



Cairo Air Improvement Project  
Compressed Natural Gas Component

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Computerized Maintenance Management  
System (CMMS) Design Concept for CNG  
Bus Facilities

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# Computerized Maintenance Management System (CMMS) Design Concept for CNG Bus Facilities

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## **SECTION I: Introduction**

### **A. Cairo Air Improvement Project Overview**

The Cairo Air Improvement Project (CAIP) is a five-year program and is the largest air pollution control effort ever funded by USAID.

CAIP works to reduce airborne lead, particulate matter, and other contaminants in Cairo through a broad range of technical, policy, legal, and institutional activities. These activities focus on reducing emissions from vehicles and industrial operations on four fronts:

- 1) Implementing vehicle inspection and maintenance programs;
- 2) Establishing air monitoring systems;
- 3) Reducing lead emissions from lead smelters; and
- 4) Introducing buses that run on compressed natural gas (CNG).

### **B. Compressed Natural Gas (CNG) Component**

Chemonics is assisting the two largest bus companies in Cairo, the Cairo Transit Authority (CTA) and the Greater Cairo Bus Company (GCBC), in introducing CNG buses and establishing support facilities for their operation and maintenance. Fifty CNG-fueled buses comprise the initial fleet, and it is expected the CNG fleet will expand significantly in the future.

New CNG maintenance garages and fueling facilities have been constructed for the CTA and GCBC. These maintenance garages are separate entities in the CTA and GCBC organizations with their own central administrations reporting directly to the Chairmen of CTA and GCBC.

## **SECTION II: The Computerized Maintenance Management System (CMMS)**

### **A. Proposed CMMS**

CAIP, with assistance from the bus companies, studied the existing diesel bus operations and maintenance (O&M) organizations and practices to determine the baseline Egyptian diesel transit bus environment. CAIP then developed a proposed new organizational structure and reporting relationship for the CNG bus garages that is designed to enhance the current system, as well as provide the necessary new equipment and management practices. This effort also includes development of proposed staffing requirements for maintenance personnel and management staff.

The new program is based on CNG transit experience from around the globe, and uses straightforward requirements to allow efficient implementation into the CTA and GCBC organizations. Some technologically sophisticated systems are proposed, but they are being implemented with proper training and provide superior capabilities for monitoring and ensuring the success of the new CNG programs at CTA and GCBC. CAIP is assisting the bus companies with developing detailed management procedures for CNG bus O&M. These include schedules for inspections; procedures for routine and preventive maintenance; management of spare parts and supplies; and monitoring, reporting, follow-up, and resolution of maintenance problems.

### **B. Need for the CMMS**

Currently, all CTA and GCBC maintenance management activities are performed without the use of computers. Significant deficiencies exist, including delay in obtaining spare parts for needed repairs, minimum level of preventive maintenance, redundancies in maintenance functions, inability to track performance of buses, and low level of safety checks.

CNG buses and their support facilities are more sophisticated than their diesel counterparts. CNG is a gas and leaks are harder to detect than those from diesel. The fuel tanks that hold the compressed gas are of a high-tech design. The gas is under high pressure, sometimes exceeding 3,000 PSI. The bus engines and transmissions are computer-controlled and require complex preventive maintenance techniques to keep them operating at optimum conditions. An enhanced maintenance and safety program is essential for safe and economical operation of the buses and their support facilities.

### **C. CMMS Description and Goals**

For sustainability reasons, CAIP is providing the bus companies with a complete computerized solution for managing and maintaining their new CNG fleets. The system includes software and hardware packages suited for transit service. The system allows implementation of modern management practices, emphasizing preventive rather than corrective maintenance, and includes enhanced quality control for spare parts, tools, and other resources.

The CMMS enables management to:

- Schedule preventive and predictive maintenance procedures, and parts and labor utilization for maintenance tasks.
- Project and monitor downtime and causes.
- Project and monitor costs, repairs, and usage of spare parts and labor.
- Analyze failures, costs, maintenance procedures, and resource usage.

CMMS usage helps in:

- Achieving high efficiency in fleet operation (by minimizing failures and maximizing operating time).
- Minimizing usage of parts and labor.
- Maximizing usage of buses and minimizing downtime.
- Maximizing buses' lifetime and replacement period.
- Minimizing maintenance and operation costs.
- Maximizing profits.
- Raising performance levels.

The goal of this project is to establish a fleet computerized maintenance management system that allows the safe and efficient functioning of a CNG bus fleet for the CTA and GCBC.

## **SECTION III. CMMS Description**

### **A. Primary CMMS Applications**

The following are the major elements of the CMMS:

#### **A1. Spare Parts Inventory**

Inventory tracking and control is improved resulting in having spare parts when they are needed and, therefore, ensuring that buses are in service the majority of the time. Parts requisitioning and ordering is integrated into the CMMS in order to achieve better ordering efficiency. Vendors and their performance are tracked. Data from the CMMS is then used to expedite future budgeting and planning efforts.

#### **A2. Maintenance Scheduling**

Preventive and routine maintenance are especially important for the safe operation of CNG buses and facilities. Scheduling is optimized for this complicated equipment, resulting in more efficient operation of both the buses and the support facilities. Advanced notices of scheduling are issued automatically, resulting in better planning for manpower utilization. Service contract renewals and terms are tracked, and early warning of expirations are produced.

#### **A3. Safety Inspections**

Visual and instrumental safety inspections, particularly of the fuel system, are critical to the safe operation of the buses, fueling facilities, and maintenance facilities. Computer scheduling of these inspections ensures an optimum inspection schedule. Furthermore, routine computer analyses of inspection results warn of impending safety problems.

#### **A4. Fuel and Fluids Tracking**

The CMMS tracks the rate of fuel and fluids consumption on a per-bus basis and/or for the entire fleet. The system is programmed to automatically warn of excessive fuel and/or fluids usage, indicating a problem situation. This tracking provides early warning of a fuel and/or fluids leak, indicating a potentially hazardous situation.

#### **A5. Performance Monitoring**

Tracking performance of drivers, buses, mechanics, inspectors, and systems through use of the CMMS leads to improvement in efficiencies and, therefore, cost savings. Both on-road and in-maintenance tracking is performed. Downtime and its causes, costs, repairs, spare parts' usage, and labor usage are all tracked. The CMMS is used to analyze tracking data, predict future performance, summarize resources expended, analyze failures, costs, and procedures, and generate reports. Such tracking and analysis is used in continuous quality improvement.

## **A6. Training**

CMMS outputs are used in training operators, mechanics, inspectors, management personnel, and other employees. The training schedules are maintained on the system as well. These uses of the CMMS result in improved efficiency and better-trained workers, ultimately resulting in cost savings.

## **A7. Computer-generated Reports**

Many types of reports are generated by the CMMS to support various needs. Both routine and customized reports can be generated, and queries can be made.

## **A8. Clearinghouse**

Maintaining a clearinghouse of data and information about CNG is done on the CMMS. Keeping a computerized inventory of books, pamphlets, service bulletins, CD-ROM's, etc., allows workers to access needed information easily. The materials and their usage are tracked, and some of the materials are entered directly into the CMMS. Sound and readily available information leads to productivity improvements and safety enhancement.

## **A9. Transportation Issues**

There is a significant need to track bus and personnel locations on a real-time basis. There is also a need to analyze current routing and scheduling and make adjustments, as well as to plan new routes. These functions are easily performed using the CMMS.

## **A10. Financial Issues**

The purchasing and inventory control functions interface with the CMMS, resulting in more efficient operations. Ultimately, these efficiencies lead to cost reductions.

## **A11. Interdepartmental Cooperation**

Servicing, operating, and maintaining a CNG fleet will require a higher level of interdepartmental cooperation and a need for sharing information. The CMMS fulfills these needs readily. The technical, procurement, warehouse, human resources, operation, and workshop functions are all linked.

## **A12. QA/QC and Auditing**

Routine and non-routine checks of systems, data, personnel behavior, costs, part failures, and many other items are easily checked by using the CMMS. Solutions, new approaches, remedial measures, and new designs are all indicated by the results of computer analyses. Many parts and failures are predicted and, therefore, preventative measures can be employed. The results of these analyses are a reduction in costs and the increase in the safety of operations.

## **B. CMMS Design Concept**

The CMMS design concept is based on a revamped maintenance management structure for both the CTA and GCBC. The existing structure was studied in depth, and the revamped structure is designed to minimize disruption of the current organization. Annex A contains details of the revamped structure and highlights where the CMMS will support and enhance it.

