NASA Electronic Publishing System—Cost/Benefit Methodology

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SUMMARY

As a management tool, a cost/benefit analysis provides an excellent basis for determining the economic and managerial advantages of a proposed electronic duplicating system versus current and more traditional printing and duplicating alternatives. In this analysis, the four alternatives are (1) printing or duplicating through a Government Printing Office commercial vendor, (2) duplicating through use of the cost per copy program, (3) duplicating through use of the central computing high-speed laser printer, and (4) duplicating through use of the proposed electronic duplicating system (EDS). For reference, at the time the analysis was conducted, the costs represent actual costs that would occur if each alternative is used as defined.

The process consists of an analysis of each alternative's projected cash inflows (benefits) and outflows (costs) for a typical printing and duplicating workload over a 5-year system life. A risk assessment of each alternative was performed, according to its value or impact, in terms of software, hardware, and communication configuration costs, document processing time, ability to meet workload, the quality of the output, the turnaround time (from receipt of request to delivery), costs of training, installation, and integration, and finally the benefits to the user. After determining the recommended option, a sensitivity analysis was performed in terms of annual production (overall workload) and turnaround time. The next step was to calculate the return on investment (ROI). The ROI is the ratio of the benefits (cost savings for staffing, hardware, software, space, and business process reengineering) received divided by the cost of the recommended option. The ROI is calculated for each year of the system life.

One major advantage of a cost/benefit analysis is that the result is not subjective. However, the disadvantage is that workload and turnaround time improvements cannot be fully assessed until the recommended system is operational and any reengineering that its use enables is implemented. Before embarking on any new business process involving reengineering alternatives, it is recommended that a cost/benefit analysis be performed with the support of management. Without that support and input to the models, the results may not provide the information needed. The better the model is defined, the more useful the analysis will be to the decision maker.

ACKNOWLEDGEMENTS

The author acknowledges the many individuals who contributed to the material contained in this report. Specific thanks go to Pamela Caswell, technical editor, of the Lewis Research Center. I would especially like to thank the Xerox Corporation staffmembers, Joanne Blaylock, Federal District Operations, and Karen Murphy, Federal Government Operations, for providing the source information so that solutions for centralized printing and copying could be presented as alternatives, and the Jet Propulsion Laboratory's Photographic, Printing, and Duplicating Services Section for the use of the GPO Cost Management System.
INTRODUCTION

During the preparation of the first report on the NASA Electronic Publishing System—Electronic Printing and Duplicating Evaluation Report and the subsequent report covering the Stage I Evaluation, it became clear that a report on the cost/benefit methodology used in each should be prepared for use as a reference. This report walks the reader through the steps in preparing a generic cost/benefits analysis for printing and duplicating alternatives.

Figure 1 is a schematic of the model used to support the cost/benefit analysis of the electronic duplicating system. Discounted cash-flow analysis is a modern approach to judging the relative merits of alternative strategies, which characterizes all cash inflows (benefits) and outflows (costs) associated with each alternative over the system life. The timing of those inflows and outflows must be related to the start of the project.

Discounted cash-flow techniques recognize the inherent time value of money; that is, money received earlier has a greater value than money received later. To reflect this, all cash inflows and outflows are discounted to convert them to an equivalent time frame -- in this case the start of electronic duplicating. This discounted value for the cash flow is called the present value of the future cash flow.

The sum of all of the present value cash flows for an alternative is the net present value (NPV) of all cost and benefits for that alternative. If the NPV is positive for an alternative, its time-valued benefits outweigh its costs, and it is viable from a cash-flow standpoint. If the NPV for an alternative is negative, its costs exceed its benefits over the life of the project. In comparing alternative strategies,
the alternative with the highest NPV returns the highest level of benefits for the costs incurred over the life of the EDS.

In accordance with Automated Information Management (AIM) cost/benefit guidelines, this evaluation also presents the traditional measures -- total nondiscounted cost, total nondiscounted benefit, cost/benefit ratios, and payback periods for each of the alternatives considered. The cost/benefit ratio is the total benefit divided by total cost in nondiscounted terms for a given alternative. The payback period for an alternative is the length of time required for the cash proceeds to equal the original cash outlay.

The following costing assumptions provide the basis for performing cost/benefits analysis of alternatives for the EDS.

1. All cash flows are stated in terms relative to the cost/benefit ratios that would derive if the current printing and duplicating methods were continued over the system life. In other words, all costs are incremental, and all benefits are incremental benefits for all alternatives.

2. A conservative discount rate of 2.5 percent is assumed for present value calculations for all future inflows and outflows.

3. The EDS under evaluation is assumed to have a system life of 5 years and to have a 50 percent residual value at the end of its life.

4. All cash flows are time-phased in 1-year intervals, with each cash inflow or outflow assumed to take place at the end of the period in which it falls.

5. The evaluation phase of the EDS is assumed to require 3 months, during which time equipment is installed, tested, and integrated and software is customized if necessary.

6. Processing of printing and duplicating jobs is assumed to begin immediately on acceptance of the EDS as operational.

7. All printing and duplicating is assumed to transfer totally to EDS system before benchmark demonstration test is conducted (prior to the end of the evaluation).

