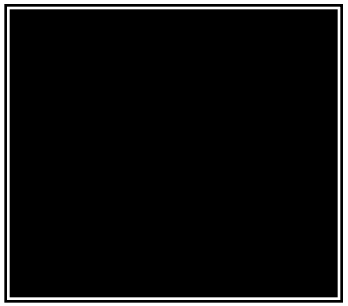
Lean Aircraft Initiative
Plenary Workshop

Factory Operations Team



October 16, 1996

Presented by:
Tom Shields
MIT

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Factory Operation Benchmarking

- Review of benchmarking activities
- Results
- Analysis of data
- Conclusions
- Next steps
- Focus group status report

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Benchmarking Objective

Develop comparative benchmarking on member factory flow measures.

Flow Variables:

- Touch Labor
- Cycle Time
- Router Queuing
- Batch Sizes

Support Variables:

- IE Hours
- Part Characteristics
- Distance Traveled
- # of Process Steps
- Process Controls
- Quality

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Benchmarking Ground Rules

- Specific parts and data to be collected determined by sector representatives
- Questionnaire based
- Data verification

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Metric Definitions

- **Cycle Time (Hours)**
  - The total time from initiation of work order to completion of manufacturing process on work order.
- **Waiting Time (Hours)**
  - Cycle Time - Touch Labor. The time the work order spends on the floor without work being charged to the work order.
- **Router Queuing (Hours)**
  - Time between creation of work order and first process step.

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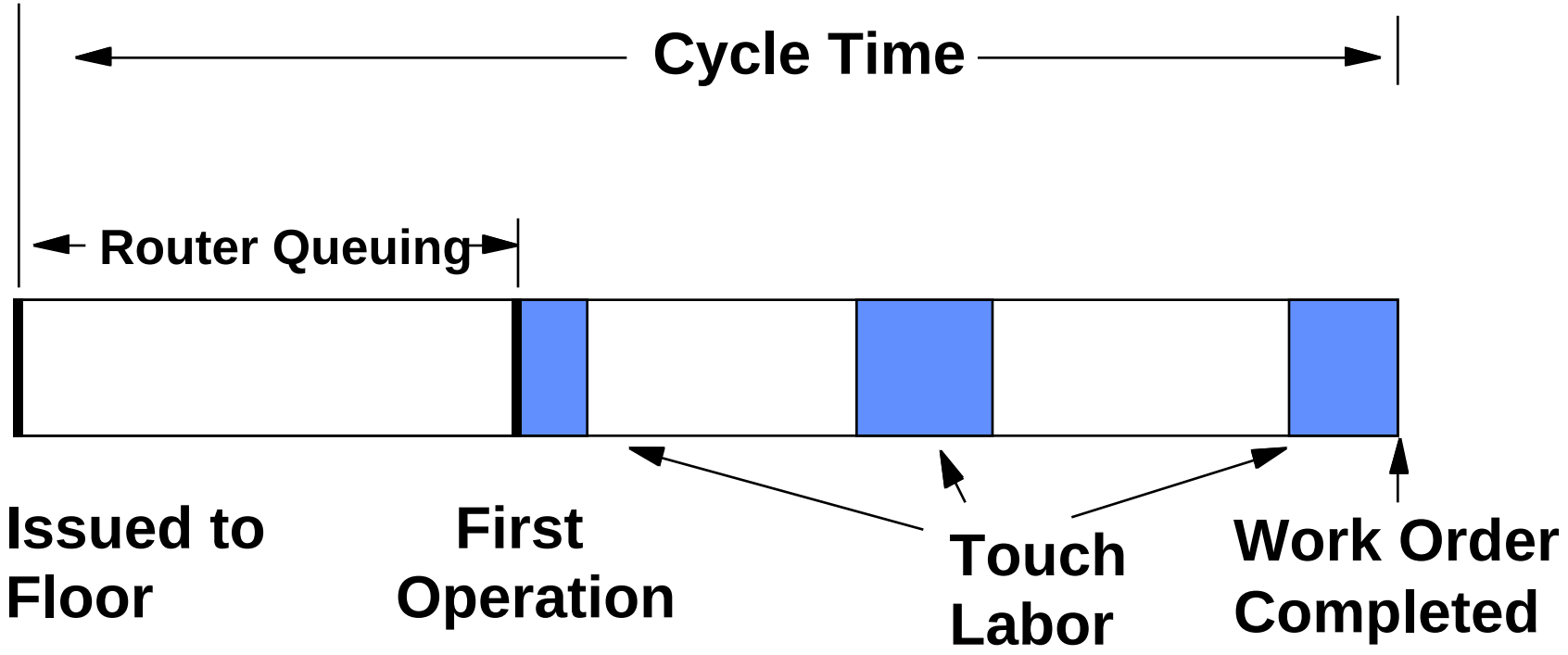
Part Manufacturing Timeline



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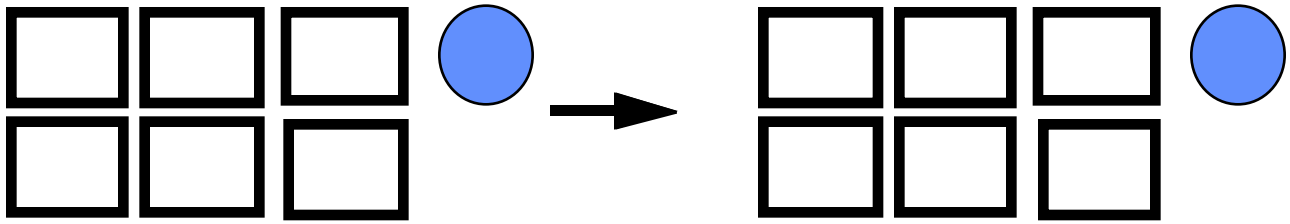
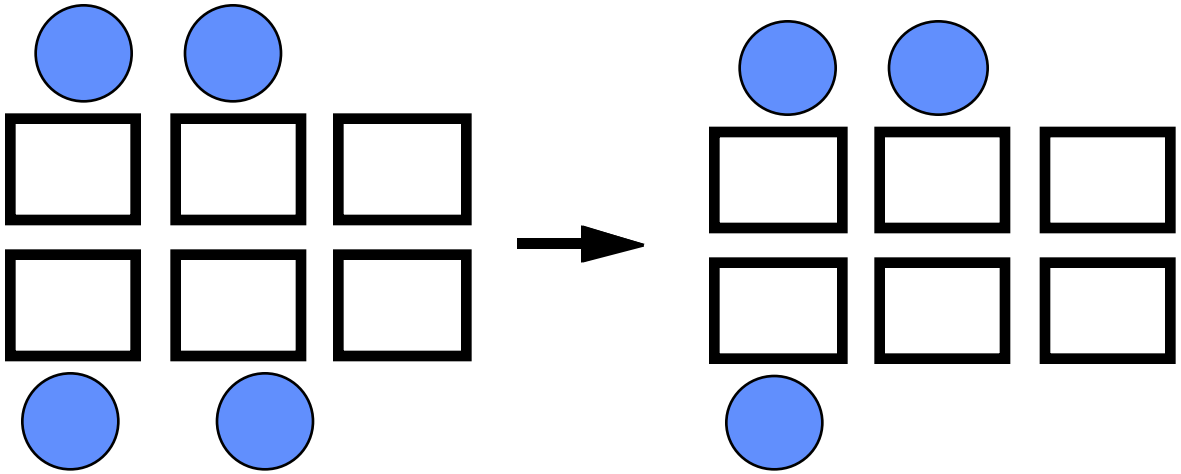
Touch Labor Measurement

Process #1: One Person/Operation per Batch



Process #2: Multiple Persons/Operations per Batch



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Flow Efficiency Metric

- **Flow Efficiency in principle (Unitless)**

$$= \frac{\text{Fabrication Time}}{\text{Cycle Time}}$$

- **Flow Efficiency surrogate (Unitless)**

$$= \frac{\text{Touch Labor/part/crew size}}{\text{Cycle Time - Router Queuing}}$$

