Submitted to:

Washington Metropolitan Area Transit Authority

Assessment of Elevator and Escalator Maintenance & Repair Program
Final Elevator Audit Submission

Submitted by:

Draft prepared:
September 30, 2010
Executive Summary

VTX was asked by WMATA to perform an audit of the Elevator Escalator preventive maintenance organization and procedures. As part of the effort, VTX audited 30 escalators and 9 elevators at the following stations:

- DuPont Circle
- Woodley Park
- Foggy Bottom
- Bethesda

VTX also reviewed and observed how ELES utilized Maximo® for preventive maintenance procedures and management activities. We also observed the work flow process for both planned and corrective maintenance activities.

WMATA has significant challenges maintaining 100% of the elevators and escalators in the system. There are no comparable installations like this in the United States in either the public or private sector. It is clear that WMATA has made significant investments in training and recruiting of elevator mechanics to perform maintenance on the equipment.

We have concluded that the mechanics have the basic skills necessary to perform the preventive maintenance tasks required. We also conclude that the leaders of ELES have a clear understanding of what is required to maintain the elevators and escalators in this system.

Our analysis has revealed the following areas of concern that will need attention and support for ELES to reach its full potential.

- There are significant safety concerns with water intrusion into the elevator and escalator machinery and controller areas. This is a life/safety hazard for anyone working in those conditions. Further, the water also damages the equipment and can inhibit preventive maintenance activities due to safety concerns. This is a significant problem that requires correction.
- WMATA has effectively adapted wage rate changes for their mechanics with the local elevator unions. This adaptation must be considered for the vital positions of supervisors and superintendents within ELES. These vital members of your staff are responsible to direct the mechanic’s efforts in accordance with the direction of ELES management. The qualifications of management and supervision at this level needs to be at the highest level possible to accomplish the necessary requirements and procedures. Several positions in this area are vacant, in part due to some supervisors returning to the mechanic’s ranks.
- There are some mechanical and procedural recommendations for the elevators and escalators provided in this report. These recommendations should be easily incorporated into the existing maintenance procedures.

Effective preventive maintenance of the elevators and escalators at WMATA will require constant vigilance forever. There is no “end game” that can be reached once any changes are made. Training, recruiting, education and close supervision will always be required. Even with the major investments in both elevator and escalator modernization, it must be remembered that the basic equipment designs (and key components) are over 40 years old.
This means that while improvements gained with the modernization program are significant, the basic modular escalator design has been obsolete for over 20 years. Simply put, this means that WMATA will have increasingly demanding maintenance challenges even with the massive capital improvement program.

Successful and effective maintenance of all WMATA elevators and escalators is achievable. The organization, plans and procedures are largely appropriate for their mission. The challenge will be to continually improve, reinvest and adapt as the equipment continues to age and operate exposed to the weather.
Findings and Recommendations
Findings – Elevator and Escalator Audits

The following report focuses on those units made available to us for a maintenance assessment. This section summarizes the findings of our two basic tasks under this agreement.

Methodology

The escalators were allowed to be removed from service for assessment primarily between the hours of 9:00 a.m. and 2:30 p.m., Monday – Friday. Call backs for units shut down within the system took precedence and minor delays were experienced.

For purposes of observation, multiple balustrade panels at the top and bottom of each unit were removed. For those units with glass balustrades, several decking panels were removed to allow inspection of the handrail drive rollers and chains. The floor plates at the top and bottom of each unit were removed and four steps within the rise were removed. A visual inspection of the internal and external condition of each unit was performed and observations of equipment and maintenance conditions were noted. A random check of various operating and safety switches within each unit was performed. Not all switches were checked. The escalator machine rooms and components contained therein were also inspected. Several units had the controllers located within the upper pit/truss area. Those areas were observed as well. Photographs documenting the equipment conditions were taken. These photographs are incorporated within the individual Station-Unit assessment reports in the following section.

