Development of Repair Time Standards for Engine & Transmission (power plant) Replacement of Transit Vehicles

Final Report

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16. Abstract

This project is the continuation of the successful Repair Time Standards research initiative started two years ago to establish accurate repair time standards for vehicles in public transit systems. During this third phase the engine removal and replacement system were studied and evaluated. Standards that optimize the time required to perform tasks, continually improve reliability of services and conserve resources at a minimum cost will be established. One of the tasks during phase III was to benchmark the proposed methodology and preliminary results with current practices from other transit agencies nationwide including the Metropolitan Transit Authority in New York City, New York; the Metropolitan Atlanta Rapid Transit Authorization in Atlanta, Georgia; the San Francisco Municipal Railway in San Francisco, California; and the Metropolitan Bus Authority in San Juan, Puerto Rico.

This report summarizes the results of the visits to these facilities. In addition, during this research we explored another technique used for developing standards namely MODular Arrangement of Predetermined Time Standard (MODAPTS). This tool was used to validate the observations taken at the various transit facilities in central Florida, and to develop reliable standards which resulted on improved productivity.

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EXECUTIVE SUMMARY

This project is the continuation of the successful Repair Time Standards research initiative started two years ago to establish accurate repair time standards for vehicles in public transit systems. During the Phase I time standards for each element in the process of repairing the braking system were reported and validated. In Phase II, time standards for the complex process of preventive maintenance were established. In addition, a database that compiles information related to the systems previously analyzed has been developed and tested. During this phase III the engine removal and replacement system were studied and evaluated. Standards that optimize the time required to perform tasks, continually improve reliability of services and conserve resources at a minimum cost were established.

This report describes in detail the process followed during the development of the repair time standards for engine & transmission (Power plant) replacement. The study is conducted from on-site observations taken from three participating transit facilities. The processes are observed and analyzed at HARTline (Tampa, Fl), PSTA (Clearwater, Fl), and Lynx (Orlando, Fl). Job's process benchmarking is utilized to generate new process flows considering the best practices that fulfill the requirements of transit maintenance departments with similar characteristics.

One of the objectives of the Repair Time Standards research project, sponsored by Florida Department of Transportation, is to benchmark the proposed methodology and preliminary results with current practices from other transit agencies nationwide. This report presents the results of four visits to facilities outside the state of Florida. These facilities included: the Metropolitan Transit Authority in New York City, New York; the Metropolitan Atlanta Rapid Transit Authorization in Atlanta, Georgia; the San Francisco Municipal Railway in San Francisco, California; and the Metropolitan Bus Authority in San Juan, Puerto Rico.

In this research, we also explored another technique used for developing standards; MODular Arrangement of Predetermined Time Standard (MODAPTS). This technique is widely used in Europe, and it is becoming more popular in the US. The main advantages of MODAPTS include: no stopwatch required, no performance rating, ergonomically sensitive, and methods sensitive. This tool was used to validate the observations taken at the various transit facilities in central Florida, and to develop reliable standards which resulted on improved productivity.

1.0 INTRODUCTION AND SCOPE

Competition has pushed the public sector to restructure itself to operate more effectively. Fundamental tools available to accomplish this objective include: methods, time study standards, MODular Arrangement of Predetermined Time Standard (MODAPTS), and work design. This study incorporates principles of industrial engineering and work measurement to establish standards for transit vehicles. Establishing time standards is a step in the systematic development of new work-centers and the improvements in methods used in existing work-centers. Areas such as planning, control, training, and scheduling are closely related to standard functions. To operate effectively, all these areas depend on time and operational procedures.

The objective of this study is to establish accurate repair time standards for transit vehicles in Florida public transit systems. This project develops standards in order to minimize the time required to perform tasks, continually improve reliability of services and to conserve resources and minimum costs by specifying direct/indirect materials of tools to provide repair service.

The previous reports (Phase I and Phase II) on the repair time standard for transit vehicles respectively, describes in detail the time standard development for brake system component and preventive maintenance (PM) of transit vehicles. This phase is further extended to develop time standard for engine & transmission (Power-plant) replacement.

2.0 REVIEW OF RELATED WORK

One of the main request from the steering committee, comprised of members of the Florida Maintenance Training Advisory Committee for this phase was to benchmark the proposed methodology and preliminary results with current practices from other transit agencies nationwide. The mission of the benchmark activity is to share and validate results related to repair time standards for transit buses.

Preliminary research and literature review indicated that several agencies have been working on the standardization of repair processes. During the first six months of the current phase for this project, four facilities outside the state of Florida were visited. These facilities included: the Metropolitan Transit Authority in New York City, New York; the Metropolitan Atlanta Rapid Transit Authorization in Atlanta, Georgia; the San Francisco Municipal Railway in San Francisco, California; and the Metropolitan Bus Authority in San Juan, Puerto Rico.

The Metropolitan Transit Authority (MTA-NYC) is the largest transit agency in the US and one of the places where a type of standards has been developed. During a presentation of the RTS methodology at the TRB 85th annual conference, a representative (Joane Boiano) from MTA-NYC showed interest in our research since her agency had been working on a similar project. As a result, a connection was established with MTA-NYC for benchmarking purposes.

Another contact established was with Brooks McAllister and Don Goddard from the Metropolitan Atlanta Rapid Transit Authorization (MARTA) in Atlanta, Georgia.

This communication was facilitated through the TRB fleet maintenance committee and Stephen M. Stark - Senior Director, Program Management Support at MTA NYC-transit.

The San Francisco Municipal Railway (Muni) and the Metropolitan Bus Authority (or AMA, for its Spanish Acronym) were the other two agencies visited. The visits consisted in meeting with maintenance personnel such as supervisors, planners, or industrial standards developers, to discuss their procedures when dealing with standardization of operations. Most of the visits were initiated with a brief presentation (see Appendix A) summarizing the objective of this project, followed by a discussion of their experiences and opportunities for improvement. Also, a set of questions directly related to repair time standards were discussed. Appendix B shows the questionnaire and the answers given by the MTA-NYC group. Typically, a tour of the maintenance facilities and depots was arranged to observe their methods when performing repairs.

The following section summarizes the activities and findings from the visits to these four facilities. Documentation collected during the visits and pictures are also included.

2.1 TRANSIT FACILITIES VISITED—GENERAL INFORMATION

The following sections provide information on the facilities visited, in terms of their location, population served, and other general statistics.

2.1.1 METROPOLITAN TRANSIT AUTHORITY (MTA)-NEW YORK CITY, NY

Metropolitan Transit Authority (New York City) is the largest agency in the MTA regional transportation network with the largest bus fleet as compared to any other public agency in North America. With 181 local and 38 express bus routes in the five boroughs (covering 2,109 miles) and a fleet close to 4,566 buses, MTA bus division serves approximately 2.5 million riders daily (762 million annually). Every bus at NYC Transit is accessible to people in wheelchairs via front or rear-door lifts; some newer buses have low floors that enable customers to enter via front-door ramps [1].

2.1.2 METROPOLITAN-ATLANTA RAPID TRANSIT AUTHORIZATION (MARTA)—ATLANTA, GA

The Metropolitan Atlanta Rapid Transit Authority (MARTA) is the Nation's 9th largest transit agency and carries 98 percent of all transit riders in the Atlanta region. It offers bus, rail, shuttle and park and ride services to the public. There are about 120 bus routes, including 5 Blue Flyer routes. The fleet size consists of 556 buses (Compressed Natural Gas-441, Clean Diesel-145). MARTA provides easy service to elderly and disabled passengers 110 Lift-Vans for Paratransit Service. All of MARTA's trains and rail stations, as well as their entire bus fleet are accessible to handicapped individuals.

2.1.3 SAN FRANCISCO MUNICIPAL RAILWAY (MUNI)-SAN FRANCISCO, CA

The San Francisco Municipal Railway (Muni) is the seventh-largest public transit system in the United States. It has approximately 700,000 boardings on an average weekday.

Their fleet of about 1,000 vehicles, over half of which are electric, consists of subway-surface light-rail vehicles (Metro streetcars), electric trolley buses, diesel buses, cable cars all the time, which are the only ones in the world still operating, and a unique collection of historic streetcars. It has nearly 785 diesel and trolley buses operating over 71 lines with a total of 80 lines including the street car lines. It serves a total of 46.7 square miles and employs more than 4,500 people in over 200 different job classifications. [2]

The operating hours of the diesel and trolley buses depend on the line; however, some electric trolley bus lines might operate 24 hours per day and seven days per week thus making the service available anytime to the public.

2.1.4 METROPOLITAN BUS AUTHORITY ("Autoridad Metropolitana de Autobuses" - AMA) SAN JUAN, PR

The metropolitan authority of buses is one of the authorities that provide a service of buses as an alternative of transportation in the metropolitan area of San Juan. The agency was created in 1959 as a public corporation to offer low cost services, what nowadays is a reality of the service proposed.

The metropolitan bus authority serves seven municipalities of the metropolitan area of San Juan including: San Juan, Guaynabo, Bayamón, Trujillo Alto, Toa Baja, Cataño, and Carolina. AMA operates 30 routes where 28 of them offer regular service and two are express routes. AMA employs almost 1,200 workers where 656 are bus drivers. Currently, AMA is serving about 113,000 individuals daily. Table 1 summarizes operational statistics from 1996 to 2000.

Statistics for the year 2000 by the National database of Collective Transportation reveal that the fleet of the system of the AMA consists of 301 available buses for service in its maximum capacity with 196 buses operating on regular routes. Fifty three of such buses provide special accommodations to handicapped individuals. Each one of the buses has installed a system of "Geographic Position System (GPS)". With this modern system the buses are monitored to maintain a control and supervision more secure and efficient. Some of the characteristics of the vehicles used by AMA are presented in Appendix C.

Table 1. Characteristics and Operations of the AMA System

	1996	1997	1998	1999	2000
Miles of passengers yearly (millions)	62.02	73.62	80.89	85.14	99.67
Profit in annual miles of vehicles (millions)	4.81	4.76	5.61	6.60	6.45
Profits in annual hours of vehicles (thousands)	518.4	491.0	561.5	624.7	619.2
Trips undertaken yearly (millions)	17.23	19.37	22.40	25.14	28.14
Approximation of trips undertaken weekly	52,692	58,966	67,130	76,150	84,114
Available vehicles for maximum service	241	250	268	288	301
Vehicles operated to maximum service	157	155	188	194	196
Trips undertaken by passenger/profits of vehicle mile	3.58	4.07	3.99	3.81	4.36
Trips undertaken of passengers/ hour vehicles profits	33.24	39.45	39.88	40.24	45.44
Operational expenses ($ millions)	$37.04	$33.35	$35.97	$38.32	$42.97
Operational expenses /mile vehicle profit ($)	$7.70	$7.01	$6.41	$5.81	$6.66
Operational expenses /hour vehicle profit ($)	$71.44	$67.92	$64.05	$61.33	$69.39

Reference: Federal Transit Administration, Transit Profiles, National Transit Database, 1996-2000

2.2 MAINTENANCE DEPARTMENTS

In MTA, buses are housed, washed, and maintained at 18 depots, while general overhauls and heavy maintenance take place at the Bronx's Zerega Avenue and Brooklyn's East New York Central Maintenance Facilities. Additionally, two shops located at the Ninth Avenue in Manhattan and the East New York in Brooklyn rebuilds individual bus components. Finally, buses are painted at the Cross-town and Zerega shops. Improvements in Capital Program and Preventive Maintenance have increased bus mileage between 1982 and 2002 nearly quadruple [1].

In MARTA buses are housed, washed, and maintained at four locations. Currently, there is a project to renovate all 48 miles of MARTA rail by early 2007 as part of an $80 million capital program. In the last years, MARTA has been expanding by offering more routes to new popular locations and opening a new Park & Ride facility that serves three bus routes in North Fulton County to satisfy the needs of transit riders in Atlanta.

The majority of Muni's facilities are dedicated to the storage, maintenance, and dispatch of Muni's fleet of revenue vehicles. The Woods Division, the Flynn Division, and the Kirkland Division house motor coaches. The Woods Division is Muni's largest motor coach facility. This facility handles storage, maintenance, and dispatch of approximately 265 standard-size motor coaches, making it Muni's largest facility in terms of the number of vehicles based there. The only motor coach facility to accommodate articulated buses is the Flynn Division. All maintenance, operations, and storage functions are performed at this location. A new facility that was recently built is the Isles Creek Bus Maintenance Facility. The new facility provides parking for 135

Muni buses, and buildings for operations and maintenance personnel, service bays, and vehicle fueling and washing.

AMA's maintenance department is significantly large. Almost one quarter of the company workers are maintenance technicians. Recent improvements to the services provided by AMA have enabled the system to serve 113,000 transit riders daily. AMA envisions utilizing data from an automatic location system to line up preventive maintenance for the units, and to coordinate mayor maintenance as a function of the vehicle utilization. In addition, they are planning to improve how maintenance is conducted and how drivers are schedule.

2.3 STANDARD REPAIR TIMES (SRT)

From the facilities visited only the New York City Department of Buses MTA had an internal industrial standards department. The group was active from 1994 to 2004 developing credible and equitable labor time standards, as well as procedures for frequently performed maintenance activities. The major goal of this group was to standardize the performance of work and meet appropriate industry standards for safety, quality, reliability, functionality, and appearance within the STR. Refer to Appendix D for a presentation of the Industrial Standards Department.

MTA defines standard repair times as a list of work tasks and the cumulative time to perform the task. The procedures list the tasks required to ensure that a vehicle, system, or component, is ready to return to service after a quality repair is performed at the lowest possible cost and with minimum delay. Standard repair time is equitable when the repair described in the procedure can be performed by an experienced operator working at normal pace in a time that is less than or equal to the standard. Typically, the operations that the technicians perform more frequently will take less time that the estimated standard.

To accurately estimate the required time, detailed studies were necessaries. The department worked in collaboration with supervisors, engineers and maintainers. The complete study was developed in a separate environment with people from the training department. The standards were developed and recorded in videos and documents to be later presented to the managers and supervisors of the depots for validation and execution.

2.3.1 STANDARD REPAIR TIMES DEVELOPMENT

The SRT were developed from analysis of observations and work sampling data in addition to other industrial engineering methods. The steps followed for the standards development were:

1. Information from the original equipment manufactures (OEM) standard repair time's documents, other transit agencies, and industry groups including APTA and the Technology and Maintenance Council of the American Trucking Association such as the American Trucking Association was collected. MTA-NYC requires OEM SRT

for each bus specification. This information was used as an input to develop the task's time.

2. Supervisors created a comprehensive list of the work elements or tasks required to perform a specific repair.
3. People from the industrial group (independent sources) observed the processes and analyzed them for improvements. The processes are then modified and the total time is later compared with the data collected from other sources.
4. Elements missing from any source are performed and observed to determine the correspondent times and then added to the general process.
5. The final time is established for the entire procedure and included in the document (Bulletin).

Appendix E and Appendix F show the process followed in more detail. This in formation was given by the MTA personnel during our visit.

2.3.2 STANDARD REPAIR TIMES PROCESS AND TOOL DEVELOPMENT

The industrial standards group used time and motion studies as well as work sampling to establish time standards. Appendix G shows the Technical Services Bulletins (Job Procedures) followed at MTS.

Additionally, they applied ergonomic principles to modify tools and work stations to create a faster, easier and safer work environment. They designed a multifunctional and ergonomically designed Hub & Drum rebuilding stand. This new tool provided an ergonomic method that reduced the number of maintainers from two to one while giving less equipment use and cost. Appendix H show recommendations given for tool improvement and facility layout.

2.3.3 PRODUCTIVITY AGREEMENT WITH LABOR

MTA-NYC successfully negotiated productivity improvements with the hourly workers unions in successive contracts from 1994 through 1999. Contracts included approval of SRT, a joint committee of union and management to develop SRT, an independent expert to resolve any disputed SRT, training provisions for employees not at specific skill levels, methods for reclassifying employees who cannot meet the SRT owing to a lack of mechanical aptitude, approval of OEM flat rate SRT, and adoption of a PIP that includes a bonus for complying with SRT [3].

2.3.4 MONITORING OF PRODUCTIVITY AND COMPLIANCE

MTA-NYC uses electronic databases to track and report time taken to complete tasks. In general, the process is as follows: 1. An employee's supervisor initiates a work order for a given job, (2) then tracks the work performance on that job, (3) each SRT has a unique code, (4) the numbering system is common to all directives and bulletins distributed by MTA NYCT. Compliance is monitored daily by both management and the union. Supervisor productivity is monitored biweekly in a comprehensive performance [3].

2.3.5 IMPACT

MTA-NYC maintenance personnel use electronic diagnostic equipment to reduce troubleshooting time. MTA-NYC also uses kits or bill of materials (BOM) for most work performed in its overhaul and unit rebuild shops.

Picture 1. Bill of Material Kit

Picture 1 shows the Kit/BOM. Kits/BOMs have greatly improved productivity by reducing setup time and waiting time for parts from the storeroom. In the small unit shop, kits/BOMs are provided once a day and delivered to the individual employee's workbench before the shift begins. The kits/BOMs contain 100% replacement parts. As a result, they eliminate the need to sort out and retrieve parts from bins. MTA-NYC has also developed special tools to facilitate safety and efficiency.

According to the MTA representatives, they give the documents to the technicians and they have to complete the jobs based on the standards given. These documents are called "Industrial Standards Bulletin". They describe the procedures that technicians have to follow to complete the job. The total time to complete the job is presented at the beginning of the bulletin, a bill of materials and the tools required are also summarized in this bulletin.

Technicians need to fill out a work sheet with the job completed and the time after every shift. A computer software called "MIDAS" (see Appendix I) is used to track the information from the jobs completed. The times spent by the technicians are monitored and reviewed by the supervisors in a daily basis. If the technician does not meet 95% of the time required to complete the job, he/she is sent to training school. If the situation becomes repetitive, the technician is relocated. The information entered to the system is also used by other technicians coming in the following shift to verify the status of the jobs that need to be completed.

It was found that the process of entering information to the system was complex and time consuming. Moreover, it was pointed out that the system was not user friendly; therefore technicians and supervisors spend too much time from their shifts inputting information into the system.

Job specialization becomes apparent when the technicians consistently select the same type of job to be performed on a daily basis. The advantage is that a specialized workforce is more consistent (with respect to the standard time) and on target when completing the repairs. However, to avoid monotony and reduce turnover, technicians are encouraged to go to training school to specialize in other activities after performing the same job for more than two years.

3.0 POWER-PLANT DESCRIPTION

The engine and transmission (power-plant) are installed longitudinally, straight in from the rear of the bus. The transmission and the power plant can be removed from the bus separately. However, the engine cannot be removed by itself. Engine replacements are less frequent than transmission replacements. Engines are mostly replaced when the vehicle reaches approximately its 500,000 miles. On the other hand, transmissions are commonly replaced when the bus is surrounding the 250,000 miles. Proper maintenance on engine related systems such as fuel, cooling, and air intake is expected to ensure the long life of the fleet.

Currently, an engine replacement takes approximately three days to be performed. Availability of parts is very important to reduce completion time since new engines need to have the exact characteristics that match with the vehicle specifications. The majority of buses found at the participant facilities are make Gillig and New Flyer. The technical specifications or power train depends on the model and year of the buses. However, the power train has similar characteristics and the replacement processes are alike. Table 2 shows the most common types of engine and transmissions found in the fleet studied.

Table 2. Fleet Model and Types of Engine and Transmission

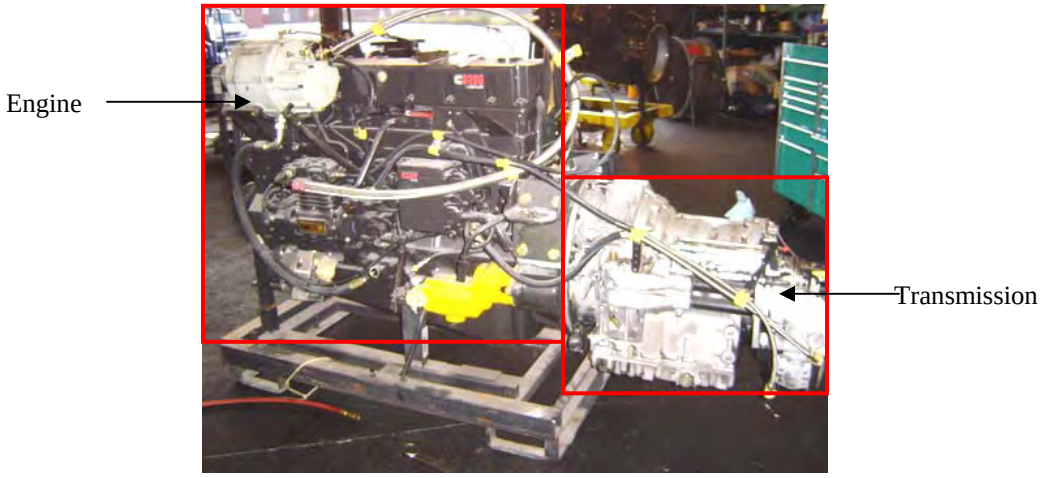
Model	Year	Engine	Transmission
Gillig Phantom	1994-1998	Detroit Diesel Series 50	Voith D863.3
Gillig Phantom	1989	Detroit Diesel Series 92	Voith D863.3
New Flyer D40LF	1996	Detroit Diesel Series 50	Allison B400R
Gillig Low Floor	1998	Cummins C8.3	Voith D864.3
New Flyer C40LF	1998	Detroit Diesel Series 50G	Allison B400R
New Flyer D40LF	2000	Cummins ISC	Voith D863.3
Gillig Phantom / Low Floor	2001	Cummins ISM	Allison B400R
New Flyer D60LF #100-115	2002	Cummins ISL	Allison B500R
Gillig Phantom / Low Floor	2002, 2003, 2004	Cummins ISL	Voith D864.3

It was found that the three participating transit facilities presented some differences in their policies of power plant removal. The decision of removing the complete unit when the engine or the transmission needs to be replaced depends on the facility. Likewise, the number of technicians who participate in the job varies depending on the facility and the type of job. Table 3 shows some of the differences initially found in the pilot observations:

Table 3. Differences in the Processes among Facilities

	HARTline	Lynx	PSTA
Engine/Transmission Repair	Outsourcing	Outsourcing	In house
Unit Removal - Process	Separated	Together	Separated
Number of technicians	One or two	Two or three	Not observed yet

When a job of engine replacement is performed the power plant unit is typically removed. In other words, the transmission is also removed but not necessarily changed. Due to the complexity of the system connections, it takes less time to remove the power plant and then the transmission can be separated when the unit is out of the bus. Picture 2 shows the power plant unit as it is.



Picture 2. Power Plant Unit

4.0 REPAIR TIME STANDARD METHODOLOGY

The process followed to determine the standard times for power plant replacement was based on the systematic approach developed by [4] for repair time standards for transit vehicles. Figure 1 provides a description of the process followed to develop the time standard for power plant removal and installation.

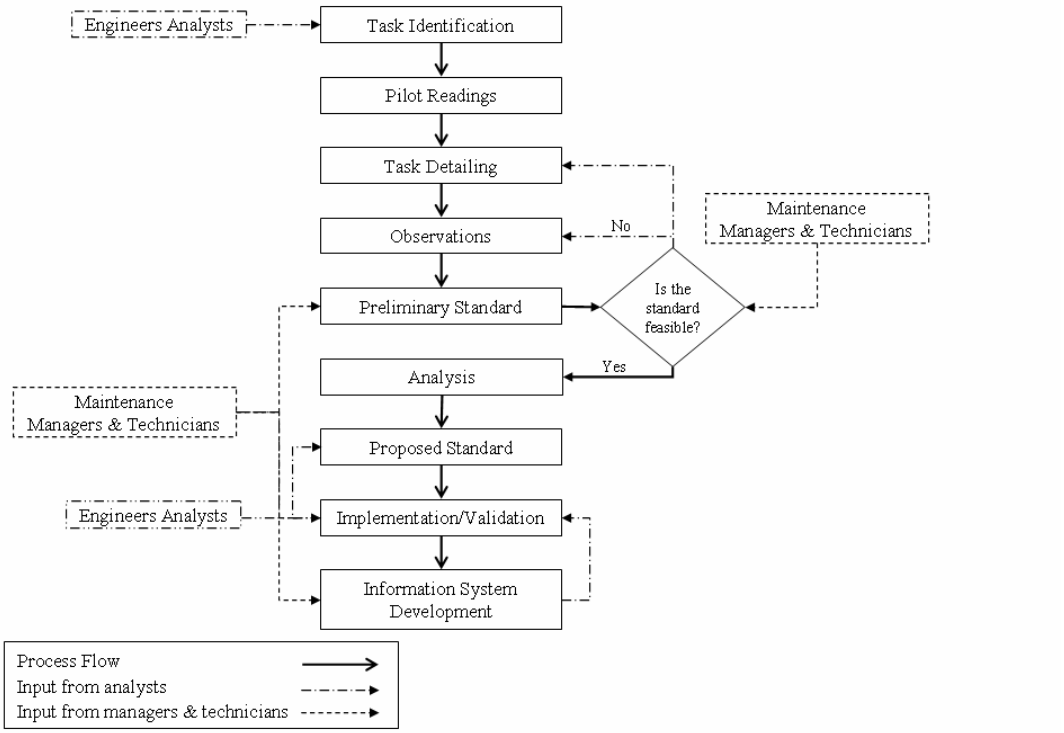


Figure 1. Repair Time Standard Methodology

1. **Task identification--** Determines which system will be studied.
2. **Pilot readings--** Allow the analysts to become familiar with the process being studied.
3. **Task detailing--** Encompasses the selection of the major processes within a task along with the corresponding elements.
4. **Observations--** Record current practices performed by the most experienced technicians.
5. **Preliminary standards--** Developed after completing the required observations. In this step, the workflow is analyzed and the best practices among facilities are benchmarked to develop a standardized flow.
6. **Analysis--** Grouping and comparison of processes to develop the best procedures for the facilities. The recorded times are analyzed to understand variability and to identify foreign elements.
7. **Proposed time standards--** Final standard time which includes allowances.
8. **Implementation and verification--** Entails the practice of maintenance using the standards developed. A technician, who consistently works at a normal pace, is selected for verification.
9. **Information system development--** It is included to record data on buses, technicians, standard times, etc. It is required to enforce the standards usage and Control technicians' performance.

Each task is described in detail in the following sections.

4.1 TASK IDENTIFICATION

After the successful completion of standards for brakes and Preventive Maintenance (PM), the next task undertaken was to develop time standards for power-plant (Engine/Transmission) of the transit buses as indicated by the steering committee, comprised of members of the Florida Maintenance Training Advisory Committee

4.2 PILOT READINGS

Due to the low frequency of power-plant replacements pilot readings were taken as observations to calculate the standard. The process was easily understood by the analysts since they had already developed standards for preventive maintenance, fact that helped in the quick familiarization with the process and its components. It has been found that no written procedures are followed. Therefore, when a new technician is being introduced to the job, he/she must be instructed and accompanied an experienced technician. Although different technicians have been observed during the pilot readings, they perform the process in a similarity manner. These observations were used to develop the preliminary process flow that is described in the following sections.

4.2.1 POWER PLANT REPLACEMENT PROCESS

The engine replacement job compounds three main processes: (1) Removing engine accessories, connections and assembly; (2) replacing assemblies, connections and preparing new engine; and (3) reinstalling engine accessories, connections and assembly. Figure 2 shows the general components of power plant replacement job. The explanation and steps of each one are presented subsequently.

Figure 2. General components of power plant replacement job

Removing Engine Accessories, Connections and Assembly--This step involves the disconnection of the components located around and under side of the engine compartment and that go connected to the engine or transmission. Among the processes making part of this section are drain fluids, engine and transmission accessories removal, electrical connections removal, and system connections removal. This process ends with the removal of the power plant assembly. Figure 3 shows the modular approach to remove engine accessories, connections and assembly. Arrows going in both directions mean that any process can be performed first.

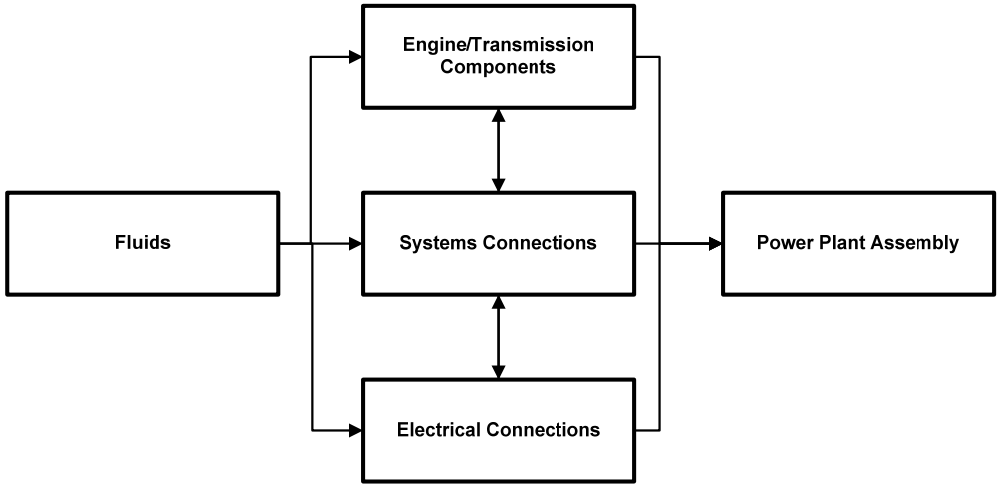


Figure 3. Engine Accessories, Connections and Assembly Process Removal

Replacing Assemblies, Connections and Preparing New Engine--This process encompasses the pressure cleaning of the engine compartment, the inspection and replacement of the engine assemblies and wires, the inspection and cleaning of the radiator and systems, and the conditioning of the new engine. Figure 4 presents the modular approach to replacing assemblies, connections and preparing new engine. Arrows going in both directions mean that any process can be performed first.

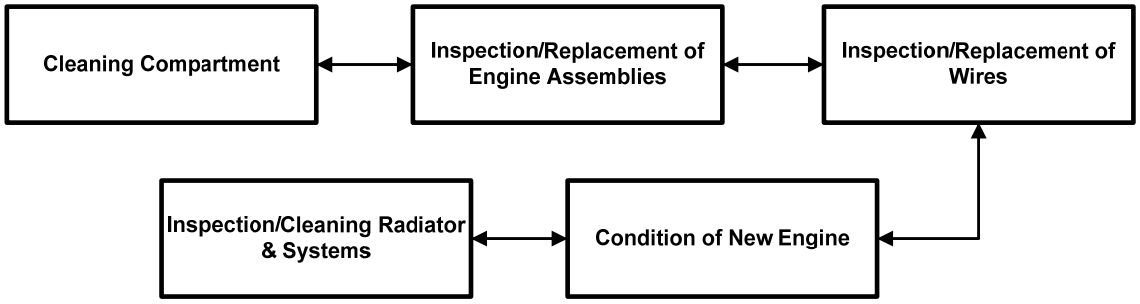


Figure 4. Process of Replacing Assemblies, Connections and Preparing New Engine

Reinstalling Engine, Connections and Assemblies --After preparing the engine and compartment and having the system components ready, the engine/transmission is ready to be installed. It is necessary to install the mounts and the assemblies, and then, reinstall the hoses, pipes and components as seen in Figure 5.

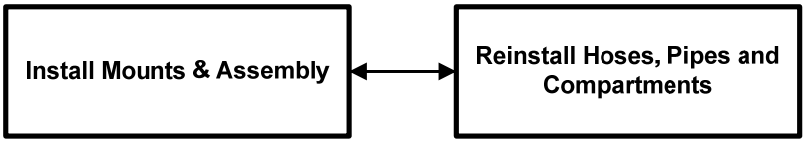


Figure 5. Process of Replacing Reinstalling Engine, Connections and Assemblies

After the power plant is installed the next step is to start the engine and perform a road test to ensure that the systems are working properly.

4.3 TASK DETAILING

Task detailing encompasses the selection of the major processes within a task along with the corresponding elements. From each of the main components of the process the list of operations was generated. Some operations are combined due to the variability in completion time and the small units of time per subcomponent. The task detailing is shown in Appendix J.

4.4 OBSERVATIONS

A total of three observations were taken to develop the standards, being Lynx Orlando the facility that assisted the analysts in the observation process. This facility has a larger number of buses and their mileage average is a lot bigger than the Tampa and Clearwater fleet. PSTA Clearwater does not perform this type of jobs in a regular basis. Similarly, HART, Tampa performs more transmission replacements than power-plant jobs.

It was observed that technicians from Lynx process this job faster due to the availability of tools and the skills developed when performing this job regularly. During the observations, some differences were found among technicians.

The engine removal process is usually performed by two or three technicians. The total time used to calculate the number of observations is taken from the technician leader or the one who takes the longer time in the complete process. If the other technicians report less time it may be because they join the process after the starting time or because they are helpers assisting intermittently.

While collecting the data other inconsistencies were observed:

1. Element differences: Although every operator followed the same process to complete the power-plant replacement job, each operator had a unique method of working on the elements of each process. Due to this variation the data collection became difficult and much more challenging. However, it also helped us to identify the best practice by comparing various styles.

2. Facility Layout: Each participating facility had a different work-floor layout; hence travel times varied significantly depending on the layout. An attempt was made to develop the time standard independent of the facility layout. Thus the standard developed considered the travel times in the vicinity of the bus. This might result in an actual increase or decrease in the travel times depending upon the facility design. This makes the standards independent of the facility, yet effective.

3. Equipment: Equipment used by the different facilities for performing the operations varied. Thus the time taken by working on the commonly used equipment was considered for the standard development. This would not require any facility to buy additional equipment for implementing the time standard.

The initial visits to the facilities by the time standard analysts were to understand the power-plant replacement process. The total time to complete the job was recorded.

The number of observations required is going to be calculated from three observations by using the statistical formula presented in the RTS methodology. The results expected are within a 95% of confidence level. Table 4 shows the results of the calculations.

$$n = \left\{ \frac{st_{\alpha/2,v}}{k\bar{x}} \right\}^2 = \left(\frac{674.6 * 4.303}{0.05 * 13895.7} \right)^2 = 4.177986 \cong 5$$

Table 4. Data Required Determining Number of Observations

Total Time from Reading 1	14502 secs.
Total Time from Reading 2	14016 secs.
Total Time from Reading 3	13169 secs.
Mean	13895.7 secs.
Standard Deviation	674.6
Degrees of Freedom (n-1)	1
Percentage Points of the *t* Distribution	4.303
k (5% probability of error)	0.05
Number of observations	4.177986
Number of observations to take	**5**

The three readings considered to calculate the observations are summarized in Appendix K.

4.5 PRELIMINARY STANDARD

A preliminary process flow is deducted from the observations taken and shown as follows. Time per element is not yet recorded since the preliminary standards is not yet determined. However, an estimation of time per process is calculated. The summary of times and the averages are presented in Table 5 and Table 6.

Table 5. Preliminary Process Flow Power Plant Removal

Description Summary	Reading 1 secs.	Reading 2 secs.	Reading 3 secs.	Average
Number of technicians	**3**	**2**	**2**	
Process Description				
Set Up	**1330**	**1780**	**1180**	**1430**
Fluids Draining	**1537**	**570**	**1883**	**1330**
Disconnect Coolant Lines & Pipes	**2137**	**2028**	**2040**	**2069**
Disconnect Middle components	**4448**	**4523**	**5203**	**4725**
Disconnect Components Inside the Bus	**1730**	**1360**	**1580**	**1557**
Bumper & Front Motor Mounts out	**503**	**1735**	**1985**	**1408**
Take out power plant from bus	**2077**	**1143**	**1080**	**1434**
Total average time in Seconds	**14502**	**14016**	**13169**	**13950.67**
Total average time in Minutes	**230**	**219**	**250**	**233**
Total average time in Hours	**3.83**	**3.65**	**4.17**	**3.88**

Notes:
Fluid drain in Reading 3 takes longer because technicians waited until the oil drained completely. Disconnect Middle components includes drive shaft, air intake for turbo and exhaust, lines.

Table 6. Preliminary Process Flow Power Plant Installation

Description Summary	Reading 1 secs.	Reading 2 secs.	Average
Number of technicians	**3**	**3**	
Process Description			
Bring New Power Plant + Alignment	**2855**	**2974**	**2914.5**
Connect Middle Components	**4365**	**6425**	**5395**
Connect Coolant Lines and Pipes (Left Side of the Bus)	**2570**	**2852**	**2711**
Connect Drive Shaft	**753**	**1685**	**1219**
Connect Cables inside the bus	**2045**	**2397**	**2221**
Fill Fluids + Start Bus	**1240**	**850**	**1045**
Total average time in Seconds	**13828**	**17183**	**15505.5**
Total average time in Minutes	**230.4667**	**286.3833**	**258.425**
Total average time in Hours	**3.83**	**4.77**	**4.3**

4.6 ANALYSIS

Before the standards were established, an extensive and thorough analysis and review of each element was conducted. It is important to emphasize that the time standards developed are realistic and feasible. This is supported by:

Actual readings: The standards are developed using actual data for the time required to complete work elements and tasks.

Normal pace: All the time suggested is to be performed at normal working pace, i.e., with no speed increment.

Facility layout: All the standards are based on flexible facility design, with no changes to it. Thus these standards can be implemented widely and effectively.

Other considerations: The approach used gives the time that is actually taken by the technicians to do the job, i.e., times are not based on the theoretic study.

4.6.1 ALLOWANCES

It was observed that technicians were subject to several stress level. To reduce the stress for the technicians certain allowances were added to the standard time. The main purpose of the allowances is to provide a fair time to perform an operation by the average worker in order to meet the established standards when performing at normal rate. These allowances are meant to give flexibility and justify rest for the operator thus, resulting on smooth and efficient working. The total allowance assigned for this study is 15%. Table 7 presents the allowances considered for this study.

Table 7. Allowances

Type of Allowance	Percent added to Normal Time
Personal	5
Basic Fatigue	4
Standing	2
Intermittent Loud Noise	2
Tediousness	2
Total	**15%**

Personal Allowance: This includes those cessations in work necessary for maintaining the general well being of the employee.

Basic Fatigue Allowance: The basic fatigue allowance is a constant to account for the energy expended to carry out the work and to reduce monotony.

Standing Allowance: This allowance generally accounts for the energy utilized in standing and gives flexibility and rest to the technician for standing continuously.

Intermittent Loud Noise Allowance: This allowance is generally accounts for the sound made by the equipments used. For instance the noise made by the air gun.

Tedious Allowance: This allowance is generally applied to elements that involve repeated use of certain parts of the body.

NOTE: The allowances established may vary depending upon the working and atmospheric conditions. It may also vary due to the facility layout.

4.6.2 TECHNICIAN PERFORMANCE RATING

The skill and effort of the technician will directly impact the actual time required to perform each element of the study. When different technicians are observed a variability factor is introduced. Even when the same technician is observed, performance might vary from time to time. For that reason, it will be necessary to adjust upwards to normal time of the good technician and the time of the poor technician downwards.

Since most of the technicians typically followed the same pace from beginning to end, it is customary to apply one rating to the entire study. Therefore, the analyst assigned a fair and impartial performance rating to each study. In the performance rating the observer evaluates the technician's effectiveness in terms of normal technician performing the same task. For example, if a technician performs below normal a performance rate of 90% to 95% will be assigned to that technician. On the other hand, if the technician works much faster than normal, then a 105% to 110% will be assigned.

4.7 PROPOSED TIME STANDARD

In this research a time standard is developed for the power-plant replacement taking into account all the activities required to complete the job. Refer to Appendix L for the flow process chart and time standards for the proposed method. Table 8 and Table 9 show the proposed time standard for the power plant removal and installation respectively.

Table 8. Proposed Time Standard Power Plant Removal

POWER PLANT REMOVAL				
Description	**Reading 1 (secs.)**	**Reading 2 (secs.)**	**Reading 3 (secs.)**	**Average**
Set Up	1130	1350	1180	1182.00
Fluids Draining	2207	1793	1663	1743.93
Disconnect Coolant Lines & Pipes	1315	2028	2645	1878.79
Disconnect Middle components	5858	3300	3208	4095.47
Disconnect Components Inside the Bus	2645	1360	1940	1816.12
Bumper & Front Motor Mounts out	503	2010	1845	1468.49
Take out power plant from bus	1162	1143	1458	1225.29
Total average time in Seconds	14820	12984	13939	13410.09
Allowances (15%)				2011.51
Time Standard in Minutes				257.03
Time Standard in Hours				4.28

The proposed time standard has approximately a total of 133 elements for power plant removal. From these a total of 126 elements were classified as operations, 4 elements were classified as transport or travel, 3 inspections, and 0 delays. The power plant installation process has a total of 78 elements. From these a total of 68 were classified as operations, 10 as transport, and 0 as delays. The complete flow process chart is shown in Appendix L.

Table 9. Proposed Time Standard Power Plant Installation

POWER PLANT INSTALLATION			
Description	**Reading 1 (secs.)**	**Reading 2 (secs.)**	**Average (secs.)**
Bring New Power Plant + Alignment	2855	2974	2914.5
Connect Middle Components	4365	6425	5395
Connect Coolant Lines and Pipes (Left Side of the Bus)	2570	2852	2711
Connect Drive Shaft	753	1685	1219
Connect Cables inside the bus	2045	2397	2221
Fill Fluids + Start Bus	1240	850	1045
Total average time in Seconds	13828	17183	15505.5
Allowances (15%)			2325.825
Total average time in Minutes			297.18875
Total average time in Hours			4.95

5.0 VALIDATING TIME STANDARDS THROUGH: MODULAR ARRANGEMENT OF PREDETERMINED TIME STANDARDS

MODular Arrangement of Predetermined Time Standards (MODAPTS) was developed by G. Chris Heyde, and introduced in 1966. MODAPTS is a predetermined time system used for calculating reliable production standards and improving an organization's productivity. Furthermore, many companies have used MODAPTS not only to determine plant capacity, to balance work, and to improve productivity but also to identify movements that are not ergonomically appropriate and take corrective action in the design phase of the task. MODAPTS is "solutions" oriented; therefore, immediate operational productivity improvements could be expected once the system is used [5].

The main advantages of MODAPTS include: no stopwatch required, no performance rating, ergonomically sensitive, and methods sensitive. Therefore, MODAPTS is a reliable tool to validate the results obtained in the time study described in the previous sections. The objective is to disintegrate to the lowest level all the movements that are necessary to perform the required tasks. This would help us to identify unnecessary movements that increase the total time to perform the task. The next section provides an introduction to MODAPTS and the codes that will be utilized for validation purposes.

5.1 INTRODUCTION TO MODAPTS

MODAPTS has been accepted around the world as a valid and useful predetermined time system since its first publication. In fact, MODAPTS is widely used in the USSR, Japan, Germany, Australia, New Zealand, Korea, and the United States. This worldwide usage is a tribute to MODAPTS simplicity, logic, effectiveness, low cost, and diversity of application.

MODAPTS is recognized by the U.S. Department of Labor as a preferred system for developing fair work standards for rehabilitation facilities. It complies with MIL-STD 1567A, specifications developed by the Department of Defense for work measurement programs of defense contractors.

This method is considered to be a very reliable technique. It has been used for more than 20 years in more than 40 countries around the world. Not only is MODAPTS reliable, it is also consistent. Consistency is a measure of dispersion between different analysts working up a standard for the same job. MODAPTS has proven to yield coherent results with an accuracy level of 3% because of accessibility [5].

5.1.1 USES OF MODAPTS IN THE TRANSPORTATION INDUSTRY

MODAPTS has been widely used in transportation environments. For example, Ford Motor Company plants to determine time standards for the different processes. A Baylor University glossary of management terms observes that Ford engineers, managers and union members work together to achieve a competitive product through improved quality using techniques such a predetermined times. As a predetermined time system, MODAPTS contributes to this effort by evaluating competing methods and setting

widely accepted time standards. Work measurements studies have evolved to estimate the time needed by qualified and motivated workers to perform a specified task at a specified level of performance [6].

MODAPTS has been used in many sectors including manufacturing, transportation and health care because it is easy to use. This technique enables design engineers, process personnel, line supervisors, industrial engineers, and ergonomics analysts to evaluate various work tasks and to identify potential risks at the job site without complex recording and data analysis equipment [7].

MODAPTS is based on the study of the basic human body movement. The time for any body movement can be expressed in terms of a multiple of the time taken for a single finger move. The time taken for a finger move is called a MOD. A MOD is a unit of work whose values assumes that the motions are carried out with minimal energy expenditure and that the time to move is proportional to the fifth root of the moment of inertia of the body part moved [6]. Figure 6 contains the equivalent values between a MOD and time is shown in the following figure:

Conversions
1 MOD = 0.129 sec.
1 MOD = 0.00215 min.
1 sec. = 7.75 MODS
1 min. = 465 MODS

Figure 6. MODAPTS Conversions

The application of MODAPTS on this study consists of the following steps:

1. Document the method of operation
2. Analyze the operation by projecting the body parts used to carry out an action or a series of actions
3. Look up or recall from memory the elements on the data cards and write them down the analysis form
4. Add the frequency, and divide by 7.75 to obtain the normal time in seconds.