## **C. CMMS Specifications**

### **C1. General Specifications**

The following are the key items required:

- Arabic and English interface.
- Y2K compliant.
- Simple user interface.
- Multiple reports (daily, quarterly, yearly, and historical).
- Simplicity of error messages.
- High security levels.
- Local technical support.

### **C2. Hardware Architecture**

To support the CMMS, CAIP offers the following minimum required hardware specifications for the server and workstations. At each garage, CAIP envisions one server and approximately 10 workstations, each accompanied by a printer (see Annex B, Figure B1 for garage computer network).

The server requires: current Pentium technology; 512MB RAM; 50x CD-ROM drive; 1.44MB floppy drive; 20GB internal tape backup; network card; four 10GB hard disks; 8MB AGP VGA card; two serial, one parallel, and two USB ports; and a 56k/v90 internal modem.

The workstations require: current Pentium technology; 128MB RAM; CD-ROM drive; 1.44MB floppy drive; network card; 10GB hard disk; 8MB AGP VGA card; and two serial, one parallel, and two USB ports.

The monitors for the server and workstations must be plug-and-play compatible and require a nominal, 15-inch (13.8-inch viewable) area.

The network requires a continuous power supply, two hubs (12-port and 8-port) with transceivers to fiber optic cables, two racks and patch panels matching the hubs, and a face plate with external box and surface mounting suitable for an RJ45 connector.

### **C3. Software Architecture**

The CMMS includes five interrelated modules as follows:

- System Control Module;
- Gate Module;
- Personnel Module;
- Inventory Module; and
- Maintenance Module.

Each of these modules in the CMMS is designed to support multiple companies, branches, currencies, languages, and users, as well as featuring security controls, client/server applications, and the ability to modify screen layouts. Please refer to Annex B for details and flowcharts showing the relationship and interconnectivity of the CMMS modules.

The System Control Module controls the other four modules, databases, forms, and the form controls, and can perform this for multiple companies, branches, departments, and divisions. The system setup of users and groups, as well as the assigning of security rights to them, is performed through this module. The operator can also view which users are active on the system at any time through the System Control Module.

The Gate Module is the user-level entry into the CMMS, recording employee timesheets, bus logs, and repair requests.

The Personnel Module holds the electronic records of all employees, assigning each a unique identification number, and allows management to route employees to positions according to skill level and availability, as well as to training courses as required. The module tracks vacation, sick leave, overtime, days absent, etc.

The Inventory Module allows the management to adjust minimum/maximum levels of inventory, add, issue, receive, and transfer spare parts, and track stock over multiple companies, branches, and stores, and do so by item cost or by average price. The module is barcode-enabled and can produce inventory lists by quantity and cost. The module alerts the operator when inventory is “slow-moving” or needs to be restocked.

The Maintenance Management Module records the technical information for maintenance units, and provides setups for preventive maintenance scheduling, technical and safety procedures, and required resources. The module notifies all other departments related to maintenance with the required labor skills, materials, and tools needed for each new maintenance operation.

## SECTION IV. Other Factors

### A. Proposed Staffing

The figures presented in the table below are the estimated staffing requirements for a garage housing 25 full-size CNG transit buses. The estimates for transportation and maintenance personnel were based on the number of buses and the distance they operate per day. Staffing requirements for the rest of the garage employees are estimates based on the CNG team's experience with facility management in Egypt and the US. The total estimated staff for maintaining and operating the CMMS is two.

**Personnel Requirements for CNG Transit Garages**

<b>Department</b>	<b>No. of People</b>
General Manager	1
Auditing	2
Labor Relations	3
Legal	2
Transportation	147
Manager	1
Drivers	60
Conductors	60
Fare collectors	6
Route planning	4
Dispatchers	6
Fuelers	2
Cleaners	4
Other	4
Maintenance	67
Manager	1
Routine	7
Preventive	8
Repair	5
Specialized shops	40
Part stores	6
Technical	13
Manager	1
QA/QC	4
Information system	2
Performance evaluation	2
Training	2
Clearinghouse	2
Safety	16
Manager	1
Industrial	3
Fire fighters	4
Security	12
Financial	14
Manager	1
Accounting	2
Cashier	4
Budgeting	1
Purchasing	2

Inventory control	4
Administration	20
Manager	1
Personnel	3
Payroll	3
Secretary	2
Garage administration	6
Housekeeping	5
<b>TOTAL</b>	<b>285</b>

### B. Staff Training on the CMMS

The supplier of the software in conjunction with CAIP is to conduct staff training.

### C. CMMS Cost Information

The following table is a summary of the estimated cost of the CMMS for the CTA garage plus the GCBC garage. These are initial costs for hardware and software and do not include training and longer-term O&M costs.

**Estimated Cost of CMMS**

Category	Item	GCBC	CTA	Comments
Hardware	Server	8,700	9,200	
	Workstation	23,500	24,500	11 unit for each facility
	Printers	5,000	5,500	6 units for each facility
	Network	3,000	3,500	
	Special Devices	800	900	
Software	1 Full package +11 user licenses	17,000	18,000	
	Technical Support	1,200	1,200	
	<b>Subtotal</b>	<b>59,200</b>	<b>62,800</b>	
Shipping	Transportation	2,000	2,000	
	Insurance	500	500	
	<b>Subtotal</b>	<b>61,700</b>	<b>65,300</b>	
Contingency		9,255	9,795	15% of total
	<b>Subtotal</b>	<b>70,955</b>	<b>75,095</b>	
<b>Grand Total</b>			<b>124,775</b>	<b>US\$</b>

## **ANNEX A**

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CMMS Design Concept for Maintenance Management in CNG  
Garages of CTA and GCBC

## **ANNEX A**

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# CMMS Design Concept for Maintenance Management in CNG Garages of CTA and GCBC

## **A. Introduction**

CAIP proposes to establish the new CTA garage as its own new sector under the CTA corporate structure and the new GCBC garage as a new general department under the GCBC Branch Operations Sector. This proposal is based on the current CTA and GCBC corporate structures and additional requirements that the new CNG vehicles would impose on existing garages. These proposed changes allow the new CNG garages to act autonomously, rather than having to fit into the existing diesel sector/garage management structure. The new garage managers report directly to the chairmen of their respective organizations.

Although these proposed changes are slightly different, the proposed organizational structures for the garages themselves are identical. The proposed organizational structure is presented in Figure A1. This figure not only represents the organizational structure of the garages, but also dictates the institutional changes required at CTA and GCBC to implement successful CNG bus programs.

As the organization chart in Figure A1 illustrates, the new garages have nine directors reporting to the garage general manager, representing the Maintenance, Safety, Transportation, Financial, Administration, Auditing, Legal, and Labor Relations Departments.

## **B. Maintenance Department**

The Maintenance Department serves as one of the central hubs for O&M activities in the new CTA and GCBC CNG garages. The Maintenance Department is in charge of routine maintenance, preventive maintenance, repair work, any heavy maintenance that is carried out at the garage level, specialized repair shops (e.g., brakes, tires, battery charging), and the Parts Stores. Routine inspection and maintenance of CNG fuel systems is also included in the Maintenance Department's regular duties.

To aid the Maintenance Departments of the new CTA and GCBC garages in carrying out their necessary tasks, CAIP proposes to enhance some of the existing personnel management skills and implement several new technology-related maintenance concepts.

CAIP proposes to implement an electronic parts management system and electronic maintenance scheduling (part of the proposed CMMS). In tandem with the CMMS maintenance scheduling, one of CAIP's major activities with the CTA and GCBC Maintenance Departments is restructuring the existing "maintenance teams" used in the diesel garages into incentive-oriented "performance teams." Moreover, because proper CNG fuel system maintenance is so important during the implementation phase of this project, CAIP is providing specific support for fuel system inspection and maintenance.

### **B1. Performance Teams**

The existing CTA and GCBC diesel transit garages are organized with maintenance teams of roughly 25 staff per 40 buses. Under these existing programs, the maintenance teams only

work on the specific buses to which they are assigned (i.e., maintenance personnel from one team generally do not work on the buses assigned to another maintenance team). CAIP seeks to enhance this sense of teamwork by adding incentives for the maintenance teams that provide the best overall CNG buses to the public users. Performance indicators include timely service and scheduled maintenance, maximum in-service usage, and even cleanliness. These new teams of CNG maintenance personnel are called “Performance Teams.”