The mechanics of the cost/benefit calculations have been accommodated by developing a spreadsheet model that provides a handy means of assigning cost/benefit items to the period in which they will be realized. Spreadsheet capabilities include built-in functions for calculating the present value of a stream of cash flows (cost/benefit), cost/benefit ratios, and payback periods. A sample model demonstrating the methodology and use of the software is presented in the following analysis.

ASSUMPTIONS AND SPECIFICATIONS

Assumptions

The assumptions for the hypothetical situation under study are presented in table 1.
<table>
<thead>
<tr>
<th>Duplicating requirement per month</th>
<th>Quantity/jobs</th>
<th>Pages</th>
<th>Total pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total impressions</td>
<td>1,040,000/43</td>
<td>1,040,000</td>
<td>1,040,000</td>
</tr>
<tr>
<td>2. Electronic media (saddle stitch)</td>
<td>5,000/10</td>
<td>50 per booklet</td>
<td>250,000</td>
</tr>
<tr>
<td>3. 1-Sided prints</td>
<td>12,000/3</td>
<td>5 per booklet</td>
<td>60,000</td>
</tr>
<tr>
<td>4. 2-Sided prints</td>
<td>4,000/4</td>
<td>20 per booklet</td>
<td>80,000</td>
</tr>
<tr>
<td>5. Scans</td>
<td>100,000</td>
<td>20,000</td>
<td></td>
</tr>
<tr>
<td>6. Binds</td>
<td>1,000/4</td>
<td>100 per booklet</td>
<td>100,000</td>
</tr>
<tr>
<td>7. Single stitch</td>
<td>1,000/1</td>
<td>25 per booklet</td>
<td>25,000</td>
</tr>
<tr>
<td>8. Double stitch</td>
<td>1,000/1</td>
<td>25 per booklet</td>
<td>25,000</td>
</tr>
<tr>
<td>9. Saddle stitch</td>
<td>10,000/20</td>
<td>50 per booklet</td>
<td>500,000</td>
</tr>
</tbody>
</table>

Table 1

**Duplicating Specifications**

1. Tape binding
2. Saddle stitching (8.5 x 11 and 5.5 x 8)
3. 600 dpi
4. Stapling (single and double)
5. Electronic media (disks, LAN, WAN, Internet)
6. Covers
7. Scanning (hard copy)
8. >100 Pages per minute
9. Concurrency of operations
10. All jobs equal to or less than 25,000 impressions.

**ALTERNATIVES**

Alternatives under consideration are

1. Printing and duplicating using a GPO commercial printer (Costs were determined using the JPL-developed GPO Cost Management System.)
2. Duplicating using cost per copy contract machines
3. Duplicating and finishing through the use of a computer center's high-speed laser such as the Xerox 4135
4. Duplicating using electronic duplicating system (such as the networked Xerox DocuTech).

As a reference, appendix C provides comparative specifications for the Xerox 4090 and 5090.
Alternative 1 - GPO Commercial Printing Multiple Award Contracts

Table 2 summarizes a low and upper cost range for printing. This alternative requires one full-time equivalent (FTE) to prepare the GPO job orders. (To obtain a better understanding of the workings of the GPO Cost Management System, see reference 1, appendix 4.)

### Table 2 - Alternative 1 - GPO

<table>
<thead>
<tr>
<th>Job category</th>
<th>Originals</th>
<th>Finishing</th>
<th>Turnaround</th>
<th>Copies</th>
<th>Pages/pub</th>
<th>Lower cost</th>
<th>Upper cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Negatives</td>
<td>Saddlestitch</td>
<td>3 days</td>
<td>15,000</td>
<td>50</td>
<td>9,909.50</td>
<td>15,313.73</td>
</tr>
<tr>
<td>2</td>
<td>Tron</td>
<td>Looseleaf, staple</td>
<td>3 days</td>
<td>2,000</td>
<td>25</td>
<td>761.60</td>
<td>1,133.65</td>
</tr>
<tr>
<td>3</td>
<td>Tron</td>
<td>Tape</td>
<td>3 days</td>
<td>1,000</td>
<td>100</td>
<td>1,706.75</td>
<td>2,399.04</td>
</tr>
<tr>
<td>4</td>
<td>Tron</td>
<td>Looseleaf, staple</td>
<td>3 days</td>
<td>12,000</td>
<td>5</td>
<td>2,193.00</td>
<td>5,672.00</td>
</tr>
<tr>
<td>5</td>
<td>Tron</td>
<td>Looseleaf, staple</td>
<td>3 days</td>
<td>4,000</td>
<td>20</td>
<td>1,483.60</td>
<td>2,686.18</td>
</tr>
<tr>
<td>6</td>
<td>Electronic</td>
<td>Saddlestitch</td>
<td>Not Available</td>
<td>5,000</td>
<td>50</td>
<td>Req Inc in Job 1</td>
<td>Req Inc in Job 1</td>
</tr>
</tbody>
</table>

**Total:** 39,000  16,054.45  27,204.60

### Alternative 2 - Cost per Copy Program

The cost per copy is 1.38 cents each. This alternative requires two FTE to operate duplicators and finishing equipment (not included in the 1.38 cents per copy pricing). The cost per copy program is a GSA awarded contract to a duplicating vendor who provides this type of service. Electronic receipt of files is not available in this alternative.