5.1.2 MODAPTS CODES

MODAPTS codes contain 21 basic codes which are alphanumeric. The alpha code, which depends on the type of move, is combined with a number which is the MOD value for that particular code. For example, M2 is a *move(M)* which will take 2 MODS (0.258 seconds) to complete.

5.1.3 MODAPTS CLASSES OF ELEMENTS

This section describes the various classes of elements utilized in the study

1. Movement Class Elements: Represents movements through space where fingers, hands, arms, shoulders, or the trunk are involved. To perform the terminal activity, a movement is required to place the part of the arm in most cases. The arm part used for

the movement determines the numerical part of the code. For instance, if a finger is used to move a part, the numerical part of the code will become "1" (see Figure 7) and; therefore, the complete code will be "M1" (see Table 10). Likewise, if a movement requires the use of the forearm (up to the elbow), then the complete code will be "M3."

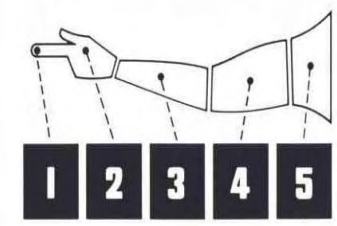


Figure 7. Arm parts used for Movement Elements

Table 10. Codes for Movement Elements

MOVE	Body Part Used	Distance Moved
M1	Finger	1"
M2	Hand	2"
M3	Forearm	6"
M4	Whole arm	12"
M5	Extended arm	18"
M7	Trunk	30"

2. Terminal Class Elements: These are activities performed after movement elements which are nearby to the item(s) being processed. The two types of activities under the terminal class are:

- **a.** GET--Activities requiring gaining control of the item(s) being processed.
- **b.** PUT--Activities requiring to place the item(s) in a location.

The following are the symbols and code used for terminal class including both GET (Table 11) and PUT (Table 12) activities. While the numerical part of the code depends on the contact type with the object being processed for the GET element, the numerical part of the code depends on the location where the object is placed for the PUT element.

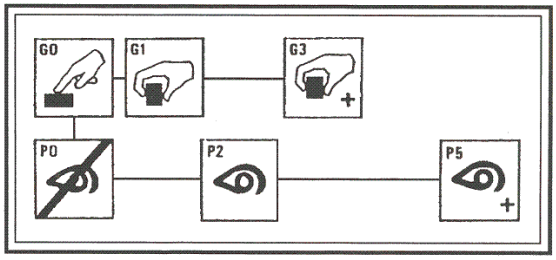


Figure 8. Terminal Class Element Symbols

Table 11. Codes for Get Elements

GET	Get Type
G0	Contact or touch
G1	Simple closing of fingers
G3	Complex closing of fingers

Table 12. Codes for Put Elements

PUT	Location
P0	To general location
P2	To specific location
P5	To exact location

3. Auxiliary Class Elements: Include activities which do not involve the use of the finger-hand-arm-shoulder-trunk system such as walking, bending, inspection, and decide. Following are the symbols and code for the auxiliary class elements. Values of the numerical type of the code might be fixed or be variable depending on the nature of the move, and whether there are higher, complex, more intense levels of the same move.

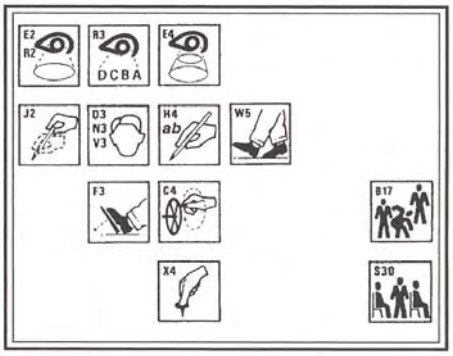


Figure 9. Auxiliary Class Element Symbols

Walk is defined as "lifting the foot entirely off the floor and placing it down in another location. It may be stepping forwards, backwards, sideways, or a partial or complete turn of the body by means of the legs."

WALK	Unit
W5	Per pace
W2.36	Per linear foot
W7.75	Per meter

Decide is an element that considers the time it would take to make a decision for the less likely or unusual case in a binary decision. For instance, a D3 will only be included in an inspection for the 10% parts rejected, but not for the 90% parts accepted. Additionally, a decide activity is only considered if no other task can be performed until a decision is made.

DECIDE	
D3	For the unusual case

If eye control is not an internal activity such as in visual inspections, code for the activity should be generated. Types of eye control include eye fixation, eye travel, and eye focus.

EYE CONTROL	Categories
E2	Eye fixation
E2	Eye travel
E4	Eye focus

Bend and arise is a vertical change in the upper part of the body including both the down and up movements. Awarded only if the hand goes below the knee when making the move.

BEND AND ARISE	
B17	Hand goes below knee

Sit and stand includes both the down and up movement, and it is recorded as one activity even if other tasks occur between.

SIT AND STAND	
S30	Production work

Extra Force takes place when the operator attains control over an object, holds back an object, or overcomes resistance while performing an activity. Only awarded when all other activities stop.

EXTRA FORCE	
X4	A hesitation (not visible)

Load factor provides additional MODS when the objects processed or transported are heavy. To calculate the effective net weight the following steps were followed: 1) measure the weight of the object, 2) if the object is slid, divide the weight by 3, 3) if the object is carried with two hands, divide the weight by two.

LOAD FACTOR	Effective Net Weight
L0	Less than 4.4 lbs.
L1	Between 4.4 and 13.3 lbs.
Add one MOD for each 4 8.8 lbs. of part thereof in excess of 13.3 lbs.	

5.2 VALIDATION OF OBSERVATIONS WITH MODAPTS

As described in the previous section, MODAPTS is an effective tool to validate the observations taken at the transit facilities because it provides a framework that can be easily applied to describe the movements necessary to perform the maintenance operations. This section provides a comparison of the results obtained using MODAPTS versus time standards.

Figure 10 shows an example of the coding developed using MODAPTS. This specific component is the drive shaft. In this figure it can be noted that certain codes have a "subroutine". Subroutines were developed for a combination of movements or actions that were frequently repeated during a process. They could contain between three over twenty elements that are followed in the same order. Each component of the power plant removal and power plant installation was coded using MODAPTS (see Appendix M). Appendix M shows coding for MODAPTS along with the corresponding subroutines.

DISCONNECT MIDDLE COMPONENTS			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Drive Shaft			
Walk to get security support to hold the shaft	W5	25	125
Get the security support	M2G1		3
Walk back to the bus with the support	W5	25	125
Put support under drive shaft for security	M2P0		2
Get tools	Subroutine		135
Loose big Nuts (transmission side)	Subroutine	2	2296
Loose big Nuts (shaft side)	Subroutine	2	2296
Get the driveshaft out	M7G1		8
Extra Force required	X4	10	40
Load Factor for the driveshaft	L5		5
Put driveshaft on security support	M7P0		7
Lift driveshaft to move it aside the bus	M7G1		8
Load Factor for the driveshaft	L5		5
Walk with driveshaft aside the bus	W5	5	25
Put driveshaft on the floor	M2P0		2

Figure 10. MODAPTS Example

Table 13 and Table 14 show a comparison between the time studied previously described versus MODAPTS for the power plant removal and power plant installation process. As seen in the tables, although the results from MODAPTS are close to the results previously obtained using time standards, MODAPTS time will typically be below the average time study estimate. This can be justified since MODAPTS only accounts for the best practices and methods to perform each activity. Moreover, according to the literature MODAPTS will generally be between 4 to 6 percent below other time standard techniques. It is important to mention that MODAPTS is a well received tool by both technicians and unions given that the performance rate which is subjective to the analyst is no longer part of the time standard process.

Table 13. Comparison of MODAPTS versus Time Study (Power Plant Removal)

POWER PLANT REMOVAL		
Description	**Average of Readings (secs.)**	**MODAPTS (secs.)**
Set Up	1220	1067.99
Fluids Draining	1888	1312.7
Disconnect Coolant Lines & Pipes	1996	1527.17
Disconnect Middle components	4122	4015.9
Disconnect Components Inside the Bus	1982	1319.48
Bumper & Front Motor Mounts out	1453	1515.94
Take out power plant from bus	1254	1138.17
Total average time in Seconds	13914	11897.35
Allowances (15%)	2087	1784.60
Time Standard in Minutes	267	228.03
Time Standard in Hours	4.44	3.80

Table 14. Comparison MODAPTS versus Time Study (Power Plant Installation)

POWER PLANT REMOVAL		
Description	**Average of Readings (secs.)**	**MODAPTS (secs.)**
Bring New Power Plant + Alignment	2914.5	2650.692
Connect Middle Components	5395	4045.569
Connect Coolant Lines and Pipes	2711	2247.18
Connect Drive Shaft	1219	648.87
Connect Cables inside the bus	2221	1963.5735
Fill Fluids + Start Bus	1045	1299.546
Total average time in Seconds	15506	12855
Allowances (15%)	2326	1928
Time Standard in Minutes	297	246
Time Standard in Hours	4.95	4.11

6.0 DATABASE

The database development is the continuation of the RTS database developed in the previous phases. It is designed and run in Microsoft Access® for the benefit of the final users since this software is user friendly and available commercially.

During Phase III, information regarding power plant replacement was included. For example, the table "system" now have the systemID 4 and 5 which corresponds to the new standards. Figure 11 shows the table "system" with the new addition.

systemID	systemName	stdTime	stdtimehours
2	Brakes	182	3 Hours 2 Min
3	PM	251	4 Hours 11 Min
4	Power Plant Removal	257	4 Hours 17 Min
5	Power Plant Installation	297	4 Hours 57 Min

Figure 11. Table "system" in the Database

Figure 12 shows the updated work flow report. This report shows at a glance the processes involved in a power plant removal and replacement, the standard times and a brief description of the processes. This can be utilized by the workers as a guideline.

System Name **Powerplant Removal 4 Hours 17 Min**

Process Name	Std Time (Min)	Description
Bring new power plant + alignment	49	Bring PP from warehouse + align it to the front and end of bus
Connect Middle Components	90	Connect hydraulic, generator, compresor, starter, and transmis
Connect Coolant Line and Pipes (Left side)	45	Connect coolant lines and pipes on the left side of the bus
Connect Drive Shaft	20	Connect driveshaft plus secure nuts
Connect Cables Inside the Bus	37	Connect wires + coolant lines inside the bus
Fill Fluids + Start Bus	17	Fill oil + coolant fluids + start bus
PP Installation Allowances	39	Time for allowances (15%) of total operation time
Grand Total	*297*	

Figure 12. Work Flow Report

7.0 ADDITIONAL WORK -- TRANSMISSION REPLACEMENT

The transmission replacement was not part of the deliverables for this phase of the project. However, there were several instances where we were able to observe the transmission replacement instead of the power plant replacement. Therefore, it was decided to collect these observations for future phases of this study. This section provides the additional work and data that was acquired during the visits to the participating facilities.

The transmission is a device that is connected to the back of the engine and sends the power from the engine to the drive wheels. The vehicle engine runs at its best at a

certain RPM (Revolutions per Minute) range and it is the transmission's job to make sure that the power is delivered to the wheels while keeping the engine within that range. This is done through various gear combinations. In first gear, the engine turns much faster in relation to the drive wheels, while in high gears the engine is loafing even though the vehicle may be going in excess of 70 MPH. In addition to the various forward gears, a transmission has a neutral position which disconnects the engine from the drive wheels, and reverse. This causes the drive wheels to turn in the opposite direction allowing the driver to back up. Finally, there for the "park" position, a latch mechanism (not unlike a deadbolt lock on a door) is inserted into a slot in the output shaft to lock the drive wheels and keep them from turning, thereby preventing the vehicle from rolling.

Transmissions are commonly replaced when the bus has operated for nearly 250,000 miles. When the transmission needs to be repaired or replaced, it is removed from the coach and later on reinstalled. When an engine is replaced, most of the time, the transmission is also removed from the coach and sometimes the transmission is replaced along with the engine. Proper maintenance on engine related systems such as fuel, cooling, and air intake is expected to ensure the long life of the fleet.

Currently, transmission replacement takes approximately one shift. Availability of parts is critical to reduce completion time since transmissions need to have the exact characteristics that match with the vehicle specifications. Two types of transmissions are mostly found in the buses studied: Voith and Allison. The process for replacing either type is very similar, and the time required to complete transmission exchange is approximately the same (within one shift plus 90 minutes). Table 15 shows the various transmission models found in the fleet studied.

Table 15. Model and Types of Transmission

Model	Year	Transmission
Gillig Phantom	1994-1998	Voith D863.3
Gillig Phantom	1989	Voith D863.3
New Flyer D40LF	1996	Allison B400R
Gillig Low Floor	1998	Voith D864.3
New Flyer C40LF	1998	Allison B400R
New Flyer D40LF	2000	Voith D863.3
Gillig Phantom / Low Floor	2001	Allison B400R
New Flyer D60LF #100-115	2002	Allison B500R
Gillig Phantom / Low Floor	2002, 2003, 2004	Voith D864.3

Only two pilot readings have been taken so far at HART in Tampa (refer to Appendix N). This step was helpful for the analysts to become familiar with the process. It was found that no written procedures were followed. Therefore, when a new technician is being introduced to the job, he/she must be instructed and accompanied an experienced technician. Although different technicians have been observed during the pilot readings, they perform the process in a similarity manner. The number of observations that would be needed of accurate time standards in shown in Table 16.

Table 16. Data to Determine Number of Observations Required

Total Time from Reading 1:	33356
Total Time from Reading 2:	31943.2
Mean	32649.6
Standard Deviation	999.029
Degrees of Freedom (n-1)	1
Percentage Points of the *t* Distribution	12.706
k (5% probability of error)	0.05
Number of observations	**7.7757**
Number of observations (round up)	**8**

The process followed for this task is described in the next section.

7.1 STEPS FOR THE TIME STANDARDS ON TRANSMISSION REPLACEMENT

The transmission exchange job currently encompasses three main processes: (1) removing transmission connections; (2) conditioning new transmission; and (3) transmission installation. Picture 3 shows the working are where a transmission replacement takes place.

Picture 3. Transmission Replacement – Work Area

Figure 13 shows the general components of the transmission replacement job. The explanation and steps of each one is presented subsequently.

Figure 13. General Components of Transmission Replacement Job

Transmission Removal Process: This step involves the separation of the parts connected to the transmission. The sub-processes within this task include: draining fluids, transmission accessories removal, electrical connections removal, and system connections removal. This process ends with the removal of the transmission from the engine and assembly. Figure 14 shows the modular approach and flow to remove the transmission.

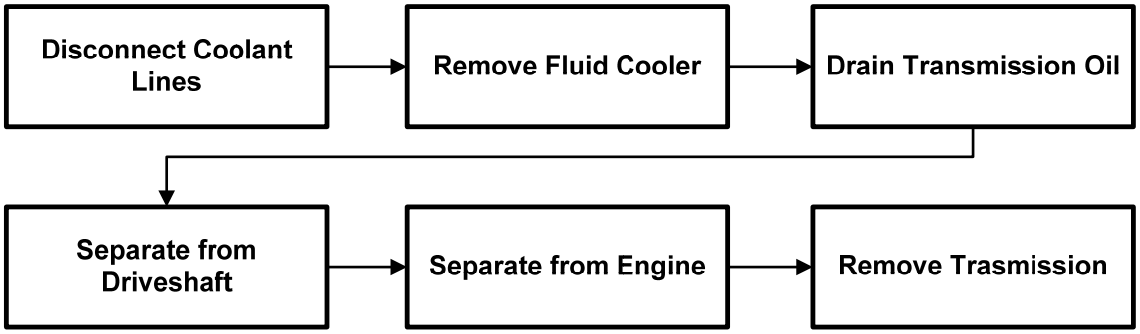


Figure 14. Transmission Removal Process

Conditioning New Transmission: This process involves the transfer of components from the old to the new transmission. Figure 15 presents the modular approach for this process. Arrows going in both directions mean that any process can be performed first. Picture 4 shows a new transmission ready to be installed

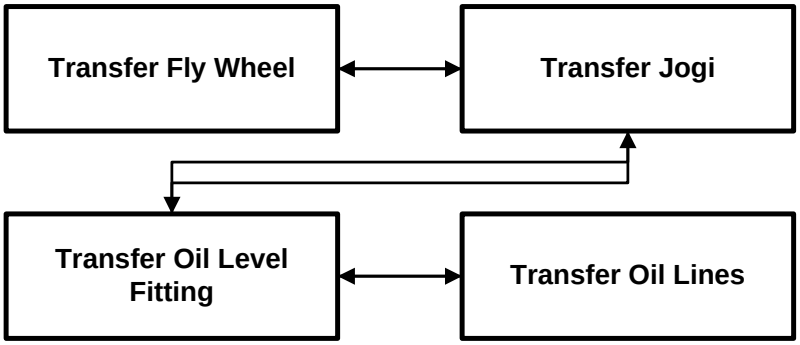


Figure 15. Process of Conditioning New Transmission

Picture 4. Transmission Ready to be Installed

Transmission Installation: After preparing the transmission to be installed, it is moved under the carriage and aligned with the engine compartment. It is then plugged into the engine and secured with nuts and bolts. After that, the components associated with the transmission are installed. The system is filled in with the fluids required (coolant and transmission oil) and then a test is executed to ensure that the systems are working properly. Figure 16 shows the process for transmission installation.

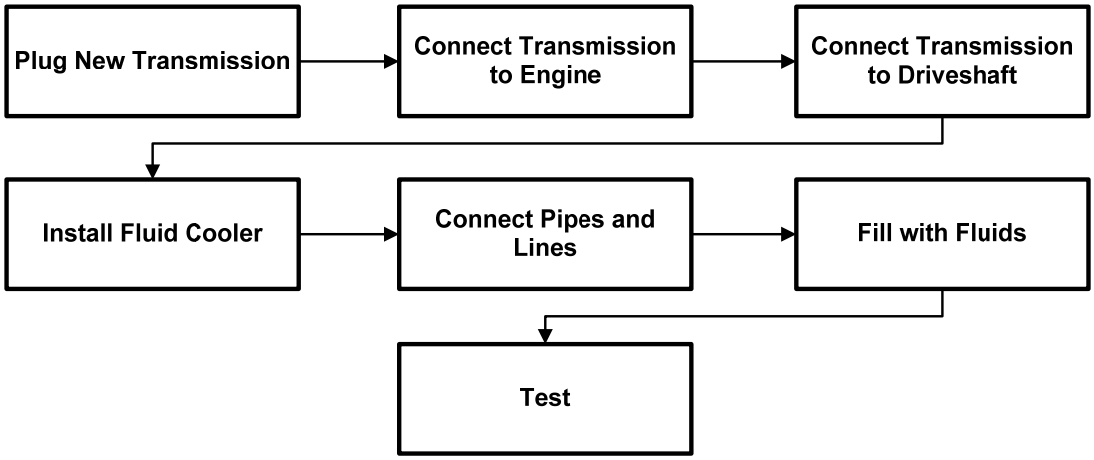


Figure 16. Process of Transmission Installation

Recommendations regarding the differences and difficulties when performing transmission and power plant replacements are included in the following section.

8.0 RECOMMENDATIONS AND FUTRURE WORK

In this project accurate repair time standards for power plant replacement and installation are presented. The main recommendations from this study are the standards and redesign of processes as shown in section 4.7. Other recommendations for work area and set up, number of technicians utilized and allowances are presented next.

Work Area and Set up Recommendations:

- *Tool Setup*: The tool set up is done at the beginning of the job. However, it was observed that there are continuous interruptions during the job due to special tools required to perform the job.

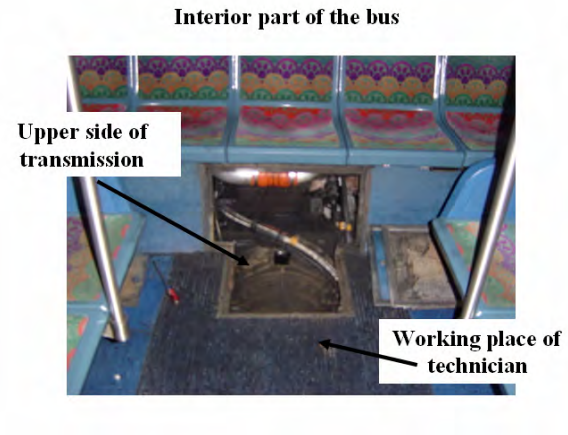
- *Part Setup*: Parts setup is optional to the technician since the only part to be replaced (i.e., power plant, transmission) is placed in a box which needs to be moved from the warehouse to the work area. The technician brings the box to the work area after the old part is removed. This could be done at any time during the job but the technician can be delayed if the hydraulic lifter is busy or if there is a line for parts procurement at the warehouse. Having the box set up at the beginning is recommended if there is enough space to place. Also, if assistance can be provided when delivering the new part, this would save considerable amount of time.

Number of Technicians Recommended:

One technician is generally required to work on the repair processes. Sometimes additional help may be required by other technicians to complete the process. The number of technicians needed for the various stages of the repair task should be carefully for optimization purposes.

Recommended Allowances:

The removal and installation of the power plant components require that technicians work under the bus and sometimes reach for nuts and screws located in hidden areas. The lack of light, the improper visibility, and the awkward positions are reflected in longer processes and sometimes delays. Therefore, it is recommended for the shop floor to be well lit. Picture 5 shows the inside area of the bus where the technician works in a kneeling position for a considerable period of time to disconnect system and electrical components from the upper part of the power plant and transmission.



Picture 5. Interior Part of the Bus – Upper Side of the Transmission

Picture 6 shows a technician working on the transmission area of the bus (under the bus). Technicians often have to reach for nuts and screws located in hidden parts of the bus where awkward positions are required and/or illumination is poor. Lack of light, improper visibility and awkward position is reflected in longer completion times and many delays. Extra allowances are strongly recommended for these processes.

Picture 6. Exterior Part of the Bus – Under Side of the Transmission

During this study various transit agencies across the nation were visited for benchmarking purposes. From the visit to MTA-New York it was learned that the bill of materials kit is an ingenious tool that would result on reduction of delays by providing all the tools and materials necessary to perform the tasks. It is recommended that when a process is started, it should be finished completely before starting the next process. The problem is that working on two processes simultaneously may require different tools; therefore, technicians would waste time looking back and forth for the tools.

The installation of an incorrect engine or transmission can delay the completion of a power plant job. Better tools to assess parts fitting should be explored. Additionally, it was observed that the lines and pipes that the facility has reserved for replacement do not always meet with the specifications of length and/or diameter. This results on delays as the technician is required to modify tools and/or items that should have been ready to use

beforehand. To minimize long delays it would be important to analyze the inventory policy among facilities and the spare part specification policies.

9.0 REFERENCES

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[4] Centeno, G., Chaudhary, R., Lopez, P., Developing Standard Times for Repair Activities in Transit Vehicles: A Systematic Approach. Paper in press submitted to Transportation Research Board, National Research Council, TRB annual conference, 2005.

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[6] Agrawal, A., A.M Genaidy, and A. Mital. Computer Predetermined Motion-Time Systems in Manufacturing Industries. Computers Ind. Engineering. Vol. 18. No. 4, pp. 571.

[7] Wigant, Robert M., White, Bob E and Doug Hunt. Combining Ergonomic and Work Measurement for Job Analysis.

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APPENDIX A

Transit Presentation

One of the main requests from the steering committee, comprised of members of the Florida Maintenance Training Advisory Committee for this phase was to benchmark the proposed methodology and preliminary results with current practices from other transit agencies nationwide. The mission of the benchmark activity is to share and validate results related to repair time standards for transit buses.

Preliminary research and literature review indicated that several agencies have been working on the standardization of repair processes. During the first six months of the current phase for this project, four facilities outside the state of Florida were visited. These facilities included: the Metropolitan Transit Authority in New York City, New York; the Metropolitan Atlanta Rapid Transit Authorization in Atlanta, Georgia; the San Francisco Municipal Railway in San Francisco, California; and the Metropolitan Bus Authority in San Juan, Puerto Rico.

The visits consisted in meeting with maintenance personnel such as supervisors, planners, or industrial standards developers, to discuss their procedures when dealing with standardization of operations. Most of the visits were initiated with a brief presentation summarizing the objective of this project, followed by a discussion of their experiences and opportunities for improvement. This Appendix presents the presentation used during the visits to the transit facilities

Developing Standard Times for Repair Activities in Transit Vehicles

A Systematic Approach

Grisselle Centeno, Ph.D.
Daniel Rojas
Paula A. López

Overview

- Initiated by Florida Department of Transportation in partnership with the Center of Urban Transportation Research (CUTR).
- The research is part of the Florida Maintenance Training and Technical Assistance Program in CUTR.
- It is guided by the committee of Florida Maintenance Transit Consortium --Including managers and supervisors of the transit agencies throughout Florida.

Overview

- The project develops standards for Gillig buses repair in order to:
  - ✓ Minimize the time required to perform tasks
  - ✓ To increase productivity and to provide a reliable service safely
  - ✓ To lower cost, allowing more quality services for more buses that need to be repaired.

- The study was started with the **brake** repair and then it was further extended to the **preventive maintenance** and currently we are working on the **engine module**.

- As part of the project a database was developed and configured with data collected from the study.

Participating entities

Transit Facilities

Data and feedback from managers, supervisors and technicians

- Hartline – Tampa, Fl
- PSTA – Clearwater, Fl
- Lynx – Orlando, Fl

CUTR

Florida Maintenance Training and Technical Assistance Program

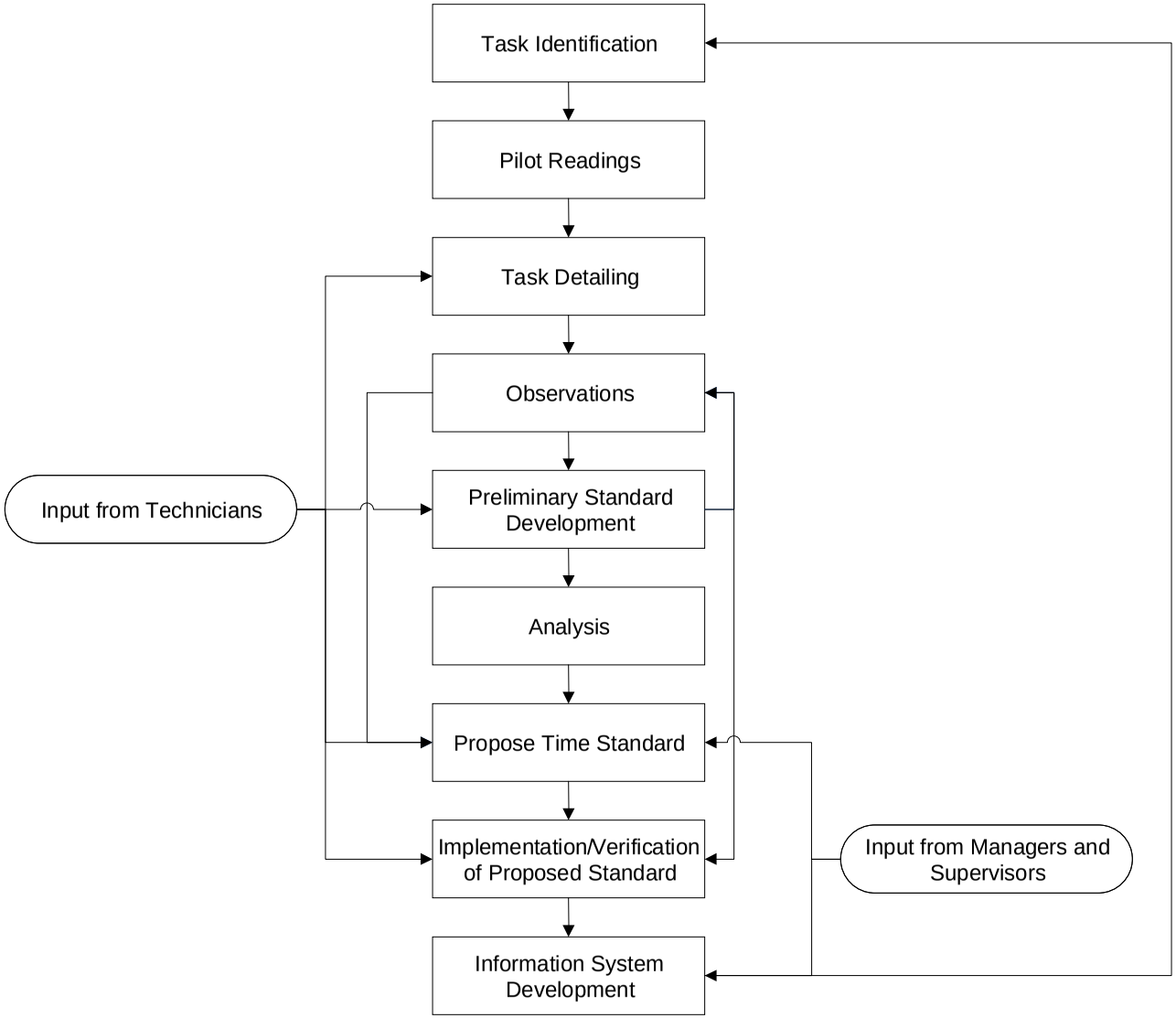
USF – IMSE

Time standards analysts

Importance of the study

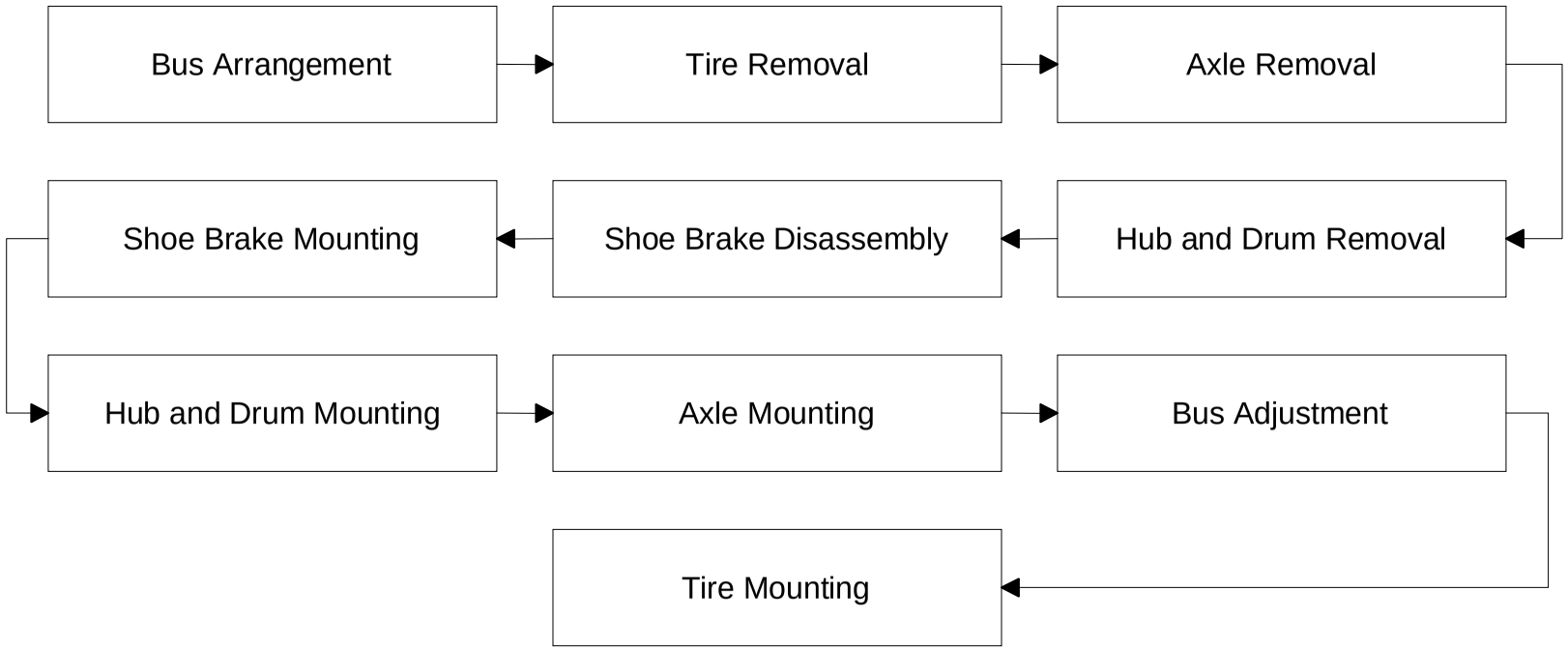
- Evaluates productivity of the workforce
- Helps determining training needs
- Allows benchmarking among transit facilities
- Facilitates better quality control on maintenance processes due to consistent practices
- Develops an information system to track workforce performance and fleet maintenance history

Methodology

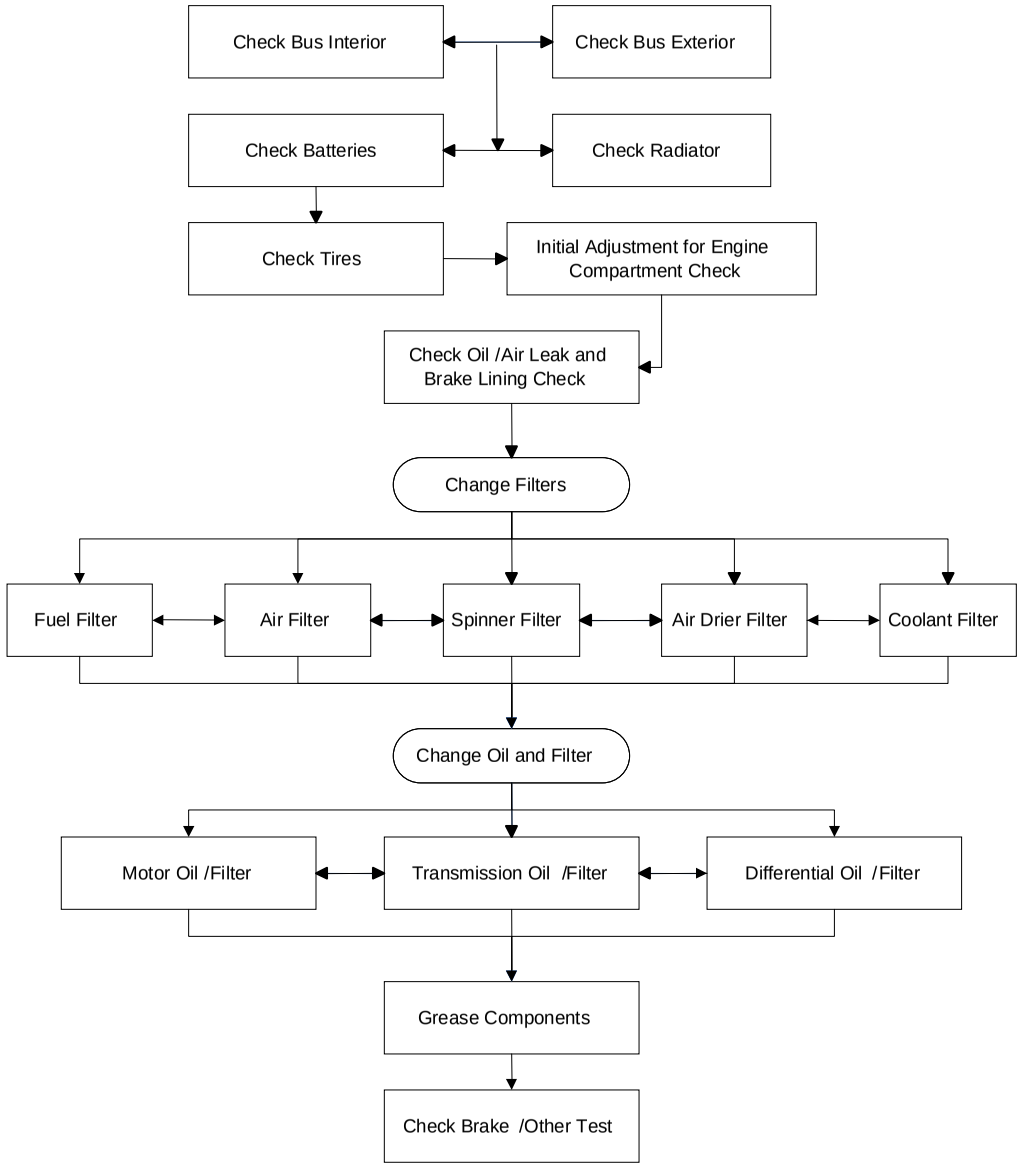


Appendix A-6

Phase I – Brake Repair



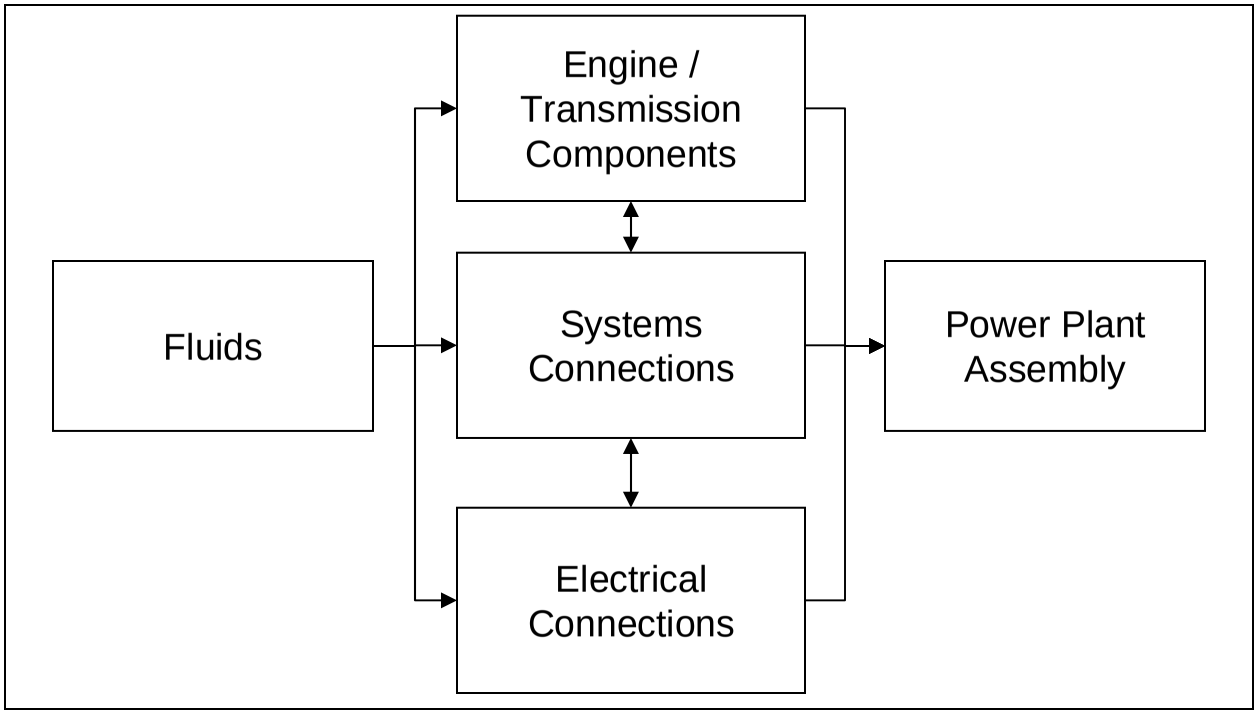
Phase II – PM (12K)



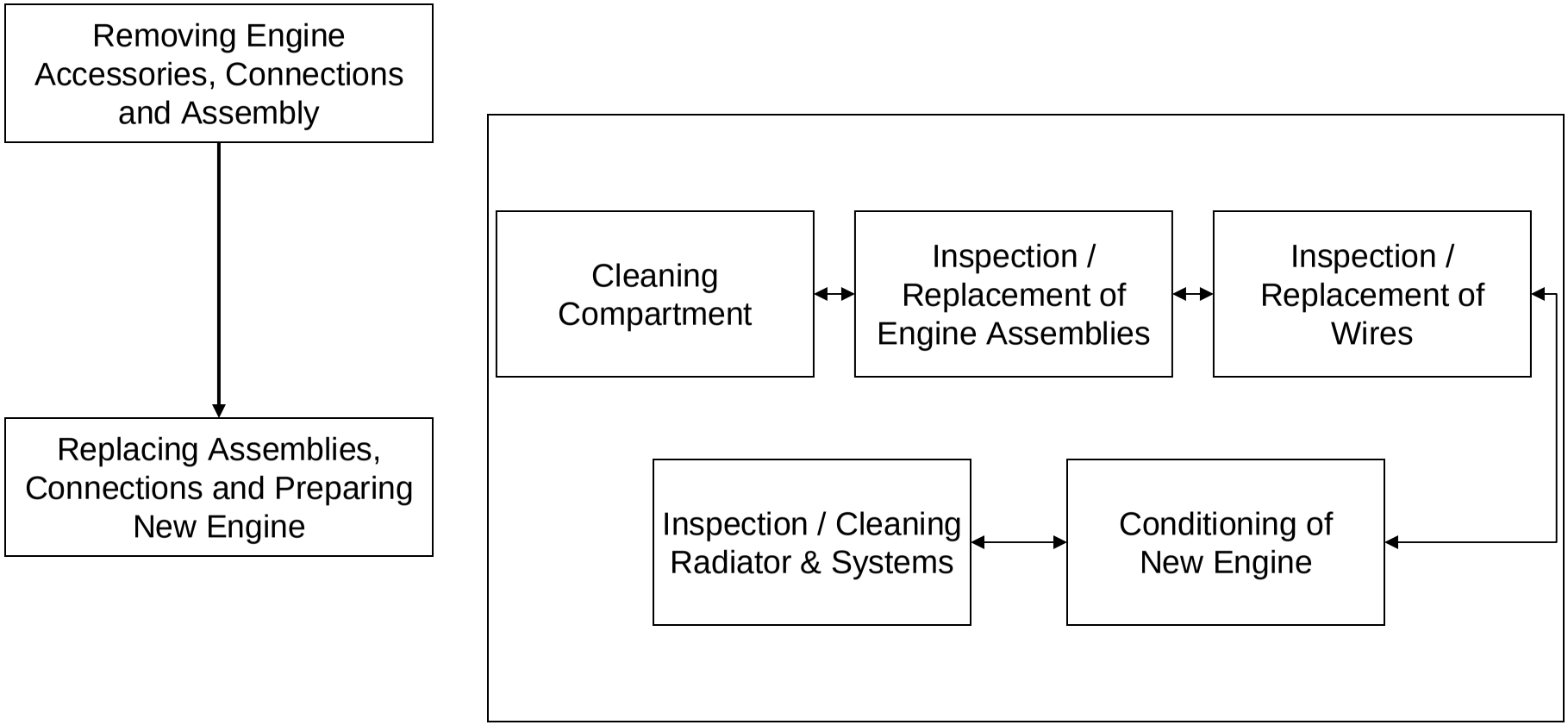
Appendix A-8

Phase III – Power Plant replacement

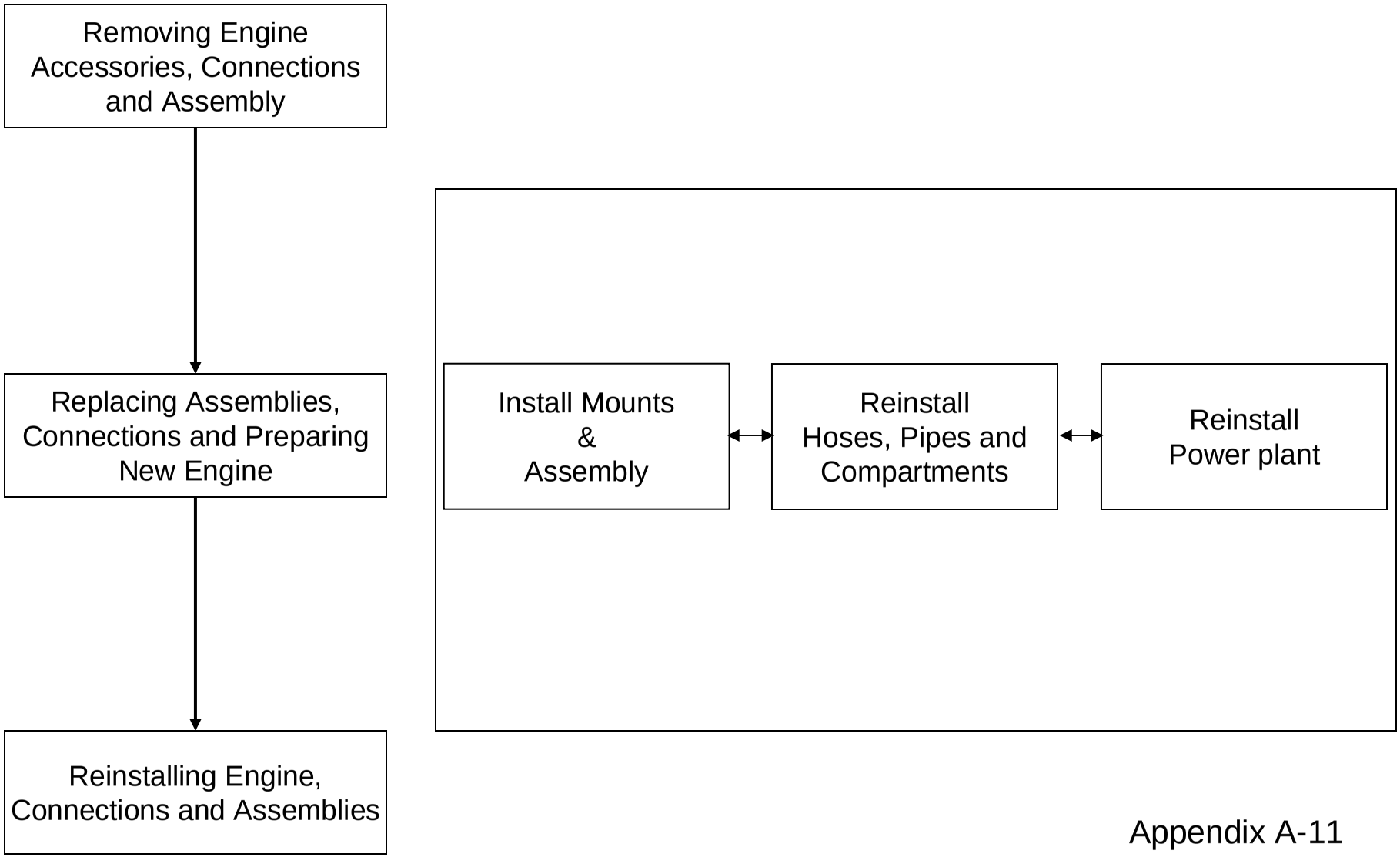
Removing Engine Accessories, Connections and Assembly



Phase III – Power Plant replacement



Phase III – Power Plant replacement



Accomplishments

Brake system

New process flow
Time reduction

- Operations 16.67 %
- Transport 60 %
- Inspections 85.77 %
- Delays 100 %

PM

New process flow
Time reduction

- Operations 47.03 %
- Transport 48.86 %
- Inspections -40 %
- Delays 92 %

Maintenance Information System

Compiles information from RTS
Evaluates and reports technicians performance
Reports bus maintenance history

Projections

- The methodology can be further used and improved to develop standards on maintenance processes of new fleet technologies nationwide.
- Scheduling models for better planning of maintenance jobs based on time standardization can be developed.
- Database improvement towards an integrated maintenance information system.

