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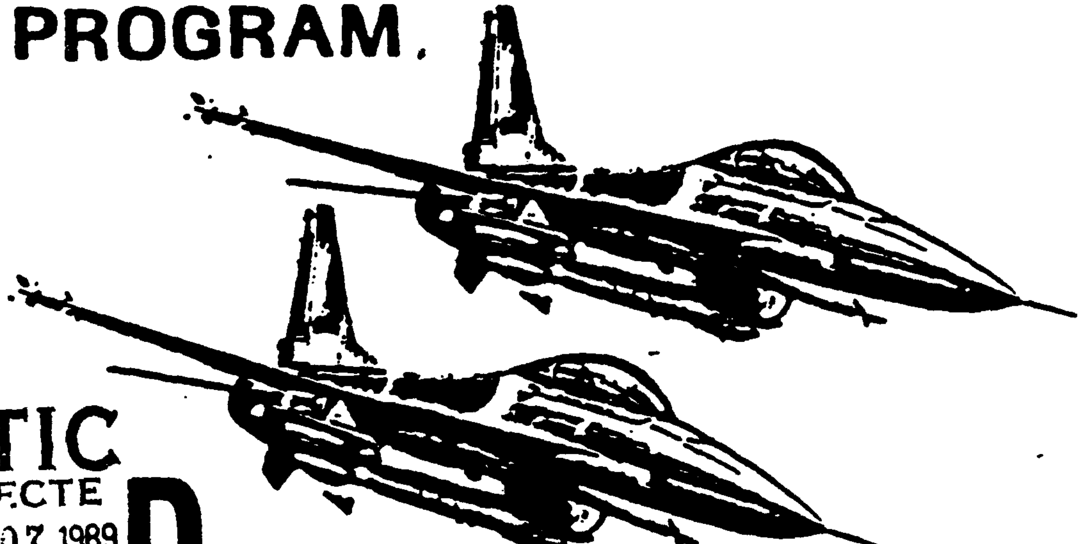

FINAL TECHNICAL REPORT

CATEGORY II PROJECT

PRINTED WIRING BOARD (PWB) PROCESS FIXTURE

AUGUST 31, 1987

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The purpose of this project is to develop a fixture to mount (PWBs) for manufacturing. Fixtures will be designed and developed to accomodate the parameters of all major machines within the PWB work center. Multiple PWBs will be mounted into the fixture at the beginning of the manufacturing process and remain mounted until test. The fixtures could be integrated into a material handling system which would increase the process flow capabilities. The likelihood of contamination of handling the boards will be reduced.

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Tracor Aerospace

FINAL TECHNICAL REPORT

CATEGORY II PROJECT

PRINTED WIRING BOARD (PWB) PROCESS FIXTURE

SUBMITTED TO:
General Dynamics Corporation
Fort Worth Division
P. O. Box 748
Fort Work, Texas 76101

PREPARED BY:

Tracor Aerospace, Inc.
6500 Tracor Lane
Austin, Texas 78725

August 31, 1987

Tracor Aerospace

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OVERVIEW AND PROJECT DESCRIPTION

The Printed Wiring Board (PWB) Process Fixture Project resulted from a Phase 1 investigation which identified the need for a universal holding fixture as a means of reducing custom fixtures, manual load/unload and contamination found in the process of assembling printed wiring boards. These needs were translated into preliminary design requirements which met various automated insertion and PCB processing equipment contraints; objective being a fixture where various sizes of PWBs would be mounted at the first operation and remain mounted until test. After 15 months of developmental effort the team concluded that a universal fixture was not cost effective due to extreme variances in PWB configuration, cost of implementation, and changes to a flexible processing equipment production philosophy.

1.0 INTRODUCTION

Earlier research had identified potential savings in assembling components onto PWBs by applying a universal fixture concept. This final report presents the results and findings which resulted from a preliminary design effort of the PWB Process Fixture Project.

1.1 PWB Assembly Description

The PWB assembly process begins at Receiving Inspection. Artwork and hole placement/quality on a PWB are 100% inspected on the first lot after a new design release (engineering change or vendor change). If the artwork and hole placement/quality passes, the lot goes to stock. All subsequent lots are visually inspected and accepted by an approved lot sampling plan.

A work order document authorizes manufacturing to pull raw boards from stock and instructs shop floor personnel on how to assemble and process the boards to completion. During assembly, raw boards are first serialized, then placed on trees or racks for staging at either auto insertion or manual insertion. At insertion operations axial, dip, ICs components etc., are inserted into the boards. Boards are then transferred to bake/wave soldering where the components are bonded to the boards and cleaned. Completed boards are visually inspected for absence of components, soldering defects, and contamination. Boards which contain deficiencies are reworked; quality boards continue through additional hand assembly/soldering or post wave soldering and conformal coating operations. Afterwards they go through functional/environmental stress screening and onto stock.

1.1.1 AS-IS Assessment During Phase 1 Tracor established the AS-IS condition. Observed in the Circuit Card Assembly (CCA) shop was, 1) the use of various material handling devices (e.g., trees, racks, and carts) to move boards between work centers; 2) redundant setups within individual operations; and 3) the use of several dedicated and costly fixtures to facilitate PWB assemblies. Furthermore, continual handling of PWBs was known to contaminate and impart static charge to board surfaces. If a fixture could be developed to lessen or eliminate material handling requirements and setup time, then Tracor and the Government could realize annual savings of approximately $29,000. Flexible fixtures would also improve efficiency of available floor space and simplify work center layouts by eliminating redundant trees, racks, and carts. Figure 1 shows the AS-IS view of the PWB process fixture project.

1.1.2 TO-BE Assessment An analysis of the CCA shop showed that diminished support and setup labor, and reduced material handling requirements between operations and/or work centers, would substantially reduce PWB assembly cost. Working from this premise, Tracor began its preliminary development and corresponding universal fixture requirements and specifications.