### Table 3 - Alternative 2 - Cost Per Copy Program

<table>
<thead>
<tr>
<th>Job category</th>
<th>Originals</th>
<th>Response</th>
<th>Finishing</th>
<th>Total Impressions</th>
<th>Cost per copy</th>
<th>Offline</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Saddlestitch</td>
<td>500,000</td>
<td>Not Available</td>
<td>GPO</td>
<td>15,313.73</td>
</tr>
<tr>
<td>2</td>
<td>Electronic</td>
<td>1 day</td>
<td>Saddlestitch</td>
<td>250,000</td>
<td>Not Available</td>
<td>Create hardcopy</td>
<td>inc in Job 1</td>
</tr>
<tr>
<td>3</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Looseleaf, stitch</td>
<td>50,000</td>
<td>1.38 cents</td>
<td>Not Applicable</td>
<td>690.00</td>
</tr>
<tr>
<td>4</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Tape</td>
<td>100,000</td>
<td>1.38 cents</td>
<td>Not Applicable</td>
<td>1,380 + cost of binding</td>
</tr>
<tr>
<td>5</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Looseleaf, stitch</td>
<td>60,000</td>
<td>1.38 cents</td>
<td>Not Applicable</td>
<td>828.00</td>
</tr>
<tr>
<td>6</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Looseleaf, stitch</td>
<td>80,000</td>
<td>1.38 cents</td>
<td>Not Applicable</td>
<td>1,104.00</td>
</tr>
</tbody>
</table>

**Total:** 1,040,000  19,315.73
Alternative 3 - Computer Center High-Speed Laser Printer

The cost per copy is 2.463 cents. Component costs are given in appendix C. This alternative requires one FTE to offload jobs and perform offline finishing. Scanning of hard copy is not available in this alternative, all work must be received electronically.

<table>
<thead>
<tr>
<th>Job category</th>
<th>Originals</th>
<th>Response</th>
<th>Finishing</th>
<th>Total impressions</th>
<th>Cost per copy</th>
<th>Offline</th>
<th>Cost if electronic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Saddle Stitch</td>
<td>500,000</td>
<td>Not Applicable</td>
<td>GPO</td>
<td>12,315.00</td>
</tr>
<tr>
<td>2</td>
<td>Electronic</td>
<td>1 day</td>
<td>Saddle Stitch</td>
<td>250,000</td>
<td>0.02463</td>
<td>Not Applicable</td>
<td>6,157.50</td>
</tr>
<tr>
<td>3</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Looseleaf, stitch</td>
<td>50,000</td>
<td>Not Applicable</td>
<td>GPO</td>
<td>1,231.50</td>
</tr>
<tr>
<td>4</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Tape</td>
<td>100,000</td>
<td>Not Applicable</td>
<td>GPO</td>
<td>2,463.00</td>
</tr>
<tr>
<td>5</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Looseleaf, stitch</td>
<td>60,000</td>
<td>Not Applicable</td>
<td>GPO</td>
<td>1,477.80</td>
</tr>
<tr>
<td>6</td>
<td>Hardcopy</td>
<td>1 day</td>
<td>Looseleaf, stitch</td>
<td>80,000</td>
<td>Not Applicable</td>
<td>GPO</td>
<td>1,970.40</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
<td>1,040,000</td>
<td></td>
<td></td>
<td>25,615.20</td>
</tr>
</tbody>
</table>

Table 4

Alternative 4 - Electronic Duplicating System - Networked DocuTech

Using the cost algorithm (fig. 2, column 2), the cost to produce each job described in table 1 was calculated (see fig. 3, column 10). The GSA contract prices for the Xerox networked DocuTech are given in table 5. This alternative requires one FTE to operate the system.

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
<th>Monthly maintenance</th>
<th>Monthly LTOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net-DocuTech 135B</td>
<td>$245,700.00</td>
<td>$6,460.00</td>
<td>$4,322.84</td>
</tr>
<tr>
<td>Print Server</td>
<td>$34,580.00</td>
<td>$294.00</td>
<td>$548.26</td>
</tr>
<tr>
<td>Mac5 Netware*</td>
<td>$485.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCP/IP software*</td>
<td>$4,995.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Booklet maker</td>
<td>$45,500.00</td>
<td>$392.00</td>
<td>$841.45</td>
</tr>
<tr>
<td>Excess &gt; 250K</td>
<td>$1,150.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cover Insertion Module</td>
<td>$12,000.00</td>
<td></td>
<td>$172.35</td>
</tr>
<tr>
<td>Job Manager</td>
<td>$4,000.00</td>
<td>$24.50</td>
<td>$60.82</td>
</tr>
<tr>
<td>Total:</td>
<td>$347,270.00</td>
<td>$8,320.00</td>
<td>$5,945.72</td>
</tr>
</tbody>
</table>

Note: High volume maintenance plan (1,200,000 copies) / signature booklet maker > 250,000 copies = 0.0023 per copy