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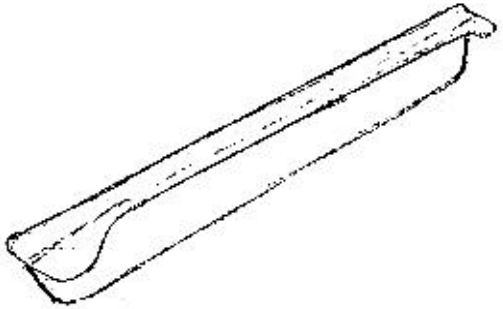
Airframe Sector

- **Extruded Sheet Metal Part**
  - Straight, aluminum
  - < 2 ft long
  - < 1/4” thick
  - “T”, “L”, “C” or “Z” cross section
- **Brake-Formed Part**
  - Aluminum
  - 2 ft long
  - < 1/4” thick
- **Machined Prismatic Part**
  - Aluminum
  - 3 Axis machine
  - < 1 ft^3



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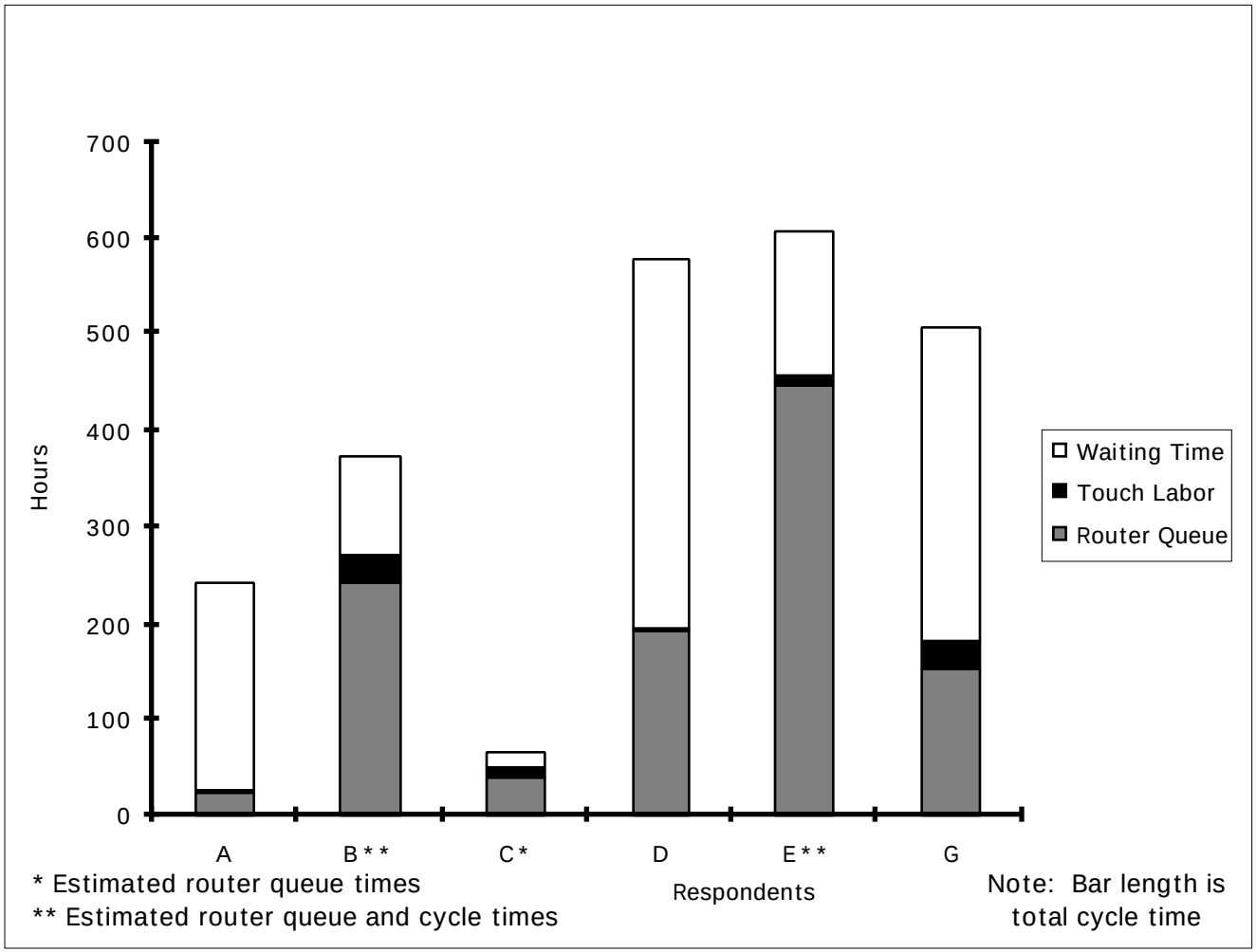
Airframe Sector - Extrusions



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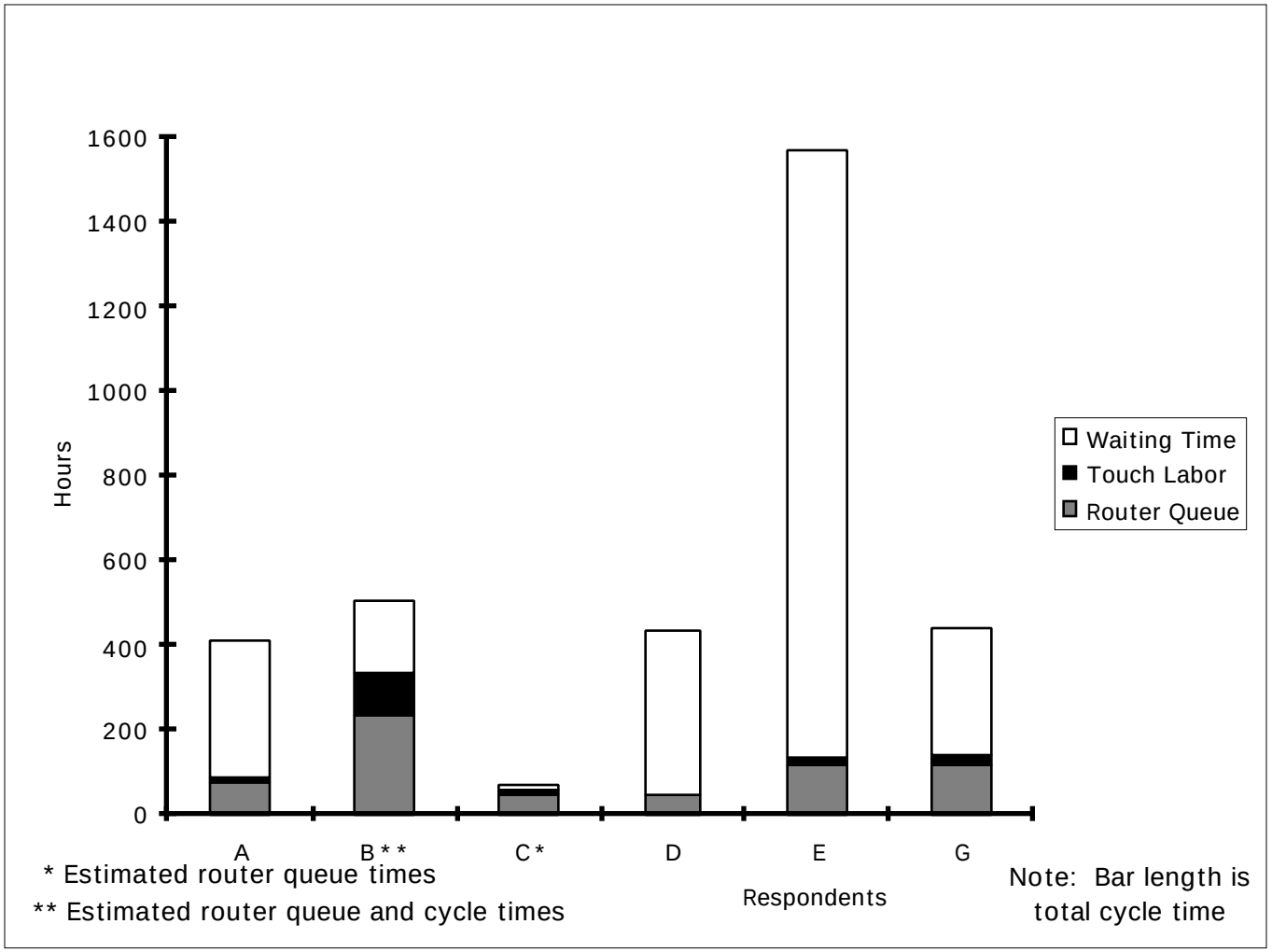
Airframe Sector - Brake-formed Parts