The actual evaluation criteria, and associated systems, for the Performance Teams’ maintenance work is determined in conjunction with CTA and GCBC management, but the overall goal is to motivate the CNG maintenance teams to provide the best and most reliable transit products to the consumer market.

## **B2. Parts Management**

The CNG buses require a consistent supply of spare parts for proper maintenance and repair to enable CTA and GCBC to provide high-quality CNG transit service in Cairo. CAIP proposes to implement the CMMS at CTA and GCBC. The CMMS is capable of simultaneously monitoring parts usage, monitoring parts inventory, and interfacing with the purchasing department to assure timely acquisition of necessary parts for near-term maintenance and repairs.

CAIP recommends that the actual Parts Stores remain inside the Maintenance Department for direct access to the necessary vehicle maintenance and repair components. The parts flow from storage is controlled through the CMMS. In this effort to manage the flow of spare parts from the CNG Parts Stores, the CMMS is accompanied by a parts request procedure for mechanics to requisition necessary spare parts for maintenance and repair needs. This new parts request procedure augments the existing system at CTA and GCBC with the additional CMMS tracking of parts usage and inventory control.

In the current CTA and GCBC parts request systems, a mechanic who needs a spare part must receive approval signatures from his manager, the maintenance engineer in charge of his maintenance team, and the used parts collection supervisor. He can then present these signatures to the Parts Stores and get the requested part.

In the CMMS, the mechanic uses a Materials Request Form (MRF) and first gets his manager’s signature and the maintenance engineer’s signature on the MRF. The mechanic then takes the MRF and the broken/used component to the Used Parts Stores (UPS). The UPS attendant takes the broken/used component, places it in storage, and signs the MRF. The mechanic then takes the MRF to the Inventory Control Section of the Financial Department and exchanges it for a Material Approval Form (MAF). The mechanic takes the MAF to the Parts Stores, receives the new component, and the Parts Stores Manager confirms in the CMMS that he has delivered the specified component to the specified mechanic.

Although the proposed system may sound cumbersome, the CTA and GCBC mechanics already use a similar system, so training to carry out a new procedure is not necessary. The only addition to the existing procedure is the recording of the materials usage in the CMMS, which provides an electronic inventory control, as well as materials accountability throughout the CNG Parts Stores. New parts have to be specifically requested, and their issuance from the Parts Stores is electronically recorded and tracked by mechanic-supervisor-engineer-UPS

manager signatures. This system allows for constant tracking of parts inventories, while simultaneously reducing the opportunity for parts to be mishandled or lost.

Figure A2 shows a flow diagram for the electronic tracking and issuance of spare parts in the new CNG garages. The integration of the CMMS with the Purchasing Department is discussed later.

### **B3. Maintenance Scheduling System**

One of the other major benefits of the proposed CMMS is that it is used to help the Maintenance Department schedule CNG vehicles for their preventive maintenance procedures. When the vehicles enter the fueling lanes on return from their daily shifts, the fueling lane personnel uses the CMMS to collect data on fuel consumption, distance the vehicle traveled, and any damage that occurred to the vehicle. By having electronic records of the distances traveled per day, the Maintenance Department is able to predict when vehicles require preventive maintenance. The CMMS serves to remind the maintenance managers when their vehicles are due for service and allows them to be prepared. This system is quite flexible and gives scheduling data several days to several weeks in advance of service dates, allowing maximum flexibility for Maintenance Department management to maximize the efficiency of their operations.

Since the CNG vehicles and their associated maintenance are new to the CTA and GCBC maintenance staffs, CAIP is concerned with overloading the maintenance personnel with an excess of new procedures and new technology. Adding exposure to new computer systems and electronic maintenance scheduling would only exacerbate the problem. In an effort to reduce this overload, the Maintenance Departments' computer staff implements the maintenance-scheduling program. The interface with the computer output is limited to paper reports (in Arabic) for maintenance supervisors and personnel. By limiting this interface, the maintenance personnel, whose primary function is to keep the CNG vehicles operating properly, are not forced to become CNG and computer literate at the same time. This also benefits the overall project by not slowing the overall vehicle implementation while maintenance staffs are receiving the required computer system training.

### **B4. CNG Fuel System Inspection and Maintenance**

The majority of past CNG fuel system failures in North America could have been prevented through the proper usage of visual inspection programs. In fact, the major concern with physical damage to CNG fuel containers on vehicles – container ruptures – can be all but eliminated through proper visual inspection regimens. Therefore, aside from the routine and preventive maintenance applicable to the standard chassis and body components, the addition of natural gas fuel systems to the new transit buses strictly requires the Performance Teams to carry out documented inspections of these fuel system components.

CAIP is working with the chassis and fuel system component manufacturers to develop acceptable inspection procedures and intervals for all the fuel system components, including containers, pressure relief devices, and high pressure fuel lines and fittings. This inspection procedure development includes the determination of specific, necessary measurement equipment, damage measurement and determination criteria, allowable repair procedures, inspector training criteria, container labeling requirements, and even equipment to condemn containers that are not repairable.

## **C. Technical Department**

The new Technical Department in the garages is in charge of implementing and maintaining the new, technologically advanced systems that are new to the CTA and GCBC staffs, including the CMMS. The Technical Department also is in charge of quality assurance/quality control (QA/QC), technical training for CNG garage personnel, and assembling a clearinghouse/library of technical literature for natural gas vehicles and fueling stations.

### **C1. Computerized Maintenance Management System (CMMS)**

The CMMS that CAIP proposes is the heart of the CTA and GCBC maintenance operations, spare parts management, and even vehicle performance evaluation. Interface with the CMMS begins as soon as vehicles enter the fueling lanes upon return from their regular transit shifts, continues through the maintenance scheduling and spare part inventory control, and finishes with logging information about how each vehicle in the fleet is performing. Figure A3 shows a potential input/output diagram for the CMMS.

#### **C1a. Fueling Lane Operations**

As the CTA and GCBC CNG vehicles end their shifts and enter the fueling lanes, data acquisition using the CMMS begins. The fueling lane personnel are responsible for using the CMMS to record the arriving vehicle's identification number, odometer reading, fuel consumption, damage found, if any, fluid consumption, and whether the vehicle was routed for additional maintenance.

The initial data collection allows CTA and GCBC management to electronically track necessary information about each of their vehicles, to track how it performed in the past (including fuel and spare parts consumption), and to determine when it is due for future maintenance. This vehicle-by-vehicle data is collected through computer terminals located in the fueling lanes. These terminals electronically send this data directly into the CMMS. The computer then stores this information in the appropriate file for each vehicle.

#### **C1b. Maintenance Scheduling**

Based on the odometer data collected, chassis, body, and engine manufacturer requirements for preventive maintenance, and other unique maintenance data collected, the CMMS produces maintenance scheduling reports. These reports notify the Maintenance Department when specific vehicles are due for maintenance. Since the system collects all historical odometer data for each vehicle, the CMMS is able to determine the average daily distance traveled and predict when vehicles are due for preventive maintenance. This data can be generated daily, or in advance, allowing the Maintenance Department to schedule vehicles more efficiently.

#### **C1c. Maintenance Data Collection**

The CMMS is used to enforce mandatory maintenance procedures by requiring that reports on those procedures be filed in the system for each vehicle. An example of this type of reporting is the required inspections of the CNG fuel systems. As each required inspection is completed, the inspection report is electronically filed in the CMMS. In this way, not only

does the CMMS remind the Maintenance Department that the inspection is required, but it also serves as a repository for inspection reports to prove that they have been completed.

This type of reporting system also is useful for tracking any information or reporting that is required by the chassis, body, or engine manufacturers to comply with their warranty regulations. That way, if a manufacturer is hesitant to provide warranty support on a specific issue, the information is readily available to expedite solving the problem.

The CMMS provides many benefits, and one of the most important is the ease with which the bus companies can implement a CNG bus performance monitoring system. By simultaneously tracking all parts usage, maintenance scheduling, and daily vehicle usage data, the Technical Department is able to determine how each and every CNG vehicle in the CTA and GCBC fleets is performing. The following is a description of the proposed “Performance Monitoring” System.