Table 5
### Hypothetical Production Workload - One Month

<table>
<thead>
<tr>
<th>Impressions</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Impressions</td>
<td>12</td>
<td>50000</td>
<td>25000</td>
<td>25000</td>
<td>25000</td>
<td>10000</td>
<td>8000</td>
<td>6000</td>
</tr>
<tr>
<td>1-sided Prints</td>
<td>20</td>
<td>0</td>
<td>50</td>
<td>30</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>2-sided Prints</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Folded Prints</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Single-sided Single-sided</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Booklet</td>
<td>5</td>
<td>50</td>
<td>0</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$6,593.25</td>
<td>$1,474.80</td>
<td>$109.63</td>
<td>$315.63</td>
<td>$1,489.00</td>
<td>$1,069.33</td>
<td>$840.37</td>
<td>$1,216.60</td>
</tr>
<tr>
<td>Cost Per Impression</td>
<td>$0.01399</td>
<td>$0.01399</td>
<td>$0.01243</td>
<td>$0.01243</td>
<td>$0.01461</td>
<td>$0.01461</td>
<td>$0.01298</td>
<td>$0.01298</td>
</tr>
<tr>
<td>Pages Per Pub</td>
<td>50</td>
<td>50</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>50</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Footnotes</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$6,593.25</td>
<td>$1,474.80</td>
<td>$109.63</td>
<td>$315.63</td>
<td>$1,489.00</td>
<td>$1,069.33</td>
<td>$840.37</td>
<td>$1,216.60</td>
</tr>
</tbody>
</table>

**Figure 2** - Networked DocuTech duplicating costs.

### MILESTONE SCHEDULE

The following generic phasing schedule was developed to show the minimal activities required to prepare the analysis. The schedule is time phased over 8 months.

![Milestone Schedule Diagram]

**Figure 3** - Generic phasing schedule.
In this section, the productivity analysis is identified in terms of the improvements that each alternative can offer. However, without a detailed time and motion study and the identification of associated costs, specific savings cannot be fully identified. However, for comparison, figures 4 to 7 show the process flow for each alternative. Elapsed time (from submission of the document to the printing or duplicating facility to the finished publication) varies from alternative to alternative (see fig. 8). Table 6 shows a comparison of productivity improvements, and figure 9, on line 84, identifies a range of productivity savings (0.5% to 6%) that may result from reengineering the internal publication processes. The source data for these calculations is the January 1993 pay period and exclude SES and excepted service salaries at NASA Headquarters but include a 30% benefit computation (data provided by the Institutional Resources Branch).
<table>
<thead>
<tr>
<th>Productivity Improvement Items</th>
<th>GPO (Alt 1)</th>
<th>Cost/copy (Alt 2)</th>
<th>Computer-center</th>
<th>EDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output quality</td>
<td>&gt;600 dpi</td>
<td>300 dpi</td>
<td>600 dpi</td>
<td>600 dpi</td>
</tr>
<tr>
<td>Finishing quality</td>
<td>Excellent</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Response time (from request to receipt of finished publication)</td>
<td>&gt;30 days</td>
<td>1-2 days</td>
<td>1 day</td>
<td>&lt;1 day</td>
</tr>
<tr>
<td>Merge with mailing lists (electronically)</td>
<td>Not applicable</td>
<td>No</td>
<td>Yes</td>
<td>Partial</td>
</tr>
<tr>
<td>Concurrency (mix of electronic and hard copy)</td>
<td>Not applicable</td>
<td>No</td>
<td>No, must go to Alt 1 or 2</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 6
<table>
<thead>
<tr>
<th>Feature</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Cost Per Thousand</th>
<th>Service Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printing (Col A)</td>
<td>326,450</td>
<td>332,617</td>
<td>342,382</td>
<td>351,287</td>
<td>360,345</td>
<td>370,195</td>
<td>380,035</td>
<td>$29.34</td>
<td>12,480,000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplies</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>39,719</td>
<td>40,713</td>
<td>41,730</td>
<td>42,773</td>
<td>43,842</td>
<td>44,930</td>
<td>45,930</td>
<td>208,776</td>
<td></td>
</tr>
<tr>
<td>JCP Total</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Duplicating Volumes</td>
<td>12,480,000</td>
<td></td>
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<tr>
<td>Inflation</td>
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<tr>
<td>Annual Printing Volumes (JCP Form 1)</td>
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<tr>
<td>Estimated Annual Volume</td>
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<td></td>
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</tr>
</tbody>
</table>

**Stapling, single and dual:** Perfect binding; Saddle stitching, 11 x 17 and 5.5 x 8.5

**Hard copy; electronic media, diskettes and electronic file transmission**

---

**Figure 9 - Cost benefit and productivity calculations.**
COST/BENEFITS ANALYSIS

Each alternative will undergo a 5-year cash flow analysis according to the costing assumptions described earlier. Figure 9 shows the cash flow analysis in constant dollars for each of the alternatives with a composite comparison. Rows 74 to 77 show various cost parameters for each alternative. The first parameter (column B) is the initial cash outlay for each of the four alternatives. Column C presents the interest rate that the acquisition organization would have to pay to borrow money. For illustration purposes, this interest rate is 6.5%. Column D shows the net present value of a series of future cash flows discounted at a fixed periodic interest rate. Column E shows the present value based on a series of equal payments discounted at a periodic interest rate over 5 years. The sum of the periods was divided by five to obtain the equal payments. Column F represents the benefits, which is calculated by using alternative 1 as the baseline and subtracting each alternative from alternative 1. Column G shows the benefit-cost ratio, which is determined by dividing the benefits by the total cost. The parameter shown in column H shows the average cost per year over the life of the alternative under analysis. Column I shows the average cost per thousand impressions of each alternative. Figure 10 provides a graphical display of each alternative and its cash flow over the 5-year life cycle.