Only one condition within the machine room and escalator unit at Foggy Bottom was determined by the inspector as unsafe and was immediately reported to WMATA personnel for appropriate disposition. The audit was not ASME A17.1 certified and not performed by an inspector representing any local Authority Having Jurisdiction. No deficiency list was created or provided to WMATA.

The site inspections of the vertical transportation units identified in this report were conducted by VTX during June, July, and August of 2010. The following tables give a summary of the overall condition of each unit organized by station. For further information, please reference the detailed Station-Unit assessment reports in the following section.
Fig. 1-3 Escalator Nomenclature

NOTES:
(1) Skirt panel.
(2) Interior panel.
(3) Handrail stand.
(4) High-deck interior.
(5) High-deck exterior.
(6) Low-deck interior.
(7) Low-deck exterior.
(8) Handrail.
(9) Exterior panel.
(10) Newel.
(11) Newel base.
(12) Dynamic skirt panel.
(13) Dynamic skirt panel cover.
**Condition and Classification Criteria**

Included in this preliminary assessment are three classifications of equipment and maintenance condition: Good, Fair, and Poor. The basic criteria for determination of each condition classification are as follows:

Good – Machine room and external and internal components of the equipment have no signs of major damage or wear, are clean, and free of excessive lubricants, dirt, and debris. The internal components of the equipment are clean, well lubricated, and adjusted for proper operation.

Fair – Machine room and external and internal components of the equipment have minor signs of damage or deteriorating wear and contain notable amounts of dirt and debris. Dirt and debris amounts associated with this classification are normally found at the end of the monthly maintenance cycle.

Poor – Machine room and external and internal components of the equipment have major signs of damage or deteriorating wear and contain excessive amounts of grease, dry lubricant, dirt, and debris. This classification is associated with equipment where a condition of prolonged absence of maintenance exists.

<table>
<thead>
<tr>
<th>Equipment Unit</th>
<th>Assessment Date</th>
<th>Location</th>
<th>Equipment Type</th>
<th>Cleanliness</th>
<th>Operation</th>
<th>Lubrication</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Woodley Park</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
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<tr>
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<td>Poor</td>
<td>Poor</td>
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<td>----</td>
<td>Poor</td>
<td>Poor</td>
<td>Fair/Poor</td>
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<tr>
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<td>----</td>
<td>Poor</td>
<td>Poor</td>
<td>Fair/Poor</td>
</tr>
<tr>
<td>Escalator A04X05</td>
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<td>Station</td>
<td>----</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td>Escalator A04X06</td>
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<td>Station</td>
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<td>Poor</td>
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<td>Fair</td>
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<tr>
<td>Elevator A04X01</td>
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<td>Traction</td>
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<td>Good</td>
<td>Fair</td>
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<td>Platform</td>
<td>Hydraulic</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment Unit</th>
<th>Assessment Date</th>
<th>Location</th>
<th>Equipment Type</th>
<th>Cleanliness</th>
<th>Operation</th>
<th>Lubrication</th>
</tr>
</thead>
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<td></td>
<td></td>
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<td>Fair</td>
<td>Fair</td>
<td>Poor</td>
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<td>Station</td>
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<td>Poor</td>
<td>Fair</td>
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<tr>
<td>Escalator A09X03</td>
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<td>Station</td>
<td>----</td>
<td>Poor</td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td>Escalator A09X04</td>
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<td>Station</td>
<td>----</td>
<td>Poor</td>
<td>Fair</td>
<td>Fair</td>
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<tr>
<td>Elevator A09X01</td>
<td>6/17/2010</td>
<td>Street</td>
<td>Traction</td>
<td>Fair</td>
<td>Fair</td>
<td>Poor</td>
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<tr>
<td>Elevator A09X02</td>
<td>6/17/2010</td>
<td>Platform</td>
<td>Hydraulic</td>
<td>Fair</td>
<td>Fair</td>
<td>Poor</td>
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</table>
## Equipment (Machine Rooms, Hoistways, and Pits)

- The elevator and escalator machine rooms (and supporting areas where applicable eg: escalator well ways) fail to provide sufficient lighting for maintenance and troubleshooting purposes. The rooms are underground and solely dependent upon electric lighting. This condition creates an unsafe working environment for technicians tasked to work in those areas.

