

# *Cost & Benefit Analysis*



## *Executive Overview*

*David F. Rico*

# *Table of Contents*



- *Methodology*
- *Breakeven Point Analysis*
- *Actual Costs & Benefits*
- *Normalized Costs & Benefits*
- *Normalized Benefits*
- *Category Costs & Benefits*
- *Summary of Costs & Benefits*
- *Conclusion*

*Methodology*

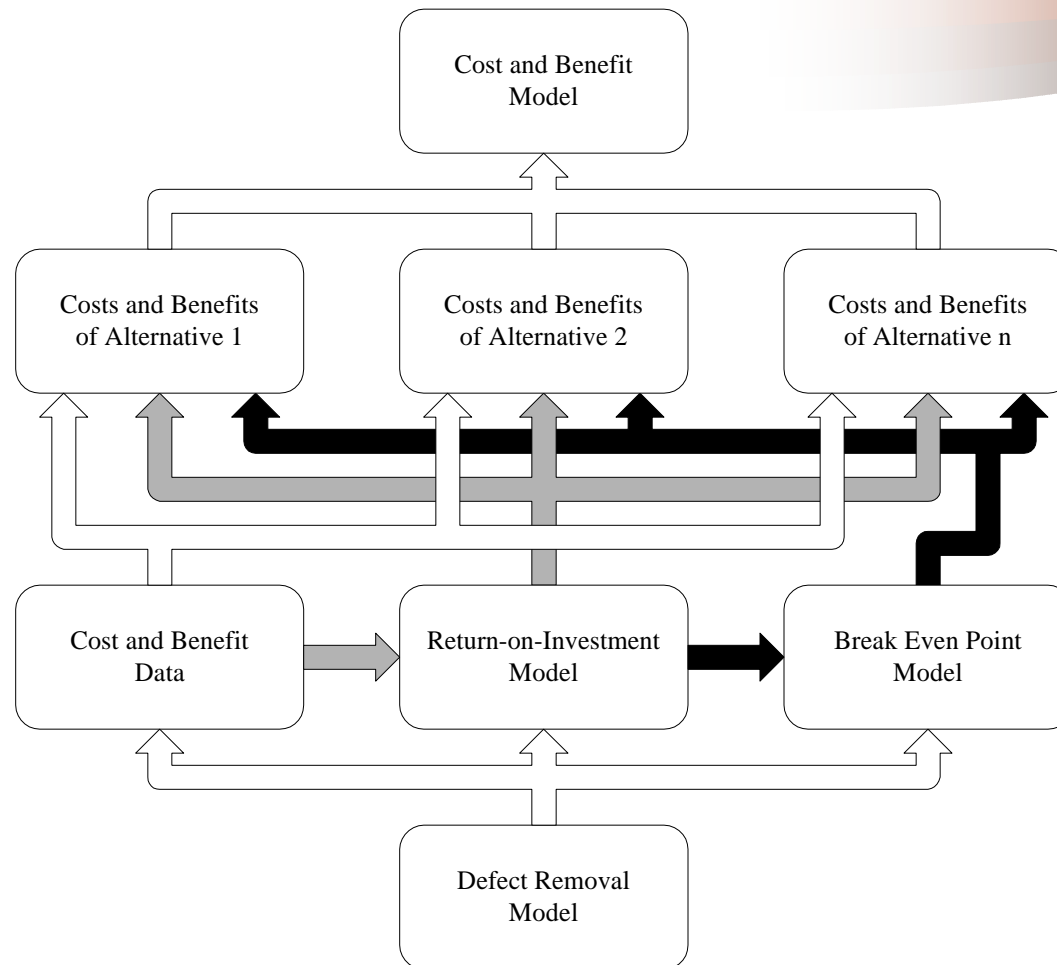


# *Origin of Cost & Benefit Analysis*

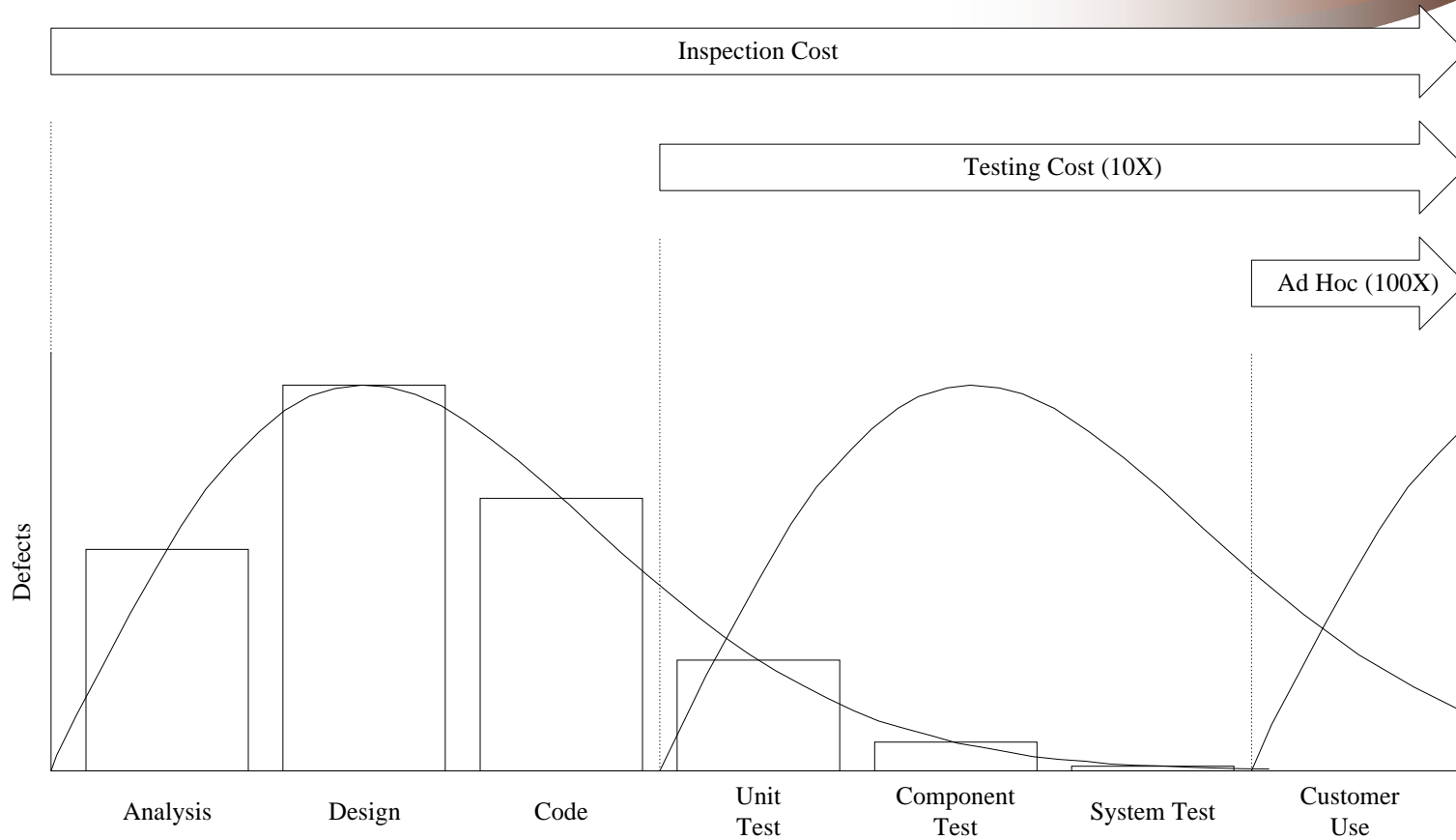


- Software Process Improvement (SPI) Study
  - Using Cost Benefit Analyses to Develop a Pluralistic Methodology for Selecting from Multiple Prescriptive Software Process Improvement (SPI) Strategies
  - David F. Rico (April 30, 1999)
- Full text, graphics, data, spreadsheets, and algorithms available online
  - <http://davidfrico.com>

# Analytical Methodology



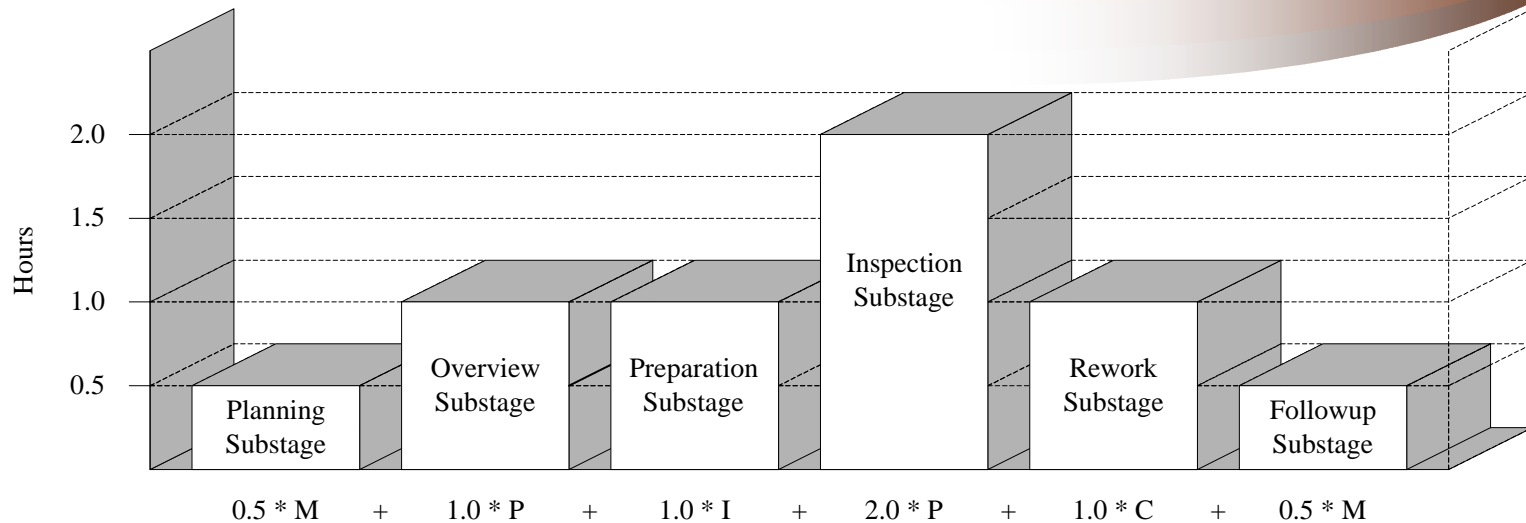
# Defect Removal Model



# Return-on-Investment (ROI) Model

|                            | PSP      | AT&T<br>Inspection | Basic<br>Inspection | BNR<br>Inspection | Gilb<br>Inspection | HP<br>Inspection | Test   | Ad Hoc  |
|----------------------------|----------|--------------------|---------------------|-------------------|--------------------|------------------|--------|---------|
| Software Size              | 10,000   | 10,000             | 10,000              | 10,000            | 10,000             | 10,000           | 10,000 | 10,000  |
| Start Defects              | 1,000    | 1,000              | 1,000               | 1,000             | 1,000              | 1,000            | 1,000  | 1,000   |
| Review Efficiency          | 67%      | 67%                | 67%                 | 67%               | 67%                | 67%              | 0%     | 0%      |
| Review Hours               | 97       | 500                | 708                 | 960               | 970                | 1,042            | 0      | 0       |
| Review Defects             | 667      | 667                | 667                 | 667               | 667                | 667              | 0      | 0       |
| Review Defects/Hour        | 6.86     | 1.33               | 0.94                | 0.69              | 0.69               | 0.64             | 0      | 0       |
| Review Hours/Defect        | 0.15     | 0.75               | 1.06                | 1.44              | 1.46               | 1.56             | 0      | 0       |
| Remaining Defects          | 333      | 333                | 333                 | 333               | 333                | 333              | 1,000  | 1,000   |
| Test Efficiency            | 100%     | 67%                | 67%                 | 67%               | 67%                | 67%              | 67%    | 0%      |
| Test Hours                 | 61       | 1,667              | 2,361               | 3,200             | 3,233              | 3,472            | 8,360  | 0       |
| Test Defects               | 333      | 222                | 222                 | 222               | 222                | 222              | 667    | 0       |
| Test Defects/Hour          | 5.47     | 0.13               | 0.09                | 0.07              | 0.07               | 0.06             | 0.08   | 0       |
| Test Hours/Defect          | 0.18     | 7.50               | 10.63               | 14.40             | 14.55              | 15.63            | 12.54  | 0       |
| Validation Defects         | 1,000    | 889                | 889                 | 889               | 889                | 889              | 667    | 0       |
| Released Defects           | 0        | 111                | 111                 | 111               | 111                | 111              | 333    | 1,000   |
| Maintenance Hours/Defect   | 2        | 75                 | 106                 | 144               | 146                | 156              | 125    | 125     |
| Development Hours          | 242      | 5,088              | 5,088               | 5,088             | 5,088              | 5,088            | 5,088  | 5,088   |
| Validation Hours           | 158      | 2,167              | 3,069               | 4,160             | 4,203              | 4,514            | 8,360  | 0       |
| Maintenance Hours          | 0        | 8,333              | 11,806              | 16,000            | 16,167             | 17,361           | 41,800 | 125,400 |
| Total Hours                | 400      | 15,588             | 19,963              | 25,248            | 25,458             | 26,963           | 55,248 | 130,488 |
| QBreak Even/Ad Hoc         | 0.78     | 6.67               | 6.67                | 6.67              | 6.67               | 6.67             | 66.67  |         |
| PBreak Even/Ad Hoc         | 6.15     | 1.65               | 1.72                | 1.81              | 1.81               | 1.84             | 10.37  |         |
| PBreak Even/Test           | 14.59    | 4.79               | 5.38                | 6.33              | 6.38               | 6.72             |        |         |
| PBreak Even/Inspection     | 35.96    |                    |                     |                   |                    |                  |        |         |
| Slope (Life Cycle Cost)    | 25.00    | 0.64               | 0.50                | 0.40              | 0.39               | 0.37             | 0.18   | 0.08    |
| Y Intercept (w/Investment) | -2000.00 | -12.19             | -9.52               | -7.53             | -7.46              | -7.05            | -14.12 |         |
| HBreak Even/Ad Hoc         | 80.25    | 21.58              | 22.43               | 23.56             | 23.61              | 23.95            | 135.27 |         |
| HBreak Even/Test           | 80.58    | 26.47              | 29.75               | 34.99             | 35.24              | 37.11            |        |         |
| HBreak Even/Inspection     | 81.44    |                    |                     |                   |                    |                  |        |         |
| ROI/Ad Hoc                 | 1,290:1  | 234:1              | 160:1               | 114:1             | 113:1              | 104:1            | 10:1   |         |
| ROI/Test                   | 430:1    | 67:1               | 42:1                | 27:1              | 26:1               | 23:1             |        |         |
| ROI/Inspection             | 143:1    |                    |                     |                   |                    |                  |        |         |

# Rico's Inspection Cost Model



$$\text{Hours} = \text{Product Size} / (\text{Inspection Rate} * 2) * (\text{Team Size} * 4 + 1)$$

| People | 10,000 Lines     |                   |                   | 100,000 Lines    |                   |                   | 1,000,000 Lines  |                   |                   |
|--------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|
|        | 60 SLOC Per Hour | 120 SLOC Per Hour | 180 SLOC Per Hour | 60 SLOC Per Hour | 120 SLOC Per Hour | 180 SLOC Per Hour | 60 SLOC Per Hour | 120 SLOC Per Hour | 180 SLOC Per Hour |
| 4      | 1,417            | 708               | 472               | 14,167           | 7,083             | 4,722             | 141,667          | 70,833            | 47,222            |
| 5      | 1,750            | 875               | 583               | 17,500           | 8,750             | 5,833             | 175,000          | 87,500            | 58,333            |
| 6      | 2,083            | 1,042             | 694               | 20,833           | 10,417            | 6,944             | 208,333          | 104,167           | 69,444            |
| 7      | 2,417            | 1,208             | 806               | 24,167           | 12,083            | 8,056             | 241,667          | 120,833           | 80,556            |