Questions ?

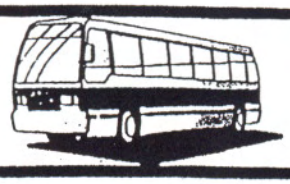
APPENDIX B

Questionnaire – Visit Questions

. This appendix presents the following:

- Sign-in sheet-The sign in sheet shows the individuals that attended the meeting at the Metropolitan Transit Authority (New York)
- Visit questions- During the visits to the different transit facilities a set of questions directly related to repair time standards were discussed.
- Visit questionnaire answers from the MTA-NYC-The previous questionnaire was distributed via email before the meeting with the MTA. The answers to the questionnaire are provided in this appendix. Note: some of the questions that were not answered were discussed during the meeting.

New York City Transit
Department of Buses



SIGN-IN SHEET

PROJECT NAME	PROJECT LOCATION	PROJECT #	DATE
Standard Repair Times		Zerega MT'G LOC.	7/11/05
MEETING PURPOSE:			PAGE # 1 OF 1

NAME (TITLE)	COMPANY DIV. / DEPT.	ADDRESS	TELEPHONE (S)	FAX #
Paula A. López (RTS. Analyst.)	University of South Florida	4202 E. Fowler Ave Tampa, Fl 33620	(813) 785-4094	
Daniel Rojas (RTS Analyst)	University of South Florida	4202 E. Fowler Ave Tampa, FL 33620	(813) 817-3376	
Nick Colella (L/S Cust. Serv.)	Buses Cust. Serv.	750 Zerega Ave Bronx, NY	347 643-5739	3476435117
Gil CARRERO (Supt.)	Buses Cust. Serv		5141	
MARK SCHMID (GEN SUPT.)	Dept of Buses Cust Service	750 ZEREGA AVE BRONX N.Y.	347 643 5104	347 643 5112
John Higgins (_____)	DOB	25 Jamaica Ave	347-643-5100	
JOANNE BOIANO (_____)	DOB	750 ZEREGA AVE	347-643 5109	347-643 5112
Peggie Ralph (_____)	DOB	750 Zerega Ave.	347-643-5400	
Steve Vidal (_____)	DOB	750 Zerega Ave	347-643-5000	
(_____)				
(_____)				

REPAIR TIME STANDARDS FOR TRANSIT VEHICLES PROJECT
Metropolitan Transit Authority – New York

Visit Questions

1. For which systems have MTA developed repair time standards?
2. How do you develop the standards?
3. How is the methodology used?
4. What do you think are the advantages and disadvantages of the methodology used?
5. Have you used any special software to develop the standards?
6. When did you start developing the standards?
7. Have you updated the standards and how? With what Frequency do you update them?
8. Do you have any documentation (published) regarding your standards?
9. Do you have any results for brakes, PMs, and/or, power plant replacement? Is it possible to share them for validation purposes?
10. For what type of fleet (e.g. diesel, hybrid) have you developed the standards?
11. Is there any significant difference on maintenance processes when you work with different types of fleet?
12. Have you developed standards for PM jobs? How many types of PMs do you perform?
13. How do you control that the time and process standards are met?
14. How do you control foreign elements when comparing a job performed with the standards?
15. How do you control the quality of the jobs when using the standards?
16. How do you ensure quality when working under the time standards?
17. Are you using the repair time standards for a purpose different to time and process improvement? For example, to train new technicians or to develop schedules.
18. How do you schedule maintenance jobs?
19. Do you predict possible scenarios of demand?
20. Have you been able to reduce road calls by using the standards implementation?
21. Have you been able to improve productivity with the standards implementation?
22. What types of technicians (e.g. type A, B, C, Master) do you manage and how do you allocate them to the jobs?
23. Do you associate inventory management to the time standards? For example, are there any cases of spare parts shortages in inventory that make a job to be delayed?
24. Why do you prefer to do ICO's (In Chassis Overhauls) rather than engine replacements?
25. Do you have the knowledge of any other transit agency performing repair time standards?

Boiano, Giovanna A.

From: Chen, Albert
Sent: Friday, July 08, 2005 3:06 PM
To: Boiano, Giovanna A.
Subject: USF Visit to NY

Joanne,

I will not be able to attend the meeting on Monday July 11th to discuss the development of standard repair times with the researchers from University of South Florida. I did attempt to fill out their questionnaire but was unable to complete questions 12 through 25 because I'm no longer work (since June 2001) in Department of Buses. Please call me if you need clarification on any of my responses. Thank you.

Albert Chen
MTA NYC Transit
Office of Management and Budget
Manager, Subway Business Planning
2 Broadway
17th floor, Cubicle D17.100
New York, New York 10004
(646) 252-2391
(646) 252-2430 Fax
albchen@NYCT.com

REPAIR TIME STANDARDS FOR TRANSIT VEHICLES PROJECT
Metropolitan Transit Authority – New York

Visit Questions

1. For which systems have MTA developed repair time standards?

   Bus systems: body, doors, windows, chassis, engine, HVAC, transmission, hydraulic, air, suspension, wheel and hub. We developed standard repair time (SRT) for many components of the various bus systems. In addition, the Industrial Standards Unit developed jobs categorized as Core Jobs which covered frequently performed maintenance jobs such as tire change, oil and filter change, air filter change, wheel reline, etc.. In fact, the Core Jobs were the first set of jobs being monitor by Management for compliance.

2. How do you develop the standards?

   First, we research to see if the manufacture / vendor have any established SRT that they have developed. Second, we develop detailed written procedures on the proper way to perform the removal and replacement of the specific component. When developing the written procedures we would reference the manufacturer's maintenance instruction manual as a source of information then we validate the procedures by actually performing the job. You would want to do the job several times to get the average SRT. Third, the finalized procedures are circulated to appropriate staff for review and approval.

3. What do you think are the advantages and disadvantages of the current methodology used?

   The advantage of using the procedures above to develop the SRT is that you get to experience the actual conditions, not theoretically estimated, you will face in doing the job which will be a dependent factor in developing SRT. The disadvantage in doing this way is that it will take time (approximately two weeks) to complete the process and establish a SRT.

4. Have you used any special software to develop the standards?

   We did not have any special software. We used Microsoft Word to write the procedures and Microsoft Excel to record the jobs with SRT.

5. When did you start developing the standards?

   I believe the Core Jobs were developed in 1996. I worked in DOB/ Industrial Standards from June 1999 to June 2001.

6. Do you have any documentation regarding your standards?

We have written procedures for Core Jobs and some Flat Rate Jobs. One of my assignments was to develop an Industrial Standards intranet site where information on standard repair times for Core Jobs and Flat Rate Jobs are posted and written procedures associated with the specific job selected can be printed. The Industrial Standards home page was interfaced with the Fleet Information Viewer (developed by Mark Salzen). Employees can access Fleet Information Viewer on kiosk located in Depots. I do not know if this is still in use and being maintained / updated with latest information.

7. Do you have any results for brakes, PMs, and/or, power plant replacement? Is it possible to share them for validation purposes?

8. For what type of fleet (e.g., diesel, hybrid) have you developed the standards?

   During my two years in Buses, we developed SRT for diesel and CNG fleet.

9. Is there any significant difference on maintenance processes when you work with different types of fleet?

   Based on my experience, I did not see a significant difference on maintenance processes between the diesel and CNG fleet. I believe there is a significant difference between the diesel / CNG and hybrid electric fleet mainly in propulsion / drive and electrical (storage batteries) system.

10. Have you developed standards for PM jobs? How many types of PMs do you perform, and how frequent?

    We have SRT for preventive maintenance jobs. Many of the Core Jobs are PM jobs. Please ask for a list of Core Jobs.

11. Have you been able to implement the standards?

    I don't know if DOB had implemented the Productivity Incentive Program since leaving DOB in June 2001.

12. What have been the challenges during the implementation phase?

13. Have you updated the standards and how? With what frequency are the standards updated?

14. How do you monitor the standards?

15. How do you control foreign elements? (*foreign elements: unexpected occurrences during the job process that are not part of the regular course*)

16. Is the quality of the jobs affected by the standards? And how is it controlled?
17. Are you using the repair time standards for a purpose different to time and process improvement? For example, to train new technicians or to develop schedules.
18. How do you schedule maintenance jobs?
19. Do you predict possible scenarios of demand?
20. Have road calls being reduced as a result of the standards implementation?
21. Have productivity improved with the standards implementation?
22. What types of technicians (e.g. type A, B, C, Master) do you manage and how do you allocate them to complete jobs?
23. Do you relate inventory management to the time standards? For example, are there any cases of spare parts shortages in inventory that make a job to be delayed?
24. Why do you prefer to do ICO's (In Chassis Overhauls) rather than engine replacements?
25. Do you know of any other transit agency performing repair time standards?

APPENDIX C

Characteristics of vehicles used by the AMA

Some of the characteristics of the bus fleet used by "Autoridad Metropolitana de Autobuses" are presented in this appendix.

Characteristics of vehicles used by the AMA

Year	*Manufacture*	*Model*	*Number of Vehicles*	*Lengh of Vehicle*	*Width of Vehicle*	*Number of Seats*
1992	TMC	RTS	11	40’	102”	43
1995	FLEXIBLE	METRO	23	40’	102”	44
1997	NOVA BUS	RTS	80	40’	102”	43
1998	NOVA BUS	RTS	18	40’	102”	43
1999	NOVA BUS	RTS	29	40’	102”	45
2000	NOVA BUS	RTS	71	40’	102”	45
2002	NOVA BUS	RTS	10	30’	102”	28
2004	ORION	V	30	35’	102”	33

Additional Information:
AMA is a public corporation adhering to the Authority of Highways and Transportation of Puerto Rico and the Department of Transportation and Public Works of Puerto Rico. It operates with 624 drivers and provides three types of services: Regular Routes, “Paratransit” (Call and Travel) and Half Rate. The most common service offered by the authority is the regular routes. In this service the user pays the regular rate (75 cents) (this rate was modified to 75 cents from December of 2005 previously the rate was of 25 cents). In the service of half rate, users that have ages between 60 and 74 years can receive the services of the AMA at 35 cents. The service call and travel is a service that is offered to people over 60 years or to people with some type of physical impediment, in which the user makes an appointment to be picked up in its residence inside the service areas of the Authority. The buses of the AMA are identifying with a nomenclature that indicates the level of service. The letters A, B and C indicate the time that a bus will be arriving. For the letter A the time is of 10-15 minutes (10-20 minutes for weekends), for B is of 20 minutes (30 minutes for weekends) and for C is of 30 minutes (1 hour for weekends). The quantity of buses varies for each route.

APPENDIX D

MTA (NYC) Industrial Standards Department (PowerPoint Presentation)*

From the facilities visited only the New York City Department of Buses MTA had an internal industrial standards department. The group was active from 1994 to 2004 developing credible and equitable labor time standards, as well as procedures for frequently performed maintenance activities. The major goal of this group was to standardize the performance of work and meet appropriate industry standards for safety, quality, reliability, functionality, and appearance within the STR. During the visit to the MTA the industrial standard department presented an overview of their program goals and responsibilities. This appendix shows the presentation of the Industrial Standards Department from the Metropolitan Transit Authority, New York.

* This information was collected during the visit to the Metropolitan Transit Authority, New York, and was not developed by the USF Team or utilized for establishing Time Standards or procedures in this research.

New York City, Department of Buses

Industrial Standards Department

History

- Repair Task Time
  - Varies
    - Maintenance Depot To Maintenance Depot
    - Overhaul Shop to Overhaul Shop
- Repair Benchmarks or Best Practices
  - Not Standardized
- No Management Task Time
  - Verification & Validation Ability

Actions:
Industrial Standards Dept. Created

- SRT (Standard Repair Times) Implemented
- PIP (Productivity Incentive Program) Implemented
- Management & Labor Committee Established to Resolve Task Time Conflicts

Results:

- System Wide
  - Productivity & Safety Improvements
- Management & Labor
  - Relation Improvements

Industrial Standard

- Definition
  - Concern with the integration and implementation of various engineering disciples for continuous performance and safety improvement of maintenance, overhaul, technology and information systems.

Industrial Standards Disciples

Engineering

- Industrial Engineering ------- Time Studies
- Methods Engineer ---------- Maintenance Method Analysis
- Production Engineer --------- Shop Layout Design
- Manufacturing Engineering - Workstation Design
- Quality Engineer ---------- Quality Control
- Safety Engineer---------- Ergonomics Principles
- Tool Design Engineer--------- Equipment,Fixture & Hand Tool Design

Management

- Management / Labor Negotiations Skill

Performance Measurements

- Effectiveness
- Efficiency
- Quality
- Productivity
- Innovation
- Quality of Work Life
- Safety
- Cost Savings

CORE RESPONSIBILITY

- EXISTING PROGRAM

  - SRT (Standard Repair Time) Validation & Verification for Management / Union Negotiations & Resolutions.

  - SRT Definition
    - Average Repair Times Set Forth By The Bus Manufactures.

CORE RESPONSIBILITY

- NEW PROGRAMS
  - Design, Develop & Implement High Performance & Ergonomically-Designed
    - *Methods*
    - *Processes*
    - *Shops*
    - *Workstations*
    - *Equipment*
    - *Tools*
- Establish SRT For New Program

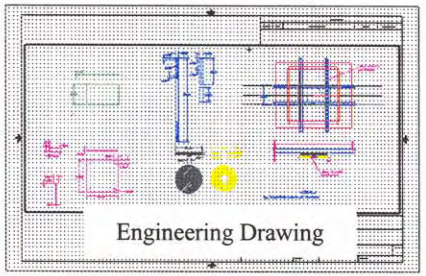
Special Projects

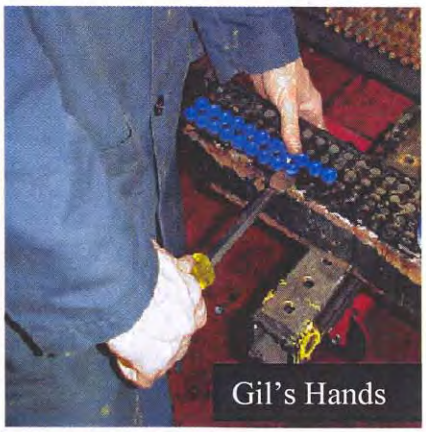
- Work Scope Development
- Bus Retrofit / Modification Method Evaluation for Performance Improvements.
- Bus Manufacturing Process Evaluation for Performance Improvements.

TOTAL INTEGRATED INDUSTRIAL STANDARDS PROGRAM
EXAMPLE # 1

Innovative Radiator Overhaul

- *New - Method, Processes, Workstation, Tooling, Procedure & Training*
  - Ergonomically Designed - Method, Processes, Fixture & Hand Tool
  - Multi-Functional Fixture Design
  - 521 % Productivity Improvement
  - Trained ENY Radiator Shop


Engineering Drawing


Gil's Hands

Radiator

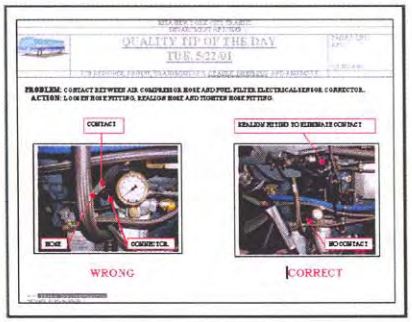
Task Times for Baseline Negotiations

Item #	Radiator	TA#	Demonstrated SRT	Shop Time	Productivity Improvement
1	NF, LF, CNG, 1990	96-79-2099	2 .3 Hrs	12 Hrs	521 %
2	NF, Artic, 1998	97-79-1097	2 .3 Hrs	12 Hrs	521 %
3	Nova, 1996	96-79-2194	3 Hrs	12 Hrs	400 %
4	RTS Repower, 1990	96-79-2798	3 Hrs	12 Hrs	400 %
5	Orion V, 1994	97-79-2493	5 Hrs	16 Hrs	320 %

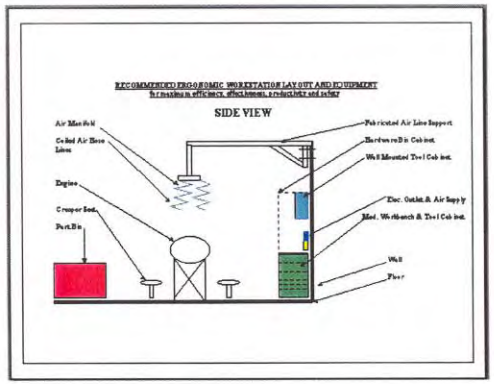
TOTAL INTEGRATED INDUSTRIAL STANDARDS PROGRAM
EXAMPLE # 2

NEW - RTS REPOWER ENGINE DRESS SHOP

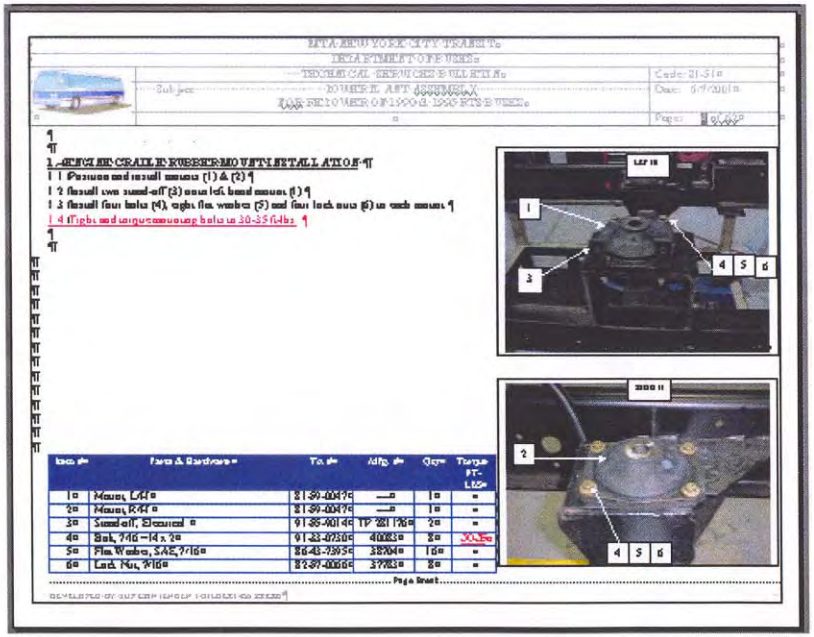
- Ergonomically-Design Shop, Workstation and Method
- User-Friendly Visual Manual
- Quality Control Program



Tip of the Day



Ergonomic Workstation

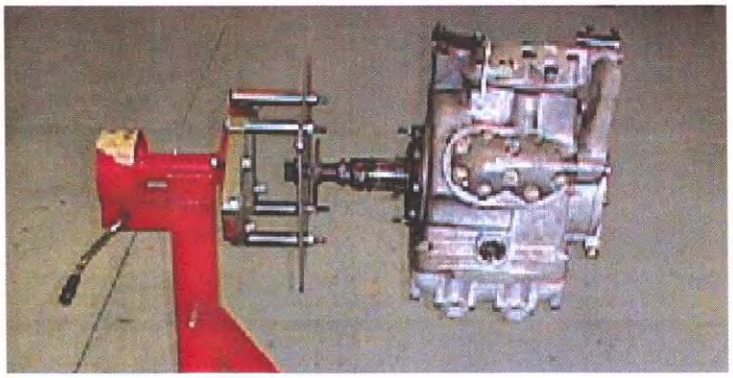


Ergonomic Method & Visual Manual

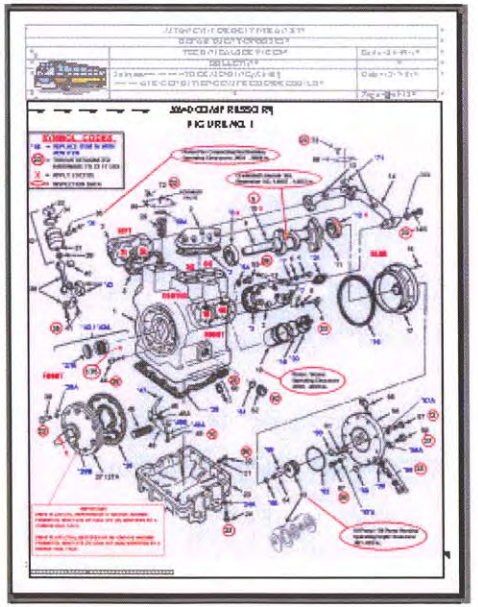
TOTAL INTEGRATED INDUSTRIAL STANDARDS PROGRAM
EXAMPLE # 3

New Thermo King X640 & X426 A/C Compressor Overhaul

- *Ergonomically – Designed - Method, Processes, Workstation, and Tooling*
  - User-Friendly Manual
  - 200% Productivity Improvements
  - Trained 9th Ave. Shop



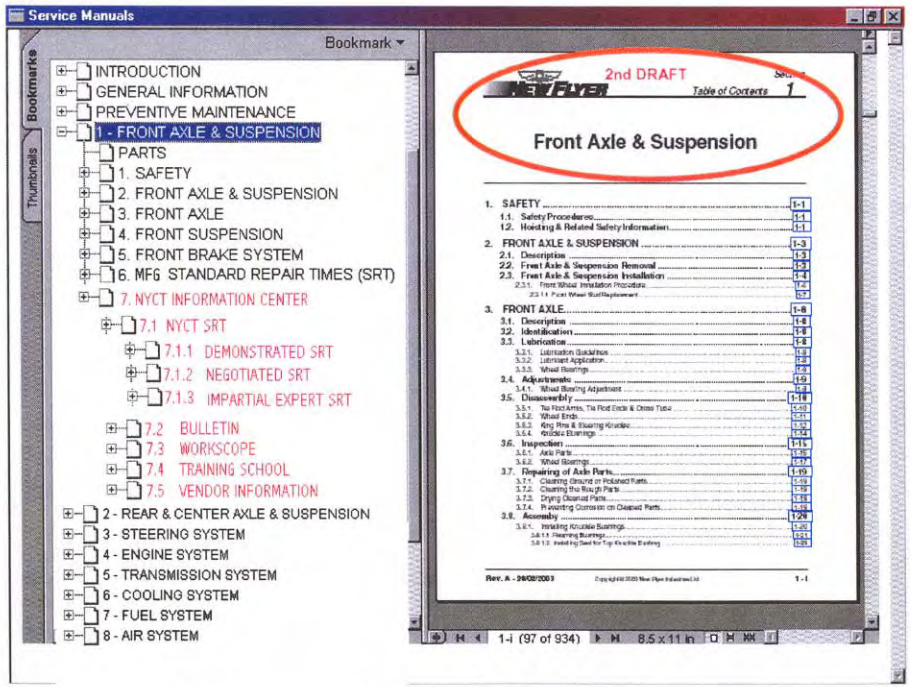
Mounting Adapter



Instructional Manual

TOTAL INTEGRATED INDUSTRIAL STANDARDS PROGRAM
EXAMPLE # 4

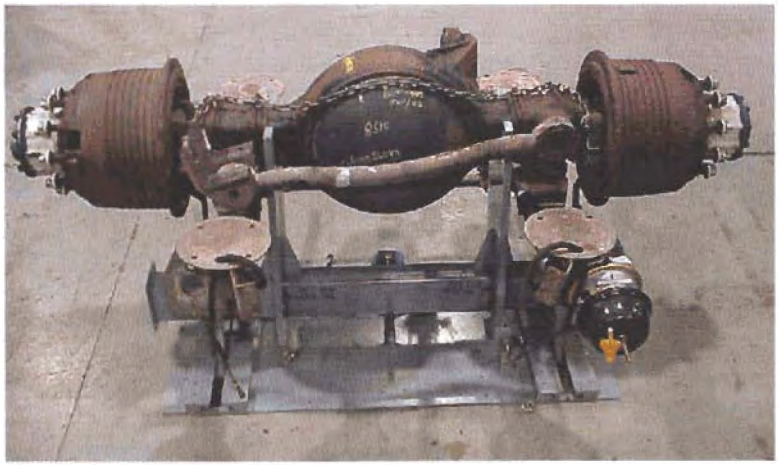
- New Service Manual & SRT Integration
  - One-Stop-Shopping
  - Corresponding DOB Information into each chapter
  - 500 % Productivity Improvement



TOTAL INTEGRATED INDUSTRIAL STANDARDS PROGRAM
EXAMPLE # 5

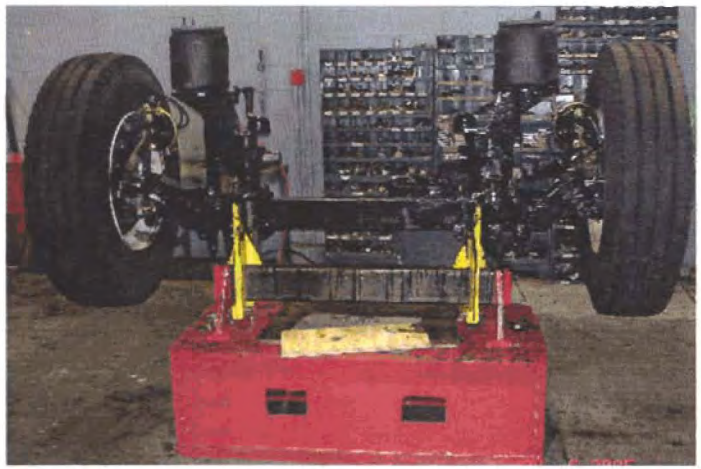
New Innovative Universal Axle Overhaul Shop

- *New - Method, Processes, Workstation, Tooling, Procedure & Training*
  - Ergonomically Designed - Method, Processes, Shop, Workstation and Fixtures
  - Multi-Functional Fixture Design



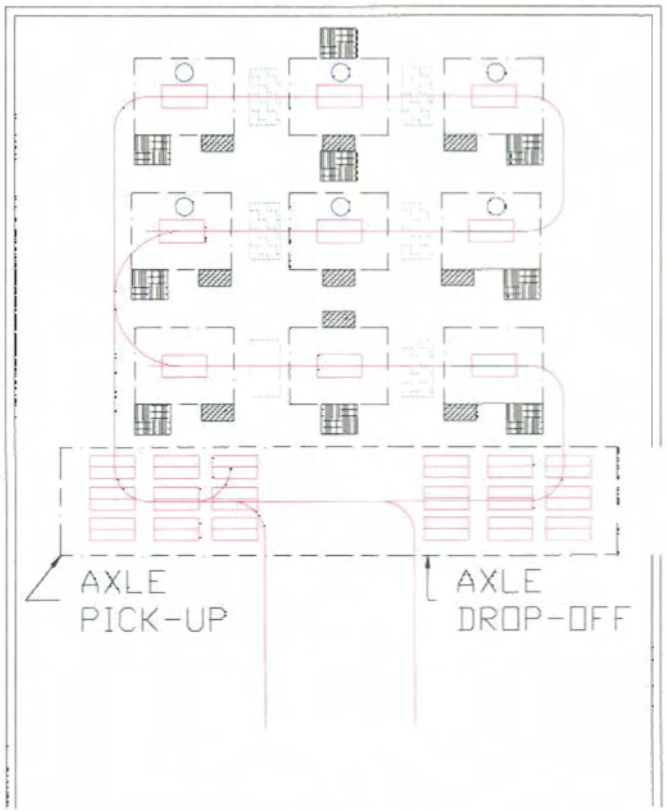
Axle R & R Fixture

Lift Table Not Shown



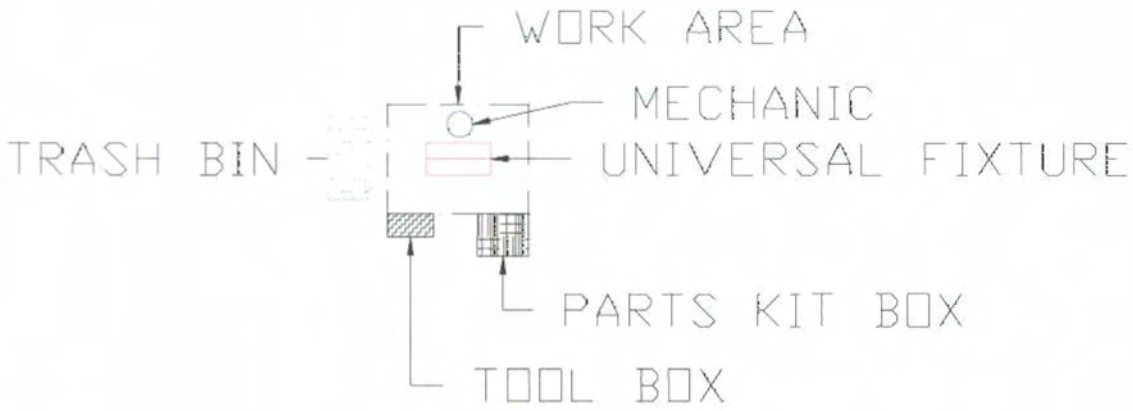
Axle Rebuilding Fixture

NEW AXLE SHOP LAYOUT



NINE

UNIVERSAL WORKSTATION



WORKSTATION LAYOUT

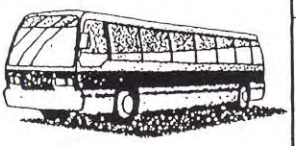
APPENDIX E

Industrial Standards Bulletin: Explanation of Development of SRT*

This appendix presents the bulletin that was distributed to the workers at the Metropolitan Transit Authority (New York) before starting the development of the standard repair times. This bulletin provides an explanation of how standard repair times were developed and applied at MTA-NYC.

* This information was collected during the visit to the Metropolitan Transit Authority, New York, and was not developed by the USF Team or utilized for establishing Time Standards or procedures in this research.

DEPARTMENT OF BUSES

	**INDUSTRIAL STANDARDS BULLETIN**	Code:
	Subject: **EXPLANATION OF DEVELOPMENT OF STANDARD REPAIR TIMES (SRT)**	Date: 9/21/98 Page: 1 of 3 Document Control Initials:

Application: All maintenance actions.

Purpose: To provide users with an explanation of how Standard Repair Times are developed and applied at NYCT.

General Information

New York City Transit's Standard Repair Times (SRT) are lists of work tasks (procedures) and cumulative time required to perform the tasks. The procedures list the tasks required to ensure a vehic system or component is ready to return to service with a quality repair at the lowest possible cost and w minimum delay. A Standard Repair Time is equitable when the repair described in the procedure can performed in a time less than—or equal to—the standard by a maintainer after he/she has performed t repair in a similar application at least once. Those SRTs that a particular maintainer performs more frequen will often require less time than the standard. Several procedures may be required to reflect accurately all tasks actually performed to return a particular vehicle, system or component to service.

NYCT's SRT Objectives and Philosophy

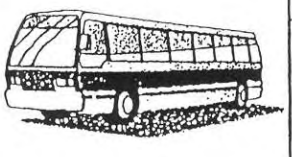
The purpose of this agreement is to standardize the performance of work that meets appropriate industry standards for safety, quality, reliability, functionality, and appearance within the SRTs.
The objective of NYCT's SRT program is to provide credible and equitable labor time standards and procedures for the maintenance service network.

A SRT is credible when the procedure accurately depicts the work that must be performed to accomplish a quality repair. A SRT is equitable when a task can be performed in a time less than—or equal to—the standard or norm by a maintainer.

To establish credible and equitable SRTs with sufficient flexibility to account for differences in complaints failure, progressive damage, customer desires, etc., SRTs have been structured using the following considerations:

- What *must* always be done to repair the item.
- What *may* have to be done to repair the item depending on its condition.
- What parts may have to be removed to access the work.
- How difficult it is for the maintainer to reach the component even after any interfering application hardware has been removed.

The SRT process is designed to be applicable to all repairs on all types of buses, systems and components.

	INDUSTRIAL STANDARDS BULLETIN	Code:
	Subject: EXPLANATION OF DEVELOPMENT OF STANDARD REPAIR TIMES (SRT)	Date: 9/21/98 Page: 2 of 3 Document Control Initials:

Application: All maintenance actions.

Purpose: To provide users with an explanation of how Standard Repair Times are developed and applied at NYCT.

How Times are Developed

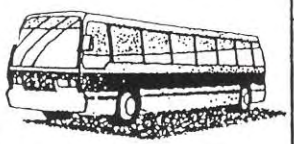
The Department of Buses will provide a controlled compendium of Industrial Standards' documents. SRTs are developed from analysis of observations and work sampling data in addition to other accepted industrial engineering methods. Task Times are also developed using input from OEM SRT documents, as well as input from industry sources, including other transit agencies and bus testing programs, and industry groups such as the American Trucking Association, the American Public Transit Association and the Truck Maintenance Council. Supervisors create a comprehensive list of all the work elements or tasks required to perform a specific repair. Independent sources are analyzed to find these same work elements and determine the time required for each. The time needed for work elements that are not included in time studies is determined by conducting our own studies or by estimation, using similar elements from existing time studies. Finally, a time is determined for the entire procedure.

Standard Repair Time

Standard Repair Time includes the actual time involved in doing productive work by all maintainers, such removing, disassembling, cleaning, inspecting, machining, installing and adjusting vehicle parts, components or systems. Also, fabrication, painting and structural work. In addition, the following operations are included on the calculation of the SRT:

- Report and assignment time (maximum of 10 minutes).
- Move the vehicle to and from the work area. (Immovable buses and outside storage are exempt.)
- Move toolbox and required equipment to the work area. (Specialty tools will be made available.)
- Obtain tools from toolbox; wipe and put away after use.
- Package and mark parts removed for warranty, recycling, salvage, etc.
- Operate vehicle or system to check for proper operation and functioning of the repair action.
- Clean work area at completion of shift.
- Properly dispose of used fluids, such as oil and coolant.

  Write summary and input MIDAS information of work performed at completion of repair or work shift
- Help from another maintainer (time for one person to complete the task times two).



INDUSTRIAL STANDARDS BULLETIN	Code:
Subject: EXPLANATION OF DEVELOPMENT OF STANDARD REPAIR TIMES (SRT)	Date: 9/21/98 Page: 3 of 3 Document Centro Initials:

Application: All maintenance actions.

Purpose: To provide users with an explanation of how Standard Repair Times are developed and applied at NYCT.

- Accessing vehicle, system or components.
- Comfort relief breaks.
- Shift changes.
- Normal work interruptions such as: seized or hard-turning fasteners, time for extremely dirty or high mileage equipment, reasonable time to get replacement parts, time for brief assistance to other mechar routine maintenance of shop equipment, time to obtain consumable equipment, and technical consultat with shop supervision.

Work Not Included in a SRT

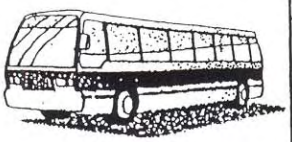
Contractual lunch and coffee break periods.

- Locating tools and required parts to perform the repair. (Specialized tools and equipment unique to th task must be available.)
- Waiting to use special tools.
- Repairing shop equipment.
- Sorting through salvage for parts.
- Reworking parts to fit a particular model of bus or adapting a part to a different application.
- Waiting for a parts' order to be filled. Replacement parts must be available within a reasonable time, e.g., available within 5 minutes at the storeroom window.

Standard Repair Time Tracking

The MIDAS system shall be used to track and report the time spent on all tasks. The line supervisors mus open a work order for the job and account for all the work performed, subtracting time for breaks or lunch The "note" area of the MIDAS work order will be used to account for and explain why jobs are not compl within the alloted time. Each SRT has a unique code in the NYCT Vehicle Maintenance Repair System (VRMS). The numbering system used is common to all the directives and bulletins distributed in the Department of Buses.

DEPARTMENT OF BUSES



INDUSTRIAL STANDARDS BULLETIN	Code:
Subject: **EXPLANATION OF DEVELOPMENT OF STANDARD REPAIR TIMES (SRT)**	Date: 9/21/98 Page: Signoff Pa Document Contro Initials:

Prepared by:

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Department of Buses

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DEPARTMENT OF BUSES

INDUSTRIAL STANDARDS BULLETIN	Code:
Subject: **EXPLANATION OF DEVELOPMENT OF STANDARD REPAIR TIMES (SRT)**	Date: 9/21/98
	Page: Signoff P

Recommended for Approval by: _____

Barbara Thomson
Assistant Chief Maintenance Officer
Industrial Standards, Methods & Procedures
Department of Buses

Approved by: _____

John Walsh
Chief Maintenance Officer
Department of Buses

APPENDIX F

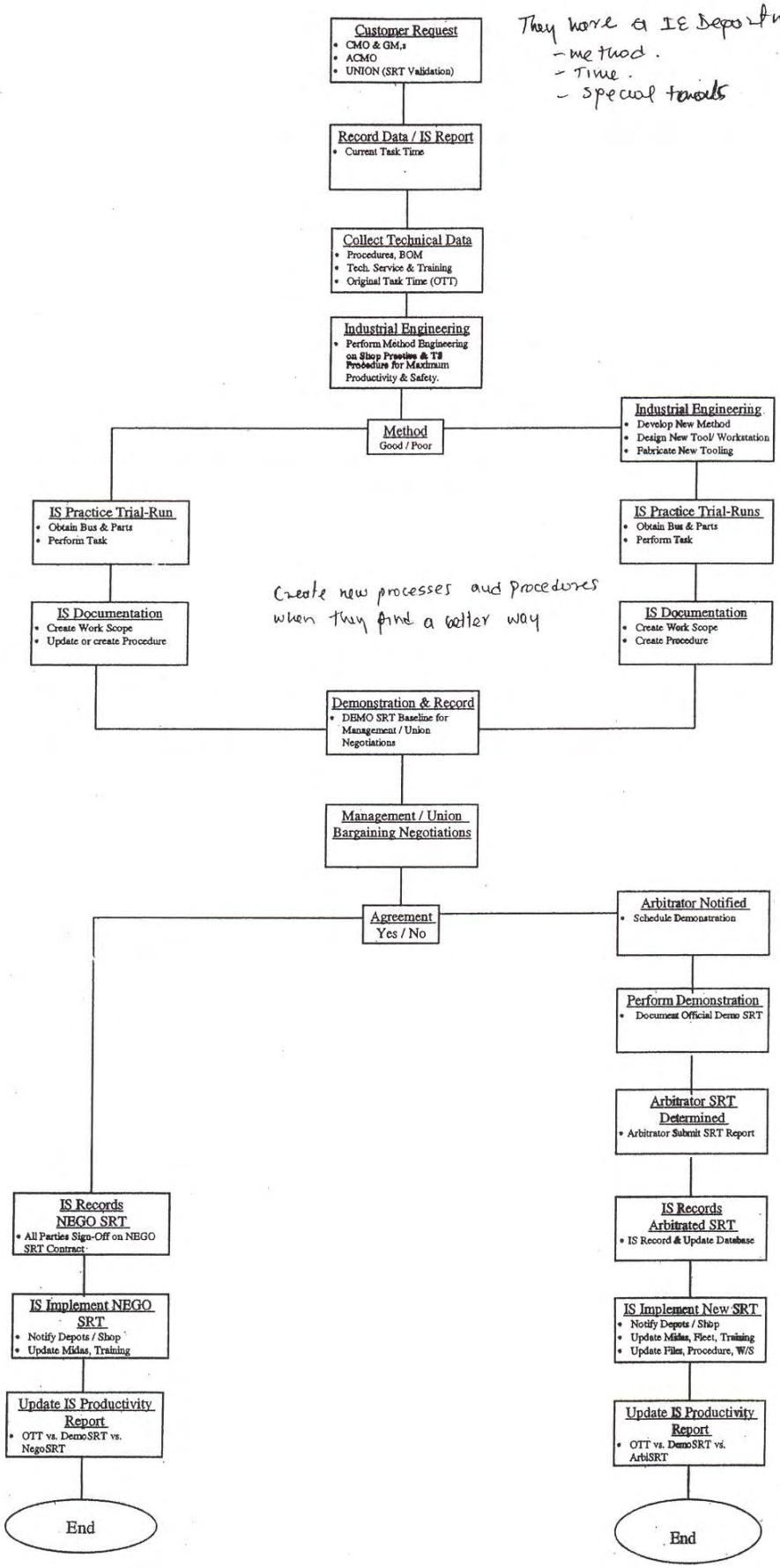
Industrial Standards Process*

This appendix shows the process followed by the Metropolitan Transit Authority (New York) during the standard repair time development.

* This information was collected during the visit to the Metropolitan Transit Authority, New York, and was not developed by the USF Team or utilized for establishing Time Standards or procedures in this research.

Industrial Standards

SRT Process



Developed by
Superintendent Gil Carrero

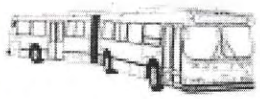
APPENDIX G

Technical Services Bulletins (Job Procedures)*

The Industrial Standards Group from the Metropolitan Transit Authority (New York) used time and motion studies as well as work sampling to establish time standards. This appendix shows some of the technical services bulletins (job procedures) followed at the MTA. Although the bulletins presented in this appendix are not directly related to the process studied in this research, they may be extremely beneficial to other transit facilities. Some of the job procedures included in this appendix are:

- Brake Reline New Flyer 60ft. Articulated Bus (7 pages)
- "S-Cam" Reline Braking System Orion/Nova (6 pages)
- Orion VII Low Floor Brake Reline (7 pages)
- Hub & Drum Rebuild Procedure with Tires (13 pages)

* This information was collected during the visit to the Metropolitan Transit Authority, New York, and was not developed by the USF Team or utilized for establishing Time Standards or procedures in this research.

MTA NEW YORK CITY TRANSIT DEPARTMENT OF BUSES		
	**TECHNICAL SERVICES BULLETIN**	Code: 74-7
	Subject: **BRAKE RELINE NEW FLYER 60FT. ARTICULATED BUS**	Date: 3/4/03
		Page: 1 of 7

Application: New Flyer 60ft. Articulated Bus Fleet with S-Cam Brakes.

Purpose: To establish a safe and efficient brake reline procedure for NF 60ft. articulated buses.

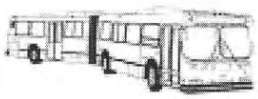
Task Time: 27.7 Hours.

Safety: All DOB safety procedures must be adhered to at all times.

Technical Notes:
This procedure requires a complete wheel assembly and brake shoe float set.

Tools and materials:

1. Stretch gauge # 42-56-6230
2. Tool kit # 92-42-3093
3. Multi purpose grease # 69-10-3400
4. Bushing & seal removal tool # 42-69-0500
5. Brake reline kit: Front axle # 92-80-0093
   Center # 92-85-5096
   Drive axle # 92-85-6096



TECHNICAL SERVICES BULLETIN	Code: 74-7
Subject: **BRAKE RELINE NEW FLYER 60FT. ARTICULATED BUS**	Date: 3/4/03
	Page: 2 of 7

Procedure:

WHEEL ASSEMBLY REMOVAL:

1. Secure bus on lift and release parking brake.
2. Remove drive axle shafts by loosing/removing axle stud lock nuts and striking axle hub with a **copper** (steel is prohibited) sledge hammer to loosen axle stud dowels. Slide axle shafts from rear axle assembly. (Prepare for collecting excessive axle oil).
3. Remove center axle covers.
4. Raise the bus and secure with safety stands.
5. Back off front, drive and center axle slack adjusters by rotating adjusting hex counter clockwise to allow clearance between the brake drum and brake lining prior to the wheel assemblies removal.
6. Remove front axle hubcap covers, gaskets, lock nuts, locking tabs, nut lock rings, and bearing adjusting nuts.
7. Remove front wheel assemblies with bearings and position in the lathe room.
8. Remove drive and center axle seals, gasket lock nuts, lock rings, and bearing adjusting nuts.
9. Remove drive and center axle wheel assemblies with bearings and position in the lathe room.