### Findings and Observations

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Unit Number</th>
<th>Assessment Date</th>
<th>Location</th>
<th>Equipment Type</th>
<th>Cleanliness</th>
<th>Operation</th>
<th>Lubrication</th>
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<td>Fair</td>
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<td>7/6/2010</td>
<td>Station</td>
<td></td>
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<td>Fair</td>
<td>Good</td>
</tr>
<tr>
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<td>Good</td>
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<td>Fair</td>
</tr>
<tr>
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<td>Escalator</td>
<td>A03S02</td>
<td>8/19/10</td>
<td>Entrance</td>
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<td>Poor</td>
<td>Poor</td>
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<tr>
<td>Escalator</td>
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<td>Poor</td>
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<td></td>
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<td>Good</td>
<td>Good</td>
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<tr>
<td>Escalator</td>
<td>A03S07</td>
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<td>Platform</td>
<td></td>
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<td>Good</td>
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<td>Hydraulic</td>
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Draft prepared: September 30, 2010
The elevator and escalator machine room areas are not climate controlled. The technological advances in vertical transportation controls systems require the use of micro processors for operation control. This equipment is dependent on climate controlled atmospheres to provide efficient operation of the logic systems. Many equipment failures are a result of extreme fluctuations in environment temperatures.

Pay more attention to and provide consistency throughout the system for general housekeeping, such as removal of trash and non elevator related equipment from machine rooms, clean up of water/oil from pits.

There appear to be discrepancies in contracted speeds and actual speeds.

A significant follow up to the status of Elevator and Escalator Services Department (ELES) requests to physical plant for repairs to machine room and supporting equipment areas needs to be performed. Specific attention needs to be given to water intrusion prevention in the machine rooms, hoistway, and pit area.

**Elevator Performance**

Our measuring tool (Maxton-SafeTach) measures the speed and forces of hydraulic and traction elevators felt during elevator movement. It provides real-time performance information.

**Escalator Performance**

The Parametricoder is a time and displacement encoding system that measures mechanical performance characteristics on escalators. It is able to secure additional performance data to allow individuals to assess conformance to design and operational parameters. It uses precision linear and rotational encoding systems, coupled with a robust data collection system, to permit simple field measurement of specific parameters of escalators and moving walks. The system has allowed us to clearly indentify key issues on client escalator systems including:

Summary: The overall speed and leveling performance indicates a lack of attention. Three of the elevators have acceptable speeds with poor leveling or no leveling. The remaining six units have inconsistent speeds ranging 10 to 30 fpm below the contract/unit rating.
- Incorrectly adjusted and/or damaged brake systems
- Worn and damaged machine components including roller chain and gear sets
- Failed electrical control elements used in processes

Summary: All escalator brakes have questionable stopping performance under no load with respect to their ability to stop and hold with full passenger load. I.e. no load stopping distances appear to be too long for the inertia mass brake systems utilized (to my knowledge) on these designs. Several units exhibit clear signs of wear in driving elements as reflected in the impacts occurring during (a) normal operation and (b) stopping.

**WMATA Operations**

- Management is limited in its ability to use best qualified field labor by “Pick” system. To be effective, management must be able to use best qualified field labor to meet equipment service needs. While the “Pick” system would appear to be beneficial in theory, its success is solely contingent upon the performance of the individual worker. The intent of the “Pick” system is to expose each worker to the broadest range of equipment and service scopes, maintenance, service repair, troubleshooting, and adjusting, by rotating work stations semi-annually. It must be realized that not all workers have the ability to perform effectively within each scope.

- As WMATA’s labor force is drawn from a union base, the ability to implement modification of the “Pick” system would require negotiations with the appropriate union representatives. While difficult, the establishment of a mutually beneficial labor relationship is critical to support the implementation of any changes within the current operational model substantial enough to demonstrate significant improvement.