# *PSP & Inspection Cost Models*

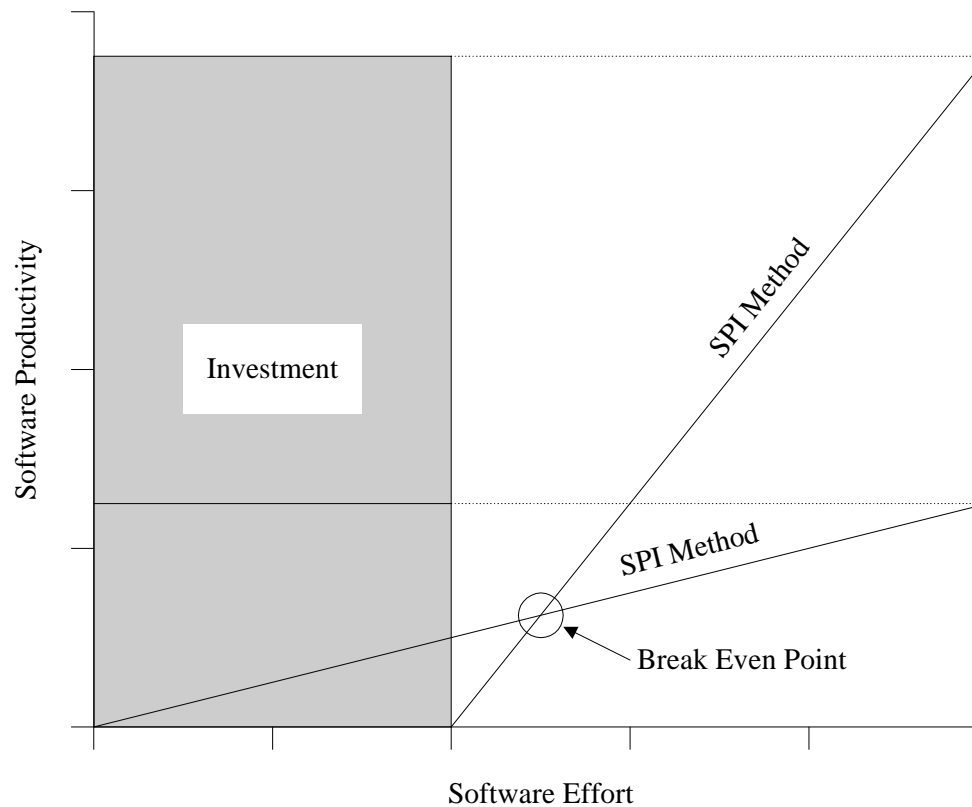
| Method     | Software Cost Model                       | Author         | Source          |
|------------|---|----------------|-----------------|
| PSP        | $SLOC / 25$                               | Rico (1998)    | Hays (1997)     |
| Inspection | $SLOC / (Rate * 2) * (Team Size * 4 + 1)$ | Rico (1993)    | Russell (1991)  |
|            | $SLOC / (Rate * 2) * 25$                  | Grady (1994)   | Hewlett Packard |
|            | $50 * KSLOC$                              | Barnard (1994) | AT&T            |
|            | $3 * KSLOC * 4 * 8$                       | Russell (1991) | Bell Northern   |
|            | $SLOC / (Rate * 2) * (5.76 * Team Size)$  | Gilb (1993)    | Fagan (1976)    |

# Software Cost Models

| Software Cost Model         | Author          | Source        | Form       | Output |
|-----------------------------|-----------------|---------------|------------|--------|
| $SLOC / 25$                 | Rico (1998)     | Hays (1997)   | Linear     | Hours  |
| $3 * KSLOC ^ 1.12$          | McGibbon (1997) | Boehm         | Log-Linear | Months |
| $5.2 * KSLOC ^ 0.91$        | McGibbon (1997) | Walston/Felix | Log-Linear | Months |
| $5.5 + 0.73 * KSLOC ^ 1.15$ | McGibbon (1997) | Bailey/Basili | Log-Linear | Months |
| $5.288 * KSLOC ^ 1.047$     | McGibbon (1997) | Doty          | Log-Linear | Months |

# Rico's Breakeven Point Model

Break Even Point = Investment / Productivity Difference \* Productivity Product



# *Breakeven Point Analysis*



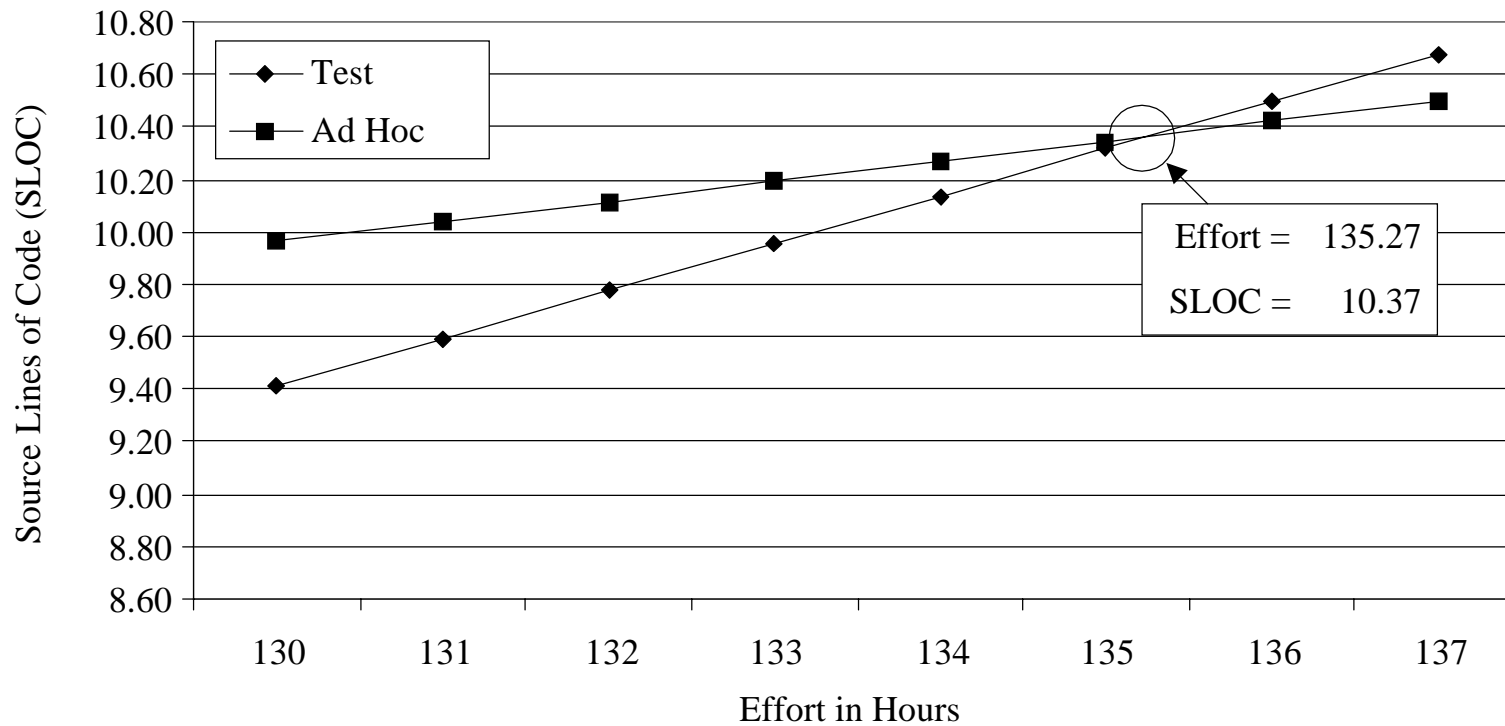
# *Breakeven Point Models*

| Method           | Life Cycle Cost * | Life Cycle Cost **    |
|------------------|-------------------|-----------------------|
| Ad Hoc           | SLOC / 0.08       |                       |
| Test             | SLOC / 0.18       | (SLOC + 14.12) / 0.18 |
| HP Inspection    | SLOC / 0.37       | (SLOC + 07.05) / 0.37 |
| Gilb Inspection  | SLOC / 0.39       | (SLOC + 07.46) / 0.39 |
| BNR Inspection   | SLOC / 0.40       | (SLOC + 07.53) / 0.40 |
| Basic Inspection | SLOC / 0.50       | (SLOC + 09.52) / 0.50 |
| AT&T Inspection  | SLOC / 0.64       | (SLOC + 12.19) / 0.64 |
| PSP              | SLOC / 25.0       | (SLOC + 2000) / 25.0  |

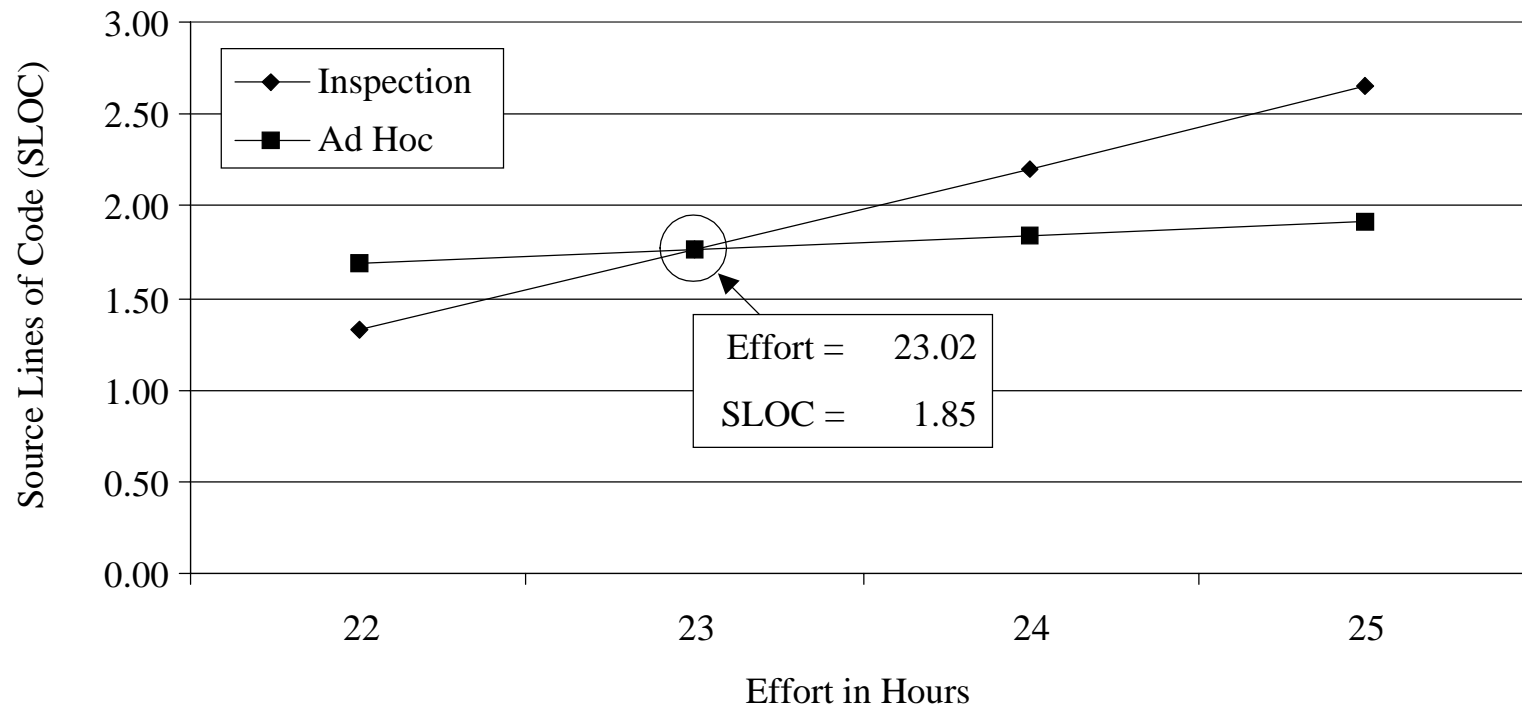
\* Yields effort in hours

\*\* Yields effort in hours (includes initial investment effort)