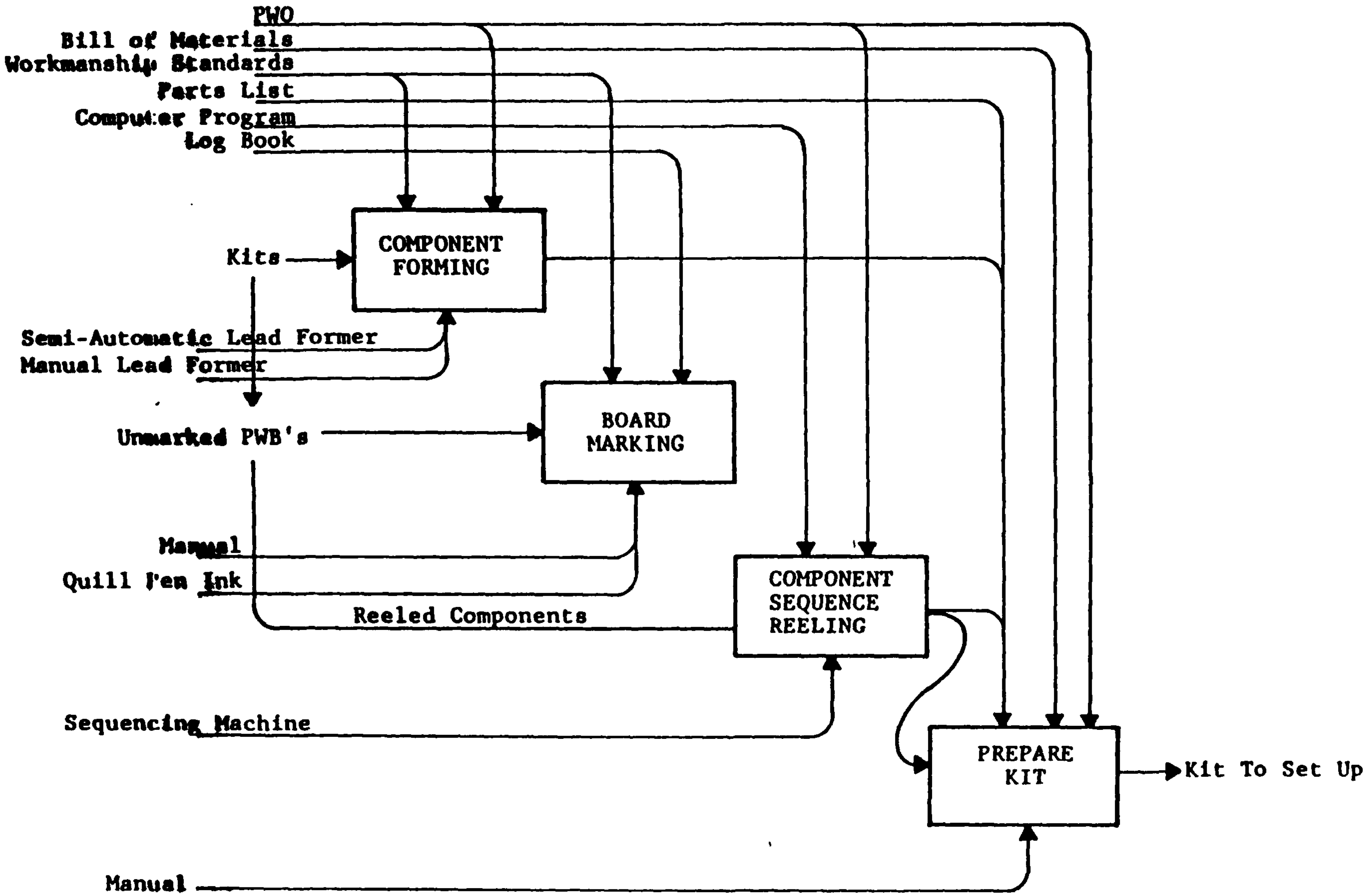


Figure 1 "AS-IS" IDEF MODEL PWB PROCESS FIXTURE

Fixture introduction into the assembly process would occur after serialization. (see Figure 2). As the PWB fixture assembly moved from the setup station to the floor it would be transported by an accomodating cart. The PWB fixture assembly would be removed and deposited at either the auto insertion table or par-a-track; in either case setup would not be required since the fixture design would take into consideration operational constraints. After completing the auto insertion operation, the fixture would be removed and placed onto the cart. For par-a-track operations, each assembler would station the PWB fixture assembly at the next operation by simply sliding it down the track. After completing the last operation in the line, the fixture with board(s) would be removed and placed into the cart. The cart would then be transported to the next work center or operation. Once at the bake/wave solder process, the PWB fixture would be removed from the cart and placed on rails which would control the movement over the solder wave. Here again, setup would not be required. Inspection and post soldering operations would be performed using sets of par-a-tracks; process being performed in the same manner as manual insertion and without setup. After completing all operations, the fully assembled PWBs would be transported by cart to the setup station. PWBs would be separated from the fixtures, placed in bags, and shipped in tote boxes to test.

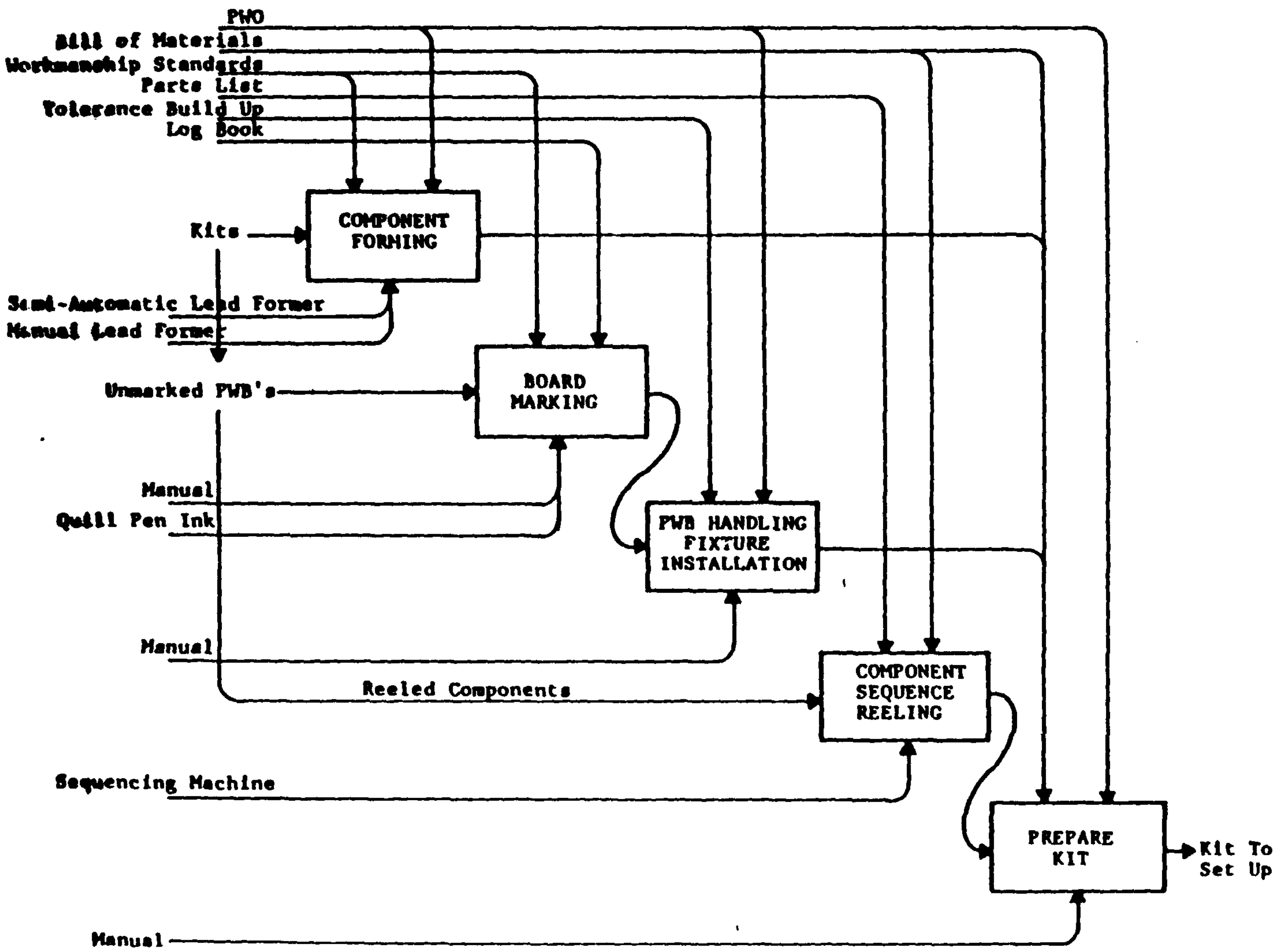


Figure 2 "TO-BE" IDEF MODEL PWB PROCESS FIXTURE

2.0 PROJECT DESCRIPTION

Preliminary design activities commenced during the summer of 1983. At this time the CCA shop was located in Building 2 (see Figure 3), where outdated equipment and unengineered layouts were used to process PWB assemblies. A comprehensive review of all PWBs was conducted during the summer to determine which board features would influence the fixture design. An industry survey followed and identified several vendors which could partically meet our requirements. During the summer and fall of 1984, a routing analysis was performed and used to provide information on work center/operation relationship. In January 1985, Tracor management recognized the need to modernize the CCA shop and made separate plans to relayout the shop and move the operations to Building 8 (see Figure 4). Concurrent with this decision was the identification of key processes requiring (semi)-automatic equipment. The first process to be upgraded was manual insertion. Instead of using par-a-tracks and succeeding line operations, programmable, operator assisted insertion machines were purchased. Wave soldering was the other process selected for modernization and included an attached in-line cleaner. The specifications for this equipment included PC controls for automatic movement of the guide rails based on data from a preset station and sensors for monitoring and controlling the temperature and flow time across the solder wave. The associated in-line cleaner was arranged so that it would directly receive soldered boards, clean them accordingly, and deposit them at an inspectors work bench. Automation of these key operations and an improved assembly layout, resulted in sufficient flexibility to process various board sizes used in Tracor's products and future savings to its customers. **However, this modernization effort, and implementation, had an adverse impact on the PWB process fixture development.**