- WMATA may consider using a continuing education program as an effective and more efficient means of analyzing and determining labor skill levels and propensities that would allow supervisors to best use personnel.
• WMATA is currently budgeted for 25 field level supervisory positions. At time of the
performance of equipment assessments, only 20 supervisors were on staff. The necessity for
well qualified, experienced supervision cannot be overstated. It is apparent having reviewed
maintenance records for the vertical transportation equipment included in this assessment
and having compared the level and quality of maintenance actually performed, that the
necessity for supervisory verification of acceptable completion of the maintenance task per
the level prescribed by schedule is critical. The field staffing appears to be at an acceptable
level. The five open supervisory positions need to be earmarked as strategic hires from the
private industry.

• WMATA has had several qualified supervisors return to field level positions due to salary
limitations imposed by WMATA budgeting constraints. As a means of filling these
supervisory vacancies, WMATA may consider performing a market analysis of comparable
salaries for qualified supervisory personnel within the private industry providing equitable
adjustment within WMATA as a means to attract additional qualified staff.

• MAXIMO – Audit of Maximo Program.

• Currently, the ELES Operation Center (EOC) is co-located with the Maintenance Operation
Center (MOC). This is a good idea; however, currently the EOC is crammed into a very small
space which does not allow for a good work environment.

Field Labor
Having performed a physical review of the equipment conditions at the stations selected for
inclusion in this report, it is apparent in some instances that the quality of maintenance being
performed is substandard when compared to manufacturers requirements and recognized
industry standards.

Several key issues of the field labors concern, which are felt to contribute to the difficulty in
maintaining the appropriate maintenance standards, were identified in discussions with field
labor.

• Perceived allocation of adequate time to perform maintenance to the levels of manufacturer’s
recommendations and industry standards were expressed.
• Accountability for conditions of the equipment when received after “Pick” rotation were
expressed.

• WMATA is currently budgeted for 142 mechanic positions. At the time of the performance of
equipment assessments, only 137 mechanics were on staff.

• Equitable/manageable distribution of work load was expressed based on the fields open
positions. VTX is not in agreement by adding just the allocated field staff believing this will
solve or minimize the issues of concern.

• Turnover rate of supporting supervisory and management staff. It is believed among the field
level personnel that this has a tremendous impact on the continuity of communication and
operations procedures.
• Contractor accountability for work performed prior to acceptance and return to service of
equipment.
• Timely performance of work identified by maintenance personnel and assigned as “L” tickets were expressed.

• Unsafe working conditions in the work area. Items of particular importance were, insufficient lighting in work areas and water intrusion in machine rooms and pit areas. Water intrusion in and around work areas where live electrically powered equipment is operational represents a direct threat to life and limb and needs to be given prioritized concern.

• Supervisor / management direction to return units to service prior to allocating adequate time to verify / prove cause of failure.

It must be clarified that while the field labor concerns identified above were expressed, the verification of all concerns expressed was not included in the scope of this report and cannot be verified by VTX.

**Maintenance**

Obvious signs of conditions requiring immediate maintenance/service address are being overlooked. Some examples witnessed during our assessments of the elevators and escalators include but are not limited to the following:

• Major amounts of oil and lubricant on step treads and risers. Symptomatic of major leak at drive motor / reducer coupling.

• Significant accumulation of metal shavings around hand rail newel areas from worn newel wheels.

• Brake pads worn beyond usable life expectancy and out of adjustment allowing unit to freewheel to stop.

• Numerous switches in safety circuits were dirty, out of adjustment, and ineffective.

• Skirt panels were adjusted too tightly to the steps, creating metal shavings along the step roller tracks in the interior of the unit.

• Hoist ropes severely rouged and worn beyond acceptable life expectancy.

• Sheet plastic being used to protect equipment from water intrusion. This is a critical life safety issue.
Findings and Work Flow – Maximo

An audit was performed of the work flow process of ELES to determine if the current process was functioning as intended and if there was any room for improvement. The current work flow process that is in place and used by ELES for their work order management is a good one. There are defined, written standards on how the process is supposed to work, and this process is followed.

