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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.

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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 1 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 the 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.

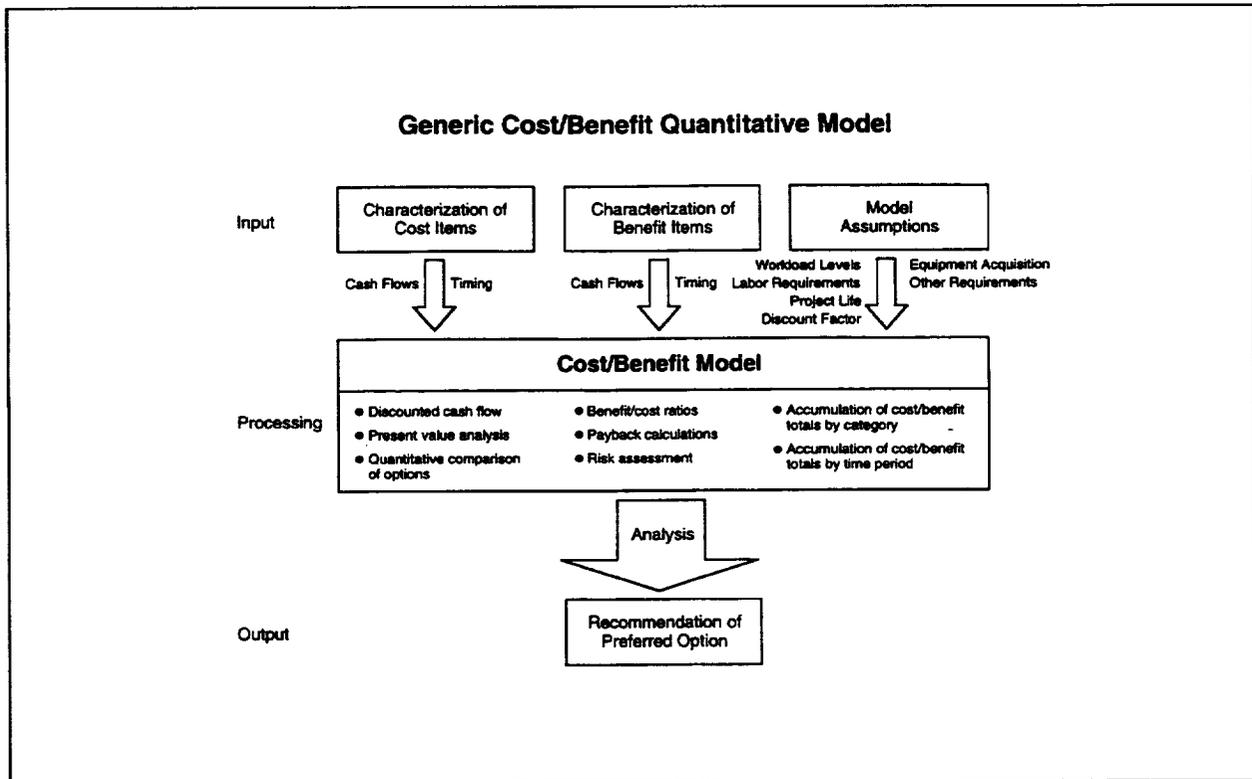


Figure 1 - Generic cost/benefit quantitative model.

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.

Duplicating requirement per month	Quantity/jobs	Pages	Total pages
1. Total impressions	1,040,000/43	1,040,000	1,040,000
2. Electronic media (saddle stitch)	5,000/10	50 per booklet	250,000
3. 1 - Sided prints	12,000/3	5 per booklet	60,000
4. 2 - Sided prints	4,000/4	20 per booklet	80,000
5. Scans	100,000	20,000	
6. Binds	1,000/4	100 per booklet	100,000
7. Single stitch	1,000/1	25 per booklet	25,000
8. Double stitch	1,000/1	25 per booklet	25,000
9. Saddle stitch	10,000/20	50 per booklet	500,000

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.)

Alternative 1 - GPO							
Job category	Originals	Finishing	Turnaround	Copies	Pages/pub	Lower cost	Upper cost
1	Negatives	Saddlestitch	3 days	15,000	50	9,909.50	15,313.73
2	Iteck	Looseleaf, staple	3 days	2,000	25	761.60	1,133.65
3	Iteck	Tape	3 days	1,000	100	1,706.75	2,399.04
4	Iteck	Looseleaf, staple	3 days	12,000	5	2,193.00	5,672.00
5	Iteck	Looseleaf, staple	3 days	4,000	20	1,483.60	2,686.18
6	Electronic	Saddlestitch	Not Available	5,000	50	Reqt Inc in Job 1	Reqt Inc in Job 1
Total:				39,000		16,054.45	27,204.60

Table 2

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.