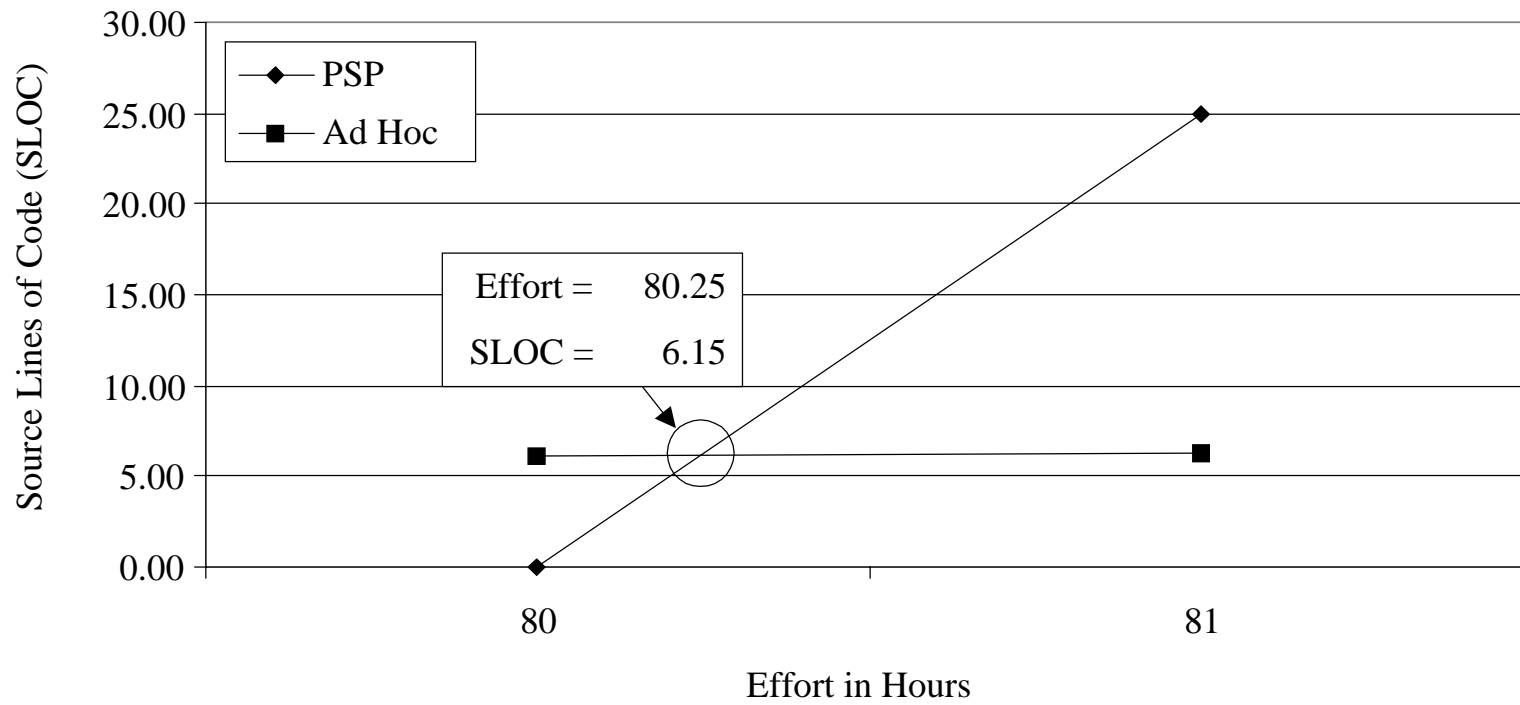
# *Test vs. Ad Hoc*



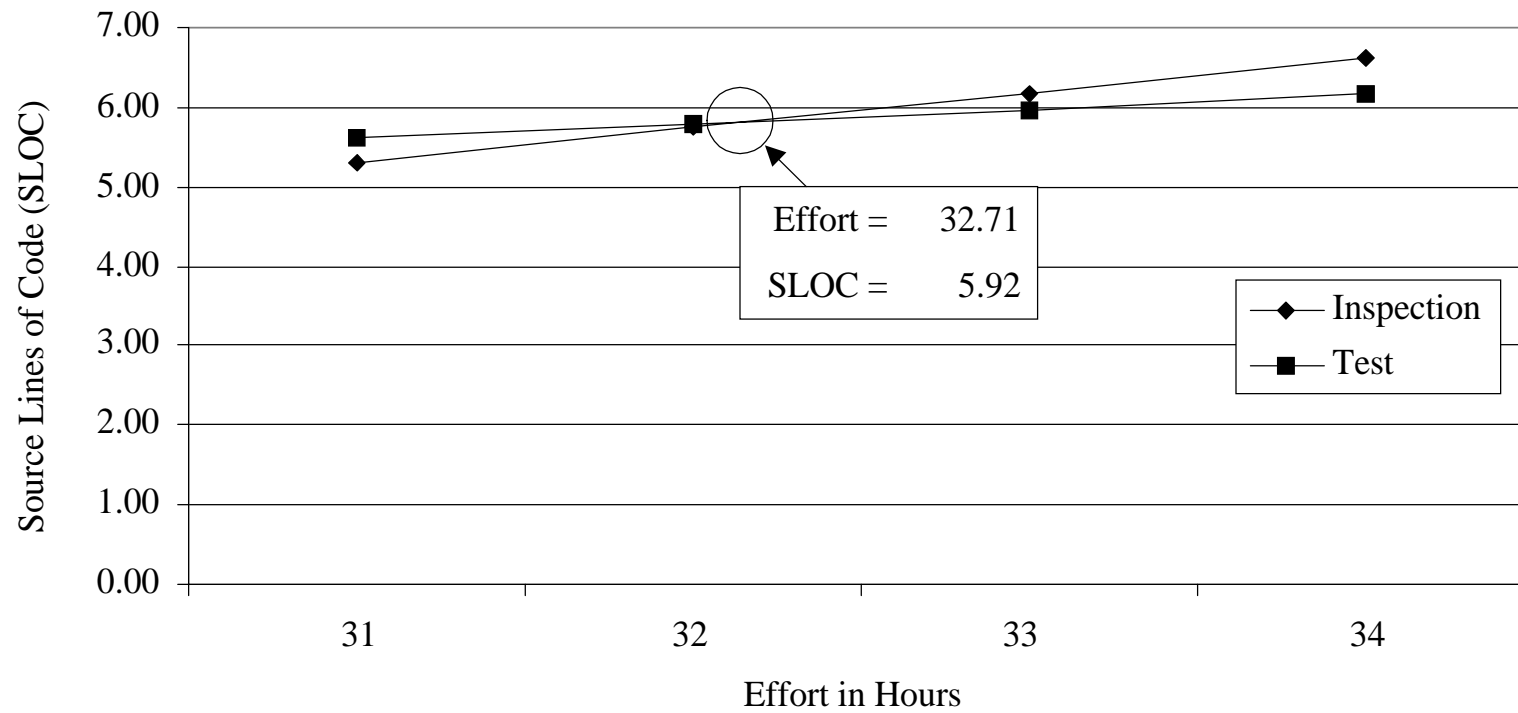
# *Inspection vs. Ad Hoc*



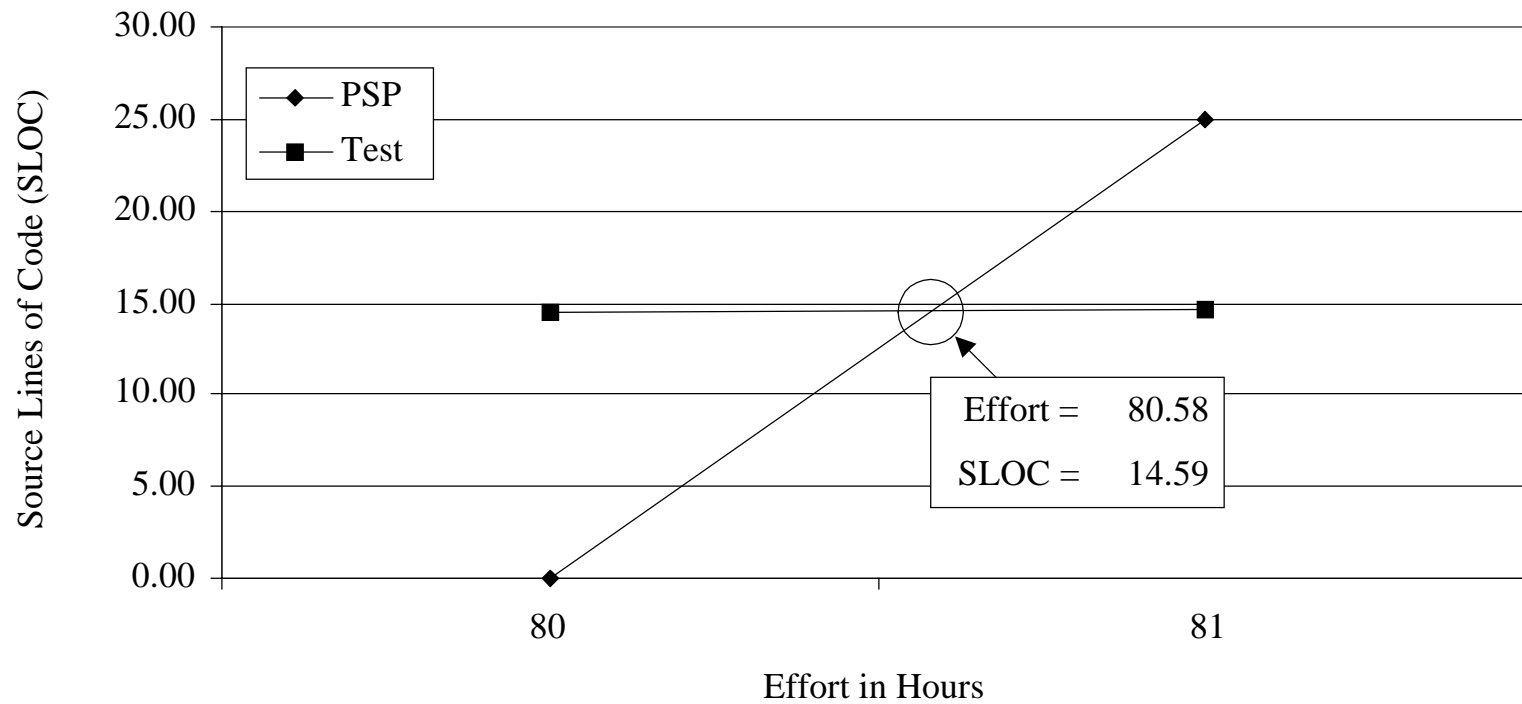
# *PSP vs. Ad Hoc*



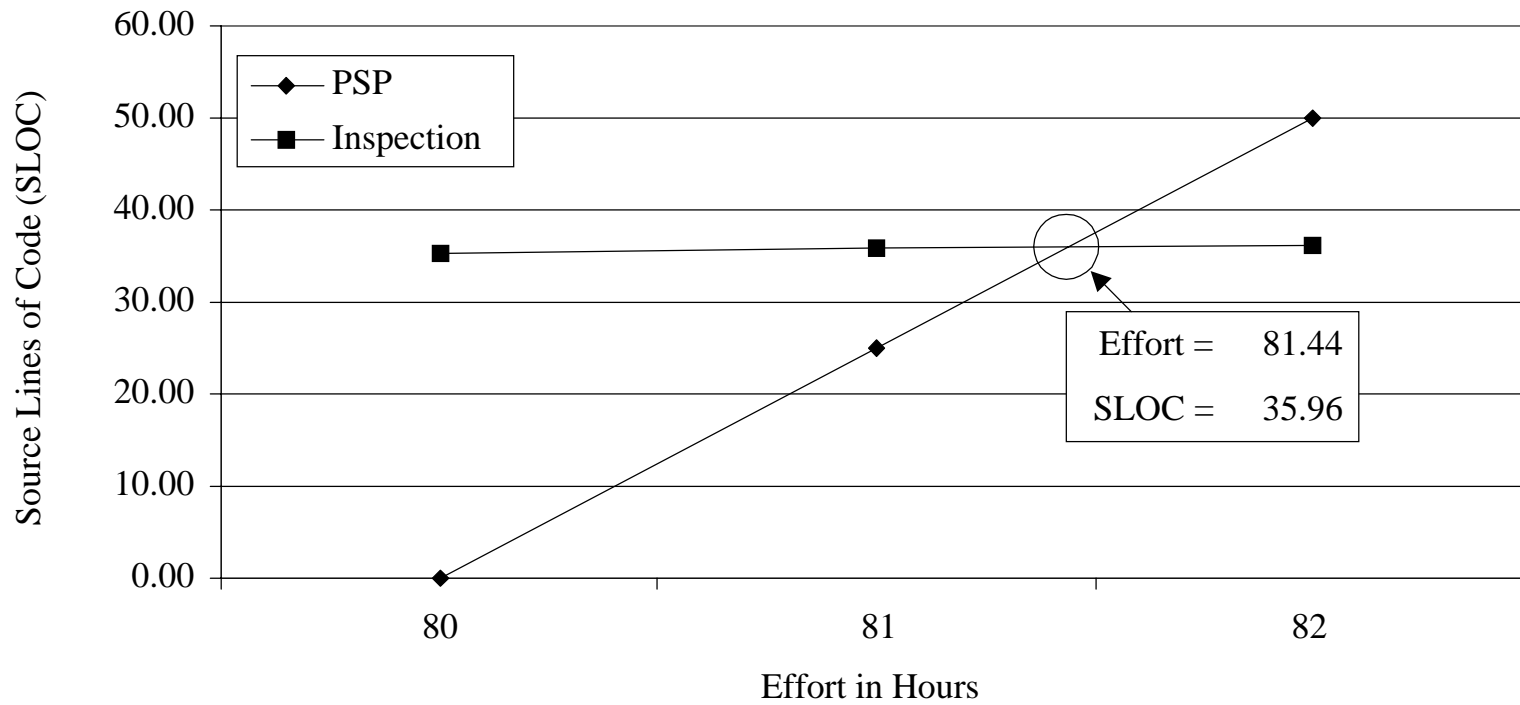
# *Inspection vs. Test*



# *PSP vs. Test*



# *PSP vs. Inspection*



# *Actual Costs & Benefits*





# Overall

|                       | PSP     | Cleanroom | Reuse     | Prevent | Inspect | Test     | CMM      | ISO     | Average  |
|-----------------------|---------|-----------|-----------|---------|---------|----------|----------|---------|----------|
| Breakeven Hours       | 80      | 53        | 8,320     | 527     | 7       | 3,517    | 10,021   | 4,973   | 3,437    |
| Training Hours/Person | 80      | 201       | 3,316     | 31      | 19      | 78       | 227      | 64      | 502      |
| Training Cost/Person  | \$7,456 | \$8,089   | \$298,440 | \$5,467 | \$1,794 | \$13,863 | \$12,668 | \$9,475 | \$44,656 |
| Effort (Hours)        | 400     | 3,245     | 16,212    | 2,100   | 836     | 37,510   | 94,417   | 53,800  | 26,065   |
| Cycle Time Reduction  | 164.03x | 3.53x     | 3.69x     | 1.69x   | 5.47x   | 6.15x    | 2.99x    | 1.14x   | 23.58x   |
| Productivity Increase | 109.49x | 4.27x     | 2.70x     | 1.88x   | 5.47x   | 6.15x    | 2.92x    | 1.13x   | 16.75x   |
| Quality Increase      | 253.62x | 42.22x    | 4.33x     | 4.77x   | 9.00x   | 5.75x    | 4.55x    | 12.44x  | 42.09x   |
| Return-on-Investment  | 1,290:1 | 27:1      | 3:1       | 75:1    | 133:1   | 9:1      | 6:1      | 4:1     | 193:1    |

® Capability Maturity Model and CMM are registered in the U.S. Patent and Trademark Office.

# *Personal Software Process (PSP)*



|                       | Rico      | CMU   | AIS   | Motorola | Webb  | Hays  | SEI      | Average |
|-----------------------|-----------|-------|-------|----------|-------|-------|----------|---------|
| Breakeven Hours       | 80.25     |       |       |          |       |       |          | 80.25   |
| Training Hours/Person |           |       |       |          |       |       | 80       | 80      |
| Training Cost/Person  |           | \$995 |       |          |       |       | \$13,917 | \$7,456 |
| Effort (Hours)        | 400       |       |       |          |       |       |          | 400     |
| Cycle Time Reduction  | 326.22x   |       |       | 1.85x    |       |       |          | 164.03x |
| Productivity Increase | 326.22x   |       | 1.07x |          | 1.19x |       |          | 109.49x |
| Quality Increase      | 1,000.00x |       | 4.47x |          | 1.62x | 8.40x |          | 253.62x |
| Return-on-Investment  | 1,290:1   |       |       |          |       |       |          | 1,290:1 |

# *Clean Room Methodology*

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|                       | McGibbon | Kaplan  | Prowell | CSR    | Average |
|-----------------------|----------|---------|---------|--------|---------|
| Breakeven Hours       | 42       | 64      |         |        | 53      |
| Training Hours/Person | 318      | 84      |         |        | 201     |
| Training Cost/Person  | \$12,398 | \$3,780 |         |        | \$8,089 |
| Effort (Hours)        | 3,245    |         |         |        | 3,245   |
| Cycle Time Reduction  | 3.53x    |         |         |        | 3.53x   |
| Productivity Increase | 3.53x    |         |         | 5.00x  | 4.27x   |
| Quality Increase      | 100.00x  | 16.67x  |         | 10.00x | 42.22x  |
| Return-on-Investment  | 33:1     |         | 20:1    |        | 27:1    |

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# Software Reuse



|                       | McGibbon | NEC   | Lim   | Raytheon | DEC   | Reifer | HP       | HP        | Average   |
|-----------------------|----------|-------|-------|----------|-------|--------|----------|-----------|-----------|
| Breakeven Hours       |          |       |       |          |       |        | 4,160    | 12,480    | 8,320     |
| Training Hours/Person |          |       |       |          |       |        | 450      | 6,182     | 3,316     |
| Training Cost/Person  |          |       |       |          |       |        | \$40,500 | \$556,380 | \$298,440 |
| Effort (Hours)        | 22,115   |       |       |          |       |        | 9,360    | 17,160    | 16,212    |
| Cycle Time Reduction  |          |       | 3.33x |          | 5.00x |        | 1.71x    | 4.70x     | 3.69x     |
| Productivity Increase |          | 6.70x | 1.84x | 2.00x    |       |        | 1.57x    | 1.40x     | 2.70x     |
| Quality Increase      |          | 2.80x | 5.49x |          |       | 10.00x | 2.05x    | 1.31x     | 4.33x     |
| Return-on-Investment  | 4:1      |       |       |          |       |        | 4:1      | 2:1       | 3:1       |

# Software Defect Prevention

|                       | Kaplan | Gilb  | Mays  | Humphrey | Grady | Kajihara | Latino  | Latino  | Average |
|-----------------------|--------|-------|-------|----------|-------|----------|---------|---------|---------|
| Breakeven Hours       | 1,560  | 10    | 11    |          |       |          |         |         | 527     |
| Training Hours/Person | 12     |       |       |          |       |          | 40      | 40      | 31      |
| Training Cost/Person  | \$900  |       |       |          |       |          | \$7,500 | \$8,000 | \$5,467 |
| Effort (Hours)        | 4,680  | 1,625 | 1,747 |          |       |          |         | 347     | 2,100   |
| Cycle Time Reduction  |        |       | 2.00x |          | 1.37x |          |         |         | 1.69x   |
| Productivity Increase |        |       | 2.00x |          |       | 1.76x    |         |         | 1.88x   |
| Quality Increase      | 2.00x  |       | 2.17x | 4.55x    | 4.00x | 10.00x   | 7.00x   | 3.67x   | 4.77x   |
| Return-on-Investment  |        | 7:1   |       |          |       |          | 40:1    | 179:1   | 75:1    |

