plate illumination	2					76 Chev vega
8										
9		10160-10g-6	108J10160-5	Lamp & lens assembly - side marker	4					76 Chev vega
10										
11		10160-10g-7	108J10160-4	Lamp & lens assembly - front directional signal	2					77 VW Rabbit
12										
13		10160-10g-8	108J10160-12	Mirror - inside rear view - multiple directional	1					Opt Source
14										
15		10160-10g-9	108J10160-4	Mirror - outside rear view door mtd	1					Opt Source
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

REVISIONS

GROUP: 10g Lamps, Mirrors & Refl.

ISSUED

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160 Sheet 5

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.		PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10h-1		Underbody assembly - rear floor	1					
2										
3		10160-001		Pan - floor center	1					
4		-002		Pan - floor rear	1					
5		-003		Panel - rocker inner ~~rear~~ LH	1					
6		-004		Panel - rocker inner ~~rear~~ RH	1					
7		-005		Panel - rear wheelhouse inner LH	1					
8		-006		Panel - rear wheelhouse inner RH	1					
9										
10										
11		10160-10h-2		Structure assembly - underbody rear	1					
12		-007		Sill - underbody center LH	1					
13		-008		Sill - underbody center RH	1					
14		-009		Riser - rear sill extension LH	1					
15		-010		Riser - rear sill extention RH	1					
16		-011		Extension - rear sill LH	1					
17		-012		Extension - rear sill RH	1					
18		-013		Spring seat - rear LH	1					
19		-014		Spring seat - rear RH	1					
20		-015		Crossmember - rear floor center	1					
21		-016		Crossmember - rear floor rear	1	(Same as -015 except holes)				
22		-017		Crossmember - rear suspension front	1					
23		-018		Crossmember - rear suspension rear	1					
24		-019		Extension - crossmember side	2					
25		-020		Spacer - rear crossmember	2					
26		-021		Spacer - center sill	2					
27		-022		Reinforcement - rear deck panel lower	1					
28										
29										
30										

REVISIONS

GROUP: 10h Underbody

ISSUED

M.S. 8-9-77

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

PROJECT NAME LLCC PARATRANSIT VEHICLE

LAYOUT NO. 108J10160 Sheet 7

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AMT REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-10h-3		Underbody assembly - front end structure	1	Purchased				77 Audi 100
2										
3		10160-10h-3A		Underbody assembly - front end structure modified	1					
4										
5		10160-10h-4		Front end structure assembly - modified Audi	1					
6										
7		10160-10h-022		Panel - plenum inner	1					Metal Spec.
8		-022A		Reinf - plenum inner defrost duct	1					"
9		-023		Panel - plenum outer	1					"
10		-23A		Panel - I.P. defroster duct	1					"
11		-024		Extension - firewall to plenum	1					"
12										
13		-025		Pan - front floor	1					"
14										
15		-026		Post "A" pillar inner - LH	1					"
16										
17		-027		Post "A" pillar inner - RH	1					"
18										
19		-028		Post "A" pillar outer - LH	1					"
20										
21		-029		Post "A" Pillar outer - RH	1					"
22										
23		-030		Tapping plate - hing mounting	4					"
24										
25		-031		Bracket - tapping plate retainer	4					"
26										
27		-032		Filler panel - "A" post to toe board, LH	1					"
28		-033		Filler panel - "A" post to toe board, RH	1					"
29										
30										

REVISIONS

ISSUED

GROUP: 10h. Underbody

PROJECT NO.

SHEET NO. 2

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.
1		10160-10h-034		Extension - RH front wheelhouse	1				
2									
3		-035		Extension - LH front wheelhouse	1				
4									
5		-036		Crossmember assembly - radiator support upper	1				
6									
7		-037		Crossmember - radiator support upper	1				
8									
9		-038		Reinforcement - rad. support. crossmember	1				
10									
11		-039		Attaching hardware - front crossmember	AR				
12									
13		-046		Panel - rocker outer - RH					
14		-047		Panel - rocker outer - LH					
15		-040		Pillar - A inner RH	1				
16		-041		Reinf. - A pillar RH	1				
17		-042		Pillar - A outer RH	1				
18									
19		-043		Pillar - A inner LH	1				
20		-044		Reinf. - A pillar LH	1				
21		-045		Pillar - A outer LH	1				
22									
23		-048		Step plate - rocker front door RH					
24		-049		Step plate - rocker front door LH					
25		-050		Step plate - rocker center door RH					
26		-051		Step plate - rocker center door LH					
27		-052		Corner plate - rocker center door RH					
28		-053		Corner plate - rocker center door LH					
29									
30									

REVISIONS

GROUP: 10h Underbody

ISSUED

PROJECT NO.

SHEET NO. 3

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

PROJECT NAME

LLCC PARATRANSIT VEHICLE

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160 Sheet 7

NO.	SIZE	PART NO.		PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10i-1		Header assembly - windshield	1					
2		-001		Header plate assembly - windshield inner	1					
3		-002		Header plate - windshield inner	1					
4		-003		Tapping plate - sunvisor mounting LH	2					
5		-004		Reinforcement - windshield header	1					
6		-005		Plate - corner "A" pillar header RH	1					
7		-006		Plate - corner "A" pillar header LH	1					
8										
9		10160-10i-2		Header Assembly - door opening RH	1					
10		-007		Header Plate - door opening RH	1					
11		-008		Reinf. - door opening header plate	1					
12		-009		Plate - door opening drip	1					
13		10160-10i-3		Header Assembly - door opening LH	1					
14		-010		Header plate - door opening LH	1					
15		-008		Reinf. - door opening header plate	1					
16		-009		Reinf.plate - door opening drip	1					
17										
18		10160-10i-4		Crossmember - roof bow	2					
19										
20		10160-10i-5		Panel - rear window inner RH	1					
21										
22		10160-10i-6		Panel - rear window "D" post inner RH	1					
23										
24		10160-10i-7		Penal - "D" post lower corner RH	1					
25										
26		10160-10i-8		Panel - wheelhouse outer RH	1					
27										
28		10160-10i-9		Bracket - wheelhouse reinforcement RH	1					
29										
30										

REVISIONS

GROUP: 10i Side & Roof Structure

ISSUED

PROJECT NO.

SHEET NO 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 10BJ10160 Sheet 7

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD
1		10160-10i-10		Panel - rear compartment inner lower	1				
2									
3		10160-10i-11		Panel - rear window inner - LH	1				
4									
5		10160-10i-12		Panel - rear window "D" post inner LH	1				
6									
7		10160-10i-13		Panel - "D" post lower corner LH	1				
8									
9		10160-10i-14		Panel - wheelhouse outer LH	1				
10									
11		10160-10i-15		Panel - center window inner LH	1				
12									
13		10160-10i-16		Header panel extension rear	1				
14		-17		Reinf. - header panel extension rear	1				
15									
16									
17		10160-10i-18		Faceplate assembly "B" post striker front RH	1				
18									
19		-013		Faceplate - "B" post striker front RH	1				
20									
21		-014		Reinforcement - "B" post striker plate	1				
22									
23		-015		Tapping plate - door striker	1				
24									
25		10160-10i-19		Panel - "B" post inner RH	1				
26		-016		Panel - "B" post inner RH					
27		-017		Reinf.	1				
28		-018		Tapping plate	1				
29									
30									

AT-50

REVISIONS

GROUP: 10i Side & Roof Structure

ISSUED

PROJECT NO.

SHEET NO. 2

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160 Sheet 7

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD
1		10160-10i-20		Panel - "B" post outer	1				
2									
3		10160-10i-21		Faceplate Assembly - "B" post striker front LH	1				
4									
5		-016		Faceplate - "B" post striker front LH	1				
6									
7		-014		Reinforcement - "B" post striker plate	1				
8									
9		-015		Tapping plate - door striker	1				
10									
11		10160-10i-22		Panel - "B" post inner LH	1				
12									
13		10160-10i-20		Panel - "B" post outer	1				
14									
15		10160-10i-24		Panel - "C" post lower inner RH	1				
16									
17		10160-10i-25		Bracket Assembly - rear hinge support RH	1				
18									
19		10160-10i-26		Reinforcement - rear striker mounting RH	1				
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

REVISIONS

GROUP: 10i Side & Roof Structure

ISSUED

PROJECT NO.

SHEET NO. 3

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.		PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD
1		10160-10j-1	108J10160-10	Panel - roof	1				
2									
3		10160-10j-2	108J10160-8	Panel - front fender - RH	1				
4									
5		10160-10j-3	108J10160-8	Panel - front fender - LH	1				
6									
7		10160-10j-4		Panel - center side - RH upper	1				
8									
9		10160-10j-5		Panel - center side - LH lower	1				
10									
11		10160-10j-6		Panel - rear quarter - RH upper	1				
12									
13		10160-10J-7		Panel - rear quarter - LH upper	1				
14									
15		10160-10j-8		Panel - rear quarter - RH lower	1				
16									
17		10160-10j-9		Panel - rear quarter - LH lower	1				
18									
19		10160-10j-10	108J10160-10	Panel - D post, upper - LH	1				
20									
21		10160-10J-11	108J10160-10	Panel - D post, upper - RH	1				
22									
23		10160-10J-12	108J10160-10	Panel - D post, lower - LH	1				
24									
25		10160-10j-13	108J10160-10	Panel - D post, lower - RH	1				
26									
27		10160-10j-14	108J10160-8	Panel - rear deck cross - lower	1				
28									
29		10160-10j-15		Panel - rear deck cross - upper	1				
30									

REVISIONS

GROUP: 10j Body Exterior Sheet Metal

ISSUED

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.		PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-10k-1		Panel - grille front	1					
2										
3		10160-10k-2		Bracket - license plate mounting rear	1					
4										
5		10160-10g-9		Mirror - outside rear view - door mounted	1*					
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

REVISIONS

GROUP: 10k Body - exterior trim

ISSUED

*assigned in group 10g

PROJECT NO.

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-10L-1	108J10160	Windshield - laminated and tinted	1					
2		10160-10L-001		Weatherstrip - windshield zip strip	1					
3		-002		Trim moulding - weatherstrip lower	1					
4		-003		Trim moulding - weatherstrip upper	1					
5		-004		Trim moulding - weatherstrip RH side	1					
6		-005		Trim moulding - weatherstrip LH side	1					
7		-006		Trim moulding - weatherstrip lower corner	2					
8		-007		Trim moulding - weatherstrip upper corner	2					
9		10160-b-013		Adhesive - weatherstrip	AR	*				3M black
10										
11										
12		10160-10L-2	108J10160	Window - front door RH tempered and tinted	1	(Part of 10160-10A-9 assembly)				
13		10160-10L-3		Window - Front door LH tempered and tinted	1	(Part of 10160-10A-10 assembly)				
14										
15		10160-10L-4		Window - sliding door tempered and tinted	2	(1 on door, 1 on LH panel)				
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

REVISIONS

GROUP: 10L. Glazing

ISSUED

*assigned in front door group

PROJECT NO.

SHEET NO. 1

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-11-1		Bumper Assembly - EA Front (less dir. signals)	1					Metal Spec.
2										
3		10160-11-2		Bumper Assembly - EA Rear	1					Metal Spec.
4										
5		-001		Face Bar - EA Bumper Front	1					Det.Met.Prds
6										
7		-002		Face Bar - EA Bumper Rear	1					Det.Met.Prds
8										
9		-003		Extrusion - bumper face bar	2					Reynolds
10										
11		-004		End cap - bumper face bar LH front, RH rear	2					Dallas Plastic
12										
13		-005		End cap - bumper face bar RH Front, LH Rear	2					Dallas Plastic
14										
15		-006		Energy Absorber Assembly - bumper	4					Delco
16										
17		-007		Bracket - EA bumper mounting front LH	1					Metal Spec.
18										
19		-008		Bracket - EA bumper mounting front RH	1					Metal Spec.
20										
21		-009		Bracket - EA bumper mounting rear reinf.	1					Metal Spec
22										
23		-010		Bracket - EA bumper mounting rear to sill	1					Metal Spec.
24										
25		-012		Attaching hardware - EA bumper systems	AR					
26										
27										
28										
29										
30										

REVISIONS

GROUP: 11 EA Bumper Systems

ISSUED

PROJECT NO

SHEET NO 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

PROJECT NAME: LLCC PARATRANSIT VEHICLE

LAYOUT NO. 108J10160, 108R7000, 108R7020

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-12-1		Kit, - wheelchair restraint complete	1					Amer Safety
2										
3			108B-7001	Belt assembly - wheelchair restraint	2					
4			108B-7001-1	Belt - nylon	1					
5			108B-7007	Clip assembly - wheelchair restraint	1					
6			108A-7007-1	Clip - spring	1					
7			108A-7007-2	Handle - clip	2					
8			108A-7002	Guide tube and bumper assembly	2					
9			108A-7002-1	Guide tube	1					
10			108A-7002	Sponge rubber	1					8570P25*
11			108A-7003	Shaft - roller	2					
12			108A-7004	Roller - corner belt guide assembly	2					
13			108A-7004	Shaft - roller	1					
14			108A-7004-2	Roller - belt	1					
15			-3	Seat - spring	2					
16			-4	Bracket - switch	1					
17			-5	Mounting bracket assembly	1					
18			-6	Spring - corner roller	2					9623K12*
19			-7	Microswitch - corner roller	1					BZ-2RD-A2
20			108A-7005	Tube - guide	2					
21			108A-7006	Roller - belt	2					
22										
23										
24			108A-7020-1	Sleeve - motor shaft	1					
25			108A-7020-2	Reel - strap	1					
26			108A-7020-3	Bracket - ratchet and reel	1					
27			-4	Bushing - teflon	1					
28			-5	Clevis - solenoid	1					
29			-6	Bracket - clutch						
30			-7	Bracket - drive motor						

REVISIONS

GROUP: 12. Belts & Restraints

ISSUED

*McMaster Carr #

PROJECT NO.

SHEET NO. 1

PARTS LIST–AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ. NO. DOT-TSC-1351

PROJECT NAME LLCC PARATRANSIT VEHICLE

LAYOUT NO. 108J10160, 108R7000, 108R7020

NO.	SIZE	PART NO.	Drawing * Reference	PART NAME	AMT REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-12-1	108A-7020-8	Plate - mounting	1					
2			-9	Retainer - belt	1					
3			-10	Shaft - belt reel	1					
4			-11	Bracket - solenoid	1					
5			-12	Gear motor drive assembly - winch	1					
6			-13	Drive assembly - winch	1					
7			-14	Coupling - winch drive	1					
8			-15	Ratchet - winch drive	1					
9			-16	Solenoid	1					
10			108A-7030	Stop - restraint hooks	2					
11			108A-7031	Deflector - restraint hooks	2					
12			108C-7040	Belt guide assembly	2					
13										
14			108R-7000	Attaching hardware - restraint systems	AR					
15			108R-7020	Attaching hardware - winch assembly	AR					
16		10160-12-2		Kit - seat belt and restractor assembly (shoulder)	1					Amer.Safety
17				Seat belt and retractor assembly - driver	1					
18				Attaching hardware - seat belt	AR					
19		10160-12-3		Kit - seat belt assembly (lap)	1					Amer.Safety
20				Seat belt assembly - wheelchair occupant	1					
21				Attaching hardware - seat belt	AR					
22										
23										
24		10160-12-3		Kit - seat belt assembly (lap)	2					Amer.Safety
25				Seat belt assembly - jump seat	1					
26				Attaching hardware - seat belt	AR					
27										
28		10160-12-3		Kit - seat belt assembly (lap)	3					Amer.Safety
29				Seat belt assembly - rear seat occupant	1					
30				Attaching hardware - seat belt	AR					

REVISIONS

GROUP: 12. Belts & Restraints

ISSUED

PROJECT NO.

SHEET NO. 2

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

MASTER PROJ NO. DOT-TSC-1351

LAYOUT NO. 108J10160

PROJECT NAME

LLCC PARATRANSIT VEHICLE

NO.	SIZE	PART NO.		PART NAME	AMT REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD	
1		10160-13-1		Tag - metal vin number - I.P. mounted	1					
2										
3		10160-13-2		Tag - consumer info. LH door mounted	1					
4										
5		10160-13-3		Tag - FMVSS certification	1					
6										
7		10160-13-4		Sticker - tire inflation pressure	1					
8										
9		10160-13-5		Sticker - vehicle acceleration & stopping distance	1					
10										
11		10160-13-6		Manual - operation and maintenance	1					
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
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REVISIONS

GROUP: 13. Vehicle Identification

ISSUED

PROJECT NO

SHEET NO. 1

PARTS LIST—AUTOMOTIVE RESEARCH ENGINEERING

ASL ENGINEERING INC.

PROJECT NAME

LLCC PARATRANSIT VEHICLE

MASTER PROJ. NO. DOT-TSC-1351

LAYOUT NO. 108J10160

NO.	SIZE	PART NO.		PART NAME	AM'T REQ'D	MODEL	FINISH WEIGHT	RELEASE RES.	RELEASE PROD.	
1		10160-14-1		Primer - body	AR					
2										
3		10160-14-2		Enamel - taxi yellow	AR					
4										
5		10160-14-3		Enamel - flat black	AR					
6										
7		10160-14-4		Enamel - vehicle interior trim (off white)	AR					
8										
9		10160-14-5		Gasoline (at shipping) - gallons	12					
10										
11		10160-14-6		Oil - engine - pints	8.5					
12										
13		10160-14-7		Oil - transmission - gallons	1.6					
14										
15		10160-14-8		Coolant - antifreeze mixture (-10°F) - quarts	8					
16										
17		10160-14-9		Sealer - sound insulation - toe board	AR					
18										
19		10160-14-10		Mastic - body sealant	AR					
20										
21		10160-14-11		Sealant - weatherstrip	AR					
22										
23		10160-14-12		Jute - front compartment toe board	AR					
24										
25		10160-14-13		Grease and miscellaneous lubricants	AR					
26										
27		10160-14-14		Fluid - brake	AR					
28										
29		10160-14-15		Fluid - power steering (auto trans)	AR					
30										

REVISIONS

GROUP: 14. Paints, Fuels & Lubes

ISSUED

PROJECT NO.