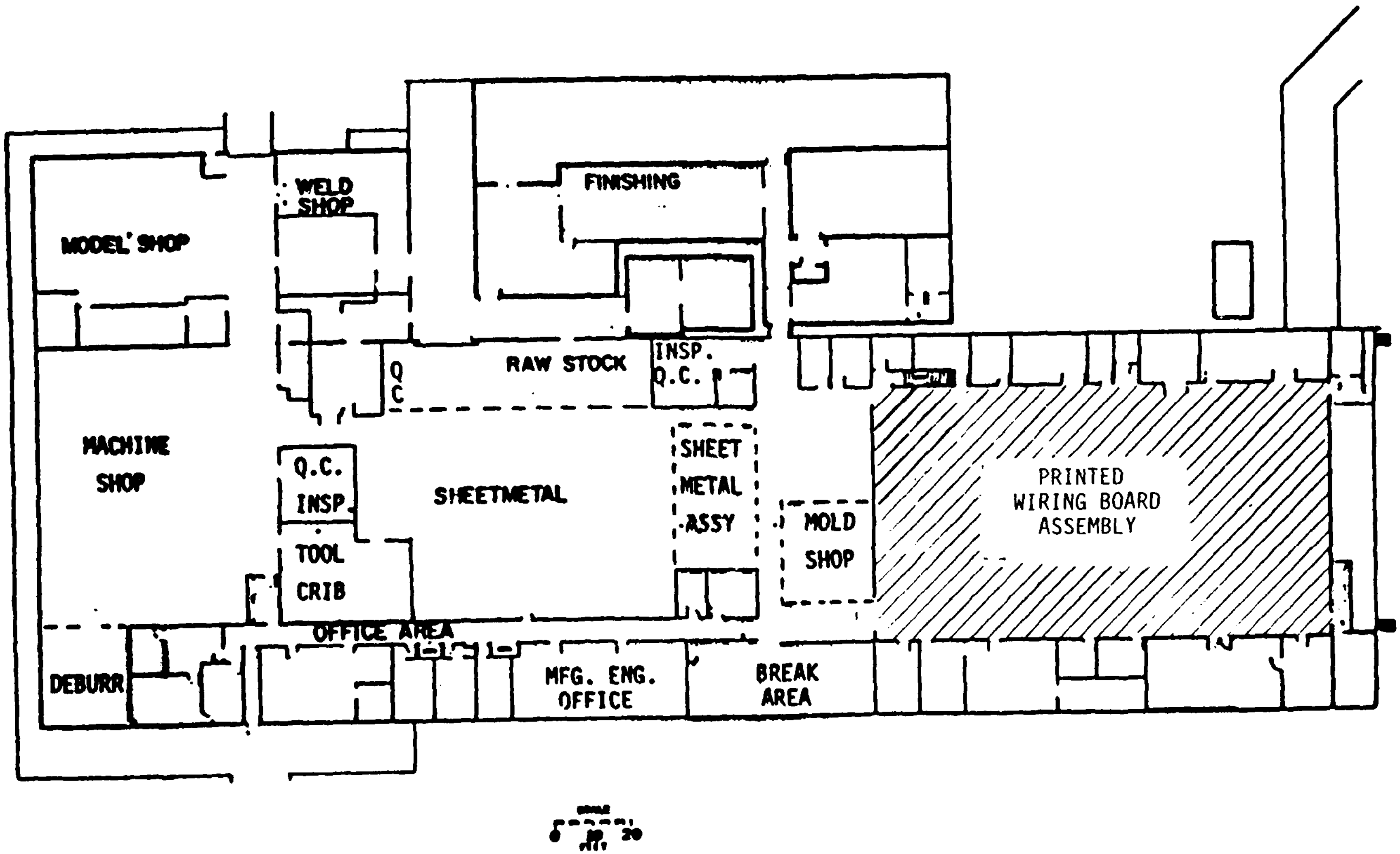


Figure 3 BUILDING 2 CCA LOCATION - Distant Location To Support Functions and Final Assembly, Plus Outdated Layouts and Equipment Made The CCA Shcp A Major Cost Driver

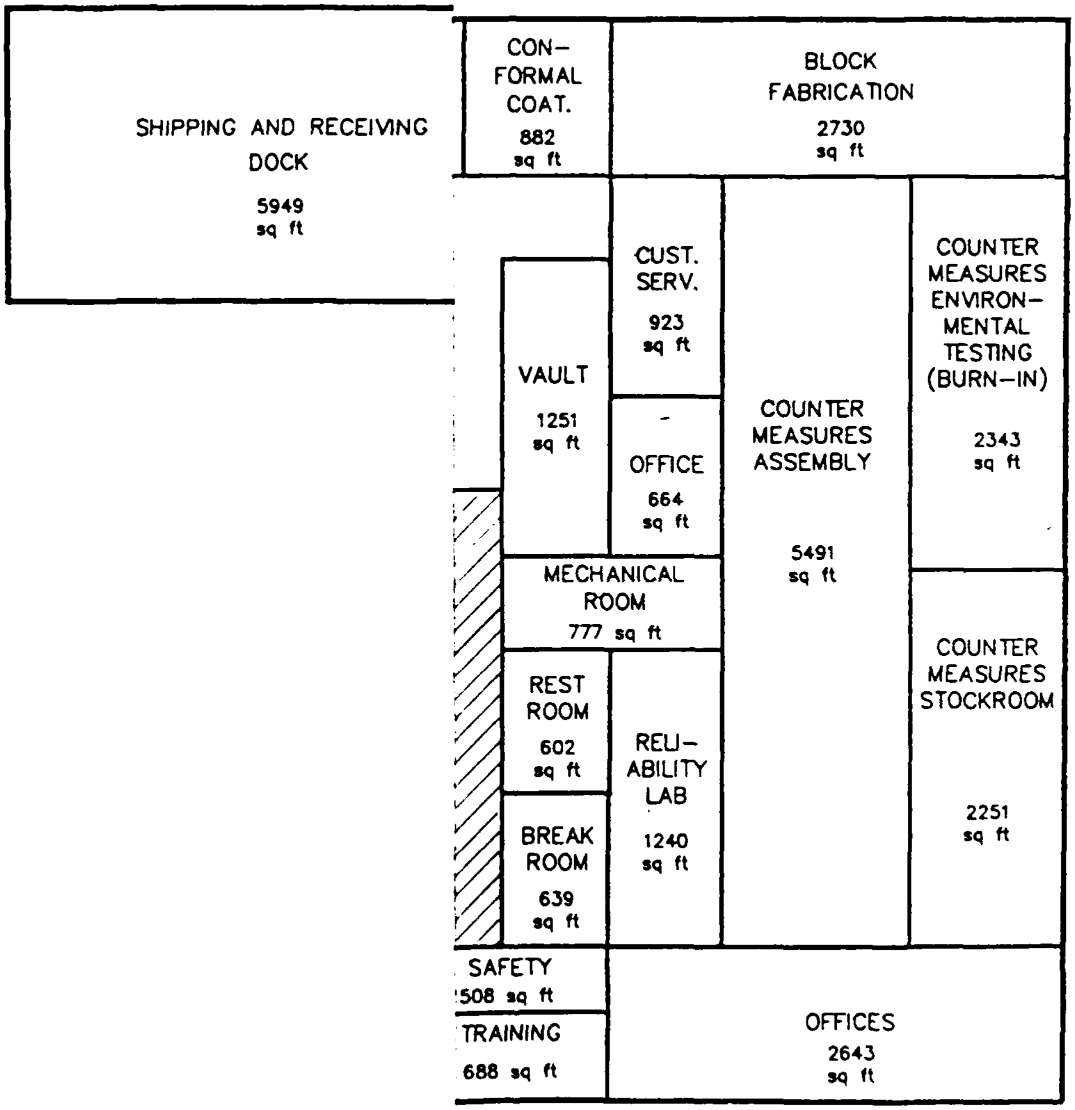


Figure 4 BUILDING 8 CCA S

2.1 Preliminary Design

2.1.1 Industry Survey Efforts to identify vendors which produce "flexible PWB fixtures" were limited due to availability. Basically three types of flexible fixtures were being produced: 1) Auto Insertion Fixtures, 2) Manual Insertion Fixtures, and 3) Wave Solder Fixtures. The best example or flexible auto insertion fixture was EMC Domestic, Inc. This company provides a palletizing system for auto insertion based on a mother-daughter concept. The scheme uses a mother plate which is configured to the original equipment manufacturer's machine bed and accomodates a standard daughter plate envelope configuration. The daughter plate or work holder secures the PWB and hinges onto the mother board for quick release and interchange to another auto insertion machine.