# Software Inspection Process

|                       | McGibbon | Fagan   | AT&T  | Rico  | BNR   | Gilb    | HP    | Average |
|-----------------------|----------|---------|-------|-------|-------|---------|-------|---------|
| Breakeven Hours       |          |         | 7     | 7     | 7     | 7       | 7     | 7       |
| Training Hours/Person | 12       | 24      |       |       |       | 20      |       | 19      |
| Training Cost/Person  | \$468    | \$2,800 |       |       |       | \$2,114 |       | \$1,794 |
| Effort (Hours)        |          |         | 500   | 708   | 960   | 970     | 1,042 | 836     |
| Cycle Time Reduction  | 1.55x    | 6.67x   | 8.37x | 6.54x | 5.17x | 5.13x   | 4.84x | 5.47x   |
| Productivity Increase | 1.55x    | 6.67x   | 8.37x | 6.54x | 5.17x | 5.13x   | 4.84x | 5.47x   |
| Quality Increase      |          |         | 9.00x | 9.00x | 9.00x | 9.00x   | 9.00x | 9.00x   |
| Return-on-Investment  | 72:1     |         | 234:1 | 160:1 | 114:1 | 113:1   | 104:1 | 133:1   |

# Software Testing

|                       | ROI Model | Farren | Rice     | Yamaura | Graham   | Ehrlick | Asada  | Average  |
|-----------------------|-----------|--------|----------|---------|----------|---------|--------|----------|
| Breakeven Hours       | 135       |        |          |         |          | 5,400   | 5,017  | 3,517    |
| Training Hours/Person |           |        | 84       |         | 72       |         |        | 78       |
| Training Cost/Person  |           |        | \$16,800 |         | \$10,926 |         |        | \$13,863 |
| Effort (Hours)        | 8,360     |        |          |         |          | 54,000  | 50,170 | 37,510   |
| Cycle Time Reduction  | 2.36x     | 5.00x  |          | 3.37x   |          | 10.00x  | 10.00x | 6.15x    |
| Productivity Increase | 2.36x     | 5.00x  |          | 3.37x   |          | 10.00x  | 10.00x | 6.15x    |
| Quality Increase      | 3.00x     | 2.00x  |          |         |          | 9.00x   | 9.00x  | 5.75x    |
| Return-on-Investment  | 10:1      | 5:1    |          |         |          | 10:1    | 10:1   | 9:1      |

# Capability Maturity Model (CMM)

|                       | Herbsleb | Putnam | Haskell | Vu    | Diaz   | Haley | Jones    | Average  |
|-----------------------|----------|--------|---------|-------|--------|-------|----------|----------|
| Breakeven Hours       | 2,318    |        | 345     |       | 1,092  |       | 36,330   | 10,021   |
| Training Hours/Person | 64       |        |         |       |        |       | 389      | 227      |
| Training Cost/Person  | \$9,820  |        |         |       |        |       | \$15,516 | \$12,668 |
| Effort (Hours)        | 23,184   |        | 3,450   |       | 10,920 |       | 363,298  | 94,417   |
| Cycle Time Reduction  | 1.85x    | 7.46x  |         | 1.75x | 2.70x  | 2.90x | 1.26x    | 2.99x    |
| Productivity Increase | 2.89x    | 7.46x  |         | 2.22x | 0.80x  | 2.90x | 1.26x    | 2.92x    |
| Quality Increase      | 3.21x    | 8.25x  |         | 5.00x | 2.17x  | 3.00x | 5.68x    | 4.55x    |
| Return-on-Investment  | 5:1      |        |         |       | 4:1    | 8:1   |          | 6:1      |
| Years to SEI Level 3  | 3.50     |        | 7.00    | 5.00  | 3.00   | 7.00  | 3.56     | 4.84     |

# ISO 9000



|                       | Roberson | Hewlett | Armstrong | Russo    | Kaplan  | Haskell | Garver | El Emam | Average |
|-----------------------|----------|---------|-----------|----------|---------|---------|--------|---------|---------|
| Breakeven Hours       | 4,160    |         |           |          | 10,400  | 360     |        |         | 4,973   |
| Training Hours/Person |          |         | 88        | 24       |         | 80      |        |         | 64      |
| Training Cost/Person  |          |         | \$8,775   | \$12,650 |         | \$7,000 |        |         | \$9,475 |
| Effort (Hours)        |          |         |           |          | 104,000 | 3,600   |        |         | 53,800  |
| Cycle Time Reduction  | 1.14x    |         |           |          |         |         |        |         | 1.14x   |
| Productivity Increase | 1.14x    | 1.11x   |           |          |         |         |        |         | 1.13x   |
| Quality Increase      | 1.22x    | 1.11x   |           |          |         |         | 35.00x |         | 12.44x  |
| Return-on-Investment  |          |         |           |          | 1:1     | 7:1     |        |         | 4:1     |
| Years to ISO 9001     |          |         |           |          |         | 1.00    |        | 2.14    | 1.57    |

# *Normalized Costs & Benefits*

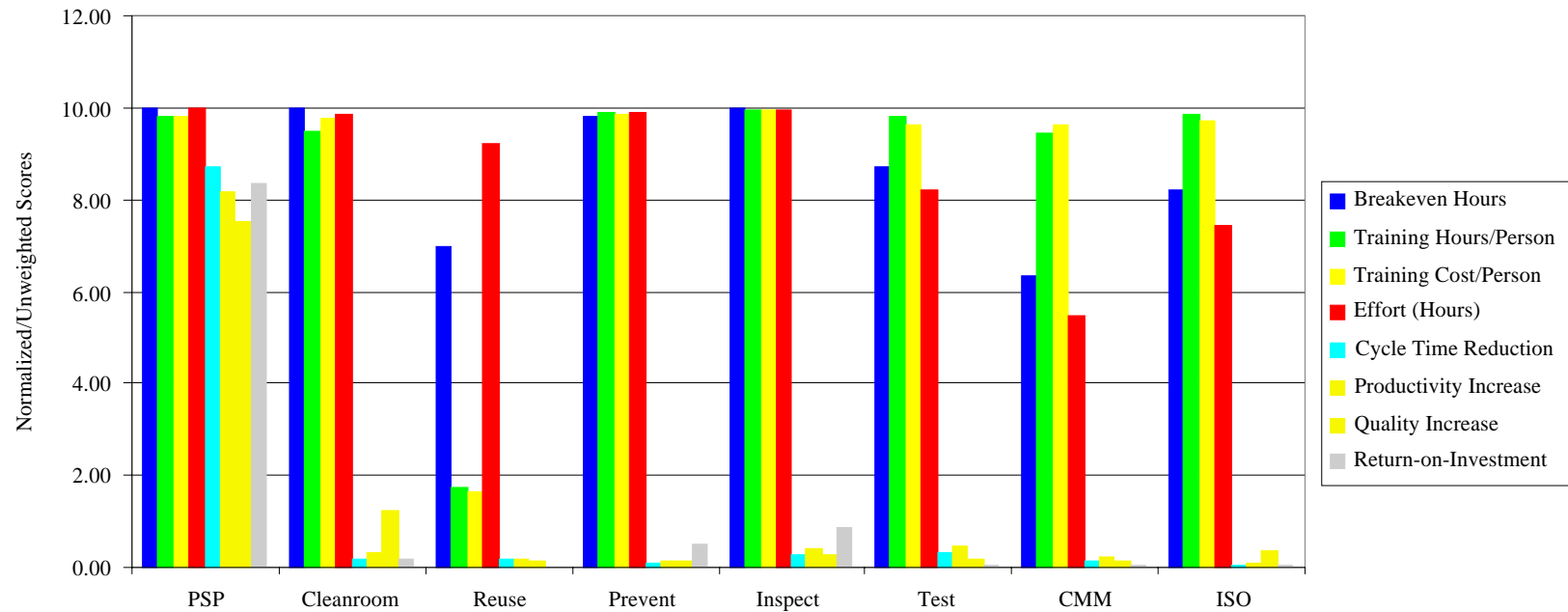


# Normalized Costs & Benefits

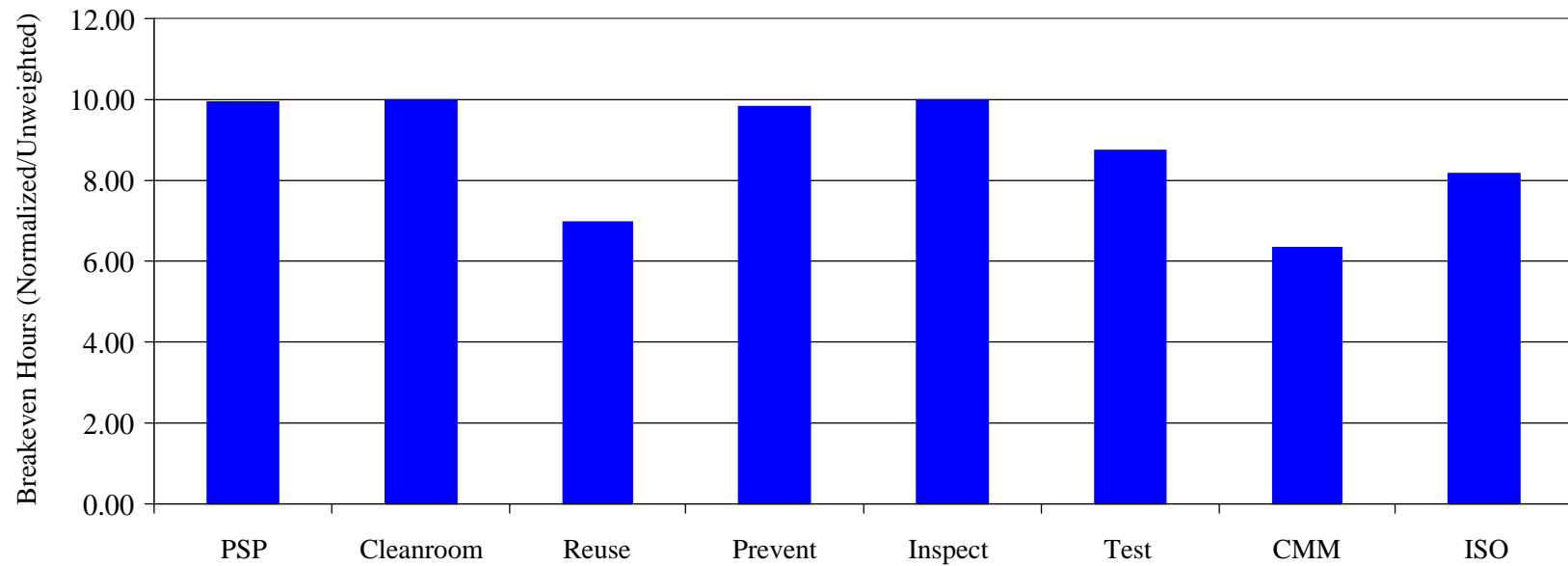


|                       | PSP   | Cleanroom | Reuse | Prevent | Inspect | Test  | CMM   | ISO   | Average |
|-----------------------|-------|-----------|-------|---------|---------|-------|-------|-------|---------|
| Breakeven Hours       | 9.97  | 9.98      | 6.97  | 9.81    | 10.00   | 8.72  | 6.36  | 8.19  | 8.75    |
| Training Hours/Person | 9.80  | 9.50      | 1.74  | 9.92    | 9.95    | 9.81  | 9.44  | 9.84  | 8.75    |
| Training Cost/Person  | 9.79  | 9.77      | 1.65  | 9.85    | 9.95    | 9.61  | 9.65  | 9.73  | 8.75    |
| Effort (Hours)        | 9.98  | 9.84      | 9.22  | 9.90    | 9.96    | 8.20  | 5.47  | 7.42  | 8.75    |
| Cycle Time Reduction  | 8.69  | 0.19      | 0.20  | 0.09    | 0.29    | 0.33  | 0.16  | 0.06  | 1.25    |
| Productivity Increase | 8.17  | 0.32      | 0.20  | 0.14    | 0.41    | 0.46  | 0.22  | 0.08  | 1.25    |
| Quality Increase      | 7.53  | 1.25      | 0.13  | 0.14    | 0.27    | 0.17  | 0.14  | 0.37  | 1.25    |
| Return-on-Investment  | 8.34  | 0.17      | 0.02  | 0.49    | 0.86    | 0.06  | 0.04  | 0.03  | 1.25    |
|                       | 72.28 | 41.03     | 20.13 | 40.34   | 41.68   | 37.35 | 31.46 | 35.73 |         |