SHEET NO 1

CALCULATION SHEET

Project	Job Order No.	Calculation Serial No.
LLCC - PTV STRUCTURAL ANALYSIS		

LOADS ANALYSIS

THE FOLLOWING ANALYSIS DEALS WITH THE FLOOR AND SUBFRAME STRUCTURAL ASSEMBLIES OF THE LLCC - PTV. THE ANALYSIS IS LIMITED IN SCOPE TO THE CRITICAL STRUCTURAL ELEMENTS AND JOINTS COMPRISING THESE ASSEMBLIES. THE UPPER BODY STRUCTURE OF THE VEHICLE IS ASSUMED TO BE NON-CRITICAL (FROM A STRUCTURAL LOADING STANDPOINT) AND ITS DESIGN IS BASED ON CURRENT PRACTICES IN AUTOMOTIVE DESIGN. THIS CONSERVATIVE ANALYSIS APPROACH ASSUMES THAT THE OPERATIONAL AND "PANIC" MANEUVERING LOADS ARE REACTED TOTALLY BY THE FLOOR AND SUBFRAME ASSEMBLIES WITH NO ASSISTANCE FROM THE UPPER BODY STRUCTURE.

SYSTEM DEFINITION

A SCHEMATIC OF THE BASIC STRUCTURE OF THE VEHICLE IS SHOWN IN FIGURE 1. THE BASIC STRUCTURE IS CONSTRUCTED FROM MILD STEEL MATERIAL HAVING A YIELD STRENGTH OF 36,000 PSI (MINIMUM). THE UPPER BODY STRUCTURE (WHICH CONTRIBUTES TO THE INERTIAL LOADING OF THE VEHICLE, BUT NOT ITS STIFFNESS - BY ASSUMPTION) CONSISTS OF THE "A", "B", "C" AND "D" PILLARS, ROOF PANEL ASSEMBLY, FRONT END SHEET METAL ASSEMBLY, GLAZING AND DOOR ASSEMBLIES.

THE WEIGHT OF THE VEHICLE (WHICH CONTRIBUTES TO THE INERTIAL LOADING OF THE VEHICLE) CAN BE DIVIDED INTO THE FOLLOWING CATEGORIES:

- SUSPENSION
- WHEELS & TIRES
- MAIN STRUCTURE
- BODY STRUCTURE
- POWER DRIVE
- FUEL SYSTEM
- STEERING SYSTEM
- WHEELCHAIR ACCOMMODATIONS
- DRIVER ACCOMMODATIONS
- PASSENGER ACCOMMODATIONS
- AIR CONDITIONING (HEATING & COOLING)
- OCCUPANTS
- MISCELLANEOUS

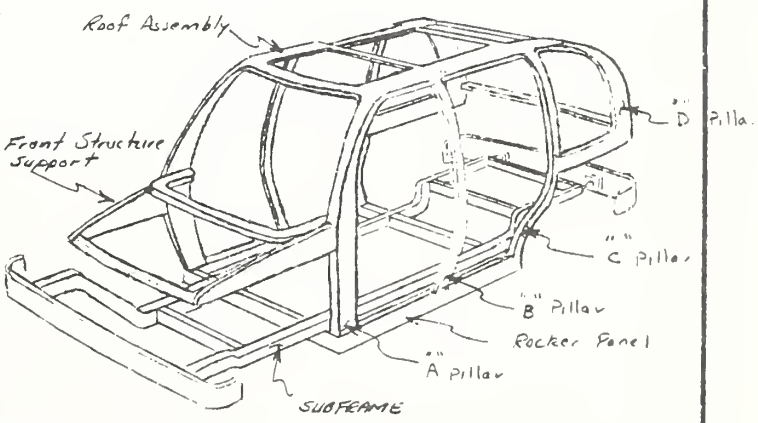

FIGURE 1

Prepared By	Date
L. S. PAULS	4 AUG '77
Checked By	**Date**

CALCULATION SHEET

Project	Job Order No.	Calculation Serial No.
LLCC – PTV STRUCTURAL ANALYSIS		

THE ASSUMED WEIGHT BREAKDOWN FOR THE LLCC-PTV IS AS FOLLOWS:

ITEM	WEIGHT (lbs)	SUSPENDED WEIGHT (lbs)
FRONT SUSPENSION	182	91
REAR SUSPENSION	105	53
WHEELS + TIRES (4)	152	—
MAIN STRUCTURE	542	542
BODY	730	730
ENGINE	370	370
TRANSAXLE	150	150
FUEL SYSTEM	140	140
STEERING SYSTEM	40	40
WHEELCHAIR RAMP	42	42
WHEELCHAIR RESTRAINT	18	18
DRIVER ACCOMMODATIONS	172	172
PASSENGER ACCOMMODATIONS	48	48
SEATS (DRIVER + PASSENGER)	151	151
HEATER	33	33
AIR CONDITIONING	72	72
MISCELLANEOUS	418	418
DRIVER OCCUPANT (95th % MALE)	215	215
PASSENGERS (5-50th % MALES)	820	820
TOTAL	4400 lbs	4105 lbs

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LLCC - PTV STRUCTURAL ANALYSIS		

THE WEIGHT OF THE VEHICLE IS ASSUMED TO BE DIVIDED INTO CONCENTRATED AND DISTRIBUTED COMPONENTS AS FOLLOWS:

- CONCENTRATED WEIGHT COMPONENTS (SUSPENDED) *

ITEM	STATION (IN)	WEIGHT (lbs)
FRONT SUSPENSION	0	91
REAR SUSPENSION	112	52
ENGINE	-10	370
TRANSMISSION	5	150
DRIVER SEAT	45	32
FRONT PASSENGER SEATS	70	55
REAR PASSENGER SEATS	~112	64
BODY (1/3 EA. STATION)	10, 55, 98	243
FUEL TANK	125	140
DRIVER (95th % male)	45	215
FRONT PASSENGERS (3-50th % Males)	70	492
REAR PASSENGERS (2-50th % Males)	112	328
	TOTAL	2719 lbs

- DISTRIBUTED WEIGHT COMPONENT (SUSPENDED)

THE DISTRIBUTED WEIGHT COMPONENT IS COMPUTED FROM THE FOLLOWING: *

$$\bar{w} = [\Sigma W_{SUSPENDED} - \Sigma W_{CONCENTRATED}] / L$$

$$= (4105 - 2719) / 173$$

$$= 8.01 \text{ lb/in}$$

* SEE FIGURE 2 FOR DIMENSIONAL REFERENCE.

Prepared By	Date
L.S. PAULS	4 AUG '77
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CALCULATION SHEET

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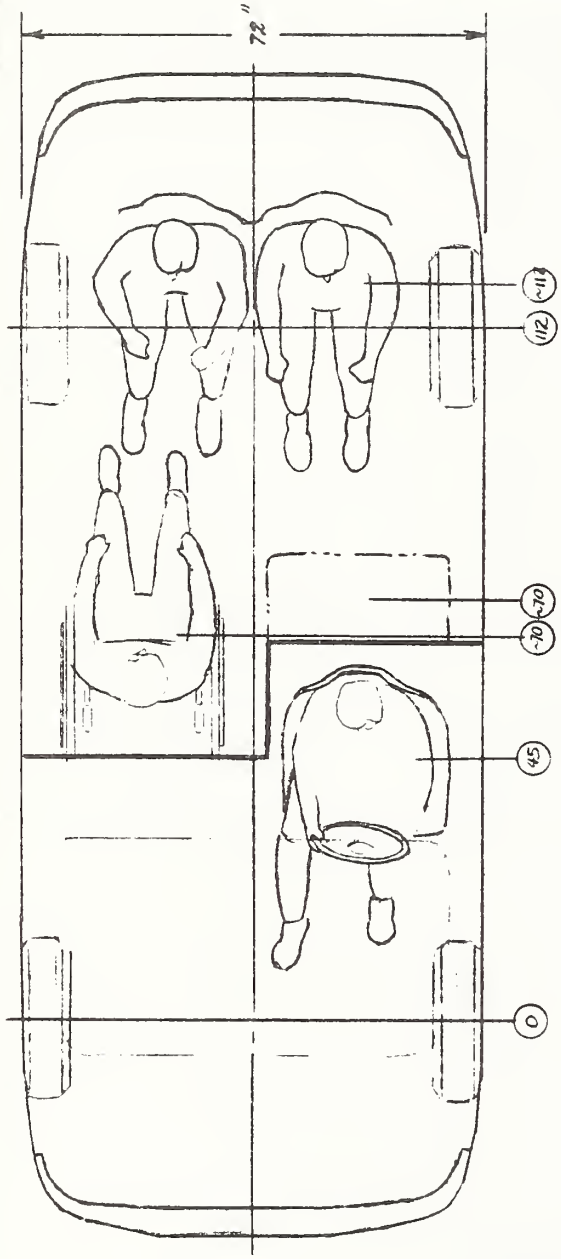
LLCC-PTV STRUCTURAL ANALYSIS		



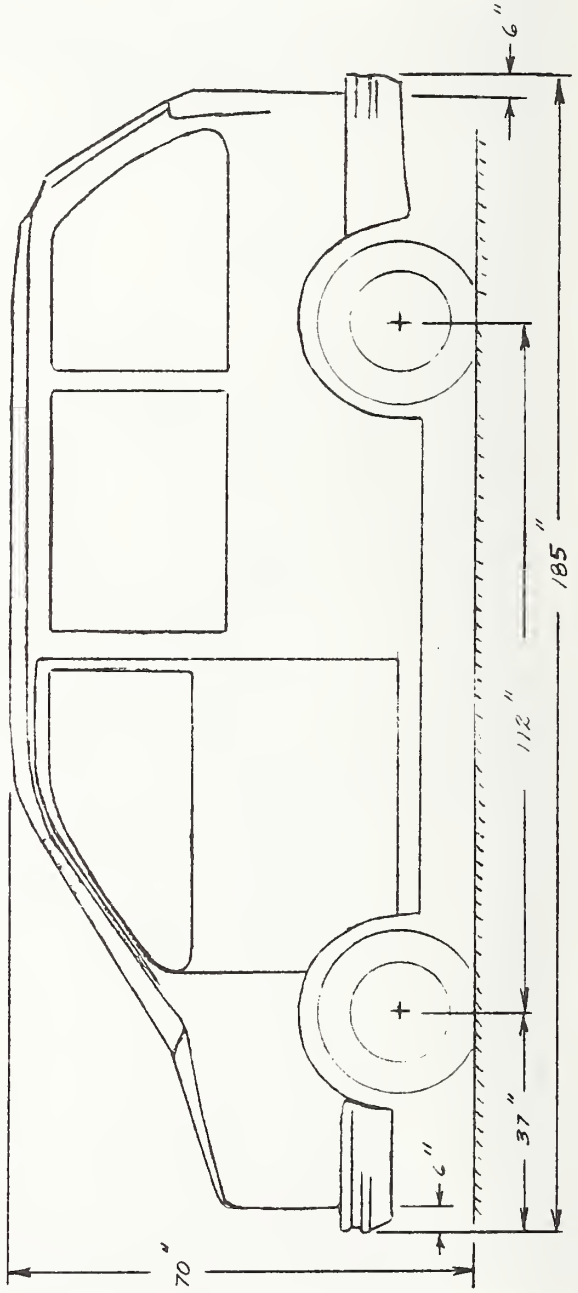


FIGURE 2

Prepared By	Date
L.S. PAULS	4 AUG '77
Checked By	**Date**

Project	Job Order No.	Calculation Serial No.
LLCC - PTV STRUCTURAL ANALYSIS		

LOADING CONFIGURATIONS

THE LOADING CONFIGURATIONS EVALUATED IN THIS ANALYSIS ARE CATEGORIZED AS FOLLOWS:

- MAXIMUM VERTICAL ROAD LOADS
- "PANIC" MANEUVERING LOADS
- 5 MPH, NO DAMAGE BUMP LOADS

Maximum Vertical Road Loads

THE MAXIMUM VERTICAL ROAD LOADS ARE DEVELOPED WHEN THE VEHICLE IS OPERATED OVER ROUGH ROADWAYS AT MODERATE SPEEDS. REFERENCE 1 SUGGESTS THE FOLLOWING FOR THIS LOADING CONFIGURATION*:

$$F_{design} = DAF \times FOS \times F_{static} \quad \ldots\ 1)$$

WHERE,

DAF = DYNAMIC AMPLIFICATION FACTOR (= 1.75)
FOS = FACTOR OF SAFETY (= 1.7)

$$\therefore \quad F_{design} = 3.0 \times F_{static} \quad \ldots\ 2)$$

NOW, FOR THIS LOADING CONFIGURATION THE DESIGN LOADS WILL BE TRANSMITTED TO THE FRONT AND REAR AXLES VIA THE TWO LONGITUDINAL FLOOR SILLS (ASSUMING THE ROOF STRUCTURE CARRIES NO LOAD). FIGURE 3 SHOWS THE FLOOR SILLS LOADED BY THE CONCENTRATED AND DISTRIBUTED VERTICAL STATIC WEIGHT COMPONENTS (THESE WEIGHT COMPONENTS MUST BE MULTIPLIED BY 3.0 TO OBTAIN THE DESIGN LOADS). THE REACTION LOADS R_L & R_R ARE DETERMINED AS FOLLOWS:

$$\Sigma \vec{M}_0 = 0 = -10(370) + 150(5) + 243(10) + 247(45) + 243(55) + 547(70) + 243(98) + 444(112) + 140(125) + \bar{W}LL_{cg} - R_R(112)$$

$$\therefore \quad R_R = [153,792 + 8.01(173)(55.5)]/112$$

$$\boxed{R_R = 2055 \text{ lbs}}$$

* REFERENCE 1 PERTAINS TO HIGHWAY TRUCK FRAME DESIGN, BUT IS CONSIDERED TO BE APPROPRIATE HERE.

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$$\Sigma F_y = 0 = R_L + R_R - 370 - 91 - 150 - 243 - 215 - 32 - 243 - 492 - 55 - 243 - 328 - 64 - 52 - 140 - 8.01(173)$$

$$\therefore \quad \boxed{R_R = 2049 \text{ lbs}}$$

THE SHEAR AND MOMENT DIAGRAMS SHOWN ON PAGE 6 MAY NOW BE CONSTRUCTED USING A STANDARD "TEXT-BOOK" APPROACH. THE INTERNAL SHEAR AND MOMENT LOADS SHOWN ON PAGE 7 MUST BE MULTIPLIED BY 3.0 TO OBTAIN THE YIELD DESIGN LOADS.

"Panic" Manouvering Loads

THE "PANIC" MANEUVERING LOADS ARE A RESULT OF EXTREME BRAKING AND ACCELERATION AND FRONT SIDE SKIDDING. IN DEALING WITH THESE LOADING CONDITIONS THE PATCH LOAD DESIGNATIONS ON PAGE 8 WILL BE USED.

Patch Loads: *

a) Vertical Load P_{Z_F} & P_{Z_R} (STATIC)

$$P_{Z_F} = \tfrac{1}{2} \times 2055 \qquad \text{(see Page 7)}$$

$$= 1028 \text{ lbs} \qquad \text{(See page 7)}$$

$$P_{Z_R} = \tfrac{1}{2} \times 2049$$

$$= 1025 \text{ lbs}$$

b) Vertical Load - Braking Mode

Assume that the COEFFICIENT OF FRICTION BETWEEN THE GROUND AND TIRES IS $\mu = 0.75$. ASSUME ALSO THAT $CG_Z \approx 24"$. THEN,

$$\Sigma \overset{+}{M_Z} = 0 \qquad \text{(D'ALEMBERT'S PRINCIPAL)}$$

$$m_{SUS}\, \bar{a}_x\, (CG_Z) + W_{SUS}\,(56) - 2P_{Z_F}\,(112) = 0$$

$$\therefore \quad P_{Z_F} = [m_{SUS}\, \bar{a}_x\, CG_Z + W_{SUS}\,(56)]/2(112)$$

* ONLY VERTICAL LOADS ARE OF INTEREST HERE SINCE IT IS ASSUMED THAT HORIZONTAL PATCH LOADS ARE REACTED BY SHEAR WEBS AND SUSPENSION COMPONENTS.