A fixture design from Fancort Industries, Inc. facilitated flexible wave soldering through the use of a spring loaded rail.

2.1.2 Preliminary Analysis The PWB process fixture's preliminary analysis concentrated on identification of board features and printed wiring board assemblies which could be processed by the fixture, and routings used in the process of PWBs. Investigative results are provided in the following sections.

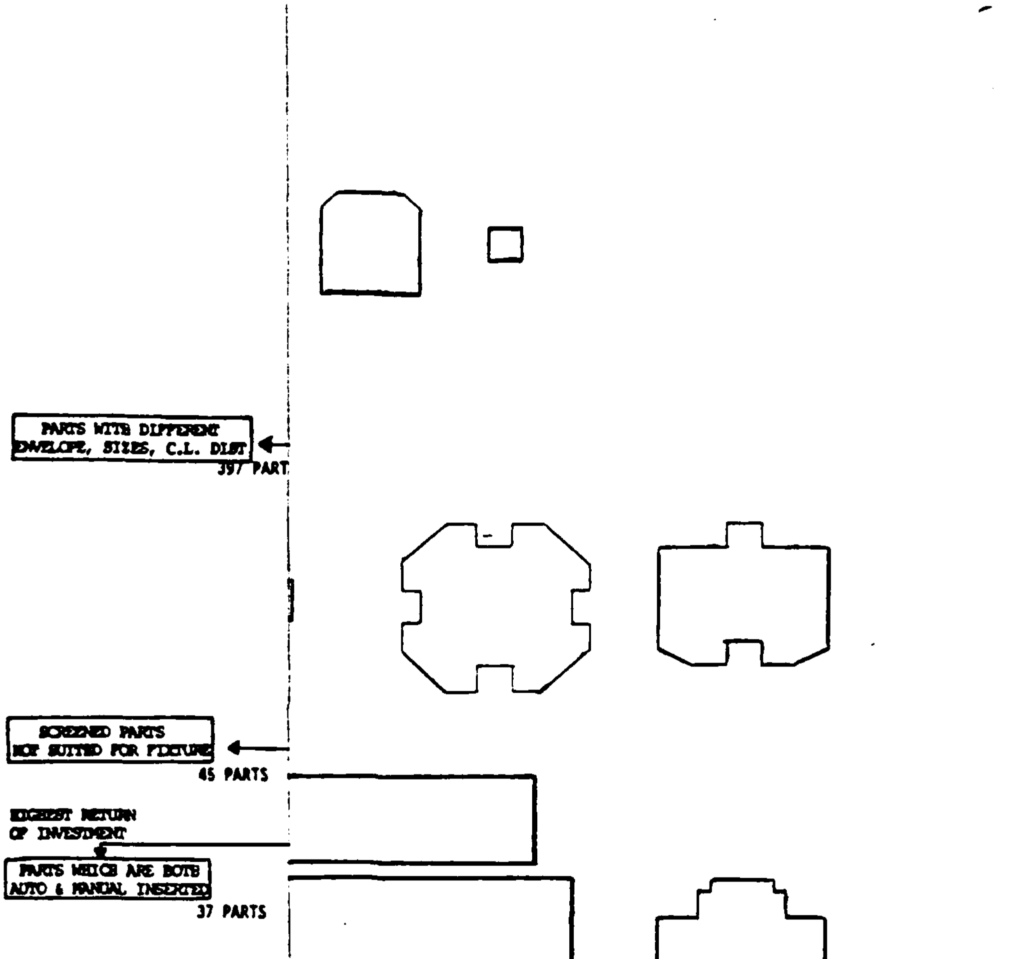
2.1.2.1 Board Feature Analysis A board feature analysis was conducted to determine the critical features necessary for fixture standardization. A methodology, based on tooling hole (T/H), center-to-center T/H distances and board envelope size, **was developed and used to sift 481 part numbers into three finite categories (see Figure 5, Panel A). These 82 parts were further reviewed** on a board by board basis for fixture plausibility, reducing the number of candidate parts to 37. A synoposis follows: Product Line "A" contained two groups. The first group contained two boards soldered to a flex circuit. These boards were eliminated from further consideration because they required a custom wave soldering fixture. The second group contained eight boards; five of which had the same board dimensions, center-to-center T/H distance and T/H diameter. These board met the criteria and were selected. The remaining three PWBs were rejected because of obselete product, and varing overall dimensions.

Product Line B examplifies the products produced at Tracor where form-to-fit and board functionality are more critical in packaging a sellable product than manufacturing standardization (see Figure 5 Panel C). Forty-two board assemblies comprise Product Line B. These assemblies were segregated into three categories; boards which contained no T/H's but had available real estate for common T/H placement, boards with T/Hs, and boards with various configurations and without T/Hs. Group One included eight parts and showed the most promise after engineering agreed to redesign the boards to accomodate the necessary tooling holes. Six boards formed Group Two; however tooling hole placement and varing diameter were cause for rejection. Group Three contained the remaining parts which had little commonality and therefore was rejected.

Twelve of fourteen parts were found within Product Line C which could accomodate flexible fixture requirements. This product line was found to be most suited since the assemblies had common T/H diameter and center-to-center T/H distance, and had the same or very similar outside configuration. The two remaining boards in the group were rejected because of hole placement and absence of tooling holes.

Assemblies within Product Line D also showed promise for the universal fixture approach. Of the sixteen boards which go into the product, twelve had the same envelope size, center-to-center T/H distance and T/H diameter. Small

Ⓐ METHODOLOGY - THIRTY SEVEN PART HINDER APPLICATION OF UNIVERSAL FIXTURE APPROACH



Ⓑ PRODUCT LINE BREAKOUT - NO. DIR

BOARD FEATURES		PRODUCT
OVERALL BOARD DIMENSIONS	L x W	3.1in X
	THK	.0
CTR-TO-CTR TOOLING HOLE DISTANCE	X	2.
	Y	2.
NUMBER OF TOOLING HOLES		
TOLLING HOLE DIAMETER		.
TOOLING HOLE TO CIRCUITRY DISTANCE		1/8 a
BOARD EDGE TO CIRCUITRY DISTANCE		1/16
NUMBER OF BOARD FINGERS		N
NUMBER OF PARTS WHICH QUALIFY		5 C

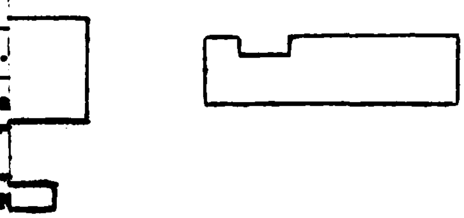


Figure 5 BOARD FEATURE ANA

board envelope size and heptagonal shape precluded the acceptance of four boards. Board feature analysis results showed that of 481 parts, only 37 assemblies offered features which accomodated a universal fixture approach. (see Figure 5, Panel B)

2.1.2.2 Routing Analysis The PCB shop is composed of eight work centers which process 481 part numbers utilizing 114 different routings. Each work center is configured so that a set of specified tasks or operations can be performed which collectively ensure high reliable and qualified printed circuit board assemblies for Tracor's commercial and military products. A routing analysis was performed on these eight work centers to identify primary and secondary work center relationship for fixture flow determination (see Figure 6). Additional information was also gathered from the analysis and revealed that:

- 61% of the parts are contained in 10 routing patterns
- 58 routings contained only one part
- average routing contained 13 distinct operations

2.2 Cost Analysis

Cost analyses were continually performed throughout the preliminary design for fixture cost determinations and savings impact; focus being on low-cost fixture design alternatives which could process a large population of PWB configuration through high tolerance and sharp temperature changes. Questions which concerned the Development Team were, 1) cost impacts from design and process changes, 2) individual fixture cost and quantity of fixtures, and 3) resultant savings to offset the cost.