The overall ranking of each alternative is shown in Table 7 for initial cost, benefit, present value, and benefit-cost ratios. Clearly, the EDS alternative is the most beneficial. Also from Table 7, the electronic duplicating system is identified as the best alternative in meeting all of the assumptions and minimal duplicating specifications cited earlier in this report. Figure 9 identifies annual savings from $609,483 to as much as $7,313,799. Even if the conservative productivity gain of $609,483 is reduced by half, the breakeven is almost reached during the first year of operation. Figure 11 displays the breakeven point and the projected cumulative saving of $609,483 over the 5-year life of the selected alternative.

![CASH FLOW COMPARISONS](image)

Figure 10 - Cumulative cash flow comparisons.
### Ranking of Alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Average Cost/Copy</th>
<th>5 Year Cost</th>
<th>Benefits</th>
<th>NPV</th>
<th>B/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GPO</td>
<td>$30.85</td>
<td>$1,924,732</td>
<td>0</td>
<td>$1,594,714</td>
<td>Not applicable</td>
</tr>
<tr>
<td>2. Cost per copy</td>
<td>$29.62</td>
<td>$1,848,389</td>
<td>76,343</td>
<td>$1,536,262</td>
<td>0.04</td>
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<tr>
<td>3. Computer center</td>
<td>$26.78</td>
<td>$1,710,361</td>
<td>214,371</td>
<td>$1,387,189</td>
<td>0.13</td>
</tr>
<tr>
<td>4. Electronic duplicating system</td>
<td>$26.22</td>
<td>$1,641,897</td>
<td>282,835</td>
<td>$1,358,598</td>
<td>0.17</td>
</tr>
</tbody>
</table>

**Table 7**

### RISK ASSESSMENT

Table 8 identifies the risk factors associated with each alternative. For each risk factor, two subjective ratings are presented. The first is the confidence level associated with each factor. High indicates that the assumptions made are based on considerable knowledge and documentation and therefore may be expected to have relatively high certainty of being valid. A low confidence level indicates that the assumptions are based on incomplete information or ambiguous requirements and therefore are more likely to be questionable. The second rating indicates the potential impact for each factor. A high potential impact indicates that if the assumptions are found to be invalid, conclusions and recommendations made by the analysis would be radically altered. A low potential impact indicates a low or minor effect for those assumptions. Of particular interest are those items that have an assigned low confidence level and corresponding high potential impact. These are items for which judgments made in constructing the model are highly subjective and uncertain. At the same time, these items have the potential to alter radically the conclusions reached. For example, the evaluation assumes that turnaround improvement expectations warrant a reduction in response time from 62 days to 2 days.

<table>
<thead>
<tr>
<th>Risk Analysis Items - Rating: (Validity/Impact)</th>
<th>GPO</th>
<th>Cost/Copy</th>
<th>Computer Center</th>
<th>EDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment/software configuration</td>
<td>NA/NA</td>
<td>Med/Med</td>
<td>Med/High</td>
<td>High/High</td>
</tr>
<tr>
<td>Equipment/software costs</td>
<td>Low/Low</td>
<td>Low/Low</td>
<td>High/Med</td>
<td>High/High</td>
</tr>
<tr>
<td>Communications configuration (LAN/WAN/Internet)</td>
<td>NA/NA</td>
<td>NA/NA</td>
<td>High/High</td>
<td>High/High</td>
</tr>
<tr>
<td>Communications costs (print server and workstation software)</td>
<td>NA/NA</td>
<td>NA/NA</td>
<td>High/High</td>
<td>High/High</td>
</tr>
<tr>
<td>Document processing times (order to receipt of request)</td>
<td>High/High</td>
<td>High/Med</td>
<td>High/High</td>
<td>High/High</td>
</tr>
<tr>
<td>Document workload (impressions/jobs per month)</td>
<td>Low/Low</td>
<td>High/High</td>
<td>High/High</td>
<td>High/High</td>
</tr>
<tr>
<td>Document quality (output and finishing results)</td>
<td>Low/Low</td>
<td>Med/Med</td>
<td>Med/Med</td>
<td>High/High</td>
</tr>
<tr>
<td>Printed publication turnaround time</td>
<td>High/High</td>
<td>High/Med</td>
<td>High/High</td>
<td>High/High</td>
</tr>
<tr>
<td>Training costs</td>
<td>Low/Low</td>
<td>Low/Low</td>
<td>Med/Med</td>
<td>Med/Med</td>
</tr>
<tr>
<td>System installation costs</td>
<td>NA/NA</td>
<td>Low/Med</td>
<td>Med/Low</td>
<td>Med/Med</td>
</tr>
<tr>
<td>System integration costs</td>
<td>NA/NA</td>
<td>Low/High</td>
<td>Med/Med</td>
<td>High/Med</td>
</tr>
<tr>
<td>Benefits to user</td>
<td>High/High</td>
<td>Med/Med</td>
<td>Med/Med</td>
<td>High/High</td>
</tr>
</tbody>
</table>