CALCULATION SHEET

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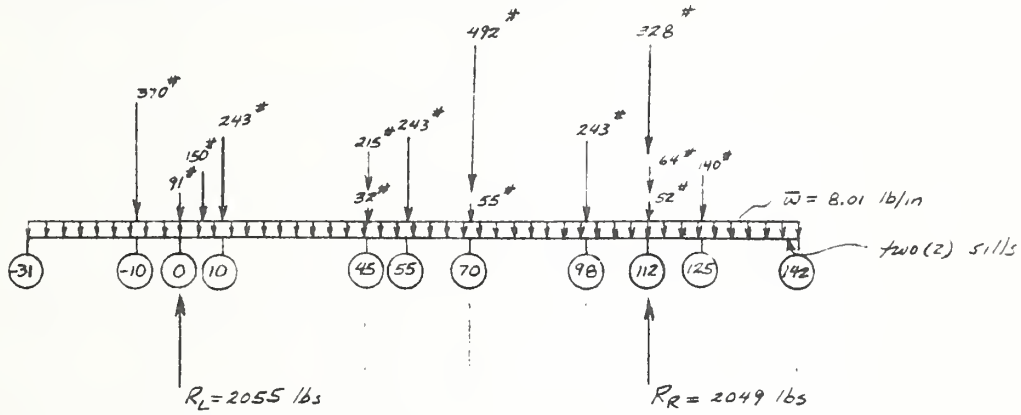
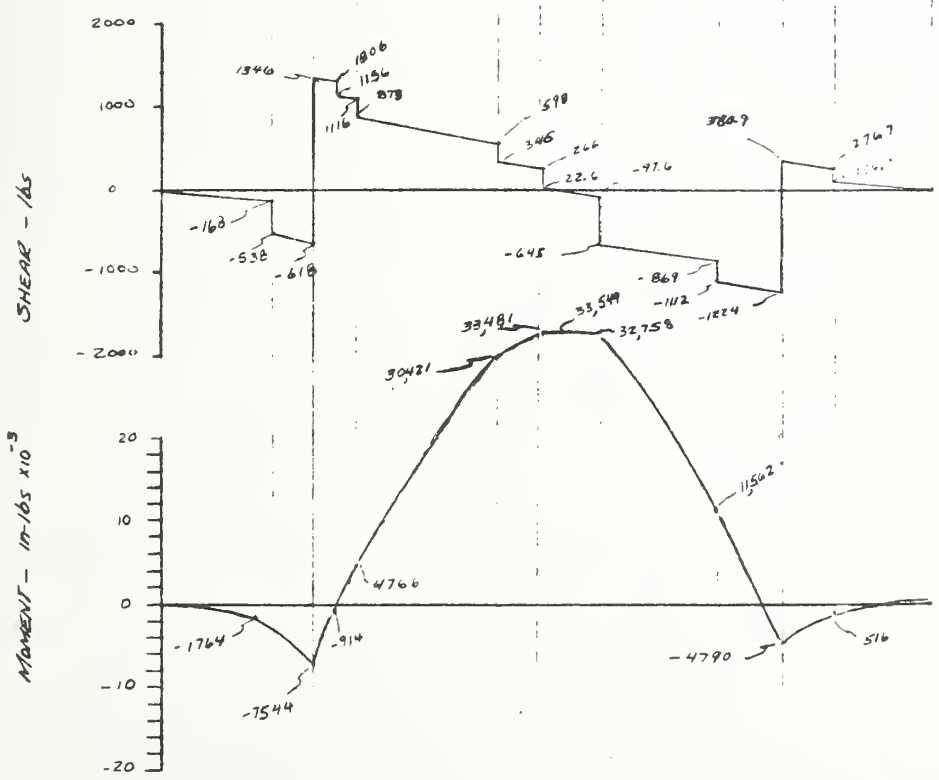
LLCC - PTV STRUCTURAL ANALYSIS		





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L. S. PAULS	4 AUG '77
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CALCULATION SHEET

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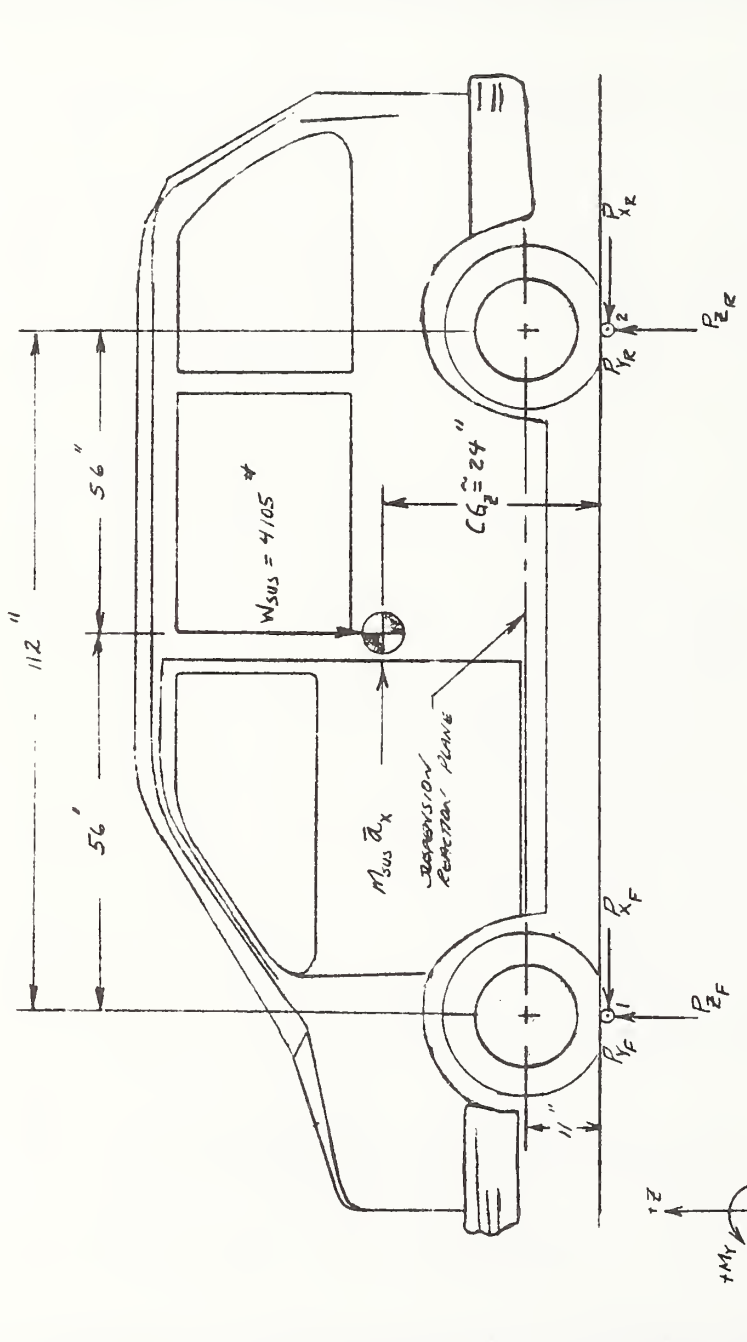
LLCC - PTV STRUCTURAL ANALYSIS		



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L.S. PAULS	9-9-77
Checked By	**Date**

NOW, BY D'ALEMBERT'S PRINCIPAL,

$$m_{SUS}\,\bar{a}_x - 2P_{x_F} - 2P_{x_R} = 0$$

THUS,

$$m_{SUS}\,\bar{a}_x = 2P_{x_F} + 2P_{x_R}$$

THE LONGITUDINAL FORCES P_{x_F} & P_{x_R} ARE DETERMINED AS FOLLOWS:

$$P_{x_F} \cong .4\,P_{z_{F_{ST}}} \qquad (P_{z_{F_{ST}}} = \text{STATIC PATCH LOAD})$$
$$= .75\,(1028)$$
$$= 771 \text{ lbs}$$

$$P_{x_R} = .75\,(1025)$$
$$= 767 \text{ lbs}$$

THUS,

$$m_{SUS}\,\bar{a}_x = 2(771) + 2(767)$$
$$= 3076 \text{ lbs}$$

$$\therefore \quad P_{z_F} = [3076\,(24) + W_{SUS}\,(56)]\,/\,2(112)$$
$$= [3076(24) + 4105(56)]/2(112)$$

$$\boxed{P_{z_F} = 1356 \text{ lbs}}$$

$$\overset{+}{\circlearrowleft} \Sigma M_1 = 0$$

$$-m_{SUS}\,\bar{a}_x\,CG_x - W_{SUS}\,(56) + 2P_{z_R}\,112 = 0$$

$$\therefore \quad P_{z_R} = [\,W_{SUS}\,(56) + m_{SUS}\,\bar{a}_x\,CG_x\,]\,/\,2(112)$$
$$= [4105(56) + 3076\,(24)]\,/\,2(112)$$

$$\boxed{P_{z_R} = 697 \text{ lbs}}$$

Prepared By	Date
L.S. PAULS	9 Sept '77
Checked By	**Date**

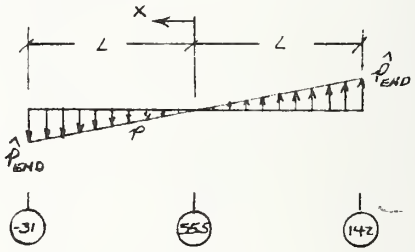
Project
LLCC – PTV STRUCTURAL ANALYSIS

Job Order No.

Calculation Serial No.

THE APPROXIMATE LOAD DISTRIBUTION IN THE FLOOR AND SUB-FLOOR STRUCTURE, FOR THE "PANIC" BRAKING MODE, IS DETERMINED AS FOLLOWS. THE TOTAL VERTICAL LOAD ACTING AT THE FRONT AND REAR TIRE PATCHES ARE $2 \times 1356 = 2712$ lbs AND $2 \times 697 = 1394$ lbs RESPECTIVELY. SHEAR AND MOMENT DIAGRAMS FOR THIS LOADING CASE ARE SHOWN ON PAGE 11. THE PITCHING MOMENT DUE TO BRAKING INERTIA SETS UP AN UNSYMMETRICAL LOAD DISTRIBUTION WHICH IS SUPERIMPOSED ON THE STATIC LOAD DISTRIBUTION AS SHOWN ON PAGE 11. THIS LOAD DISTRIBUTION IS COMPUTED AS FOLLOWS:

$$M_{PITCH} = \int_{-L}^{L} p x \, dx$$



NOW,

$$\hat{p} = Kx$$

WHERE,

$$K = \hat{p}_{END}/L$$

$$\therefore \quad \hat{p} = \hat{p}_{END} x/L$$

AND,

$$M_{PITCH} = \frac{\hat{p}_{END}}{L} \int_{-L}^{L} x^2 dx$$

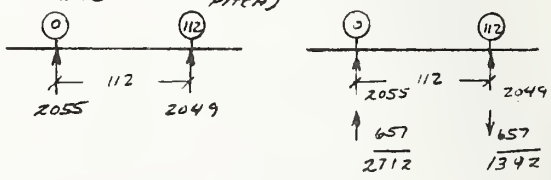
$$= \frac{\hat{p}_{END}}{L} \frac{x^3}{3} \Big|_{-L}^{L}$$

$$= \frac{2}{3L} \hat{p}_{END} L^3$$

COMPARING THE BRAKING REACTION LOADS WITH THE STATIC REACTION LOADS WE MAY COMPUTE THE PITCHING MOMENT (M_{PITCH}).

$$M_{PITCH} = 657\,(112)$$

$$= 73584 \text{ in-lbs}$$



STATIC REACTION LOADS

BRAKING REACTION LOADS

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CALCULATION SHEET

Project: LLCC - DTV STRUCTURAL ANALYSIS

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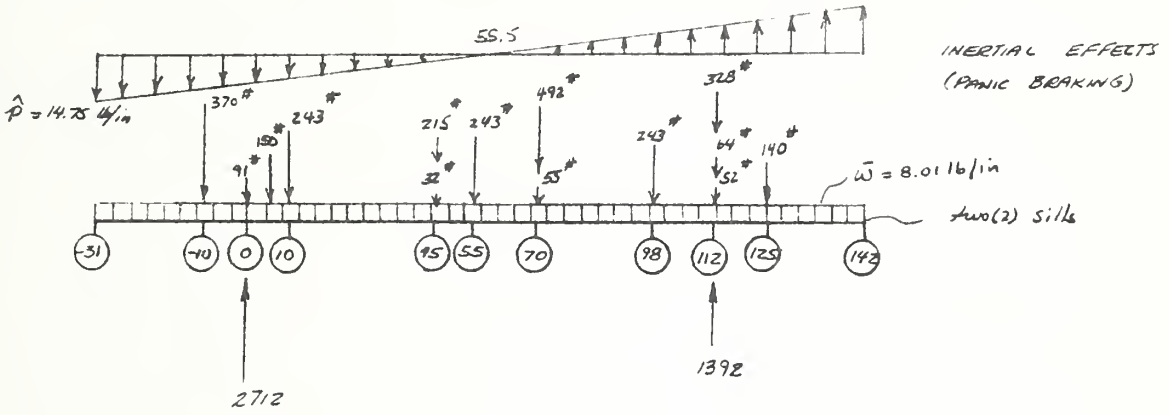
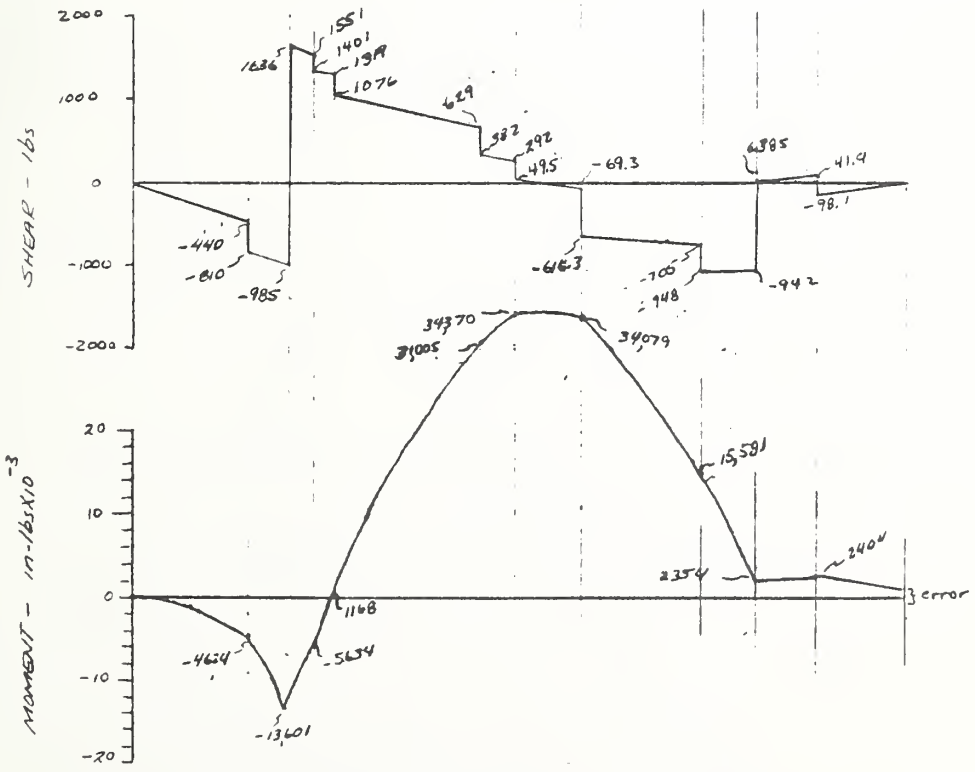


LOAD DISTRIBUTION - BRAKING MODE



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Date: 9-13-77

Checked By:

Date:

THUS,

$$73{,}584 = \frac{2}{3L}\hat{P}_{END}L^2$$

AND,

$$\hat{P}_{END} = 73{,}584\left(\frac{3}{2}\right)/L^2$$

$$= 73{,}584\left(\frac{3}{2}\right)/(86.5)^2$$

$$\boxed{\hat{P}_{END} = 14.75 \text{ lb/in}}$$

$$\therefore \quad K = \hat{P}_{END}/L$$

$$= 14.75/86.5$$

$$\boxed{K = .1705 \text{ lb/in}^2}$$

THESE VALUES ARE USED TO COMPUTE THE SHEAR AND MOMENT DISTRIBUTIONS SHOWN ON PAGE 11. THE SHEAR AND MOMENTS ARE TO BE MULTIPLIED BY A FACTOR 3.0 TO OBTAIN THE YIELD DESIGN LOADS.

C) Vertical Loads – Acceleration Mode

ASSUME THAT THE COEFFICIENT OF FRICTION BETWEEN THE GROUND AND TIRES IS $\mu = 0.75$. ASSUME ALSO THAT $CG_Z = 24"$. THEN,

$$\overset{\curvearrowleft}{\Sigma M_2} = 0 \qquad \text{(USING D'ALEMBERT'S PRINCIPAL)}$$

$$= -M_{SUS}\,\bar{a}_x\,CG_Z + W_{SUS}(56) - 2P_{Z_F}(112)$$

$$\therefore \quad P_{Z_F} = [W_{SUS}(56) - M_{SUS}\,\bar{a}_x\,CG_Z]/2(112)$$

NOW, BY D'ALEMBERT'S PRINCIPAL, WE HAVE (SEE PAGE 8)

$$\Sigma F_X - M\bar{a}_x = 0$$

$$2P_{X_F} + 2P_{X_R} - Ma_x = 0$$

THE LONGITUDINAL FORCES P_{x_F} & P_{x_R} ARE COMPUTED AS FOLLOWS:

$$P_{x_F} \cong 4\, P_{z_{F_{ST}}}$$
$$= .75\left(\tfrac{1}{2} \cdot 2055\right)$$
$$= 771 \text{ lbs}$$

$$P_{x_R} \cong 4\, P_{z_{R_{ST}}}$$
$$= .75\left(\tfrac{1}{2} \cdot 2049\right)$$
$$= 767 \text{ lbs}$$

$\therefore$

$$m\bar{a}_x = 2(771) + 2(767)$$
$$= 3076 \text{ lbs}$$

THUS,

$$P_{z_F} = [4105(56) - 3076(24)]/2(112)$$

$$\boxed{P_{z_F} = 697 \text{ lbs}}$$

SIMILARLY,

$$\Sigma \overset{+}{M}_1 = 0$$
$$= -m_{SUS}\bar{a}_x CG_z - W_{SUS}(56) + 2P_{z_R}(112)$$

$\therefore$

$$P_{z_R} = [m_{SUS}\bar{a}_x CG_z + W_{SUS}(56)]/2(112)$$
$$= [3076(24) + 4105(56)]/2(112)$$

$$\boxed{P_{z_R} = 1356 \text{ lbs}}$$

THE INERTIAL LOAD DISTRIBUTION IN THE VEHICLE FLOOR AND SUB-FLOOR STRUCTURE, FOR THE ACCELERATION MODE, IS EQUAL AND OPPOSITE TO THAT DETERMINED ON PAGES 10 & 12. THIS LOAD DISTRIBUTION (ACCELERATION INERTIA LOAD) IS SHOWN SUPERIMPOSED ON THE STATIC LOADS ON PAGE 15. THE SHEAR AND MOMENT VALUES SHOWN ON PAGE 15 MUST BE SCALED BY A FACTOR 3.0 TO OBTAIN THE DESIGN YIELD LOADS. PAGE 16 SUMMARIZES THE STATIC, PANIC BRAKING AND MAXIMUM ACCELERATION SHEAR AND MOMENT LOADS AND SHOWS THE MAXIMUM SHEAR AND MOMENT ENVELOPES TO BE USED LATER IN THE STRESS CALCULATIONS. THESE MAXIMUM SHEAR AND MOMENT LOADS MUST BE SCALED BY A FACTOR 3.0 TO OBTAIN THE DESIGN YIELD LOADS.

