Fix Your Own Circuit Boards - 30 Years of Success at SEPTA's Electronic Repair Shop

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Abstract

In regards to transit agencies fixing their own rail vehicle circuit boards and other electronic lowest replaceable units (LRUs), I have heard some criticism from personnel within the industry whom I don't believe understand or have not seen with their own eyes the full value of having organic electronic repair facilities within their own organization. Some of these criticisms are: that there is not a positive return on investment (ROI), modern electronic systems are "maintenance-free", and some other terms such as: "pay back", "plug and play" and "rebuild-versus-buy" are used glibly when trying to argue against the value of having an in-house electronic repair facility.

At the SEPTA Woodland Electronic Repair Shop we have repaired tens of thousands of circuit boards and electronic assemblies over the past 30 years and have become a capable and crucial member of SEPTA's maintenance infrastructure. The dedication and constant efforts of SEPTA personnel to promptly and economically repair the "float stock" of electronic equipment that augments the SEPTA rail fleet is at the core of its success. With experienced trained personnel and the proper test/repair equipment many of the defective equipments removed from rail vehicles are found not to be defective at all and many of them that are actual defective have very detectable problems that require inexpensive parts to return them to service. The postulate for having an in-house electronic repair shop will become more lucid as we look at the 30 years of history at SEPTA's Electronic Shop.

SEPTA Heavy Maintenance Organization

SEPTA has historically performed its own heavy repairs and have built its new shops with this component-level philosophy in mind. Here is a listing of the various SEPTA backshops with their associated product line items.

SEPTA Rail Vehicle Component-Level Back Shops	**Product Line**
Fern Rock Gear/Axle Shop	Wheels/Axles, Gear Units (All Fleets)
Fern Rock Air Shop	**CTD Brake Units, Valves, Compressors
Frazer Shop	*RRD Couplers, Electric Heads, Cam Controllers, Contactors, Various Electronic and Electromechanical
69th St Motor Shop	DC/AC Motors (All Fleets)
Wayne Junction Air Shop	*RRD Brake Units, Valves
Woodland Electrical Shop	**CTD Contactors, Breakers, Various Electromechanical Apparatus

Woodland Electronic Shop	PC Boards and Electronic Modules (All Fleets)
Woodland Overhaul Shop	**CTD Trucks, Couplers

*** RRD: Regional Rail Department**
****CTD: City Transit Division**
Table 1- SEPTA Rail Vehicle Component –Level Back Shops

Woodland Electronic Shop Overview

The Woodland Electronic Shop (WES) was opened in 1983 as a backshop within the Woodland Heavy Maintenance Facility in order to support the maintenance of the new LRV electronic systems and components and has since then assumed maintenance responsibility for all of SEPTA's Rail vehicle electronics.

The dedication and constant efforts of SEPTA personnel to promptly and economically repair the "float stock" of electronic equipment that augments the SEPTA rail fleet is at the core of its success. The "float stock" is a specified amount of spare electronics purchased at procurement time or during the operations phase that acts as a buffer for fleet availability and allows the WES to be more efficient in the assignment of work(6).

The WES has expanded in physical size twice since it opened. Both expansions were planned in order accommodate the bench test equipment for newly acquired rail vehicles (M4 & SLV). The 1st expansion was completed in 2003 and 2nd expansion was completed in 2012.

The WES has its own Microsoft Access database called the Electronic Subassembly tracking System (ESATS) which is utilized to track rail vehicle assets as they are received, repaired, and shipped.

The database provides vital information that SEPTA's Technicians, Managers, and Engineering personnel utilize to make various repair decisions. Technicians may use it to look up the history of a particular item to see if the item has a common symptom in order to expedite repair (see figure #1). The Manager may use it to create monthly production reports on actual versus budgeted work performed. Engineering personnel may use it to find the root cause of components causing the highest failure in order to make decisions to modify existing circuit design or to purchase replacement boards.