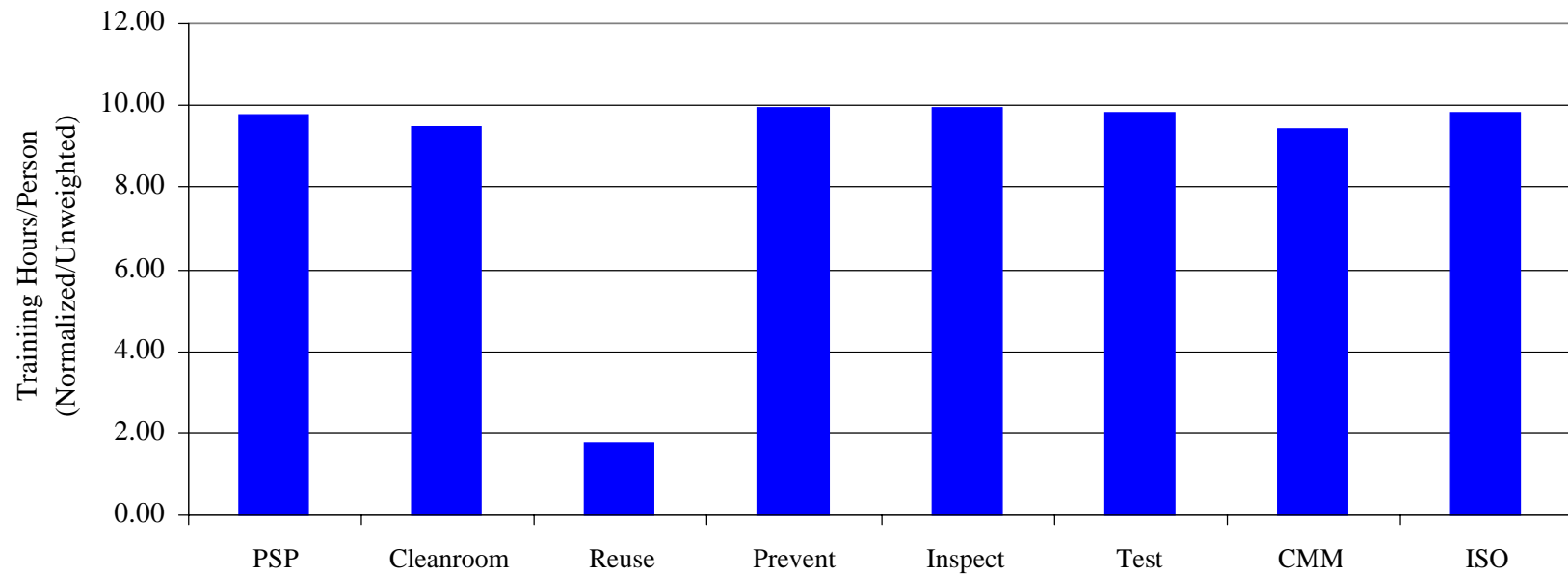
# Normalized Costs & Benefits



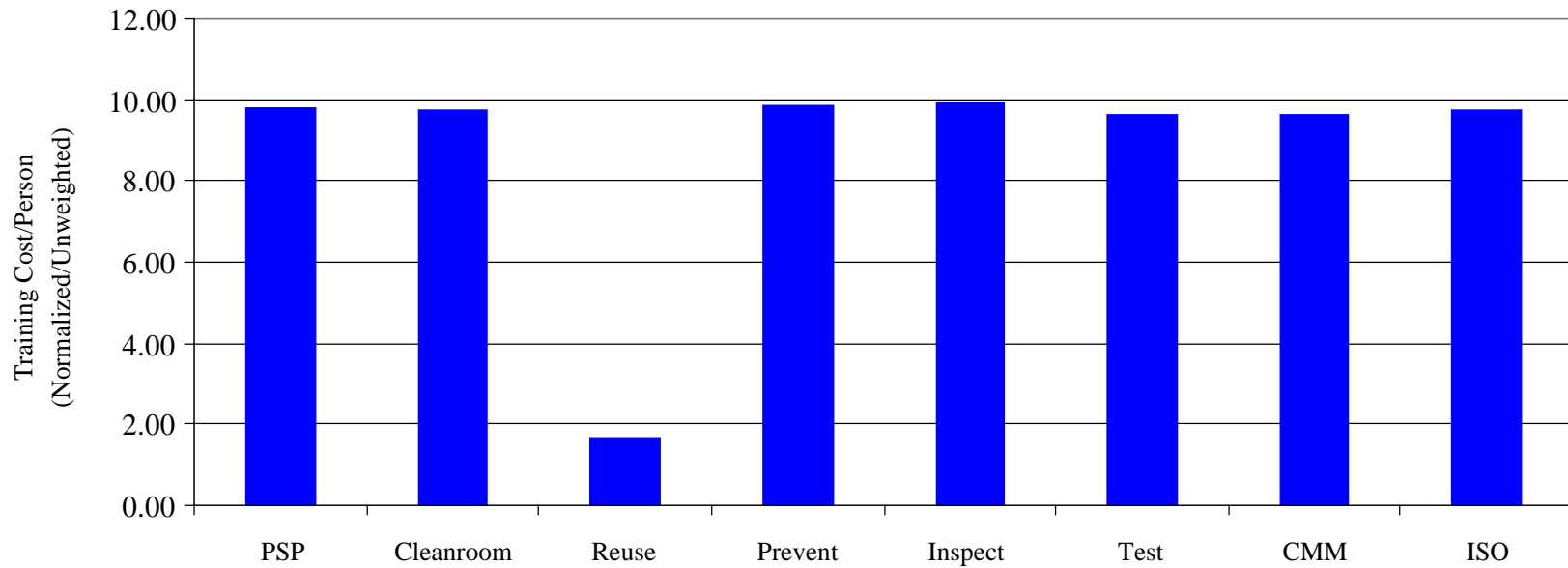
# *Breakeven Hours*



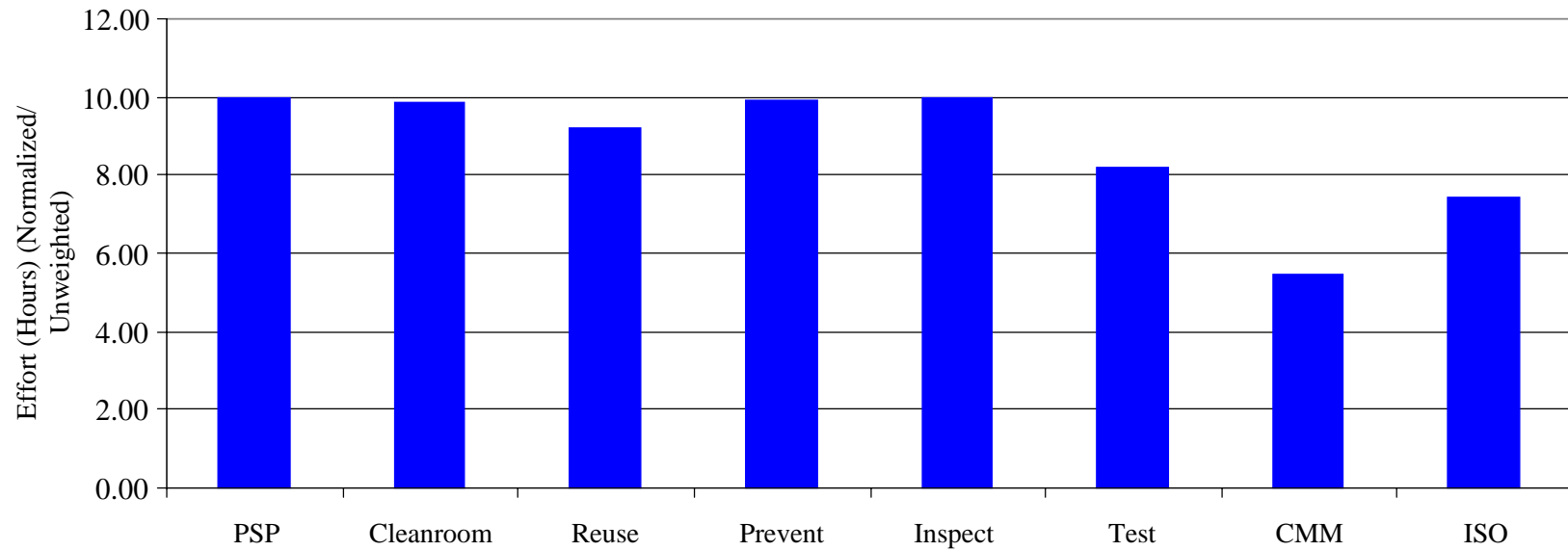
# *Training Hours/Person*



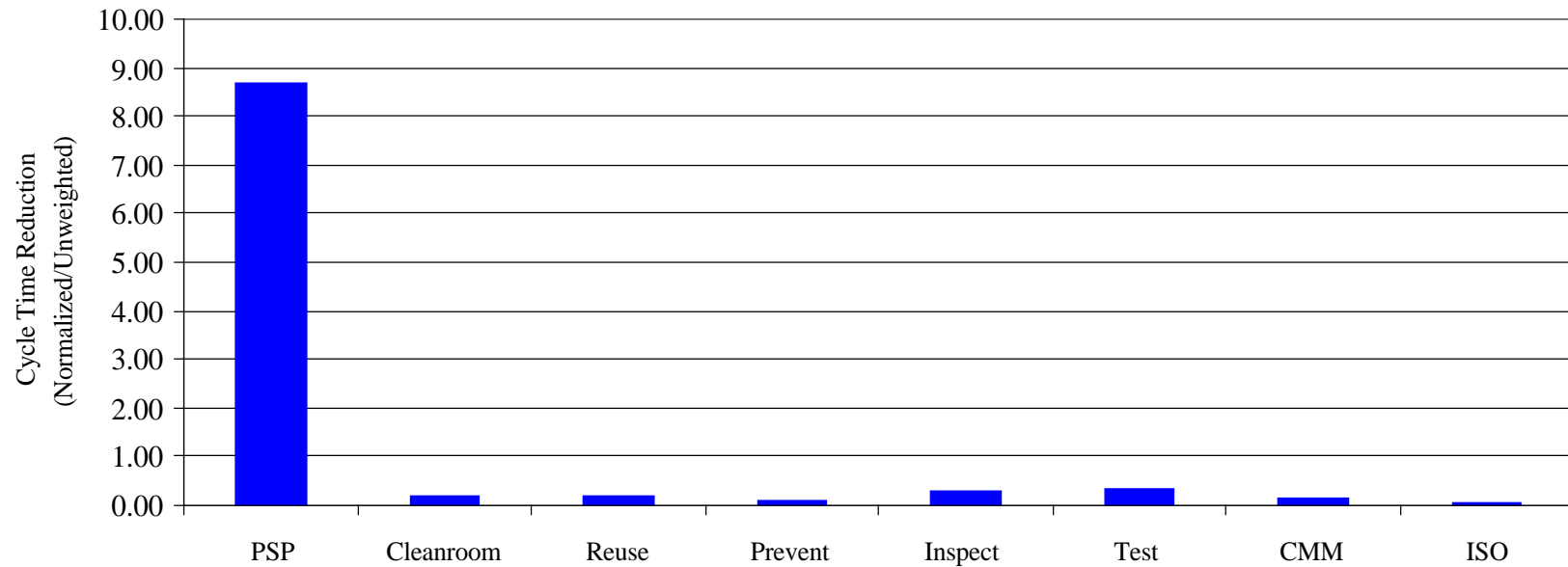
# *Training Cost/Person*



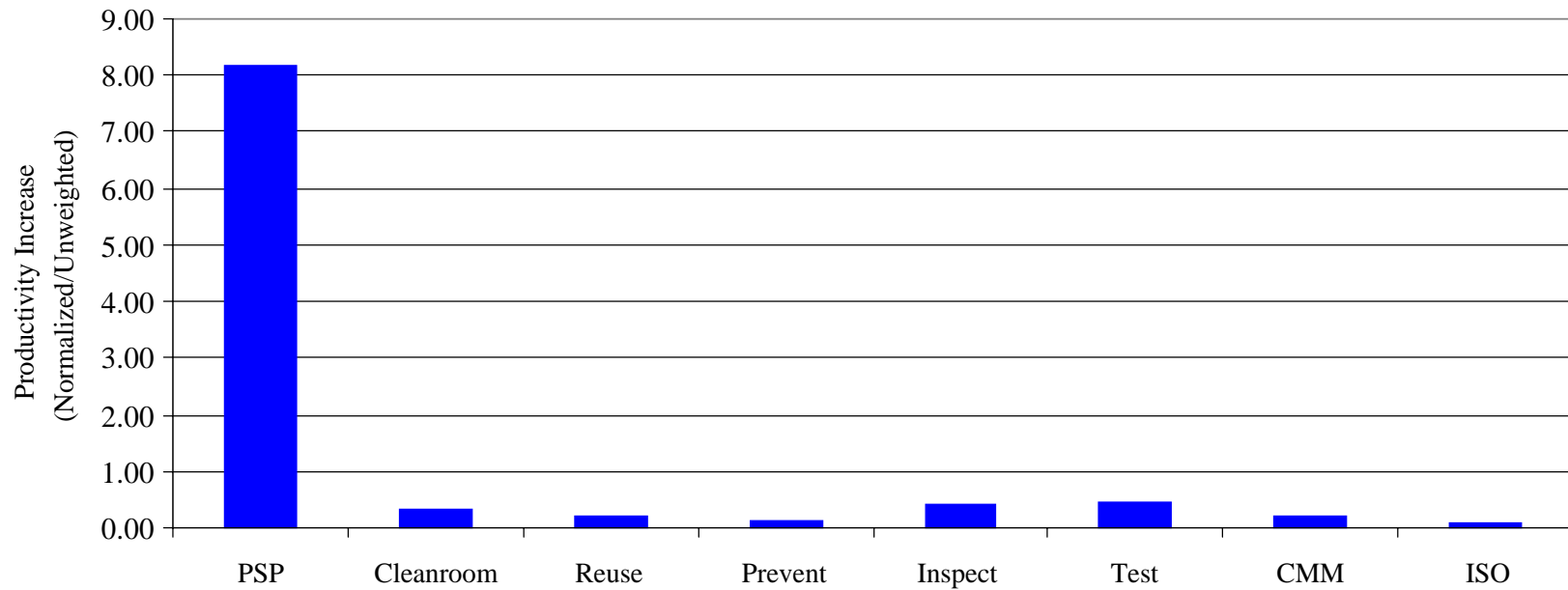
# *Effort (Hours)*



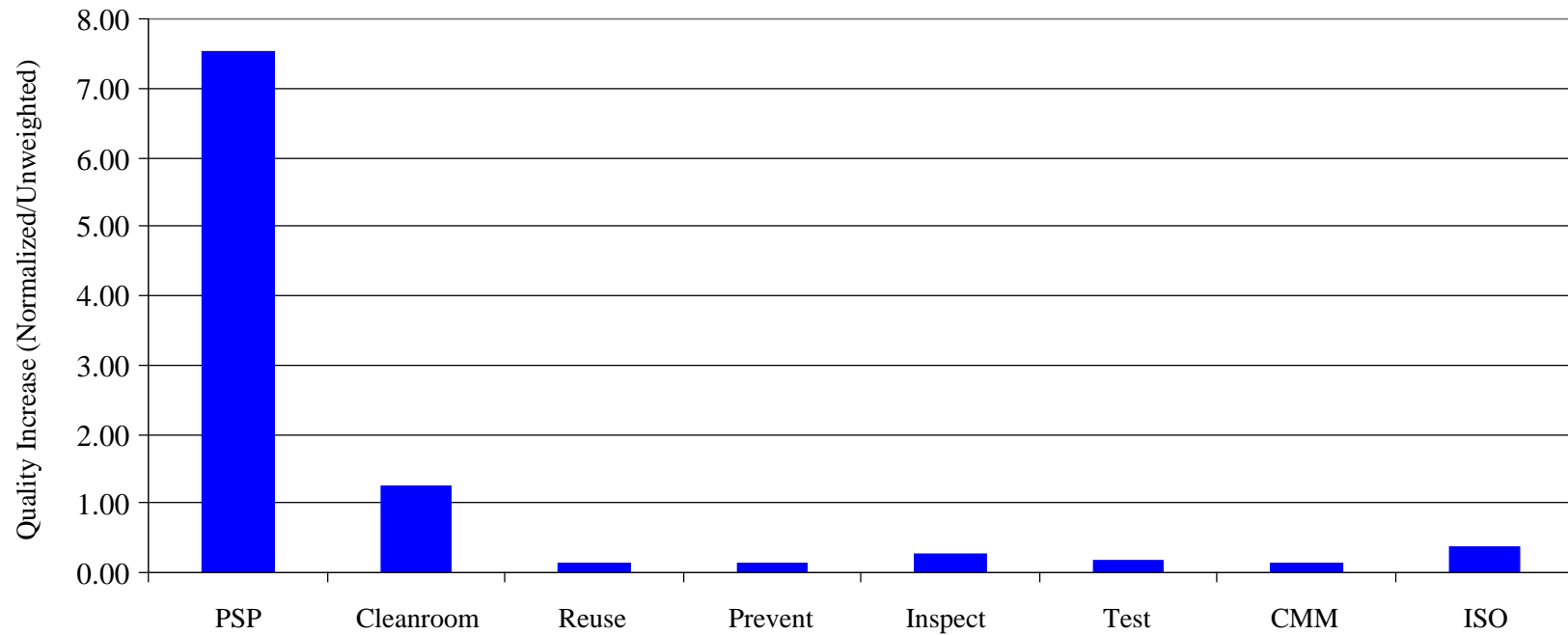
# *Cycle Time Reduction*



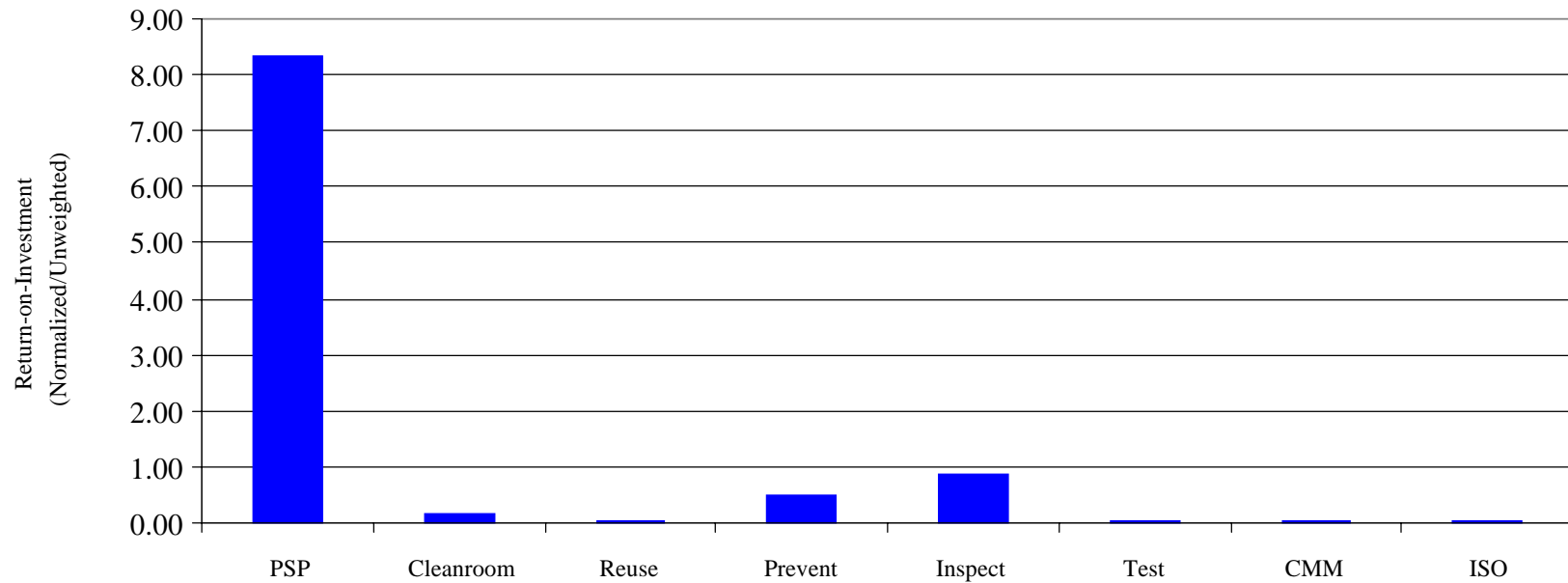
# *Productivity Increase*



# Quality Increase



# *Return-on-Investment (ROI)*



# *Normalized Benefits*



# *Normalized Benefits*

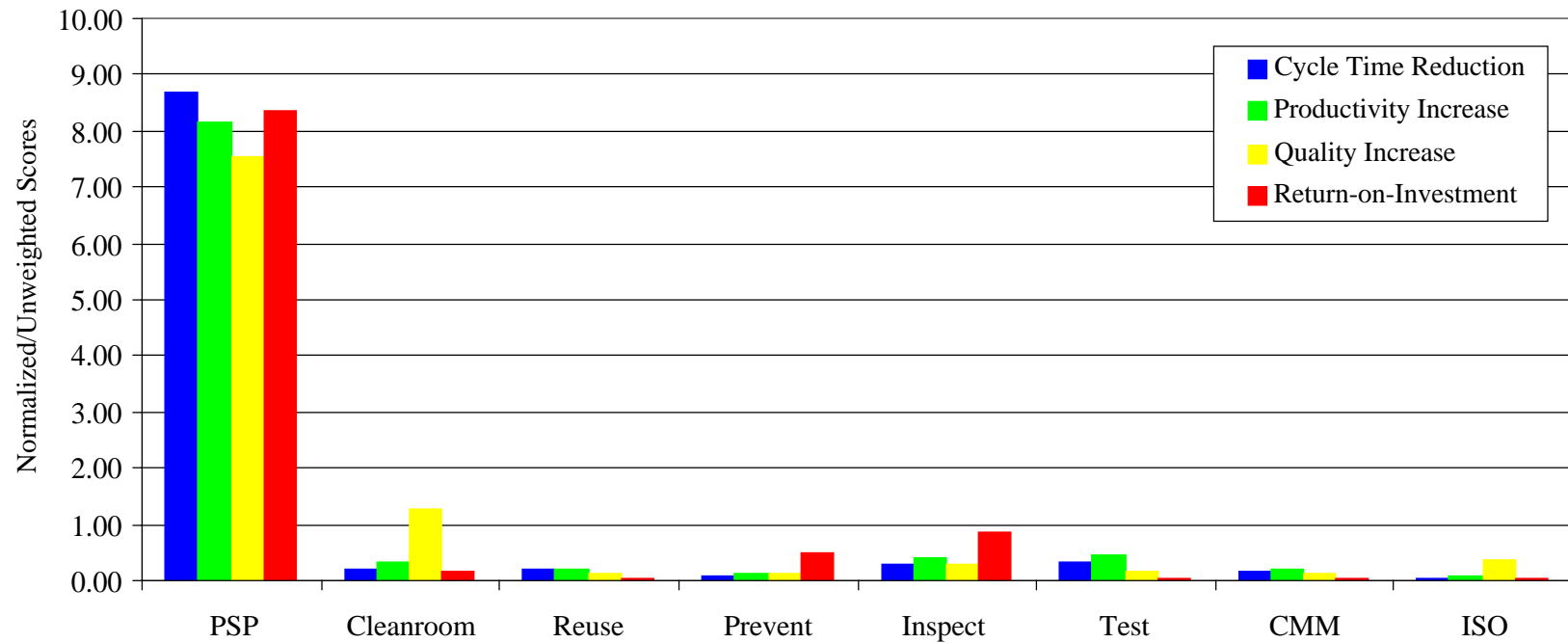


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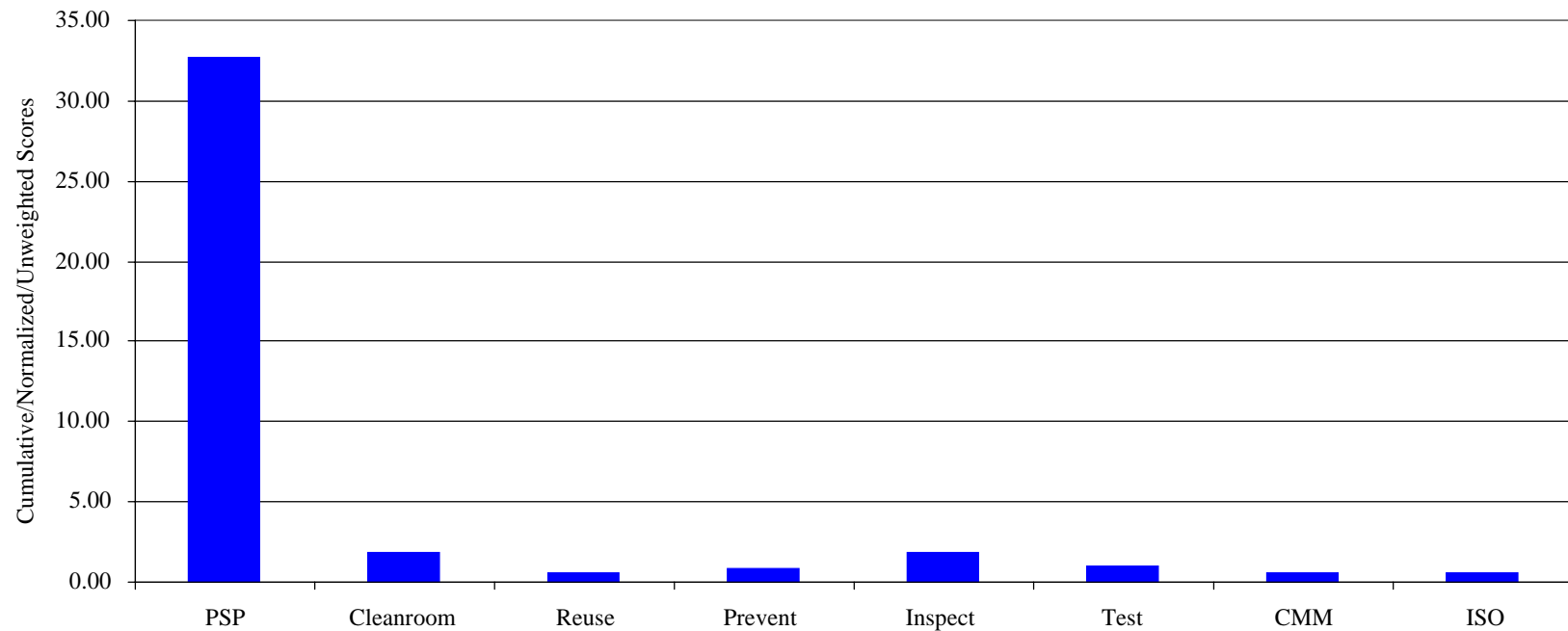
|                       | PSP   | Cleanroom | Reuse | Prevent | Inspect | Test | CMM  | ISO  | Average |
|-----------------------|-------|-----------|-------|---------|---------|------|------|------|---------|
| Cycle Time Reduction  | 8.69  | 0.19      | 0.20  | 0.09    | 0.29    | 0.33 | 0.16 | 0.06 | 1.25    |
| Productivity Increase | 8.17  | 0.32      | 0.20  | 0.14    | 0.41    | 0.46 | 0.22 | 0.08 | 1.25    |
| Quality Increase      | 7.53  | 1.25      | 0.13  | 0.14    | 0.27    | 0.17 | 0.14 | 0.37 | 1.25    |