5 MPH, NO DAMAGE BUMP LOADS

THE NO DAMAGE BUMP LOADS RESULT FROM LOW SPEED (5MPH) IMPACTS INTO A RIGID BARRIER. THE FOLLOWING ASSUMPTIONS ARE MADE HERE:

- MAXIMUM BUMPER STROKE = 4"
- IMPACT SPEED (BOTH FRONTAL & REARWARD) = 5 MPH

NOW FROM KINEMATICS

$$V\,dV = \eta a\,ds$$

OR

$$\frac{V^2}{2} = \eta a S$$

WHERE,

V = IMPACT SPEED
a = VEHICLE ACCELERATION
S = STROKE
η = STROKE EFFICIENCY

ASSUME:

$\eta = .75$
$V = 5$ MPH
$S = 3$ in

THEN,

$$a = \left(\frac{5}{60} \cdot 88 \cdot 12\right)^2 / .75(3)(2) = 1721 \text{ in/sec}^2$$

$$= 1721/386.4 = 4.45 \text{ g's}$$

CALCULATION SHEET

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LLCC – PTV STRUCTURAL ANALYSIS

Job Order No.

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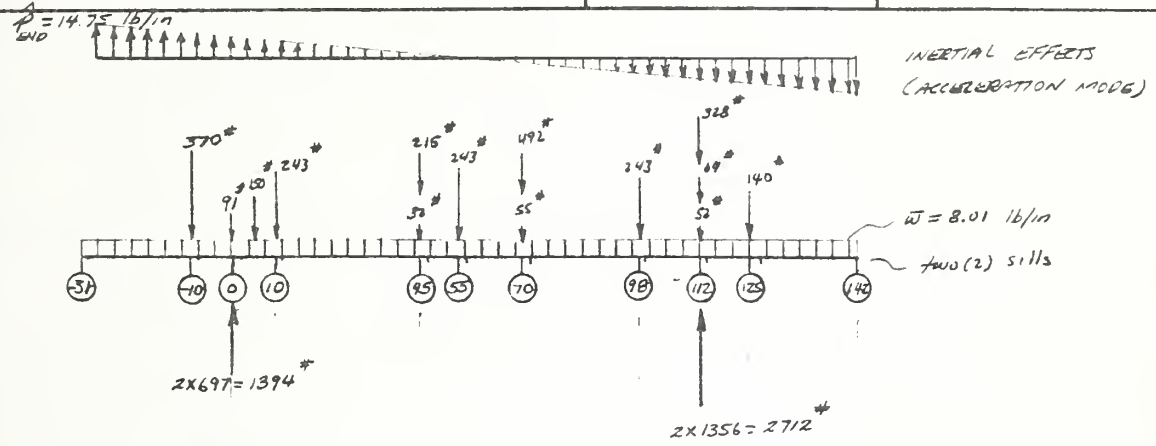
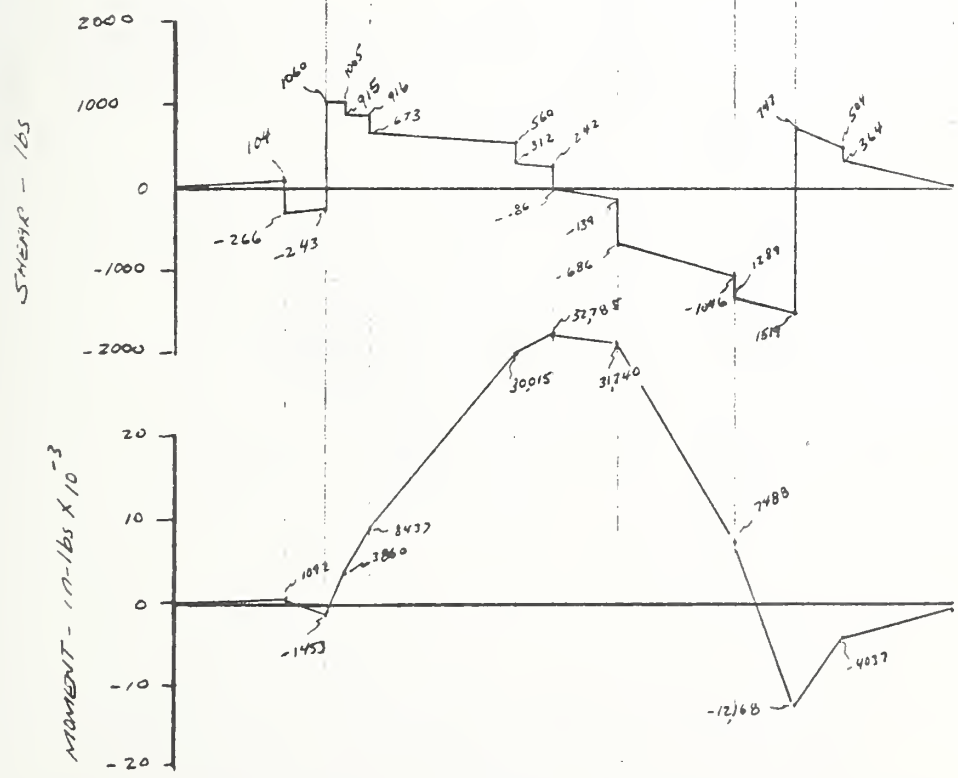


LOAD DISTRIBUTION - ACCELERATION MODE



Prepared By L.S. PAULS

Date 9/15/77

Checked By

Date

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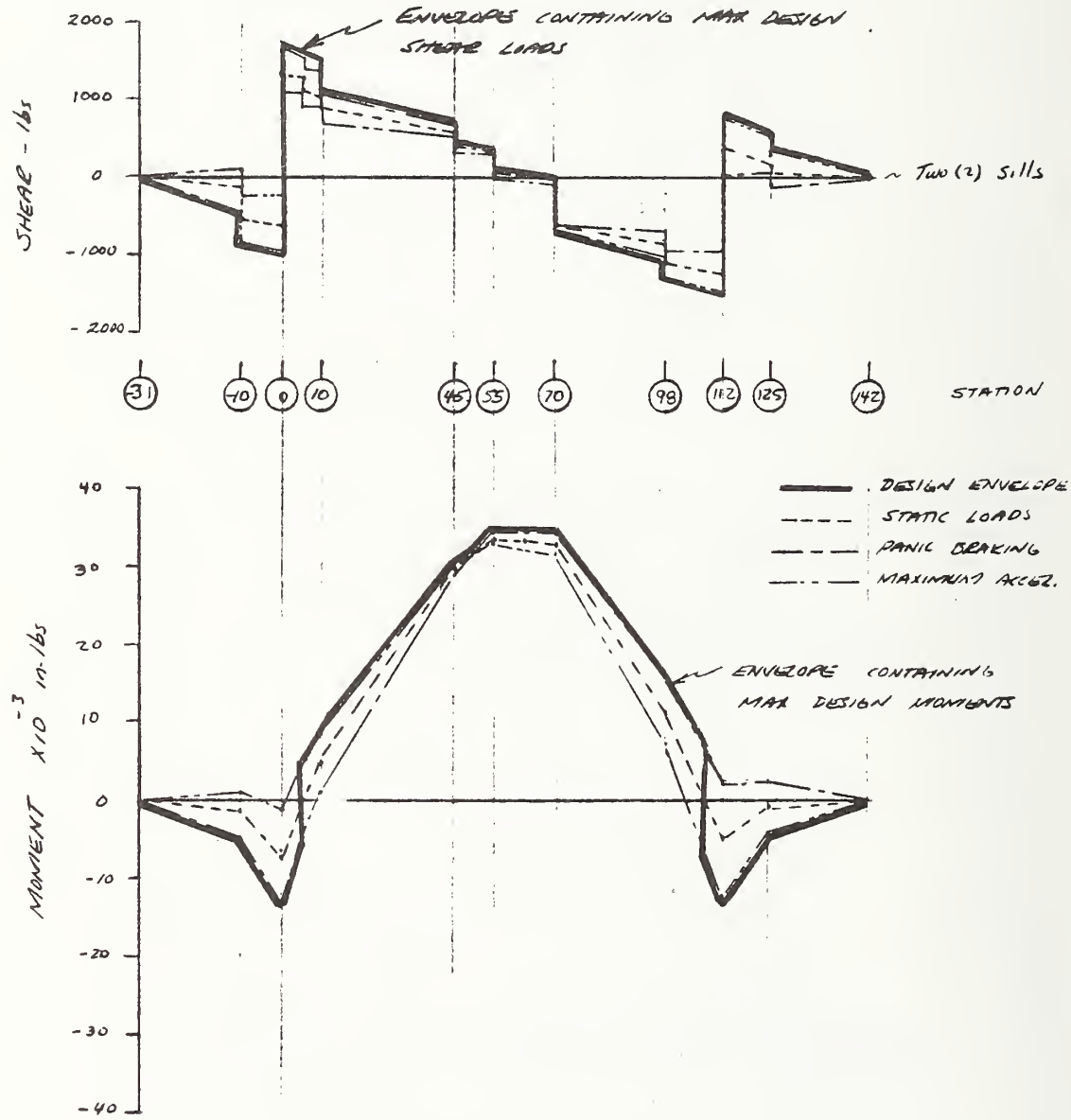
CALCULATION SHEET

Project: LLCC – PTV STRUCTURAL ANALYSIS

Job Order No.:

Calculation Serial No.:



Prepared By: L.S. PAULS

Date: 9-15-77

Checked By:

Date:

Project: LLCC-PTV STRUCTURAL ANALYSIS | Job Order No. | Calculation Serial No.

THE FRAME REACTION FORCE IS,

$$F_{BUMP} = a(g's) \times WT_{VEH}$$

$$= 4.45\ (4400)$$

$$\boxed{F_{BUMP} = 19,596\ \text{lbs (TOTAL)}}$$

THE ABOVE LOAD ACTS ON THE ENDS OF THE VEHICLE. TO FIND LOADS INTERIOR TO THE VEHICLE WE MUST ACCOUNT FOR THE INERTIAL LOAD DISTRIBUTION AS FOLLOWS:

*

$$P_1 = F_{BUMP} - \bar{a}_x \left[WT_{ENG/TRAN} + WT_{SUS_F} + \tfrac{1}{3} WT_{BODY/STRU} \right]$$

WHERE,

P_1 = LONGITUDINAL FORCE ACTING ON SILLS AT FORWARD JOINT (STATION 25, PAGE 20)

$\bar{a}_x$ = VEHICLE ACCELERATION - g's

WT = INDICATED WEIGHT COMPONENTS

$$P_1 = 19,596 - 4.45 \left[520 + 182 + 424 \right]$$

$$\boxed{P_1 = 14,585\ \text{lbs (TOTAL)}}$$

**

$$P_1 = F_{BUMP} - \bar{a}_x \left[WT_{SUS_R} + WT_{FUEL} + \tfrac{1}{3} WT_{BODY/STRU} \right]$$

$$= 19,596 - 4.45 \left[105 + 140 + 424 \right]$$

$$\boxed{P_1 = 16,619\ \text{lbs (TOTAL)}}$$

* FRONTAL IMPACT

** REARWARD IMPACT, AT STATION 104 (SEE PAGE 19)

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L.S. PAULS	9-15-77
Checked By	**Date**

STRESS ANALYSIS

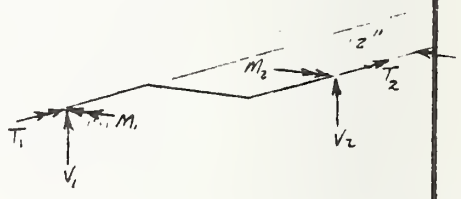
THE STRESS ANALYSIS PRESENTED HERE IS CONFINED TO THE VEHICLE FLOOR AND SUB-FLOOR STRUCTURAL SYSTEMS. IT HAS BEEN CONSERVATIVELY ASSUMED THAT THESE STRUCTURAL SYSTEMS "CARRY" ALL OF THE RIDING, MANEUVERING AND BUMP LOADS EXPERIENCED BY THE VEHICLE. OTHER PARTS OF THE VEHICLE (e.g. ROOF ASSEMBLY, SUSPENSION, FRONT-END SHEET METAL e.t.c.) ARE EITHER PURCHASED PARTS (FROM VEHICLES COMPARABLE IN SIZE AND PERFORMANCE TO THE LLCC-PTV) OR ARE ASSUMED TO BE NON-CRITICAL STRUCTURAL MEMBERS, FOR THE LOADING CONDITIONS CONSIDERED HEREIN, AND ARE THEREFORE SUBJECT TO CURRENT PRACTICES IN AUTOMOTIVE DESIGN.

THREE (3) REGIONS OF THE FLOOR AND SUB-FLOOR STRUCTURE WILL BE EVALUATED FOR STRESS USING THE LOAD DISTRIBUTIONS DEFINED ON PAGES 16 AND 17. PAGE 19 SHOWS A SCHEMATIC OF THE SUB-FLOOR STRUCTURE AND THE REGIONS TO BE EVALUATED. THE FOLLOWING SECTIONS DOCUMENT THE STRESS ANALYSIS.

REGION A (SEE PAGE 19)

TWO LOADING CONDITIONS ARE CONSIDERED FOR THIS STRUCTURAL REGION. FIRST IS THE RIDING AND MANEUVERING LOADING CONDITIONS WITH THE LOADING DISTRIBUTION AS SHOWN ON PAGE 16. SECOND IS THE LOW SPEED BUMP LOADS WITH THE LOADING INDICATED ON PAGE 17.

Riding and Maneuvering Loads



FROM PAGE 16 THE SHEAR LOADS $\bar{V}_{25}$ & $\bar{V}_{40}$ ACTING AT STATION 25 in & 40 in RESPECTIVELY ARE.