Alternative 2 - Cost Per Copy Program							
Job category	Originals	Response	Finishing	Total impressions	Cost per copy	Offline	Cost
1	Hardcopy	1 day	Saddle Stitch	500,000	Not Available	GPO	15,313.73
2	Electronic	1 day	Saddle Stitch	250,000	Not Availalbe	Create hardcopy	Inc in Job 1
3	Hardcopy	1 day	Looseleaf, stitch	50,000	1.38 cents	Not Applicable	690.00
4	Hardcopy	1 day	Tape	100,000	1.38 cents	Not Applicable	1,380 + cost of binding
5	Hardcopy	1 day	Looseleaf, stitch	60,000	1.38 cents	Not Applicable	828.00
6	Hardcopy	1 day	Looseleaf, stitch	80,000	1.38 cents	Not Applicable	1,104.00
Total:				1,040,000			19,315.73

Table 3

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.

Alternative 3 - Computer Center							
Job category	Originals	Response	Finishing	Total impressions	Cost per copy	Offline	Cost if electronic
1	Hardcopy	1 day	Saddle Stitch	500,000	Not Applicable	GPO	12,315.00
2	Electronic	1 day	Saddle Stitch	250,000	0.02463	Not Applicable	6,157.50
3	Hardcopy	1 day	Looseleaf, stitch	50,000	Not Applicable	GPO	1,231.50
4	Hardcopy	1 day	Tape	100,000	Not Applicable	GPO	2,463.00
5	Hardcopy	1 day	Looseleaf, stitch	60,000	Not Applicable	GPO	1,477.80
6	Hardcopy	1 day	Looseleaf, stitch	80,000	Not Applicable	GPO	1,970.40
Total:				1,040,000			25,615.20

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.

Alternative 4 - Electronic Duplicating System			
Model	Price	Monthly maintenance	Monthly LTOP
Net-DocuTech 135B	\$ 245,700.00	\$ 6,460.00	\$ 4,322.84
Print Server	\$ 34,580.00	\$ 294.00	\$ 548.26
Mac5 Netware*	\$ 495.00		
TCP/IP software*	\$ 4,995.00		
Booklet maker	\$ 45,500.00	\$ 392.00	\$ 841.45
Excess > 250K		\$ 1,150.00	
Cover Insertion Module	\$ 12,000.00		\$ 172.35
Job Manager	\$ 4,000.00	\$ 24.50	\$ 60.82
Total:	\$ 347,270.00	\$ 8,320.00	\$ 5,945.72

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										Impressions
Categories	Rate	Job 1	Job 2	Job 3	Job 4	Job 5	Job 6	Job 7	Costs	
Total Impressions	12	500000	250000	25000	25000	100000	80000	60000	\$12,480.00	1,040,000
1-Sided Prints	20	50	50	25	25	50	0	5	\$4.10	
2-Sided Prints	25	0	0	0	0	0	10	0	\$0.25	
11x17 Prints	25	0	0	0	0	0	0	0	\$0.00	
11x17 Impressions	15	0	0	0	0	0	0	0	\$0.00	
Single Print Jobs	15	0	0	0	0	0	0	0	\$0.00	
Scans	5	50	0	25	25	0	20	5	\$0.63	
Binds	200	0	0	0	0	1000	0	0	\$200.00	
Single Stitches	10	0	0	1000	0	0	4000	12000	\$170.00	
Dual Stitches	15	0	0	0	1000	0	0	0	\$15.00	
Total Booklets	24	0	0	0	0	0	0	0	\$0.00	
11x17 Booklets	95	10000	5000	0	0	0	0	0	\$1,425.00	
Total Cost:		\$6,951.25	\$3,476.00	\$310.63	\$315.63	\$1,401.00	\$1,000.35	\$840.13	\$14,294.98	= Total Cost
Cost Per Impression:		\$0.01390	\$0.01390	\$0.01243	\$0.01263	\$0.01401	\$0.01250	\$0.01400	\$0.01334	= Avg \$/Page
Pages Per Pub:		50	50	25	25	50	20	5	32	= Avg # Pg/Pub
Cost Per Publication:		\$0.70	\$0.70	\$0.31	\$0.32	\$1.40	\$0.25	\$0.07	\$0.53395	= Avg \$/Pub

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.