LATHE OPERATION:

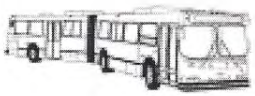
1. Calibrate lathe according to specifications stated in the "Star Lathe Model 53DS Lathe Training Manual".
2. Measure and visually inspect drums using drum micrometer to ensure drum tolerance before resurfacing.
3. Remove all bearings, seals, bearing retainers and A.B.S exciter rings (drive and center axles only) from wheel assemblies before resurfacing.
4. Prior to resurfacing, each drum must be clean and all wheel bearings and races checked for stress related defects. (OLD BEARINGS AND RACES MUST BE REPLACED AS A PAIR when replacement is necessary.)
5. Check and rebuild a matching set of shoes by first removing the rollers and using stretch gauge 42-56-6230 to check for stretch and determine if they can be re-used.
6. If stretch check is acceptable, remove old linings, clean shoes, and check proper shoe radius using Table Radius Gauge (# 613 for s-cam shoes). Replace shoes as needed.
7. If radius check is acceptable, re-bush shoes, install new rollers and appropriate linings. Torque lining bolts to specification **(18-23 ft lbs)**. Necessary tools to remove and install brake shoe bushings are included in tool kit 92-42-3093.
8. Mount first wheel assembly and matching set of rebuilt shoes on lathe and begin resurfacing.
9. While lathe is in operation, continue on to next wheel assembly and repeat all required steps (2-8).
10. After removing each wheel assembly from the lathe be sure to remove any possible contaminants such as metal filings from the hub and drum assemblies.
11. Pack all wheel bearings and hubs with **multi purpose grease** 69-10-3400 **(DO NOT OVER FILL HUBS)**.

Procedure: (continued)

12. Install inner bearings and new seals on front wheel assemblies.
13. Install inner bearings, new inner bearing retainer gaskets, new seal retainers and exciter rings on drive and center wheel assemblies.

FRONT AXLES:

1. Remove brake shoes/linings and return springs by removing anchor pin retaining bolts, lock washers, and flat strap washers. Slide anchor pins from brake spider assembly and remove shoes/linings.
2. Remove slack adjuster clevis pins.
3. Remove slack adjusters from S-cam following the reverse sequence outlined in the Technical Services Bulletin #74-2.
4. Remove S-cams from the brake spider assemblies taking note of spacer position, and quantity for re-assembly.
5. Inspect cleaned S-cams for flat spots, cracks, and/or corrosion. Replace as required.
6. Remove front brake chambers by disconnecting airlines and removing mounting nuts and washers. Transfer airline fittings and yoke from old to new brake chambers.
7. Install new brake chambers with anchor bracket; torque mounting nuts to specifications, (100-115 ft.lb.).
8. Remove camshaft bushings and seals using a long punch to remove the inner bushing and seal. Use the same punch or a bushing puller, included in tool kit 92-42-3093, to remove the outer bushing and seal.
9. Install new camshaft bushings and seals using bushing driver included in tool kit 92-42-3093 **(BOTH SEALS MUST BE INSTALLED FACING AWAY FROM BRAKE DRUMS TO AVOID POTENTIAL CONTAMINATION DUE TO EXCESS GREASE)**.
10. Apply a thin coat of **multi purpose grease** 69-10-3400 to camshaft bushings and anchor pin journals. Install S-cams using the same spacer configuration. Rotate S-cams by hand to ensure that S-cams move freely.
11. Install rebuilt front axle shoes/linings using new return springs, anchor pins, grease fittings, flat strap washers, lock washers and retaining bolts.
12. Torque anchor pin retaining bolts to specifications **(10 ft lbs)**.
13. Install new slack adjusters using the proper installation procedure. (Refer to Technical Services Bulletin #74-2 if necessary).
14. Install slack adjuster clevis pins and secure it using new cotter pins.
15. Grease front axle anchor pins, S-cams and slack adjusters.



TECHNICAL SERVICES BULLETIN	Code: 74-7
Subject: **BRAKE RELINE NEW FLYER 60FT. ARTICULATED BUS**	Date: 3/4/03
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Procedure: (continued)

DRIVE/CENTER AXLES:

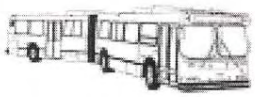
1. **Important:**
   a) Cage drive/center brake chambers using release stud, then apply parking brake to exhaust air pressure from the rear brake chambers.
   b) Disconnect the brake chambers airlines taking note of proper location for reassembly.
   c) Remove the brake chamber mounting nuts and washers and remove the brake chambers.
   d) Transfer airline fittings from old to new brake chambers. **(Do not remove the brake chamber release stud at this time).**
   e) Install new brake chambers and torque mounting nuts to specification **(110-114 ft.lb.).**
   f) Reconnect the brake chamber airlines.
   g) Release parking brake to charge the brake chambers. Remove release stud and secure inside storage pocket of each brake chamber.
2. Remove the axle brake shoes/linings and return springs by cutting locking wires, removing locking bolts and removing outer anchor pin snap rings. Slide anchor pins from the brake spider assembly and remove shoes/linings.
3. Remove slack adjuster clevis pins.
4. Remove slack adjusters from S-cam following the reverse sequence outlined in Technical Services Bulletin #74-2.
5. Remove S-cams from the brake spider assemblies taking note of spacer position and quantity for reassembly.
6. Inspect cleaned S-cams for flat spots, cracks and/or corrosion. Replace as required.
7. Remove inner camshaft seal and bushing using a long punch. To remove the outer bushing and seal use the bushing puller included in the tool kit (TA #92-42-3093).
9. Install new outer camshaft bushings and seals using bushing driver supplied in the tool kit. Install new inner bushings and seals using the short installing tool supplied in the tool kit. **(BOTH SEALS MUST BE INSTALLED FACING AWAY FROM BRAKE DRUMS TO AVOID POTENTIAL CONTAMINATION DUE TO EXCESS GREASE).**
10. Remove the anchor pin bushings and replace with new ones using bushing tool included in the tool kit. Be sure to line up locking screw holes in the bushings with the locking screw holes in the spider assembly.
11. Apply a thin coat of **multi purpose grease** 69-10-3400 to the camshaft bushing. Install S-cams using the same spacer configuration. Rotate S-cams by hand to ensure that S-cams move freely.
12. Install rebuilt brake shoes/linings using new anchor pins, snap rings, return springs, locking screws (do not over tighten), locking wire and grease fittings.
13. Install new slack adjusters using the proper installation procedure. (Refer to Technical Services Bulletin #74-2 if necessary).
14. Install slack adjuster clevis pins, and secure using new cotter pins.
15. Grease anchor pins, S-cams and slack adjusters.

Procedure: (continued)

WHEEL ASSEMBLY INSTALLATION:

EXTEND ALL A.B.S WHEEL SENSORS (if equipped) AND BE CAREFUL NOT TO HIT THEM WHEN INSTALLING WHEELS

1. Install all wheel assemblies using the proper bearing pre-load/adjusting procedure.
2. Install front wheel assemblies and outer bearings. Secure with bearing adjusting nut, nut lock ring, locking tab and lock nut. Bend locking tab over the lock nut.
3. Install and secure front axle hub cap covers using new gaskets.
4. Install drive/center wheel assemblies and outer bearings. Secure with bearing adjusting nut, lock and lock nut.
5. Install new axle shaft seals and gaskets.
6. Witness mark all slack adjuster adjusting hexes and apply service brakes at least three times to assure that all slack adjusters are adjusting properly. Check for air leaks while service brakes are applied and ensure that all brake chambers do not exceed maximum stroke throw.
7. Perform final brake adjustment by turning each slack adjuster adjusting hex clockwise until brake linings come in contact with brake drum surface. Then back off slack adjuster by turning adjusting hex counter clockwise one half of a turn, wheel should turn freely.
8. Install drive axle shafts, dowels, and axle stud lock nuts. Torque axle stud lock nuts to specifications **(40-65 ft lbs)**.
9. Road test bus, perform a decel test and parking brake check.



TECHNICAL SERVICES
BULLETIN

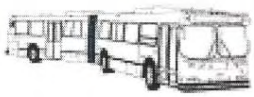
Code: 74-7

Subject:

BRAKE RELINE
NEW FLYER 60FT. ARTICULATED BUS

Date: 3/4/03

Bus Model	Year	Bus #	Description		Parts				
			Job	System	Description		TA P/N	Vendor P/N	Vendor Name
NFD60'HF	1997	1000-1069	Reline	S-Cam	Kit	Front	92-80-0093	T-BK-7002SBT	TTT
						Center	92-85-5096	T-BK-9112SBT	TTT
						Drive	92-85-6096	T-BK-8112SBT	TTT
					Brake Chamber (ASM)	FLH	86-83-0001	104298	Bendix
						FRH			
						CLH	86-83-0088	165411	Anchor Lock
						CRH	86-83-0009	165412	Anchor Lock
						DLH	86-83-0088	165411	Anchor Lock
						DRH	86-83-0009	165412	Anchor Lock
					Linings STD	Front	74-11-8000	MC4228FD	Abex
						Center	74-11-8500	MC4592AD	Abex
						Drive	74-11-8500	MC4592AD	Abex
					Linings 1X	Front	74-11-8001	MC4228FDX	Abex
						Center	74-11-8501	MC4592ADX	Abex
						Drive	74-11-8501	MC4592ADX	Abex
					Linings 2X	Front	74-11-8002	MC4228FDXX	Abex
						Center	74-11-8502	MC4592ADXX	Abex
						Drive	74-11-8502	MC4592ADXX	Abex
	1998	1070-1109	Same as above						
	2000	5250-5509	Same as above						
	2002	5510-5649	Same as above						

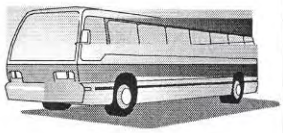
MTA NEW YORK CITY TRANSIT DEPARTMENT OF BUSES		
	**TECHNICAL SERVICES BULLETIN**	Code: 74-7
	Subject: **BRAKE RELINE NEW FLYER 60FT. ARTICULATED BUS**	Date: 3/4/03
		Page: 7 of 7

Recommended for Approval

Robert J. Ballas
Assistant Chief Maintenance Officer
Maintenance Support and Field Operations
Department of Buses

Approved by

John P. Walsh
Chief Maintenance Officer
Department of Buses

MTA NEW YORK CITY TRANSIT DEPARTMENT OF BUSES		
	**INDUSTRIAL STANDARDS BULLETIN**	Code: IS-74-02-99
	Subject: **" S-CAM " RELINE** **" S-CAM " BRAKING SYSTEM** **ORION/NOVA**	Date: 4-2-99 Page: 1 of 6

Application: All buses equipped with the S-Cam braking system.
Note: This procedure requires a complete wheel assembly and brake shoe float set.
Purpose: To outline the proper procedure to perform a four wheel reline on an S-Cam braking System utilizing three (3) maintainers.

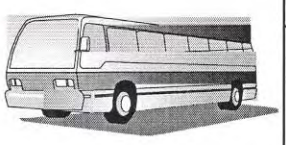
Task Time: 3 person team
20 hours- lathe operator: 6 hours; axle maintainers: 6 hours 55 minutes (1-4 races)
21 hours- each maintainer 6 hours 55 minutes (5-8 races)

Wheel Assembly Removal: Two- (2) maintainers will assist each other as necessary.

1. Secure bus on lift and release parking brake.
2. Remove rear axle shafts by removing axle stud lock nuts and striking axle hub with sledgehammer to loosen axle stud dowels. Slide axle shafts from rear axle.
3. Raise bus and secure with safety stands.
4. Back-off front and rear slack adjusters by rotating adjusting hex counter clockwise to allow clearance between brake drum and brake lining upon removal of wheel assemblies.
5. Remove front wheel hub cap cover, gasket, lock nut, locking tab, nut lock ring, and bearing adjusting nut.
6. Remove front wheel assemblies with bearings and position in lathe area.
7. Remove rear wheel axle assembly, axle seal, gasket, lock nut, lock ring, and bearing adjusting nut.
8. Remove rear wheel assemblies with bearings and position in lathe area.

Lathe Operation: One maintainer will perform lathe operation.

1. Calibrate lathe according to specifications stated in "Star Lathe Model 53DS Lathe Training Manual". (see attachment)
2. Measure and visually inspect drums using drum micrometer to ensure drum tolerance before resurfacing. (see attachment)
3. Remove all bearings, seals, and bearing retainers **(rears only)** from wheel assemblies before resurfacing.
4. Prior to resurfacing each drum, clean and check all wheel bearings and races for stress related defects. New bearings and races must be replaced as a pair, when replacement is necessary. Replace as required.
5. Check and rebuild first matching set of shoes by removing rollers and using stretch gauge **(TA# 42-56-6230)**, check for shoe stretch to determine reuse.
6. If stretch check is ok, remove old linings, clean shoes, and check shoe radius using Table Radius Gauge **(#613 for S-cam shoes)** to ensure proper shoe radius. Replace shoes as needed. (see attachment)
7. If radius check is ok, re-bush shoes, install new rollers, and appropriate linings. Torque lining bolts to specifications. **(18-23 ft.lbs.)** Necessary tools to remove and install brake shoe bushings are included in **tool kit (TA# 92-42-3093)**. (see attachment for proper lining configuration)
8. Mount first wheel assembly and matching set of rebuilt shoes on lathe, and begin resurfacing. (see attachment)
9. While lathe is in operation continue on to next wheel assembly and repeat all required steps (2-8) previously mentioned until all drums and linings are resurfaced.
10. After removing each wheel assembly from lathe be sure to remove any possible contaminants such as metal filings from hub and drum assemblies.
11. Pack all wheel bearings with grease. **(Grease TA# 69-10-3400) (Bearing packer TA# 47-88-0495)**
12. Pack but do not overfill all hub assemblies with grease. **(TA# 69-10-3400)**
13. Install inner bearings and new inner seals on front wheel assemblies.



Application: All buses equipped with the S-Cam braking system.
Note: This procedure requires a complete wheel assembly and brake shoe float set.
Purpose: To outline the proper procedure to perform a four wheel reline on an S-Cam braking System utilizing three (3) maintainers.

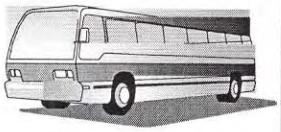
Task Time: 3 person team
20 hours- lathe operator: 6 hours; axle maintainers: 6 hours 55 minutes (1-4 races)
21 hours- each maintainer 6 hours 55 minutes (5-8 races)

Lathe Operation cont'd:

14. Install inner bearings, new inner bearing retainer gaskets, inner bearing retainers, and new inner seals on rear wheel assemblies.
15. Clean lathe and lathe attachments.

Front Axle: Two- (2) maintainers will perform all required work on front and rear axles.

1. Remove front brake shoes/linings and return spring by removing anchor pin retaining bolt, lock washer, and flat strap washer. Slide anchor pins from brake spider assembly and remove shoes/linings.
2. Remove front slack adjuster clevis pins.
3. Remove front slack adjusters by removing snap-ring and spacers from S-cam. Remove nut from slack adjuster control arm, reposition anchor bracket, and slide front slack adjuster from S-cam splines.
4. Remove and clean front S-cams from brake spider assemblies taking note of spacer position, and quantity for reassembly.
5. Inspect S-cams for flat spots, cracks, and or corrosion. Replace as required.
6. Remove front brake chambers and anchor brackets by disconnecting air line and removing two mounting nuts and washers. Transfer air line fittings and yoke from old front brake chambers to new.
7. Install new front chambers with anchor brackets; torque mounting nuts to specifications, **(100-115 ft.lbs.)** and reconnect air lines.
8. Remove front camshaft bushings and seals using a long punch to remove inner bushing and seal, and the same or a bushing puller included in tool kit, **(TA# 92-42-3093)** to remove outer bushing and seal.
9. Install new camshaft bushings and seals using bushing driver included in tool kit. (both seals must be installed facing away from brake drums to avoid potential contamination due to excess grease)
10. Apply a thin coat of grease **(TA# 69-10-3400)** to front camshaft bushings and anchor pin journals. Install front S-cams using the same spacer configuration. Rotate front S-cams by hand to ensure that S-cams move freely.
11. Install rebuilt front brake shoes/linings using new return springs, anchor pins, grease fittings, flat strap washer, lock washer, and retaining bolt.
12. Torque front anchor pin retaining bolts to specifications **(10 ft.lbs.)**
13. Install new front slack adjusters using the proper installation procedure recommended by Haldex (see attachment). Install and secure remaining spacers, new snap-ring, and control arm nut.
14. Install front slack adjuster clevis pins, and secure using new cotter pins.
15. Grease front anchor pins, S-cams, and slack adjusters. **(TA# 69-10-3400)**

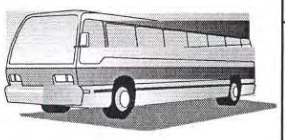
MTA NEW YORK CITY TRANSIT DEPARTMENT OF BUSES		
	**INDUSTRIAL STANDARDS BULLETIN**	Code: IS-74-02-99
	Subject: **" S-CAM " RELINE " S-CAM " BRAKING SYSTEM ORION/NOVA**	Date: 4-2-99
		Page: 3 of 6

Application: All buses equipped with the S-Cam braking system.
Note: This procedure requires a complete wheel assembly and brake shoe float set.
Purpose: To outline the proper procedure to perform a four wheel reline on an "S-Cam" braking System utilizing three (3) maintainers.

Task Time: 3 person team
20 hours- lathe operator: 6 hours; axle maintainers: 6 hours 55 minutes (1-4 races)
21 hours- each maintainer 6 hours 55 minutes (5-8 races)

Rear Axle: Two- (2) maintainers will perform all required work on front and rear axles.

1. Remove rear brake shoes/linings and return springs by cutting locking wire, remove two locking screws, and remove two outer anchor pin lock rings. Slide anchor pins from brake spider assembly and remove shoes/linings.
2. Remove rear slack adjuster clevis pins.
3. Remove rear slack adjusters by removing retaining bolt and washers. Remove nut and washer from slack adjuster control arm, and slide rear slack adjusters from S-cam splines.
4. Remove and clean rear S-cams from brake spider assemblies taking note of spacer position, and quantity for reassembly. Rear S-cams have a snap-ring located on the inboard side of brake spider assembly and must be removed with S-cam.
5. Inspect S-cams for flat spots, cracks, and or corrosion. Replace as required.
6. Remove rear camshaft seals and bushings using a long punch to remove inner bushing and seal, and a bushing puller included in tool kit **(TA# 92-42-3093)**, to remove outer bushing and seal.
7. Install new rear outer camshaft bushings and seals using bushing driver. Install new rear inner bushings using bushing puller. (both seals must be installed facing away from brake drums to avoid potential contamination due to excess grease)
8. Remove rear anchor pin bushings and replace with new using bushing tools included in tool kit. Be sure to line up locking screw holes in bushings with locking screw holes in spider assembly.
9. Apply a thin coat of grease **(TA# 69-10-3400)** to rear camshaft bushings and anchor pin bushings. Install rear S-cams using the same spacer configuration, and replace snap-rings with new. Rotate rear S-cams by hand to ensure that S-cams move freely.
10. Install rebuilt rear brake shoes/linings using new return springs, anchor pins, anchor pin lock rings, locking screws (do not over tighten), locking wire, and grease fittings.
11. **IMPORTANT:** Cage rear brake chambers using release stud, then apply parking brake to exhaust air pressure at rear brake chambers.
12. Disconnect rear brake chamber air lines taking note of proper location for reassembly.
13. Remove rear brake chamber mounting nuts and washers and remove rear chambers.
14. Transfer air line fittings from old rear brake chambers to new. **(Do not remove rear brake chamber release stud at this time.)**
15. Install new rear brake chambers and torque mounting nuts to specifications. **(110-150 ft.lbs)**
16. Reconnect rear brake chamber air lines.
17. Release parking brake to charge rear brake chambers. Remove release studs and secure in side storage pocket of rear brake chambers.



INDUSTRIAL STANDARDS BULLETIN	Code: IS-74-02-99
Subject: **" S-CAM " RELINE " S-CAM " BRAKING SYSTEM ORION/NOVA**	Date: 4-2-99
	Page: 4 of 6

Application: All buses equipped with the S-Cam braking system.
Note: This procedure requires a complete wheel assembly and brake shoe float set.
Purpose: To outline the proper procedure to perform a four wheel reline on an S-Cam braking System utilizing three (3) maintainers.

Task Time: 3 person team
20 hours- lathe operator: 6 hours; axle maintainers: 6 hours 55 minutes (1-4 races)
21 hours- each maintainer 6 hours 55 minutes (5-8 races)

Rear axle cont'd:

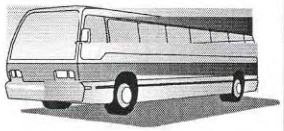
18. Install new rear slack adjusters using the proper installation procedure recommended by Haldex (see attachment). Install and secure remaining spacers, retaining bolt and washers, and control arm nut and washer.
19. Torque rear slack adjuster retaining bolts to specifications. **(60-80 ft.lbs.)**
20. Install rear slack adjuster clevis pins, and secure using new cotter pins.
21. Grease rear anchor pins, S-cams, and slack adjusters. **(TA# 69-10-3400)**

Wheel Assembly Installation: Two- (2) maintainers will assist each other as necessary.

1. Install all wheel assemblies using the proper bearing pre-load/adjusting procedure. (see attachment)
2. Install front wheel assemblies and outer bearings, and secure with bearing adjusting nut, nut lock ring, locking tab, and lock nut. Bend locking tab over lock nut wrenching flat.
3. Install and secure front hub cap covers using new gaskets.
4. Install rear wheel assemblies and outer bearings, and secure with bearing adjusting nut, lock ring, and lock nut.
5. Install new axle shaft gaskets and axle seals.
6. Witness mark all slack adjuster adjusting hexes, and apply services brakes at least three times to assure that all slack adjusters are adjusting properly. Check for air leaks while service brakes are applied, and ensure that all brake chambers do not exceed maximum stroke throw.
7. Perform final brake adjustment by turning each slack adjuster adjusting hex clockwise until brake linings come in contact with brake drum surface, then back-off slack adjuster by turning adjusting hex counter clockwise one half of a turn.
8. Remove safety stands and lower bus.
9. Install rear axle shafts, dowels, and axle stud lock nuts. Torque axle stud lock nuts to specifications. **(40-65 ft.lbs.)**
10. Perform decel test and parking brake check.

TOOLS:

Air impact gun 3/4" drive (42-89-0125)
Adapter 3/4" to 1" (42-42-0550)
Front wheel socket (42-69-8425)
Front wheel bearing socket (42-69-8430)
Rear wheel socket (42-69-8435)
Air impact gun 1/2" drive (42-89-0105)



INDUSTRIAL STANDARDS BULLETIN

Code: IS-74-02-99

Subject:

" S-CAM " RELINE
" S-CAM " BRAKING SYSTEM
ORION/NOVA

Date: 4-2-99

Application: All buses equipped with the S-Cam braking system.
Note: This requires a complete wheel assembly and brake shoe float set.
Purpose: To outline the proper procedure to perform a four wheel reline on an S-Cam braking System utilizing three (3) maintainers.

Task Time: 3 person team
20 hours- lathe operator: 6 hours; axle maintainers: 6 hours 55 minutes (1-4 races)
21 hours- each maintainer 6 hours 55 minutes (5-8 races)

Tools cont'd:

Ratchet 1/2" drive
Extension 1/2" drive 6"
Sockets 1/2" drive 15/16, 7/8, 11/16, 9/16
Air ratchet 3/8" drive (42-50-7020)
Ratchet 3/8" drive
Extension 3/8" drive 6"
Sockets 3/8" drive deep 1/2, 7/16
Box wrench 1 5/8" (42-46-4037)
Combination wrench 1" (42-46-5115)
Combination wrenches 7/8, 15/16, 13/16, 3/4, 11/16, 9/16, 1/2, 7/16
Screw drivers (phillips and standard)
Snap-ring pliers (Blue point 596A)
Needle nose pliers
Diagonal cutters
Channel lock pliers
Putty knife (42-26-2600)
Ball peen hammer (42-32-0540)
Brass punch (65-40-2705)
Punch (Craftsman 942903)
Cotter pin puller (Snap-On A173A)
Chisel 5/8" (Snap-On PPC820A)
Lady slipper pry bars (42-95-1881)
HSO tool kit Orion (92-42-3093) (2)
Torque wrench 3/4" drive (42-50-6608)
Micro torque wrench 3/4" drive (42-50-6617)
Torque wrench 1/2" drive (42-50-6604)
Torque wrench 3/8" drive (42-50-6611)
(4) Assorted race installers
7x air hammer (42-90-0172)
7x chisel (42-30-3310)
Sledge hammer 12 lbs. (42-32-1075)
Sledge hammer 3 lbs. (42-32-1045)
Wire brush (61-13-5025)
Appropriate task lighting (32-10-6215)
Eye protection (59-82-0210)

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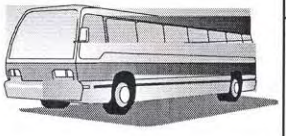	**INDUSTRIAL STANDARDS BULLETIN**	Code: IS-74-02-99
	Subject: **" S-CAM " RELINE** **" S-CAM " BRAKING SYSTEM** **ORION/NOVA**	Date: 4-2-99 Page: 6 of 6

Application: All buses equipped with the S-Cam braking system.
Note: This procedure requires a complete wheel assembly and brake shoe float set.
Purpose: To outline the proper procedure to perform a four wheel reline on an S-Cam braking System utilizing three (3) maintainers.

Task Time: 3 person team
20 hours- lathe operator: 6 hours; axle maintainers: 6 hours 55 minutes (1-4 races)
21 hours- each maintainer 6 hours 55 minutes (5-8 races)

Material:

92-80-1093 Brake kit (front)
92-85-1093 Brake kit (rear)
80-11-0007 Slack adjuster (front) 2
85-11-0006 **(ORION)** 85-67-0035 **(NOVA)** Slack adjuster LR
85-11-0005 **(ORION)** 85-67-0034 **(NOVA)** Slack adjuster RR
80-11-0086 Brake chamber (front) 2
86-11-0002 **(ORION)** 86-67-0007 **(NOVA)** Brake chamber (rear) 2

If defective:

89-11-0003 Bearing, front outer
89-53-0005 Race, front outer
89-53-8002 Bearing, front inner
89-53-8004 Race, front inner
89-47-0111 Bearing, rear outer
89-57-0027 Race, rear outer
89-57-0026 Bearing, rear inner
89-57-0025 Race, rear inner
80-11-0301 Drum (front)
80-53 0049 Hub (front)
85-11-1028 Drum (rear)
89-11-0005 Hub (rear)
85-11-0010 Brake shoe (rear)
80-11-0008 Brake shoe (front)
80-11-0010 Camshaft LF
80-11-0006 Camshaft RF
85-11-0012 **(ORION)** 85-67-0059 **(NOVA)** Camshaft LR
85-11-0013 **(ORION)** 85-67-0060 **(NOVA)** Camshaft RR

To be determined:

74-11-8000 Brake block front (standard)
74-11-8001 Brake block front (X)
74-11-8002 Brake block front (XX)
74-11-8500 Brake block rear (standard)
74-11-8501 Brake block rear (X)
74-11-8502 Brake block rear (XX)

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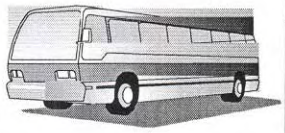
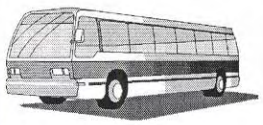
	**INDUSTRIAL STANDARDS BULLETIN**	Code: IS-74-02-99
	Subject: **" S-CAM " RELINE " S-CAM " BRAKING SYSTEM ORION/NOVA**	Date: Signoff Page: Document Control Initials:

Recommended for Approval by: _____

Barbara Thomson
Assistant Chief Maintenance Officer
Industrial Standards, Methods & Procedures
Department of Buses

Approved by: _____

John P. Walsh
Chief Maintenance Officer
Department of Buses

MTA NEW YORK CITY TRANSIT DEPARTMENT OF BUSES		
	TECHNICAL SERVICES BULLETIN	Code: 74-9
	Subject: **ORION VII LOW FLOOR BRAKE RELINE**	Date: 6/7/04
		Page: 1 of 7

Application: Orion VII Low Floor braking system.

Purpose: To establish a safe and efficient procedure for the Orion VII Low Floor brake reline.

Task Time: Three (3) maintainers - 6.92 hrs. each

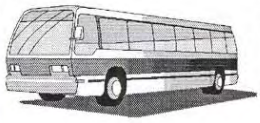
Safety: All DOB safety procedures must be adhered to at all times.

Technical note: This procedure requires a complete wheel assembly and brake shoe float set.

Tools and equipment:

Front reline kit: 92-80-3002
Rear reline kit: 92-85-3002
S-cam bushing remover and installer front axle 42-69-0744
Brake shoe stretch gauge: 42-56-3444
Brass sledge hammer: 42-32-0590
Grease: 69-10-3400
Bushing removal tool (slide hammer type): 42-69-0501
Brake shoe validator: 42-56-3442
Pliers wire twister 42-22-8200
Anchor pin bushing remover and installer 42-69-0740
Brake shoe bushing remover and installer 42-69-0742

- **WHEEL BEARINGS AND RACES MUST BE MAINTAINED OR REPLACED AS A MATCH SET.**
- **WHEEL BEARING PRELOAD/ ADJUSTMENTS MUST FOLLOW THE TMC MAINTENANCE PROCEDURE.**



TECHNICAL SERVICES BULLETIN

Code: 74-9

Subject:

ORION VII LOW FLOOR BRAKE RELINE

Date: 6/7/04

1. Front Wheel Assembly Removal:

1.1 Secure bus on lift using appropriate stands and release parking brake.
1.2 Back-off front and rear slack adjusters by rotating adjusting hex counter clockwise to allow clearance between brake drum and brake lining.
1.3 Remove front wheel hubcap covers, gasket, lock nut, locking tab, nut lock ring, and bearing adjusting nut.
1.4 Remove front wheel assemblies with bearings and move to the lathe area.

2. REAR Wheel Removal:

2.1 Using a brass sledge hammer (42-32-0590) remove rear wheel axle assembly, axle seal, gasket, lock nut, lock ring, and bearing adjusting nut.
2.2 Remove rear wheel assemblies with bearings and position in lathe area.

3. Lathe Operation:

3.1 Calibrate lathe according to specifications stated in the "Star Lathe Model 53DS Lathe Training Manual".
3.2 Measure and visually inspect drums using drum micrometer to ensure drum tolerance before resurfacing. If out of acceptable limits use a new drum.
3.3 Remove the Allen head bolts from the rear exciter ring housings; lift housings off the rear hubs.
3.4 Remove all bearings and seals from wheel assemblies before resurfacing.
3.5 Prior to resurfacing, each drum must be clean and all wheel bearings and races checked for stress related defects (IF REQUIRED, BEARINGS AND RACES MUST BE REPLACED AS A MATCHED SET)
3.6 Mount first wheel assembly on lathe and begin resurfacing.
3.7 Check and rebuild matching sets of shoes, use stretch gauge (42-56-3444) to check for stretch to determine reuse.
3.8 If stretch is ok, remove old linings (IF RELINE IS BEING DONE FOR THE FIRST TIME, THE BRAKE LININGS WILL BE RIVETED TO THE SHOES. YOU MUST DRILL OUT THE RIVETS USING A 5/16 DRILL BIT IN A DRILL PRESS AND ONLY DRILL THE MUSHROOM END OFF RIVET. THEN, WITH A PUNCH, REMOVE RIVET), clean shoes and check shoe radius using a brake shoe validator (42-56-3442) Gauge. Replace shoes as needed.
3.9 If radius check is ok, rebush shoes using tool (42-69-0742) and install appropriate linings. Torque lining bolts to **8-10 ft-lbs.**
3.10 Cut shoes to appropriate size.
3.11 While lathe is in operation, continue on to next set of shoes.
3.12 After removing each wheel assembly from lathe be sure to remove any possible contaminants such as metal filings from the hub and drum assemblies.

3.13 Pack front and rear wheel bearings and hubs with multi purpose grease 69-10-3400 **(DO NOT OVER FILL HUBS)**.
3.14 Install inner bearings and seals on front wheel assemblies.
3.15 Install inner bearings, seals and install exciter ring housing onto rear hubs.
3.16 Clean lathe and lathe attachments.

4. Front Axle:

4.1 Remove front brake shoes/linings by removing return springs, cut locking wire, remove two locking screws and remove snap-rings on anchor pins. Slide anchor pins from brake spider assembly and remove shoe/linings.
4.2 Remove front slack adjuster clevis pins.
4.3 Remove front slack adjusters by removing snap-ring and spacers (take note of the quantity) from s-cam. Remove nut from slack adjuster control arm. Reposition anchor bracket, and slide slack adjuster from s-cam splines.
4.4 Remove s-cams from brake spider assemblies taking note of spacer position, and quantity for reassembly.
4.5 Remove front brake chambers.
4.6 Remove camshaft bushings and seals using a long punch to remove inner bushing and seal, and the same or a bushing puller (42-69-0744) to remove outer bushing and seal. Clean spiders.
4.7 Install new camshaft bushings and seals using bushing driver (42-69-0744) **(BOTH SEALS MUST BE INSTALLED FACING AWAY FROM BRAKE DRUMS TO AVOID POTENTIAL CONTAMINATION DUE TO EXCESS GREASE)**.
4.8 Remove anchor pin bushings and replace with new ones using bushing tool (42-69-0740).
4.9 Inspect cleaned s-cams for flat spots and/or corrosion. Replace as required.
4.10 Apply a thin coat of multi purpose grease 69-10-3400 to the camshaft bushings and anchor pin bushings. Install s-cams using the same spacer configuration and new snap-rings. Rotate s-cams by hand to ensure they move freely.
4.11 Install new brake chambers.
4.12 Install new slack adjusters using the proper installation procedure recommended by Haldex (See pages 5-6).
4.13 Install rebuilt brake shoes/linings using new return springs, anchor pins, anchor pin snap-rings, washers, locking screws (apply never-seize and do not over tighten), locking wire and grease fittings.
4.14 Grease front anchor pins, s-cams and slack adjusters.

5. Rear axle:

5.1 Cage brakes.
5.2 Remove rear brake shoes/linings by removing return springs, cut locking wire and remove two locking screws, remove snap-rings on anchor pins. Slide anchor pins from brake spider assembly and remove shoes/linings.

5.3 Remove rear slack adjuster clevis pins.

5.4 Remove rear slack adjusters by removing the ¾ lock bolt and spacers (take note of the quantity) from s-cams. Remove nut from slack adjuster control arm. Reposition anchor bracket and slide slack adjuster from s-cam splines.

5.5 Remove s-cams from the brake spider assemblies taking note of spacer position, and quantity for reassembly.

5.6 Remove camshaft bushings and seals using a long punch to remove inner bushing and seal and use a bushing removal tool (42-69-0501) to remove outer bushing and seal. Clean spiders.

5.7 Install new camshaft bushings and seals using bushing driver (42-69-0501). **(BOTH SEALS MUST BE INSTALLED FACING AWAY FROM BRAKE DRUMS TO AVOID POTENTIAL CONTAMINATION DUE TO EXCESS GREASE).**

5.8 Remove anchor pin bushings and replace it with new ones using bushing tool (42-69-0740).

5.9 Inspect cleaned s-cams for flat spots and/or corrosion. Replace as required.

5.10 Apply a thin coat of multi purpose grease 69-10-3400 to camshaft bushings and anchor pin bushings. Install s-cams using the same spacer configuration. Install new slack adjuster, ¾ lock bolt and washer. Rotate s-cams by hand to ensure they move freely.

5.11 Remove and replace rear brake chambers.

5.12 Adjust new slack adjusters using the proper installation procedure recommended by Haldex (See pages 5-6).

5.13 Install rebuilt brake shoes/linings using new return springs, anchor pins, anchor pin snap-rings, washers, locking screws (apply never – seize, do not over tighten), locking wire, and grease fittings.

5.14 Grease rear anchor pins, s-cams and slack adjusters.

5.15 Extend all ABS wheel sensors and be careful not to hit them when installing wheels.

6. Wheel Assembly Installation:

6.1 Install front wheel assemblies and outer bearings using the proper pre-load/adjusting procedure. Then secure lock ring, locking tab and lock nut. Bend locking tab over lock nut wrenching flat.

6.2 Install and secure front hubcap covers using new gaskets.

6.3 Install rear wheel assemblies and outer bearings, using the proper preload/adjusting procedure then secure lock ring, and lock.

6.4 Install rear axle assemblies with new axle gaskets.

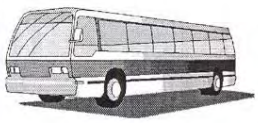
6.5 Uncage rear brakes.

6.6 Perform final brake adjustment by turning each slack adjuster adjusting hex clockwise until brake linings come in contact with the brake drum surface, then back off slack adjuster by turning adjusting hex counter clockwise one half of a turn. Wheel should turn freely.

6.7 Start bus and build air pressure to 90 psi. Apply service brake and check that all chambers do not exceed maximum stroke throw and there are no air leaks.

6.8 Check the torque value on all lug nuts. The front and rear wheels should be torqued to **500 ft-lbs.**

6.9 Road test bus, perform a decel test and parking brake check.



Installation Procedures

Note: Configuration of anchor bracket and brake adjuster housing may vary, depending upon axle.

Step 1

Note: Block wheels to prevent vehicle from rolling. Ensure system tank pressure is above 100 psi.

- Check that the push rod is fully retracted; apply air to release spring brake. If air is not available, spring brake must be manually caged back.
- Install anchor bracket loosely as illustrated (fig. 13).
- Some strap brackets have two mounting holes. Proper mounting location is determined by the length of adjuster arm. 5" and 5-1/2" adjuster arm lengths utilize the shorter hole location while 6" and 6-1/2" length adjusters utilize the longer hole locations.
- Do not tighten anchor bracket fasteners at this time.
- Apply "Anti-Seize" type lubricant to camshaft splines.

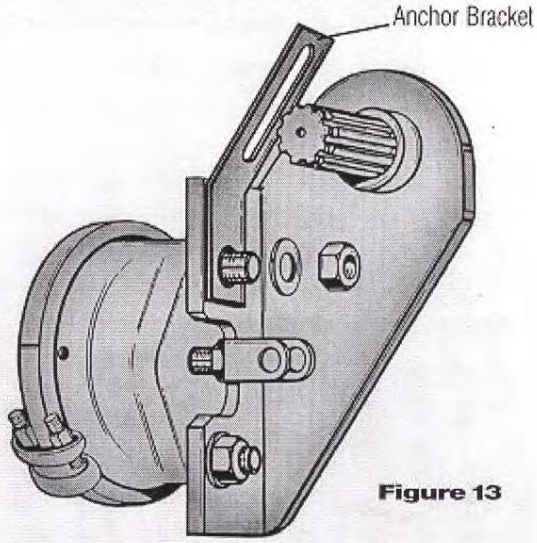


Figure 13

Step 2

- Install the brake adjuster onto the camshaft with the adjusting hex pointing **away** from the brake chamber (fig. 14).
- Secure the brake adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than .060 movement of adjuster on camshaft. (Per TMC recommended practice RP609-A.)

Note: Do **NOT** pull push rod out to meet the brake adjuster.

- Rotate the 7/16" adjusting hex nut CLOCKWISE until the clevis hole lines up with the brake adjuster arm hole.
- Apply anti-seize to clevis pin, install and secure with cotter pin.

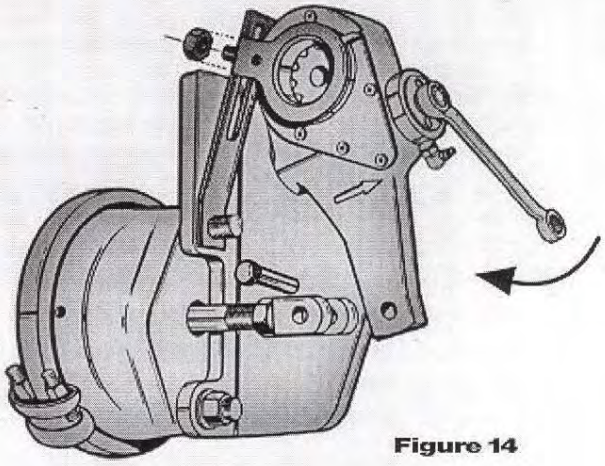


Figure 14

Installation Procedures

Step 3

- Rotate the control arm away from the adjusting hex toward the air chamber, until it comes to a definite internal stop (fig. 15).
- Most adjusters will be equipped with an "Installation Indicator." Indicator must fall within the slot for proper installation with brakes fully released (fig. 16).
- **If the control arm position is wrong, tight brakes will occur (fig.17).**
- Tighten all anchor bracket fasteners (make sure the control arm does not move from its position while tightening fasteners).

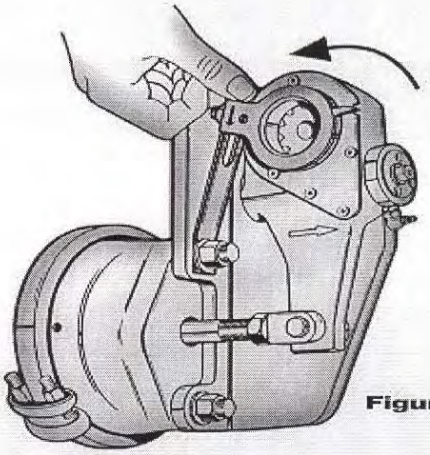
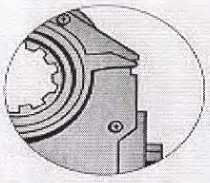


Figure 15

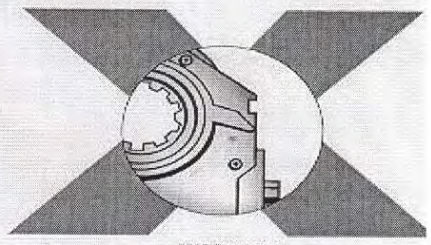
Step 4

- The adjuster must be manually adjusted at this time.
- Rotate the adjusting hex clockwise until the lining contacts the drum.
- Then back-off the adjuster by turning the adjusting hex counter-clockwise 1/2 of a turn (fig. 18).
- A minimum of 13 ft. lbs. is necessary to overcome the internal clutch. A ratcheting sound will be present.
- **Do NOT use an impact wrench or internal damage will occur!**
- **FINAL INSPECTION.** Make sure brakes are still fully released, and check that the "Installation Indicator" is within the slotted area. If out of position, repeat Step #3. **(A mis-set control arm can cause a tight brake.)**

Note: To ensure proper fit and function, always replace adjuster, mounting bracket and all related hardware.



Correct
(Brakes released)
Figure 16



INCORRECT
(Brakes released)
Figure 17

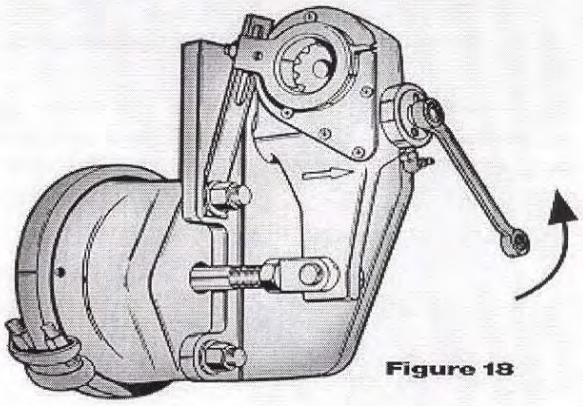
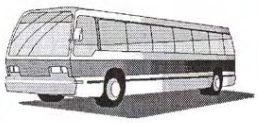


Figure 18



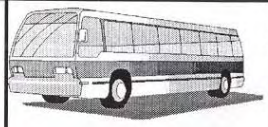
TECHNICAL SERVICES BULLETIN	Code: 74-9
Subject: **ORION VII LOW FLOOR BRAKE RELINE**	Date: 6/7/04
	Page: 7 of 7

Recommended for Approval:

John Higgins
Assistant Chief Maintenance Officer
Maintenance Support and Field Operations
Department of Buses

Approved by:

John P. Walsh
Chief Maintenance Officer
Department of Buses



INDUSTRIAL STANDARDS BULLETIN

Code: IS-74-01-04

Subject:

HUB & DRUM REBUILD PROCEDURE WITH TIRES

Date: 3/18/04

Application: New York City Transit Department of Buses (DOB) Fleet (less low-floor buses), depot procedure.