Quality control/assurance is performed to ensure the accuracy of the data that is captured through WMATA’s Computerized Maintenance Management System (CMMS), Maximo. Standard management reports are then run with the confidence that the data contained in the reports represent an accurate picture of the state of the ELES assets. Personnel understand their job functions, and perform their jobs in a competent, professional manner. Overall the current work flow process being used by the EOC is performing as intended. There are, however, a number of areas where improvements can be made.

Findings

Multiple site visits were performed to interview personnel and observe the workings of the EOC over a two month period. During these visits, multiple shift changes were observed to watch the handover of data and beginning/ending of the shifts. All three of the shifts were observed to get a good feel of the different challenges encountered by each shift. Although generally things are running well with the work order process, there are some things that were noticed during our visits and are worth noting.

ELES Operations Center
There are three shifts throughout the day (day, evening, and overnight) at WMATA, all are manned in the EOC and with ELES mechanics. There is always at least one dispatcher on at any one time in the EOC. During what is considered the peak times (Tuesday-Thursday), there are two dispatchers scheduled on a given shift. Having two dispatchers on any shift appears to be an appropriate staffing level for operations Monday through Friday. Dispatchers are responsible for entering work order data into Maximo and monitoring and recording the assignments and locations of the ELES mechanics.

They also are responsible with dealing with requests for work that comes in either through the telephone or through the MOC. During the day and evening shifts, mechanics are dealing with an abundance of callback work orders, as these two shifts encompass the peak commuting hours for the general public.

The overnight shift deals primarily with PM work orders, as the machines can generally be taken out of service with lesser impact during this time. The weekends are somewhat slower, because the ridership is generally down during this period.

There is also a day and overnight supervisor. Supervisors are responsible for monitoring and overseeing the dispatchers and their work, assuring the accuracy of the data that is input into Maximo, and overseeing the reporting on out of service units and other daily activities. Supervisors also are responsible for coordinating and scheduling the materials and outside support requests and needs. Currently, the evening supervisor position is open. This position should be filled, as the evening shift contains the PM rush home for commuters.
The EOC was moved from its location at the Carmen Turner facility to its new location at the Jackson Graham Building to be co-located with the MOC for WMATA on June 28th. It will relocate back to the Carmen Turner facility again in approximately 90 days. The current setup in the Jackson Graham building is very cramped and not setup well for either the supervisors or the dispatchers. It is not conducive to the work that is being done. There is little space on the desks to keep both a telephone and a notepad. There are also less workstations available than before. There are only two very cramped workstations, as opposed to the four they had previously.

This situation causes major issues during the shift changeovers, as one shift cannot begin work until the previous is completely finished and logged out. This causes the handover between shifts to be less effective than it could be if all of the dispatchers could be logged in at once and communicate while looking at the same information simultaneously. It would also allow a few minutes for the on-coming shift to get settled and logged in to their programs prior to the previous shift leaving.

It appears that the transition to the new building was not well thought out before it was implemented. A lot of things such as phone lines and other essentials were left undone prior to taking over the new space. More forethought should be given to ensure that the workstations are up and running and tested, prior to moving back to the Carmen Turner facility in the future to prevent possible data gaps.

Both supervisors and dispatchers understand the importance of accurate data being entered into Maximo for reporting purposes. This is critical to ensuring that the data contained in Maximo is accurate and the reports that are run present an accurate picture of the maintenance being done. There is also very good communication between dispatchers and between dispatcher and supervisors while working their shift. This level of communication leads to some nice synergy and also ensures that all of the inquiries are handled promptly during peak rushes.

The change in shifts between dispatchers is handled very well. There is good communication between dispatchers and between supervisors during the shift change activities to ensure that nothing is dropped and any critical issues are carried over from one shift to the next.

**Maximo**

Currently, Maximo version 6.2TR is being used. An upgrade to Maximo version 7 is planned for sometime in the future. Overall, Maximo is not being used to its full potential. There needs to be some more development of the software to configure it better for ELES use. One of the biggest problems is that ELES equipment and work orders are not easily filtered from the rest of WMATA’s equipment. The wrong fields are used to setup filtering and sorting to exclude other WMATA equipment. These fields then lose their intended functionality.