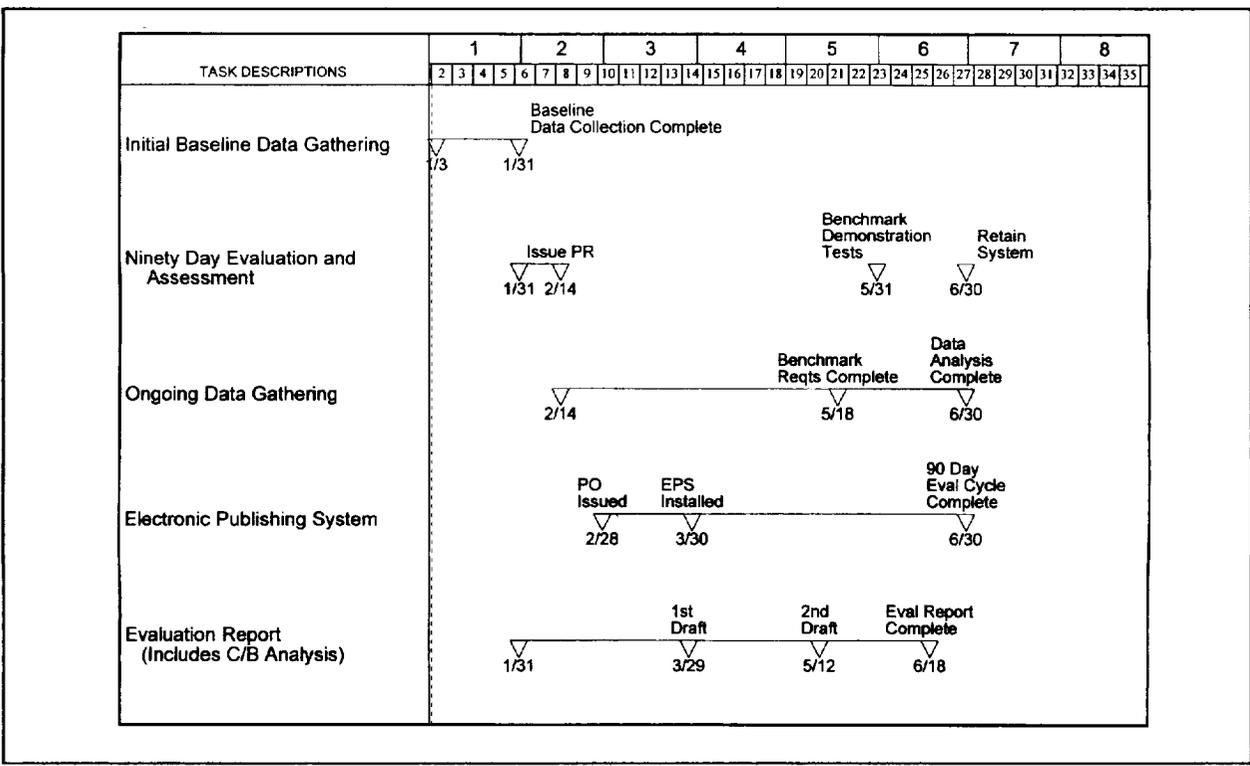


Figure 3 - Generic phasing schedule.

PRODUCTIVITY ANALYSIS

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).

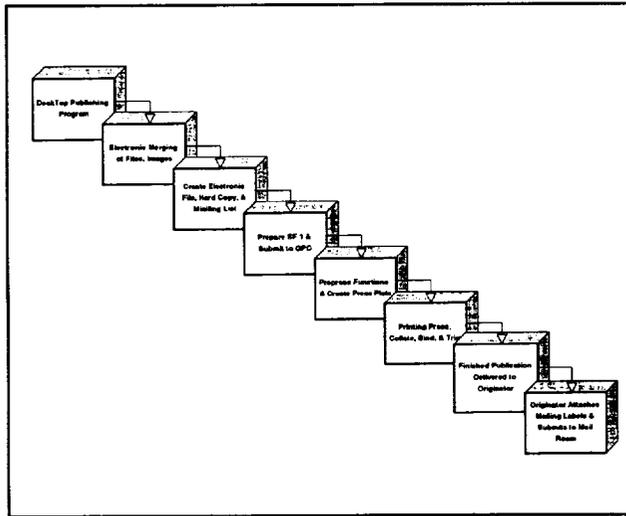


Figure 4 - Alt 1 (GPO).