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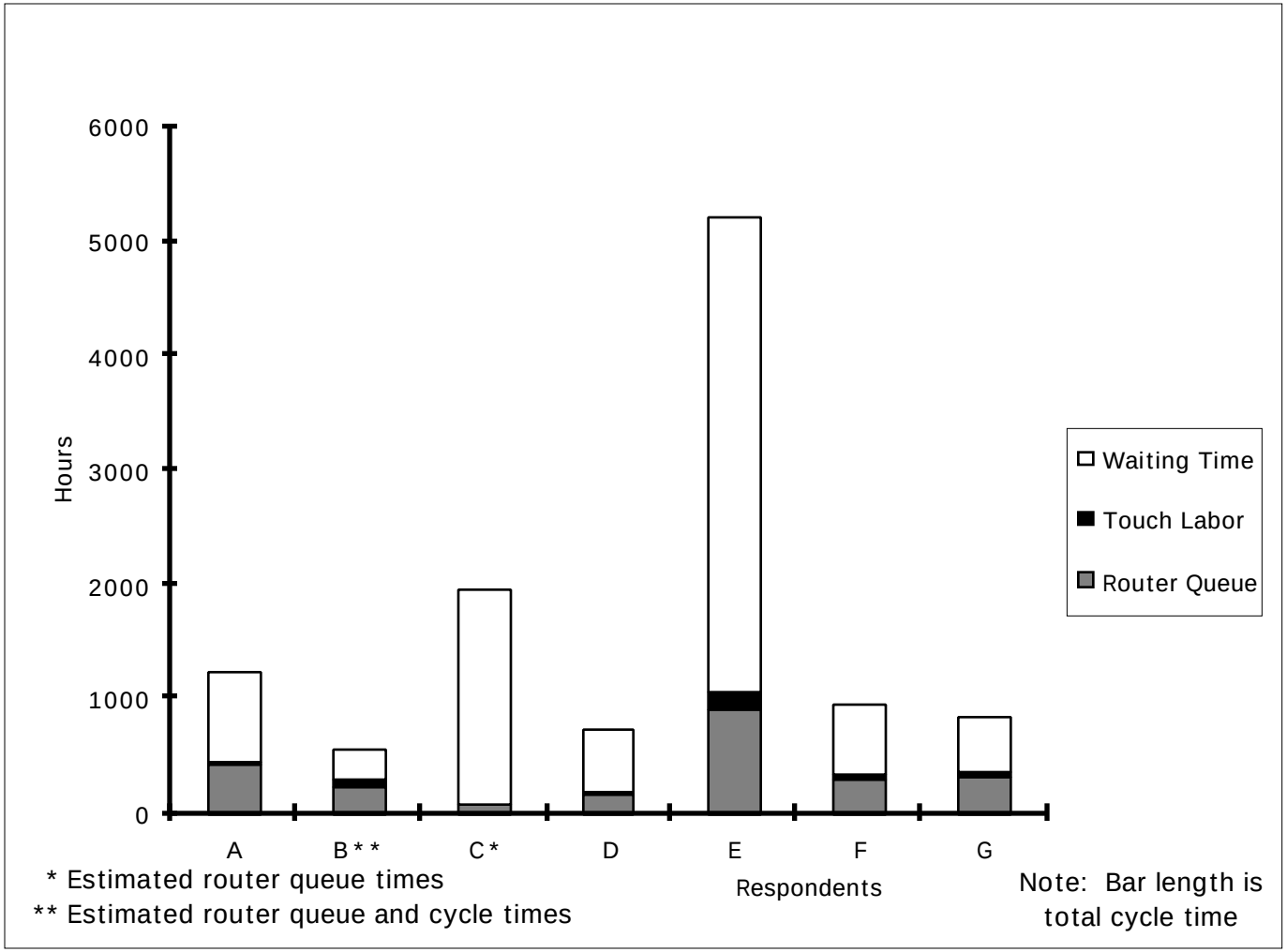
Airframe Sector - Machined Parts



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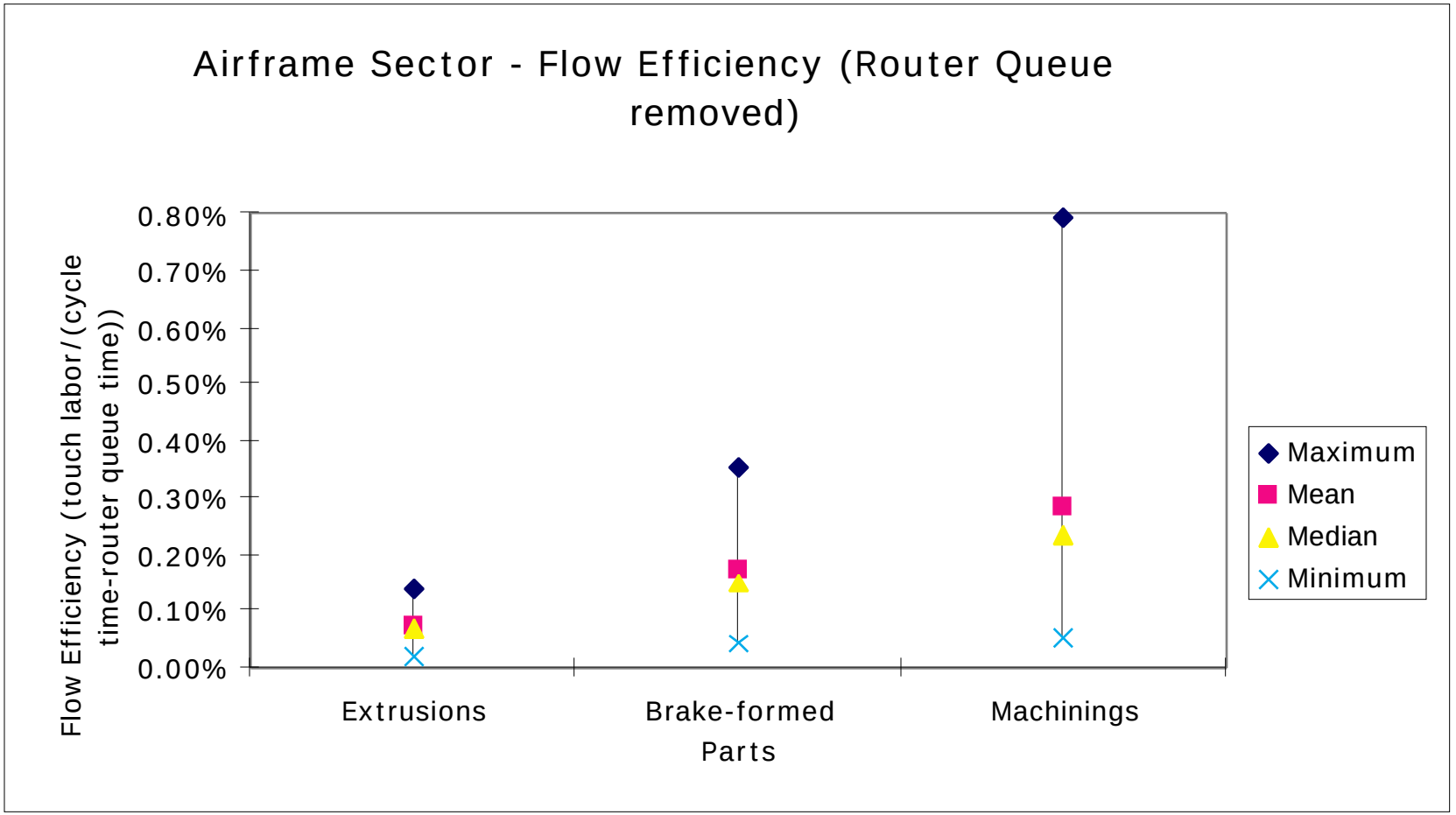
Airframe Sector - Flow Efficiency