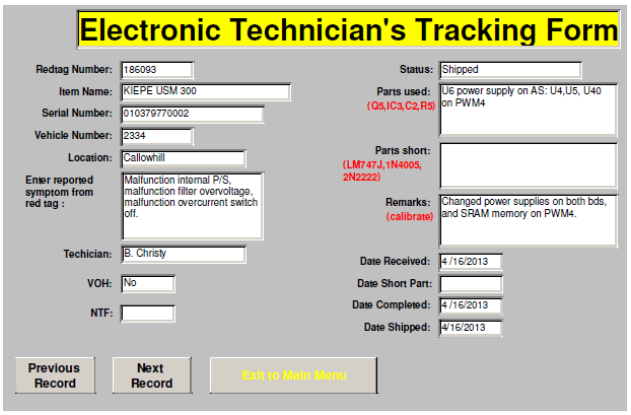

Figure 1-ESATS Technician's Redtag Search (5)

The following copy of a query performed in ESATS is vital in determining what items in our rail fleets have the highest failure rates, so that we can improve vehicle and vehicle systems reliability. Of course these numbers must be interpreted by personnel acquainted with the Electronic Shop product line. Using Table #2, at 1st glance you might think that the DYTP 110C GTO Driver Board is the highest failure rate item in the shop and that we should find a solution to this problem immediately. In actuality it was a high failure rate item that hade a hybrid circuit component on the board that was failing at a high failure rate and this caused us to replace the hybrid chip as part of campaign on the fleet. So the high number is actually indicative, in this case, of a problem area that is being resolved. In order to extrapolate data that we need we would have to design a query to filter out only the information that we require.

Item Name	Row Summary	2011	2012	2013
DYTP 110C GTO driver board	2536	670	493	98
W/S Panel	1686	144	137	42
DYSF 118A IGBT protection board	1504	159	107	34
Local Control Unit	1305	62	64	36
Ditch light controller	1196	94	58	10
HVAC COMP Board	794	70	63	11
AGATE logic	733	124	95	21

Table 2- ESATS Crosstab Query- Items in Descending Count Order

Here is an overview of the product line listing the vehicle type, the inventory location, and the amount of repairable items associated with each fleet. The newer the fleet the more electronic items there are to repair. For instance, for a vehicle that was designed in 1981 we have 85 repairable product items and for a vehicle that was designed in 1997 we have 126 repairable product items (a 33% increase) (6).

Vehicle Type	Inventory Location	Total Repairables
SL-IV & SL-V		214
	Frazer Shop	
	Overbrook Shop	
	Powelton Shop	
	Roberts Shop	
	Wayne Shop	
LRV (Single)		92
	Elmwood Shop	
	Callowhill Shop	
LRV (Double)		Same as S/E
	MSH Shop	
B-IV (Subway)		85
	Fern Rock Shop	
N5 (Norristown)		68
	P&W Shop	
M4 (Elevated)		127
	69th St. Shop	
	Bridge St. Shop	
PCC2 (RT 15)		32
	Callowhill Shop	
Vehicle Types = 8	Stock Locations = 13	Product Line = 618

Table 3- SEPTA WES Product Line Synopsis

SLV System	Vender
Propulsion Control and Power	Mitsubishi
Friction Brake Control	Wabtec
Auxiliary Power	Trantechnik
Automatic Train Control	Alstom
HVAC	Westcode
Communications	Woojin
Door Control	Faiveley
Central Diagnostics	Quester Tangent

Table 4- SEPTA SLV System with Bench Test Equipment

What is Maintenance Management

The best definition of maintenance management that I've come across is "A company first "engineers out" of the equipment as much maintenance as it can; next, takes good care of the equipment that it chooses to use; and, finally, bears down hard on any maintenance problems remaining." (1)

With this definition in mind, one can conclude that a company can only manage its equipment to the level it maintains it. At what level do you manage your equipment and? This will be the level that you stop managing your assets and have whether consciously or unconsciously decided to consider this equipment as a consumable item and not a strategic asset.