One example is the serial number field on equipment. This field is used to sort ELES equipment. This does not allow ELES to keep the unit’s serial number in Maximo. This prevents ELES from using the full capabilities of Maximo. While it is currently usable in the current setup, ELES is being shortchanged by not being able to use certain fields as they are intended, since they are now used for sorting, filtering, or grouping.

Maximo is hard for new users to navigate. There is a lot of clicking back and forth to find certain areas or assets. To be able to properly use the program to its maximum potential, good user training is needed. It is essential that training is given to all personnel whose job functions...
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involve heavy use of the Maximo system. In addition, ongoing training should be strongly considered to ensure that employees are using the most efficient processes in their daily work, and to take advantage of any software upgrades that have been applied.

The work flow process feature of Maximo should be enabled. This would allow ELES to setup a custom work flow with supervisory approval to better document and control their work flow process. Using this module, ELES would be able to have work orders automatically e-mailed to the appropriate supervisor or other personnel for approval before moving to the next step in the work order process. This can also be setup in the inventory section so that a supervisor is automatically sent an e-mail to approve a request for materials. The work flow process can be setup through Maximo so that the approvals are automatically requested and there is no need for interaction from the dispatcher or EOC.

There are a few items worth noting when discussing the way that Maximo is currently setup. Right now there is no keyword search for assets. This would be very helpful to allow personnel who are not intimately familiar with the ELES setup in Maximo to find assets and report on them. All of the codes contained in Maximo are simple numbers; there is no logic to them. There are a lot of purely numeric codes that dispatchers must know and enter for work orders. This makes for an extremely difficult learning curve for new users and also makes it harder for casual users of the program and management to be able to get into Maximo and find things for themselves. Some thought should be given to making these codes have some “intelligence” behind them.

Abbreviations and other methods can be used to help users easily identify the proper codes to be used. Currently, because of all of the generic, numeric codes used within Maximo, it is vital that an up to date user’s guide be maintained and distributed to ELES employees to help them navigate the system. This practice is being performed currently, and must continue.

The use of the maintenance alert function in Maximo allows open work orders for the same piece of equipment to be searched during the creation of a work order so that duplicate work orders are not created. This is very helpful to eliminate the possibility of assigning duplicate work and wasting the time of mechanics sent to work on jobs that are already in progress.

Failure codes are used to identify common problems that occur on the elevators and escalators. Using these codes allows for the tracking of multiple failures of the same type, as well as trending to see the frequency of certain types of common problems. There is not currently in Maximo any estimated versus actual statistics reports. This makes it hard for maintenance supervisors to check the accuracy of the time estimates for work, as well as how well mechanics are performing based on the estimated time for the job. This is a standard industry report that should be programmed into Maximo and used.

**Work Flow Process**
The current callback process is changing now that the EOC is co-located with the MOC. Currently, the station manager calls the MOC to notify them of a problem, the MOC then creates a work order in Maximo. EOC monitors the elevator/escalator out of service report in Maximo to find units that have been called in for repair but have not yet been assigned an estimated completion date. The EOC then opens and finishes entering information on the work order created by the MOC. The EOC notifies the appropriate supervisor via e-mail of the issue and work order number. The supervisor assigns the work order to an employee(s) and replies to the
EOC with the assignment via e-mail. The EOC then assigns the appropriate personnel to the work order.

Once the mechanic(s) is on-site, they call the EOC to let them know the job has begun. The EOC now puts this work order in-progress in Maximo. The MOC is slowly transitioning the calls coming from the station managers to go directly to the EOC to create the work orders. This is a very good idea, as it allows the EOC staff to ask relevant elevator/escalator questions that the MOC may not be aware of, to get as much and as complete information on the work order as possible, so that the job may be completed as quickly as possible. This should be completely put in place as soon as possible to benefit both ELES and the MOC.