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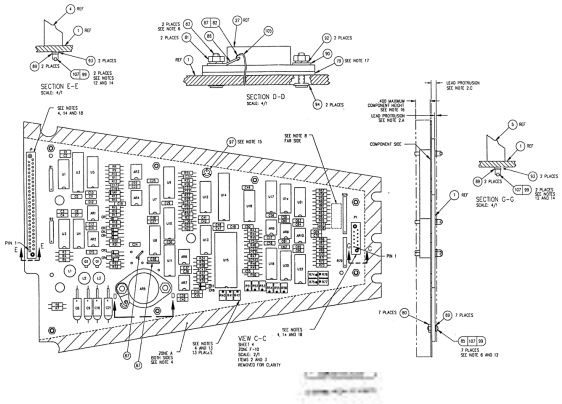
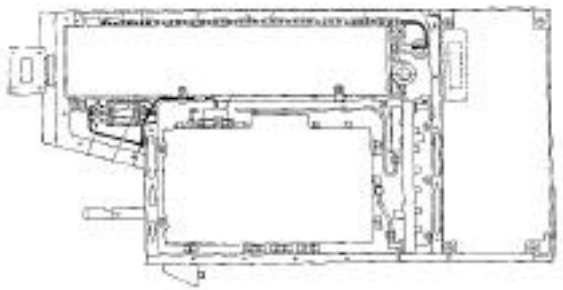
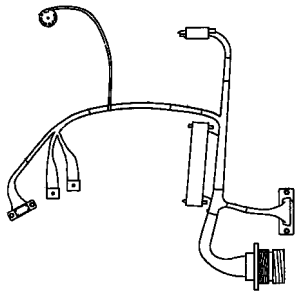
Electronic Sector

- **Printed wiring assembly**
  - **Component insertion through final test**
  - **Does not include wafer board fabrication**
- **Electronic Chassis**
  - **Less chassis fabrication**
- **Cable / Harness**
  - **All assembly operations**







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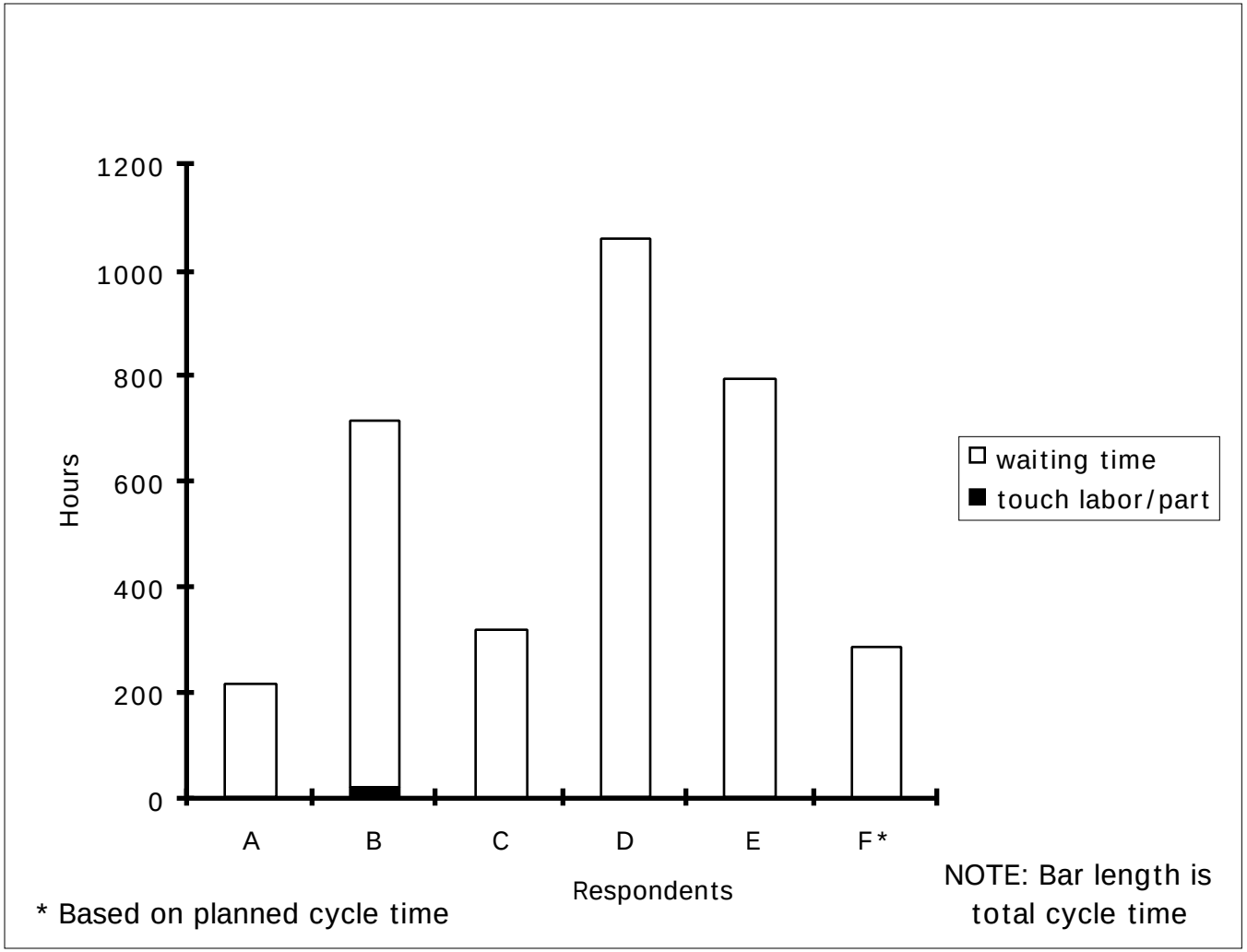
Electronic Sector - Printed Wiring Assembly



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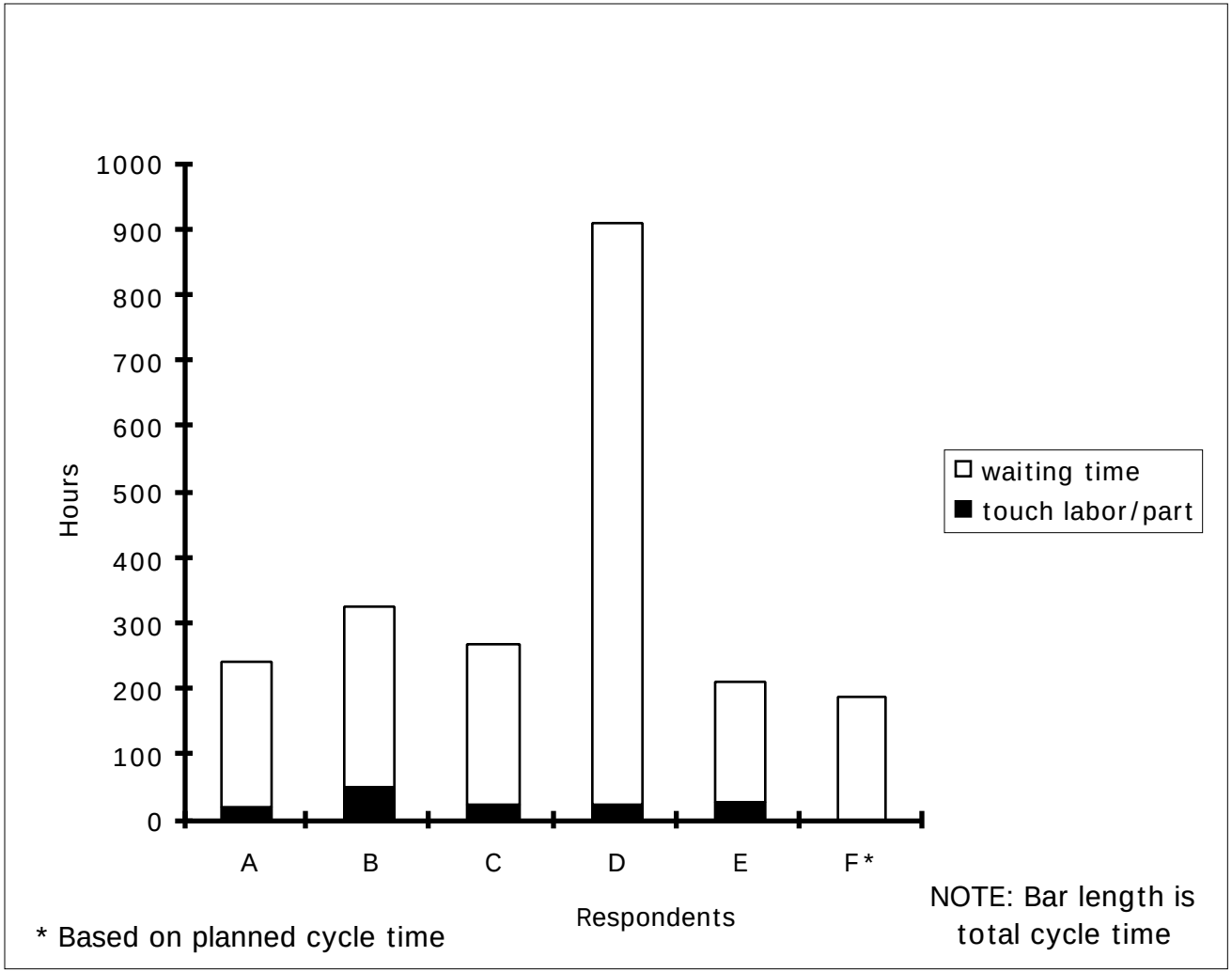
Electronic Sector - Chassis