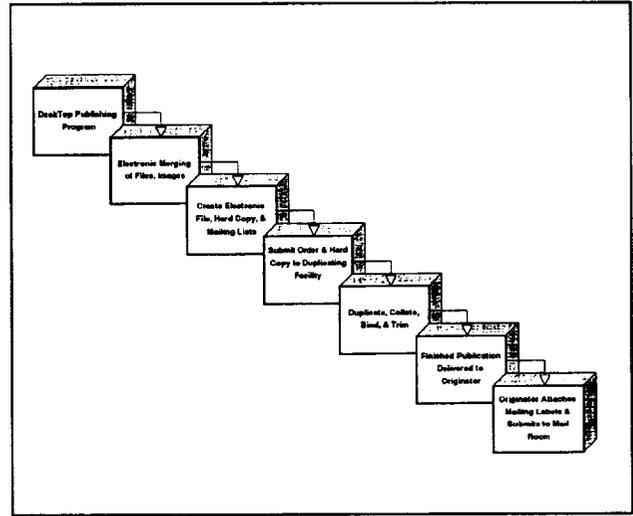


Figure 5 - Alt 2 (cost per copy contract).

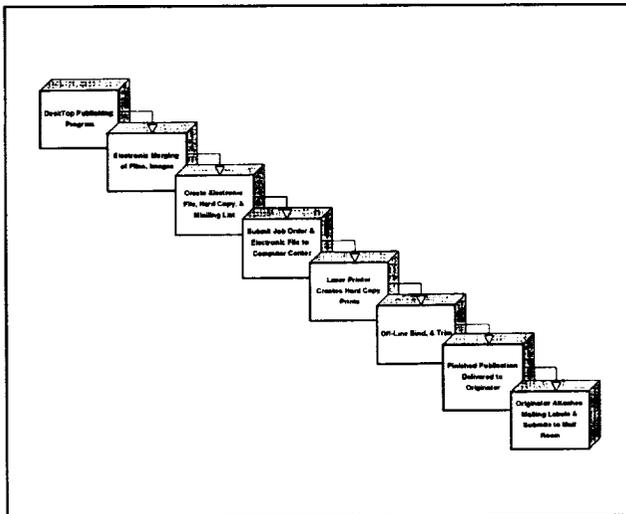


Figure 6 - Alt 3 (computer center).

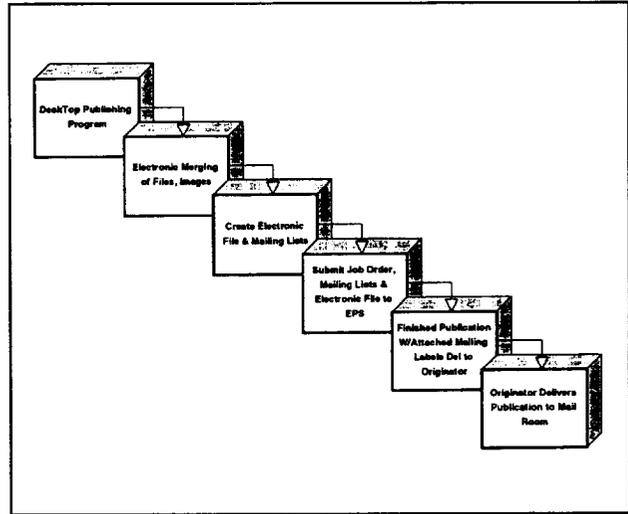


Figure 7 - Alt 4 (electronic duplicating system).

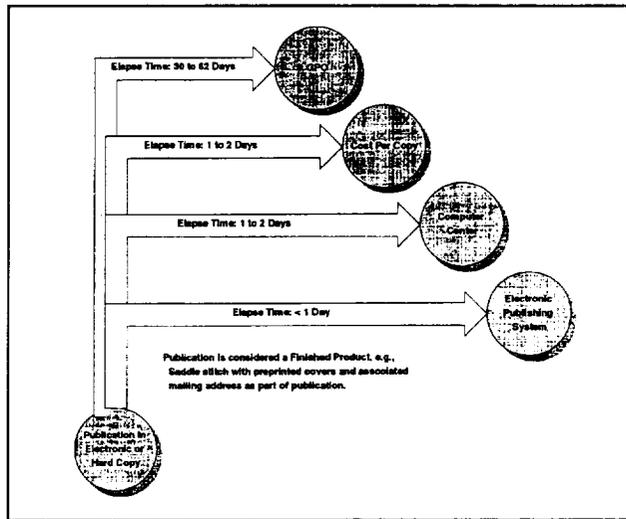


Figure 8 - Elapsed times.