At onset of the project, 139 PWBs were being processed through the CCA shop in Building 2; 25 of which were auto inserted. Four years later the quantity of part numbers increased to 481, of which 98 parts were auto inserted. This vast growth in part numbers and corresponding piece part quantity proved insufficient to provide a positive return for the universal fixture concept.

2.2.1 Engineering Change Order Impact Part proliferation and associated impact on the engineering design change cost associated with standardization was one concern. Through the board feature analysis it was shown that only 37 PWB assemblies were suited for a universal fixture concept; however, 98 parts are currently auto inserted and contain critical secondary operations which the universal fixture concept addressed. This meant that 61 parts would require design changes (primarly tooling hole requirements) to make the PWBs compatable. To institute an immediate change would cost $1,210.00 based on cost estimates provided in Table 1. An alternative to an immediate change would be to incorporate the change into the next revision as other requirements dictated the need for an ECO.

ITEM	COST
o Estimated cost to initiate and process an engineering change order (ECO)	$600.00
o Engineering time to add or modify tooling holes for standardization, 2.5-3 hrs/part	150.00
o Drafting time for schematic/artwork, 3-6 hrs/part	200.00
o PCB vendor charge to modify process/tooling (one-time charge)	250.00
o Modify work instructions utilizing computer-aided processing system (CAPS)	10.00
TOTAL	$1,210.00

Table 1 Tooling Hole Cost Impact - Estimated Cost Per PWB Change Exceeds $1,200, Making Implementation a Function of Other Incorporated ECOs

A rigorous savings excercise was conducted for determining savings per board. The analysis and results shown in

Table 2 attempted to normalize all the board configurations and production factors so that a simplified comparison could be performed against cost data. The savings analysis showed that 1.747 mins/bd could be saved through implementation of a universal fixture concept.

The Development Team addressed the issue of the ECO cost ($1,210.00) and the quantity of PWB assemblies required to break even. Using average rates for assemblers and loading it through G&A, a composite hourly rate of $19.53 or $ .3256/min was calculated. Using the following calculation, it was found that the average part number would have to yield a production quantity of 2,127 pieces over its life to payback the cost of generating the ECO.

$$\text{Breakevenpoint} = \frac{\text{Cost of ECO}}{\text{min/board saved X rate/min}}$$

Using historical and forecasted production data, 18 PWB part numbers were identified which exceeded this quantity over a 5 year period. Of the ninety-eight parts, five PWBs had or would be produced in quantities in excess of this threshold. From the foregoing analysis Tracor concluded that the approach of instituting a ECO change on the sixty-one boards would be an incremental one.

2.2.2 Production Constraints In addition to the ECO issue, the Development Team looked at production constraints and their effects on PWB process fixture requirements and compiled the following information:

2.2.2.1 Lot Size Determinates Manual insertion at Tracor is cost effective in production programs where total delivery quantities vary from 1 to 200; typical of an engineering development effort. Full scale production programs which offer delivery quantities ranging from several hundred to the thousands of units can be planned for auto insertion. On these type of

I. A. & B. Percentage refers to the currently auto-insertable (A.1) boards that fit fixture requirements which have ongoing commitments.

C. Percentages reflect the boards that fit fixture requirements, are not currently auto inserted, and have ongoing commitments.

II. Percentages reflect the boards that fit fixture requirements (2 & 4/Fixt.).

III. Percentage reflects the total amount of fixtureable boards.

IV. A. & B. Percentages reflect the boards that fit fixture requirements in respective 2/fixt and 4/fixt categories.

C. & D. Percentage reflects the total amount of fixtureable boards.

V. Percentage represents the amount of time saved by using the fixture/vice setup. The other percentage reflects the total amount of fixtureable boards.

Computations

I. Auto Insertion

A. Load/Unload Auto-Inserter

1. Savings (Not loading board by board)

$(46.0\%)\ (.25\ \frac{min}{PCB}) = 0.1150\ \frac{min}{PCB}$

2. Negative savings (loading 4 PCB fixture)

$(46.0\%)\ (.25\ \frac{min}{Fixt})\ (\frac{1\ fixt.}{4\ PCB}) = -\ 0.0288\ \frac{min}{PCB}$

3. Net Savings $= +\ 0.0862\ \frac{min}{PCB}$

B. Setup (Mount Tooling Plate, Mat'l Handling)

$(46.0\%)\ (\frac{2\ min}{ave\ lot})\ (\frac{ave\ lot}{50\ PCB}) = +\ 0.0184\ \frac{min}{PCB}$

C. Increased Utilization (Lower Vol. PCBs may now be auto-inserted since custom tooling not req'd. Assume ave. of 3 $\frac{min}{PCB}$ saved)

1. Component insertion savings

$(17.4\% + 4.2\%)\ (3.70\ \frac{min}{PCB}) = +\ 0.7992\ \frac{min}{PCB}$

2. Board/Fixture Load/Unload Savings

a) 4/fixture boards

i) ⊕ savings

$(17.4\%)\ (.40\ \frac{min}{PCB}) = .0696\ \frac{min}{PCB}$

ii) ⊖ savings

$(17.4\%)\ (.25\ \frac{min}{fixt})\ (\frac{1\ fixt}{4\ PCB}) = -.0109\ \frac{min}{PCB}$

I. Auto Insertion (Cont.)

b) 2/Fixture Boards

i) ⊕ savings

$(4.2\%)\ (.40\ \frac{min}{PCB}) = .0168\ \frac{min}{PCB}$

ii) ⊖ savings

$(4.2\%)\ (.25\ \frac{min}{fixt})\ (\frac{1\ fixt}{2\ PCB}) = -.0053\ \frac{min}{PCB}$

c) Net Savings $= +\ 0.0702$

II. Manual Assembly

A. Load/Unload at Work Station

1. 4/fixture boards (63.4%)

a) ⊕ savings

$(.634\%)\ (.40\ \frac{min}{PCB}) = .2536\ \frac{min}{PCB}$

b) ⊖ savings

$(.634\%)\ (.25\ \frac{min}{fixt})\ (\frac{1\ fixt}{4\ PCB}) = -.0396\ \frac{min}{PCB}$

2. 2/Fixture Boards (4.2%)

a) ⊕ savings

$(.042\%)\ (.40\ \frac{min}{PCB}) = .0168\ \frac{min}{PCB}$

b) ⊖ savings

$(0.42\%)\ (.25\ \frac{min}{fixt})\ (\frac{1\ fixt}{2\ PCB}) = -.0053\ \frac{min}{PCB}$

3. Net Savings $= +\ 0.2255$

III. Prep

Load/Unload PCB on Fixture

$(67.6\%)\ (.25\ \frac{min}{PCB}) = -\ 0.1690$

IV. Wave Solder

A. Load/Unload PCB at Bake Ovens

1. 4/fixture boards (63.4%)

a) ⊕ savings

$(.634\%)\ (.2\ \frac{min}{PCB}) = .1268\ \frac{min}{PCB}$

b) ⊖ savings

$(.634\%)\ (.25\ \frac{min}{fixt})\ (\frac{1\ fixt}{4\ PCB}) = -.0396\ \frac{min}{PCB}$

2. 2/Fixture Boards (4.2%)

a) ⊕ savings

$(.042\%)\ (.2\ \frac{min}{PCB}) = .0084\ \frac{min}{PCB}$

Table 2 SAVINGS ANALYSIS - Detailed Analysis Revealed Savings of 1.747 min/PCB Using The UNIVERSAL

:o Insertion (Cont.)

b) 2/Fixture Boards
i) ⊕ savings
(4.2%) (.40 $\frac{min}{PCB}$) = .0168 $\frac{min}{PCB}$

ii) ⊖ savings
(4.2%) (.25 $\frac{min}{fixt}$) ($\frac{1\ fixt}{2\ PCB}$)
= -.0053 $\frac{min}{PCB}$

c) Net Savings = + 0.0702 $\frac{min}{PCB}$

nual Assembly
Load/Unload at Work Station
1. 4/fixture boards (63.4%)
a) ⊕ savings
(.634%) (.40 $\frac{min}{PCB}$) = .2536 $\frac{min}{PCB}$

b) ⊖ savings
(.634%) (.25 $\frac{min}{fixt}$) ($\frac{1\ fixt}{4\ PCB}$)
= -.0396 $\frac{min}{PCB}$