For a vehicle maintenance system to be effective there has to be a feedback loop about what parts are replaced and why they are replaced or there will be no way to control these expenses. The air Force realizes this and takes an integrated diagnostics approach to test equipment deliverables.

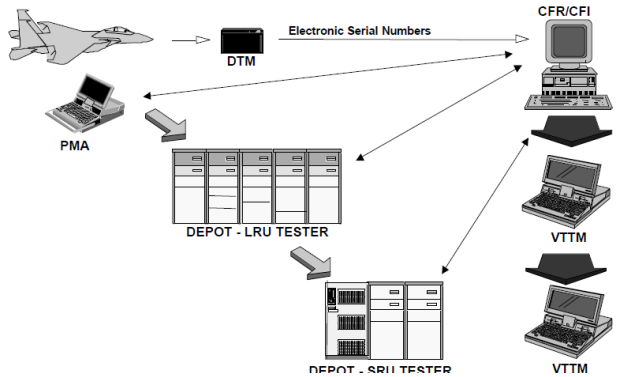

Figure 1- F-15 Program Diagnostic Support System (5)

Fixing Boards is a Worthwhile Investment

I was informed by an associate at another transit agency that they recently suffered 3 failures to their AC inverters on their trackless trolley (TT) and that they would have to pay $100,000.00 each to replace all 3 units. This agency did have their own Electronic Repair Shop to maintain their last fleet of trackless trolleys, but since they acquired the new TTs they dismantled the shop and now have to replace electronic units, modules, and circuit boards with new ones.

At some point the vender will no longer supoort their particular system and since you have always relied upon them for their parts you will have no choice but to go out for bid to get a new system or an alternately designed part to perform the same function.

Circuit Boards and Electronic Modules are Expensive

When I worked in the Electronic Shop, I often received phone calls from our Purchasing Department asking me if we repaired certain items that were being requested in stock. Most of the time, I could tell them that we have sufficient spare stock to repair for the fleets and that an addition to stock was not necessary, However, there was one particular request about seven different Communication Based Train Control (CBTC) circuit boards that we did not receive test equipment for that Purchasing had an inquiry about. Purchasing wanted to know why these boards were so expensive and why there was an astronomical 94% price increase in just the course of 2 years.

Here is the answer from Rail Vehicle engineering department:

> "These are so expensive because SEPTA has no alternative but to purchase these parts from the OEM.
>
> This is why our equipment specifications have a requirement that the Vendor provide SEPTA with all test equipment, documentation and training to allow us to repair the circuit boards in our electronic repair shop at Woodland. The CBTC project did not have a specification from Engineering, but rather was supplied for liquidated damages from the M4 program. It was understood from the beginning that SEPTA would not have the capability to repair the circuit boards.
>
> The complexity and safety aspect of these boards prevents SEPTA from creating drawings and specifications that would allow an alternate supplier to produce these boards."

This particular vender has a monopolistic which affords them a great deal of bargaining therefore, dissipating our buying power

Purchasing also ask the Electronic Shop for recommendations on setting quantities of items being requested in stock since we had the failure history and usage information on the spares available.

Circuit Board Testing and Repair is cheaper In-house

The electronic Shop performed a cost comparison between repairing a specific board in-house versus contracting out the repair. We utilized figures from our tracking database (at the time it was R:Base) and quoted pricing from one of equipment the manufacturers an we found that the outside cost was over twice as expensive.

One of the biggest problems with the repair contract is the long lead time it takes for repair. The vender's quoted time to repair from the comparison above was 15 weeks. Having in-house capability ensures that you can respond to emergency requests and have sufficient surge capacity to handle an excessive amount of failures in sa short time frame

Circuit board failures usually are not destructive in nature as shown in figure 1. Historically, most failures are caused by one component of a board or module going bad and can be replaced in a relatively short time frame with very little expense.