$\bar{V}_{25} = 1000$ lbs (ACTING ON TWO SILLS)

$\bar{V}_{40} = 800$ lbs (ACTING ON TWO SILLS)

HENCE, USING A DESIGN FACTOR (F.OS x D.A.5 = 3.0)

$V_1 = 3\bar{V}_{25}/2 = 1500$ lbs/sill

$V_2 = 3\bar{V}_{40}/2 = 1200$ lbs/sill

CALCULATION SHEET

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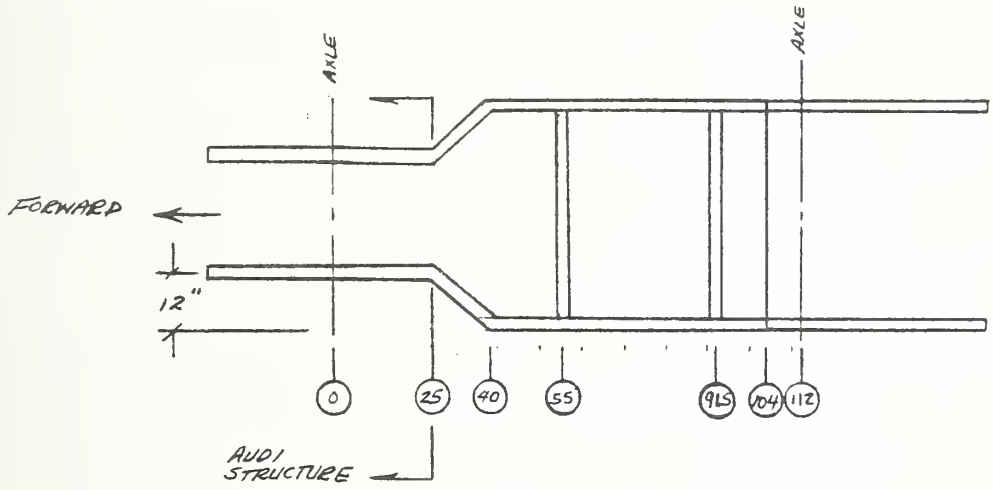
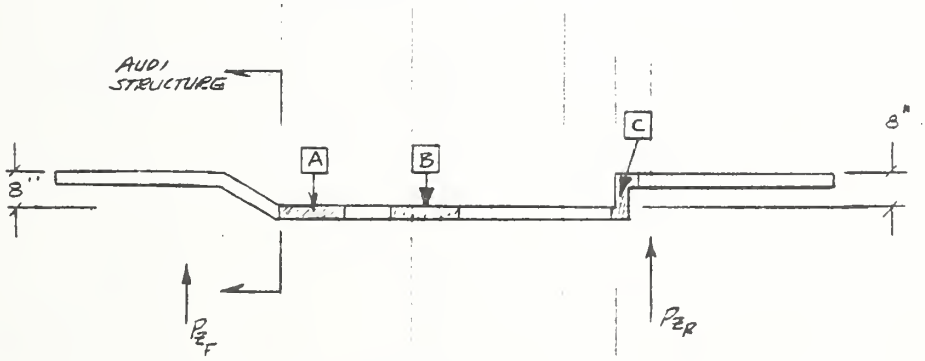


FLOOR SUB-FRAME, TOP VIEW



FLOOR SUB-FRAME, SIDE VIEW

□ INDICATES AREAS TO BE ANALYZED

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CALCULATION SHEET

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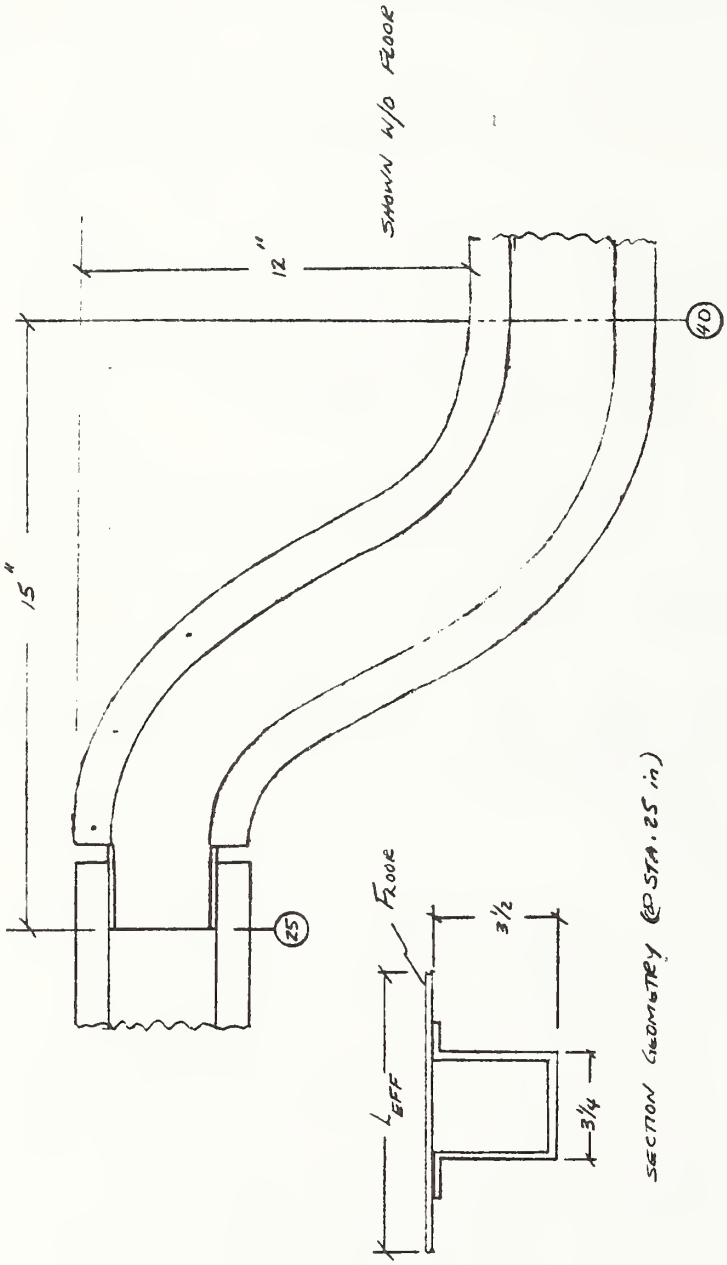

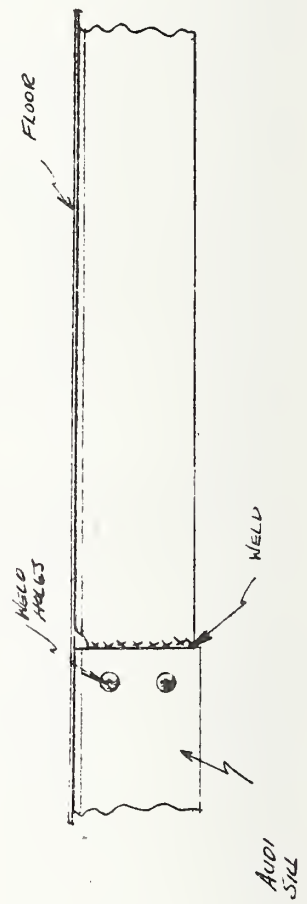

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Riding and Maneuvering Loads .... cont'd

FROM PAGE 16 THE BENDING MOMENT LOADS $\bar{M}_{25}$ AND $\bar{M}_{40}$ ACTING AT STATION 25 in & 40 in RESPECTIVELY ARE:

$\bar{M}_{25} = 19{,}000$ in-lbs (two sills)

$\bar{M}_{40} = 28{,}000$ in-lbs (two sills)

HENCE, USING A DESIGN FACTOR (F.O.S. × D.A.F. = 3.0) EACH SILL WILL BE DESIGNED FOR THE FOLLOWING LOADS:

$$M_1 = 3\,\bar{M}_{25}/2 = 28{,}500 \text{ in-lb}$$

$$M_2 = 3\,\bar{M}_{25}/2 = 42{,}000 \text{ in-lb}$$

THE TORSION LOADS ACTING ALONG THE SILL ARE A RESULT OF THE 12" JOG IN THE SILL (SEE PAGE 20). THE EFFECTIVE TORSION LOAD IS COMPUTED AS FOLLOWS:

$T_1 \equiv T_2$ (ASSUMED)

$T_1 + T_2 = V_2\,(12)$

OR

$T_1 = T_2 = T$

AND

$T = 6\,V_2$

$= 6(1200)$

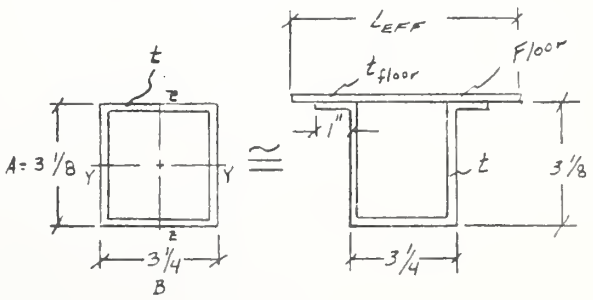
$$T = 7200 \text{ in-lbs} \quad \text{(design load)}$$

Section @ Sta - 25 in

$$I_{YY} \cong \frac{2t(3.125)^3}{12} + 2t(3.25)\left(3.\frac{125}{2}\right)^2$$

$= 5.09t + 15.87t$

$= 20.96t \text{ in}^4$



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Riding & Maneuvering Loads .... Cont'd

$$I_{zz} \cong \frac{2}{12} t (3.25)^3 + 2(t)(3.125)\left(\frac{3.25}{2}\right)^2$$

$$= 5.72\,t + 16.50\,t$$

$$= 22.2\,t \text{ in}^4$$

CALCULATE MATERIAL THICKNESS REQUIREMENTS FOR BENDING

$$\sigma_b = \frac{M c}{I}$$

$$\sigma_b = \frac{M_1 c}{I_{yy}}$$

$$\sigma_b = \frac{28{,}500\left(\frac{3.125}{2}\right)}{20.96\,t}$$

FOR MILD STEEL,

$$\sigma_{YIELD} \cong 36{,}000 \text{ psi}$$

LET $\sigma_b = \sigma_{YIELD}$ THEN,

$$t = \frac{28{,}500\left(\frac{3.125}{2}\right)}{20.96\,(36000)}$$

$$\boxed{t = .059 \text{ in} \quad (16 \text{ gage})}$$

CHECK SHEARING STRESS OF SECTION

$$\sigma_s = \frac{V_1}{A_{2S}} + \frac{I}{2[A]t}$$

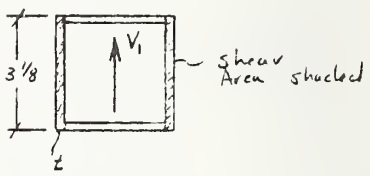
FOR DIRECT SHEAR THE EFFECTIVE SHEAR AREA IS

$$A_{shear}{}_{2S} = 2\,t\,(3.125)$$

$$= 2(.059)(3.125)$$

$$= .369 \text{ in}^2$$

$$\sigma_{S_{direct}} = 1500/.369 = 4065 \text{ psi}$$



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Riding & Maneuvering Loads .... cont'd

FOR TORSION,

$$\sigma_{s_{TORSION}} = \frac{T}{2[A]t} = \frac{7200}{2(3.125)(3.25)(.059)}$$

$$= 6008 \text{ psi}$$

$\therefore$

$$\sigma_s = 4065 + 6008$$

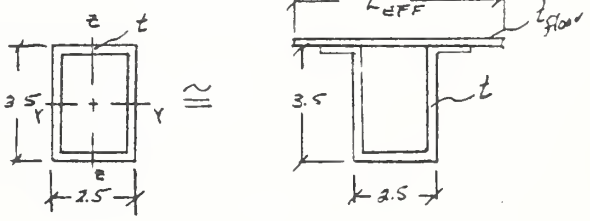
$$= 10{,}073 \text{ psi} \quad < \sigma_{s_{ALLOW}} \cong .58\,\sigma_{yield} = 21{,}000 \text{ psi} \quad \therefore \text{ SECTION OK}$$

SECTION @ STA -40 in.

$$I_{YY} \cong \frac{2}{12} t (3.5)^3 + 2t(2.5)\left(\frac{3.5}{2}\right)^2$$

$$= 7.15t + 15.3t$$

$$= 22.5t$$



$$\sigma_b = \frac{M_2 (3.5/2)}{22.5t}$$

OR $$t \rightarrow \frac{M_2 (3.5)}{45\,\sigma_{ALLOW}}$$

$$= \frac{42{,}000\,(3.5)}{45\,(36{,}000)}$$

$$\boxed{t = .091 \text{ in} \quad (12 \text{ gage})}$$ MILD STEEL

CHECK SHEAR STRESS

$$\sigma_s = \frac{V}{A_{40}} + \frac{T}{2[A]t}$$

$$= \frac{1200}{2.5(3.5) - (2.5-.182)(3.5-.182)} + \frac{7200}{2(3.5)(2.5)(.091)}$$

$$= 1133 + 4521 = 5654 \quad << \sigma_{s_{ALL}} \cong .58\,\sigma_{yield} = 21{,}000 \text{ psi} \quad \therefore \text{ SHEAR O.K.}$$

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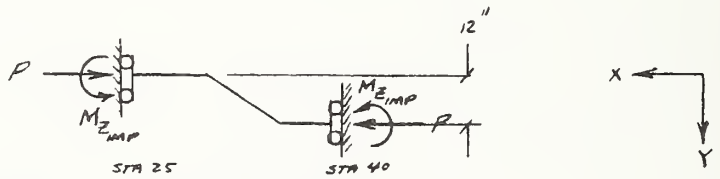
Low Speed Impact Loading

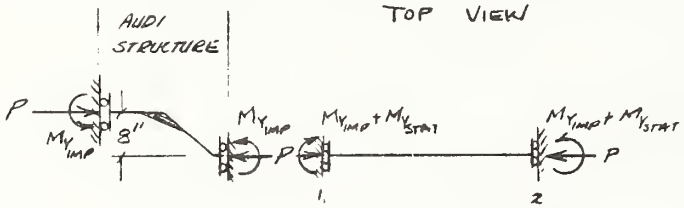
THE MAXIMUM COMPRESSIVE LOADS FOR THIS CASE IS DETERMINED BY SUPERIMPOSING THE DIRECT AND BENDING STRESSES AS FOLLOWS:

$$\sigma_{c_{MAX}} = \frac{P}{A} + \frac{M_Y C_Y}{I_{YY}} + \frac{M_Z C_Z}{I_{ZZ}} \quad \ldots A)$$

THE ASSUMED LOADING CONFIGURATION IS AS FOLLOWS:



TOP VIEW



SIDE VIEW

AT STA 25 IN,

$$M_{Y_1} = M_{Y_2} = M_{Y_{IMP}} + M_{Y_{STAT}}$$

$M_{Y_{STAT}} = \frac{1}{2} M_{25}$ (PAGE 16)

$= \frac{1}{2}(19{,}000)$

$= 9{,}500$ in-lb

$M_{Y_{IMP}} = 8P/2$

$P = \frac{1}{2} F_{BUMP}$ (PAGE 17)

$= \frac{1}{2}(14{,}585) = 7293$ lbs/sill

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Low Speed Impact Loading ... cont'd

$$\therefore \quad M_{y_{imp}} = \frac{8}{2}[7293]$$

$$= 29170 \text{ in-lb}$$

$$M_{z_{imp}} = \frac{12}{2} P$$

$$= 93758 \text{ in-lb}$$

$$\therefore \quad \sigma_{max} = \frac{7293}{2(.059)[3.125+3.25]} + \frac{(9500+29170)(\frac{3.125}{2})}{20.96\,(.059)} + \frac{4,3758(\frac{3.25}{2})}{22\,(.059)}$$

$$= 9695 + 48,860 + 54,782$$

$$= 113337 \gg 36,000 \text{ psi} \quad \text{SECTION IS INADEQUATE}$$

FIND THICKNESS REQUIREMENTS OF SECTION BY SOLVING FOR t IN EQUATION A, PAGE 24, AFTER SUBSTITUTING FOR I_{yy} & I_{zz}.

$$I_{yy} = 20.96\,t$$

$$I_{zz} = 22t$$

$$\therefore \quad t_{req} = \frac{1}{36,000}\left[\frac{7293}{2[3.125+3.25]} + \frac{(9500+29170)(\frac{3.125}{2})}{20.96} + \frac{43758(\frac{3.25}{2})}{22}\right]$$

$$= \frac{1}{36,000}[572 + 2883 + 3232]$$

$$= \frac{6687}{36,000}$$

$$\boxed{t_{req} \geq .186 \text{ in}} \quad \text{MILD STEEL}$$

FOR $\sigma_{YIELD} = 75,000$

$$\boxed{t_{req} \geq \frac{36,000}{75,000}(.186) = .089 \text{ in}}$$

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LOW SPEED IMPACT LOADING .... CONT'D

AT STA 40 in,

$M_{Y_2} = M_{Y_{IMP}} + M_{Y_{STAT}}$

$M_{Y_{STAT}} = \frac{1}{2} M_{40}$ (Page 16)

$= \frac{1}{2}(28{,}000)$

$= 14{,}000$

$M_{Y_{IMP}} = 8P/2$

$P = \frac{1}{2} F_{BUMP}$ (Page 17)

$= \frac{1}{2}(14{,}585) = 7293$ lbs/s.11

$\therefore M_{Y_{IMP}} = \frac{8}{2}(7293)$

$= 29{,}170$

$M_{Z_{IMP}} = \frac{12}{2} P$

$= 43{,}758$ in-lb

$I_{YY_{40}} \cong 22.5\,t$

$I_{ZZ_{40}} \cong \frac{2}{12} t (2.5)^3 + 2(t)(3.5)\left(\frac{2.5}{2}\right)^2$

$= 2.604\,t + 10.94\,t$

$= 13.54\,t$

FOR MILD STEEL, ($\sigma_{YIELD} = 36$ KSI)

$$t_{req} = \frac{1}{36{,}000}\left[\frac{7293}{2[3.5+2.5]} + \frac{(14000+29{,}170)\left(\frac{3.5}{2}\right)}{22.5} + \frac{43\,758\left(\frac{2.5}{2}\right)}{13.54}\right]$$

$= \frac{1}{36{,}000}[608 + 3358 + 4040]$

$\boxed{t_{req} = .222 \text{ in}}$ Sta 40

FOR $\sigma_{YIELD} = 75$KSI

$\boxed{t_{req} = \frac{36}{75}(.222) = .107 \text{ in}}$ Sta 40

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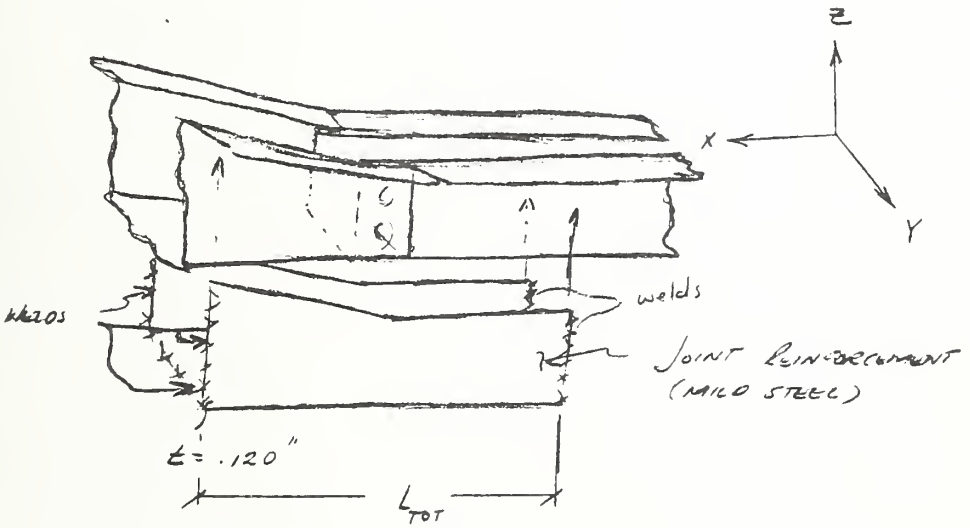
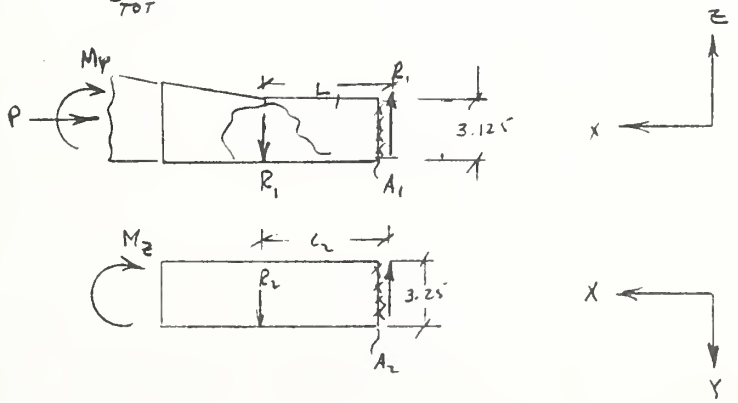
LOW SPEED IMPACT LOADING .... CONT'D