Legend: NA - Not Applicable; H - High; Med - Medium; L - Low

Table 8
The areas with a low confidence level and a high impact potential include assumptions about:

1. Communications requirements and costs
2. Document processing times and workloads
3. Value of improved document quality
4. Document request turnaround time
5. Level of demand for remote printing of publications
6. Level of training for users.

**SENSITIVITY ANALYSIS**

The sensitivity analysis was based on the highest composite ranking alternative in terms of the five following parameters: lowest cost per copy, lowest 5-year cost, greatest dollar benefit, lowest NPV, and highest benefit-cost ratio. The model parameters with the greatest level of uncertainty are the number of impressions (copies) per month and the turnaround improvement (reduction from request of publication to its receipt by the requestor) elapsed time. These are highly subjective and are an attempt to reflect what is anticipated to occur based on performance at other NASA installations for the productivity improvement value and on the estimated number of impressions based on past monthly production statistics. The assumed benefit value is that value at which the cost per page fully recovers the cash outflow for the selected alternative or the EDS as shown by table 7. This value is identified in figure 11 as the breakeven point, that is, where the productivity savings fully recovers the cost of the alternative. Table 9 identifies the cost per thousand impressions when the production volume varies from 3 million to 18 million impressions per year. Figure 12 shows the relative ranking of each alternative for each production volume in bar format versus the selected alternative. At 3 million impressions per year, table 9 and figure 12 clearly show that this alternative is the most expensive option when the volume drops to 3 million (assuming that the computer center receives all files electronically). Figure 13 is a radar area chart which shows the relative relationship of the EDS versus GPO alternatives. Each axis represents the production volumes with the alternative cost identified for each volume.

<table>
<thead>
<tr>
<th></th>
<th>GPO</th>
<th>Cost/copy</th>
<th>Computer center</th>
<th>EDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Mil</td>
<td>$44.95</td>
<td>$41.72</td>
<td>$67.66</td>
<td>$81.92</td>
</tr>
<tr>
<td>6 Mil</td>
<td>$30.49</td>
<td>$30.26</td>
<td>$33.83</td>
<td>$40.96</td>
</tr>
<tr>
<td>9 Mil</td>
<td>$28.67</td>
<td>$26.44</td>
<td>$22.55</td>
<td>$27.31</td>
</tr>
<tr>
<td>Pivot</td>
<td>$29.34</td>
<td>$29.08</td>
<td>$26.20</td>
<td>$25.92</td>
</tr>
<tr>
<td>15 Mil</td>
<td>$25.55</td>
<td>$23.38</td>
<td>$22.44</td>
<td>$21.67</td>
</tr>
<tr>
<td>18 Mil</td>
<td>$25.03</td>
<td>$22.62</td>
<td>$19.32</td>
<td>$18.39</td>
</tr>
</tbody>
</table>

Table 9
CASH FLOW & PRODUCTIVITY COMPARISONS

Figure 11 - Productivity versus cash outflow.

Figure 12 - Sensitivity to volume.

RETURN ON INVESTMENT

Figure 9, line 70 (column C to column G) identifies the return on investment for years 1 to 5. The return on investment is determined by dividing the benefits received by the cost of the selected alternative. In this case, alternative 4 at the end of year 1 gives an investment cost of $323,532, which is divided into estimated benefits of $609,483 giving a factor of 1.88; or, in other terms, for every dollar spent, one dollar and 88 cents is returned. Year 2 gives a factor of 1.89, year 3 a factor of 1.87, year 4 a factor of 1.85, and year 5 a factor of 1.82. For each year after year 1, the factors decrease because the benefit costs are kept constant and investment dollars are inflated at 2.5% per year. The estimated benefits figure is derived from the reengineering of the publication process using a count of 1713 FTE's, which alternative 4 provides at 0.5 percent per year (see fig. 9, line 84, column B).
RECOMMENDATIONS

In the performance of the cost benefit analysis for the justification and acquisition of an electronic duplicating system alternative, it is extremely important that the requirements of the decision maker be known so that the resulting analysis will provide the information to aid the decision maker in making the appropriate choice. The decision maker’s input to the analyst performing the cost benefit analysis will no doubt affect the final result. Therefore, the better the problem is defined, the more useful the final evaluation report will be to the decision maker.

All direct and indirect costs should be identified early on, as some of these costs will directly affect the cost recovery figure. Because each situation is different, the cost/benefit methodology contained herein represents a departure point for the justification of electronic duplicating alternative. The solution arrived at for a particular alternative may differ from the alternative selected in this report.