2. 2/Fixture Boards (4.2%)
a) ⊕ savings
(.042%) (.40 $\frac{min}{PCB}$) = .0168 $\frac{min}{PCB}$

b) ⊖ savings
(0.42%) (.25 $\frac{min}{fixt}$) ($\frac{1\ fixt}{2\ PCB}$)
= -.0053 $\frac{min}{PCB}$

3. Net Savings = + 0.2255 $\frac{min}{PCB}$

rep
oad/Unload PCB on Fixture
57.6%) (.25 $\frac{min}{PCB}$) = - 0.1690 $\frac{min}{PCB}$

ve Solder
Load/Unload PCB at Bake Ovens
1. 4/fixture boards (63.4%)
a) ⊕ savings
(.634%) (.2 $\frac{min}{PCB}$) = .1268 $\frac{min}{PCB}$

b) ⊖ savings
(.634%) (.25 $\frac{min}{fixt}$) ($\frac{1\ fixt}{4\ PCB}$)
= -.0396 $\frac{min}{PCB}$

2. 2/Fixture Boards (4.2%)
a) ⊕ savings
(.042%) (.2 $\frac{min}{PCB}$) = .0084 $\frac{min}{PCB}$

IV. Wave Solder (Cont.)

b) ⊖ savings
(0.42%) (.25 $\frac{min}{fixt}$) ($\frac{1\ fixt}{2\ PCB}$)
= -.0053 $\frac{min}{PCB}$

3. Net Savings = + 0.0903 $\frac{min}{PCB}$

B. Load/Unload PCB at Cleaner
1. 4/fixture boards (63.4%)
a) ⊕ savings
(.634%) (.2 $\frac{min}{PCB}$) = .1268 $\frac{min}{PCB}$

b) ⊖ savings
(.634%) (.25 $\frac{min}{fixt}$) ($\frac{1\ fixt}{4\ boards}$)
= -.0396 $\frac{min}{PCB}$

2. 2/Fixture Boards (4.2%)
a) ⊕ savings
(.042%) (.2 $\frac{min}{PCB}$) = .0084 $\frac{min}{PCB}$

b) ⊖ savings
(0.42%) (.25 $\frac{min}{fixt}$) ($\frac{1\ fixt}{2\ boards}$)
= -.0053 $\frac{min}{PCB}$

3. Net Savings = + 0.0903 $\frac{min}{PCB}$

C. Setup at Base (No rack adjustments)
($\frac{4\ min}{ave\ lot}$) ($\frac{Ave\ Lot}{50\ PCBs}$) X 67.6%
= + 0.0541 $\frac{min}{PCB}$

D. Load/Unload PCB into Carrier
(67.6%) (.25 $\frac{min}{PCB}$) = + 0.1690 $\frac{min}{PCB}$

V. Touch-Up
A. Decreased handling (Using Fixture & Swivel Vice)
(5%) (67.6%) (7442 $\frac{hrs}{yr}$) ($\frac{60\ min}{hr}$) ($\frac{1\ yr.}{48,195\ PCB}$)
= + 0.3132 $\frac{min}{PCB}$

TOTAL SAVINGS = 1.747 $\frac{min}{PCB}$

s of 1.747 min/PCB Using The UNIVERSAL F...

programs Tracor's production control organization releases PWB orders with auto insertion requirements varying between 150 and 250 pieces.

2.2.2.2 Span Time and Affects of Open Work Orders Using 1985 data, production work orders had a floor-to-stock span time of 4 weeks in the CCA shop; with an average number of 200 open work orders per day. For the ninety-eight PWBs this equated to 4,550 board assemblies on the floor between prep and conformal coating operations. Using four PWBs per fixture, approximately 1,126 fixtures plus 10% for spares and repairs would be required to support production requirements.

Using similar palletless fixture suppliers as basis for determing future cost, the average cost of a PWB fixture (at quantities shown) would be $136.50 (fully burden). This put the cost of accomodating the ninety-eight PWBs at $222,043. A cost comparison was made between the PWB process fixture approach and use of auto insertion fixtures. Cost of fabricating a auto insertion fixture was based on actual in-house cost, and procurements from UNIVERSAL and PWB work holder vendors. Cost comparisons to support in-house fabrication are shown in Table 3.

Fixture No.	Labor Hrs.	Make Span (Days)	Total $
301W	25.5	5	$368
514W	20.3	5	$527
515W	22.7	6	$546
970W	12.0	5	$301
971W	16.0	3	$412
972W	11.5	2	$262
973W	15.0	3	$373

Table 3 In House Fabrication - Span Time Makes In-House Fixture Fabrication Most Advantageous

A review of procurement records showed the average cost per auto insert fixture to be $1,800 from UNIVERSAL and $1,500 from PWB work holder vendors. Fixtures from UNIVERSAL were 20% higher and had a 6 weeks' delivery schedule as opposed to 2-3 week vendor delivery schedule. These costs and delivery factors were the cause for selecting PWB work holder vendors as shown in Table 4.

Owner / Tool No.	Used on Part No.
USAF 411/TN106007	141053-0001 & -0002
	141222-0001
	141056-0001 & -0002
USAF 408/TN104720	141184-0001
	141044-0001
	141047-0001 & -0003
	141047-0002 & -0004
	141050-0001 & -0002
	141154-0001
USAF0393/TN104720	141184-0001
	141044-0001
	141047-0001 & -0003
	141047-0002 & -0004
	141050-0001 & -0002
	141154-0001
USAF 409/TN106006	151885-0001
	141150-0001 & -0002
	141082-0001 & -0002
	141079-0001
	141062-0001
USAF 410/TN106006	151885-0001
	141150-0001 & -0002
	141082-0001 & -0002
	141079-0001
	141062-0001

Table 4 Auto Insertion Fixtures - Over the Last 3 years, Vendor Procured Fixtures Have Permitted Multiple PWBs to be Inserted On Common Tooling

Comparing cost and savings on fixtures for future production programs (Table 5), cost avoidance against the $222,043 initial outlay to purchase flexible fixtures against the $24,000 for vendor supplied auto insertion fixtures, made the project development unattractive.

Production Program	PWBs	Unique Fixtures	In-House Fab	Vendor Fab	Cost Avoidance	
					In-House	Vendor
A	17	6	$398	$1,500	$2,391	$ 9,000
B	6	2	$398	$1,500	$ 797	$ 7,000
C	32	8	$398	$1,500	$3,187	$12,000
TOTAL	55	16	$398	$1,500	$6,375	$24,000

Table 5 Cost Avoidance - Using Three Likely Production Programs, PWB Process Fixture Would Provide $6,375/$24,000 in Future Savings

2.3 Program Management Plan

The project was kicked-off in July 1983. Since then numerous individuals have contributed to the technical effort. Representatives from Manufacturing are shown in Figure 7. Manufacturing Engineering was instrumental in providing the board feature analysis; the Model Shop provided data regarding in-house fixture cost; and Quality Assurance provided input on proces control requirements. The Project Investigator provided routing analysis overall CBA, and project direction.

2.4 Conclusion

A comparison of the cost and anticipated savings lead to the conclusion that a flexible fixture approach was not cost effective; especially where form-to-fit and functionality are primary drivers in achieving an optimum design. This is not to say that product designs can not be made producible.