Scope: To develop a safe and high quality process for rebuilding the wheel/hub/drum assembly for buses.

Safety: All DOB safety procedures must be adhered to at all times.

Task Time: 65 Minutes Per Assembly

Special Instructions:

VEHICLE SAFETY SENSITIVE PROCESS

The Wheel/Hub/Drum assembly rebuilding process is a vehicle safety sensitive process. Any dirt, debris, rust, scaling, nicks, burrs or flaking paint on the mating surface between wheel/drum/hub assembly can contribute to wheel lug nuts loosening up during operation. To insure maintenance safety, allow for sufficient working space, and establish a properly equipped work area/facility, to perform hub and drum rebuild. **See page 11 for a recommended work area layout.**

LIST OF TOOLS:

Air impact gun – 3/4" drive (1/2" drive preferred if available) **for installation only** (42-90-0160)
Air impact gun - 1" drive **for removal purposes only** (42-46-2504)
Torque wrench – 3/8" drive (42-50-6611)
Torque wrench - ¾" drive (42-50-6617)
Adapter - ½" female to ¾" male (as required)
Impact socket – 1 5/16" in ¾" drive (42-44-2885)
Impact socket - 1 ½" in ¾" drive (42-44-2900)
Impact socket - 1 5/16" in 1" drive (42-44-3155)
Impact socket – 1 ½" in 1" drive (42-44-3170)
Goggles or Safety glasses (59-82-0210)
Ratchet – 3/8" drive (42-42-5080)
Brass hammer 4 lbs. (42-32-0576)
Brass punch (42-34-3905)
Wire Wheel, 8 inch, (61-13-7132)
Wire Cup, 4 inch, (48-70-4250)
Axle Stud Remover (42-42-7853)
Pneumatic grinder (42-83-8670)
Die Grinder (42-26-0810)
Ratchet –1/2" (42-42-7302)

LIST OF SPECIALIZED TOOLS:

Hub / Drum Complete Rebuilding Kit (Transport # TP441083)
Modified Hydraulic Lift Table with Welded Hub / Drum Rebuilding Stand (42-69-0314)
Hub / Drum Rebuilding Stand, (42-69-0312) (see drawing, page 12)
Octagon Wheel Support (42-69-0318) (see drawing, page 12)
Rear Drum Horseshoe Lifting Tool (42-69-0302)
Front Drum Horseshoe Lifting Tool (42-69-0300)
Lug Stud Height Gage (42-56-5602 - Front; 42-56-5600 – Rear)

Hub Outer Diameter Ring Gage (42-69-0316) (see drawing, page 12)
Race Installation Kit (42-69-0310)
Race Removal Kit (42-69-0308)
Short Striking Handle (42-69-0306)
Long Striking Handle (42-69-0304)
Overhead Steel Crane (recommend Sissco)
Crane Trolley (recommend Sissco)
1 Ton Electric Chain Hoist (Grainger)
Wheel Stud Hole No-Go Gauge (Steel) RTS, ARTI, MCI (77-30-0002)
Wheel Stud Hole No-Go Gauge (Aluminum) RTS, ORION (77-55-0010)
Wheel Stud Hole No-Go Gauge (Steel) Low Floor (42-56-3483)
Drum Micrometer (RTS, MCI, ORION, ARTI as required): (42-56-7340)

MATERIALS:

Dust Mask (59-35-1001)
Stud lock nuts front (as required): 77-57-0007
Stud lock nuts rear (as required): 77-57-0008
Penetrating Oil (69-12-3154)
Degreaser (70-17-0935)
Yellow Marker (58-46-0367)
Spacer Kit (42-34-0220)
Never-Seize (70-43-1000)

PROCEDURE:

1. Prior to proceeding with a hub and drum rebuild, conduct a thorough inspection of the tire sidewalls for cuts, gashes and bulges; and inspect tread depth to insure it has a 8/32" minimum depth (fig 2).
2. Position wheel, drum and hub assembly onto octagon wheel support, in figure 1 (also see drawing, page 12).
3. Remove lug nuts and separate wheel from drum and hub assembly, as in figure 3.

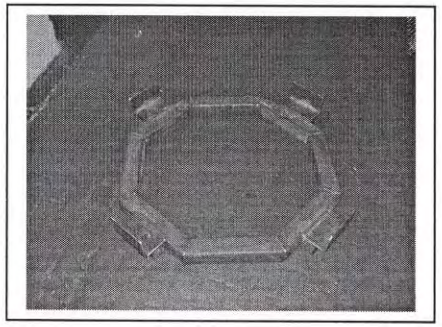


Figure 1

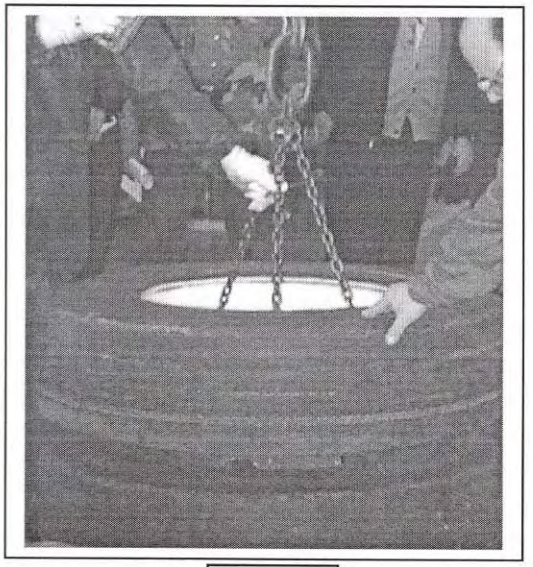


Figure 2

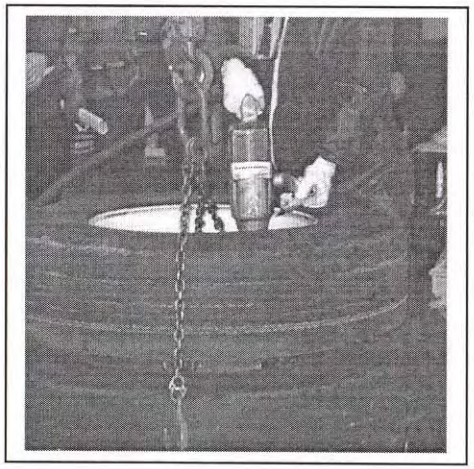


Figure 3

4. Discard plastic "wheel guard" rim protector, if equipped.
5. Remove and discard hub-retaining screws from drum and hub assembly, figure 4.

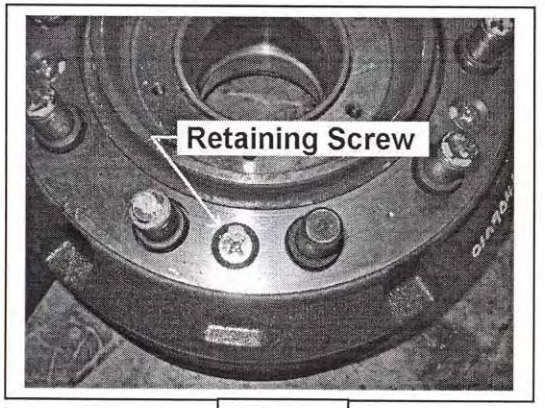


Figure 4

NOTE

Retaining screws are no longer used. Do not reinstall retaining screws.

6. Remove drum and place hub assembly onto hub rebuilding stand / hydraulic lift table, figures 5 and 6 (see drawing of stand, page 12).

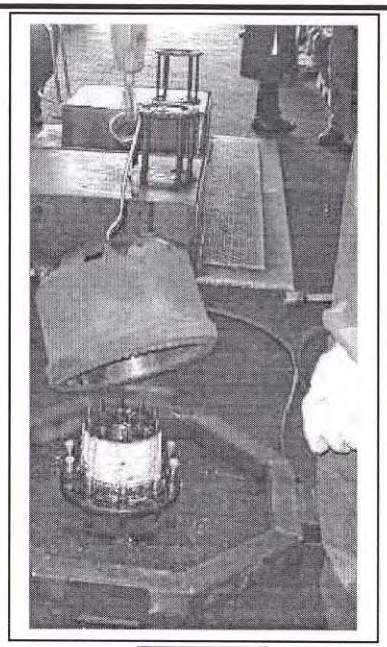


Figure 5

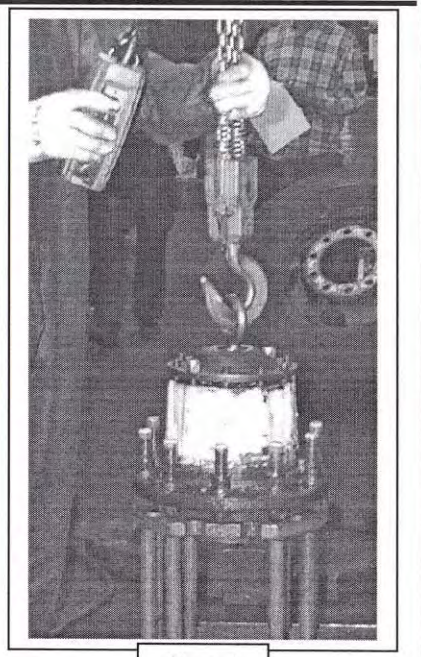


Figure 6

7. Clean hub-to-drum mating surface, hub outside perimeter, and rear hub-to-axle mating surface using pneumatic (or electric) drill with attached wire wheel & wheel cup, figures 7 and 8.

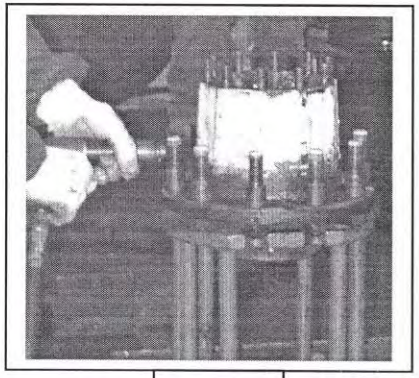


Figure 7

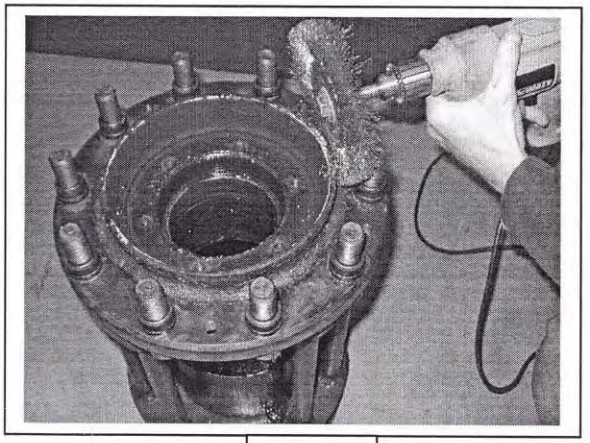


Figure 8

8. Inspect lug stud height using height gage and inspect axle studs for damage and replace as necessary. If a broken stud is found replace the stud and the adjacent studs on either side of the broken stud. If two or more studs are broken replace all the studs.

NOTE

Nova or Orion front hubs equipped with obsolete studs (too short 1-7/8" or too long 2-3/8") must be replaced with the new replacement studs (2-1/8" length, TA # 80-11-0051).

9. Inspect hub outside diameter with Go/No-Go Hub Ring Gage (see drawing, page 12). If hub fails inspection mark as unserviceable and discard in accordance with depot procedure.

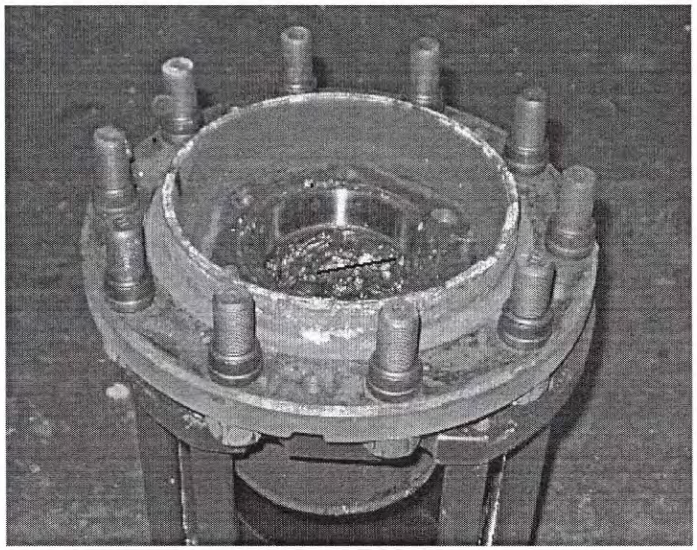


Figure 9

10. Torque lug studs to 250 ft. lbs (figure 10). Check for stud movement. Mark loose studs with yellow marker and replace as necessary. Wipe the area clean and witness mark with yellow marker.

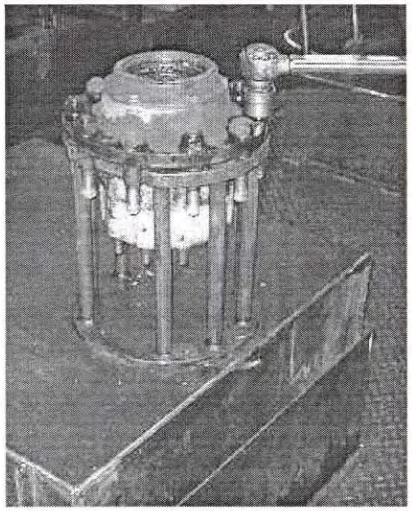


Figure 10

11. Remove rear wheel seal and retainer. Clean inner hub and remove inner and outer races, figure 11. **Use a brass hammer only – DO NOT use a steel hammer**.

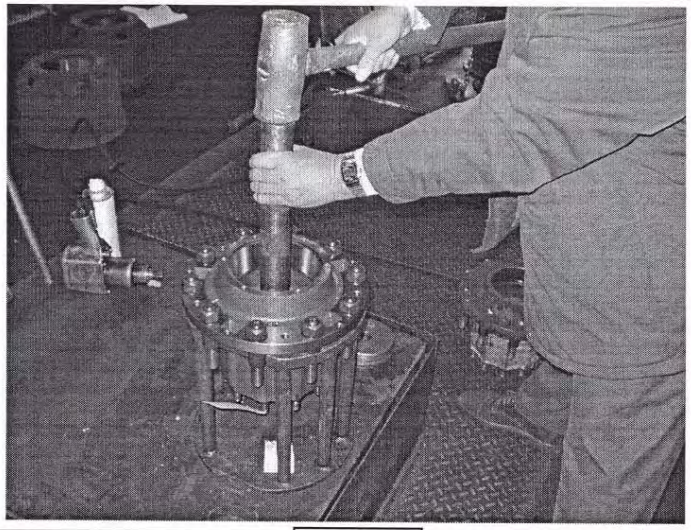


Figure 11

12. Wipe race landings clean, and install new races (races and bearings may be issued as a single part number / unit from stock) and bearings as available, figures 12 and 13.

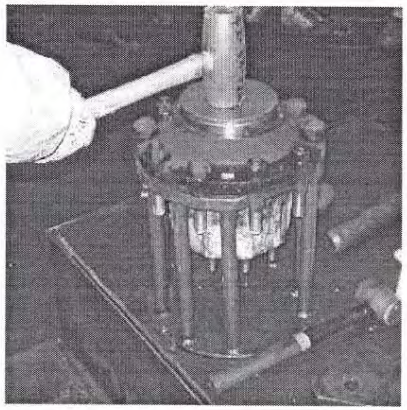


Figure 12

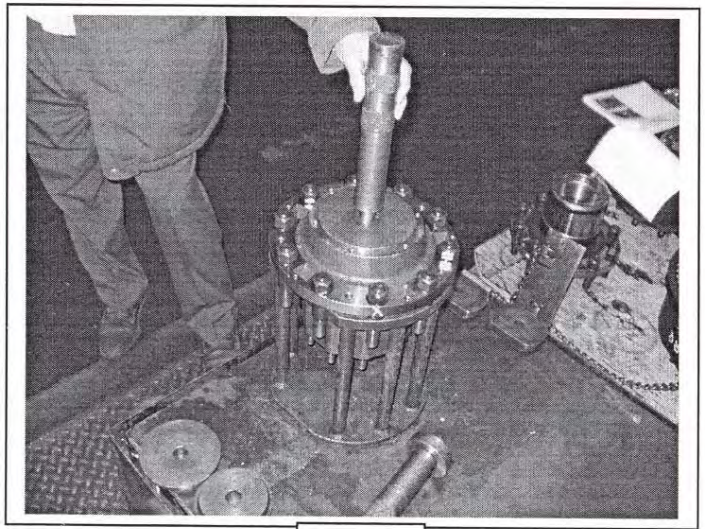


Figure 13

13. Install new drum. Install four retaining collars with washers and nuts to seat the drum to the hub, figures 14 and 15.

NOTE

Retaining screws are no longer used. Do not reinstall retaining screws.

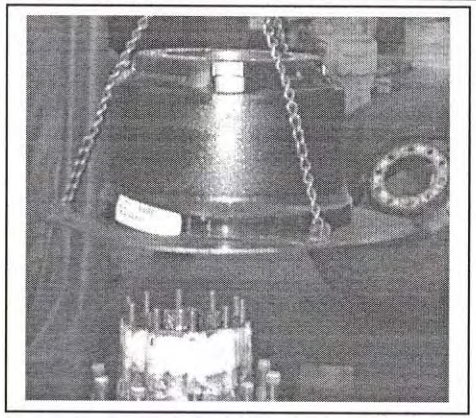


Figure 14

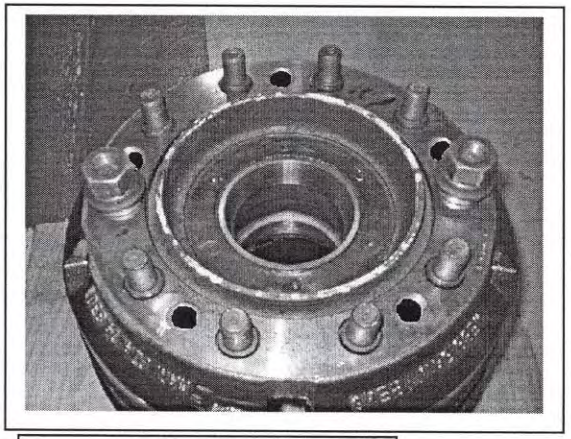


Figure 15

14. Prepare tire(s) for remounting on rebuilt hub and drum assembly according to the following steps.
15. Continue to inspect tires (same as step 1) during remounting process; inspect rim stud holes for elongation using Go/No-Go gage (see list of Specialized Tools for specific gage) as shown in figure 16, and any rim damage such as dents, cracks, or sharp nicks around hand holes (fig 17).

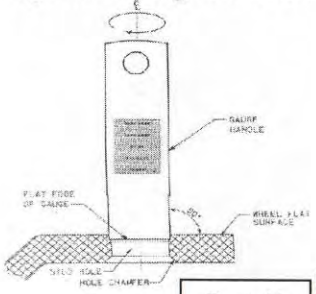


Figure 16 Sketch of stud hole gage in use.

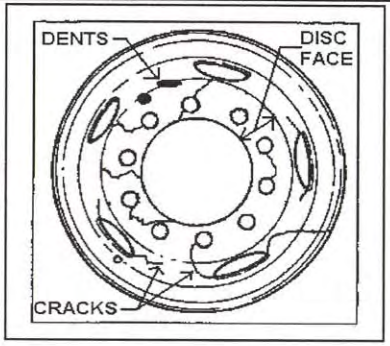


Figure 17

16. Clean wheel (s) mating surfaces (both sides) using disc sander. The mating surfaces must be clean of all dirt, rust and paint (figures 18 and 19).

NOTE

For brand new power coated wheel the surface common to the lug nuts requires no sanding.

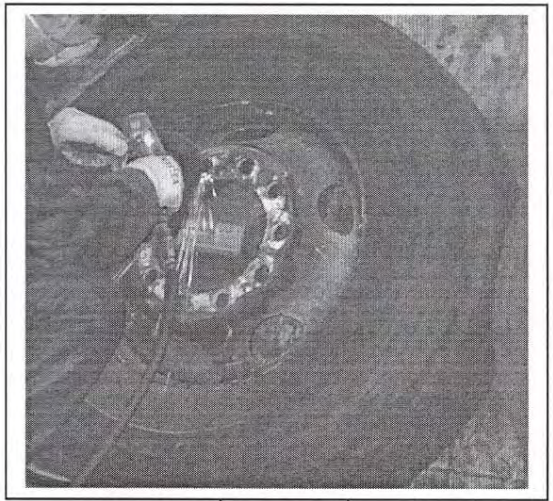


Figure 18

Figure 19

17. Carefully apply a film of never-seize around the center hole edge perimeter only.
18. Mount wheel (s) with wheel hand holes aligned to drum vent holes (see sketch, figure 20) and valve stem (s) aligned. Rear tires must be a matched set (fig 21 & 22).

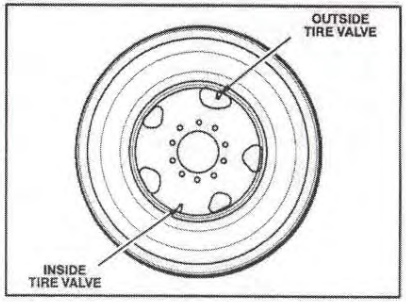


Figure 20

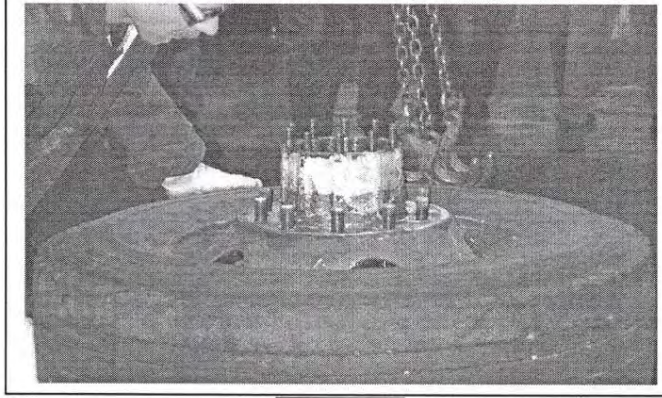


Figure 21

19. Install lug nuts and tighten wheel lug nuts in two steps and in sequence (in diagram below, figure 23), and as described below, using a ½" air gun. **This is not a final torque.**
    Run the nuts until they make contact with the rim.
    Use the impact wrench to tighten the nuts below the specified torque (fig. 22).

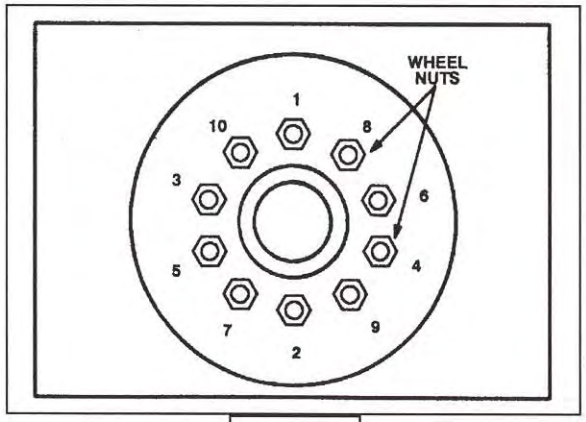


Figure 23

Quality Control

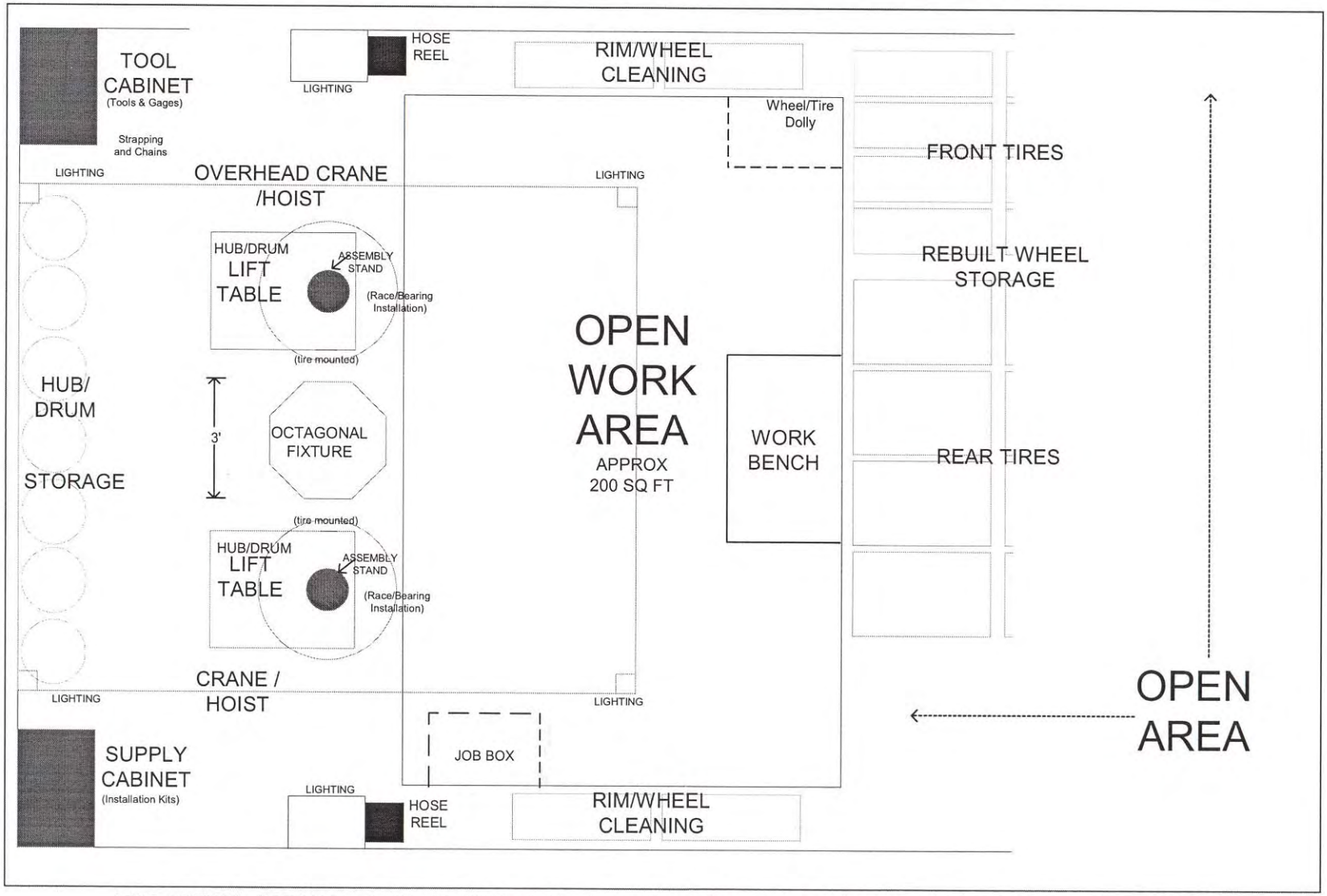
Use of a ½ " air impact gun is advised, to tighten the lug nuts, but avoid over-torquing the lug nuts.

20. Once hub and drum and tires are all assembled, remove from the rebuild stand and place in storage (fig 24). Mark tire with white chalk 'LUG NUT TORQUE NEEDED'

Figure 22

Figure 24

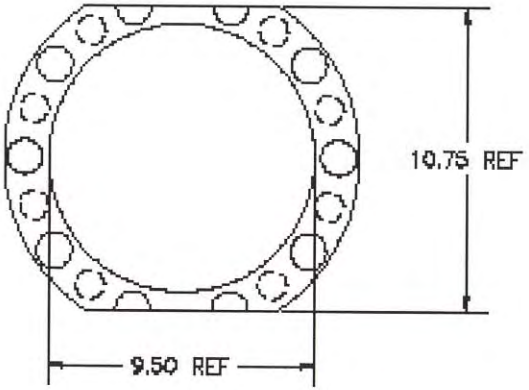
HUB AND DRUM WORK AREA LAYOUT



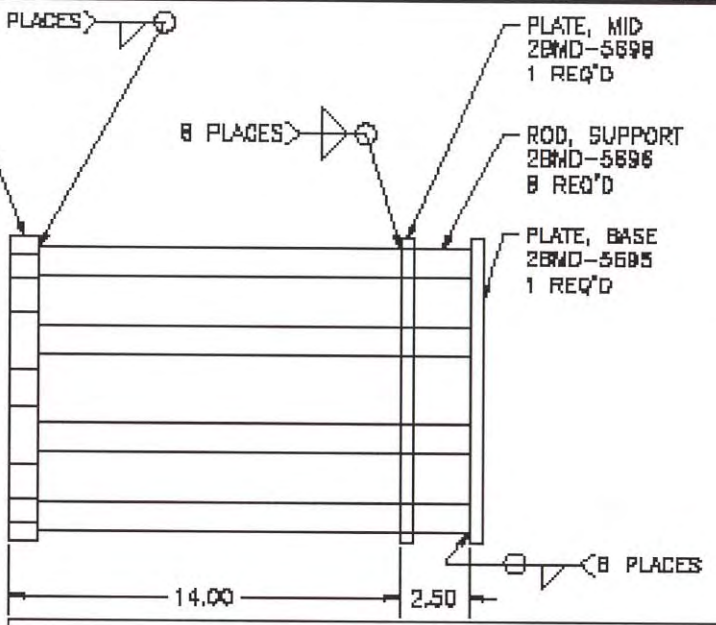
THE ACTUAL ARRANGEMENT OF EQUIPMENT AND ACTIVITIES IS DEPENDENT ON THE INDIVIDUAL FACILITY
MINIMUM OF 700 SQ FT REQUIRED

REFERENCE DRAWINGS OF KEY REBUILD TOOLS

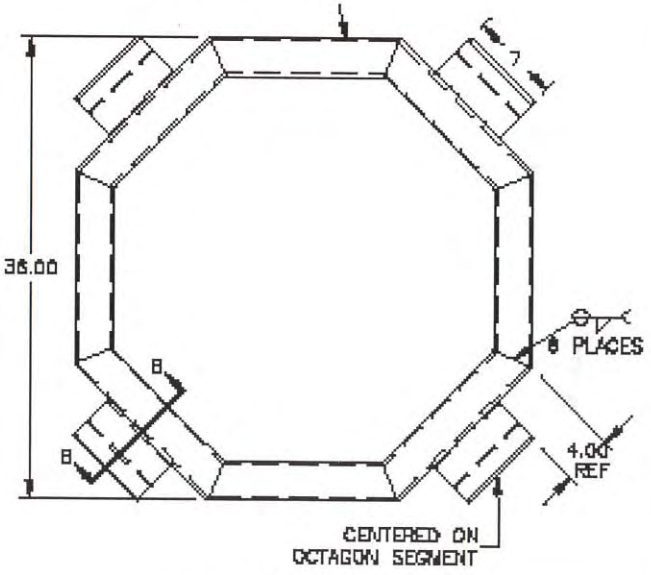
REBUILD STAND TOP END VIEW



REBUILD STAND SIDE VIEW

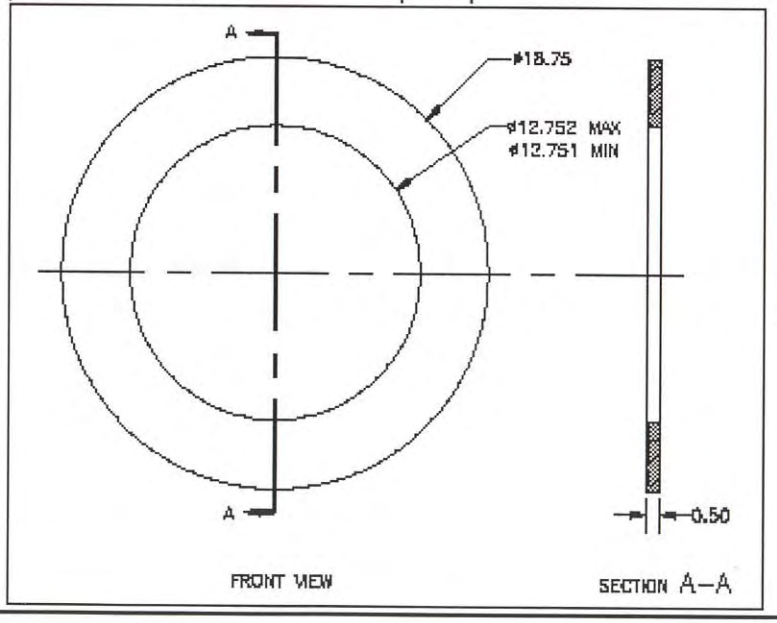


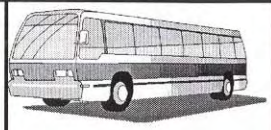
WHEEL SUPPORT TOP VIEW



OCTAGON TABLE

HUB RING GAGE BOTH VIEWS





INDUSTRIAL STANDARDS BULLETIN | Code: IS-74-01-04

Subject:

HUB & DRUM REBUILD PROCEDURE WITH TIRES

Date: 3/18/04

Developed by: _____
for Gilbert Carrero
Superintendent, Industrial Standards

Recommended for Approval: _____
William Wallace
Acting Assistant Chief Maintenance Officer,
Maintenance Support & Field Operations

Recommended for Approval: _____
William Livingston
Assistant Chief Maintenance Officer,
Central Maintenance Facility

Approved By: _____
John P. Walsh
Chief Maintenance Officer
Department of Buses

APPENDIX H

Industrial Standards Recommendations: Tool and Facility Layout Improvement*

The Industrial Standards Group from the Metropolitan Transit Authority (New York) applied ergonomic principles to modify tools and work stations to create a faster, easier and safer work environment. They designed a multifunctional and ergonomically designed Hub & Drum rebuilding stand. This new tool provided an ergonomic method that reduced the number of maintainers from two to one while giving less equipment use and cost. This appendix show the recommendations of the industrial standards group at the MTA-NYC for tool improvement and facility layout. The recommendations provided during the visit to MTA-NYC are:

- Zerega CMF Axle Overhaul Shop (12 pages)
- Cross-Town Paint Shop Productivity Action Plan (10 pages)
- Zerega CMF Hub & Drum Overhaul Shop (10 pages)
- New & Innovative CMF Roof Heating Unit Filter R & R Method (12 pages)

* This information was collected during the visit to the Metropolitan Transit Authority, New York, and was not developed by the USF Team or utilized for establishing Time Standards or procedures in this research.

Industrial Standards
Recommendation

NEW

ZEREGA CMF
AXLE OVERHAUL SHOP

"The First Universal & Multi-Functional Axle Shop in the Nation. "

"Faster, Easier & Safer"

Superintendent Gil Carrero, 8/04/04

INNOVATIVE AXLE SHOP

- Synchronized & Lean Remanufacturing Process

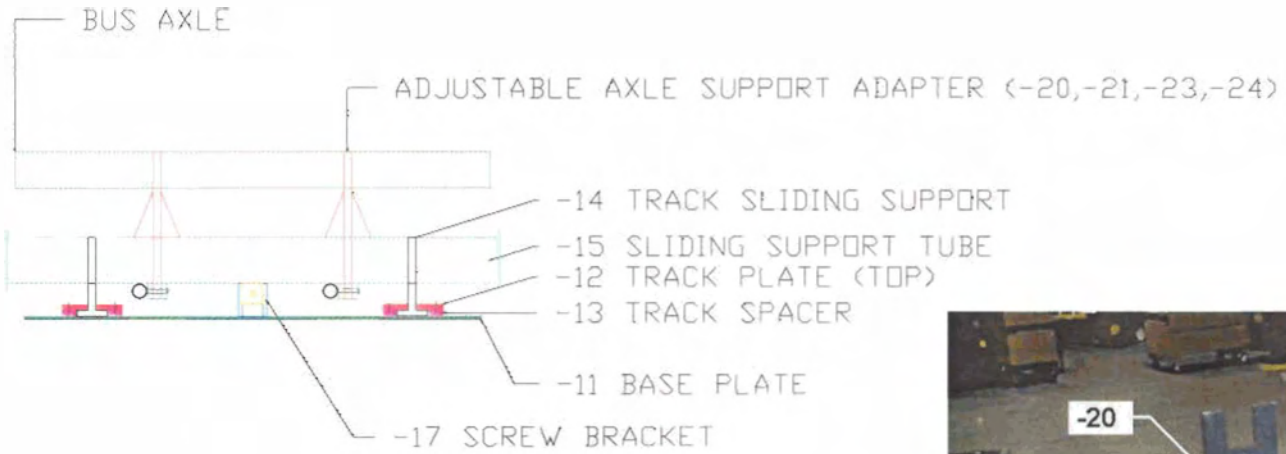
- High Productivity, Safety & Flexibility
  - Industrial Engineering Designed into
    - Method
    - Workstation
    - Fixture
    - Facility Layout

- Dramatic Cost Savings
  - Equipment, Labor & Material Handling

INNOVATIVE UNIVERSAL AXLE FIXTURE
(Designed by DOB)

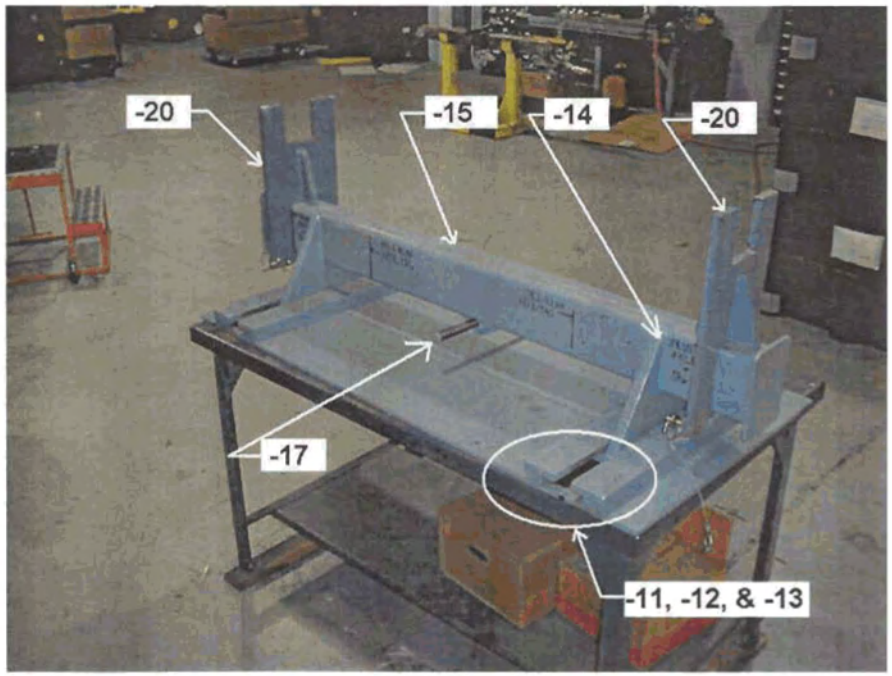
- Multi-Functional
  - Axle Removal
  - Axle Rebuilding
  - Axle Replacement
- Universal
  - Any Bus
  - Any Front Axle
  - Any Tag Axle
  - Any Rear Axle
- Cost Savings
  - One Fixture VS. Eight Custom Fixtures

ENGINEERING DRAWING



FRONT VIEW

Designed By Superintendent
Gil Carrero 4/21/04



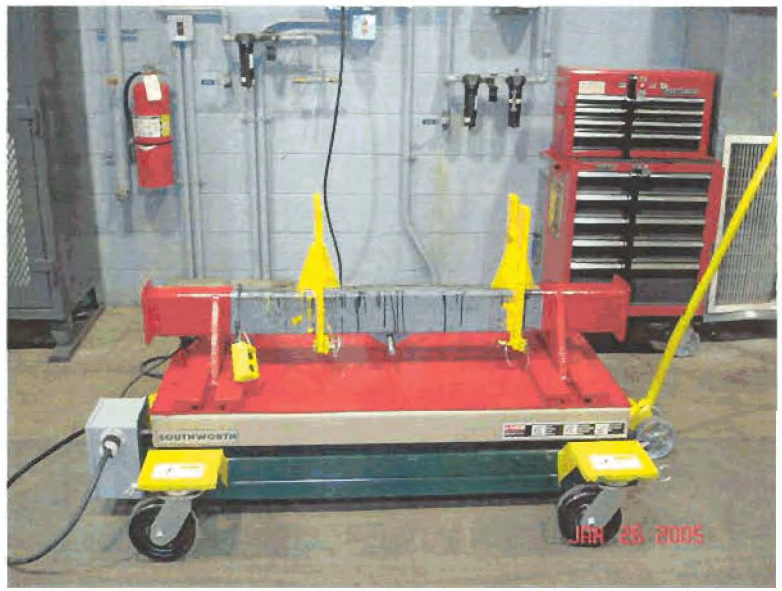
REBUILDING FIXTURE:

Floor Mounted

AXLE REMOVAL & INSTALLATION:

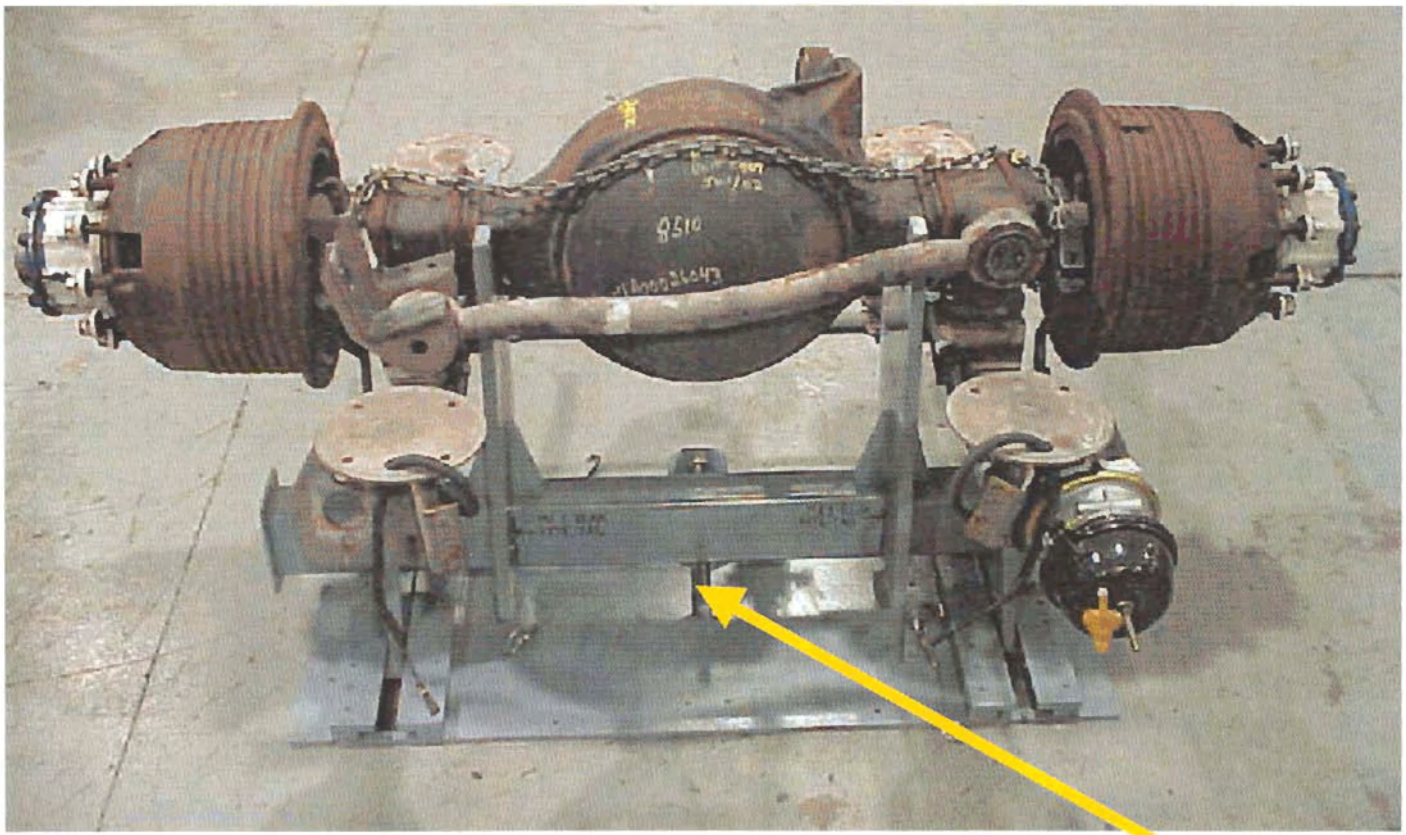
Universal Fixture Bolted to Lift Table

UP POSITION



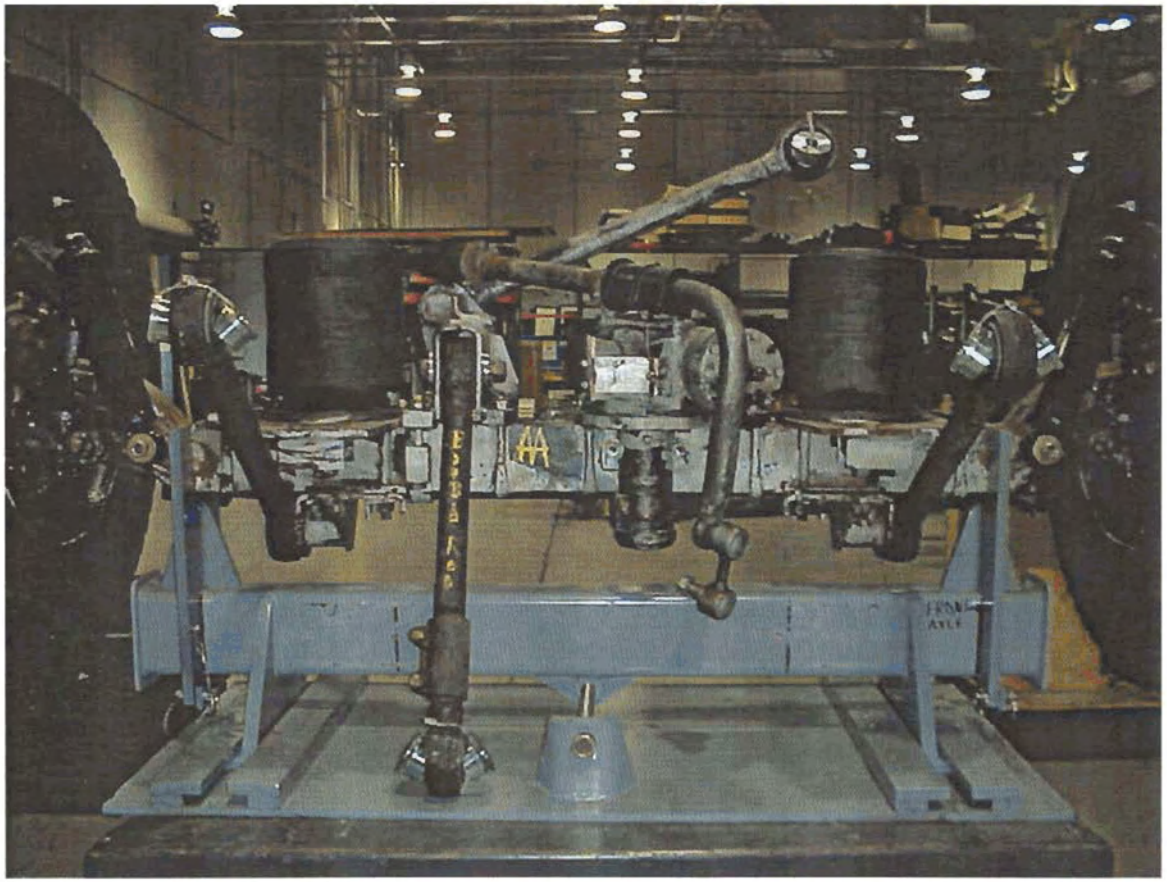
DOWN POSITION

FEATURE



Adjustment For Axle R & R

Remove, Rebuild, Replace



Nova Front Axle

BUS / AXLE ADAPTES

FRONT AXLES: Nova, Artic, MCI
TAG AXLE: MCI

REAR AXLE:
Nova

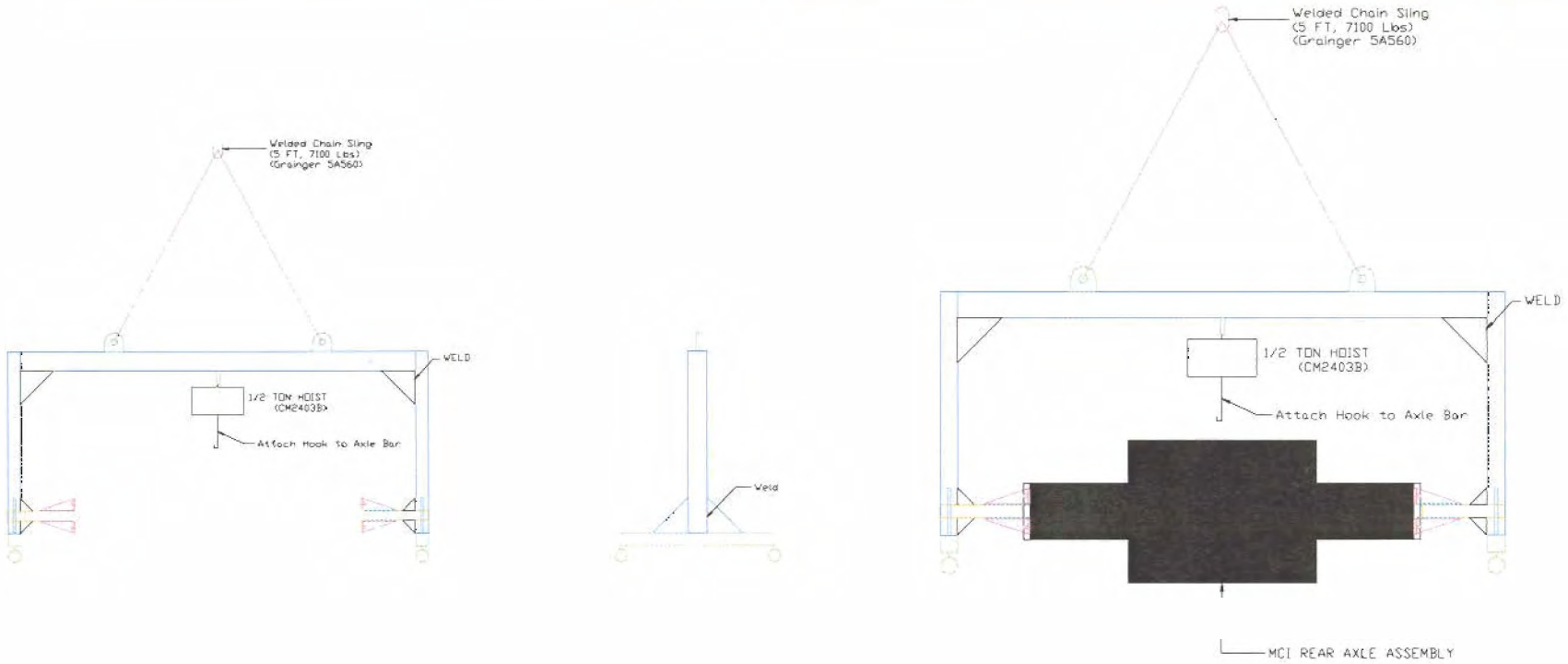
REAR AXLE: MCI

TAG & REAR AXLE: ARTIC

R & R Axle Adapters

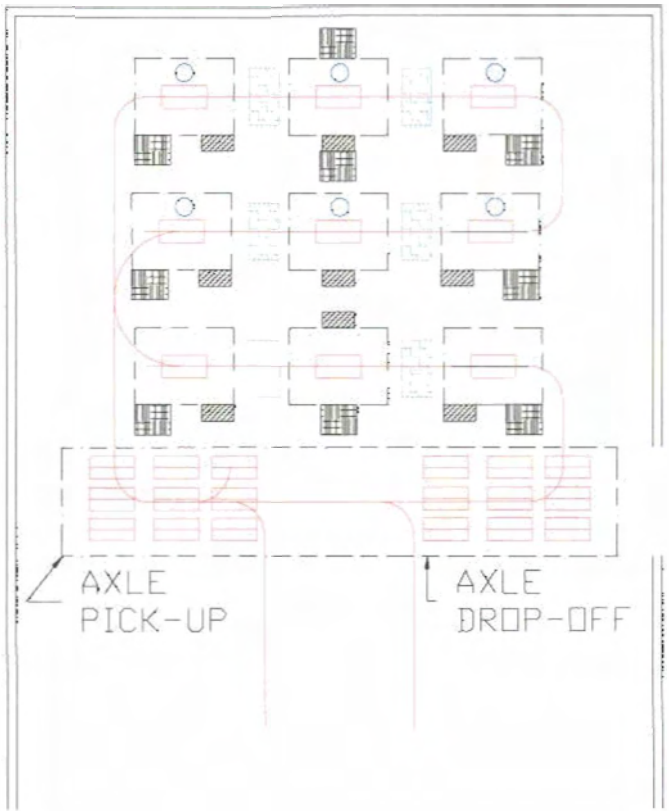
Axle Lifting & Rotation Fixture

Engineering Drawing

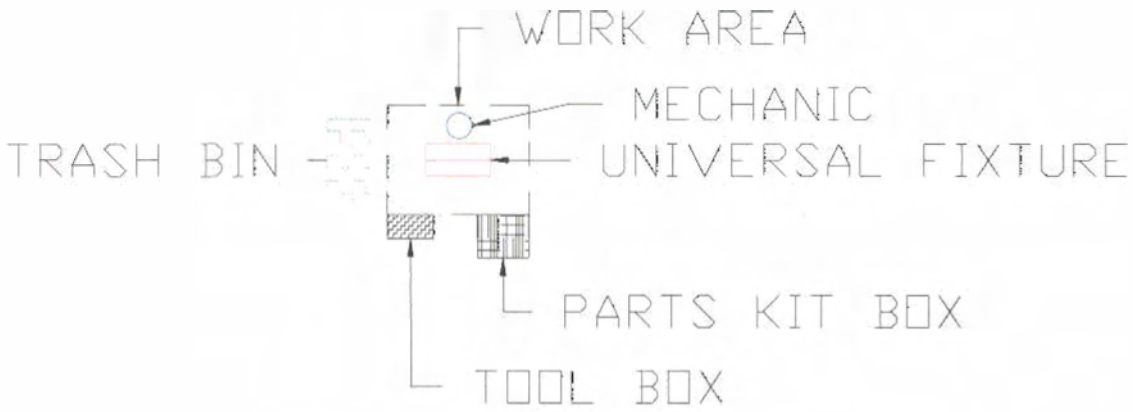


REAR AXLE HOIST & ROTATE FIXTURE
(MCI)

ZEREGA NEW AXLE SHOP



NINE
UNIVERSAL WORKSTATION



WORKSTATION LAYOUT

CONCLUSION: New Benchmark

- Faster
  - Productivity Improvements
- Easier
  - Universal Workstation & Fixture
- Safer
  - Ergonomic Process
- Cost Savings
  - Labor & Equipment

Industrial Standards

By Superintendent Gilbert Carrero

Cross-Town Paint Shop Productivity Action Plan

7/11/2005

Paint Shop -Production Line

- Current Situation
  - Production Line Problems
    - Workstation Balancing
    - Bottleneck Problems
    - Capacity Constrain Problems
    - Equipment Reliability Problems

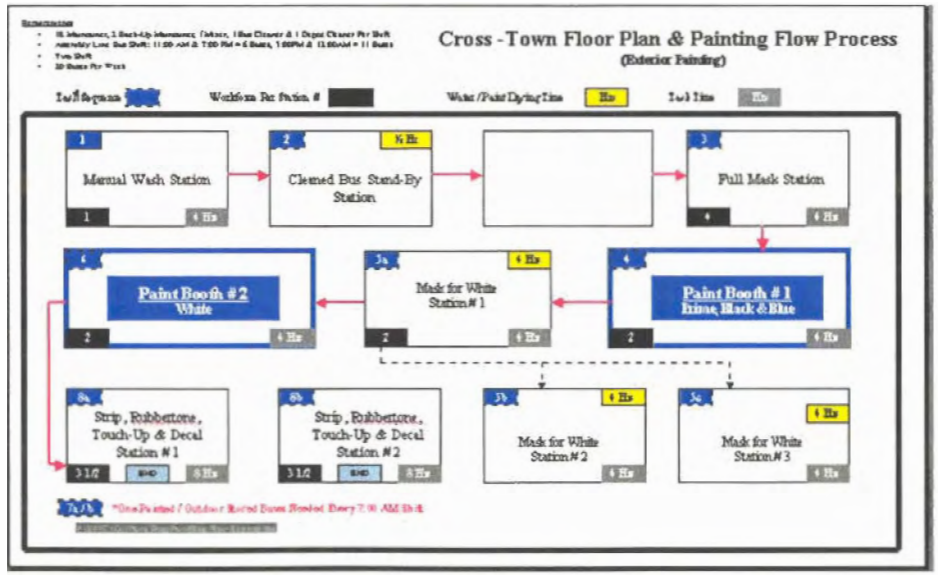
Goal

- Double Productivity
  - 20 Versus 10 Buses Per Week
- Improve Paint Process Efficiency
  - Masking Process
- Improve Production Line Efficiency
  - Bus Shifting Process
- Improve Production Capacity

Double Productivity

Exterior Painting

- Recommendation
  - Synchronized Manufacturing Process
    - New Production Flow Process Chart
- Benefits
  - 20 Bus Vs. 10 Buses

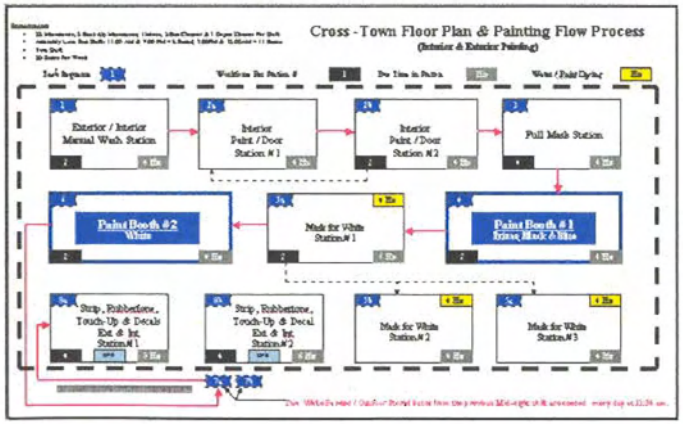


Productivity Recommendation

Exterior & Interior Painting

- Recommendation
  - Synchronized Manufacturing Process
    - New Production Flow Process Chart

- Productivity Improvement
  - 20 Bus Vs. 10 Buses



Improve Masking Paint Process Efficiency

- **Current Method** – Manual Cut & Masking Process
  - Custom Cut Masking Paper and Tape Paper onto Bus

Recommend New Method – Wrap-Around Masking Method

- Wrap-Around Paper Blanket with Pre-Cut Patterns

Productivity Improvement

- Estimated 4 Maintainer Vs. 6 Maintainer Per Shift

Recommend

Equipment Evaluation & Cost Analysis

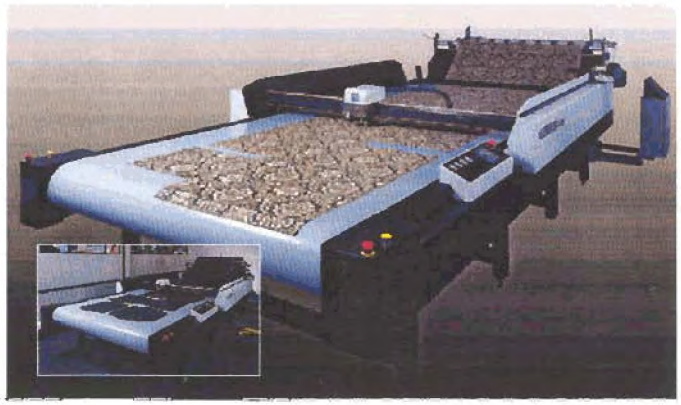
Programmable Cutting System

Features

- Automatic, Continuous-Cutting
- Microsoft Windows- based
- Fast,Powerful Servo Drive with Multiple Tool Mounts
- Very Low Maintenance System with Small Footprint

Benefits

- High-Volume Precision Cutting
- Easy Integration
- Simple Operation
- Reduced Labor, Operation cost



Improve Production Capacity

- Current Situation
  - Production Line Needs Two Additional Workstations
    - Two Freshly Painted Buses Must Be Stored Outdoors
    - Rain Effects Productivity
- Recommendations
  - Install Two Bus Canopies Covers or
  - Overhead Roof Extensions

Improve Production Line Efficiency

- Current Situation
  - Bus Shifting is Not Synchronized

- Recommendations
  - Balance Production Line
  - Synchronized Bus Shifting
    - 11:00 AM & 7:00 PM = 8 Buses,
    - 3:00PM & 12:00AM = 11 Buses Buses

Equipment Problems

- Current Situation
  - Air Compressor Overheating
    - One Paint Booth Effective
    - Two Paint Booths Ineffective
  - Center Paint Booth Creates Bottle Necks
    - Convert Center Booth to a Masking Workstation

Industrial Standards
Recommendation

NEW

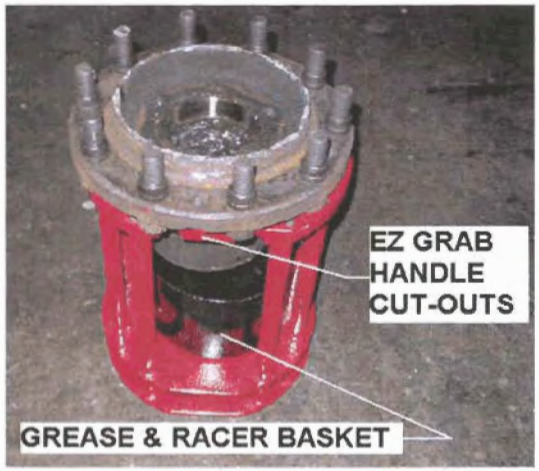
ZEREGA CMF
HUB & DRUM OVERHAUL SHOP

"First Ergonomically-Designed Hub & Drum Overhaul Shop In DOB"
"Faster, Easier & Safer"

Benefits:

- ✓ Faster, Easier & Safer
  - ✓ Ergonomic Method & Tooling
  - ✓ One Maintainer vs. Two Maintainer
  - ✓ No Forklift
  - ✓ Less Equipment Cost

Multi-Functional & Ergonomically-Designed Hub & Drum Rebuilding Stand



TOOL CONCEPT - SAFETY ENG. - TOOL DESIGN - FABRICATION - TESTING - TRAINING - PRODUCTION

ENGINEERING ASSEMBLY DRAWING

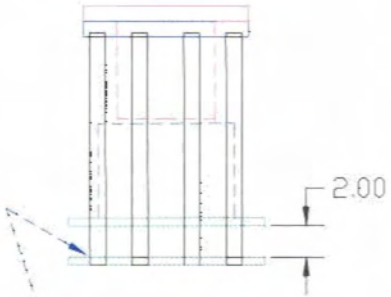
MULTI-FUNCTIONAL AND ERGONOMICALLY DESIGNED
WHEEL / HUB REBUILT STAND
(All Buses, Except LF CNG)

Designed by Superintent Gil Correro

Tool Features:

- Dual purpose base for folklift & floor work requirements
- Stud nut torquing requirements using folklift
- Hold hub for racer R & R
- Hold hub for stud R & R
- Safety basket to catch grease & racers
- Ergonomic height for EZ hub, drum & wheel assembly
- EZ tilt base to allow EZ wheel assembly removal
- Stand Compatible to Pneumatic Wheel / Hub Mobile Workstation (Design in process)

DWG. REV. B

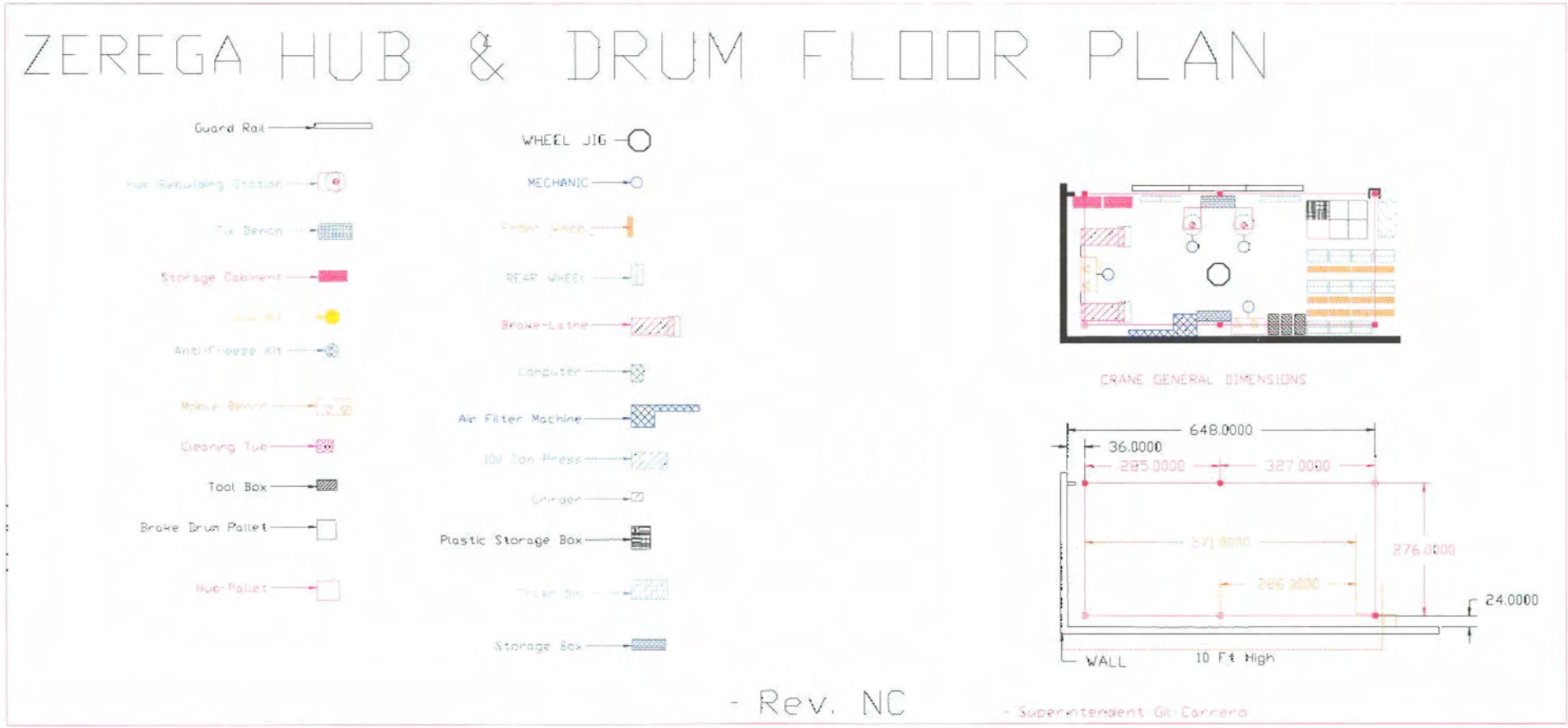


Filler weld each rod perimeter at three locations

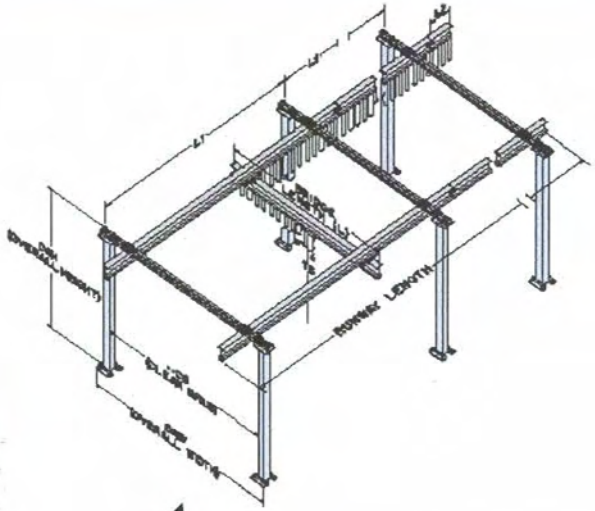
PAINT TOOL ASEMBLY BRIGHT RED

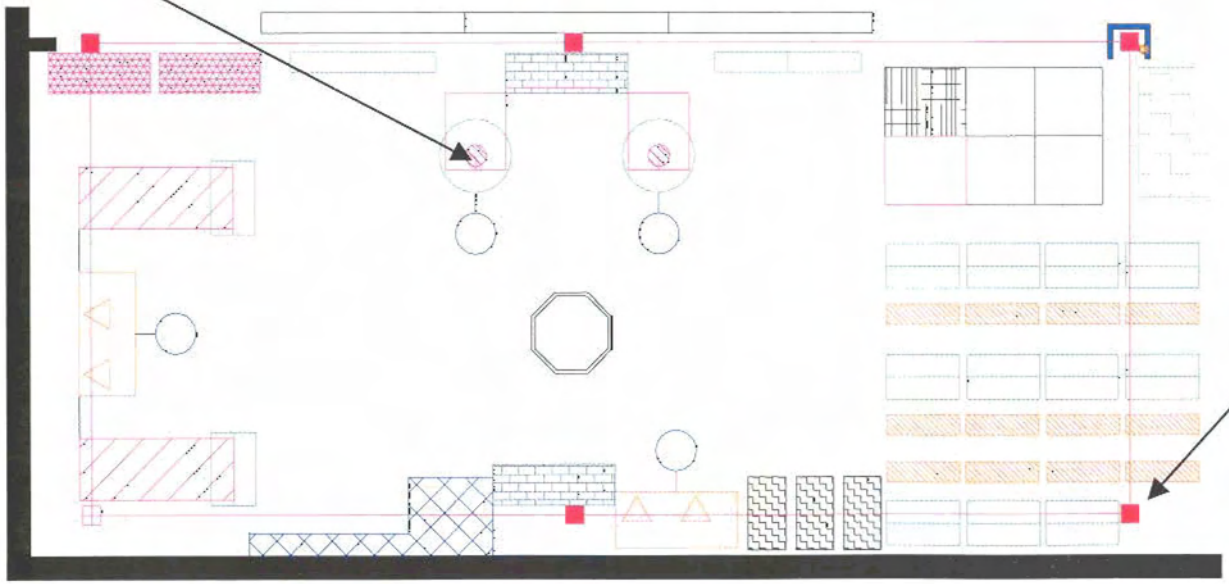
Stationary Rebuilding Workstation

Shop Floor Plan



Equipment Layout Floor Design





1 Ton Overhead Crane

New Shop

Crane on order

Old Shop: Forklift Required

Conclusion:

- ✓ **Faster, Easier & Safer**
  - ✓ **Ergonomic Method, Tooling & Shop**
  - ✓ **One Maintainer vs. Two Maintainer**
  - ✓ **No Forklift**
  - ✓ **Less Equipment Cost**

New & Innovative
CMF Roof Heating Unit Filter R &R Method

"Facility Engineering"

User-Friendly & Hazard-Free, Ergonomically-Designed Method

- ✓ *$ 227,781 Labor Cost Saving in Ten Years*
- ✓ *1200 % Productivity Improvement (10 Min Vs Two Hrs)*
- ✓ *600 % Safety Improvement (All 6 Issues Eliminated)*
- ✓ *100 % Efficiency Improvement (1 vs. 2 Man)*
- ✓ *Dramatic Quality Of Work Life Improvement*

Industrial Standards Recommendation
Developed By Gilbert (Gil) Carrero
11-18-03

"THE GOAL"

- PRIMARILY
  - Improve Safety

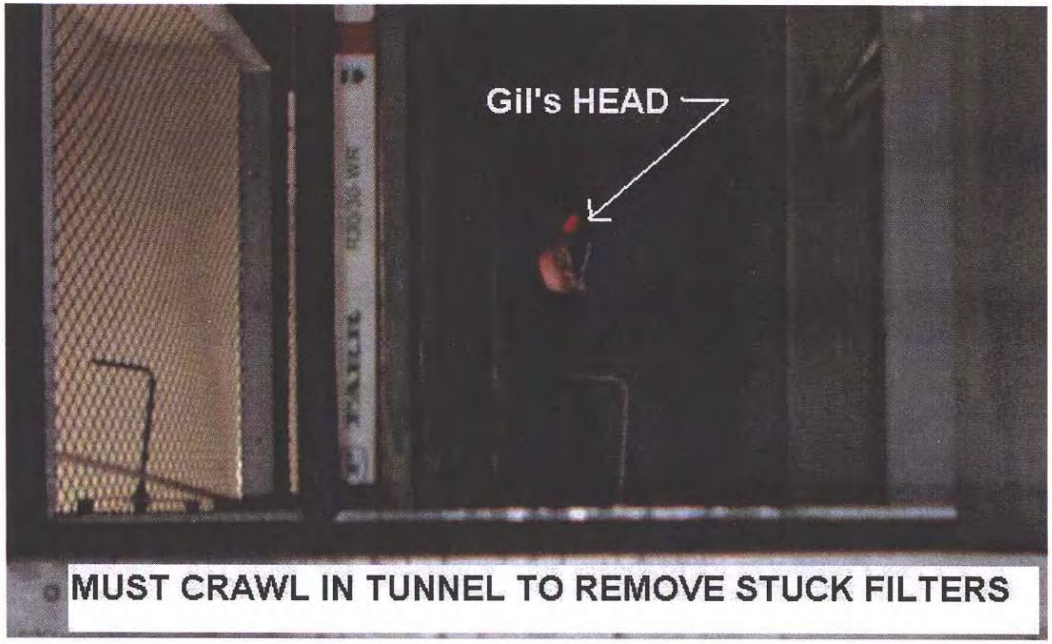
- SECONDARY
  - Improve Performance
    - Productivity
    - Efficiency
    - Effectiveness
    - Innovation
    - Quality
    - Quality of Life

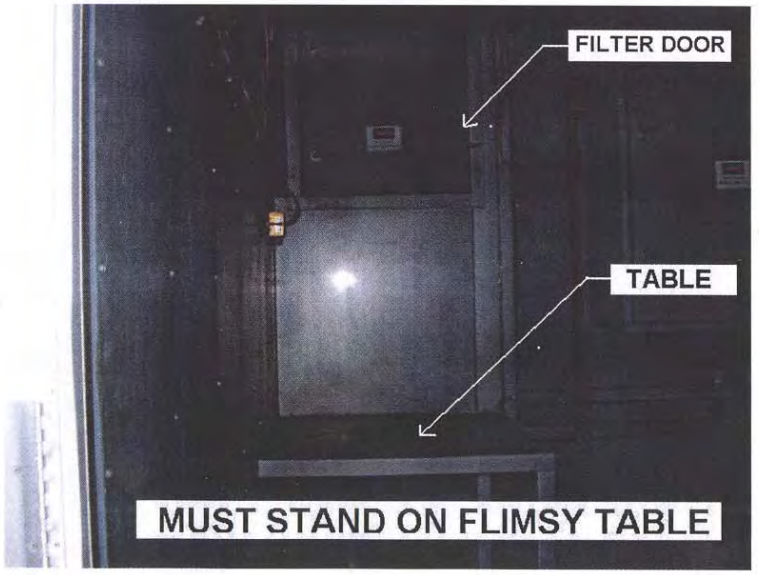
CURRENT SIX SAFETY ISSUES
Filter Located Inside Heating Unit

1. Must Crawl to Remove Stuck Filters (Often)
2. Tight Working Condition
3. Dirty Process
4. Must Stand on Flimsy Table
5. Step Ladder Needed
6. Two-Man Job for safety Reasons

CURRENT METHOD

Inside Unit, Crawl In Tunnel Method





NEW METHOD & HAND TOOL

Outside Unit, EZ Hand Gripper Method

- SAFER, CLEANER, FASTER & EASIER
  - Hazard-Free Method
  - Grab Filter Using Gripper and R & R
  - One-Man Job

TOTAL INTEGRATED INDUSTRIAL ENGINEERING

- FASTER, EASIER, CLEANER & HAZARD-FREE METHOD

1200% PRODUCTIVITY IMPROVEMENT

Current Method

- 1 Hr x 2 Man Per Unit = 2 Hours

New Method

- 10 Minute x 1 Man Per Unit

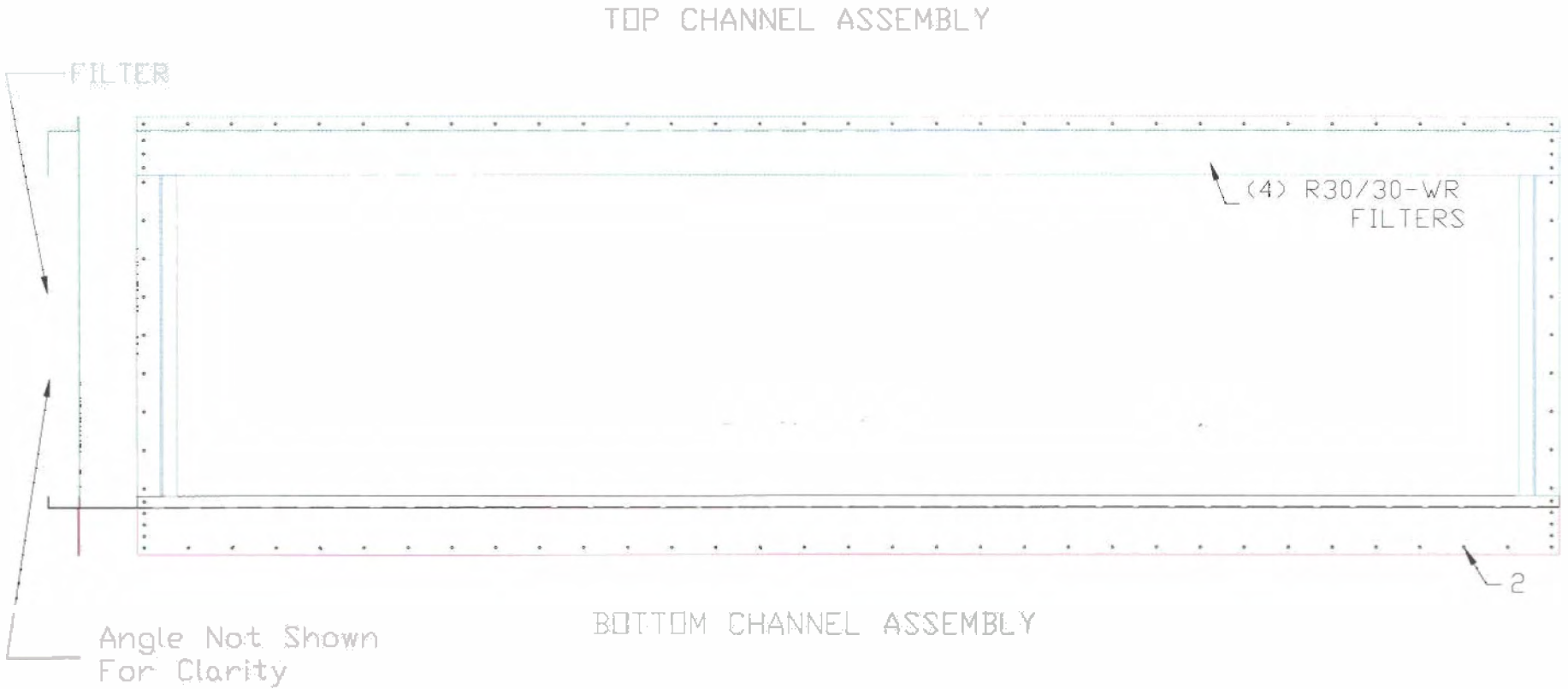
Productivity Improvement

- 12 X (120 min / 10 Min.)

$ 227,781
Cost Savings in 10 Years

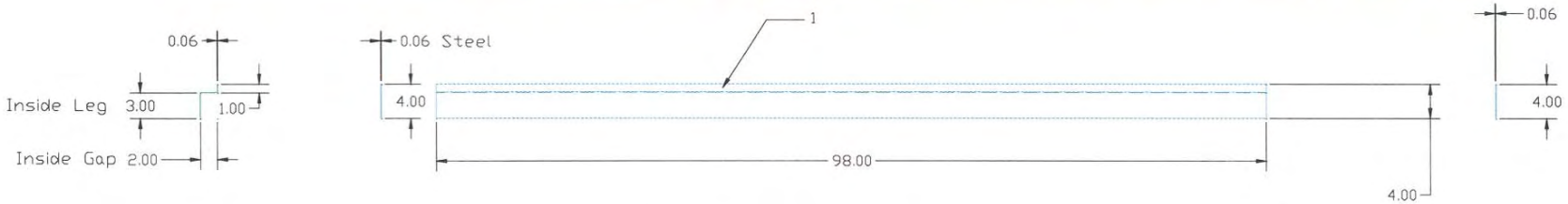
- 23 Heat Units, 368 Filters, 16 Filters Per Unit
- Filters Replaced 4 time Per Year
- Current Method
  - (23 unit x 2 man-hrs x 4 time per year x 10 Year period x $ 45 hr)= $ 82,800.00
- New Method
  - (23 unit x .166 man-hrs x 4 time per year x 10 Year period x $ 45 hr)= $ 6,872.4
- Cost Saving
  - ($ 82,800- $ 6,872.4) = $ 75,927 x 1 Shop +2 Depots = $ 227, 781

ENGINEERING ASSEMBLY DRAWING

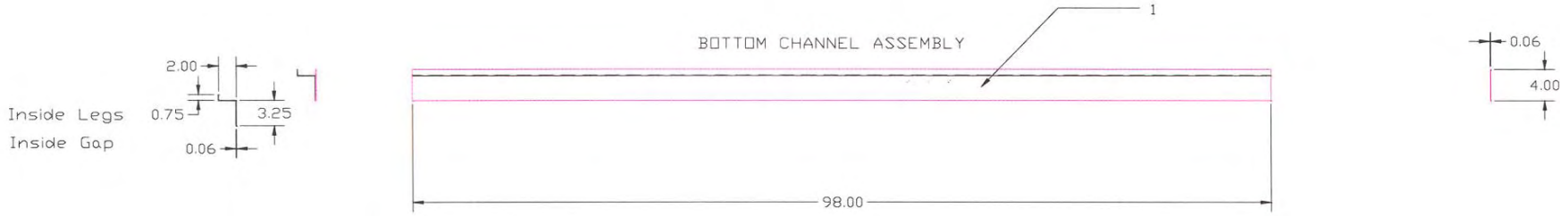


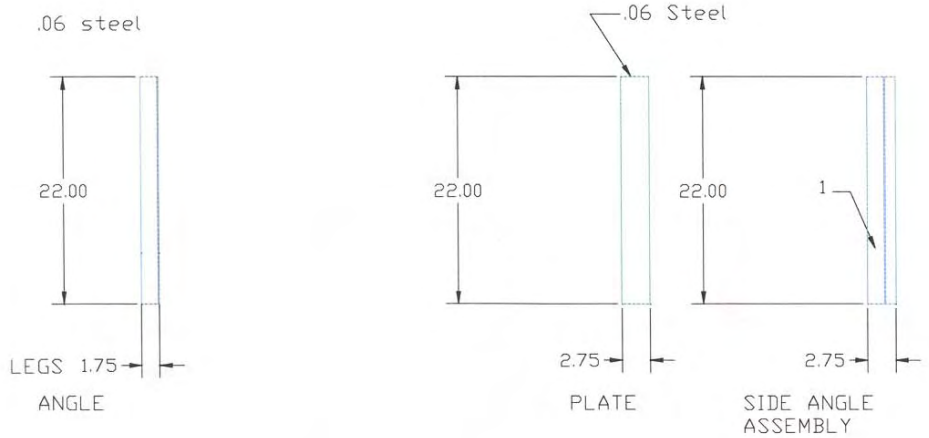
INNOVATIVE METHOD & FRAME ASSEMBLY DEVELOPED BY SUPERINTENDENT GIL CARRERO

ENGINEERING SUB-ASSEMBLY DRAWING



TOP CHANNEL ASSEMBLY





BILL OF MATERIAL

BILL OF MATERIAL
(ALL MATERIALS 1/16 GALVANIZED STEEL)
(2) STRIPS, 98" X 4"
(2) STRIPS 22" X 2.75"
(1) Z-CHANNEL 3" LEG X 2" LEG X 1" LEG X 98"
(1) Z-CHANNEL .75" LEG X 2" LEG X 3.25" LEG X 98"
(1) L-ANGLE 1.75" LEGS X 22"
(69) SELF-DRILL SCREWS, 10-16 X 3/4,

NOTE

1 = SPOT WELD EVERY FOUR INCHES
2 = TRANFER HOLE PATTERN FROM METAL STRIPS IN HEATING UNITS.

DWG. REV A

NOTE

USE 51" GRIPPER ARM MADE BY UNGER TO INSTALL FILTERS

Frame Installation Procedure

- Remove top & bottom strips located outside the heating unit.
- Apply sikaflex to mating surfaces common to frame assembly & opening perimeter.
- Position top & bottom frame with strip onto unit & secure using self-tapping screws.
- Install new filters using 51 inch gripper hand pole.
- Repeat steps 1,2, & 3 for LH & RH side assemblies.
- Remove dirty filters located inside the unit and discard.

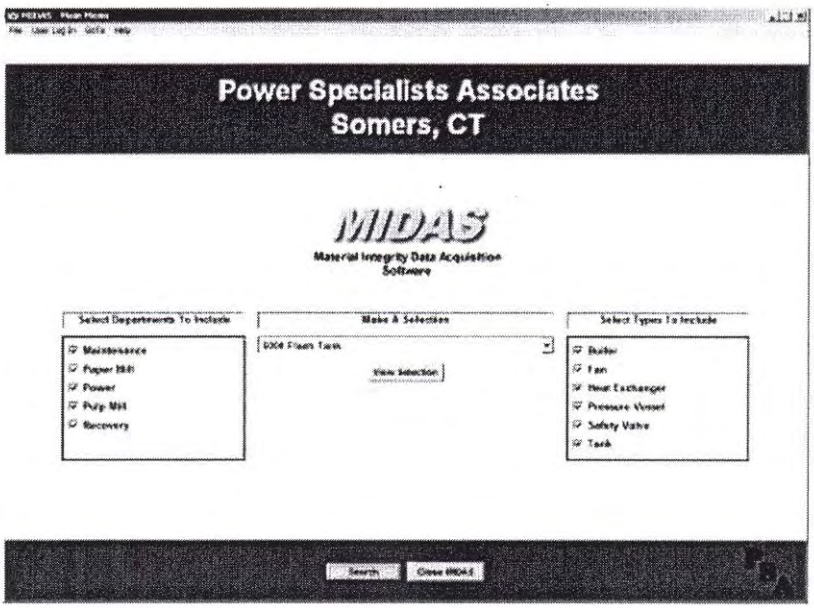
APPENDIX I

MIDAS Commercial Software

At the Metropolitan Transit Authority (New York), technicians need to fill out a work sheet with the job completed and the time after every shift. A computer software called "MIDAS" is used to track the information from the jobs completed. MIDAS is a computerized document and data management system. The idea of MIDAS is very similar to the database developed during this research. The main difference is that MIDAS has been described as a non user friendly system. It was found that the process of entering information to the system was complex and time consuming. The main characteristics of MIDAS are provided in this appendix.

MIDAS - Commercial Software Specifications

MIDAS™
(Material Integrity Data Acquisition Software)



Does your mill need to simplify archiving and retrieval of documents, reports, procedures, and equipment data?

MIDAS™ is a computerized document and data management system providing one-source access to critical information on industrial equipment, design specifications, manufacturer's data, and operating conditions.

MIDAS™ archives your information in one accessible location, allowing users to retrieve and print information at any time from any networked computer.

MIDAS™ stores data for equipment such as tanks, pressure vessels, safety valves, heat exchangers, deaerators, fans, and boilers.

MIDAS™ can be used to document records relating to equipment maintenance, including test data, inspection reports, and maintenance history.

MIDAS™ makes it easy to comply with legal requirements, inspection planning, and records maintenance.

MIDAS™ features:

Information Acquisition and Storage

Access design and operating specifications, test data, and inspection reports for all types of equipment

Direct data importing

Information Retrieval and Distribution

Retrieve information and data from anywhere on your computer network

Use any of numerous filtering options for quick access to equipment descriptions, design, operating, or manufacturer's criteria

Review documents on-line and print as needed

Test Data and Inspection Reports

Enter data and reports directly into ***MIDAS***™ for analysis and comparison to previous results

Enter new or edited information with ease

Customize summary reports for quick results overviews

Equipment History Tracking

Review equipment histories

Utilize regression analysis of historical data to optimizing outage planning and NDE inspection protocol

Upcoming Inspection Notification

Track required inspections; issue reminders when an inspection is imminent or overdue

Data Analysis and Equipment Integrity Calculations

Analyze test data using data sheets, statistics, line graphs, wall maps, and data distribution tools

Trend future indications with regression analysis

View and print standard, difference, and regression wall maps

Source: http://psaengineering.com/software.htm

APPENDIX J

Task Detailing

Task detailing encompasses the selection of the major processes within a task along with the corresponding elements. From each of the main components of the process the list of operations was generated. Some operations are combined due to the variability in completion time and the small units of time per subcomponent. The task detailing is shown in this appendix.