OTHER CONSIDERATIONS

On completion of the cost benefit analysis, the next step in the approval process is the preparation of a Federal Information Processing (FIP) Resource Decision Document (FRDD) for alternative 3 (computer center). Alternative 3 also requires the approval of the NASA Printing Management Officer (NPMO) who forwards the request to the JCP. Alternative 4 does not require a FRDD but does require the approval of the NPMO who notifies the JCP regarding the acquisition of the EDS.
### APPENDIX A - ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>B/C</td>
<td>Benefit/cost</td>
</tr>
<tr>
<td>COTS</td>
<td>Commercial off the shelf</td>
</tr>
<tr>
<td>EDS</td>
<td>Electronic duplicating system</td>
</tr>
<tr>
<td>FIP</td>
<td>Federal Information processing</td>
</tr>
<tr>
<td>FTE</td>
<td>Full time equivalent</td>
</tr>
<tr>
<td>FRDD</td>
<td>Federal Information Processing Resource Decision Document</td>
</tr>
<tr>
<td>GPO</td>
<td>Government Printing Office</td>
</tr>
<tr>
<td>GSA</td>
<td>General Services Administration</td>
</tr>
<tr>
<td>JCP</td>
<td>Joint Committee on Printing</td>
</tr>
<tr>
<td>NPMO</td>
<td>NASA Printing Management Officer</td>
</tr>
<tr>
<td>NPV</td>
<td>Net present value</td>
</tr>
<tr>
<td>PV</td>
<td>Present value</td>
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APPENDIX B - REFERENCES


7. General Services Administration Authorized ADP Schedule Price List, FSC Group 70, Part I, Section A. FSC Class 70215-0004, Contract GSOK94AGS5816, Period 10/1/93 to 9/30/94.
APPENDIX C - BACKGROUND DATA

1. Source data for alternative analysis of cost per thousand impressions for range of annual production volume.
2. GPO production profile for range of annual production volumes.
3. Comparative specifications for Xerox Network DocuTech, 4135, 4090, and 5090 printing and duplicating systems.

<table>
<thead>
<tr>
<th>A</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<td>1</td>
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<td>Computer Ctr</td>
<td>EPS</td>
</tr>
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<td>$ Sensitivity To # Of Copies</td>
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</table>

Source Data For Sensitivity Calculations

Operator + LTCP + Maintenance Costs

- 9.62%
- 18.27%
- 72.12%
- 100.00%
### GPO Production Profile at Selected Annual Production Volumes

<table>
<thead>
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<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<th>K</th>
<th>L</th>
<th>M</th>
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<th>O</th>
<th>P</th>
<th>Q</th>
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<td>17</td>
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<td>Jobs</td>
<td>Pages</td>
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<td>Cost</td>
<td>Total</td>
<td>Cost</td>
<td>Cost</td>
<td>Cost</td>
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<td>Inc in Saddle</td>
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<td>Saddles</td>
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<td>50</td>
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<td>Monthly Copies</td>
<td>500,000</td>
<td>750,000</td>
<td>1,040,000</td>
<td>1,250,000</td>
<td>1,500,000</td>
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<td>9</td>
<td>Annual $2</td>
<td>102,828</td>
<td>258,653</td>
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<td>450,541</td>
<td>134,850</td>
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<td>18,000,000</td>
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### Comparative printing & duplicating system specifications.