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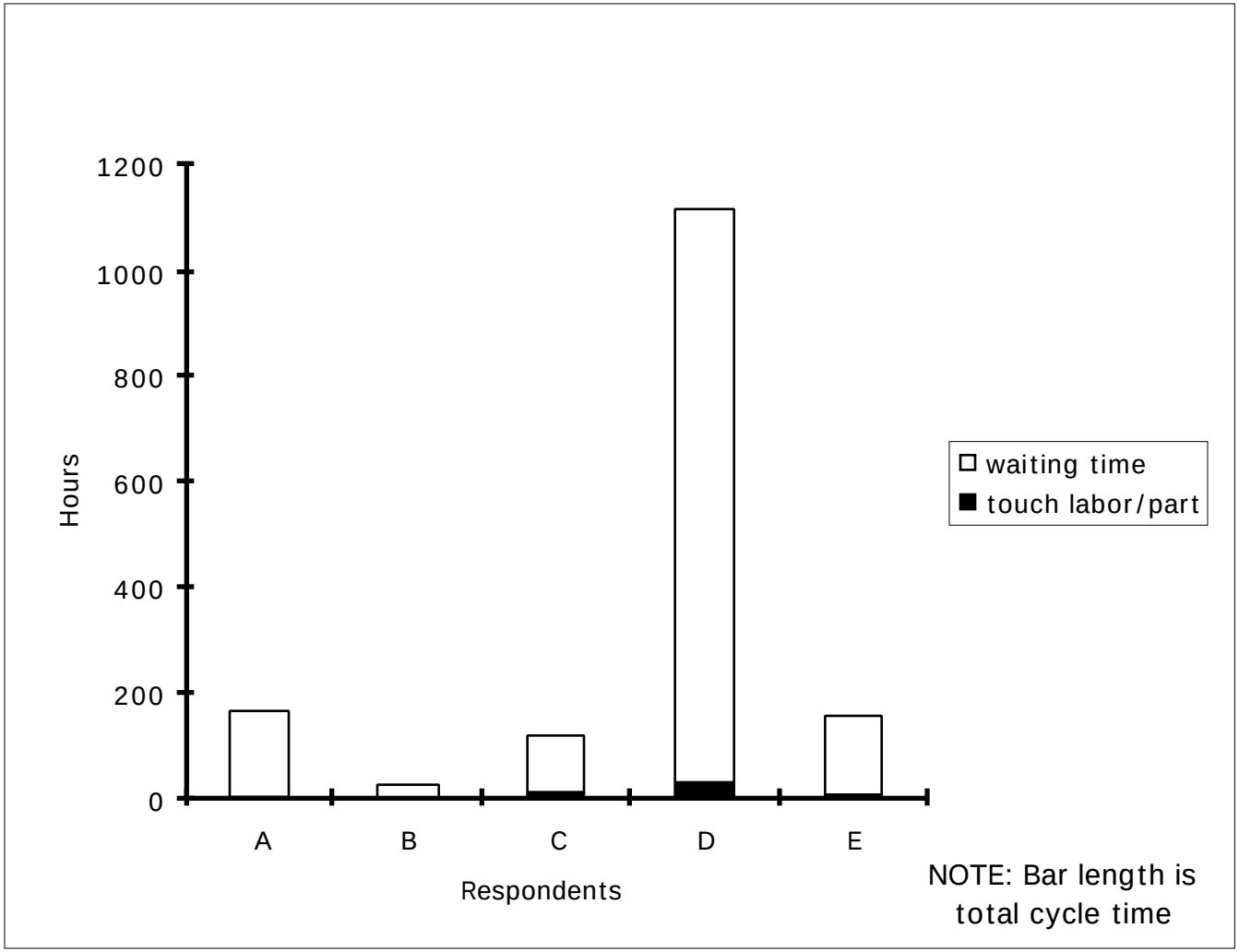
Electronic Sector - Cable / Harness



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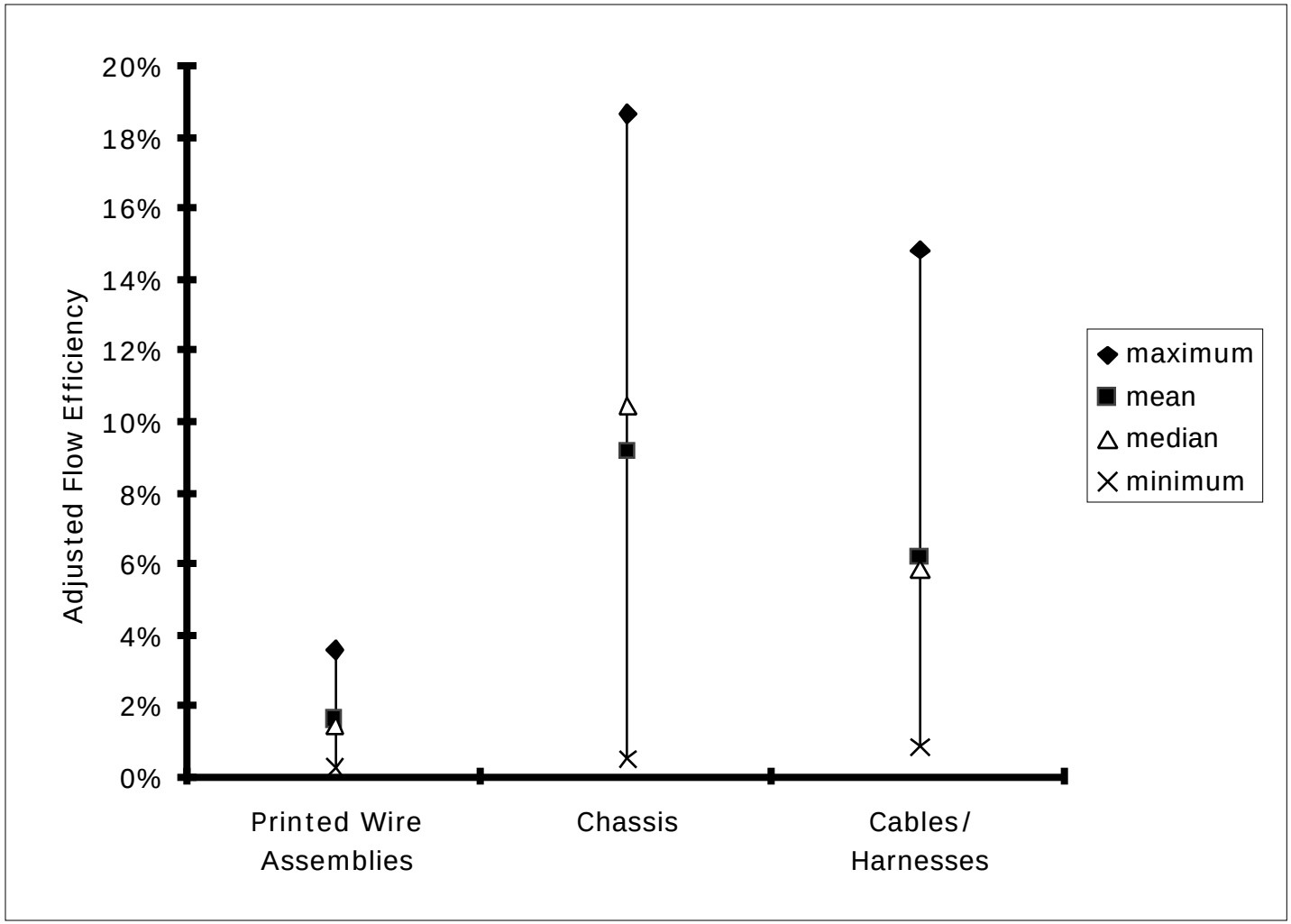
Electronic Sector - Flow Efficiency