Productivity Comparisons				
Productivity improvement items	GPO (Alt 1)	Cost/copy (Alt 2)	Computer-center	EDS
Output quality	>600 dpi	300 dpi	600 dpi	600 dpi
Finishing quality	Excellent	Good	Excellent	Excellent
Response time (from request to receipt of finished publication)	>30 days	1-2 days	1 day	<1 day
Merge with mailing lists (electronically)	Not applicable	No	Yes	Partial
Concurrency (mix of electronic and hard copy)	Not applicable	No	No, must go to Alt 1 or 2	Yes

Table 6

	A	B	C	D	E	F	G	H	I	J
1	COST BENEFIT CALCULATIONS - GENERIC									
2	Workload Profile: Stapling, single and dual; Perfect binding; Saddle stitching, 11 x 17 and 5.5 x 8.5									
3	Hard copy, electronic media, diskette and electronic file transmittal									
4	Combined Annual Operating Expense As Reported in JCP Form 1									
5										
6										
7	Equipment	Maintenance	Supplies	Labor	Space	Depreciation	Cost	Date Acq	Rental	One Time Purche
8	Printing (Col A)	0	0	0	0	0	0		0	0
9										
10	Duplicating (Col C)	0	0	0	0	0	0		0	0
11										
12	JCP Total	0	0	0	0	0	0		0	0
13										
14	Annual Duplicating Volumes			12,480,000		Inflation = 2.50%		Shifts=	1	
15	Annual Printing Volumes (JCP Form 1)			0		Paper = 0.0050				
16	Estimated Annual Volume			12,480,000						
17										
18										
19	Alternative 1 (GPO)									
20	Service Life	Base	Year 1	Year 2	Year 3	Year 4	Year 5	Service Life \$		
21	Investment (GPO Contracts)	Not Applicable	326,455	334,617	342,982	351,557	360,345	1,715,958		
22	Network HW/SW	Not Available	0	0	0	0	0	0		
23	Labor (GS 11-5)	0	39,719	40,712	41,730	42,773	43,842	208,776	GPO Coordinator	
24	Supplies	Not Applicable	0	0	0	0	0	0		
25	Maintenance	Not Applicable	0	0	0	0	0	0		
26	Depreciation	Not Applicable	0	0	0	0	0	0		
27	Space	Not Applicable	0	0	0	0	0	0		
28	Finishing	Not Applicable	0	0	0	0	0	0		Included in Final Product
29	Alternative 1 Total	0	366,174	375,329	384,712	394,330	404,188	1,924,732		
30	Cost Per Thousand:		\$29.34	\$30.07	\$30.83	\$31.60	\$32.39	30.85		
31	Alternative 2 (Cost Per Copy Program)									
32	Service Life	Base	Year 1	Year 2	Year 3	Year 4	Year 5	Service Life \$		
33	Investment (On Site Dupl)	Not Applicable	231,789	231,789	231,789	231,789	231,789	1,158,944		
34	Network HW/SW	Not Available	0	0	0	0	0	0		
35	Labor (WG 9-2)	0	68,765	70,484	72,246	74,052	75,903	361,450	Duplicating Operator	
36	Supplies (Paper Only)	0.0050	62,400	63,960	65,559	67,198	68,878	327,995		
37	Maintenance	Not Applicable	0	0	0	0	0	0		
38	Space	0	0	0	0	0	0	0		
39	Finishing-Single Staple Only	0	0	0	0	0	0	0		Tape Binding/Saddle Stitching Off-Line
40	Alternative 2 Total	0	362,954	366,233	369,594	373,039	376,570	1,848,389		
41	Cost Per Thousand:		\$29.08	\$29.35	\$29.61	\$29.89	\$30.17	29.62		
42	Alternative 3 (Computer Center)									
43	Service Life	Base	Year 1	Year 2	Year 3	Year 4	Year 5	Service Life \$		
44	Investment (4135)	0	98,877	98,877	98,877	98,877	98,877	493,384	Assumes all electronic receipt	
45	Network HW/SW	38,995	3,220	3,220	3,220	3,220	3,220	55,095	Software Licenses + 1 time Purchase	
46	Labor (GS 9-5)	0	65,850	67,291	68,974	70,898	72,485	345,078	Computer Operator	
47	Supplies (Paper/Ink/Toner/Fuser)	0.0062	77,777	79,721	81,714	83,757	85,851	408,819	Paper + Toner + Ink + Fuser	