<table>
<thead>
<tr>
<th>Spec</th>
<th>Alt 4 - Network DocuTech (Copier/Central Printer)</th>
<th>Alt 3 - 4135 (Central Printer)</th>
<th>4090 (Central Printer)</th>
<th>5090 (Copier)</th>
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<tr>
<td>Speed</td>
<td>135 ppm</td>
<td>135 ppm</td>
<td>92 ppm</td>
<td>135 ppm</td>
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<tr>
<td>Resolution</td>
<td>600 dpi</td>
<td>600 dpi</td>
<td>100 dpi</td>
<td>300 dpi</td>
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<tr>
<td>Imaging</td>
<td>Laser</td>
<td>Laser</td>
<td>Light Lens</td>
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<tr>
<td>Max Paper Size</td>
<td>11&quot; x 17&quot;</td>
<td>11&quot; x 17&quot;</td>
<td>8.5&quot; x 14&quot;</td>
<td>11&quot; x 17&quot;</td>
</tr>
<tr>
<td>Stock Size</td>
<td>3</td>
<td>4 (+1 roll feed opt.)</td>
<td>2 (+2 opt.)</td>
<td>3</td>
</tr>
<tr>
<td>Stock Capacity</td>
<td>6,300</td>
<td>6,900 (+ roll feed opt.)</td>
<td>1,500 (+2,000 add. opt.)</td>
<td>6,300</td>
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<tr>
<td>Duplexing</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Stacker</td>
<td>8&quot; x 10&quot; to 9&quot; x 14&quot;, 3,000 max</td>
<td>2 @ 2,500 exs</td>
<td>2 @ 2,750 exs (opt. 1 @ 2,000)</td>
<td>8&quot; x 10&quot; to 9&quot; x 14&quot;, 3,000 max</td>
</tr>
<tr>
<td>Finisher</td>
<td>3x10-9x14&quot;, 2-70 sheets (32K, top)</td>
<td>opt. (finishing partner)</td>
<td>opt. finisher (2-50 pg.)</td>
<td>3x10-9x14&quot;, 2-70 sheets (32K, top)</td>
</tr>
<tr>
<td>Saddle Stitch</td>
<td>5.5 x 8.5 &amp; 11x17 in line (opt. sign book maker)</td>
<td>opt. (finishing partner)</td>
<td>opt. (finishing partner)</td>
<td>no</td>
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<tr>
<td>Thermal Binder</td>
<td>3.5 x 11&quot; 15-125 sheets, 425 bounds /reel</td>
<td>opt. (finishing partner)</td>
<td>opt. (finishing partner)</td>
<td>3.5 x 11&quot; 15-125 sheets, 425 bounds /reel</td>
</tr>
<tr>
<td>Duty Cycle</td>
<td>1,000,000 per month</td>
<td>4,000,000 per month</td>
<td>2,000,000 per month</td>
<td>1,000,000 per month</td>
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<tr>
<td>CPU</td>
<td>DEC 11</td>
<td>DEC J-11</td>
<td>DEC 3-11</td>
<td>34 microprocessors, 5 mips</td>
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<tr>
<td>RAM</td>
<td>16 mb</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Hard Drive</td>
<td>1,140 mb</td>
<td>2 @ 182mb ea. std (1,124 mb opt)</td>
<td>2 @ 170mb ea. std (1,123 mb opt)</td>
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<tr>
<td>Interface</td>
<td>Ethernet XNS</td>
<td>Ethernet XNS</td>
<td>Ethernet XNS</td>
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<tr>
<td>PostScript</td>
<td>Interpress</td>
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<td>Interpress</td>
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<tr>
<td>Print Manager</td>
<td>80386 PC</td>
<td>Functionality in Network Server</td>
<td>Functionality in Network Server</td>
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<td>Network Server - HW</td>
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<tr>
<td>Network Server - SW</td>
<td>PS or HP/PCL, Novell, TCP/IP, Appletalk</td>
<td>PS or HP/PCL, Novell, TCP/IP, Appletalk</td>
<td>PS or HP/PCL, Novell, TCP/IP, Appletalk</td>
<td>n/a</td>
</tr>
<tr>
<td>Media Server - SW</td>
<td>DOS, OS/2, Mac, SUN</td>
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<td>n/a</td>
<td>n/a</td>
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<td>RAM</td>
<td>8 mb std, 16 mb optional</td>
<td>32 mb standard</td>
<td>32 mb standard</td>
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<tr>
<td>Hard Drive</td>
<td>650 mb</td>
<td>424 mb standard</td>
<td>424 mb standard</td>
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<tr>
<td>PDL's</td>
<td>Postscript level 2 - Adobe, PCL 4 &amp; 5</td>
<td>PS 162, HP PCL 4 &amp; 5, TIFF, ASCH, CUNFT</td>
<td>PS 162, HP PCL 4 &amp; 5, TIFF, ASCH, CUNFT</td>
<td>n/a</td>
</tr>
<tr>
<td>Client Support</td>
<td>IBM PC, Apple Macintosh, Unix Workstation</td>
<td>IBM PC, Apple Macintosh, Unix Workstation</td>
<td>IBM PC, Apple Macintosh, Unix Workstation</td>
<td>n/a</td>
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<tr>
<td>Scanner</td>
<td>Scan rate @ 2.5 sec per document, 23 ppm</td>
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<td>n/a</td>
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<tr>
<td>Supply yields</td>
<td>Dry ink = 220k, developer = 750k, fuser agent = 250k</td>
<td>Dry ink = 260k, developer = 360k, fuser agent = 250k</td>
<td>Dry ink = 105k, developer = 360k, fuser agent = 140k</td>
<td>n/a</td>
</tr>
<tr>
<td>Administration (Accounting)</td>
<td>Stores up to 10,000 accounts</td>
<td>Not applicable, internal to computer complex job control system</td>
<td>Not applicable, internal to computer complex job control system</td>
<td>Stores up to 10,000 accounts</td>
</tr>
</tbody>
</table>

**Note:** Alternative 3 - Central Printer @ Computer Center & Alternative 4 - Copier @ Duplicating Facility (Data Source: Xerox Corporation, Mr. Bob Sullivan, Federal District Operations)
The NASA Scientific and Technical Information Office was assigned the responsibility to examine the benefits of the utilization of electronic printing and duplicating systems throughout NASA Installations and Headquarters. The subject of this report is the documentation of the methodology used in justifying the acquisition of the most cost beneficial solution for the printing and duplicating requirements of a duplicating facility that is contemplating the acquisition of an electronic printing and duplicating system. Four alternatives are presented with each alternative costed out with its associated benefits. The methodology goes a step further than just a cost benefit analysis through its comparison of risks associated with each alternative, sensitivity to number of impressions and productivity gains on the selected alternative and finally the return on investment for the selected alternative. The report can be used in conjunction with the two earlier reports, NASA TM-106242 and TM-106510 in guiding others in determining the cost effective duplicating alternative.