#### **C1d. Performance Monitoring System**

Operation of the new CNG garage is organized around the CMMS. This CMMS is used to record and monitor every aspect of the performance of the new CNG vehicles. It also is used to track and account for the use of labor time, spare parts, supplies, and other resources, as well as scheduling preventive and corrective maintenance. Reports and analyses provided by the CMMS provide essential responses and quality measurements for the continuous quality improvement program. By means of this system, data on the performance of each bus, each performance team, and even of each driver and mechanic, is made available on a continuous basis, not only to bus company management, but also to the teams themselves. Among the types of information and statistical data tracked and reported by the CMMS are the following:

- Daily fuel consumption per kilometer by each bus compared to past performance by that bus and driver, as well as to fleet averages (anomalies in fuel consumption may indicate maintenance problems, or a need for more training in driving techniques);
- Daily consumption of fluids and other supplies by each bus, compared against past performance and fleet norms for all buses;
- Daily kilometers operated by each bus compared against past performance and fleet norms;
- On-road service calls by type of incident, performance team, mechanic responsible (if maintenance related), bus, and bus driver; and
- Consumption of spare parts and supplies by bus, performance team, and the fleet as a whole; existing parts and supplies inventories; and the expected period that existing inventories would last based on historical consumption patterns (this is used to ensure that adequate, but not excessive, parts and supplies inventories are on hand at all times).

Supervisors, managers, and the team members themselves use the outputs from this system to assess performance and identify any problem areas where attention or additional training may be required. To ensure that all team members are able to take advantage of this system, they

undergo training and receive extensive coaching in using the CMMS, as well as in the concepts and techniques of continuous quality improvement.

### **C1e. Spare Parts Management**

As explained above, the maintenance personnel are required to request any spare parts through the Inventory Control Section (ICS) of the Financial Department. At each step in the process, the CMMS is used to record the transactions. Since the CMMS knows the initial spare parts inventory of the CNG Parts Stores, as each additional spare part is distributed, the system is updated and the resulting inventory of each component is known instantly. As the inventory of a specific part is depleted, the Purchasing Department is notified by the CMMS and, thus, knows that these parts need to be ordered before the stock is depleted completely.

For auditing purposes, the CMMS tracks all of the incoming used parts submitted during approval for replacement components. All of the outgoing new spare parts and the signatures given in approval of the transaction are tracked as well. When the Auditing Department audits the Parts Stores and Purchasing Department, they will have specific data on exactly what should be in inventory. If there is a discrepancy in any parts inventory data, the UPS inventory is used to confirm inventory quantities.

This type of parts management system offers another benefit, namely, the CMMS tracks the total number of parts used and the period over which they were used. Parts consumption data is readily available for budgeting in the Financial Department.

### **C2. Quality Assurance/Quality Control**

The QA/QC Section of the Technical Department plays a role similar to the one it currently has at the CTA and GCBC diesel garages. This includes monitoring the quality of service maintenance, vehicle performance (including overall fuel, oil, and parts consumption), vehicle repairs, correlation between distances traveled and fuel consumption, revenue per kilometer, and proper flow of required paperwork inside the respective garages.

In addition to these tasks, the QA/QC Section has the new responsibility of confirming all CNG fuel system inspection procedures. Although the Maintenance Department is required to electronically file all fuel system inspection reports, the actual paper checklist inspection report is filed with QA/QC Section. Although this might seem overcautious, it is essential that all required fuel system inspections are done in a timely manner. This task is aided by the CMMS, which provides electronically filed reports to the QA/QC Section directly. The QA/QC staff is required to confirm that they have received the associated paper reports.

### **C3. Training in Conjunction with CTA's Central Administration for Training Affairs**

Since the content of the required CNG training for new CNG vehicle operators, mechanics, and technicians is fundamentally new and technologically advanced, the Training Section is an integral part of the Technical Department. The Training Section is in charge of coordinating all training with the CTA Central Administration for Training Affairs. Due to its overall smaller size, GCBC uses CTA's Central Administration for Training Affairs for its training needs.

During the development and operation of the initial pilot fleets at CTA and GCBC, CAIP is monitoring operations and maintenance closely in order to identify and correct any

deficiencies in the training curricula. Once any necessary changes are made to the curricula, training proceeds on a continuous basis. Continuous training serves three purposes:

- Refreshing and/or updating training already given to CNG operations and maintenance staff.
- Career advancement training for higher-level positions.
- Expansion of the supply of trained staff as required by the expansion of the CNG bus fleets.

#### **C4. CNG Information Clearinghouse**

Since this is the first large-scale implementation of CNG transit buses at CTA and GCBC, it is important for each facility to have immediate access to technical data and safety information about the use of CNG and natural gas vehicles, in general. The CNG clearinghouse/library in each garage is an integral part of the Technical Departments. It also serves to answer any questions or concerns that new mechanics may have, even after conclusion of their general and specific training programs.

One of the unanticipated problems in some new CNG transit garages in North America was the lack of readily available information on natural gas vehicles for garage employees. Many employees in these garages received basic training, but did not have easy access to all the information they required or wanted. This situation led to employees being uncomfortable with, or afraid of the vehicles they were working on, and consequently, resulted in poor labor relations and employee performance.

Since CNG technology is so new in this application in Egypt, it is important to have readily available information for technicians performing maintenance and repairs directly on CNG vehicles. Employees involved with work not directly connected to the CNG fleet should also have access to materials in the clearinghouse. The CNG clearinghouse in the Technical Department serves both purposes.

#### **D. Safety Department**

The Safety Department is in charge of occupational safety, fire fighting, and garage security. Occupational safety requirements cover the “dos and don’ts” of using natural gas vehicles in the CTA and GCBC garages. These requirements ensure that CNG vehicle usage, fueling, and maintenance are being done in a safe manner and follow all the written safety rules published by the manufacturers of the vehicles and fueling stations. The occupational safety personnel also are required to endorse the CNG fuel system inspection procedures, intervals, and accuracy. This additional effort by the Safety Department, combined with QA/QC confirmation of the inspections, ensures that the required inspections are being performed, and moreover, being done so correctly.

One of the most important duties of the Safety Department is site security. The CNG buses are brand new at the CTA and GCBC garages, and the natural gas fueling station equipment is substantially different from the current diesel equipment. It is imperative that the security staff keeps a watchful eye on the entire facilities. Opportunities for vandalism, and even sabotage, of new equipment is not uncommon in major metropolitan areas. While the CAIP

team is working to increase public awareness about the safety of natural gas vehicles, it is still necessary to have security personnel enforcing rules against trespassers on the properties.

### **E. Transportation Department**

The main purpose of the Transportation Department is to ensure that buses are ready to operate each morning with drivers, fare collectors, proper dispatching, and route planning. The Transportation Department also includes the bus fuelers and cleaners, since they are an integral part of readying buses for morning call. Since appearance and cleanliness is undoubtedly part of the criteria upon which the garage Performance Teams are rated, the bus cleaning personnel also is part of individual teams.

### **F. Financial Department**

The proposed Financial Department is in charge of the garage accounting, cashier, budgeting, purchasing, and inventory control. Purchasing and inventory control plays an integral role in the proposed parts management system and both sections will have direct links to the CMMS.

The CMMS designed to simultaneously warn the Inventory Control and Purchasing Sections that the Parts Stores is running low on a particular part or set of parts. When this occurs and it is determined that there is an actual shortage, the Purchasing Section interfaces with the corporate Purchasing Department to obtain a new supply of parts.

### **G. Auditing Department**

The Auditing Department is directly in charge of monitoring the garage accounting, payroll, cashier, purchasing, and inventory control. The Auditing Department also plays an integral role in maintaining the integrity of the CMMS by conducting regular checks of the Parts Stores to confirm the CMMS inventory reports.

If the Parts Stores does not have the inventory to match the CMMS inventory reports, the UPS is audited as a second check on the electronic inventory. CTA and GCBC routinely store used parts that are collected in the current diesel inventory control program for up to six months before they are given up for public auction. Therefore, quarterly auditing of the Parts Stores is done to take advantage of the UPS as a backup inventory control method.