Once work has been completed on a job, mechanics call the EOC to close out and complete the work order, and relay all hours that were performed on the job. Supervisors have and use blackberries to assign work and respond to requests when they are out in the field. As mentioned, currently the dispatchers are monitoring Maximo and an out of service report in to find new work orders called into the MOC. This should be changing now that they are co-located with the MOC. This was a very inefficient process.

Currently both e-mails and phones are used to communicate information to and from the EOC to supervisors and mechanics. An excel spreadsheet, called locator, is used to track mechanic whereabouts by dispatchers. Whenever a mechanic is assigned to a job, the unit that they are working on is placed next to their name in the spreadsheet. This method for tracking the mechanics seems to be working very well for them. This locator spreadsheet is also a valuable tool during the shift change-over; it is used to see if there are any mechanics still working and/or any units still out of service. An outage report is sent via e-mail out hourly. This report contains what units are currently out of service by sector (maintenance supervisor). Multiple programs are used and need to be monitored by the dispatchers. Maximo, excel, and outlook are all used almost constantly by the dispatchers to monitor the status of work and check for any new work that comes in. This is in addition to any calls that may come in at any given time.

During times of high call volume, the work order information is captured on paper and then later transferred to Maximo when the call volume dies down. This is a standard industry practice, and should be continued during times of peak inquiries to make sure that all of the information is taken down, as Maximo can lag a little, preventing the real time updating of the program.

E-mail is used during change of shifts to notify of the current status of equipment and to let the maintenance supervisors prioritize and assign work. The locator spreadsheet is transferred, as well as an out of service report detailing all of the units that are not in service at that particular time. A lot of close out information is called in right at the end of a shift. This creates a lot of issues during shift turn over and leaves the potential for something to be dropped. Work order closeout information should be called in shortly after completion of work. Mechanics also need to be better aware of what information is needed to create, update, and close a work order. Too much time is wasted by the dispatchers explaining what is needed. Much of the time the information transmitted by the mechanic is incomplete or incorrect and needs to be coached out of the mechanics by the dispatchers. This increases the work load on the EOC and causes routine calls from mechanics to take up more time than is necessary.

Quality control/assurance is being performed on every work order that is done. The dispatchers are being tracked and graded and this information is shared with them. Overall, the dispatchers
and supervisors seem to have a pretty good handle on Maximo and their job responsibilities. They perform their job competently and professionally.

The process for emergencies or entrapments is working smoothly. The locator spreadsheet is used to find a free employee. The EOC contacts that employee via the phone to go to the entrapment site. The initial call for the issue comes from the MOC straight to the EOC. The mechanics are being dispatched to trouble spots in an efficient manner.

The process for work orders is displayed in figure 1. This process is generally the same for all work types, the exception being that scheduled maintenance or preventive maintenance work orders are generated previously in Maximo and the mechanics call into the EOC when they begin work. The only suggestion for a change in the process is one that is currently being implemented. The beginning of callback process, circled in red, begins in the MOC; it should begin with the EOC.

**Preventive Maintenance**
Maximo automatically generates the PMs each month. Supervisors review the PMs and approve them for the month prior to generation. The EOC creates a child work order off the original PM work order when the crew starts calls in to start work. The process for performing the PM from the EOC side then remains the same as a normal work order, the crew calls in when work begins and ends; EOC creates the child work order and closes it. PMs are scheduled based on codes B,C, E, taken from a paper form containing all of the PM steps. The work flow process for PMs is a standard one, and is running smoothly. There are some PM balancing issues that should be addressed to spread the PM schedule out equally throughout the year.

We propose a semi and annual schedule for clean downs with a small percentage of working hours monthly as a contingency for unexpected circumstances.