| Return-on-Investment  | 8.34  | 0.17      | 0.02  | 0.49    | 0.86    | 0.06 | 0.04 | 0.03 | 1.25    |
|                       | 32.74 | 1.93      | 0.55  | 0.86    | 1.82    | 1.01 | 0.55 | 0.54 |         |

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# Normalized Benefits



# Average Benefits



# *Worst Normalized Benefits*

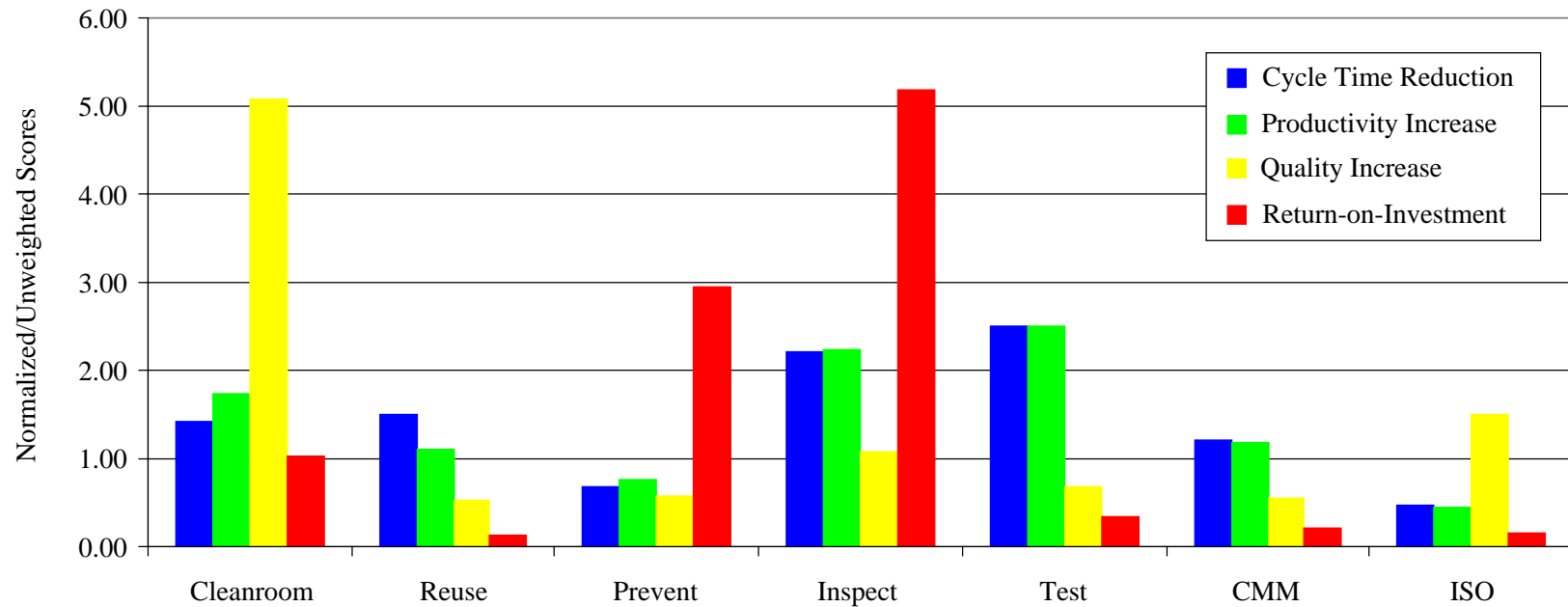


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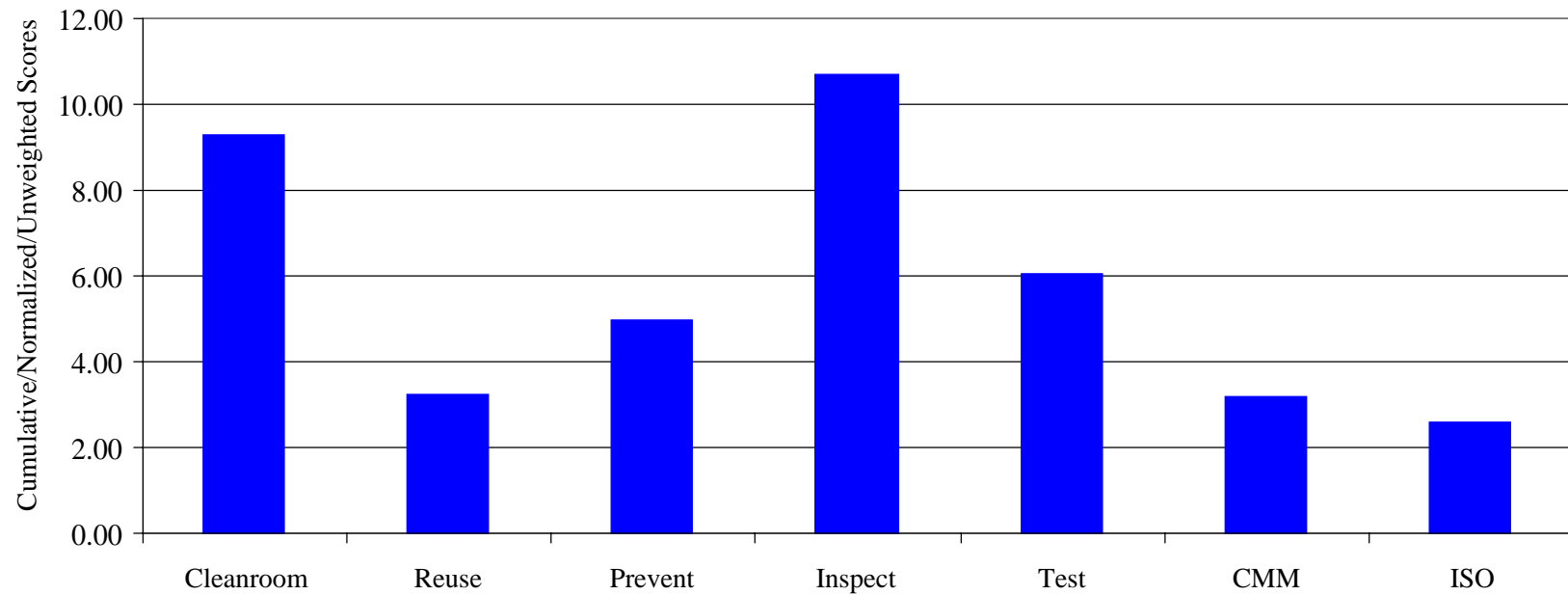
|                       | Cleanroom | Reuse | Prevent | Inspect | Test | CMM  | ISO  | Average |
|-----------------------|-----------|-------|---------|---------|------|------|------|---------|
| Cycle Time Reduction  | 1.43      | 1.50  | 0.68    | 2.22    | 2.49 | 1.21 | 0.46 | 1.43    |
| Productivity Increase | 1.74      | 1.10  | 0.77    | 2.23    | 2.51 | 1.19 | 0.46 | 1.25    |
| Quality Increase      | 5.08      | 0.52  | 0.57    | 1.08    | 0.69 | 0.55 | 1.50 | 1.25    |
| Return-on-Investment  | 1.03      | 0.13  | 2.94    | 5.18    | 0.34 | 0.22 | 0.15 | 1.25    |
|                       | 9.29      | 3.25  | 4.97    | 10.71   | 6.04 | 3.17 | 2.57 |         |

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# *Worst Normalized Benefits*