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Engine Sector

Items Benchmarked

- Turbine Disk
- Combustor

- Three companies responded
- Usable data from one company
- Results not reported by sector
- Used in total data analysis

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Summary Observations After Data Collection

- Each respondent's data collection system was different
- Multiple work methods observed
- Questionnaire method insufficient for gathering detail data
- Few respondents tracked their actual elapsed cycle times
- Work order lot size not the batch size used for processing

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Analysis

- Hypotheses
  - Higher flow efficiencies with lower lot sizes
  - Higher flow efficiencies with shorter distance traveled
  - Higher flow efficiencies with fewer process steps
- Analysis by sector
- Analysis with all sectors combined
- Influence of process type
- Wait time analysis

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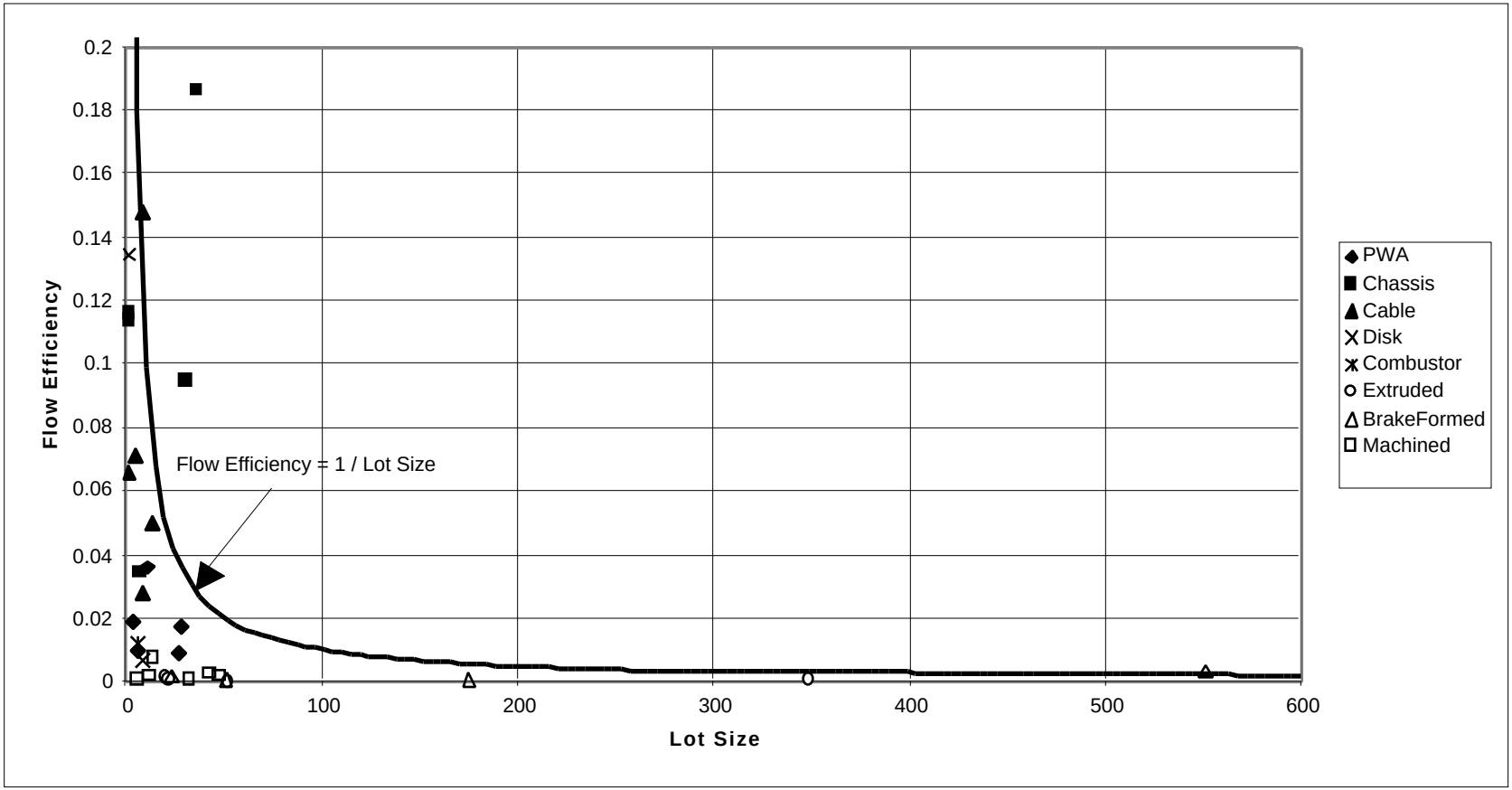
Flow Efficiency vs. Lot size (Combined)



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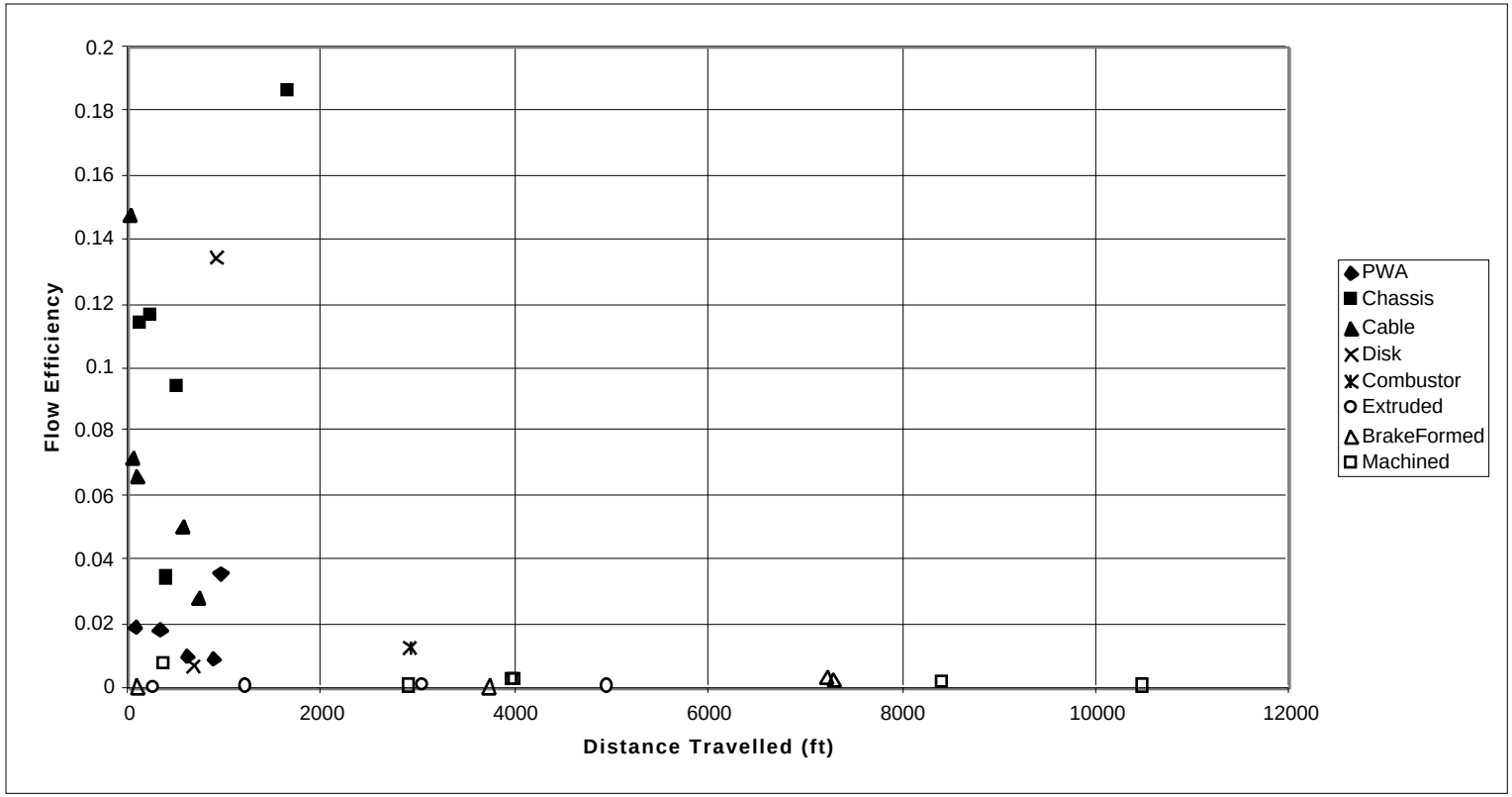
Flow Efficiency vs. Travel Distance (Combined)