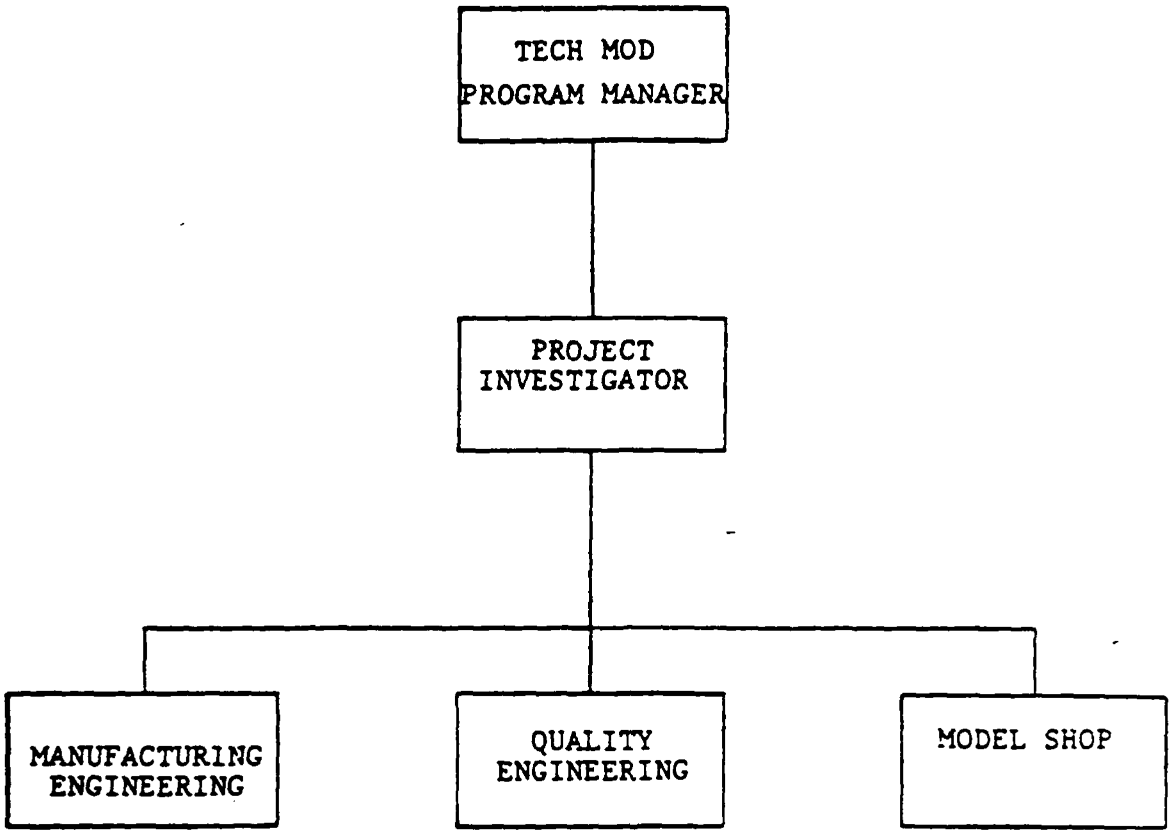
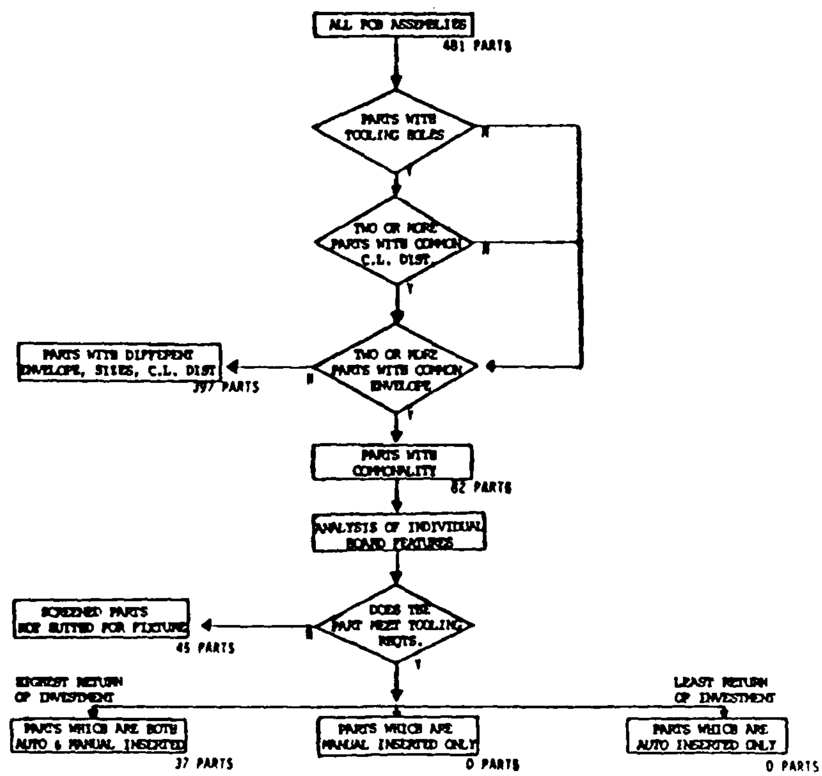


Figure 7 PROJECT ORGANIZATIONAL STRUCTURE

Tracor Aerospace

Considerable effort on the part of the Government and industry has lead to the development of flexible manufacturing systems. Electronic assembly contractors like Tracor are taking advantage of this technology and incorporating it into their production facilities. Resulting benefits parallel those of the PWD process fixture project. Reduction of setup and material movement between processes; elimination of contaminates due to handling; and in general, improved quality and reduction of manufacturing cost.

Ⓐ METHODOLOGY - THIRTY SEVEN PARTS IDENTIFIED AS CANDIDATES FOR FLEXIBLE FIXTURE



Ⓑ PRODUCT LINE BREAKOUT - NO. DIRECT COMMONALITY CAN BE FOUND WITHIN PCB ASSEMBLIES

BOARD FEATURES		PRODUCT LINE A	PRODUCT LINE B	PRODUCT LINE C	PRODUCT LINE D
OVERALL BOARD DIMENSIONS	L x W	3.1in X 2.825in.	6.468in X 6.437in	7.703in X 7.5in	6.94in X 5.30in
	THK	.065in.	.125in	.125in	.125in
CTR-TO-CTR TOOLING HOLE DISTANCE	X	2.750in	-	7.450in	4.80in
	Y	2.500in	-	.525in	6.05in
NUMBER OF TOOLING HOLES		4	NONE	2	3
TOLLING HOLE DIAMETER		.062in	NONE	.125in	.109in
TOOLING HOLE TO CIRCUITRY DISTANCE		1/8 and 3/32	NO STD	BETWEEN 1/16-3/16	BETWEEN 1/32-9/32
BOARD EDGE TO CIRCUITRY DISTANCE		1/16 AND 1/32	1/16 AND 1/32	BETWEEN 1/16-3/16	BETWEEN 1/16-7/32
NUMBER OF BOARD FINGERS		NONE	NONE	2	NONE
NUMBER OF PARTS WHICH QUALIFY		5 OF 10	8 OF 42	12 OF 14	12 OF 16

Ⓒ PCB CONF

Figure 5 BOARD FEATURE ANALYSIS - Subjective Methodology Identified 37 of 481 Parts Within Tracor Which Are Suited For A UNIVERSAL Fexture Application