# *Worst Average Benefits*



# *Poorest Normalized Benefits*

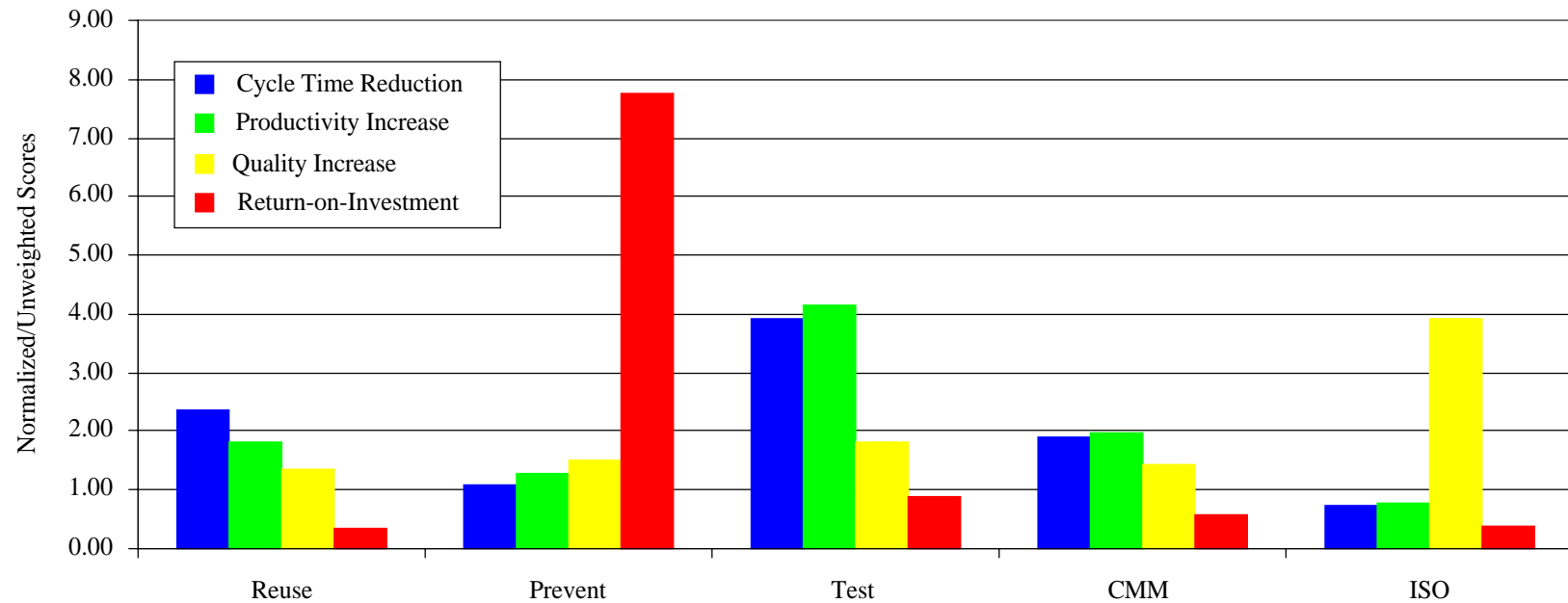


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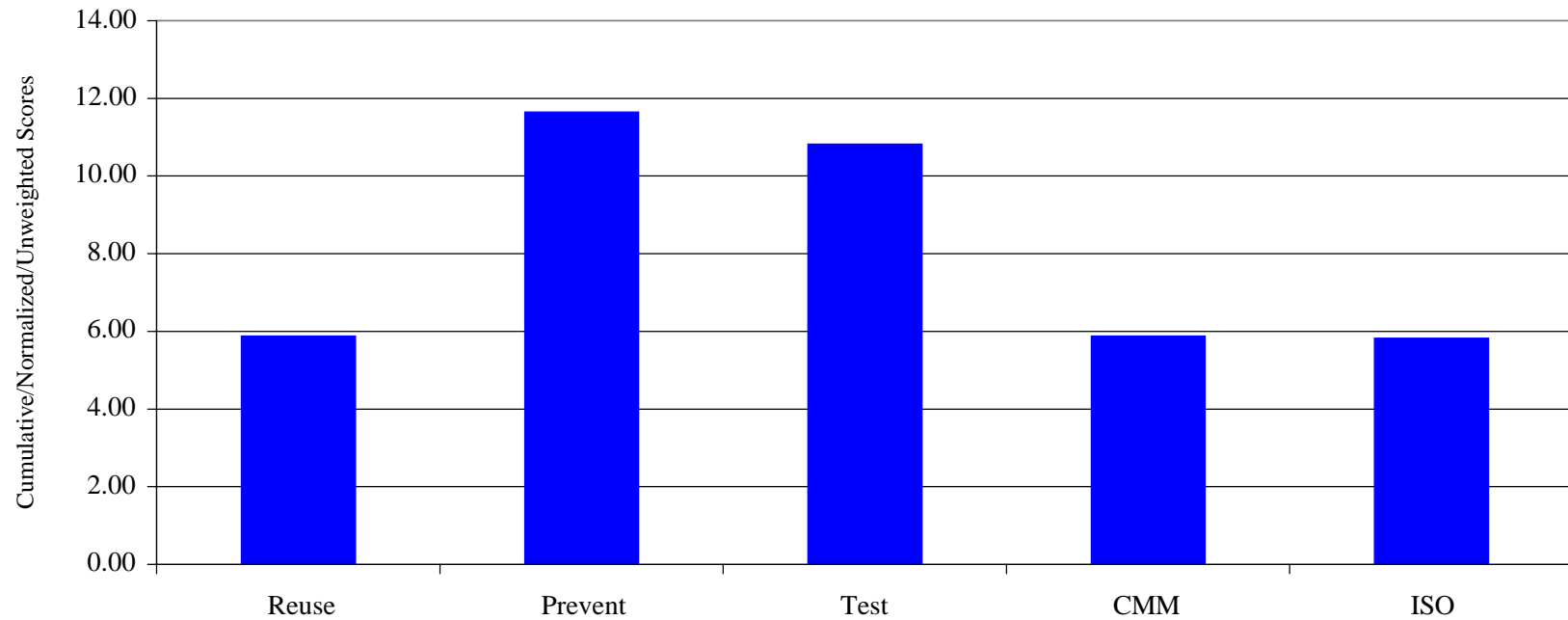
|                       | Reuse | Prevent | Test  | CMM  | ISO  | Average |
|-----------------------|-------|---------|-------|------|------|---------|
| Cycle Time Reduction  | 2.36  | 1.08    | 3.93  | 1.91 | 0.73 | 2.00    |
| Productivity Increase | 1.83  | 1.27    | 4.16  | 1.98 | 0.76 | 2.00    |
| Quality Increase      | 1.36  | 1.50    | 1.81  | 1.43 | 3.91 | 2.00    |
| Return-on-Investment  | 0.34  | 7.78    | 0.90  | 0.58 | 0.40 | 2.00    |
|                       | 5.88  | 11.62   | 10.80 | 5.90 | 5.80 |         |

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# Poorest Normalized Benefits



# *Poorest Average Benefits*



# *Category Costs & Benefits*



# *Actual Costs & Benefits*

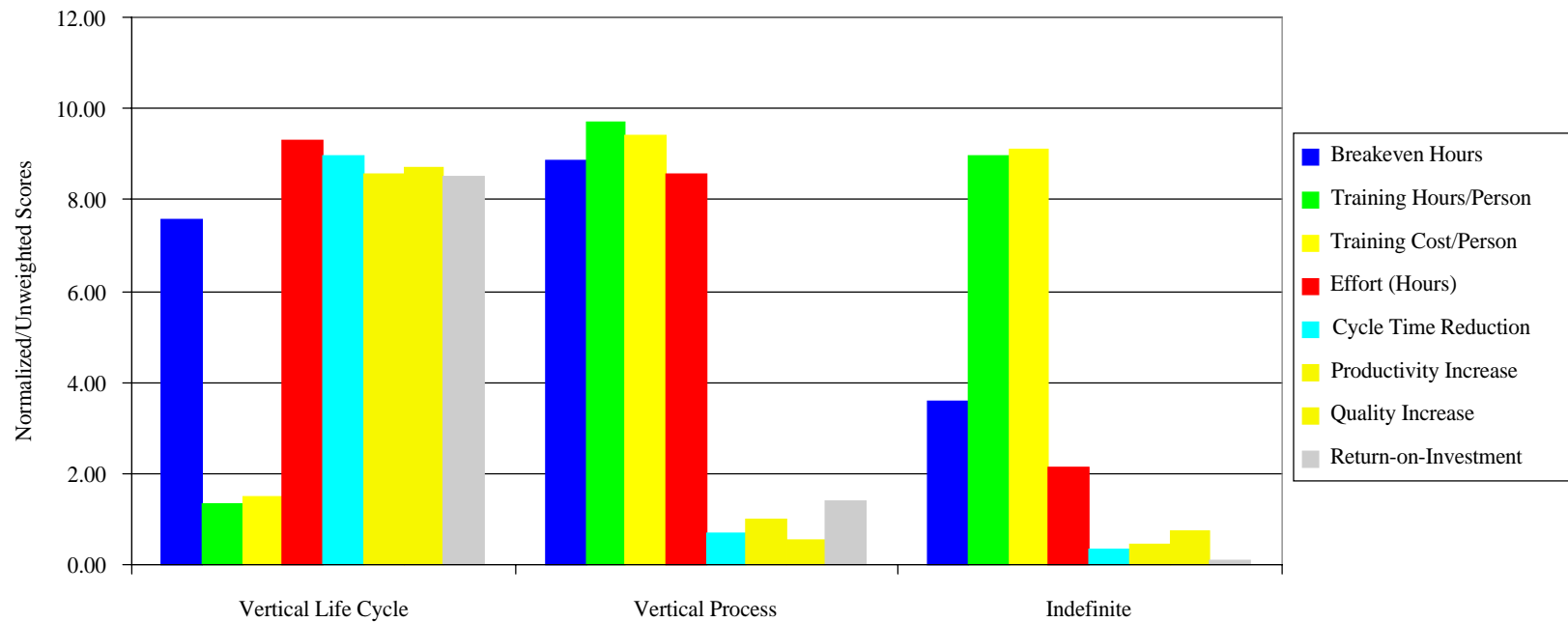


|                       | Vertical Life<br>Cycle | Vertical<br>Process | Indefinite |
|-----------------------|------------------------|---------------------|------------|
| Breakeven Hours       | 2,818                  | 1,350               | 7,497      |
| Training Hours/Person | 1,199                  | 42                  | 145        |
| Training Cost/Person  | \$104,662              | \$7,041             | \$11,072   |
| Effort (Hours)        | 6,619                  | 13,482              | 74,108     |
| Cycle Time Reduction  | 57.08x                 | 4.43x               | 2.06x      |
| Productivity Increase | 38.82x                 | 4.50x               | 2.02x      |
| Quality Increase      | 100.06x                | 6.51x               | 8.50x      |
| Return-on-Investment  | 440:1                  | 72:1                | 5:1        |

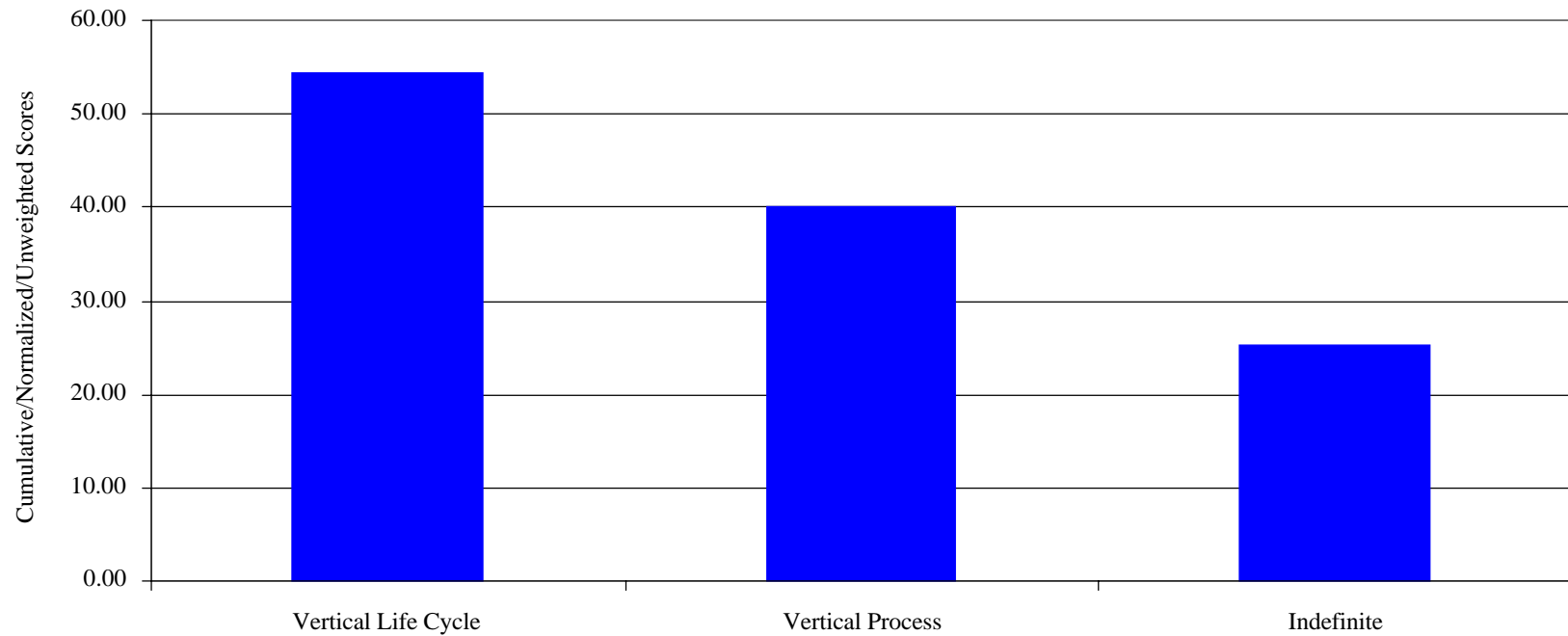
# *Normalized Costs & Benefits*

|                       | Vertical Life<br>Cycle | Vertical<br>Process | Indefinite |
|-----------------------|------------------------|---------------------|------------|
| Breakeven Hours       | 7.58                   | 8.84                | 3.57       |
| Training Hours/Person | 1.35                   | 9.69                | 8.95       |
| Training Cost/Person  | 1.48                   | 9.43                | 9.10       |
| Effort (Hours)        | 9.30                   | 8.57                | 2.13       |
| Cycle Time Reduction  | 8.98                   | 0.70                | 0.32       |
| Productivity Increase | 8.56                   | 0.99                | 0.45       |
| Quality Increase      | 8.70                   | 0.57                | 0.74       |
| Return-on-Investment  | 8.51                   | 1.40                | 0.09       |
|                       | 54.46                  | 40.18               | 25.36      |