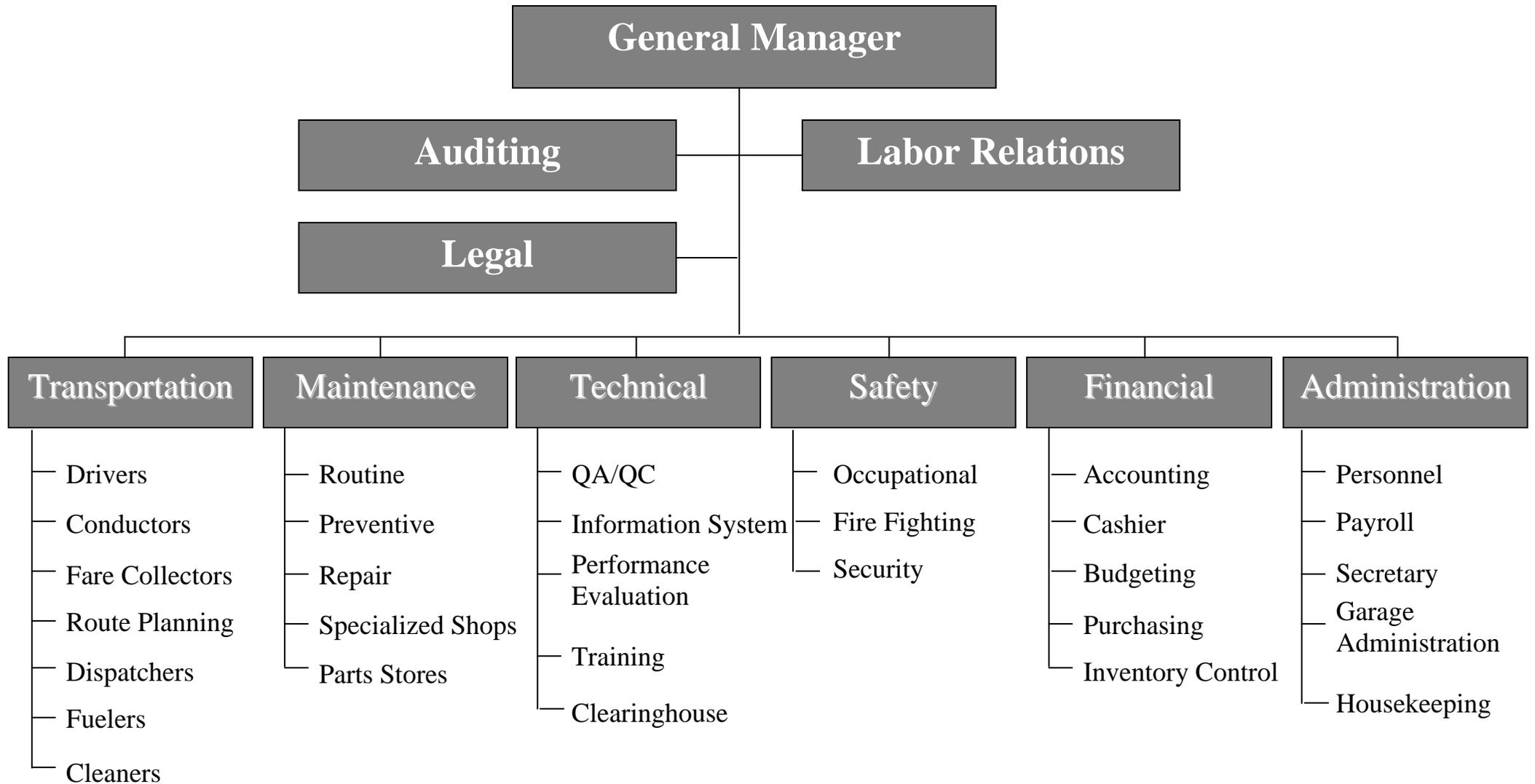
### **H. Administration Department**

The Administration Department is in charge of garage personnel issues, payroll, secretarial functions, and overall housekeeping.

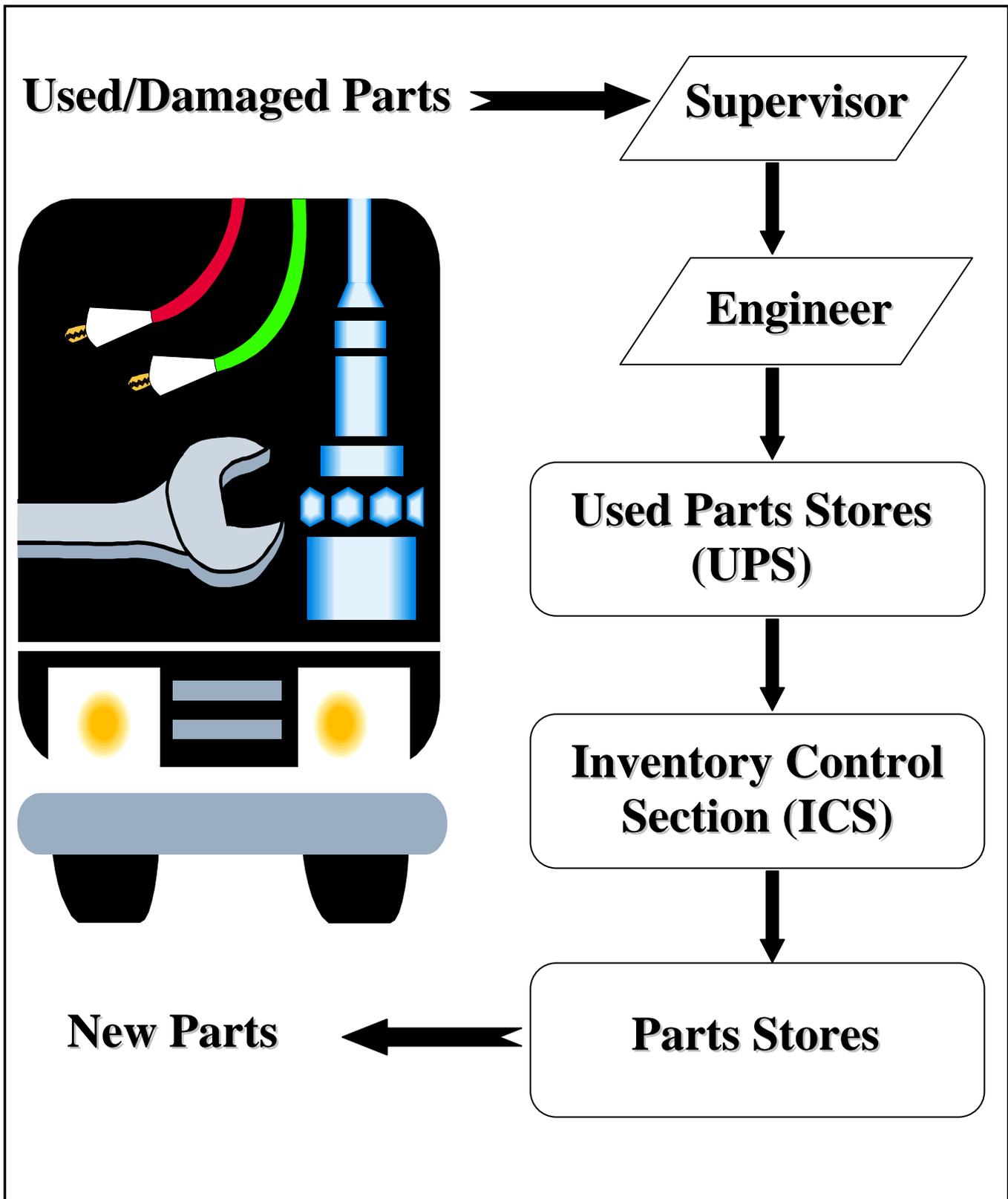
### **I. Legal and Labor Relations Departments**

The Legal and Labor Relations Departments play similar roles to these departments in the existing diesel garages.