Figure 2- Damage from a Propagating PCB Fault (4)

In fact, sometimes quite often they aren't bad at all. Especially when rail vehicles and rail vehicle system are new there is a learning period in which carhouse technicians often swap out good boards and modules until they find the defective one and many times these suspected units get sent back to the electronic shop for test/repair.

We have seen as high as a 50% no trouble found (NTF) rate with the product items coming into our shop from newly equipped fleets. IN figure 2 you can see that

the Air force has a shocking NTF rate of 8%.on their F-15 Fighter Jet Program.

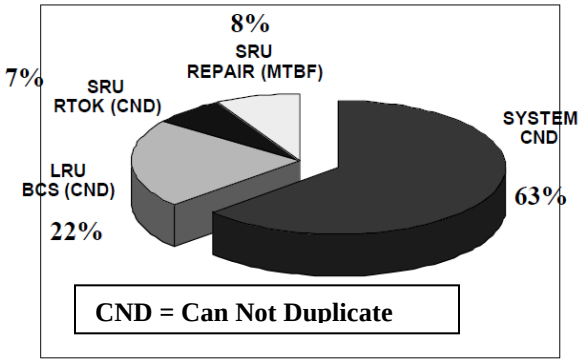

Figure 3- F-15 Program False Alarms (5)

You can either pay a lot of money or save a lot of money in our industry. According to a recent article in the International Rail Journal (IRJ), there is a 50 Billion Dollar train maintenance market and is primed for growth with one of the main reasons due to the increasing level of both the technology and the amount of equipment on the vehicles.

This article goes on to say that "around 60% of the total market is still accounted for by railways which maintain their own vehicles and therefore have a decisive influence on the market for traditional reasons. While there is a trend for railways to focus on their core business and transfer maintenance and repair of their vehicles to manufactures or independent providers, this market is developing more slowly than was expected by many companies in recent years. Switching responsibility for vehicle maintenance is a ground-breaking and time-consuming process, especially for European state-owned railway, and a more rapid shift in market share is being hindered by the traditional structures of the train operators which have their own large and high quality maintenance facilities".

Transit Performance Measures Ideology

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Since we in the transit agencies are not for-profit nor do we serve private interests, we should not think like private industry when we measure our performance industry.

We are much like the military, in that we have many different possible measures of success or failure and there is no way to combine them into a "bottom-line" number associated with terms like "ROI" and "buy-back'. We are stewards of strategic equipment assets.