POWER PLANT REMOVAL				
Description	**Reading 1**	**Reading 2**	**Reading 3**	**Average**
Set Up	**1130**	**1350**	**1180**	**1220**
Remove cover in the interior part of the bus				
Take bus to the working bay				
Bay preparation and bus preparation				
General starting inspection				
Secure bus with lifters				
Fluids Draining	**1537**	**570**	**1883**	**1330**
Loose plug to drain engine oil				
Drain engine oil				
Put back plug and tight				
Loose plug to drain transmission oil				
Drain transmission oil				
Put back plug and tight				
Loose hydraulic line #1				
Drain oil				
Loose Loose hydraulic line # 2				
Drain oil				
Loose line to spinner filter				
Drain oil				
Bring and put plug				
Loose plug to drain coolant				
Drain coolant				
Put back plug and tight				
Disconnect Coolant Lines & Pipes	**2137**	**2028**	**2040**	**2068**
Loose claps that hold coolant lines				
Loose transmission coolant line #1				
Drain Oil				
Loose transmission coolant line #2				
Drain oil				
Loose transmission coolant line #3				
Drain oil and get plugs				
Thermostat housing Coolant Line				
Loose nuts of coolant line				
Drain coolant				
Loose nuts form other side of the line				
Engine Coolant Line				
Loose nuts of coolant line				
Radiator Coolant Line				
Loose nuts of coolant line				
Air Compressor Coolant Line				
Loose nuts of coolant line				
Heating System Coolant Line				
Loose nuts of coolant line				
Disconnect coolant pipes				
Loose nuts of coolant pipe 1				
Loose nuts form other side of the pipe				
Loose nuts of coolant pipe 2				
Loose nuts form other side of the pipe				
Loose coolant pipe-radiator to thermostat				
Loose Intake pipe				

Description	Reading 1	Reading 2	Reading 3	Average
Disconnect Middle components	**5868**	**4523**	**5203**	**5198**
Disconnect Drive Shaft				
Start loosing nuts connectors to transmission				
Loose nut connectors to transm (*2)				
Loose nut connectors to shaft (*2)				
Get driveshaft out				
Air intake for turbo & Exhost				
Loose remaining brackets				
Loose air intake for the turbo				
Take intake out and place it aside				
Take pipe out and put it aside				
Loose exhost from the turbo				
Loose nuts of brackets				
Loose nuts connectors				
Separate exhost				
Loose nut of wiring that goes to the generator				
Loose nuts of oil filter				
Loose nuts of discharger				
Loose nuts of Spinner filter				
Loose nuts of fuel line				
Loose nuts and bracket that holds transm oil stick				
Cut belt and put it aside				
Loose nuts next to the hydraulic pump (clear bumper area)				
Lift dolly				
Disconnect wire in front of engine				
Clear front area of engine (move lines to sides)				
Take transmission meter out and put aside				
Clear oil lline from front side				
Disconnect Components Inside the Bus	**1730**	**1360**	**1580**	**1557**
Go inside the bus				
Take out nuts of brackets of the entige pipe				
Set up light				
Loose return fuel line				
Loose nuts of brackets of the entige pipe				
General compartment inspection				
Cut cables				
Loose nuts of cables of temperature service				
Loose nuts of wires				
Loose nuts of wires that measure oil pressure + temp				
Loose nut of brackets				
Bumper & Front Motor Mounts out	**503**	**1735**	**1985**	**1408**
Loose nuts of bumper holder (*4)				
Clear working place while tech 1 lower bus				
Loose bar placed on the bumper				
Loose brackets				
Loose nuts from bumper				
Take bumper aside				
Front Motor Mounts				
Loose brackets that hold hydraulic oil line				
Continue loosing nuts from mounts				
Loose coolant line from water pump				

Description	Reading 1	Reading 2	Reading 3	Average
Put jack to hold front of engine and take mount out				
Take mounts out				
Take out power plant from bus	**2077**	**1143**	**1080**	**1433**
Put/align dolly (crane) under the bus				
Inspect that PP is ready to be taken out				
Secure PP to crane				
Rest PP on the crane				
Take security jack out				
Inspect that PP is ready to be taken out (compartment)				
Pull PP out of the engine compartment				
Place PP aside				
Total average time in Seconds	**14982**	**12709**	**14951**	**14214**
Total average time in Minutes	**250**	**212**	**250**	**237**
Total average time in Hours	**4.2**	**3.6**	**4.2**	**4**

POWER PLANT INSTALLATION			
Description	**Reading 1**	**Reading 2**	**Average**
Bring New Power Plant + Alignment	**2855**	**2974**	**2914.5**
Get Power Plant from warehouse			
Push PP under the bus and align it			
Get tools			
Go to get parts			
Secure brackts			
Aling back rear to end of bus			
Secure nuts on back rear			
Secure brackets and monting parts			
Clear compartment			
Get wrench			
Loose PP from dolly			
Pull dolly out			
Go inside the bus			
Secure back part of PP to the bus			
Mount brackets on upper side of transmission			
Connect Middle Components	**4365**	**6425**	**5395**
Connect hydraulic lines			
Connect generator lines			
Get tools			
Install brackets and adjust nuts			
Connect fuel lines			
Get tools			
Secure brackets			
Get tools			
Connect compresor lines			
Raise bus with crane			
Connect Lines Down the Bus			
Connect hydraulic filter lines			
Connect and secure brackets of the lines			
Connect line that goes to the spinner filter			
Connect fuel filter lines			
Secure brackets			
Connect starter lines			
Help other tech to connect transmission oil line			
Secure brackets and secure nuts			
Install transmission oil lines (TOL) (first attempt)			
Tighten transmission lines (first attempt)			
Go to warehouse to get fitting hoses for TOL			
Prepare fitting hoses to be installed (biuld them)			
Install transmission oil lines			
Install transmission cooler pipes			
Connect transmission wires (lower side)			
Connect Coolant Lines and Pipes (Left Side of the Bus)	**2570**	**2852**	**2711**
Connect transmission coolant line #1			
Connect transmission coolant line #2			
Connecttransmission coolant line #3			
Thermostat housing Coolant Line			
Engine Coolant Line			
Radiator Coolant Line			

Description	Reading 1	Reading 2	Average
Air Compressor Coolant Line			
Heating System Coolant Line			
Connect coolant pipes			
Connect coolant pipe 1			
Connect coolant pipe 2			
Connect coolant pipe-radiator to thermostat			
Connect Intake pipe			
Connect exhaustor			
Connect cables inside the bus			
Get tools			
Secure clamps + nuts +lines			
Connect Drive Shaft	**753**	**1685**	**1219**
Get drive shaft			
Go to warehouse to get driveshaft secures			
Install driveshaft secures			
Tighten driveshaft secures			
Connect Cables inside the bus	**2045**	**2397**	**2221**
Install wires that go to the ENC			
connect wires that measure oil pressure + temp			
Install coolant lines (upper side)			
Install air line to air compressor (upper side)			
Install exhost (upper side)			
Get off the bus			
Look for tools			
Go inside the bus			
Connect cables of temperature service			
Get off the bus			
Look for tools			
Go inside the bus			
Tighten nuts that connect transm to eng (upper)			
Get off the bus			
Go inside the bus			
Check connections			
Fill Fluids + Start Bus	**1240**	**850**	**1045**
Go to get engine oil fluid			
Fill engine oil fluid			
Take out oil filter			
Go to get transmission oil			
Fill transmission oil			
Take out engine oil			
Go to get coolant fluid			
Fill coolant fluid			
Go to get air pipe			
Install air pipe			
Get tools			
Install panel control			
Apply more coolant			
Start bus (first attempt)			
Start bus (second attempt)			
Start bus (third attempt)			
Start bus (fourth attempt)			

Description	Reading 1	Reading 2	Average
Total average time in Seconds	13828	17183	15505.5
Total average time in Minutes	270.47	326.38	298.425
Total average time in Hours	4.51	5.44	4.97375

APPENDIX K

Power Plant Removal and Replacement Observations

The power plant removal and replacement observation are provided in this appendix.

Appendix K Table of Contents

Date	10/26/2004
Maintenance Type	Powerplant Removal
Bus	
Make/year	
Miles	
Number of Technicians	3

Summary Technician 1	**Total**	**Time**
Operations	35	8875
Transport	9	530
Inspection	5	897
Delay	1	1800
Total time spend by technician 1		12102
Total time spend by technician 1		201.7
Total time spend by technician 1		**3.36**

Technician 1					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Bring bus & remove cover in the interior part of the bus					600
Tool set up					530
Loose hydraulic reservor lines to the engine					320
Loose claps that hold lines					300
Take off lines (spinner oil)					600
Go to get tools					0
Open clap left hand side					20
Loose screws of transmission					280
Check transmission parts					40
Inspection of work area					130
Go to get flashlight					110
Inspect engine parts					252
Go to get hydraulic gun					216
Take off the air line to desconnect sensor					1200
Loose claps that hold electrical wires					1560
Separate the wires					120
Take off the wires					50
Loose screws that hold engine (inside bus)					660

Date	10/26/2004
Maintenance Type	Powerplant Removal
Bus	
Make/year	
Miles	
Number of Technicians	3

Summary Technician 2	**Total**	**Time**
Operations	15	4729
Transport	5	375
Inspection	1	390
Delay	3	2847
Total time spend by technician 2		8341
Total time spend by technician 2		139.01667
Total time spend by technician 2		**2.32**

Technician 2					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Remove plugs to drain transmission oil					45
Drain transmission oil					330
Go to get tools (while drain oil)					
Loose screw transmission (while drain oil)					0
Put transmission plug (while drain oil)					0
Move (drained) oil container aside					47
Disconnect oil lines & drian oil					1115
Bring the jack (to receive power plant)					10
Loose screws that hold power plant					10
Take off fuel filter(fill with gasoline)					12
Inspect for missing parts to disconnect					343
Inspecting bus					132
Align jack with Powerplant					65
Lower bus					20
Hold Powerplant to jack					480
Assits technician 2 removing wires					915
Pull out Powerplant & move it aside					90

Date	10/26/2004
Maintenance Type	Powerplant Removal
Bus	
Make/year	
Miles	
Number of Technicians	3

Summary Technician 3	**Total**	**Time**
Operations	10	2084
Transport		
Inspection		
Delay	2	932
Total time spend by technician 3		3016
Total time spend by technician 3		50.266667
Total time spend by technician 3		**0.84**

Technician 3					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Disconnect coolant lines					1315
Go to get tools					10
Loose oil reservor lines					430
Drain engine oil					50
Clean lines and tools					128
Go to get tools					14
Loose Screws and nut from oil reservor					190
Loose a screw					50
Low the bus					138
Take off support at the rear part					315
Go inside the bus to inspect if everything is right					390
Loose screws that hold engine (inside the bus)					240
Go inside the bus					35
inside					320
inside					265
inside					480
	Total Time Whole Procces			Total Sec	14972
				Total Min	249.5333333
				Total Hours	4.158888889

Date	11/2/2004
Maintenance Type	Powerplant Removal
Bus	
Make/year	
Miles	
Number of Technicians	2

Summary Technician 1	**Total**	**Time**
Operations	25	9716
Transport	4	210
Inspection	0	0
Delay	1	900
Total time spend by technician 1		10826
Total time spend by technician 1		180.43
Total time spend by technician 1		**3.01**

Technician 1					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Remove cover in the interior part of the bus					830
Set up					520
Loose plug to drain oil					50
Drain oil					300
Loose plug to drain coolant					40
Drain coolant					180
Loose oil line to manifold					145
Go to get plugs					55
Put plug to the oil line manifold					38
Loose air line					40
Get plug					20
Go to get tools					40
Loose hydraulic oil lines					170
Drain oil					480
Get the hydraulic lines / other components					3050
Loose pipe that holds oil meter					250
Loose engine mounts					200
Get the hydraulic lines off					235
Break					900
Back to work and set up					140
Go to get jack to support power plant					75
Raise the bus					35
Prepare to take engine support off					440
Take off rear engine support					1020
Bring dolly and place it under the bus					40
Align dolly with power plant					230
Secure engine to dolly					205
Retire jack and wood that supported engine					48
Prepare the bus to retire power plant					80
Pull out powerplant					540

Date	11/2/2004
Maintenance Type	Powerplant Removal
Bus	
Make/year	
Miles	
Number of Technicians	2

Summary Technician 2	**Total**	**Time**
Operations	48	5764
Transport	4	375
Inspection	1	30
Delay	2	910
Total time spend by technician 2		7079
Total time spend by technician 2		117.98
Total time spend by technician 2		**1.97**

Technician 2					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Go to get tools & air gun & air line					85
Loose claps that hold coolant lines					50
Get tools					15
Drain coolant from lines					140
Loose claps					250
Place nuts in table					20
Assists technician 1					843
Disconnect coolant lines					180
Get connector between coolant pipes					80
Disconnect coolant pipes from transmission					40
Place first (part 1) coolant pipe aside					10
Place second (part 1) coolant pipe aside					70
Get tools					30
Loose claps - connect part 2 coolant pipes					80
Place second (part 2) coolant pipe aside					80
Collect claps with nuts and screws					45
Get tools					40
Get bracket 1 for coolant pipes					170
Transport container to its place					40
Get tools					10
Inspect bracket 2					30
Get tools and air gun					15
Get bracket					195
Loose connectors coolant pipe 3					110
Get claps that hold coolant pipe 3					135
Get pipe 3					30
Place pipe 3 aside					78
Rasie bus					10
Bring jacks to hold bus					80
Down bus to jacks					100
Get tools					50

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Go inside the bus		⇨			15
Tools set up inside the bus	○				45
Go to get spray to loose nuts and screws	○				200
Spray nuts/ screws	○				10
Loose computer harness	○				550
Break				⊃	900
Back to work and set up	○				310
Take off brackets of transmission	○				120
Take off sensors of water temperature	○				180
Disconnect wires that connect with engine	○				240
Go tools rack		⇨			75
Take off rear engine support (assists tech 1)	○				408
Idle					10
Align dolly with power plant (assists tech 1)	○				230
Secure engine to dolly	○				105
Retire jack and wood that supported engine	○				48
Prepare the bus to retire power plant	○				40
Pull out powerplant	○				540
Total Time Whole Process				Total Sec	10737
				Total Min	178.95
				Total Hours	2.9825

Date	8/24/2005
Maintenance Type	Powerplant Removal
Bus	
Make/year	
Miles	
Number of Technicians	2

Summary Technician 1	**Total**	**Time**
Operations	95	8503
Transport	6	923
Inspection	3	118
Delay	8	2965
Total time seconds		12509
Total time minutes		208.48
Total time spend by technician 1		**3.47**

Technician 1					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Set up					240
Park bus					215
Bay preparation					220
Wait for Tech1 to remove control box					120
Get flashlight					10
Inspection					45
Secure bus with lifters					40
Drain Fluids					
Go to bring waste oil container					70
Take tools					10
Loose plug to drain engine oil					40
Drain oil					60
Put back plug and tight					60
Move container					10
Get another tool					25
Loose plug to drain transmission oil					50
Drain transmission oil					420
Put back plug and tight					30
Transmission Coolant Lines					
Get a tool (wrench)					15
Loose transmission coolant line #1					120
Drain Oil					90
Get caps for transmission and line					20
Loose transmission coolant line #2					90
Get a tool (hammer)					15
Drain oil					80
Get caps for transmission and line					30
Loose transmission coolant line #3					245
Drain oil and get plugs					105
Disconnect Drive Shaft					
Get tools					20
Go to get wipes					90
Get tools (air gun)					15

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Loose nut connectors to transm (*2)					118
Loose nut connectors to shaft (*2)					185
Get driveshaft out					40
Put shaft aside					30
Hydraulic Oil					
Place container					8
Loose line #1					30
Drain oil					80
Clean floor					35
Loose line # 2					45
Drain oil					75
Get caps for lines 1 and 2					30
Go to warehouse to bring towels					110
Idle					
Go around					
Assists tech 1					
Loose line to spinner filter					75
Drain oil					70
Bring and put plug					40
Assists tech 1					
Get airgun					30
Get and put plugs to all of remaining oil lines					150
Wait for tech 1 to finish with brackets					
Take bumper out					
Loose nuts of bumper holder (*4)					135
Move lines					10
Get plastic holders to group and hold lines					45
Move containers aside					20
Clear working place while tech 1 lower bus					40
Loose bar placed on the bumper					75
Loose air intake for the turbo					150
Loose brackets					45
Air intake for turbo					
Loose remaining brackets					40
Take intake out and place it aside					35
Loose coolant pipe-radiator to thermostat					300
Idle					70
Get airgun and tools					15
Loose line to radiator					85
Loose line to thermostat					130
Break					1800
Idle					720
Take pipe out and put it aside					20
Loose exhost from the turbo					300
Loose nuts of brackets					55
Loose nuts connectors					80
Get tool to loose exhost					15
Separate exhost					205
Intake pipe					
Loose nuts and bracket that holds transm oil stick					135
Move tools aside and clear dolly					150
Move dolly under the bumper					20
Cut belt and put it aside					25
Get tools					100

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Loose nuts next to the hydraulic pump					75
Loose nuts from bumper					240
Get bar and pull bumper out					270
Wait for tech 1 (help)					40
Take bumper aside					35
Lift dolly					15
Disconnect wire in front of engine					50
Go around					240
Clear front area of engine (move lines to sides)					180
Move tools rack aside					20
Get tool and airgun and pass them on tech1					80
Take transmission meter out and put aside					35
Clear oil lline from front side					70
Front Motor Mounts					
Remove nuts					35
Loose brackets that hold hydraulic oil line					75
Continue loosing nuts from mounts					190
Loose coolant line from water pump					170
Go to warehouse to get a small jack					240
Idle					70
Put jack to hold front of engine and take mount out					140
Take mounts out					155
Get dooly					27
Clean floor					75
Put/align dolly (crane) under the bus					390
Inspect that PP is ready to be taken out					47
Secure PP to crane					156
Take jack out					43
Inspect that PP is ready to be taken out					26
Go inside the bus					23
Push PP from inside the bus					116
Move PP aside					30

Date	8/24/2005
Maintenance Type	Powerplant Removal
Bus	
Make/year	
Miles	
Number of Technicians	2

Summary Technician 2	**Total**	**Time**
Operations	80	8560
Transport	3	210
Inspection	4	240
Delay	3	2340
Total time seconds		11350
Total time minutes		189.17
Total time spend by technician 2		**3.15**

Technician 2					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Tool Set up					1800
Loose nuts of rear engine control box					120
Set up crane to move bus up					180
Go get trash can					60
Get tools					60
Lose nuts and drain coolant					30
Wait for coolant to drain					300
Set up light					30
Go somewhere					30
Disconnect coolant lines					

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Get tools					30
Get tools					30
Loose nuts of coolant line					60
Get tools					30
Loose nuts					120
Disconnect coolant line 2					120
Get tools					10
Loose nuts of coolant line					60
Go to help other thechnician					20
Loose nuts of coolant line					300
Get tools					30
Loose nut					10
Get tools					40
Loose nut					120
Inspection					30
Get tools					30
Loose nut					30
Get tools					20
Loose nut					20
Get tools					20
Loose nut					30
Get tools					10
Loose brackets that attach to transmission					120
Get tools					10
Loose main air line to the starter					20
Get tools					20
Loose nut for oil return line					20
Get tools					10
Loose nut for oil pressure gate					120
Loose nut of signal line to agrevate the starter					60
Loose nut for fuel line					60
Get tools					30
Loose nut of hydraulic					60
Get tools					30
Loose nut of brackets attached to the bus					420
Inspection					120
Get tools					20
Go somewhere					
Operate crane to move bus down					60
Get tools					20
Loose nut of wiring that goes to the generator					300
BREAK					1800
Get tools					30
Loose nuts of oil filter					120
Loose nuts of discharger					180
Get tools					30
Loose nuts of Spinner filter					240
Loose nuts of fuel line					120

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Get tools					20
Loose nuts to open cavity from inside the bus					20
Get tools					10
Loose nuts of seats					120
Take out seats					60
Loose nuts to open cavity from inside the bus					60
Take out nuts of brackets of the entige pipe					60
Get tools					120
Set up light					30
Loose return fuel line					30
Loose nuts of brackets of the entige pipe					180
Inspection					60
Cut cables					60

Loose nuts of cables of temperature service					60
Get tools					60
Loose nuts of wires					180
Get tools					30
Get tools					20
Loose nuts of wires that measure oil pressure					240
Loose nut of brackets					240
Take out power plant montain nuts					180
Inspection					30
Wait for other technician to finish					420
Set up crate to hold engine					60
Loose nuts that hold engine to the chasis					60
Move tools and equiptment					60
Set up crate to hold transmission					30
Get tools					30
Cut cables + Loose nuts					180
Wait for other technician to finish					120
Take out power plant from bus					420
Move crane with power plant on it					120
Total Time whole Process				Total Sec	23099
				Total Min	384.9833333
				Total Hours	6.416388889

Date	11/16/2004
Maintenance Type	Powerplant Installation
Bus	
Make/year	
Miles	
Number of Technicians	3

Technician 1		
Summary Technician 1	Total	Time
Operations	50	13209
Transport	10	552
Inspection	3	488
Delay	8	4858
Total time spend by technician 1		19107
Total time spend by technician 1		318.45
Total time spend by technician 1		5.31

Technician 1					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Tools set up					260
Parts set up					375
Bus parking					270
Move PP in front of the bus					140
Put lifter to the bus					135
Lift bus					35
Place PP under the bus carriage					198
Align PP with bus					868
Put jack to hold PP					70
Continues aligning PP					195
Holds PP to bus (back part)					428
Lift the bus					29
Take dolly aside					40
Open frame (bus carriage)					135
Continue opening frame to install cross member with mounts					440
Idle					30
Get tools					15
Loose nuts in frame					12
Tight screws frame with cross member and mounts					190
Attach PP to mounts					40

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Realign mounts/PP/frame					325
Tight PP to mounts					190
Verify alignment (some distance left/right from PP to frame)					135
Realign/ verify (measure)					68
Loose (take off) chain used to open frame					138
Go and put chain in its place					40
Bring stick (to measure the oil) and put it in					15
Go to get the ladder					65
Lift the bus more					100
Put jack stands in the back					50
Go inside the bus					20
Check corrections					280
Disconnect coolant line					360
Inspects connections inside the bus					258
Break					1200
Connect coolant lines under the bus					242
Take tools back to the rack					40
Inspects conections					152
Go to get battery charger					35
Connects charger to battery					22
Put batteries to charge					138
Connects more hoses					360
Idle while technician 2 finishes rebuilding the hose					300
Connects coolant line to engine					100
Idle					255
Inspects PP connections					78
Goes somewhere and comes back					130

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Secure hoses with claps					146
Goes inside the bus to check something					25
Inspect upperside connections					95
Comes back to the work area					30
Secure hoses with claps					240
Connect components on the top of the engine					2100
Lunch time					1800
Goes inside the bus					25
Tights/Secures one clap from inside					315
Connects the starter					840
Install crank shaft					
Goes to warehouse to get parts (shaft mounts)					142
Get tools					70
Gets cram shaft					40
Cleans cram shaft					360
Install crank shaft with help from tech 2					125
Continues installing shaft and finishes					1215
Idle					53
Break					900
Goes to warehouse					40
Idle because there is nobody at warehouse					320
Remove jack stands					50
Lows the bus					25
Install pipes of intake, turbo, heater, and remaining lines					300
Fill fluids					850
				Total time in seconds	19107
				Total time in minutes	318.45
				Total time in hours	5.3075
				Total Time	5 H 18 Min

Date	11/16/2004
Maintenance Type	Powerplant Installation
Bus	
Make/year	
Miles	
Number of Technicians	3

Technician 2		
Summary Technician 2	Total	Time
Operations	43	11555
Transport	3	75
Inspection	0	0
Delay	10	6015
Total time spend by technician 2		17645
Total time spend by technician 2		294.083333
Total time spend by technician 2		4.90

Technician 2					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Looses PP from dolly					130
Holds PP under the bus					428
Looses the dolly					170
Push dolly out					30
Get tools and parts					50
Open frame (bus carriage)					135
Continue opening frame to install cross member with mounts					440
Bring small jack					10
Align cross member with frame					40
Opens frame (more)					80
Tight screws frame with cross member and mounts					190
Attach PP to mounts					40

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Realign mounts/PP/frame					325
Tight PP to mounts					190
Verify alignment (some distance left/right from PP to frame)					135
Realign/ verify (measure)					68
tight PP to mounts					102
Take air gun to pass it to tech 3					10
Lift bus					70
Wait					100
Put jack stands in the back					50
Connects hydraulic line from fan motors to hydraulic pump					360
Break					1200
Assists technician 1					242
Go to the warehouse					20
Wait for parts					190
Checks / measures hoses					40
Goes back to the warehouse					15
Waits for another hose					230
Goes back to the warehouse					40
Waits for another hose					160
Builds the hose					280
Checks new hose (finds that it is too long)					40
Cuts hose/ rebuilts it					300
Builds another hose					609

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Connects coolant hoses to transmission					216
Idle					195
Tights coolant hoses					168
Secure hoses with claps					240
Secure hoses and tight them					2100
Lunch time					1800
Idle					340
Connects the starter					840
Continues preparing coolant pipes					540
Stops with coolant pipes to help tech					
Assists techn 1 installing cram shaft					125
Cuts coolant hose (connector)					65
Continues installing coolant pipes					610
Cleans claps that hold coolant pipes					487
Continuous installing coolat pipes					
Continues installing coolant pipes					480
Break					900
Idle (comes back from break)					900
Finishes with coolant pipes					720
Remove jack stands					50
Put back belts					350
Total time in seconds					17645
Total time in minutes					294.083333
Total time in hours					4.90138889
Total Time					4 H 54 Min

Date	11/16/2004
Maintenance Type	Powerplant Installation
Bus	
Make/year	
Miles	
Number of Technicians	3

Technician 2		
Summary Technician 2	Total	Time
Operations	33	9802
Transport	16	535
Inspection	0	0
Delay	8	4995
Total time spend by technician 2		15332
Total time spend by technician 2		255.533333
Total time spend by technician 2		4.26

Technician 3					
Description	Operation	Transport	Inspection	Delay	Time (Sec)
Go inside the bus		⇨			50
Connecting wires from inside	○				145
Go off the bus to get tools		⇨			55
Get (select) parts	○				70
Go inside the bus		⇨			15
Continues conecting wires and lines from inside the bus	○				235
Go to get tools		⇨			35
Select tools	○				70
Idle				▯	130
Continues looking around for parts (Idle time)				▯	420
Go inside the bus		⇨			20

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Connects wises/ lines					325
Wait					70
Put the jack stands in the front					75
Go inside the bus					20
Check corrections					280
Disconnect coolant line					145
Go to the warehouse					20
Get new hose (bacause the other one was short)					285
Measure and cut new hose					48
Store old hose that didn't work					40
Prepares new hose to be installed					83
Break					1200
Goes inside bus					70
Install hoses in the top of the engine					132
Gets off the bus					40
Assists technician 1 (inspecting conections)					75
Gets tools					40
Goes inside the bus					25
Tight screws/components on the top of the engine					67
Continues connecting parts o the top					695
Gets off the bus					30
Gets tools/ parts					100
Goes back inside the bus					40
Continues connecting parts o the top					740
Gets of the bus					20
Gets some tools					50
Goes inside the bus					30

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Connect components on the top of the engine					2100
Lunch time					1800
Idle					340
Bring coolant pipes					25
Install coolant pipes & put coolant pipes holder					997
Goes inside the bus					20
Connect components from the top of the PP (Inside the bus)					1240
Idle					135
Goes back inside the bus					30
Checks transmission connections					255
Install transmission electrical sensors					60
Break					900
Goes inside the bus					35
Continues intalling transmission electrical sensors					660
Put plastic holders to hold transm wires & sensors					110
Checks transmission connectors					135
Goes to the work area (outside of the bus)					30
Remove jack stands					50
Put back bumper					420
Total time in seconds					15332
Total time in minutes					255.533333
Total time in hours					4.25888889
Total Time					4 H 16 Min

Date	8/25/2005
Maintenance Type	Powerplant Replacement - Installation
Bus	373
Make/year	Gillig /1998
Miles	
Number of Technicians	3

Summary Techncian 1	Total	Time
Operations	58	10720
Transport	9	1480
Inspection	3	500
Delay	5	3360
Total time spend by technician 1		16060
Total time spend by technician 1		267.67
Total time spend by technician 1		4.46

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Go to get new power plant and align it to bus		⇨			1080
Get tools	○				20
Go to get parts		⇨			10
Secure brackts	○				120
Aling back rear to end of bus	○				120
Secure nuts on back rear	○				120
Secure brackets and monting parts	○				1020
Right Side of Bus					
Connect hydraulic lines	○				60
Connect generator lines	○				180
Get tools	○				30
Install brackets and adjust nuts	○				60
Connect fuel lines	○				180
Get tools	○				20
Secure brackets	○				120
Get tools	○				20
Connect compresor lines	○				480
Raise bus with crane	○				20
Down the Bus					
Connect hydraulic filter lines	○				120
Connect and secure brackets of the lines	○				180
Connect line that goes to the spinner filter	○				120
Connect fuel filter lines	○				60
Secure brackets	○				300
Connect starter lines	○				120
Help other tech to connect transmission oil line	○				360
Secure brackets and secure nuts	○				480
Go to get all pipe lines to connect		⇨			30
Left Side of the Bus					
Connect coolant pipe line	○				180
Replace brackets of coolant pipe with new ones	○				240
Connect coolant pipe 2	○				60
Get coolant pipe	○				30
Connect coolant pipe 3	○				240
Connect brackets	○				960
Connect coolant pipe 4	○				120
Connect and secure brackets	○				300
Help other technician	○				180
Go somewhere		⇨			60

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Secure brackets	○				180
Inspection			□		20
Break				D	1200
Get drive shaft	○				20
Place drive shaft and secure	○				120
Secure clamps	○				60
Inspect + Re-secure nuts	○				60
Get tools	○				60
Get hydraulic lines	○				20
Connect hydraulic line that goes to hydraulic filter	○				120
Clean oil spilage	○				40
Delay				D	240
Inside the bus					
Inspection			□		120
Connect transmission dip strip	○				120
Connect transmission stick pipe	○				120
Inspection			□		360
Operate crane to lower bus	○				30
Middle parts of the bus					
Go to get intake pipe that goes to the carburator		⇨			30
Break				D	1800
Connect intake pipe	○				300
Connect exaustor	○				360
Connect cables inside the bus	○				240
Get tools	○				120
Secure clamps + nuts +lines	○				1200
Fill Fluids					
Go to get engine oil fluid		⇨			60
Fill engine oil fluid	○				120
Take out oil filter	○				30
Go to get transmission oil		⇨			120
Fill transmission oil	○				180
Take out engine oil	○				30
Delay				D	120
Go to get coolant fluid		⇨			60
Fill coolant fluid	○				180
Go to get air pipe		⇨			30
Install air pipe	○				120
Get tools	○				30
Install panel control	○				180
Apply more coolant	○				60
Delay (tech 2 is starting bus)				D	0
					16060
					267.67
					4.46

Date	8/25/2005
Maintenance Type	Powerplant Replacement - Installation
Bus	373
Make/year	Gillig /1998
Miles	
Number of Technicians	3

Summary Techncian 2	Total	Time
Operations	41	11198
Transport	6	703
Inspection	2	380
Delay	9	3580
Total time spend by technician 2		15861
Total time spend by technician 2		264.35
Total time spend by technician 2		4.41

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Set Up					
Clear compartment					40
Push PP under the bus and align it					960
Get airgun and pass it in to tech 3					135
Get wrench					40
Loose PP from dolly					200
Pull dolly out					10
Go around					90
Assists tech 2 mounting engine mount (support)					645
Get tools and nuts/screws					45
Align PP while tech2 tighten PP to eng. Mount					255
Get jack (support) out and put it aside					75
Hydraulic Lines (HL) Installation					
Install front bracket (holds hyd. Lines)					480
Hold hydraulic lines to bracket					180
Connect third HL (upper side) and secure it					130
Delay (Tech has been called by supervisor)					540
Go to get a ladder					120
Connect transmission oil line to transmission					70
Check connections with tech 3					150
Unhold transmission lines					30
Install transmission oil lines (TOL) (first attempt)					195
Delay (Tech has been called by supervisor)					180
Tighten transmission lines (first attempt)					720
Delay					180
Go to warehouse to get fitting hoses for TOL					40
Prepare fitting hoses to be installed (biuld them)					300
Install transmission oil lines					175
Install transmission cooler pipes					255
Connect transmission wires (lower side)					620

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Idle					80
Go to warehouse to get driveshaft secures					138
Install driveshaft secures					135
Idle					40
Tighten driveshaft secures					138
Idle					180
Tighten driveshaft secures					480
Assists tech 2 lowering bus					70
Take tools					20
Break					1200
Install engine mounts (10 nuts)					1115
Exhost installation					
Get tools					30
Get brackets					40
Bring exhost pipe					35
connect exhost pipe and secure it					480
Coolant pipes					
Bring coolant pipe (water pump to transm cooler)					15
Connect coolant pipe					140
Get bracket and rubber elbow					55
Secure and tighten coolant pipe					1020
Put brackets to hold coolant line					100
Get tools					20
Secure coolant pipes/lines					195
Get exhost fitting elbow					40
Connect elbow (assisted by techn 2)					70
Go around					215
Connect coolant line (Thermostat to Reservoir)					210
Tighten nuts/brackets from coolant lines/pipes					360
Assists techn 2 installing exhost and tighten					480
Inspect that everything is correctly installed					230
Tighten all brackets for security					90
Idle					580
Fill air tanks (and wait)					200
Walk around					100
Waits for techn 2 to finish with fluids					600
Start bus (first attempt)					40
Start bus (second attempt)					20
Start bus (third attempt)					20
Start bus (fourth attempt)					20
					9001
					150.02
					2.50

Date	8/25/2005
Maintenance Type	Powerplant Replacement - Installation
Bus	373
Make/year	Gillig /1998
Miles	
Number of Technicians	3

Summary Techncian 3	Total	Time
Operations	12	3550
Transport	7	222
Inspection	1	150
Delay	1	180
Total time spend by technician 3		4102
Total time spend by technician 3		68.367
Total time spend by technician 3		1.139

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Go inside the bus		⇨			35
Helps aligning PP	○				925
Secure back part of PP to the bus	○				240
Mount brackets on upper side of transmission	○				120
Install wires that go to the ENC	○				240
connect wires that measure oil pressure + temp	○				180
Install coolant lines (upper side)	○				270
Install air line to air compressor (upper side)	○				100
Install exhost (upper side)	○				140
Get off the bus		⇨			32
Look for tools	○				40
Go inside the bus		⇨			30
Connect cables of temperature service	○				735
Get off the bus		⇨			35
Look for tools	○				40
Go inside the bus		⇨			30
Tighten nuts that connect transm to eng (upper)	○				520
Get off the bus		⇨			30
Idle				D	180
Go inside the bus		⇨			30
Check connections			□		150
					4102
					68.37
					1.14

APPENDIX L

Proposed Time Standard

Appendix L Table of Contents	
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POWER PLANT REMOVAL

Summary	Total
Operations	126
Transport	4
Inspection	3
Delay	0
Total	133

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Set Up					1182
Take bus to the working bay		⇨			
Bay preparation and bus preparation	○				
General starting inspection			□		
Raise bus	○				
Secure bus with lifters	○				
Fluids Draining					1744
Go to bring waste oil container		⇨			
Take tools	○				
Loose plug to drain engine oil	○				
Drain engine oil	○				
Put back plug and tight	○				
Move container	○				
Get another tool	○				
Loose plug to drain transmission oil	○				
Drain transmission oil	○				
Put back plug and tight	○				
Move container	○				
Loose hydraulic line #1	○				
Drain oil	○				
Loose Loose hydraulic line # 2	○				
Drain oil	○				
Get caps for lines 1 and 2	○				
Loose line to spinner filter	○				
Drain oil	○				
Bring and put plug	○				
Go to bring waste coolant container		⇨			
Take tools	○				
Loose plug to drain coolant	○				
Drain coolant	○				
Put back plug and tight	○				
Disconnect Coolant Lines & Pipes					1879
Get a tool (wrench)	○				
Loose transmission coolant line #1	○				
Drain Oil	○				
Get caps for transmission and line	○				
Loose transmission coolant line #2	○				
Get a tool (hammer)	○				
Drain oil	○				
Get caps for transmission and line	○				
Loose transmission coolant line #3	○				
Drain oil and get plugs	○				
Thermostat housing Coolant Line	○				

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Get tools					
Loose nuts of coolant line					
Drain coolant					
Loose nuts form other side of the line					
Put line aside					
Engine Coolant Line					
Get tools					
Loose nuts of coolant line					
Radiator Coolant Line					
Loose nuts of coolant line					
Air Compressor Coolant Line					
Get tools					
Loose nuts of coolant line					
Heating System Coolant Line					
Get tools					
Loose nuts of coolant line					
Disconnect coolant pipes					
Loose nuts of coolant pipe 1					
Loose nuts form other side of the pipe					
Put pipe aside					
Loose nuts of coolant pipe 2					
Loose nuts form other side of the pipe					
Put pipe aside					
Get airgun and tools					
Loose coolant pipe-radiator to thermostat					
Loose Intake pipe					
Disconnect Middle components					4095
Disconnect Drive Shaft					
Get tools					
Start loosing nuts connectors to transmission					
Loose nut connectors to transm (*2)					
Loose nut connectors to shaft (*2)					
Get driveshaft out					
Put shaft aside					
Air intake for turbo & Exhost					
Loose remaining brackets					
Loose air intake for the turbo					
Take intake out and place it aside					
Take pipe out and put it aside					
Loose exhost from the turbo					
Loose nuts of brackets					
Loose nuts connectors					
Get tool to loose exhost					
Separate exhost					
Get tools					
Loose nut of wiring that goes to the generator					
Loose nuts of oil filter					
Loose nuts of discharger					
Loose nuts of Spinner filter					
Loose nuts of fuel line					
Loose nuts and bracket that holds transm oil stick					

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Cut belt and put it aside					
Get tools					
Loose nuts next to the hydraulic pump (clear bumper area)					
Lift dolly					
Disconnect wire in front of engine					
Clear front area of engine (move lines to sides)					
Move tools rack aside					
Take transmission meter out and put aside					
Clear oil lline from front side					
Disconnect Components Inside the Bus					1816
Get set of tools to inside the bus					
Go inside the bus					
Take out nuts of brackets of the entige pipe					
Set up light					
Loose return fuel line					
Loose nuts of brackets of the entige pipe					
General compartment inspection					
Cut cables					
Loose nuts of cables of temperature service					
Loose nuts of wires					
Loose nuts of wires that measure oil pressure + temp					
Loose nut of brackets					
Take bumper & Front Motor Mounts out					1468
Loose nuts of bumper holder (*4)					
Move lines					
Get plastic holders to group and hold lines					
Move containers aside					
Clear working place while tech 1 lower bus					
Loose bar placed on the bumper					
Loose brackets					
Loose nuts from bumper					
Get bar and pull bumper out					
Take bumper aside					
Remove nuts					
Loose brackets that hold hydraulic oil line					
Continue loosing nuts from mounts					
Loose coolant line from water pump					
Put jack to hold front of engine and take mount out					
Take mounts out					
Take out power plant from bus					1226
Get dooly					
Put/align dolly (crane) under the bus					
Inspect that PP is ready to be taken out					
Secure PP to crane					
Take security jack out					
Inspect that PP is ready to be taken out (compartment)					
Pull PP out of the engine compartment					
Place PP aside					

POWER PLANT INSTALLATION

Summary	Total
Operations	78
Transport	10
Inspection	0
Delay	0
Total	88

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Bring New Power Plant + Alignment					2915
Get Power Plant from warehouse		⇨			
Push PP under the bus and align it	○				
Get tools	○				
Go to get parts	○				
Secure brackts	○				
Aling back rear to end of bus	○				
Secure nuts on back rear	○				
Secure brackets and monting parts	○				
Clear compartment	○				
Get wrench	○				
Loose PP from dolly	○				
Pull dolly out	○				
Go inside the bus		⇨			
Secure back part of PP to the bus	○				
Mount brackets on upper side of transmission	○				
Connect Middle Components					5395
Connect hydraulic lines	○				
Connect generator lines	○				
Get tools	○				
Install brackets and adjust nuts	○				
Connect fuel lines	○				
Get tools	○				
Secure brackets	○				
Get tools	○				
Connect compresor lines	○				
Raise bus with crane	○				
Connect Lines Down the Bus	○				
Connect hydraulic filter lines	○				
Connect and secure brackets of the lines	○				
Connect line that goes to the spinner filter	○				
Connect fuel filter lines	○				
Secure brackets	○				
Connect starter lines	○				
Secure brackets and secure nuts	○				
Install transmission oil lines (TOL)	○				
Tighten transmission lines (first attempt)	○				
Go to warehouse to get fitting hoses for TOL		⇨			
Prepare fitting hoses to be installed)	○				
Install transmission oil lines	○				
Install transmission cooler pipes	○				
Connect Coolant Lines and Pipes (Left Side of the Bus)					2711
Connect transmission wires (lower side)	○				

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Connect transmission coolant line #1					
Connect transmission coolant line #2					
Connecttransmission coolant line #3					
Thermostat housing Coolant Line					
Engine Coolant Line					
Radiator Coolant Line					
Air Compressor Coolant Line					
Heating System Coolant Line					
Connect coolant pipes					
Connect coolant pipe 1					
Connect coolant pipe 2					
Connect coolant pipe-radiator to thermostat					
Connect Intake pipe					
Connect exhaustor					
Connect cables inside the bus					
Get tools					
Secure clamps + nuts +lines					
Connect Drive Shaft					1219
Get drive shaft					
Go to warehouse to get driveshaft secures					
Install driveshaft secures					
Tighten driveshaft secures					
Connect Cables inside the bus					2221
Go inside the bus					
Install wires that go to the ENC					
connect wires that measure oil pressure + temp					
Install coolant lines (upper side)					
Install air line to air compressor (upper side)					
Install exhost (upper side)					
Connect cables of temperature service					
Tighten nuts that connect transm to eng (upper)					
Check connections					
Get off the bus					
Fill Fluids + Start Bus					1045
Go to get engine oil fluid					
Fill engine oil fluid					
Take out oil filter					
Go to get transmission oil					
Fill transmission oil					
Take out engine oil					
Go to get coolant fluid					
Fill coolant fluid					
Go to get air pipe					
Install air pipe					
Get tools					
Install panel control					
Apply more coolant					
Start bus (first attempt)					
Start bus (second attempt)					
Start bus (third attempt)					
Start bus (fourth attempt)					

APPENDIX M

MODAPTS

MODAPTS SUBROUTINES

Clean Bus			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Get the hose	M5G1		6
Go to the compressor	W5	5	25
Turn on the compressor switch	M2P0		2
Walk to the bus	W5	3	15
Wash the front of the bus for 10 min		10	4650
Walk to the right side of the bus	W5	5	25
Wash the right side of the bus for 7 min		7	3255
Walk to return hose to initial position	W5	5	25
Put hose in its place	M2P0		2
Walk to the lifter	W5	15	75
Move to get switch	M2G1		3
Turn on the switch of the lifter	M4P0		4
Wait until bus is raised (lifter time 8 sec)		480	62
Walk to get the hose	W5	15	75
Get the hose	M2G1		6
Walk to the bus	W5	4	20
Bent to wash under the bus	B17		17
Wash under the bus for (3 min)		3	1395
Walk to compressor	W5	5	25
Move to get compressor	M2G1		3
Turn off the compressor	M5P0		5
Walk to the hose place	W5	4	20
Put the hose in its place	M2P0		2
Walk from the hose to inside the bus	W5	30	150
	Total MODS Units		**9867**

Operate crane			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk to the lifter	W5	15	75
Turn on the switch of the lifter	M2P0		2
Wait until bus is raised (lifter time)	7.75	8	62
Walk to the bus	W5	15	75
	Total MODS Units		**214**

Loose Claps			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Reach the nut	M7P5		12
Untight nut	M5G0	29	145
Apply extra force	X4		4
Put tool on pocket	M3P2		5
Get the nut	M5G0		5
Get the clap	M5G1		6
Walk to put clap and nut in box	W5	3	15
Put the claps and nut on box	M2P0		2
Walk back to the bus	W5	3	15
	Total MODS Units		**209**

MODAPTS SUBROUTINES

Loose Brackets			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Reach the nut	M7P5		12
Untight nut	M5G0	29	145
Apply extra force	X4		4
Put tool on pocket	M3P2		5
Get the nut	M5G0		5
Get the clap	M5G1		6
Walk to put clap and nut in box	W5	3	15
Put the claps and nut on box	M2P0		2
Walk back to the bus	W5	3	15
	Total MODS Units		**209**

Secure Brackets			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Reach the nut	M7P5		12
Untight nut	M5G0	29	145
Apply extra force	X4		4
Put tool on pocket	M3P2		5
Get the nut	M5G0		5
Get the clap	M5G1		6
Walk to put clap and nut in box	W5	3	15
Put the claps and nut on box	M2P0		2
Walk back to the bus	W5	3	15
	Total MODS Units		**209**

Get tools			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk to tools	W5	5	25
Get drawer	M2G1		3
Open drawer	M5P2		7
Decide which tool to get	D3	20	60
Get the tool	M4G1		5
Close the drawer	M5P2		7
Walk back to bus	W5	5	25
	Total MODS Units		**132**

Set up Light			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk to get the light	W5	10	50
Get the light	M2G1		3
Walk to the bus	W5	10	50
Set up light in position desired	M4P2		6
	Total MODS Units		**109**