**Quality Control/Assurance**
Every work order is reviewed by one of the EOC supervisors for accuracy and completeness. Each dispatcher is scored on the accuracy and completeness of all of their work orders each shift. A report is compiled daily of the accuracy and completeness of each work order done by the dispatcher. This report is then rolled up weekly, monthly, and annually. Dispatchers get a hard copy or e-mail of the report for review, and discussions are had with the supervisors as needed. This process that is in place for the maintaining of quality control and assurance is a very thorough one. By checking each and every work order that is processed, not only is ELES assured of having accurate data contained in Maximo, but the importance of having this accurate data is reinforced to those entering the data. This process also allows management to quickly see any areas of common problems or mistakes by the people entering data and to address them quickly, to prevent the problems from continuing or “snowballing”.

**Reporting**
There is a good variety of reports available for use within Maximo. Many of these reports are queries that were created for ELES and are working well. Personnel are using a good mix of Maximo and other software to get the best reporting tools available. Word reports are used by the EOC to document the major daily happenings and the out of service report details equipment not in service at a given time. Excel is used to create the locator spreadsheet to track the daily usage of mechanic’s time. In addition the ability to export data from Maximo to excel is used to great advantage by personnel to distribute reports and run queries on data outside of Maximo. Some examples of the reports being run in Maximo are a variety of out of service
reports detailing the equipment currently not in service, sorted or grouped by whether the work was scheduled or unscheduled, its status and other key indicators. Also, there are a number of downtime reports which are critical for seeing the percentage of time an asset or number of assets was available for a given period. These reports allow management to clearly see how well maintenance is doing in maintaining the uptime of the elevators and escalators. Generally personnel have a good handle on the reporting capabilities within Maximo and how to extract the data stored within the program.

*Remote Monitoring*

There appears to be some significant problems with the remote monitoring system that are preventing it from working as intended. The system currently dumps work orders into Maximo, but they are not being issued by the EOC. The work orders do not have accurate fault information listed on them, and the fault that is noted is not always an accurate fault condition on the actual machine. In addition, many times the machine that is listed as being in alarm does not have any problems. There are false reports of failures and subsequently mechanics are falsely dispatched which wastes valuable mechanic time.

Testing and validation needs to be done on the remote monitoring system as a whole to make sure that the correct fault is captured on the correct machine and then that information is transmitted to Maximo with all of the pertinent information associated with the fault. This should also include some type of e-mail notification by Maximo that a fault was received and a work order was created. All of the different fault conditions that are required to be tracked should be tested for each machine associated with the remote monitoring system. It appears that the remote monitoring system was never commissioned or validated. This should be done before the work orders that are being sent to Maximo are issued.

*Inventory*

The inventory process begins when a mechanic notifies his supervisor of a part need. The supervisor updates the work order and the part is reserved from stock. If the part is not in stock, the supervisor sends an e-mail to the parts department requesting the materials needed for the job. The dispatchers in EOC get an e-mail copy of the request and forward that to the parts department. The dispatchers record the parts used on the work order.

It appears that the EOC is getting involved in a process that they should not be a part of. Other than adding inventory items to a work out on close-out, the dispatchers should not be getting involved in the materials process. It also appears that inventory on hand is not accurately tracked in Maximo. This leads to lengthy delays in machine availability due to awaiting materials/parts with long lead times. The parts department does not appear to be using Maximo to track inventory items to its full potential. By doing so, it would allow them to keep a current stock on all critical items with significant lead times to prevent lengthy out of service delays that could be prevented.

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Figure 1. Observed Basic Work Flow Process

1. Problem found by station manager
2. Station manager calls the MOC with details of an issue
3. MOC creates a work order in Maximo
4. EOC sees an elevator/escalator work order without a target finish date
5. EOC opens the work order and verifies the completeness and accuracy of the information on the work order
6. EOC sends out an e-mail to the appropriate maintenance supervisor with the work order number and request for work
7. The maintenance supervisor assigns the work order and replies to the EOC with the mechanic assignment
8. When the mechanic arrives on scene, they call the EOC to put the work order in-process
9. Maintenance is performed
10. The mechanic calls the EOC to inform them that the job has been completed and if any additional (child) work orders are needed.

PMs to be generated by Maximo

Maintenance supervisors review a list of PMs to be generated for the month

Maximo creates the PM work orders for the month

Maintenance supervisor assigns work orders to a mechanic