NOW CONSIDER THE WELDED JOINT AT STATION 25. SINCE HIGH MOMENTS OCCUR IN THE JOINT, FOR THE LOW SPEED IMPACT CASE, A SIMPLE PLUG WELDED JOINT WILL NOT BE POSSIBLE. THE FOLLOWING JOINT CONFIGURATION IS RECOMMENDED.





$$R_1 = \frac{M_Y}{L_1}$$

$$R_2 = \frac{M_Z}{L_2}$$

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STRESS ON WELDS, A_1,

$$A_{weld_1} = .707\,tL$$
$$= 2(.707)(.12)(3.125")$$
$$= .5303\ in^2$$

$$\sigma_{s_{weld}} = \frac{R_1}{.5303} = \frac{M_y}{L_1(.5307)}$$

$$\sigma_{s_{allow}} = 14{,}000$$

$$\therefore \quad L_1 = \frac{M_y}{14{,}000(.5303)} = \frac{(9500 + 29170)}{14{,}000\,(.5303)}$$

$$L_1 = 5.2$$

$$L_{tot} \cong 2L_1 = 10.4\ in$$

$$A_{weld_2} = .707\,tL$$
$$= 2(.707)(.12)(3.25")$$
$$= .551$$

$$\sigma_{s_{weld}} = \frac{R_2}{.551} = \frac{M_2}{L_2(.551)}$$

$$L_{2_{req.}} = \frac{43758}{14000\,(.551)}$$
$$= 5.67\ in$$

$$L_{tot} \cong 2L_2 = 11.34$$

THE JOINT REINFORCEMENT SHOWN ON PAGE 27 SHOULD BE APPROXIMATELY 12 1/2 inches long to distribute the joint moments.

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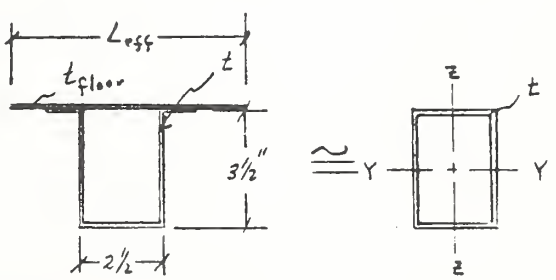
REGION B (SEE PAGE 19)

IN THIS REGION IT IS ASSUMED THAT THE LOW SPEED IMPACT LOADS ARE ADEQUATELY DISTRIBUTED THROUGHOUT THE FLOOR AND SIDE STRUCTURE SO THAT IT IS NOT A CRITICAL LOADING IN THIS REGION. THE DESIGN LOADING WILL BE FROM RIGING AND MANEUVERING. FROM PAGE 16, (AND USING A DESIGN FACTOR = 3.0)

$$M_{55} = 34{,}000\ (3)$$
$$= 102{,}000\ \text{in-lbs} \quad (\text{two sills})$$

$$V_{55} \cong 0$$

SECTION @ STA - 55 in



$$I_{YY} = \frac{2}{12}t(3.5)^3 + 2(2.5)t\left(\frac{3.5}{2}\right)^2$$
$$= 7.15t + 15.3t$$
$$= 22.4t$$

THE BENDING STRESS IS,

$$\sigma_b = \frac{M_{YY}\, C_Y}{I_{YY}}$$

$$= \frac{\frac{1}{2}(102{,}000)\left(\frac{3.5}{2}\right)}{22.4t}$$

FIND t_{req}:

$$t_{req} = \frac{\frac{1}{2}(102{,}000)\left(\frac{3.5}{2}\right)}{22.4\,(36{,}000)}$$

$$= .111 \text{ in.} \quad (11 \text{ gage - mild steel})$$

FOR $\sigma_{YIELD} = 75{,}000$ psi

$$t_{req} = \frac{36000}{75{,}000}(.111) = .0533 \text{ in} \quad (17 \text{ gage})$$

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REGION C (SEE PAGE 19)

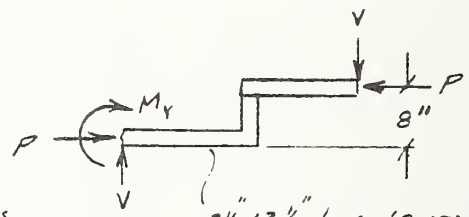
REVIEWING PAGE 16 IT APPEARS THAT FOR THIS REGION THE MANEUVERING LOADS ARE MINIMAL. THE LOW SPEED INHABIT LOADS ARE CRITICAL. FROM PAGE 17,

$P = \frac{1}{2}(16,615)$ lbs (total)

$= 8309.5$ lbs

$M_Y = 8(8309.5)$

$= 66,476$ in-lb



THE BENDING STRESS IN THE SILL IS,

$$\sigma_b = \frac{M_y c_y}{I_{yy}}$$

$I_{yy} = 22.4\ t$

$$\therefore \quad t_{req} = \frac{66,476\left(\frac{3.5}{2}\right)}{22.4\,(36,000)}$$

$= .144$ in (9 gage – mild steel)

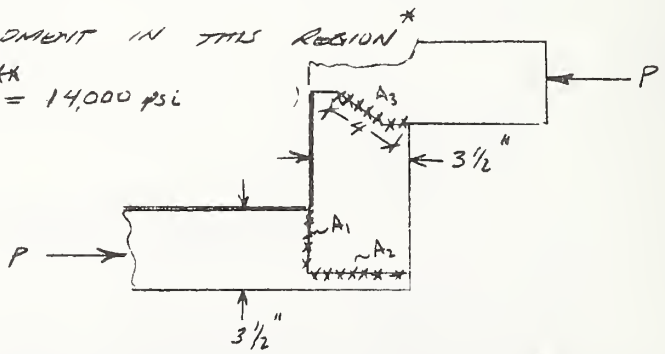
FOR $\sigma_{yield} = 75,000$

$$t_{req} = \frac{36,000}{75,000}(.144)$$

$= .0691$ in (14 gage – 75ksi yield Material)

CONSIDER NOW THE WELDMENT IN THIS REGION*

ALLOWABLE WELD STRESS = 14,000 psi**



* APPROACH IN REF(2)

** REF(3)

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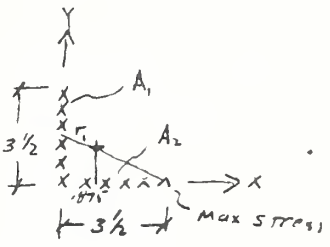
CONSIDER WELDS A_1 & A_2



$\bar{A}_1 = .707\ t\ L$

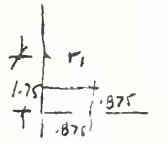
$\bar{A}_2 = .707\ t\ L$

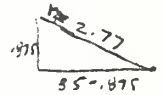
$(\bar{A}_1+\bar{A}_2)\ C.g_x = A_1(0) + A_2\frac{(3.5)}{2}$

$C.g_x = \frac{\bar{A}_2(3.5)}{2(\bar{A}_1+\bar{A}_2)}$

$= \frac{3.5}{4}$

$= 0.875$





$C.g_y = C.g_x = 0.875$

$r_1 = \sqrt{(1.75-.875)^2 + .875^2}$

$= 1.23$

$J_1 = A_1\left(\frac{L^2}{12} + r_1^2\right)$

$= .707t\left[\frac{3.5^2}{12} + 1.23^2\right]L$

$= 6.33\ t$

$J_2 = J_1$

$J_{TOT} = 2(J_1 + J_2) = 25.32\ in^4$

$\sigma_{shear} = \frac{Mr}{J} = \frac{66,476(2.77)}{25.32t} = \frac{7272}{t}$

$t = .12 \Rightarrow \sigma_{shear} = 60,602\ psi\ .>>\ \sigma_{allow} = 14,000\ psi$

WELD A_3 CARRIES ONLY A SHEAR LOAD, HENCE

$\sigma_s = \frac{P}{A_3} = \frac{8309.5}{2(.707)t(4)} = \frac{1469}{t}$

For $t = .12$

$\sigma_s = 12,243\ psi < \sigma_{Allow} = 14,000\ psi$, WELD OK

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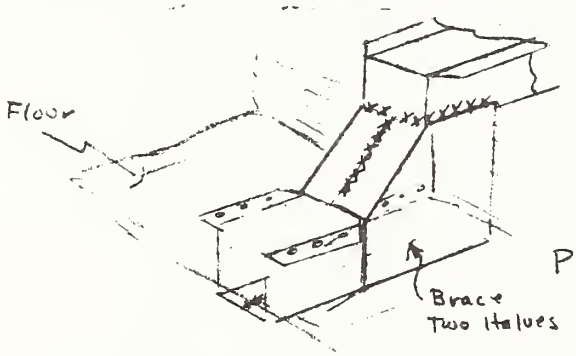
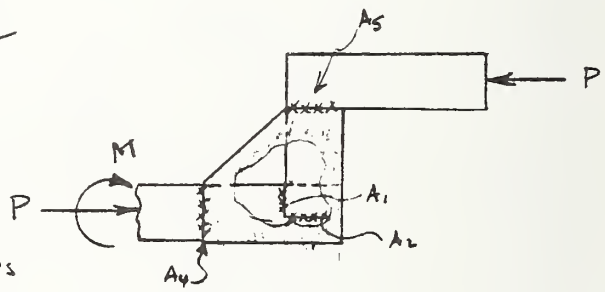
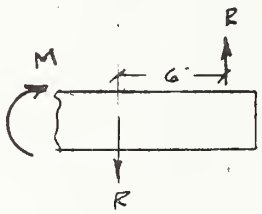
WELDS A_1 & A_2 ON PAGE 30 APPEAR TO BE AN INEFFICIENT METHOD FOR REACTING TIRE BUMP LOADS. A BETTER DESIGN IS TO USE A BRACE. THE FOLLOWING CALCULATIONS ARE PERFORMED TO SIZE THE BRACE.







$R = \frac{M}{6} = .167 M$

$M = 66,476$ in-lb

$\therefore R = 11,079$ lbs

STRESS IN WELD A_4

$$\sigma_s = R/A_4$$

$$A_4 = 2(3.5)t(.707) + 2.5t(.707)$$
$$= 4.949t + 1.768t$$
$$= 6.717t$$

FOR $t = .12$

$$\sigma_s = 11079/6.717(.12)$$
$$= 13,746 \text{ psi} < \sigma_{ALOW} = 14000 \text{ psi}, \text{ weld OK}$$

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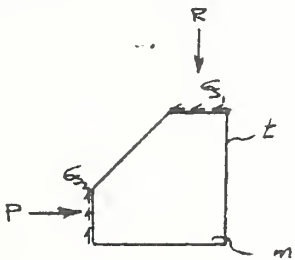
SINCE A_1+A_2 (AND A_5) $\geq A_4$ AND LOADS ACTING ON THESE WELDS ARE THE SAME AS THAT FOR A_4, BY DEDUCTION THESE WELDS WILL BE AS SAFE AS A_4. NOW CONSIDER THE BRACE.



MAX SHEAR STRESS (σ_{s_2})

$$\sigma_{s_2} = \frac{R}{A_s}$$

$$A_s = 2(3.5)(t)$$

$$\therefore \sigma_{s_2} = \frac{11,079}{7.0t}$$

$$= 1583/t$$

FOR $t = .12$

$$\sigma_{s_2} = 13,190 \text{ psi} < \sigma_{s_{ALLOW}} = .56(36,000) = 20,160 \text{ psi}$$

MAXIMUM COMPRESSION STRESS

$$\sigma_{c_{MAX}} = \frac{R}{A_c}$$

$$A_c = 2(3.5)t + 2.5t$$

$$= 9.5t$$

$$\therefore \sigma_{c_{MAX}} = \frac{11,079}{9.5t}$$

$$= \frac{1166}{t}$$

$t = .12$

$$\sigma_{c_{MAX}} = 9,718 \text{ psi} \quad \text{OK}$$

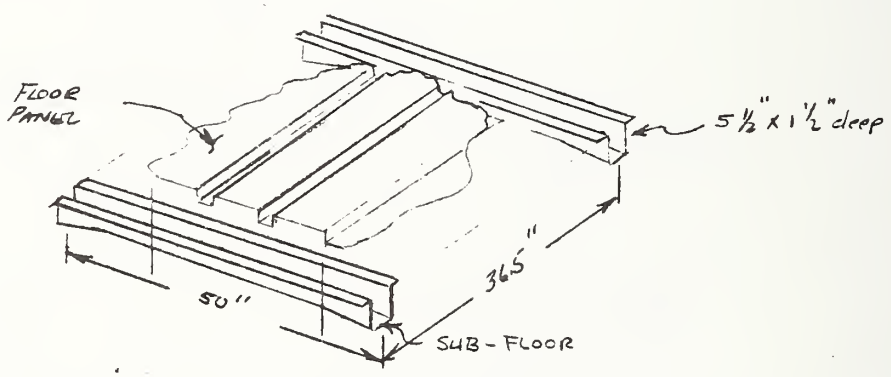
Project: LLCC – PTV STRUCTURAL ANALYSIS

Job Order No.:

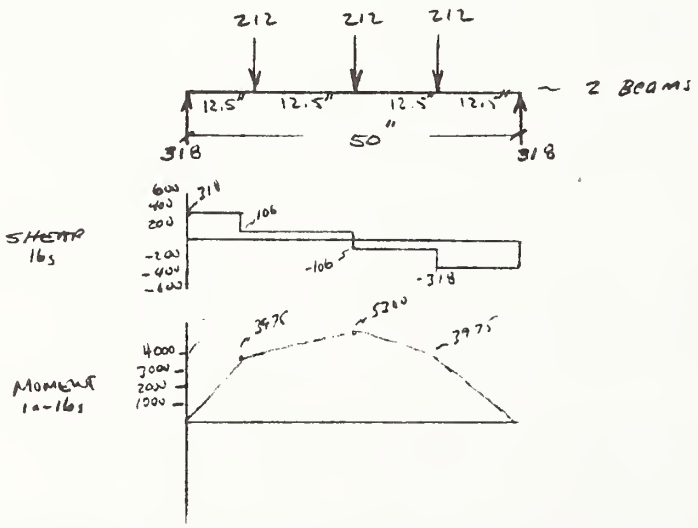
Calculation Serial No.:

FLOOR ASSEMBLY

THE FLOOR ASSEMBLY MUST WITHSTAND LIVE LOADS INDUCED BY PASSENGERS ENTERING AND LEAVING THE VEHICLE. THE FOLLOWING SKETCH DESCRIBES THE FLOOR ASSEMBLY.



IT IS ASSUMED THAT THREE 95$^{+4}_{-5}$ 0 ADULT MALES ARE STANDING ON THE FLOOR SIMULTANEOUSLY. THE LOADING OF THE SUB-FLOOR IS,



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LLCC - PTU STRUCTURAL ANALYSIS

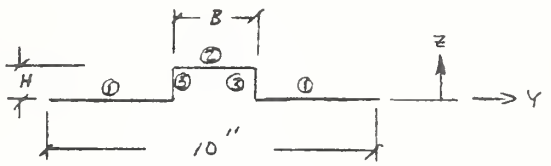
Job Order No.

Calculation Serial No.

$A_1 = (10-B)t$

$A_2 = Bt$

$A_3 = 2Ht$



$$GG_z = \frac{A_3\frac{H}{2} + A_2 H}{A_1 + A_2 + A_3}$$

$$= \frac{2Ht\frac{H}{2} + BHt}{\frac{(10-B)t}{H} + \frac{Bt}{H} + 2Ht}$$

$$= \frac{H+B}{\frac{(10-B)}{H} + \frac{B}{H} + 2}$$

$$= \frac{H+B}{\frac{10}{H} + 2}$$

$$I_{YY} \cong \frac{2}{12}tH^3 + 2Ht\left(\frac{H}{2} - cg_z\right)^2 + Bt\left[H - cg\right]^2 + \left[10-B\right]t\,cg_z^2$$

$$= t\left[\frac{H^3}{6} + 2H\left(\frac{H}{2} - cg_z\right)^2 + B\left[H - cg\right]^2 + \left[10-B\right]cg_z^2\right]$$

ASSUME

$H = .5$ in

$B = 2$ in

THEN, $cg_z = \frac{.5+2}{\frac{10}{.5}+2} = \frac{2.5}{22}$

$= .114$ in

$$\therefore I_{YY} = t\left[\frac{.5^3}{6} + 2(.5)\left(\frac{.5}{2} - .114\right)^2 + 2(.5-.114)^2 + (10-2)(.114)^2\right]$$

$$= t\left[.0208 + .0185 + .298 + .104\right]$$

$$= .441t \text{ in}^4$$

$$\sigma_b = \frac{5804(.5-.114)}{.441t}$$

$$t = \frac{5804(.5-.114)}{.441(36000)} = .141 \qquad \text{(too thick try } H = .75\text{)}$$

Prepared By	L.S. PAULS	Date	9-17-77
Checked By		Date	

Project: LLCC – PTV STRUCTURAL ANALYSIS | Job Order No. | Calculation Serial No.