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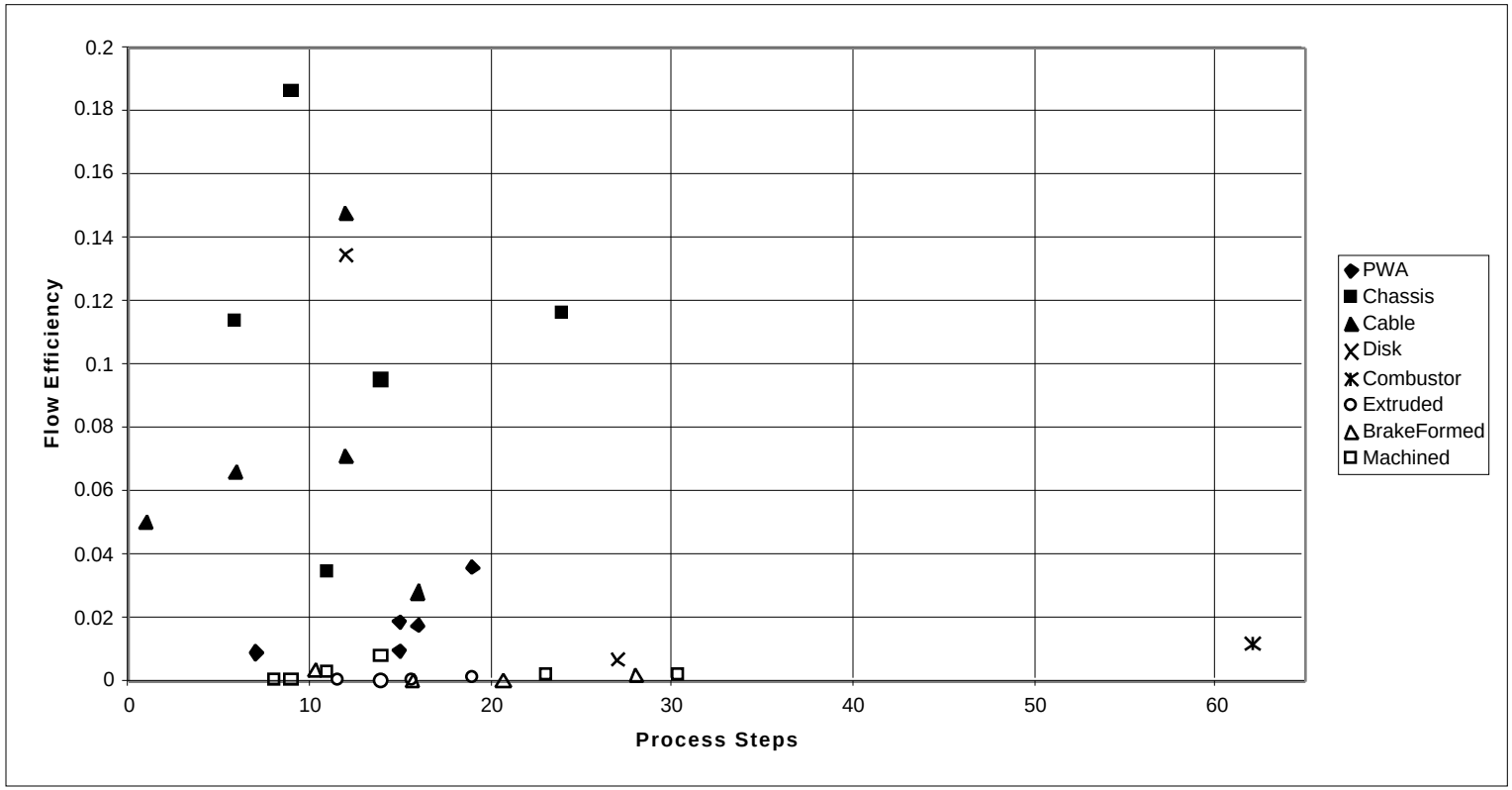
Flow Efficiency vs. Process Steps (Combined)



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Process Type

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Job Shop Considerations

Factors that influence performance of job shops

- What the facility has optimized
- Operations may be capacity limited
- Machine utilization effect on set up
- Numbers of parts that are processed in this area
- Production environment

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Wait Time Components

- Transportation delay
- Lot delay (while all parts are processed)
- Storage delay

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Wait Time Analysis - Airframe Sector

	Wait Fraction	Lot Delay
Extrusion	95%	2%
Brake Formed	97%	2%
Machining	94%	3%

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Wait Time Analysis - Electronic Sector

- Could not determine wait times directly
- Bounded the problem
  - Defined maximum wait times
  - Defined I. E. factor necessary to achieve zero wait time
- Process defined one respondent in each type of part that was doing at least twice as good as the other respondents