FLEXIBLE FIXTURE

LEAST RETURN OF INVESTMENT

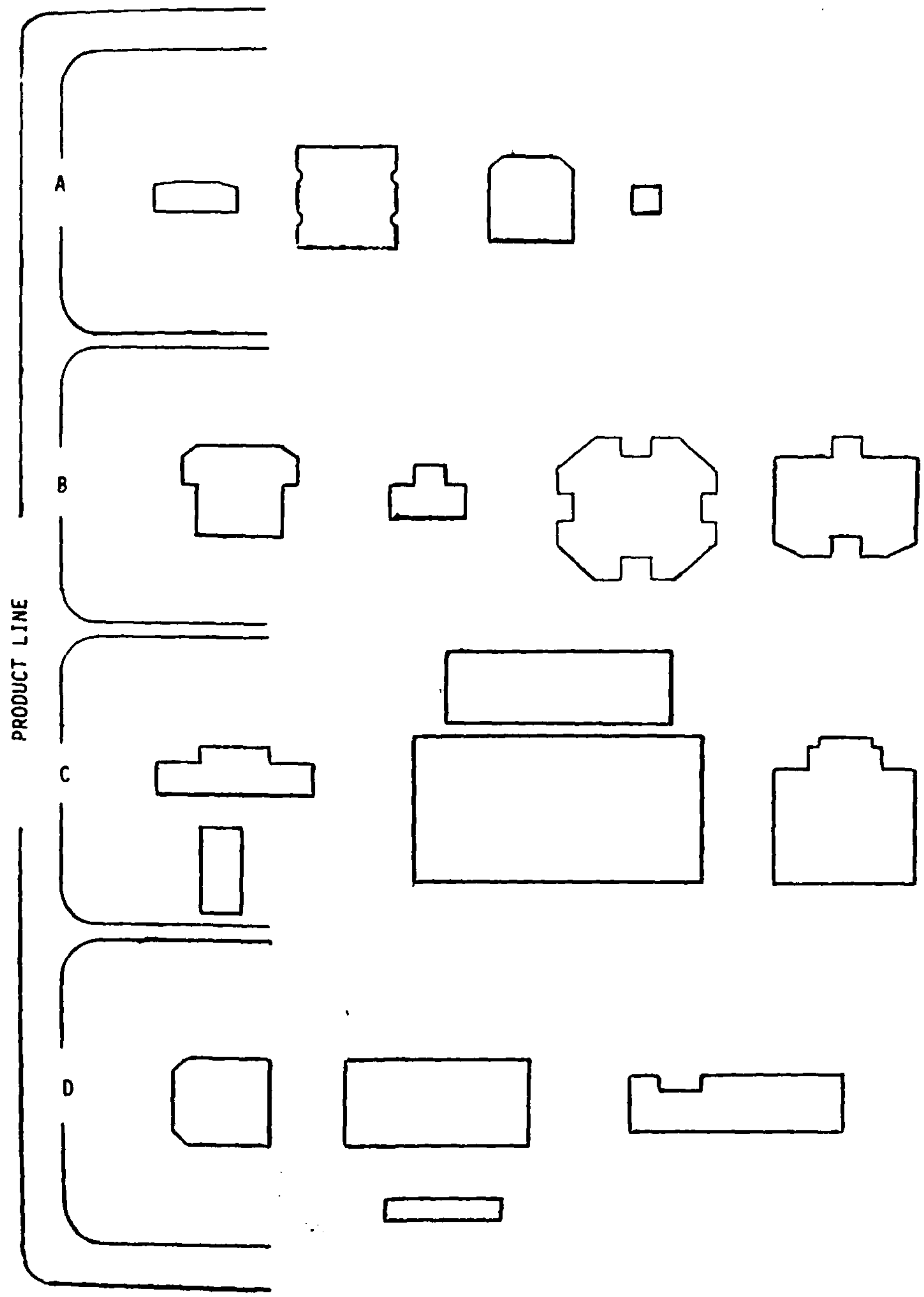
PARTS WHICH ARE AUTO INSERTED ONLY

0 PARTS

THIN PCB ASSEMBLIES

PRODUCT LINE C	PRODUCT LINE D
.703in X 7.5in	6.94in X 5.30in
.125in	.125in
7.450in	4.80in
.525in	6.05in
2	3
.125in	.109in
BETWEEN 1/16-3/16	BETWEEN 1/32-9/32
BETWEEN 1/16-3/16	BETWEEN 1/16-7/32
2	NONE
12 OF 14	12 OF 16

© PCB CONFIGURATIONS - MULTITUDE OF SHAPES HINDER APPLICATION OF UNIVERSAL FIXTURE APPROACH



Identified 37 of 481 Parts Within Tracor's Product Lines
UNIVERSAL Fexture Application

Ⓐ From - To Work Center Matrix - Nine Percent Coverage (523 Parts) With 56 Routings

FROM / TO

Work Centers	STORES IN	411120	411121	411122	411123	411124	411125	411130	411110	STORES OUT
Stores In		10	44					1	1	
411120			8	39			7	3		2
411121		23		2	2		4	4	26	2
411122		1	1		36	5	1	1		
411123		2	2	1		7	17	12		2
411124				1	3		3	6		6
411125		3	1	1	2	7		12		8
411130		1	2				2			33
411110		20	3	1						3
Stores Out										

NO.	NAME
411110	Auto Insertion
411120	Manual Assy
411121	Manual Prep
411122	Bake/Wave Solder
411123	Touch-Up
411124	Post Wave Solder
411125	Manual Solder
411130	Conformal Coat

Ⓑ Work Center F

FROM
Stores In
411110
411120
411122
411123
411125
411130
Stores In
411121
411120
411120
411125
411123
411122
411124
411124

Ⓒ Primary Flow of PWB Work Centers

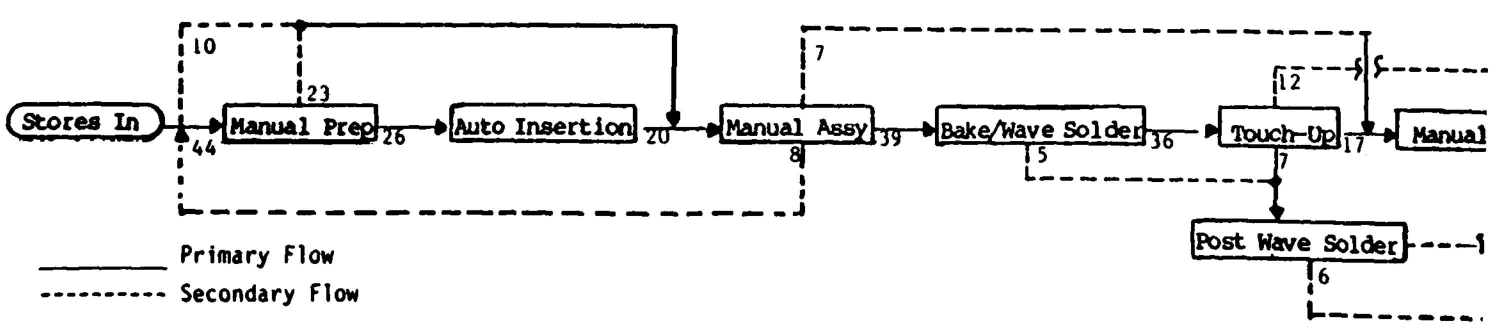
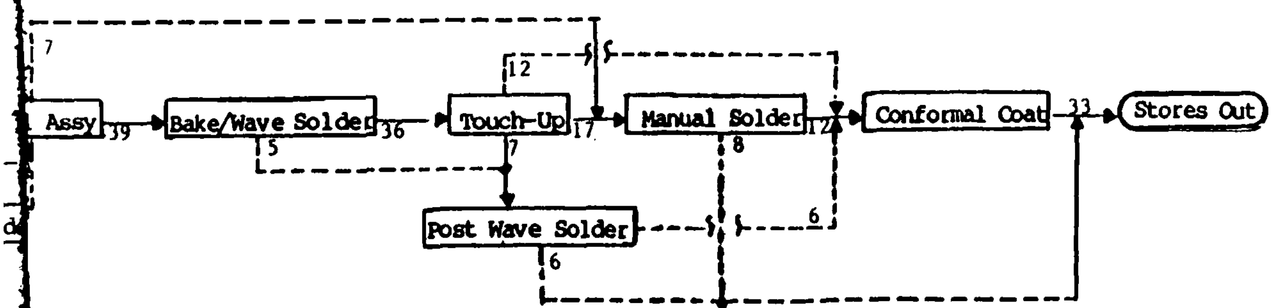


Figure 6 ROUTING ANALYSIS - Seventy-Six Percent of PCB Assemblies Are Produced Within This Flow

(523 Parts) With 56 Routings		
STORES OUT	NO.	NAME
	411110	Auto Insertion
	411120	Manual Assy
	411121	Manual Prep
2	411122	Bake/Wave Solder
2		
	411123	Touch-Up
2	411124	Post Wave Solder
6		
8	411125	Manual Solder
33	411130	Conformal Coat
3		

Ⓑ Work Center From - To Relationships - Identifies Juxtaposed Work Centers

FROM	TO	HITS
Stores In	411121	44
411110	411110	26
411120	411120	20
411122	411122	39
411123	411123	36
411125	411125	17
411130	Stores Out	33
Stores In	411120	10
411121	411120	23
411120	411121	8
411120	411125	7
411125	Stores Out	8
411123	411124	7
411122	411124	5
411124	411130	6
411124	Stores Out	6



semblies Are Produced Within This Flow