TRY $H = .75$
$B = 2$

THEN,

$$C_{g_z} = \frac{.75 \div 2}{\frac{10}{.75} \div 2} = .179$$

$$\therefore \quad I_{yy} = t\left[\frac{.75^3}{6} + 2(.75)\left(\frac{.75}{2} - .179\right)^2 + 2(.75 - .179)^2 + (10-2)(.179)^2\right]$$

$$= t[.0703 + .0576 + .6521 + .256]$$

$$= 1.036\,t$$

$$G_b = \frac{5804(.75 - .179)}{1.036\,t}$$

OR

$$t = \frac{5804(.75 - .179)}{1.036(36{,}000)}$$

$$= .089 \text{ in.}$$

TRY $H = 1$
$B = 2$

THEN,

$$C_{g_z} = \frac{1 \div 2}{\frac{10}{1} \div 2} = \frac{3}{12} = \frac{1}{4} = .25$$

$$\therefore \quad I_{yy} = t\left[\frac{1}{6}^3 + 2(1)\left(\frac{1}{2} - .25\right)^2 + 2(1 - .25)^2 + (10-2)(.25)^2\right]$$

$$= t[.167 + .125 + 1.125 + 0.5]$$

$$= 1.917\,t$$

$$G_b = \frac{M\,c}{I_{yy}}$$

$$t = \frac{5804(1 - .25)}{1.917(36{,}000)} = .0631 \qquad \text{(use 16 gage steel)}$$

Prepared By L.S. PAULS	Date 9/17/77
Checked By	Date

CALCULATION SHEET

Page ____ Of ____

Project | Job Order No. | Calculation Serial No.

LIST OF REFERENCES

1. W.J. SIDELKO, "AN OBJECTIVE APPROACH TO HIGHWAY TRUCK FRAME DESIGN," FORD MOTOR CO., SAE REPORT 660162
2. M.F. SPOTTS, "DESIGN OF MACHINE ELEMENTS", PRENTICE-HALL INC., ENGLEWOOD CLIFFS, N.J., 1961
3. SPECIFICATION FOR THE DESIGN OF COLD-FORMED STEEL STRUCTURAL MEMBERS, AMERICAN IRON & STEEL INSTITUTE, 1968 EDITION.

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BODY TOOLING AND FIXTURING

Tooling List for Major Body Forms

The following tooling will be required for forming major components of the body.

3-Piece Draw

- Hood - Outer
- Hood - Inner
- Door - R.R. - Outer
- Door - R.R. - Inner
- Fender - L.F.
- Fender - R.F.
- Roof Panel - Outer
- Rear Quarter - L.H.
- Rear Quarter - R.H.
- Rear Wheelhouse - Forward Panel - L.H.
- Rear Wheelhouse - Forward Panel - R.H.
- Backlite Enclosure - Upper - L.H.
- Backlite Enclosure - Upper - R.H.
- Backlite Enclosure - Cross Panel
- Hatch - Outer
- Hatch - Inner

Punchable Die

- "A" Pillar - R.H. - Outer
- "A" Pillar - R.H. - Inner
- "A" Pillar - L.H. - Outer
- "A" Pillar - L.H. - Inner
- Front Structure - Forward Rail - L.H. - Outer
- Front Structure - Forward Rail - L.H. - Inner
- Front Structure - Forward Rail - R.H. - Outer
- Front Structure - Forward Rail - R.H. - Inner
- Front Crossmember
- Front Structure - Rear Rail - R.H. - Inner
- Front Structure - Rear Rail - R.H. - Outer
- Front Structure - Rear Rail - L.H. - Inner
- Front Structure - Rear Rail - L.H. - Outer
- Firewall - Upper
- Firewall - Lower
- Firewall Panel - L.H.
- Firewall Panel - R.H.

Punchable Die (Cont.)

"B" Pillar - L.H. - Inner
"B" Pillar - L.H. - Outer
"B" Pillar - R.H. - Inner
"B" Pillar - R.H. - Outer
Roof Panel - Inner
Passenger Divider Panel - L.H.
Passenger Divider Panel - R.H.
"C" Pillar - L.H. - Inner
"C" Pillar - L.H. - Outer
"C" Pillar - R.H. - Inner
"C" Pillar - R.H. - Outer
Rear Wheelhouse - Rear Panel - L.H.
Rear Wheelhouse - Rear Panel - R.H.
Rear Rail - L.H. - Inner
Rear Rail - L.H. - Outer
Rear Rail - R.H. - Inner
Rear Rail - R.H. - Outer
Bumper, Front and Rear
Rear - Seat - Back Panel
Rear - Seat - Lower Panel
Trunk - Floor Panel
Trunk - Rear Panel
Roof - Inner Rear Structure
Backlite - Surround Panel
Backlite - Lower
Rear Door - Track Rail - R.H. - Outer
Rear Door - Track Rail - R.H. - Inner
Rear Wheel - Splash Pan - L.H.
Rear Wheel - Splash Pan - R.H.
Back Panel - Lower L.H.
Back Panel - Lower R.H.

Fixturing List for Body Build

- Sub-assembly:
  - L.F. Door Fixture
  - R.F. Door Fixture
  - R.R. Door Fixture
  - Hood - Assembly Fixture
  - Front Sub-structure Fixture
  - Rear Sub-structure Fixture
  - Hatch - Assembly Fixture
- Plug Gages:
  - L.F. Door Opening
  - R.F. Door Opening
  - R.R. Door Opening
  - Windshield Opening
  - L.R. Quarter Window Opening
  - R.R. Quarter Window Opening
  - Backlite Opening
  - Hood Opening
  - Hatch Opening
- Final Body-in-White Assembly Fixture

FINAL ASSEMBLY PROCESS

BODY PAINTED

Operation Number	Part Number	Operation	Tooling
10	10160-3	Load body on body truck	Hand tools
	034	Assembly striker - front door latch to "B" pillar	Body trucks
20	035	Hinge assembly, frt door upper, R.H.	Torque wrench
	036	Hinge assembly, frt door upper, L.H.	
	037	Hinge assembly, frt door lower, R.H.	
	038	Hinge assembly, frt door lower, L.H.	
	039	Assembly to door six bolts	
30	10160-10-3	Assembly door and hinge assembly to body with four bolts	Torque wrench
40	10160-10-3	Assembly door assembly - sliding R.H. mounted to body with slave holders	Slave holders
50	10C-1	Hatch assembly, rear deck mounted	Torque wrench
	009	to body with hinge assembly rear	
	010	hatch and 12 bolts rear hatch	
	012	lockwasher - rear hatch	
	011	Nut - rear hatch hinge mounting	
60	10160-10D-6	Hood assembly engine compartment	
	10D-6	Hinge assembly hood, L.H.	Torque wrench
	10D-7	Hinge assembly hood, R.H.	
	006	Assembly to hood with four screws hinge attachments	
70	007	Bumper hood assembly to hood	Screw driver
	008	with screws - hood bumper attachment	
	009	Striker assembly hood latch to hood	Power wrench
	012	with screws - striker attachment	
80	10D-8	Latch assembly - hood to hood with three screws	
	013	and washers - hood latch mounting	
90	002	Cover - plenum chamber air intake to be painted with body.	

Operation Number	Part Number	Operation	Tooling
100	10160-10-3	Body and structure assembly clean with phosphate solution for corrosion (bonderized)	Wash off bootn Body trucks
110	10160-3	Bonderized body air blow off and dried	Air blowers Infra ray heat booth
120	10160-10-2	Body in white assembly primed	Spray booth, spray guns and spray pots
130	10160-10-2	Primed painted body to be heated and dried	Infra ray heat booth Floor conveyor thru heat booth
140	10160-10-2	Primed body to be hand scuffed with fine grit paper and washed off	Hose with nozzle
150	10160-10-2	Primed body to be sealed in all openings to prevent water leaks	
160		Apply waterproof sealing material	
170	10160-10-1	Body assembly painted spray body with finish paint, two coats, wet on wet	Spray booth and exhaust system
180		Transfer painted body to heat booth	Floor conveyor thru heat booth
190		Transfer body to trim line.	

SUBASSEMBLY

Operation Number	Part Number	Operation	Tooling
5	10160-1A-1	Engine & transmission assembly cp	Holding fixture
	10160-1A-3	Engine assembly (sub assy oper 195)	
	-001	Assy. damper engine front mount to engine.	Power wrench
15	-002	Hardware engine front mount attachment to engine	Torque wrench
25	-003	Engine mount RH to engine	Torque wrench
	-004	Engine mount LH to engine	
	1A-2	Crossmember and mount assembly Transmission rear to engine	
35	-007	Heat shield RH engine mount	Torque wrench
	-008	Hardware - eng. mounting to engine	
45	10160-1G-1	Housing assy - fuel injection to engine	Hand wrench
55	10160-1A-5	Pump & pulley assy. water to engine (subassembly 215) with	Hand wrench
	-037	Plate	
	-038	Bolt short	
	-039	Bolt long	
	-040	Lock washer	
65		Pump to engine	Torque wrench
	-043	Gasket, water pump to engine	
	-042	Lockwasher, water pump to engine	
	-041	Bolt, water pump to engine	
75	10160-1A-6	Pump & pulley assembly - air bracket	Torque wrench
	-045	air pump mounting	
	-046	Attaching hardware - air pump	
	-047	Idler assembly - air pump belt tension	
	-048	Manifold - air injection	
	-049	Checkvalve - air pump	
	-050	Valve - anti backfire	
	-051	Filter air pump	

Operation Number	Part Number	Operation	Tooling
85		Hose assembly to engine	
	-052	Hose - air cleaner to filter	Pliers
	-053	Hose - air filter to air pump	
	-054	Hose - air pump to check valve	
	-055	Hose - air pump to backfire valve	
	-056	Hose backfire valve to intake manifold	
95	10160-1A-057	Hose check valve to manifold	Pliers
	-058	Clamp - air hose	
	-059	Attaching hardware - air injection manifold	
105	10160-1J-1	Distributor assembly to engine with	Hand wrench
	-012	Clamp distributor mounting	
	-015	Seal distributor mounting	
	-013	Washer distributor mounting	
	-014	Bolt distributor mounting	
115	10160-1J-001	Ignition coil assembly to engine	Pliers
	-002	Washer coil wire	Hand wrench
	-003	Lockwasher coil wire	
	-004	Nut coil wire	
	-005	Cable coil to starter	
	-008	Washer coil mounting	
	-009	Screw coil mounting	
135	-006	Resister coil to engine	Hand wrench
	-007	Washer resister mounting	
	-008	Screw resister mounting	
	-010	Condensor distributor ignition	
155	-024 to 027	Cable sparkplug	Screw driver
	-029	Holder sparkplug cable	
	-028	Clip sparkplug cable	
	-030	Sleeve spark plug cable	
	-031	Bracket sparkplug cable	
165	10160-1K-1	Transmission assembly cp	Torque wrench
	-001	to engine with bolts	

Operation Number	Part Number	Operation	Tooling
175	10160-1K-2	Starter assembly to engine with	Torque wrench
	-003	Flat washer starter mounting	
	-002	Bolt starter mounting	
	-004	Lockwasher starter mounting	
	-005	Nut starter mounting	
185	10160-8-008	Cable - starter to battery	Hand wrench
	-006	To cable - starter to ignition starter lock	
	-007	Attaching hardware starter cable	
195	10160-1A-3	Engine assembly dressed less trans.	Power tool
	-012	Assembly bracket alternator	
	-011	Plate alternator	
	10160-1A-4	Alternator assembly and	
	-013	Ground wire to engine	
	10160-1A-10	Engine assembly	
	-014	Bolt alternator	
	-015	Washer alternator	
	-016	Bolt alternator	
	-017	Sleeve alternator bushing	
	-018	Bushing alternator mounting bushing	
	-019	Retainer alternator mounting bushing	
	-020 & 021	Lockwasher and nut	
205	-022	Bracket alternator belt adj. to engine with	Power Tool
	-023	Bushing	
	-024	Sleeve alternator mounting	
	-028	Bolt tension adj.	
	-025 & 026	Washer flat lock washer	
	-027	Cap screw	
	-032	Belt alt. to AC clam	
	-029	Washer flat	
	-030	Lock washer	
	-031	Nut tension adj.	
215	10160-1A-5	Pump & Pulley (assy to APR 55)	
	-033	Pump assembly	
	-034	Pulley	
	-035	Lock washer	
	-036	Bolt bulley alt.	

BODY PAINTED AND TRIMMED

Operation Number	Part Number	Operation	Tooling
10	10160-10-1	Body Painted	
	10A-040	Weather strip assembly RH	
	-041	Weather strip assembly LH	
		Cement to door	Glue gun
20	-042	Channel glass run rear RH	Pneumatic
	-043	Channel glass run rear LH	Screw driver
		Located and assy to door	
		Two screws	
30	-044	Retainer - run channel RH	Pneumatic
	-045	Retainer - run channel LH	Screw driver
		Locate and assy to door lower	
40	-046	Bracket - run retainer RH	Pneumatic
	-047	Bracket - run retainer LH	Screwdriver
		Locate and assy to door with four screws.	
50	10160-10A-7	Regulator assy. front door RH	Pneumatic
	10A-8	Regulator assy. front door LH	Power wrench
		Assy and secure to door three bolts	
60	10160-10A-5	Latch assy. front door RH	Pneumatic
	-10A-6	Latch assy. front door LH	Screw driver
		Secure with three screws	
70	-017	Handle assy front door outside RH	
	-018	Handle assy front door outside LH	
	-019	Pad door handle front	Hand wrench
	-020	Pad door handle rear	
	-021	Secure with two nuts	
80	-024	Lock cylinder & key assy. Fnt door	Pliers
	-025	Retainer - lock cylinder snap in cylinder to secure lock	
90	-022	Assy. rod - door outside handle to latch	Pliers
	-023	Snap retainer to latch rod	
	-026	Secure rod - lock cylinder to latch	
100	-030	Assy. rod - latch lock RH	Pliers
	-031	Assy. rod - latch lock LH	
	-032	Assy. push button - latch lock rod to latch R and L	
	-033	Press retainer on latch lock rod R & L	

Operation Number	Part Number	Operation	Tooling
110	10160-10A-9	Window assy front door RH	
	-10A-10	Window assy front door LH	
		Insert glass assy into regulator and rear channel	
120	-063	Seal-vent window rubber RH	
	-064	Seal-vent window rubber LH	
		Cement into door frame	
	10160-10A-11	Locate window assy vent RH	Pneumatic
	-10A-12	Locate window assy vent LH	Screw driver
		Secure with three screws after glass assy is located into channel	
130	-065	Weatherstrip - front door glass belt snap into place & turn up window	
140	-055	Retainer - trim panel rear RH	Pneumatic
	-056	Retainer - trim panel rear LH	Screw driver
		secure with four screws	
	-057	Retainer - trim panel upper	
		secure with four screws	
	-058	Retainer att.	
150	-050	Panel - front door interior trim	Power screw
	-051	Panel - front door interior trim	Driver
	-059	Secure with eight screws	
160	-052	Armrest - front door RH	Power screw
	-053	Armrest - front door LH	driver
	-054	Secure with three screws	
170	10160-10B-2	Door assy sliding RH glazed	None
	-002	Weather strip - sliding door	
	10B-4	Window to glass and install into door	
180	-013	Adhesive - weatherstrip	Glue
		apply to door and to	applicator
	-012	Weatherstrip seal and assy	
		Weatherstrip to door	
190	-014	Plug paint-drain rectangular	None
	-015	Plug paint-drain round	
	-016	Plug paint-drain lower	
		Snap into drain holes	

Operation Number	Part Number	Operation	Tooling
200	-055	Lock assy - sliding door	Screw driver
	-006	Handle - sliding door outer	
	-007	Handle - sliding door inner	
	-008	Tumbler and key assy door lock to door	
210	-009	Latch assy - sliding door rear	Screw driver
	-010	Attaching hardware to lock and latch	
220	10160-10B-1	Door assy - sliding RH mounted	
	-017	Lower guide assy sliding door RH	
	-018	with three screws	
230	-019	Bracket body side upper guide RH	Power Screw driver
	-020	Roller assy guide bracket assy to	
	-022	body with screw - bracket mounting	
	-021	Nut - roller mounting	
240	-023	Hinge assy. sliding door rear RH assy to door	Power Screw driver
	-024	Screws hinge assy mounting	
250	10160-10B-4	Kit - sliding door electric operation CP to body	Screw driver
260	10160-10C-2	Hatch assy rear deck glazed	
	-002	Weatherstrip - rear hatch to glass	Rubber hammer
	-001	rear hatch lace cord around outer perimeter insert glass assy into hatch and pull cord. Tap glass to set	
270	-007	Apply adhesive to hatch and weather strip - rear hatch seal then apply weatherstrip to hatch	Glue applicator
280	10160-10C-4	Cylinder assy rear hatch gas locate to hatch and body and attach with attaching hardware - gas cylinder	Torque wrench
290	10160-10C-5	Latch lock and key assy. rear hatch assy in hatch with attaching hardware	Power wrench
300		Instrument panel assy complete assy to body side and windshield opening	Power wrench