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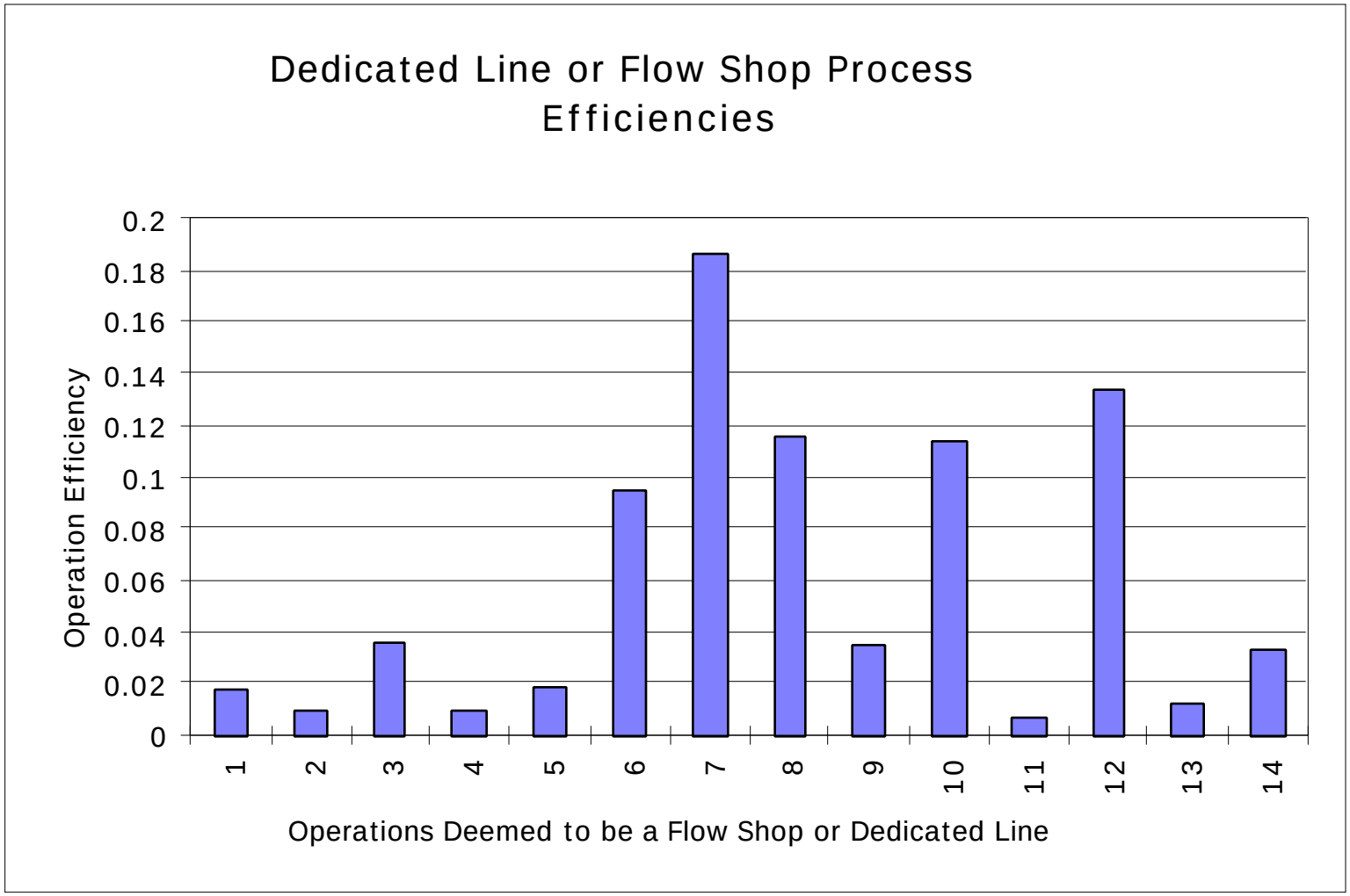
Dedicated Lines or Flow Shops



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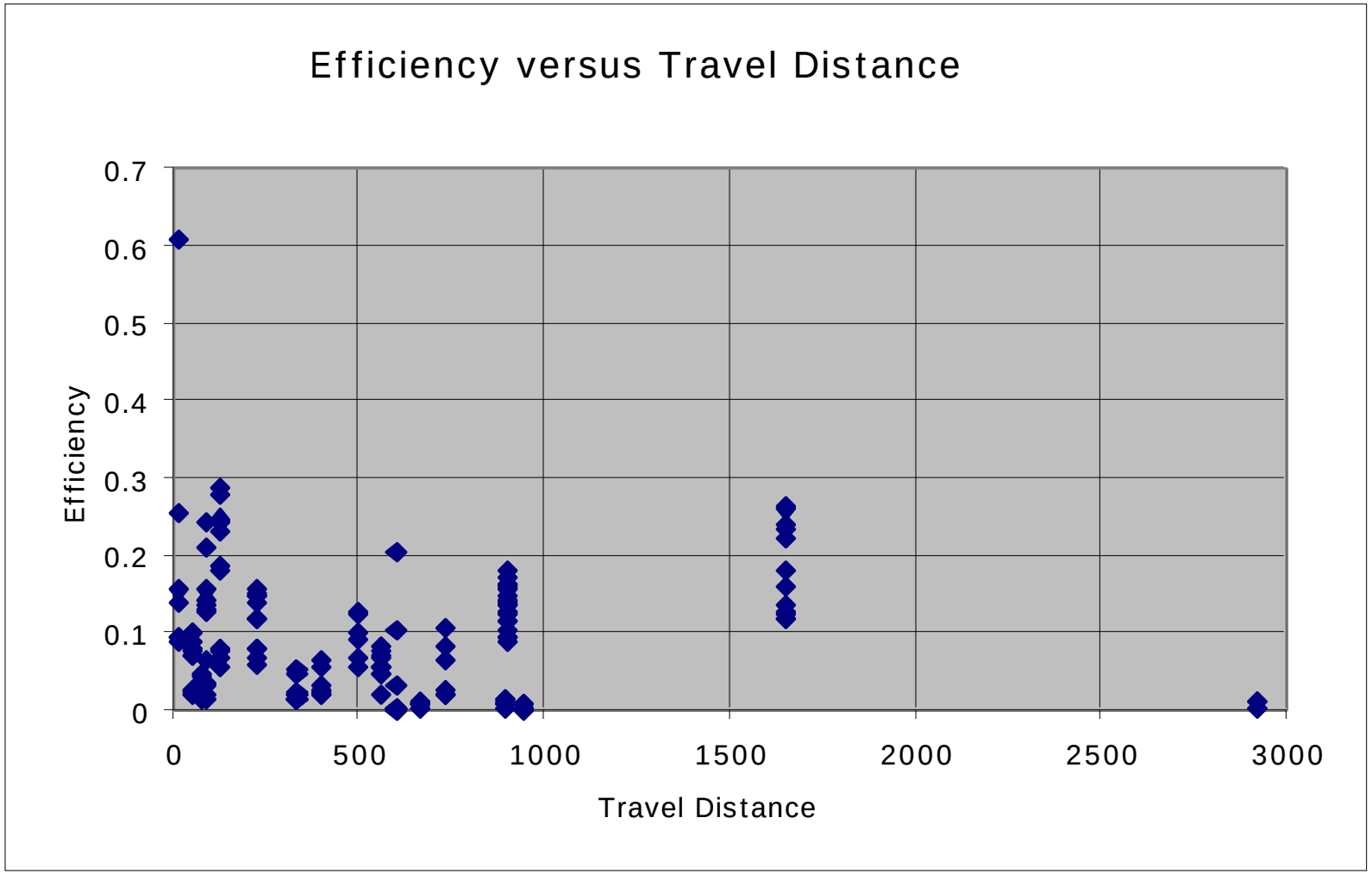
Wait Time Analysis



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Wait Time Analysis Conclusions

- **Dedicated line or flow shop**
  - All wait time in dedicated line or flow shop is waste
  - Transportation delay does not predominate
  - Predominate wait time component is storage delay
- **Job shop**
  - Storage and transportation delay predominate
  - research could not differentiate other contributing factors
- **Most opportunity for lean improvement is to concentrate on wait time reduction**

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Cycle Time Reduction

Wait Time = Waste

- **Gather data to understand wait time**
  - part/assembly/product ACTUAL cycle time key
  - part/assembly/product ACTUAL fabrication time
  - Determine wait time and their components
- **Analyze causes of wait time**
- **Implement steps to reduce wait times**
- **Evaluate results to the production system**
- **Standardize the improvement across the system**
- **Reflect on the process and select next effort**

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Observations

- **Few respondents tracked actual cycle times**
- **Router cueing time ranged from 4 to 42% of total cycle time in the airframe sector**
- **Wait fraction for airframe sector averages 96%**
- **Wait fraction for engine sector averages 87%**
- **Could not determine wait times in electronic sector**
  - Comparison of wait time bounds
  - One electronic sector company showed at least two times better performance

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Conclusions

Wait time reduction = cycle time reduction

- Within sectors apples to apples comparison achieved for each type of part
- Flow efficiency varied inversely with lot size and travel distance
- In job shops storage and transportation delay greater than lot delay times
- For dedicated lines or flow shops the largest component of wait time was storage delay

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Next Steps

- Report to respondents
- Application of lessons learned into future research

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Factory Operations Status Report

- Focus on LEM overarching practice - Identify and Optimize Enterprise Flow
- Concentrate on factors that effect “Order to point of use delivery cycle time”
- Use LEM to classify results
- Focus Group Identified field research site
- Data collection methodology developed at MIT
- Site introductory visit completed
- Data collection to commence next week