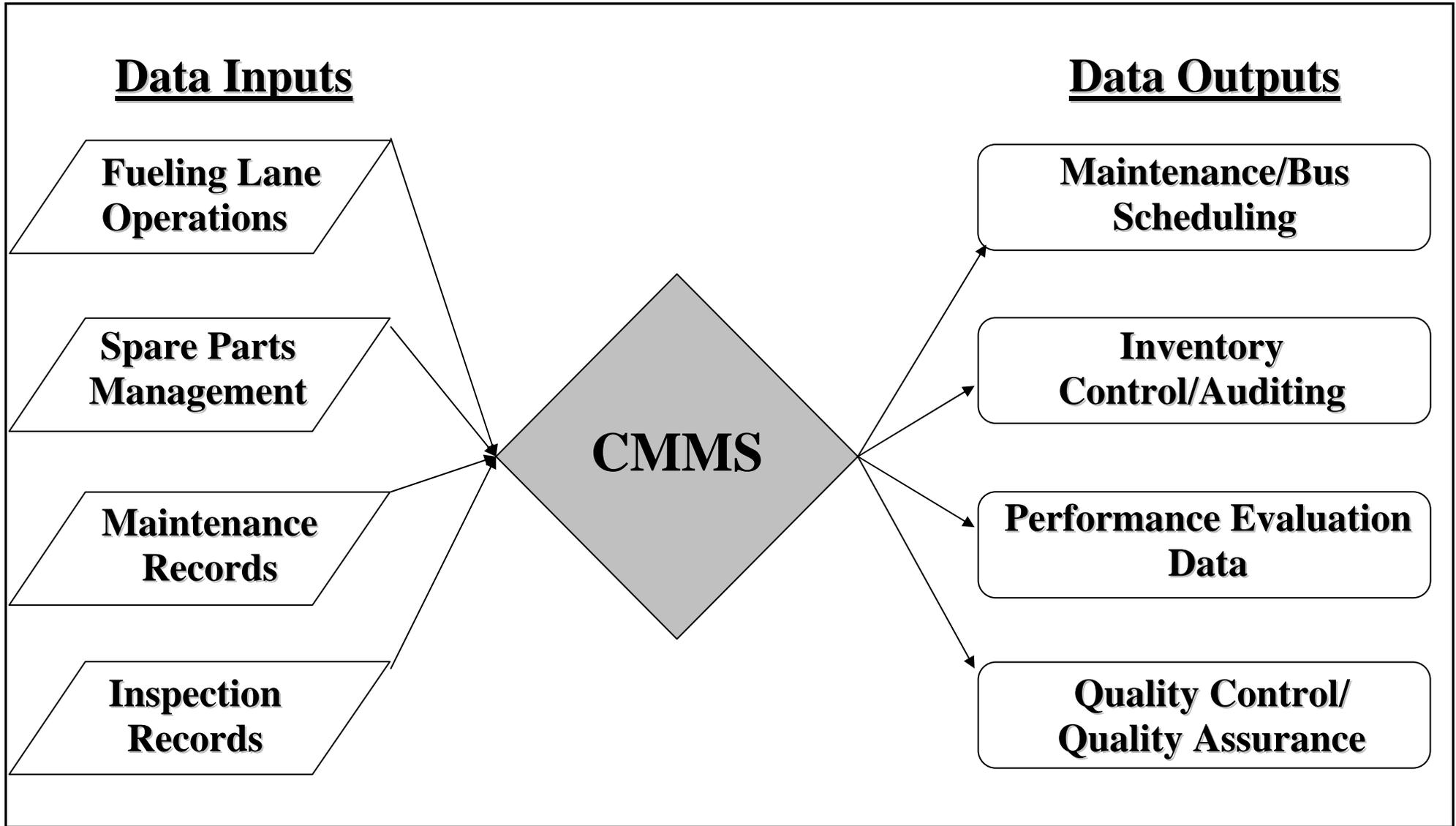
**Figure A1. Proposed Organization Chart for CTA and GCBC CNG Garages**