Operation Number	Part Number	Operation	Tooling
310	10160-10L-1	Windshield - laminated & tinted	Holding fix with
	-001	weatherstrip - windshield zip strip to windshield assy weatherstrip to glass	suction cups
320		Windshield and weatherstrip assy install	
	-002	Trim moulding strip lower	Rubber Hammer
	-003	Trim moulding strip upper	
	-004	Trim moulding strip RH	
	-005	Trim moulding strip LH	
	-006	Trim moulding strip lower corner	
	-007	Trim moulding strip upper corner	
		Insert into weatherstrip and tap with rubber hammer lace cord into outer perimeter of inner lip	Holding fix with suction cups
340	-013	Apply adhesive to body insert windshield assy into opening pull cord and tap with rubber hammer to set	Rubber hammer
350	10D-2	Motor assy windshield wiper assy to body with	Power wrench
	-001	screws - attaching windshield wiper	
	10D-1	Linkage assy w/s wiper assy to motor	
360	-002	Cover - plenum chamber air intake assy to body	Screw driver
	-003	With screws plenum cover	
	10D-3	assy blade assy to linkage	
370		Install dash and toeboard insulation apply cement to installation and locate to dash	Cement applicator
380	10160-1G-2	Pedal & linkage assy accelerator insert rod through dash and assy pedal to floor two screws	Screw driver
390	10160-8-3	Harness assy - body wiring rear lamps assy to body wire clips	None
400	10160-10B-4	Harness assy electric door dash to RH door assy to body with wire clips	None

Operation Number	Part Number	Operation	Tooling
410	10160-8-4	Harness assy wheelchair restraint to be layed out on floor to be covered with carpet - driver floor	None
420	10160-10F-1	Headlining assy roof spray top of headliner with cement and apply to roof	Glue spray applicator
430	10160-10F-2 10F-17	Seat assy rear bench three passenger locate to holes in floor and bolt down	Torque wrench
440	10160-10F-3 10F-4 10F-18	Trim moulding - rear wheel House arm rest LH and RH Attaching hardware	
450	10160-12-3	Belt assy lap bolt to floor and hook up to wire harness	Torque power wrench
460	10F-6 10F-7	Mat - rear floor rubber Mat - center floor rubber	
470	10F-5	Receptacle - cigar ash to trim moulding arm rest	Screw driver
480	10160-10F-20 10F-21	Seat track & adjuster assy - driver assy to floor with attaching hardware	Torque wrench
500	10160-10-2	Belt and retractor assy driver to floor and B post	Torque wrench
510	10160-12-1	Restraint assy - wheelchair assy and bolt to floor	Torque wrench
520	10160-10F-23	Carpet - driver floor install and screw to floor	Screw driver
530	10160-10F-16	Seat assy - driver bulkhead jump assy to seat track and adjuster 10F-20	Wrench
540	10160-10F-15	Panel trim - wheelhouse side to wheelhouse restriant	Screw driver

Operation Number	Part Number	Operation	Tooling
550	10160-10F-8	Panel - trim sliding door & center side locate and assy to door and center of body	
560	10160-10F-9	Panel - trim rear hatch	Pneumatic power wrench
	10F-10	Panel- trim driver bulkhead	
	10F-11	Panel- trim wheelchair locate and assy to front bulkhead	
570	10160-10F-12	Moulding - wheel recess	Pneumatic power wrench
	10F-13	Moulding - corner	
	10F-14	Moulding - bulkhead cap Locate & assy to bulkhead	
580	10160-10B-4	Kit - sliding door electric operation complete assy to wire harness and dash panel	Screw driver
590	10160-7-1	Heater & blower assy - complete	Hand wrench
	7-001	attaching hardware - heater assy	
	7-2	Air conditioning assy - HD complete kit	Hand wrench
	7-002	Attaching hardware P/C assembly	

FINAL ASSEMBLY

Operation Number	Part Number	Operation	Tooling
10	10160-10-1	Load body assy painted and trimmed complete load on body truck and move body to conveyor	Floor conveyor body trucks power hoist
20		Brake line and hose assembly	Hand box wrench
	-07	Connector to dash with	
	-016	Hex head screw	
	-017	Lockwasher	
	-018	Hex nut	
30	-012	Locate and assy bracket to frame	Hand box wrench
	-07	with connector	
	-016	Bolt hex head	
	-017	Lock washer	
	-018	Nut	
40		Brake lines to connector	Open end box wrench
	-006	Brake to connector No. 7	
	-002	with retainer spring	
	-019	Protective sleeves five places	
	-011	and brake hose	
50	-003	Assy brake line master cylinder to connector	Open end box wrench
	04-05	Brake line to chassis left and right to connector	
60	-010	Locate and assemble brake line to connector	Open box wrench
	-008	Brake line to rear axle to	
	-009	Connector with two protection sleeves	
70	10160-1J-2	Harness assy engine electrical to dash with two bolts	Box wrench hand
80	10160-8-2	Harness assy front lamps front compartment to dash & head lamps R&L	
90	10160-8-1	Battery - 12V 80 amp install and secure to battery tray attach	Hand box wrench

Operation Number	Part Number	Operation	Tooling
100	10160-8-001	Cable - battery ground	Hand wrench
	-002	Cable - battery to starter solenoid with attaching	
	-003	hardware - battery cables	
110	10160-1A-1	Engine and transmission assy C/P move engine assy to final line locate crossmember and engine assy to body with eight bolts	Torque power wrench Drifet pin
120	-060	E.G.R. valve assy	
	-061	Tube & connector assy - E.G.R. valve to filter	Open end box wrench
	-062	Filter - E.G.R.	
	-063	Tube assy. filter to exhaust manifold	
	-064	Line - E.G.R. vacuum	
130	10160-1A-8	Compressor & clutch assy - air conditioner to engine	Hand torque wrench
	-065	with bracket - AC compressor mounting and attaching hardware	
	-066	AC compressor mounting	
140	-067	Hose assy - AC compressor to condenser	Hand pliers
	-068	Hose assy - AC compressor to evaporator	
150	10160-1A-9	Pump assy - power steering	Hand box wrench
	-069	Bracket - power steering pump mtg	
	-070	Attaching hardware P/S	
	-071	Pump assembly hose P/S	
	-072	Hose assy power steering pump return to engine	
160	10160-1F-001	Carburetor assy to engine	Hand box wrench
	-021	with gasket - carburetor	
	-022	Stud - intake manifold to carburetor	
	-023	Washer - manifold to carburetor	
	-024	Nut - manifold to carburetor	

Operation Number	Part Number	Operation	Tooling
170	10160-1F-027	Air cleaner assy to manifold with	
	-031	Seal - air cleaner lower	
	-025-026	Bracket - air cleaner front & rear	
	-033	with flat washer air cleaner mtg	
	-034	Lockwasher - air cleaner mounting	
	-035	Bolt air cleaner mounting	
	-036	Hose - air cleaner to exhaust manifold	
	-037	Holder - air cleaner holder	
	-038	Clamp - air cleaner holder	
	-039	Clamp - air cleaner hose	
180	10160-1G-1	Housing assy CIS fuel injection	
	-001	Distributor assy fuel to manifold	Hand wrench
	-002	Valve - fuel injection to head	
	-003	Fuel line injection valve to fuel distributor and injection valve	Open box wrench
	-004	Valve cold start to manifold	
	-005	Switch thermo to block	
	-006	Fuel line - cold start from distributor to cold valve	
	-007	Regulator - CIS pressure relief valve	
190	-012	Pump-fuel electric to engine	Hand torque wrench
	-014	Accumulator - fuel to engine	
	-016	Filter - fuel to engine	
200	-008	Fuel line regulator to distributor	Open end box wrench
	-009	Fuel line regulator return	
	-010	Fuel line distributor to fuel tank	
	-011	Fuel line tank to pump	
	-013	Fuel line pump to accelerator	
210	28-15	Assy rod to carburetor	Pliers
	28-17	with bearing bushing and	
	28-18	Circlip to rod	
	28-24	Clamping spring	
	28-23	Bearing bushing	
	28-19	Connecting rod to carburetor rod	
220	28-13	Boot insert into dash insert	Hand wrench
	28-07	Rod insert thru boot & assemble to connecting rod	
	28-21	with ball joint	
	28-22	Lock clip	
	28-20	Hex nut	

Operation Number	Part Number	Operation	Tooling
230	28-6	Load washer	Hand wrench
	28-5	Bushing	
	28-9	Spring to rod (No. 7)	
	28-4	Lever assy to pedal & rod (No. 9)	
	28-10	with hex head screw	
	28-11	Washer	
	28-12	Hex nut	
240		Radiator assy - engine cooling	Pneumatic
	-037	Baffle - radiator left	Power wrench
	-038	Baffle - radiator right assembly to body w/11 three bolt each side	
250	10160-1H-1	Radiator assy - engine cooling locate radiator into	Pneumatic Power wrench
	-032	Cowl - radiator into shroud and assemble to R&L side baffle with six bolts	
	-039	Baffle - radiator upper assemble to shroud	
260	-001	Hose radiator return locate to radiator and engine and	Hand wrench
	-002	Secure with two clamps	
270	-016	Housing - thermostat lower	Hand wrench
	-007	Hose radiator outlet to	
	-008	housing with two clamps	
	-013	Hose T-pipe to thermo housing	
	-014	with clamp	
	-015	Clamp to T-pipe	
280	-029	Hose - water pump to pipe	Hand wrench
	-030	Clamp - pipe hose lower	
	-031	Clamp - pipe hose upper	
	-028	Pipe coolant	
	-029	Hose - water pump to pipe assemble to water pump & AC engine & thermostat	
290	-034	Fan and motor assy - radiator electric assy with	Hand wrench
	-035-036	Attaching hardware to radiator	

Operation Number	Part Number	Operation	Tooling
300	128-2-9	Cooling & Heating circuit bypass hose from intake	Pliers
	2-12	Radiator circuit	
	2-13	Heater circuit	
		Attach to heater and engine	
310	10160-7-1	Exhaust system - C/P purchased	Hand wrench
	-001	Manifold assy 002 gasket	
	-003	Hex nut inlet	
320	-004	Muffler & pipe assy primary	Head box wrench
	-005	with attaching hardware	
	-006	Muffler assy final attach	
	-007	with attaching hardware	
	-008	Tail pipe	
	-010	Strap assy assmeble with	
	-009	attaching hardware tail pipe	
330	10160-4-4	Arm assy -frt suspension upper LH	Torque wrench
	4-5	Arm assy -frt suspension upper RH	
		Locate and assemble to upper wheelhouse	
340	10160-4-6	Arm assy - frt suspension lower LH	Torque wrench
	10160-4-7	Arm assy - frt suspension lower RH	
		Locate and assemble to front sill two places	
360	10160-2-1	Shaft & joint assy axle drive LH	Torque wrench
	2-2	Shaft & joint assy axle drive RH	
	-007-8	Assembly to transmission and knuckle R&L	
370	10160-2-001	Front hub to knuckle assy with bearing, spacers, retainers hub, washer, nut and cotter pin to upper & lower control arms	Torque wrench
380	10160-3-1	Caliper assy - front disc brake LH	Torque wrench
	3-2	Caliper assy - front disc brake RH	
		Locate to hub and assemble to steering knuckle	

Operation Number	Part Number	Operation	Tooling
390	108-D-10033 -018 -019	Pedal, pad & pivot assy power brake locate and assemble to steering column support bracket. Attaching hardware	Torque wrench
400	10155-3-021	Switch assy brake light to dash and wire harness	Screw driver
410	108A-10037 -001 -002 -003	Booster & master cylinder assy power brakes Reservoir - power brake master Cylinder, cap-brake and Booster assy - power brake vacuum locate and assemble to brake pedal and secure to dash	Pneumatic wrench
420	108-A-10036 -001 -002	Brake line hose connection power disc brake system C/P Valve - combination proportioning and metering Brake line - master cylinder to rear axle connector assemble to master cylinder and brake line	Torque wrench
430	10160-5-1 5-2 5-001 3-4 3-5 5-002	Suspension & axle assy - rear C/P Axle assy - rear suspension Attaching hardware - hub & drum to axle Hub - drum & brake assy rear C/P LH Hub - drum & brake assy rear C/P RH Rod assy - rear suspension	Torque wrench
440	3-005 5-006 5-007	Spring - rear suspension coil Bumper - rear suspension jounce Attaching hardware shock absorber	Hand torque wrench
460	5-008 5-009 5-010	Compressor - shock air electric Brake assy - shock load level Attaching hardware Locate and assy to axle and body	Hand torque wrench
470	5-4	Arm & bushing assy. Rear suspension control. Locate to axle & body with attaching hardware	Hand torque wrench

Operation Number	Part Number	Operation	Tooling
480	10160-6-1	Wheel & tire assy locate and assemble to hub	Torque wrench
490	10160-6-2	Jack assy - bumper install into body	
500	10160-6-3	Ramp assy - wheelchair loading to under body with	Hand wrench
	-012	Ramp extrusion	
	-013	Retainer bracket	
510	10160-11-1	Bumper assy EA front locate and assemble to front bumper brackets	Torque wrench
	-001	Face bar - EA bumper front	
	-004	End cap - bumper face bar	
	-007	Bracket EA bumper mounting front LH	
	-008	Bracket EA bumper mounting front RH	
520	10160-11-2	Bumper assy - EA rear	Torque wrench
	-002	Face bar - EA bumper rear	
	-005	End cap bumper bar	
	-006	Energy absorber assy bumper	
	-009	Bracket EA bumper mounting rear	
	-010	Bracket EA bumper mounting rear	
	-012	Attaching hardware	
530	10160-12-1	Kit - wheelchair restraint complete	Torque wrench
	-7001	with Belt assy wheelchair restraint	
	-7002	Guide tube and bumper assy	
	-7004	Roller - corner belt guide	
	-7003	Shaft - roller	
	-7005	Tube guide	
	-7006	Roller - belt to floor	
	10160-12-2	Kit seat belt & retractor assy	Torque wrench
	12-3	Kit seat belt assy lap Shoulder to lap assembly	

Estimates of the tooling and fixturing required to support each of the two production levels are presented in Tables A4-1 and A4-2. The manning required is also shown for each.

Table A4-1

100 UNITS PER YEAR

	Tooling	Tool Cost	Manpower
Body Paint Shop			
8	Body trucks	$ 4,000	
4	Torque wrenches	1,400	
6	Slave door holders (sliding door)	150	
	Hand tools	50	
1	Wash-off bonderize booth	3,500	
1	Air blow off	1,500	
1	Infra heat booth	8,500	
1	Spray booth	10,000	
3	Spray guns and paint pots	1,050	
	Subtotal	$30,150	4
Subassembly			
4	Holding fixture engine	$ 2,000	
7	Torque wrenches	2,450	
	Hand wrenches	125	
	Subtotal	$ 4,575	2
			6
Body Trim & Painted			
14	Pneumatic power screw drivers	$ 750	2
6	Penumatic torque wrenches	2,100	2
	Glue applicator	150	
	Small hand tools	50	1
1	Glass holding fixture with suction cups	500	1
	Subtotal	$ 3,550	6
Final Line			
6	Body trucks	$ 6,000	2
9	Torque wrenches	3,100	2
1	Power hoist	1,500	
	Small hand tools	300	2
	Subtotal	$10,900	6
	TOTAL	$49,175	18

Table A4-2

5,000 UNITS PER YEAR

	Tooling	Tool Cost	Manpower
Body Paint Shop			
30	Body trucks	$15,000	2
1	Slave door holding fixture sliding door	2,800	2
	Misc. hand tools	500	4
1	Wash off bonderize booth	3,500	2
1	Air blow off fan	1,500	1
1	Infra heat booth	16,000	
1	Spray booth (paint)	10,000	2
6	Spray guns and paint pots	2,500	2
1	Infra heat booth (paint)	16,000	
1	Floor conveyor through heat booth	20,000	2
	Subtotal	$87,800	17
Subassembly			
12	Holding fixtures (engine)	$ 6,000	2
10	Torque wrenches	3,500	3
	Misc. hand wrenches	300	1
	Subtotal	$ 9,800	6
Body Trim & Painted			
1	Conveyor line	$10,000	2
12	Pneumatic power screw driver	4,200	4
2	Glue applicators	300	2
	Small hand tools	150	4
	Glass holding fixture with suction cups	500	2
	Subtotal	$15,150	14
Final Line			
20	Body trucks	$18,000	4
15	Torque wrenches	5,250	14
2	Power hoists	3,000	2
	Small hand tools	100	14
	Subtotal	$26,350	34
	TOTAL	$139,100	71

APPENDIX B

REPORT OF INVENTIONS APPENDIX

In compliance with the requirements of the Contractor Report Exhibit to basic contract covering this program, a thorough review was made of the work done and of the Final Report to determine whether any inventions or discoveries were achieved or patents submitted as a result thereof. It was determined that no "subject inventions" or discoveries were made or patents applied for.

This program did result in a number of innovations and improvements that evolved in vehicle redesign and manufacturing analysis. Noteworthy among these were:

1. Improvement of passenger accommodation and comfort by increasing wheelbase without increasing overall vehicle length.
2. Identification of those elements of life cycle cost over which the vehicle designer and manufacturer can exercise some influence and/or control.
3. Insight to the special economic and planning problems that affect low volume production of vehicles, i.e., in that range that lies between a few or tens of vehicles and the mass production rates of 100,000 units per year.
4. Maximum utilization of production shelf item components in order to minimize time and cost to develop, tool, and test.

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