Train Maintenance Global Market

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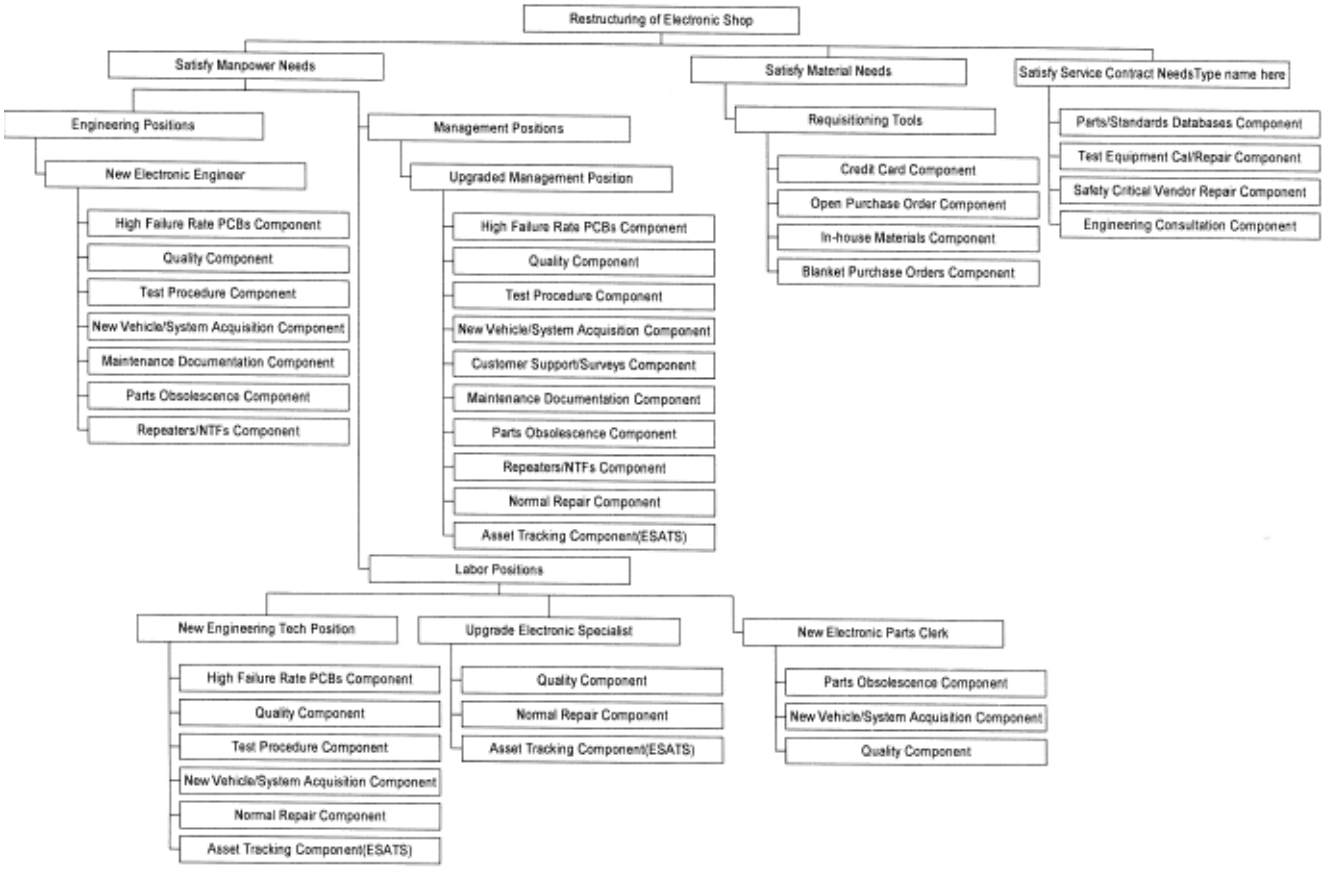
B – Partnering for Success