# Normalized Costs & Benefits



# *Average Costs & Benefits*

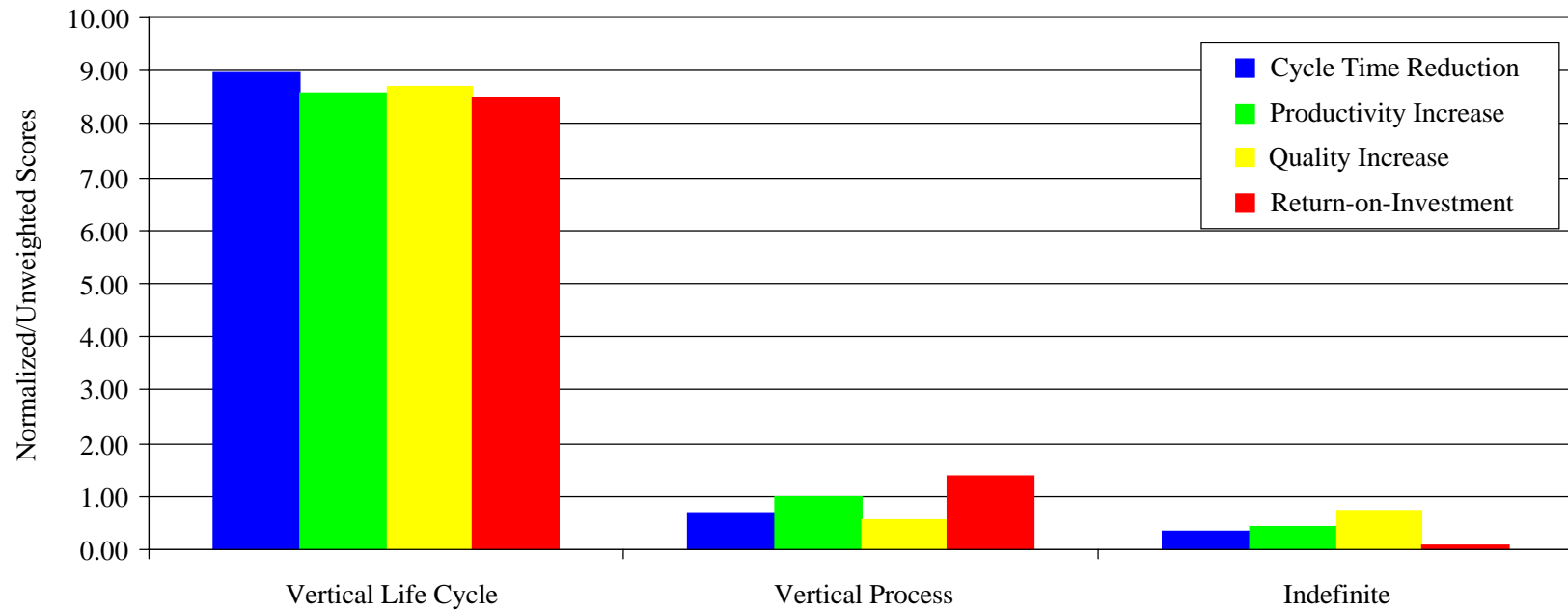


# *Normalized Benefits*

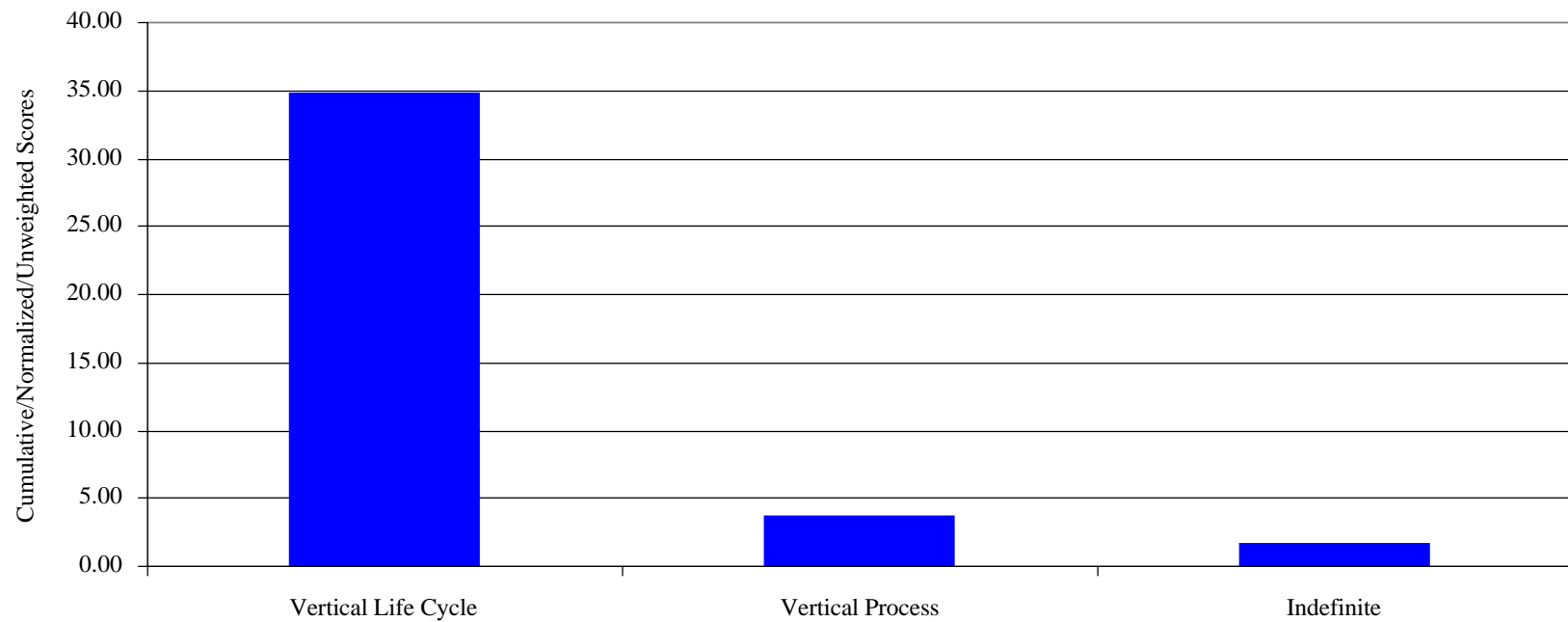


|                       | Vertical Life<br>Cycle | Vertical<br>Process | Indefinite |
|-----------------------|------------------------|---------------------|------------|
| Cycle Time Reduction  | 8.98                   | 0.70                | 0.32       |
| Productivity Increase | 8.56                   | 0.99                | 0.45       |
| Quality Increase      | 8.70                   | 0.57                | 0.74       |
| Return-on-Investment  | 8.51                   | 1.40                | 0.09       |
|                       | 34.75                  | 3.65                | 1.60       |

# Normalized Benefits



# Average Benefits

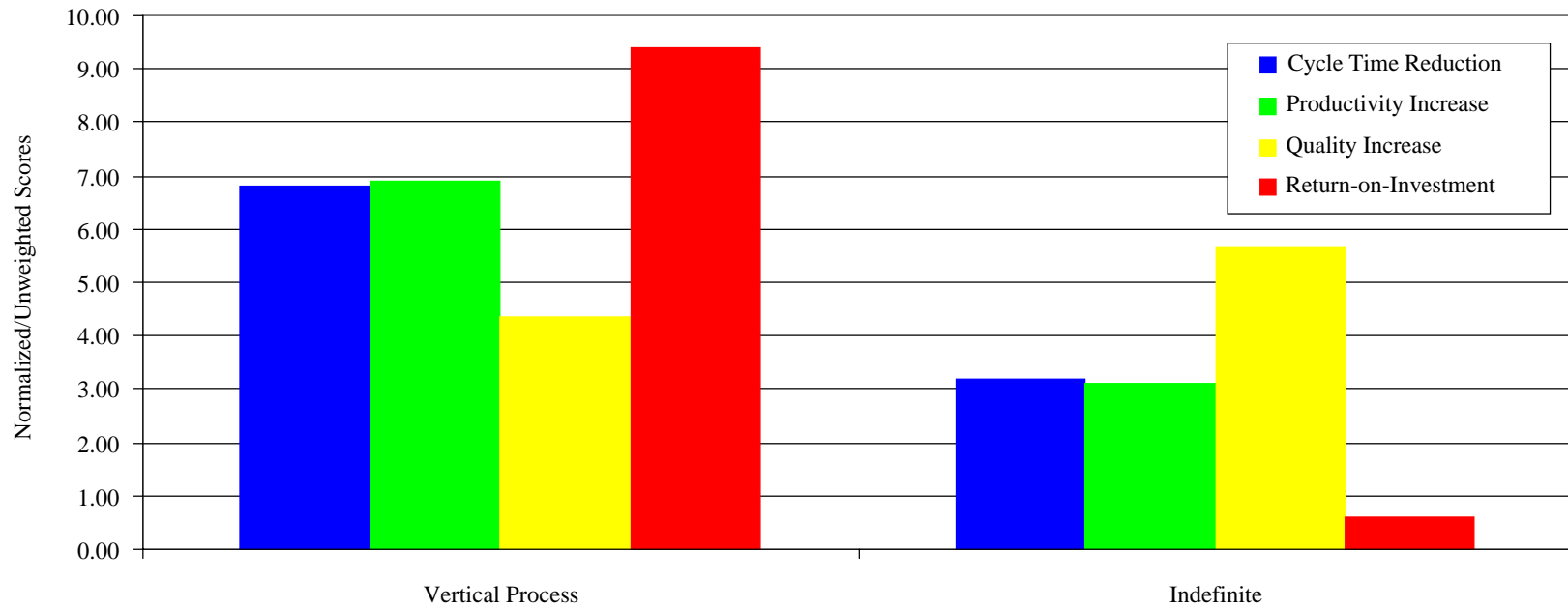


# *Worst Normalized Benefits*

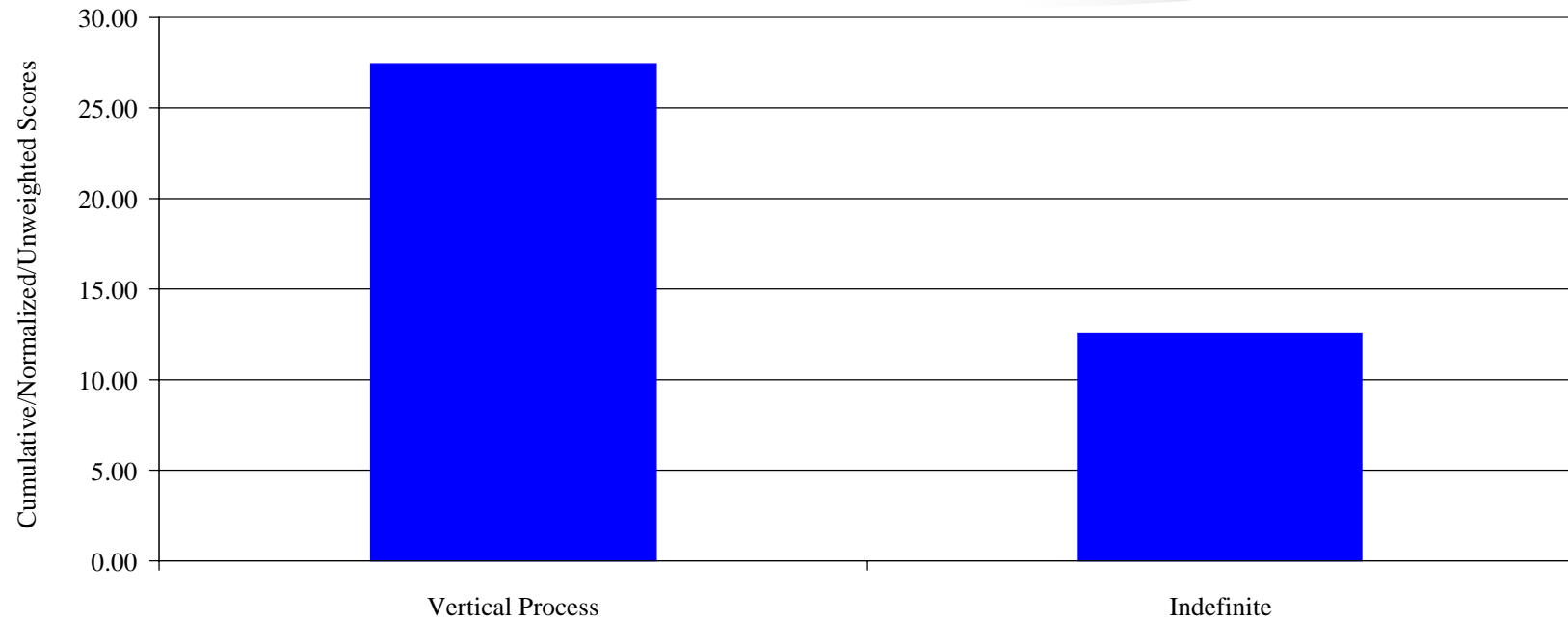


|                       | Vertical<br>Process | Indefinite |
|-----------------------|---------------------|------------|
| Cycle Time Reduction  | 6.82                | 3.18       |
| Productivity Increase | 6.90                | 3.10       |
| Quality Increase      | 4.34                | 5.66       |
| Return-on-Investment  | 9.38                | 0.62       |
|                       | 27.44               | 12.56      |

# *Worst Normalized Benefits*



# *Worst Average Benefits*



# *Summary of Costs & Benefits*



# Summary of Alternatives

|                       | PSP  | Cleanroom | Reuse | Prevent | Inspect | Test | CMM     | ISO  |
|-----------------------|------|-----------|-------|---------|---------|------|---------|------|
| Breakeven Hours       | Good | Good      | Good  | Good    | Good    | Good | Average | Good |
| Training Hours/Person | Good | Good      | Poor  | Good    | Good    | Good | Good    | Good |
| Training Cost/Person  | Good | Good      | Poor  | Good    | Good    | Good | Good    | Good |
| Effort (Hours)        | Good | Good      | Good  | Good    | Good    | Good | Average | Good |
| Cycle Time Reduction  | Good | Poor      | Poor  | Poor    | Poor    | Poor | Poor    | Poor |
| Productivity Increase | Good | Poor      | Poor  | Poor    | Poor    | Poor | Poor    | Poor |
| Quality Increase      | Good | Poor      | Poor  | Poor    | Poor    | Poor | Poor    | Poor |
| Return-on-Investment  | Good | Poor      | Poor  | Poor    | Poor    | Poor | Poor    | Poor |

# *Summary of Worst Alternatives*



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|                       | Cleanroom | Reuse | Prevent | Inspect | Test    | CMM  | ISO  |
|-----------------------|-----------|-------|---------|---------|---------|------|------|
| Cycle Time Reduction  | Poor      | Poor  | Poor    | Average | Average | Poor | Poor |
| Productivity Increase | Average   | Poor  | Poor    | Average | Average | Poor | Poor |
| Quality Increase      | Good      | Poor  | Poor    | Poor    | Poor    | Poor | Poor |
| Return-on-Investment  | Poor      | Poor  | Average | Good    | Poor    | Poor | Poor |

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# *Summary of Poorest Alternatives*



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|                       | Reuse | Prevent | Test    | CMM  | ISO     |
|-----------------------|-------|---------|---------|------|---------|
| Cycle Time Reduction  | Poor  | Poor    | Average | Poor | Poor    |
| Productivity Increase | Poor  | Poor    | Average | Poor | Poor    |
| Quality Increase      | Poor  | Poor    | Poor    | Poor | Average |
| Return-on-Investment  | Poor  | Good    | Poor    | Poor | Poor    |

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# Summary of Categories

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|                       | Vertical<br>Life Cycle | Vertical<br>Process | Indefinite |
|-----------------------|------------------------|---------------------|------------|
| Breakeven Hours       | Good                   | Good                | Poor       |
| Training Hours/Person | Average                | Good                | Good       |
| Training Cost/Person  | Average                | Good                | Good       |
| Effort (Hours)        | Good                   | Good                | Poor       |
| Cycle Time Reduction  | Good                   | Poor                | Poor       |
| Productivity Increase | Good                   | Poor                | Poor       |
| Quality Increase      | Good                   | Average             | Average    |
| Return-on-Investment  | Good                   | Average             | Average    |

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*Conclusion*



# *PSP Surpasses Competition*

- PSP exhibits astonishing benefits
  - 82:1 cycle time reduction over CMM and ISO 9000
  - 55:1 productivity increase over CMM and ISO 9000
  - 30:1 quality increase over CMM and ISO 9000
  - 258:1 return on investment over CMM and ISO 9000
  - 1,290:1 return on investment over ordinary approaches
- CMM and ISO 9000 among worst software process improvement (SPI) approaches
- CMMi and ISO 9000-2000 may perform worse than the Software CMM v1.1 or ISO 9000-1995