**Figure A2. Parts Request Flowchart**



**Figure A3. CMMS Input-Output Diagram**

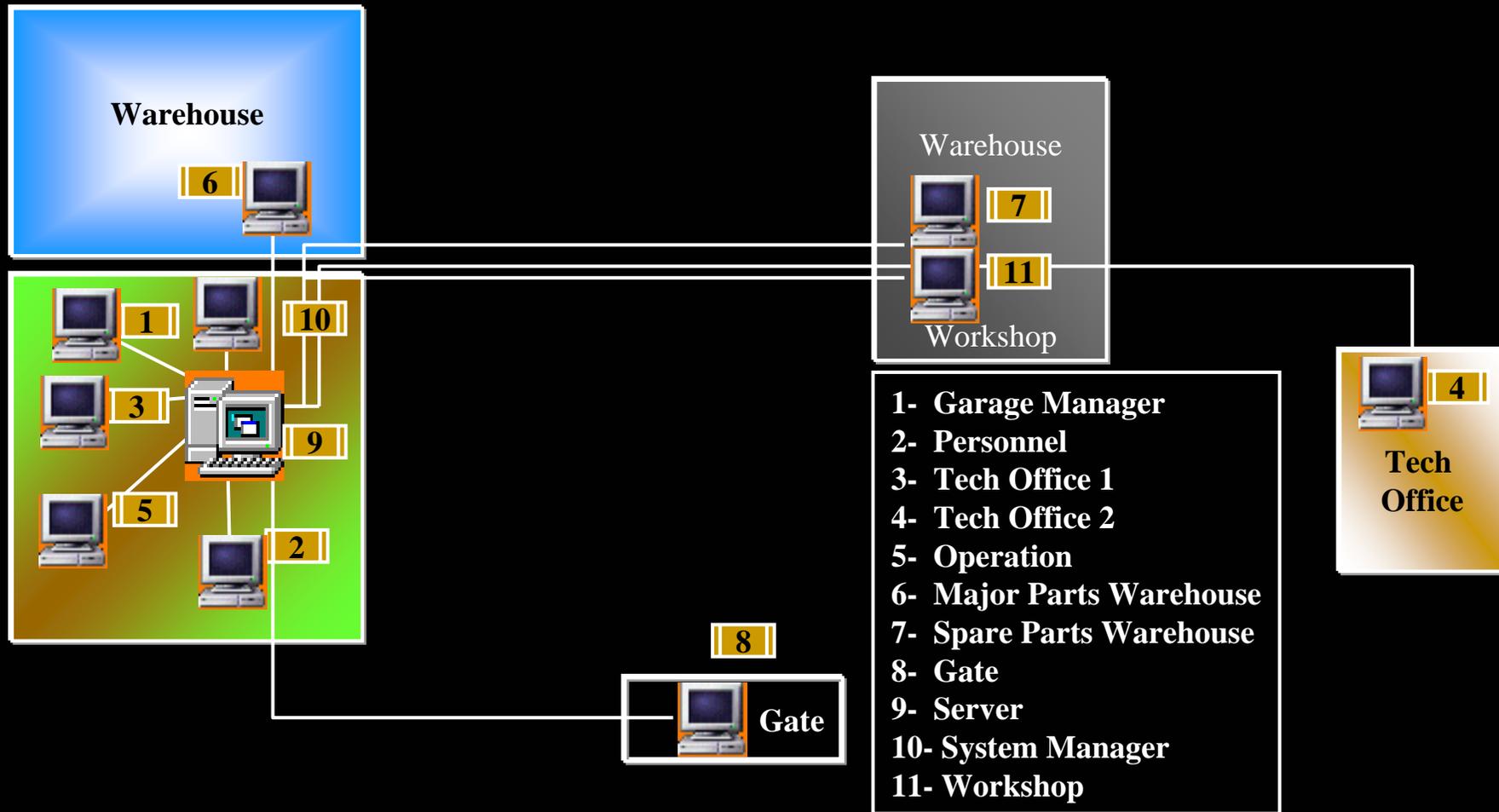


## **ANNEX B**

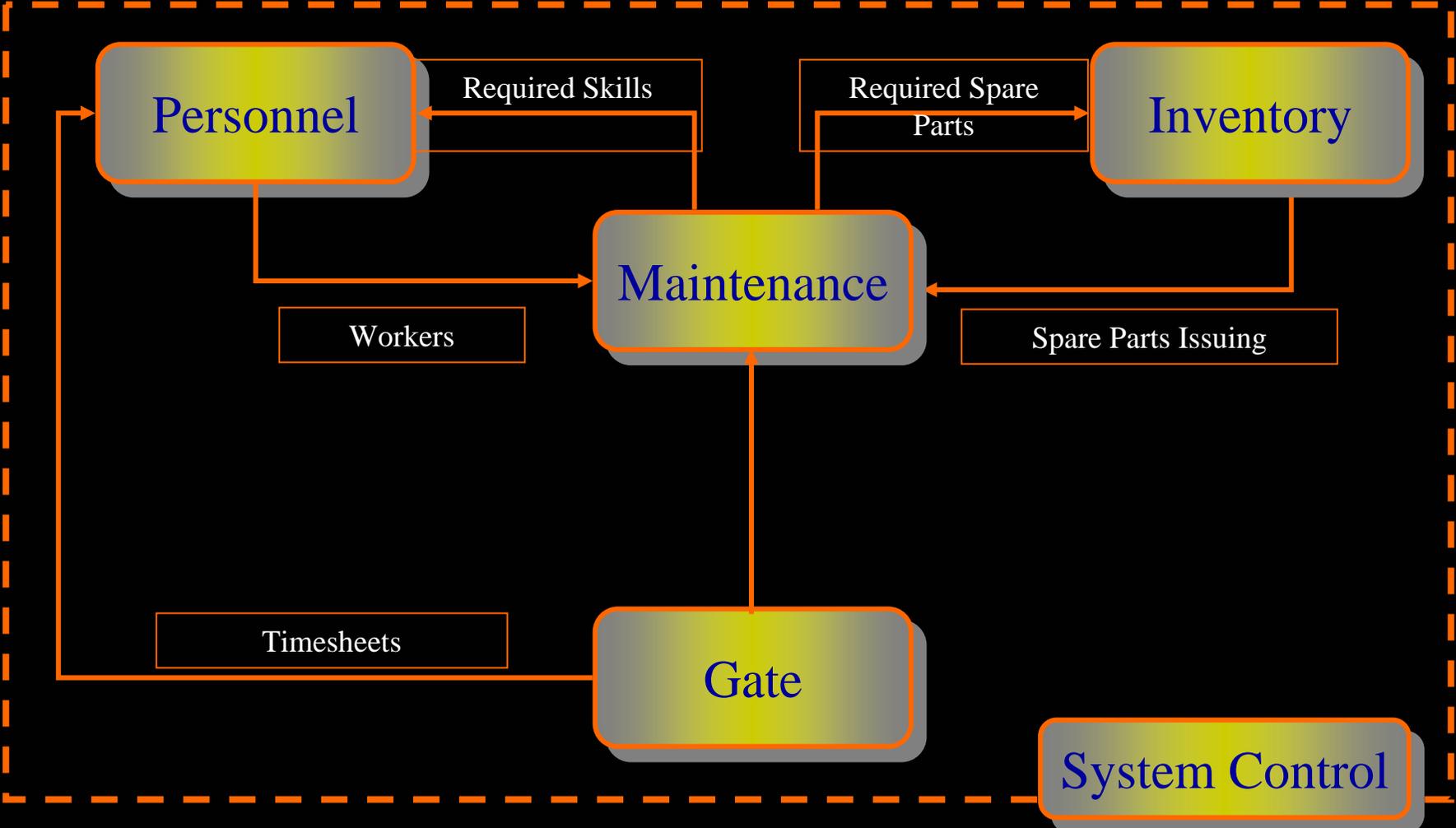
### CMMS Software Architecture: Relationship and Interconnectivity

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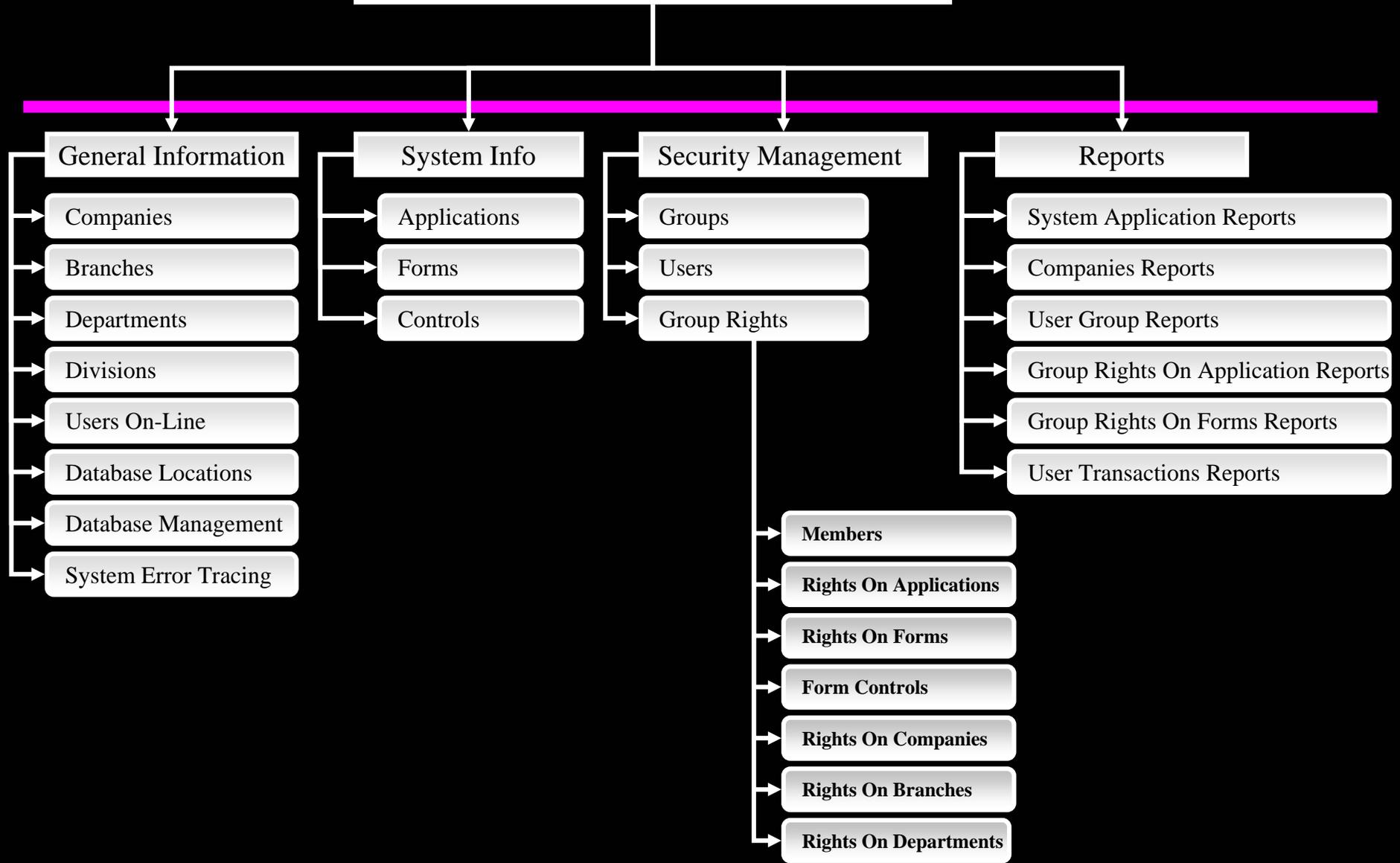
# Figure B1. Garage Computer Network