WBS---SEPTA Electronic Shop Restructuring



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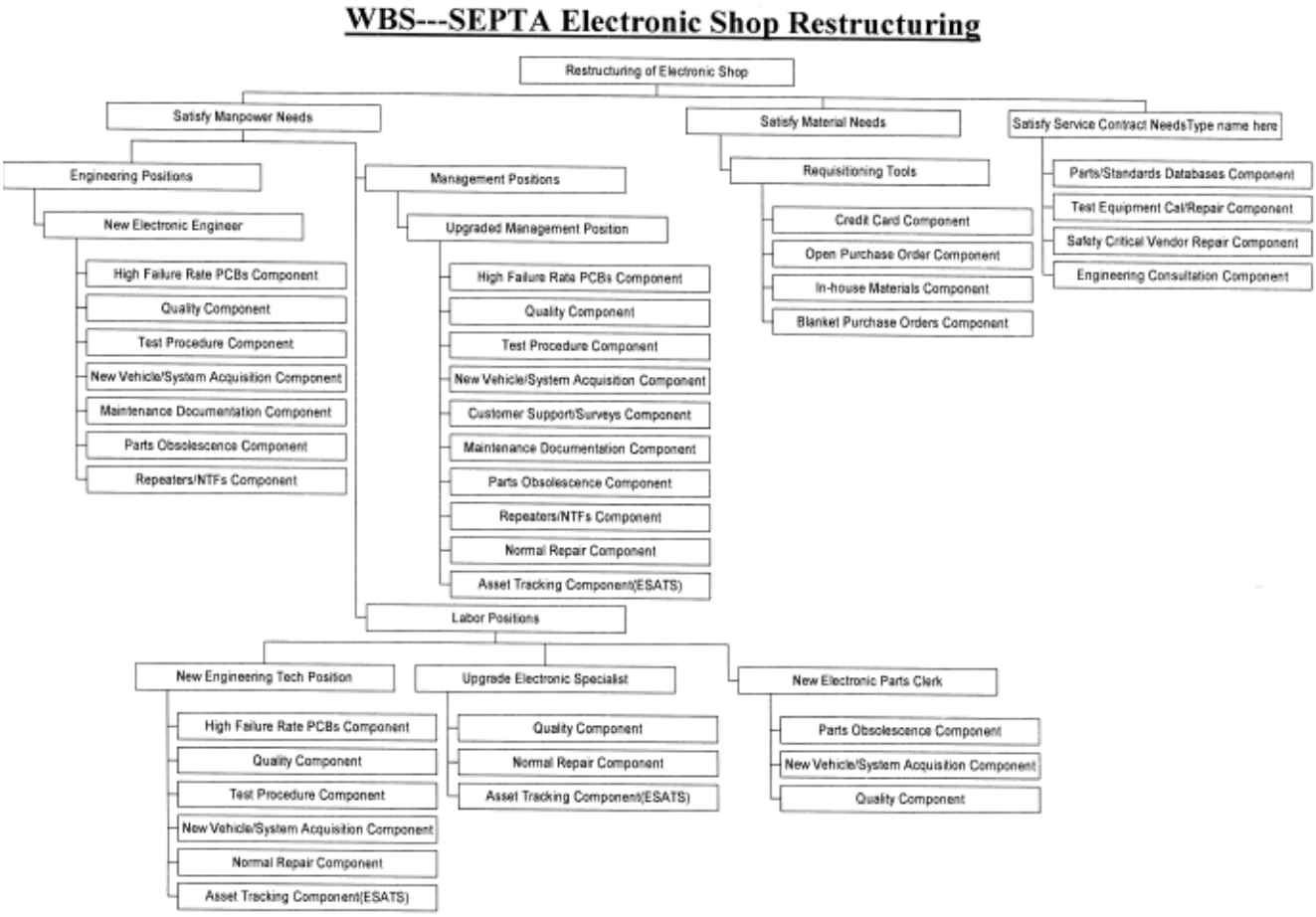
WBS---SEPTA Electronic Shop Restructuring
Restructuring of Electronic Shop
Satisfy Manpower Needs
Satisfy Material Needs
Satisfy Service Contract NeedsType name here
Engineering Positions
Management Positions
Requisitioning Tools
Parts/Standards Databases Component
Test Equipment Cal/Repair Component
Safety Critical Vendor Repair Component
Engineering Consultation Component
New Electronic Engineer
Upgraded Management Position
Credit Card Component
Open Purchase Order Component
In-house Materials Component
Blanket Purchase Orders Component
High Failure Rate PCBs Component
Quality Component
Test Procedure Component
New Vehicle/System Acquisition Component
Maintenance Documentation Component
Parts Obsolescence Component
Repeaters/NTFs Component
High Failure Rate PCBs Component
Quality Component
Test Procedure Component
New Vehicle/System Acquisition Component
Customer Support/Surveys Component
Maintenance Documentation Component
Parts Obsolescence Component
Repeaters/NTFs Component
Normal Repair Component
Asset Tracking Component(ESATS)
Labor Positions
New Engineering Tech Position
Upgrade Electronic Specialist
New Electronic Parts Clerk
High Failure Rate PCBs Component
Quality Component
Test Procedure Component
New Vehicle/System Acquisition Component
Normal Repair Component
Asset Tracking Component(ESATS)
Quality Component
Normal Repair Component
Asset Tracking Component(ESATS)
Parts Obsolescence Component
New Vehicle/System Acquisition Component
Quality Component