Loose small nuts			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Reach the nut		M7P5	12
Untight nut	29	M5G0	145
Place nut in box		M3P0	3
	Total MODS Units		**160**

MODAPTS SUBROUTINES

Secure Small Nuts			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Reach the nut		M7P5	12
Untight nut	29	M5G0	145
Place nut in box		M3P0	3
	Total MODS Units		**160**

Loose Big Nuts			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Reach the nut	M7P5		12
Untight nut	M7G0	29	203
Time allowed to loose nuts		2	930
Place nut in box	M3P0		3
	Total MODS Units		**1148**

Secure Big Nuts			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Reach the nut	M7P5		12
Untight nut	M7G0	29	203
Time allowed to loose nuts		2	930
Place nut in box	M3P0		3
	Total MODS Units		**1148**

Set up Crane			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk to crane	W5	15	75
Get the crane	M5G1		6
Walk with the crane to the bus	W5	15	75
Extra force required to move crane	X4		4
Position crane	M5P0		5
	Total MODS Units		**165**

Greese Nuts			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk to get the grease	W5	15	75
Get grease container	M2G1		3
Put grease on nuts	M3G0		3
Move hand to nut	M3P0		3
Grease nut	M1P0	3	3
Walk back to bus	W5	15	75
	Total MODS Units		**162**

MODAPTS POWER PLANT REPLACEMENT

SET UP PROCESS			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
CLEAN THE BUS			
Get the hose	M5G1		6
Go to the compressor	W5	5	25
Turn on the compressor switch	M2P0		2
Walk to the bus	W5	3	15
Wash the front of the bus for 10 min			4650
Walk to the right side of the bus	W5	5	25
Wash the right side of the bus for 7 min		7	3255
Walk to return hose to initial position	W5	5	25
Put hose in its place	M4P0		4
Walk to the lifter	W5	15	75
Move to get switch	M2G1		3
Turn on the switch of the lifter	M4P0		4
Wait until bus is raised (lifter time 8 sec)		8	62
Walk to get the hose	W5	15	75
Get the hose	M2G1		6
Walk to the bus	W5	4	20
Bent to wash under the bus	B17		17
Wash under the bus for (3 min)		3	1395
Walk to compressor	W5	5	25
Move to get compressor	M2G1		3
Turn off the compressor	M5P0		5
Walk to the hose place	W5	4	20
Put the hose in its place	M4P0		4
Walk from the hose to inside the bus	W5	30	150
Take bus to the working bay			
Drive bus from washing area to bay (8 min)		8	3720
Bay Preparation and Bus Preparation			
Walk to Bring Crankshaft Pulley puller	W5	60	300
Get Crankshaft Pulley puller	M2G1		3
Load factor	L1		1
Walk with crankshaft pulley puller to the bay	W5	60	300
Position crankshaft pulley puller in the bay	M2P0		2
Walk to bring Engine/transmission assembly dolly	W5	60	300
Get assembly dolly	M2G1		3
Load factor	L4		
Walk with assembly dolly back to the bay	W5	60	300
Position assembly dolly in the bay	M2P0		2
Walk to bring 1 flywheel lock, #J36375	W5	60	300
Get the flywheel lock	M2G1		3
Walk back to the bay with the flywheel lock	W5	60	300
Release flywheel lock in bay	M2P0		2
Walk to Bring Mechanics Toolbox	W5	60	300
Get the toolbox	M2G1		3
Load Factor	L17		17
Walk back to the bay with the toolbox	W5	60	300
Position the toolbox next to the bay	M2P0		2
Open the toolbox cover	M7G1		8
Put the cover on top	M7P0		7
Remove cover in the interior part of the bus			
Get tools	subroutine		132
Walk Inside the bus	W5	45	225
Bent to reach nuts of seats	B8.5		8.5

DESCRIPTION	CODE	FREQ	MODS
Loose nuts of seats	subroutine		1150
Rise from floor to take out the seats	B8.5		8.5
Reach the seats	M5G4		9
Move the seats	M5P0		5
Load factor for seats	L4		4
Walk to put seats in other position	W5	3	15
Get tool	subroutine		132
Bent to reach the cover	B8.5		8.5
Loose the nut	subroutine		160
Reach the cover	M4G1		5
Rise to put cover next to	B8.5		8.5
Put the cover aside	M4P0		4
Walk outside the bus	W5	45	225
	Total MODS Units		**8273**
	Total Seconds		**1067.217**
	Total Minutes		**17.78695**
	Allowance	**15%**	**2.6680425**
	Standard Time		**20.4549925**

FLUIDS DRAINING			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Lift bus using the crane			
Walk to the lifter	W5	15	75
Get the switch	M2G0		2
Turn on the switch of the lifter	M4P0		4
Wait until bus is raised (lifter time)		8	62
Fluids Draining			
Walk to bring waste oil container	W5	25	125
Get waste oil container	M2G1		3
Load Factor of container	L1		1
Walk back to the bus with the waste oil container	W5	25	125
Position waste oil container under the bus	M2P0		2
Get tools	Subroutine		132
Loose plug to drain transmission oil			
Reach the plug	M7G1		8
Untight the plug	M7P0	10	70
Extra force required to loose plug	X4	10	40
Take the plug	M2G1		3
Walk to place plug in container	W5	5	25
Place plug in container	M2P0		2
Drain Transmission oil			
Drain Transmission oil		5	2325
Walk to get the plug	W5	5	25
Get the plug from container	M2G1		3
Walk back to the bus to put the plug	W5	5	25
Put back the plug	M2P5		7
Tight the plug	M2G0	10	20
Walk to get waste oil container	W5	1	5
Get waste oil container	M2G1		3
Move waste oil container	W5	2	10
Walk to the engine plug position	W5	2	10
Get tools	Subroutine		132
Loose plug to drain engine oil			
Reach the plug	M7G1		8
Untight the plug	M7P0	10	70
Extra force required to loose plug	X4	10	40
Take the plug	M2G1		3
Walk to place plug in container	W5	5	25
Place plug in container	M2P0		2
Drain Engine oil			
Drain engine oil (5 min)		5	2325
Walk to get the plug	W5	1	5
Get the plug from container	M2G1		3
Walk back to the bus to put the plug	W5	5	25
Put back the plug	M2P5		10
Tight the plug	M7G0	10	70
Walk to get waste oil container	W5	2	10
Get waste oil container	M2G1		3
Move waste oil container	W5	2	10
Get tools	Subroutine		132
Loose plug to hydraulic line #1			
Reach the line	M7G1		8
Untight the line	M7P0	10	70
Extra force required to loose plug	X4	10	40

DESCRIPTION	CODE	FREQ	MODS
Target the line to the container	M2P2		4
Drain hydraulic line #1			
Drain hydraulic oil (1 min)		1	465
Walk to get waste oil container	W5	1	5
Get waste oil container	M2G1		6
Move waste oil container	W5	2	10
Get tools	Subroutine		132
Loose plug to hydraulic line #2			
Reach the line	M7G1		8
Untight the line	M7P0	10	70
Extra force required to loose plug	X4	10	40
Target the line to the container	M2P2		4
Drain hydraulic line #2			
Drain hydraulic oil (2 min)		2	930
Walk to get waste oil container	W5	1	5
Get waste oil container	M2G1		6
Move waste oil container	W5	2	10
Get tools	Subroutine		132
Loose line to spinner filter			
Reach the line	M7G1		8
Untight the line	M7P0	10	70
Extra force required to loose plug	X4	5	20
Target the line to the container	M2P2		4
Drain Spinner Filter Oil			
Drain spinner filter oil (2 min)		2	930
Walk to get waste oil container	W5	1	5
Get waste oil container	M5G1		6
Move waste oil container aside	W5	5	25
Drain Coolant			
Walk to get the waste coolant container	W5	25	125
Get waste coolant container	M2G1		3
Walk and position the waste coolant container	W5	25	125
Loose plug to drain coolant			
Reach the line	M7G1		8
Untight the line	M7P0	10	70
Extra force required to loose plug	X4	5	20
Target the line to the container	M2P2		4
Drain coolant (2 min)		2	930
Walk to get waste oil container	W5	1	5
Get waste coolant container	M2G1		6
Move waste coolant container	W5	2	10
	Total MODS Units		**10161**
	Total Seconds		**1310.769**
	Total Minutes		**21.84615**
	Allowance	**15%**	**3.2769225**
	Allowed Time		**25.1230725**

COOLANT LINES AND PIPES			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Disconnect Coolant Lines and Pipes			
Walk to get the waste coolant container	W5	5	25
Get waste coolant container	M2G1		3
Walk and position the waste coolant container	W5	5	25
Get a tool (wrench)	subroutine		132
Coolant radiator to engine, top			
Loose claps	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Target the line to the container	M2P2		4
Drain coolant (2 min)		2	930
Walk to the other line	W5	1	5
Get the tool from the pocket	M2G1		3
Hydraulic, cooler to reservoir, at reservoir			
Loose claps	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Target the line to the container	M2P2		4
Drain coolant (2 min)		2	930
Walk to the other line	W5	1	5
Get the tool from the pocket	M2G1		3
Coolant, transmission cooler to block and radiator houses\tubes			
Loose claps	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Target the line to the container	M2P2		4
Drain coolant (2 min)		2	930
Walk to the thermostat housing coolant line	W5	1	5
Get the tool from the pocket	M2G1		4
Coolant, radiator to engine hoses			
Loose claps	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Target the line to the container	M2P2		4
Drain coolant (2 min)		2	930
Walk to the other line	W5	1	5
Get the tool from the pocket	M2G1		3
Coolant, marine pump to main heater valve			
Loose claps	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Target the line to the container	M2P2		4
Drain coolant (2 min)		1.5	697.5
Walk to the radiator coolant line	W5	1	5
Get the tool from the pocket	M2G1		3
Coolant, marine pump to lower radiator tube			
Loose hydraulic coolant line	subroutine	4	836
Reach the line	M5P5		10

DESCRIPTION	CODE	FREQ	MODS
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Target the line to the container	M2P2		4
Drain coolant (2 min)		2	930
Walk to the air compressor line	W5	1	5
Get the tool from the pocket	M2G1		3
Disconnect other end of Coolant radiator to engine, top			
Reach the other end of the line	M5P5		10
Untight the other end of the line	M2G0	10	50
Extra force required to separate the lines	X4	5	20
Walk to put the line aside	W5	5	25
Load factor for the line	L1		1
Put the line aside	M2P0		2
Walk to the other line	W5	1	5
Disconnect other end of hydraulic, cooler to reservoir, at reservoir			
Reach the other end of the line	M2P5		7
Untight the other end of the line	M2G0	10	50
Extra force required to separate the lines	X4	5	20
Walk to put the line aside	W5	5	25
Load factor for the line	L1		1
Put the line aside	M2P0		2
Walk to the other line	W5	1	5
Disconnect other end transmission cooler to block and radiator houses\tubes			
Reach the other end of the line	M2P5		7
Untight the other end of the line	M2G0	10	50
Extra force required to separate the lines	X4	5	20
Walk to put the line aside	W5	5	25
Load factor for the line	L1		1
Put the line aside	M2P0		2
Walk to the other line	W5	1	5
Disconnect other end of coolant, radiator to engine hoses			
Reach the other end of the line	M2P5		7
Untight the other end of the line	M2G0	10	50
Extra force required to separate the lines	X4	5	20
Walk to put the line aside	W5	5	25
Load factor for the line	L1		1
Put the line aside	M2P0		2
Walk to the other line	W5	1	5
Disconnect other end of Coolant, marine pump to main heater valve			
Reach the other end of the line	M2P5		7
Untight the other end of the line	M2G0	10	50
Extra force required to separate the lines	X4	5	20
Walk to put the line aside	W5	5	25
Load factor for the line	L1		1
Put the line aside	M2P0		2
Walk to the other line	W5	1	5
Disconnect other end of the Coolant, marine pump to lower radiator tube			
Reach the other end of the line	M2P5		7
Untight the other end of the line	M2G0	10	50
Extra force required to separate the lines	X4	5	20
Walk to put the line aside	W5	5	25
Load factor for the line	L1		1
Put the line aside	M2P0		2
Walk to get caps	W5	25	125
Get the caps	M2G1		3
Walk back to the bus to put caps	W5	25	125
Put the caps on engine	M2P2		4

DESCRIPTION	CODE	FREQ	MODS
Walk to get the other cap	W5	2	10
Get the cup	M2G1		3
Walk to the heater valve	W5	2	10
Put the caps on heater valve	M2P2		4
	Total MODS Units		**11835.5**
	Total Seconds		**1526.7795**
	Total Minutes		**25.446325**
	Allowance	**15%**	**3.81694875**
	Allowed Time		**29.2632738**

DISCONNECT MIDDLE COMPONENTS			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Drive Shaft			
Walk to get security support to hold the shaft	W5	25	125
Get the security support	M2G1		3
Walk back to the bus with the support	W5	25	125
Put support under drive shaft for security	M2P0		2
Get tools	Subroutine		135
Loose big Nuts (transmission side)	Subroutine	2	2296
Loose big Nuts (shaft side)	Subroutine	2	2296
Get the driveshaft out	M7G1		8
Extra Force required	X4	10	40
Load Factor for the driveshaft	L5		5
Put driveshaft on security support	M7P0		7
Lift driveshaft to move it aside the bus	M7G1		8
Load Factor for the driveshaft	L5		5
Walk with driveshaft aside the bus	W5	5	25
Put driveshaft on the floor	M2P0		2
Air intake for turbo & Exhaust			
Get tools	Subroutine		132
Loose claps (Loose air intake for the turbo)	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Walk with the line to put it aside	W5	5	25
Put the line aside of the bus on the floor	M2P0		2
Walk back to the bus to loose coolant pipe-radiator to thermostat	W5	5	25
Get the tool from the pocket	M2G1		4
Loose claps (loose coolant pipe-radiator to thermostat)	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Target the line to the container	M2P2		4
Drain coolant (2 min)		2	930
Walk with the line to put it aside	W5	5	25
Put the line aside of the bus on the floor	M2P0		2
Get tools	Subroutine		135
Loose claps (loose line to radiator)	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Walk with the line to put it aside	W5	5	25
Put the line aside of the bus on the floor	M2P0		2
Walk back to the bus to loose thermostat line	W5	5	25
Get the tool from the pocket	M2G1		4
Loose claps (loose thermostat line)	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Walk with the line to put it aside	W5	5	25
Put the line aside of the bus on the floor	M2P0		2
Walk back to the bus to loose pipe	W5	5	25
Get the tool from the pocket	M2G1		4
Loose claps (loose pipe)	subroutine	4	836
Reach the line	M5P5		10

DESCRIPTION	CODE	FREQ	MODS
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Walk with the pipe to put it aside	W5	5	25
Put the pipe aside of the bus on the floor	M2P0		2
Walk back to the bus to loose exhaust from the turbo	W5	5	25
Get the tool from the pocket	M2G1		4
Loose claps (loose exhaust from the turbo)	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Separate Exhaust		5	2325
Walk aside to put exhaust on floor	W5	5	25
Put exhaust on floor	M2P0		2
Get tools	Subroutine		132
Loose nuts and bracket that holds transm oil stick	Subroutine		160
Time allowed to loose nuts		2	930
Loose nuts next to the hydraulic pump	Subroutine		160
Walk back to the bus to loose main air line to the starter	W5	5	25
Get the tool from the pocket	M2G1		4
Loose claps that attach to transmission	subroutine	4	836
Loose claps (loose main airline to the starter)	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Walk aside to put line on floor	W5	5	25
Put line on floor	M2P0		2
Get tools	Subroutine		132
Loose nuts for oil return line	Subroutine		160
Get tools	Subroutine		132
Loose nuts of signal line to aggravate the starter	Subroutine		160
Loose nuts for fuel line	Subroutine		160
Loose nuts for hydraulic	Subroutine		160
Loose nuts of brackets attached to the bus	Subroutine		160
Time allowed to loose nuts		10	4650
Inspection		2	930
Lift bus using the crane			
Walk to the lifter	W5	15	75
Get the switch	M2G0		2
Turn on the switch of the lifter	M4P0		4
Wait until bus is raised (lifter time)		8	62
Get tools	Subroutine		132
Loose nuts of wiring that goes to the generator	Subroutine		160
Time allowed to loose nuts		5	2325
Loose nuts of oil filter	Subroutine		160
Time allowed to loose nuts		2	930
Get tools	Subroutine		132
Loose nuts of discharger	Subroutine		160
Time allowed to loose nuts		2	930
Loose nuts of Spinner filter	Subroutine		160
Time allowed to loose nuts		2	930
Loose nuts of fuel line	Subroutine		160
Time allowed to loose nuts		2	930
	Total MODS Units		**31113**
	Total Seconds		**4013.577**
	Total Minutes		**66.89295**
	Allowance	**15%**	**10.0339425**
	Allowed Time		**76.9268925**

MODAPTS POWER PLANT REPLACEMENT

DISCONNECT COMPONENTS INSIDE BUS			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Get tools	subroutine		132
Walk Inside the bus	W5	45	225
Walk to get the light	W5	2	10
Get the light	M2G1		3
Walk back to set up light	W5	2	10
Set up light	M2P0		2
Get tools to loose nuts	M4G1		5
Bent to reach nuts of seats	B8.5		8.5
Loose nuts of brackets of the entige pipe	Subroutine		160
Time allowed to loose nuts		2	930
Loose claps of return fuel line	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Put the line aside	M5P0		5
Get tools to cut cables	M4G1		5
Put tool on cables to cut	M4P0		4
Cut cables		5	2325
Inspect that all cables have been cut		2	930
Loose nuts of cables of temperature service	Subroutine		160
Time allowed to loose nuts		2	930
Loose nuts of wires	Subroutine		160
Time allowed to loose nuts		2	930
Loose nuts of wires	Subroutine		160
Time allowed to loose nuts		2	930
Loose nuts of brackets	Subroutine		160
Time allowed to loose nuts		2	930
Walk outside the bus	W5	45	225
	Total MODS Units		**10225.5**
	Total Seconds		**1319.0895**
	Total Minutes		**21.984825**
	Allowance	**15%**	**3.29772375**
	Allowed Time		**25.2825488**

BUMPER & FRONT MOTOR MOUNTS OUT			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Lower bus using lifter			
Walk to the lifter	W5	15	75
Get the switch	M2G0		2
Turn on the switch of the lifter	M4P0		4
Wait until bus is lowered (lifter time)		30	232.5
Get tools	Subroutine		132
Loose nuts of bumper holder	Subroutine	4	640
Loose claps placed on the bumper	subroutine	4	836
Reach the bar	M5P5		10
Untight the bar	M2G0	10	20
Extra force required to separate the bar	X4	5	20
Walk to put the bar aside	W5	5	25
Put bar on floor	M2P0		2
Walk back to the bus	W5	5	25
Loose brackets	Subroutine		160
Loose nuts from bumper	Subroutine	4	4592
Walk back to the bus	W5	5	25
Take bumper aside		5	2325
Front Motor Mounts			
Get tools	Subroutine		132
Loose nuts	Subroutine	8	1280
Loose brackets that hold hydraulic oil line			160
Loose coolant line from water pump			
Loose claps	subroutine	4	836
Reach the line	M5P5		10
Untight the line	M2G0	10	20
Extra force required to separate the lines	X4	5	20
Disconnect other end			
Reach the other end of the line	M5P5		10
Untight the other end of the line	M2G0	10	50
Extra force required to separate the lines	X4	5	20
Walk to put the line aside	W5	5	25
Load factor for the line	L1		1
Put the line aside	M2P0		2
Walk back to the bus	W5	5	25
Get mounts	M2G0		2
Walk to put mounts aside	W5	5	25
Put mounts on floor	M2P0		2
	Total MODS Units		**11745.5**
	Total Seconds		**1515.1695**
	Total Minutes		**25.252825**
	Allowance	**15%**	**3.78792375**
	Allowed Time		**29.0407488**

MODAPTS POWER PLANT REPLACEMENT

Take out PP from bus			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk to get dolly	W5	45	225
Get dolly	M2G1		3
Walk back with dolly	W5	45	225
Align dolly under PP	M2P0		2
Inspect that PP is ready to be taken out		5	2325
Secure nuts PP to dolly	subroutine	4	4592
Get dolly with PP	M2G1		3
Pull dolly with PP out of bus	M2P1		3
Walk and put dolly aside	W5	10	50
Time allowed for weight		3	1395
	Total MODS Units		**8823**
	Total Seconds		**1138.167**
	Total Minutes		**18.96945**
	Allowance	**15%**	**2.8454175**
	Allowed Time		**21.8148675**

MODAPTS POWER PLANT INSTALLATION

Bring New Power Plant and Alignment			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Get Power Plant from warehouse (5 min)		5	2325
Push PP under the bus and align it (15 min)		10	4650
Walk to the warehouse	W5	60	300
Get parts from the warehouse	M2G1		3
Walk to working area	W5	60	300
Get tools	subroutine		132
Secure Brackets	subroutine		209
Align back rear to end of bus		5	2325
Get tools	subroutine		135
Secure Nuts		6	960
Secure Brackets	subroutine	10	2090
Secure Mounting Parts	subroutine	10	2090
Get tools	subroutine		132
Loose Nuts	subroutine	4	836
Get dolly	M5G1		6
Walk with dolly to put it aside	W5	15	75
Put dolly aside	M2P0		2
Get tools	subroutine		132
Walk Inside the bus	W5	45	225
Bent	B8.5		8.5
Mount brackets on upper side of transmission	subroutine	2	418
Arise	B8.5		8.5
Walk out of the bus	W5	45	225
	Total MODS Units		**17587**
	Total Seconds		**2268.723**
	Total Minutes		**37.81205**
	Allowance	**15%**	**5.6718075**
	Standard Time		**43.4838575**

Connect Middle Components			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Air intake for turbo & Exhost			
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get tools	Subroutine		132
Secure claps (Secure air intake for the turbo)	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M2G1		4
Secure claps (secure coolant pipe-radiator to thermostat)	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M2G1		4
Secure claps (secure line to radiator)	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M2G1		4
Secure claps (secure thermostat line)	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M2G1		4
Secure claps (secure pipe)	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Walk to get the exhaust from aside	W5	5	25
Get the exhaust	M2G1		3
Walk back with the exhaust	W5	5	25
Put the exhaust	M2P0		2
Get tools	Subroutine		135
Secure claps (Secure exhaust to the turbo)	subroutine	4	836
Reach the line	M5P5		10

DESCRIPTION	CODE	FREQ	MODS
tight the line	M2G0	10	20
Secure Exhaust		10	2325
Get tools	Subroutine		132
Secure nuts and bracket that holds transmit oil stick	Subroutine		160
Time allowed to loose nuts		2	930
Secure nuts next to the hydraulic pump	Subroutine		160
Walk back to the bus to secure main air line to the starter	W5	5	25
Get the tool from the pocket	M2G1		4
Secure claps that attach to transmission	subroutine	4	836
Secure claps (Secure main airline to the starter)	subroutine	4	836
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Reach the line	M5P5		10
tight the line	M2G0	10	20
Get tools	Subroutine		132
Secure nuts for oil return line	Subroutine		160
Get tools	Subroutine		132
Secure nuts of signal line to aggravate the starter	Subroutine		160
Secure nuts for fuel line	Subroutine		160
Secure nuts for hydraulic	Subroutine		160
Secure nuts of brackets attached to the bus	Subroutine		160
Time allowed to Secure nuts		10	4650
INSPECTION		5	2325
Lift bus using the crane			
Walk to the lifter	W5	15	75
Get the switch	M2G0		2
Turn on the switch of the lifter	M4P0		4
Wait until bus is raised (lifter time)		8	62
Get tools	Subroutine		132
Secure nuts of wiring that goes to the generator	Subroutine		160
Time allowed to loose nuts		5	2325
Secure nuts of oil filter	Subroutine		160
Time allowed to loose nuts		2	930
Get tools	Subroutine		132
Secure nuts of discharger	Subroutine		160
Time allowed to loose nuts		2	930
Secure nuts of Spinner filter	Subroutine		160
Time allowed to loose nuts		2	930
Secure nuts of fuel line	Subroutine		160
Time allowed to loose nuts		2	930
Connect Transmission Wires		10	4650
	Total MODS Units		**31343**
	Total Seconds		**4043.247**
	Total Minutes		**67.38745**
	Allowance	**15%**	**10.1081175**
	Allowed Time		**77.4955675**

Connect Coolant Lines and Pipes			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get tools	Subroutine		132
Coolant radiator to engine, top			
Secure claps	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Time allowed to secure the lines		3	1395
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M3G1		4
Hydraulic, cooler to reservoir, at reservoir			
Secure claps	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Time allowed to secure the lines		3	1395
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M3G1		4
Coolant, transmission cooler to block and radiator houses\tubes			
Secure claps	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Time allowed to secure the lines		3	1395
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M3G1		4
Coolant, radiator to engine hoses			
Secure claps	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Time allowed to secure the lines		3	1395
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M3G1		4
Coolant, marine pump to main heater valve			
Loose claps	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20

Time allowed to secure the lines		3	1395
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M3G1		4
Coolant, marine pump to lower radiator tube			
Secure hydraulic coolant line	subroutine	4	836
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Time allowed to secure the lines		3	1395
Walk to get the line from aside	W5	5	25
Get the line	M2G1		3
Walk back with the line	W5	5	25
Put the line	M2P0		2
Get the tool from the pocket	M3G1		4
Connect other end of Coolant radiator to engine, top			
Reach the other end of the line	M5P5		10
tight the other end of the line	M2G0	10	50
Extra force required to secure the lines	X4	5	20
Time allowed to connect and inspect		3	1395
Walk to the other line	W5	1	5
Connect other end of hydraulic, cooler to reservoir, at reservoir			
Reach the other end of the line	M5P5		10
tight the other end of the line	M2G0	10	50
Extra force required to secure the lines	X4	5	20
Time allowed to connect and inspect		3	1395
Walk to the other line	W5	1	5
Connect other end of coolant, transmission cooler to block and radiator houses\tubes			
Reach the other end of the line	M5P5		10
tight the other end of the line	M2G0	10	50
Extra force required to secure the lines	X4	5	20
Walk to the other line	W5	1	5
Connect other end of coolant, radiator to engine hoses			
Reach the other end of the line	M5P5		10
tight the other end of the line	M2G0	10	50
Extra force required to secure the lines	X4	5	20
Walk to the other line	W5	1	5
Connect other end of Coolant, marine pump to main heater valve			
Reach the other end of the line	M5P5		10
tight the other end of the line	M2G0	10	50
Extra force required to secure the lines	X4	5	20
Walk to the other line	W5	1	5
Connect other end of Coolant, marine pump to main heater valve			
Reach the other end of the line	M5P5		10
tight the other end of the line	M2G0	10	50
Extra force required to secure the lines	X4	5	20
Walk to the other line	W5	1	5
Connect other end of the Coolant, marine pump to lower radiator tube			
Reach the other end of the line	M5P5		10
tight the other end of the line	M2G0	10	50
Extra force required to secure the lines	X4	5	20
	Total MODS Units		**17420**
	Total Seconds		**2247.18**
	Total Minutes		**37.453**
	Allowance	**15%**	**5.61795**
	Allowed Time		**43.07095**

MODAPTS POWER PLANT INSTALLATION

Connect Drive-Shaft			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk to get the drive shaft	W5	25	125
Get the driveshaft	M2G1		3
Walk back with the driveshaft	W5	25	125
Extra Force required	X4	10	40
Load Factor for the driveshaft	L5		5
Put driveshaft aligned	M5P0		5
Get tools	Subroutine		132
Secure big Nuts (transmission side)	Subroutine	2	2296
Secure big Nuts (shaft side)	Subroutine	2	2296
	Total MODS Units		**5027**
	Total Seconds		**648.483**
	Total Minutes		**10.80805**
	Allowance	**15%**	**1.6212075**
	Standard Time		**12.4292575**

Connect Cables Inside Bus			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Walk Inside the bus	W5	45	225
Bent	B8.5		8.5
Install wires that go to the ENC		4	1860
Connect wires that measure oil pressure + temp		2	930
Install coolant lines (upper side)			
Get the tool from the pocket	M3G1		4
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Time allowed to secure the lines		2	930
Install air line to air compressor (upper side)			
Get the tool from the pocket	M3G1		4
Reach the line	M5P5		10
tight the line	M2G0	10	20
Extra force required to secure the lines	X4	5	20
Time allowed to secure the lines		2	930
Install exhaust (upper side)			
Get the tool from the pocket	M3G1		4
Reach the exhaust	M5P5		10
tight the exhaust	M2G0	10	20
Extra force required to secure the exhaust	X4	5	20
Time allowed to secure the exhaust		2	930
Get the tool from the pocket	M3G1		4
Connect cables of temperature service		10	4650
Secure nuts that connect transmission to engine		4	4592
	Total MODS Units		**15221.5**
	Total Seconds		**1963.5735**
	Total Minutes		**32.726225**
	Allowance	**15%**	**4.90893375**
	Standard Time		**37.6351588**

Fill Fluids + Start Bus			
DESCRIPTION	**CODE**	**FREQ**	**MODS**
Bring bus down using the crane			
Walk to the lifter	W5	15	75
Get the switch	M2G0		2
Turn on the switch of the lifter	M4P0		4
Wait until bus is down (lifter time)		5	38.75
Walk to bring oil	W5	25	125
Get oil	M2G1		3
Load Factor of container	L1		1
Walk back to the bus with the oil container	W5	25	125
Position oil container under the bus	M2P0		2
Fill transmission Oil			
Get tools	Subroutine		132
Tight plug of transmission oil			
Walk to get plug	W5	5	25
Get the plug from container	M2G1		3
Walk back to put plug	W5	5	25
Put the plug	M2P2		4
tight the plug	M7P0	10	70
Extra force required to loose plug	X4	10	40
Fill Oil		2	930
Fill engine Oil			
Get tools	Subroutine		132
Walk to get plug	W5	5	25
Get the plug from container	M2G1		3
Walk back to put plug	W5	5	25
Put the plug	M2P2		4
tight the plug	M7P0	10	70
Extra force required to loose plug	X4	10	40
Fill engine Oil		2	930
Fill hydraulic line #1			
Get tools	Subroutine		132
Walk to get plug	W5	5	25
Get the plug from container	M2G1		3
Walk back to put plug	W5	5	25
Put the plug	M2P2		4
tight the plug	M7P0	10	70
Extra force required to loose plug	X4	10	40
Fill hydraulic line #1 Oil		2	930
Fill hydraulic line #2			
Get tools	Subroutine		132
Walk to get plug	W5	5	25
Get the plug from container	M2G1		3
Walk back to put plug	W5	5	25
Put the plug	M2P2		4
tight the plug	M7P0	10	70
Extra force required to loose plug	X4	10	40
Fill hydraulic line #2 Oil		2	930
Fill Spinner Filter Oil			
Get tools	Subroutine		132
Walk to get plug	W5	5	25
Get the plug from container	M2G1		3
Walk back to put plug	W5	5	25
Put the plug	M2P2		4

DESCRIPTION	CODE	FREQ	MODS
tight the plug	M7P0	10	70
Extra force required to loose plug	X4	10	40
Fill Spinner Filter Oil		5	2325
Walk to bring coolant container	W5	25	125
Get coolant container	M2G1		3
Load Factor of container	L1		1
Walk back to the bus with the coolant container	W5	25	125
Position coolant container under the bus	M2P0		2
Fill Coolant			
Get tools	Subroutine		132
Walk to get plug	W5	5	25
Get the plug from container	M2G1		3
Walk back to put plug	W5	5	25
Put the plug	M2P2		4
tight the plug	M7P0	10	70
Extra force required to loose plug	X4	10	40
Fill Coolant		2	930
Start bus (first attempt)		40	310
Start bus (second attempt)		20	155
Start bus (third attempt)		20	155
Start bus (fourth attempt)		20	155
	Total MODS Units		**10056**
	Total Seconds		**1297.224**
	Total Minutes		**21.6204**
	Allowance	**15%**	**3.24306**
	Allowed Time		**24.86346**

APPENDIX N

Transmission Removal and Replacement Observations

PILOT READING 1 TRANSMISSION REPLACEMENT

Date	10/5/2004
Maintenance Type	Transmission Replacement
Bus #	601
Make/year	Gillig - 1996
Miles	
Number of Technicians	1
Start Time	No starting and ending time
End Time	Process performed in more than one shift

Summary	**Total**	**Time (sec)**
Operations	79	27536
Transport	20	2540
Inspection	1	40
Delay	7	3470
	Total time	**33586**

Description	**Operation**	**Transport**	**Inspection**	**Delay**	**Time (Sec)**
REMOVAL					
Tools Set up	○				1840
Bus inside preparation (remove engine cover)	○				1725
Take tools	○				29
Remove oil plug	○				156
Drain oil	○				276
Take tools	○				35
Loose and remove nuts	○				150
Separate coolant pipes from cooler	○				1035
Drain coolant	○				375
Take tools	○				23
Loose and remove nuts	○				81
Remove fluid cooler unit	○				442
Go to bring more tools		⇨			220
Loose nuts from transmission union with driveshaft	○				483
Go to get bar to separate transmission from driveshaft		⇨			240
Take big plugs (feeders)	○				648
Put plastic taps to feeders holes	○				60
Take grease cleaner spray	○				10
Loose more nuts	○				180
Get more tools	○				30
Remove the engine cover	○				70
Loose and separate fluid level pipe	○				170
Remove nuts that connect transm with engine (*8)	○				310
Remove TPS from transmission	○				230
Move draining container aside		⇨			40
Place nuts in box and return tools to rack	○				240
Go to get jack		⇨			190
Prepare jack to support transmission	○				480
Place jack under the transmission and align it	○				130
Hold transmission to jack with chains	○				250
Loose more nuts from TPS	○				600
Go to get a ladder to go inside the bus		⇨			85
Get tools	○				40

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Place flashlight close to the conections place	○				105
Go inside the bus		⇨			30
Loose nuts that connect transm with engine upper side	○				130
Get off the bus and go to tools rack		⇨			45
Get flashlight	○				15
Go inside the bus		⇨			30
Loose upperside connectors and wires	○				280
Inspect that all the connectors are separated from unit			□		40
Get off the bus		⇨			30
Secure transmission to jack with chains	○				310
Go inside the bus		⇨			25
Remove nuts that connect transm with engine upper side	○				140
Get off the bus		⇨			25
Loose transmission from compartment	○				400
Down jack with transmission	○				60
Move transmission aside		⇨			45
Clean hands	○				180
Break time (lunch)				D	1800
PREPARATION					
Clean engine side that connects with transmission	○				120
Go to get electronic cleaner		⇨			30
Clean engine side with electronic cleaner & sand paper	○				480
Get new screws and nuts to connect transm with engine		⇨			115
Clean screws and nuts	○				130
Delay (Go around)				D	70
Take air gun and tools	○				40
Remove screws and nuts of fly wheel from old transmission	○				70
Take fly wheel and put it aside	○				40
Take out the jogi (connects transmission with driveshaft)	○				180
Clean jogi	○				110
Go to get the lifter		⇨			660
Prepare old engine for storage	○				130
Move old transmission from jack to the floor		⇨			200
Take air gun and tools	○				30
Prepare new transmission to be lifted	○				120
Transfer holder chain from old to new transmission	○				290
Clean the jack	○				110
Lift new transmission and put it on the jack	○				240
Secure transmission to the jack (with chains)	○				540
Transfer holder chain from new to old transmission	○				260
Take fitting pipe out from old transmission	○				600
Lift old transmission and put it in the box	○				165
Clean new transmission holes and conectors with air gun	○				170
Clean the flywheel	○				140
Clean screws of flywheel	○				100
Idle				D	180
Install flywheel to new transmission					
Go to get lubricant for screws		⇨			230
Put flywheel screws (*12)	○				170
Tighten screws	○				190

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Clean the jogi	○				480
Delay (Move around)				D	250
Go to get sandpaper		⇨			60
Clean jogi with sandpaper	○				130
Delay (Move around)				D	160
Delay (Move around)				D	110
Install jogi on the transmission					
Get tools	○				30
Go to get tool and lubricant		⇨			150
Put jogi on transmission	○				20
Lubricate screw	○				20
Put screw	○				10
Get lubricant again	○				15
Relubricate screw	○				10
Tighten screw	○				15
Get old screws from box	○				18
Install screws to jogi	○				260
Grease engine connector	○				70
INSTALLATION					
Push jack with new transmission under the bus	○				40
Align transmission with engine (first attempt)	○				50
Break				D	900
Align transmission with engine (second attempt)	○				360
Put screws that connect transmission with engine	○				235
Tighten srews	○				450
Get security chain off the transmission	○				180
Go to warehouse to return jack		⇨			90
Put back connections (estimated time)	○				9000
Total time in Seconds					33586
Total time in Minutes					559.766667
Total time in Hours					9 H - 20 Min

PILOT READING 2 TRANSMISSION REPLACEMENT

Date	7/26/2005
Maintenance Type	Transmission Replacement
Bus #	2102
Make/year	Gillig - 2001
Miles	
Number of Technicians	1
Start Time	8:00am + sometime from previous sh
End Time	4:30pm + some time from next shift

Summary	**Total**	**Time**
Operations	155	28048
Transport	46	5008
Inspection	9	1050
Delay	12	5130
	Total time	**39236**

Description	**Operation**	**Transport**	**Inspection**	**Delay**	**Time (Sec)**
REMOVAL					
Tools Set up					1500
Bus inside preparation (remove engine cover)					1080
Take tools					30
Remove oil plug					40
Drain oil					180
Take tools					60
Loose and remove nuts					240
Separate coolant pipes from cooler					840
Drain coolant					300
Take tools					60
Loose and remove nuts					240
Remove fluid cooler unit					720
Go to bring more tools					70
Place container					30
Get lamp					15
Get tools					10
Loose transmission nuts					60
Go to get special tools					60
Try tools					30
Go to get another tool					20
Take out filter and dispose it					45
Plug hydraulic lifter to AC					130
Lower bus					17
Get air line and connect it to the bus					20
Cover coolant pipe					15
Go inside the bus and get back					120
Get tools					20
Separate from DriveShaft					
Loose nuts					45
Turn drive shaft					20
Loose nuts					32
Go to get a mop					10
Clean the floor					15

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Go to get jack support 1 (tall jack)		⇨			45
Go to get jack support 2 (small jack)		⇨			90
Place supports under the driveshaft	○				495
Raise the bus	○				15
Try to place supports under the driveshaft again	○				360
Take plugs out (the two big plugs on sides)	○				33
Raise the bus	○				15
Take jack and support aside	○				18
Visual inspection			□		40
Go inside the bus and come back		⇨			180
Delay (walk around)				D	80
Go inside the bus		⇨			20
Loose claps that hold wires (upper side of the transmission)	○				130
Clean the floor	○				10
Get tools	○				30
Go inside the bus		⇨			20
Loose upper side connectors	○				300
Get off the bus	○				25
Get tool and try to loose a nut	○				10
Go around looking for tools		⇨			80
Go inside the bus		⇨			20
Disconnect upper side components	○				170
Get off the bus		⇨			20
Get tools	○				50
Go inside the bus		⇨			20
Disconnect upper side components	○				70
Get off the bus		⇨			25
Get tools	○				30
Go inside the bus		⇨			28
Disconnect upper side components	○				220
Get off the bus		⇨			25
Delay (walk around)				D	60
Loose fluid level line	○				120
Delay (walk around)				D	60
Loose nuts (*7) connect transmission to engine	○				250
Go to get jack		⇨			60
Raise jack up to transmission	○				80
Align jack with transmission	○				70
Hold transmission to jack with chains	○				120
Go to get a screw to secure transmission with chain		⇨			30
Secure transmission on jack	○				70
Go inside the bus		⇨			25
Loose nuts that connect transm with engine upper side	○				190
Get off the bus and go to tools rack		⇨			35
Go inside the bus		⇨			20
Remove nuts that connect transm with engine upper side	○				70
Get off the bus		⇨			20
Shake transmission to separate it from engine	○				30
Ask and wait for help to separate transmission				D	40
Remove DriveShaft					
Get tools	○				20

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Call for assistance and wait					60
Loose driveshaft nuts					40
Take drive shaft out					20
Shake transmission to separate it from engine					60
Go inside the bus					30
Check if there are missing tools to loose					60
Secure transmission on jack (it was a little loose)					50
Shake transmission and separate it from engine					120
Down jack with transmission					95
Move transmission aside					40
Clean hands					120
Break					900
PREPARATION					
Clean floor					60
General inspection of compartment and transmission					240
Go to warehouse to bring transmission					840
Go to get scissors to cut box wrapage					190
Check transmission with suppervisor					420
Recordserial numbers (new and old transmissions)					200
Go somewhere					120
Inspect parts on the bus to check for any oil spills					60
Inspect old transmission to check for any oil spilage					60
Take out the housing plate from old to put on new trans					240
Secure chains to new transmission to lift with cartlifter					180
Take out transmission from box with cartlifter					180
Look for tools					30
Take out coolant filter from old transmission					30
Look for tools					30
Loose knots to take out the filter					30
Take out the filter					120
Inspect old and new transmission to check if old filter work					30
Connoct the filter to the NEW transmission					
Thighten the knots					30
Go for tools					60
Take out old bracket from old filter					60
Connect bracket to new transmission					30
Go somewhere to look for parts					420
Connect sensor of low oil to new engine					180
Inspect old engine for parts to do					120
Loose chains that hold new transmission					120
Connect chains to the old transmission					360
Lunch Time					1800
Loose bolts that connect the drive shaft on the old trans					60
Go somewhere					60
Look for tools					30
Take out drive shaft connector					240
Connect drive shaft connector to NEW transmission					
Look for tools					60
Thighten the knots					180
Put the safety locks					240
Go to get housing plate from floor					30

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Connect housing plate from OLD tranm. To NEW trans	○				
Go somewhere		⇨			360
Look for tools	○				30
Thighten knots of housing plate	○				60
Go somewhere		⇨			120
Continue thighten knots of housing plate	○				60
Go somewhere		⇨			240
Clean old engine	○				60
Thigthen knots of crane that hold old transmission	○				180
Look for tools	○				30
Separate fitting of oil fluid level line from old transmission	○				60
Go somewhere		⇨			120
Drive forklift to unmount old tranmission from the dolley	○				60
Unmount old tranmission from dolley (take out chains)	○				180
Clean oil spilage	○				120
Go somewhere		⇨			180
Look around for missing component	○				300
Go somewhere		⇨			120
Move dolley where old transmission was placed	○				30
Go somewhere		⇨			180
Place old transmission in box container	○				60
Go somewehre		⇨			180
Secure chains to new transmission to lift with cartlifter	○				120
Bring dolley to hold new tranmission	○				60
INSTALLATION					
Lift transmission and put it on the jack	○				260
Secure transmission with chains	○				300
Get tools	○				15
Ensure that nuts are well tighten	○				40
Loose transmission holder (used to llift it)	○				60
Move bobcat aside	○				60
Look around for missing component	○				120
Ask technician for help pushing the transmission	○				90
Push transmission under the bus	○				110
Align transmission with engine (install)	○				600
Go to call another technician for help		⇨			240
Delay				D	360
Align transmission with engine (install) Second attempt	○				900
Get tools and nuts	○				85
Put and tighten nuts that connect transmission to engine	○				440
Loose chains from jack	○				140
Down jack and put it aside	○				40
Thighten 2 more nuts from the lower side	○				105
Break				D	1320
Delay				D	300
Install Driveshaft					
Get tools	○				30
Tighten nuts (to the driveshaft)	○				130
Get airgun	○				10
Tighten nuts (to the driveshaft)	○				75
Down bus	○				65

Description	Operation	Transport	Inspection	Delay	Time (Sec)
Go inside the bus		⇨			20
Quick inspection			□		40
Get off the bus		⇨			20
Tighten nuts (to the transmission)	○				180
Hammering driveshaft to align it with transmission	○				40
Get lamp	○				10
Get nut and tighten it	○				30
Hammering driveshaft to align it with transmission	○				50
Rotate driveshaft	○				10
Connect nut from the other side	○				5
Hammering driveshaft to align it with transmission	○				38
Get security nuts	○				20
Tighten nuts	○				120
Tighten all nuts from both sides	○				120
Lookin aroun for a tool				D	90
Tighten driveshaft	○				130
Raise the bus	○				60
Undercarriage inspection			□		40
Go to get bobcat car		⇨			240
Get old transmission out of the box	○				40
Get bracket (that holds cooler) from old transmission	○				100
Put old transmission back in the box	○				180
More car back	○				20
Take braket and install it	○				180
Cooler Installation					
Take cooler from table	○				15
Call for assistance and wait				D	60
Tighten cooler to bracket	○				230
Go to get an special tool		⇨			130
Go to get a small jack		⇨			35
Put cooler on the jack	○				10
Move it to draining place	○				5
Drain oil and coolant remaining in the cooler	○				40
Take cooler for cleaning	○				120
Go inside the bus		⇨			30
Bring cooler back to working area	○				120
Install coolant pipes	○				
Install upperside nuts and wires	○				
Install oil level fitting	○				
Install oil level line	○				
Install oil filter	○				
Fill with oil and coolant	○				9000
Total time in Seconds					35312.4
Total time in Minutes					588.54
Total time in Hours					9 H - 9 Min