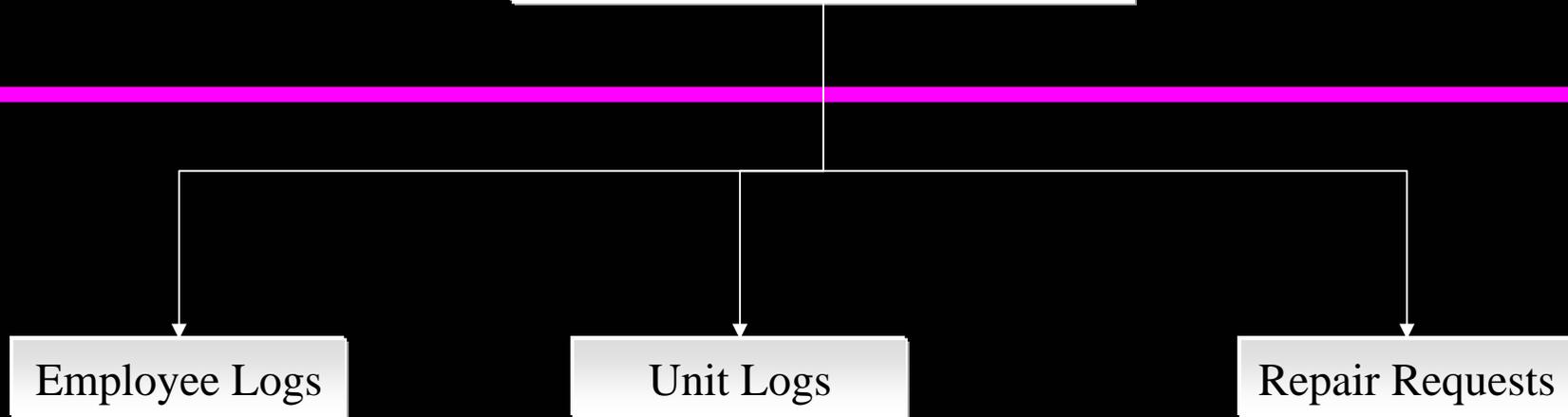
**Figure B2. CMMS System Relations**



**Figure B3. System Control Module**



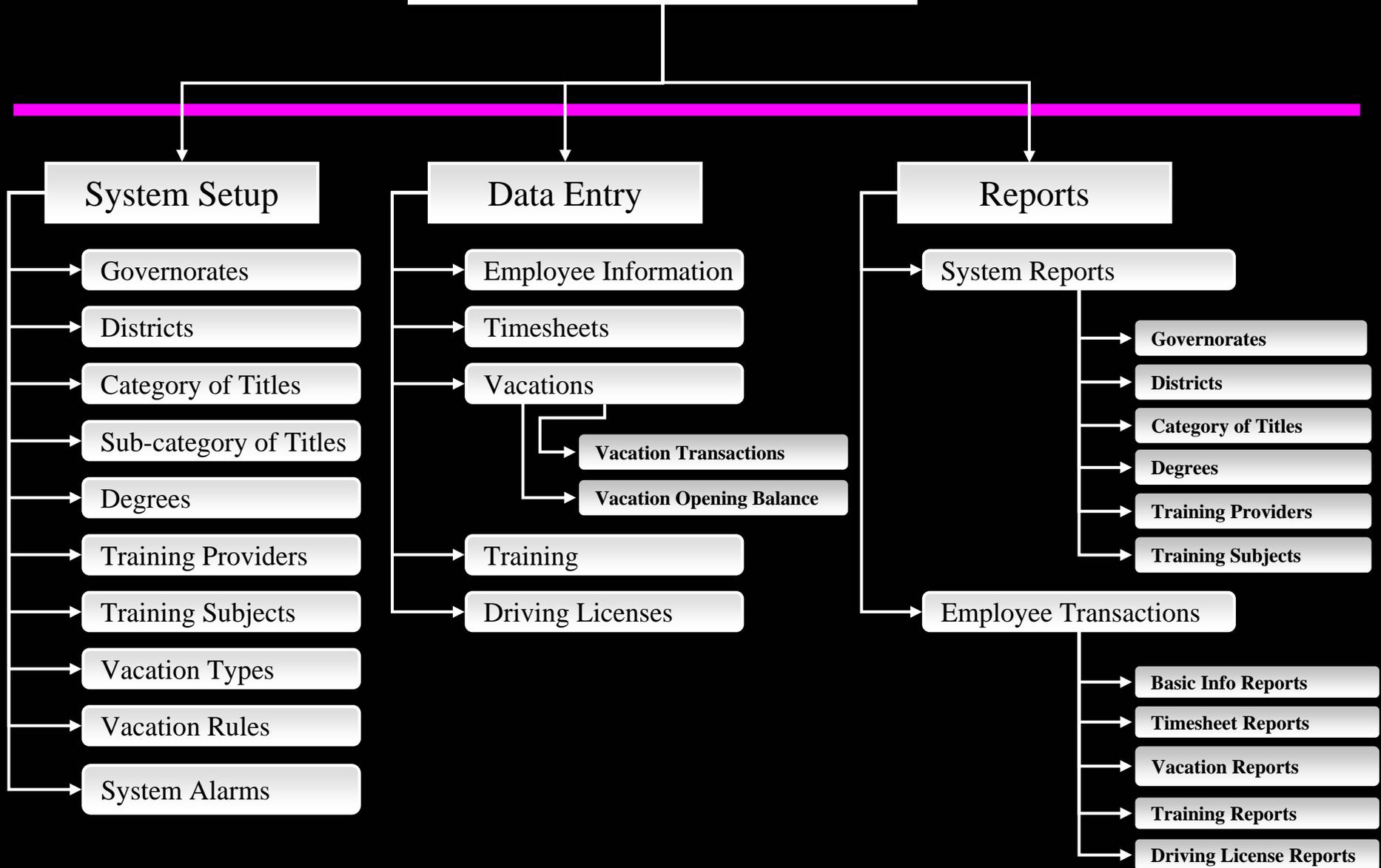
## Figure B4. Gate Module



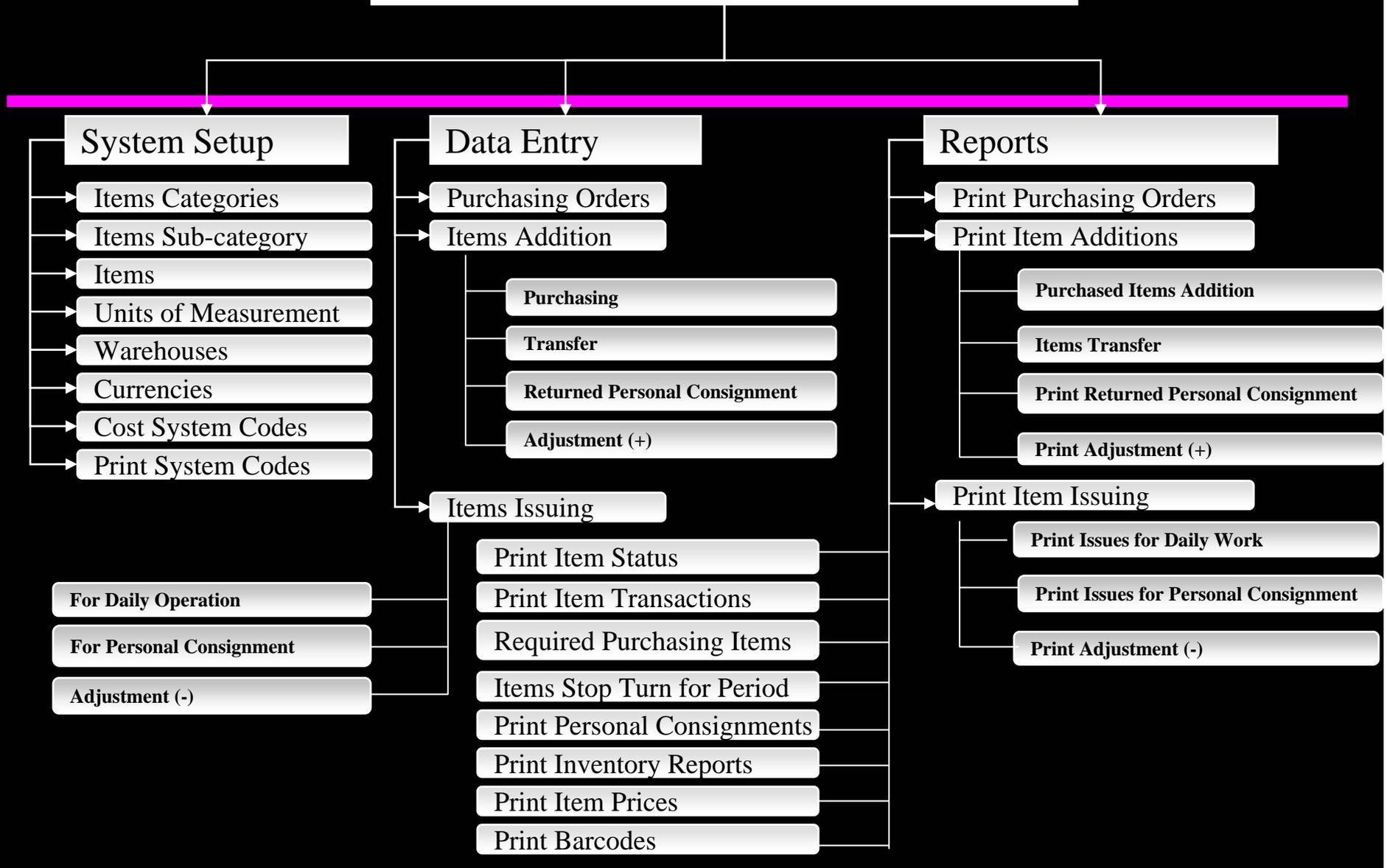
- **Records Employee (Timesheet) Logs**
- **Records Unit (Bus) Logs**
- **Records Repair Requests**



**Figure B5. Personnel Module**



# Figure B6. Inventory Module



**Figure B7. Maintenance Management Module**