48	Maintenance (Per Copy)	0.0037	46,176	46,176	46,176	46,176	46,176	230,880	Electronic files only/No hard copy	
49	Depreciation (10%)	0	7,799	7,799	7,799	7,799	7,799	38,995	Amortization of Purchased Components	
50	Space	0	0	0	0	0	0	0		Raised Flooring
51	Finishing (In-Line)	0	27,622	27,622	27,622	27,622	27,622	138,110	Duplo In-Line Finishing System	
52	Alternative 3 Total	38,995	326,920	330,506	334,181	337,949	341,810	1,710,361		
53	Cost Per Thousand:		\$26.20	\$26.48	\$26.78	\$27.08	\$27.39	26.78		
54	Alternative 4 (Electronic Publishing System)									
55	Service Life	Base	Year 1	Year 2	Year 3	Year 4	Year 5	Service Life \$		
56	Investment (LTOP)	0	52,604	52,604	52,604	52,604	52,604	263,020	NetDoc/PrintMgr	
57	Network HW/SW	5,490	6,579	6,579	6,579	6,579	6,579	38,386	Incl 1 Time Pur. Yr 1 + Print Server	
58	Labor (WG 9-2)	0	68,765	70,484	72,246	74,052	75,903	361,450	Duplicating Operator	
59	Supplies (Paper/Ink/Toner/Fuser)	0.0062	77,777	79,721	81,714	83,757	85,851	408,819	Paper + Toner + Ink + Fuser	
60	Maintenance (>1.2M = .002)	0	99,840	99,840	99,840	99,840	99,840	499,200	Includes Finishing & Network Systems	
61	Depreciation (10%)	LTOP	1,098	1,098	1,098	1,098	1,098	5,490	Amortization of Purchased Components	
62	Space	0	0	0	0	0	0	0		No Raised Flooring Required
63	Finishing (In-Line)	0	18,870	12,166	12,166	12,166	12,166	65,532	Insertion Module/SigBkMaker	
64	Alternative 4 Total	5,490	323,532	322,492	326,247	330,096	334,041	1,641,897		
65	Cost Per Thousand:		\$25.92	\$25.84	\$26.14	\$26.45	\$26.77	26.22		
66	Alternative Cash Flow Comparisons									
67	Alternative 1	0	366,174	375,329	384,712	394,330	404,188	1,924,732		
68	Alternative 2	0	362,954	366,233	369,594	373,039	376,570	1,848,389		
69	Alternative 3	(38,995)	326,920	330,506	334,181	337,949	341,810	1,710,361		
70	Alternative 4	(5,490)	323,532	322,492	326,247	330,096	334,041	1,641,897		
71	Return On Investment #4		1.88	1.89	1.87	1.85	1.82			Assumes Productivity Increase of 5% /Yr
72										
73	Alternative Summary									
74	Alternatives	Initial Cash Outfl	Interest Rate	NPV	PV	Benefits	B/C Ratio	Avg Cost/Yr	Avg Cost/Thousand	
75	Alternative 1	0	6.50%	1,594,751	1,599,714	0	Not Applicable	384,948	\$30.85	
76	Alternative 2	0	6.50%	1,534,485	1,536,263	76,343	0.04	369,678	\$29.62	
77	Alternative 3	(38,995)	6.50%	1,387,189	1,421,543	214,371	0.13	342,072	\$26.78	
78	Alternative 4	(5,490)	6.50%	1,358,598	1,364,640	282,835	0.17	328,379	\$26.22	
79	Annual Productivity Savings Based On 5% to 6% Per Year									
80		Pay Period 3	Productivity - 5%	Productivity - 1%	Productivity - 2%	Productivity - 3%	Productivity - 4%	Productivity - 5%	Productivity - 6%	
81	Total Hours/Pay Period	137,053	685	1,371	2,741	4,112	5,482	6,853	8,223	
82	FTE/Pay Period	1,713	9	17	34	51	69	86	103	
83	Avg \$/FTE (Incl Benefits)	\$71,153								
84	Average Savings/Yr	Not Applicable	\$609,483	\$1,218,967	\$2,437,933	\$3,656,900	\$4,875,866	\$6,094,833	\$7,313,799	
85										

Figure 9 - Cost benefit and productivity calculations.

COST/BENEFITS ANALYSIS

Each alternatives 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 shownn 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.

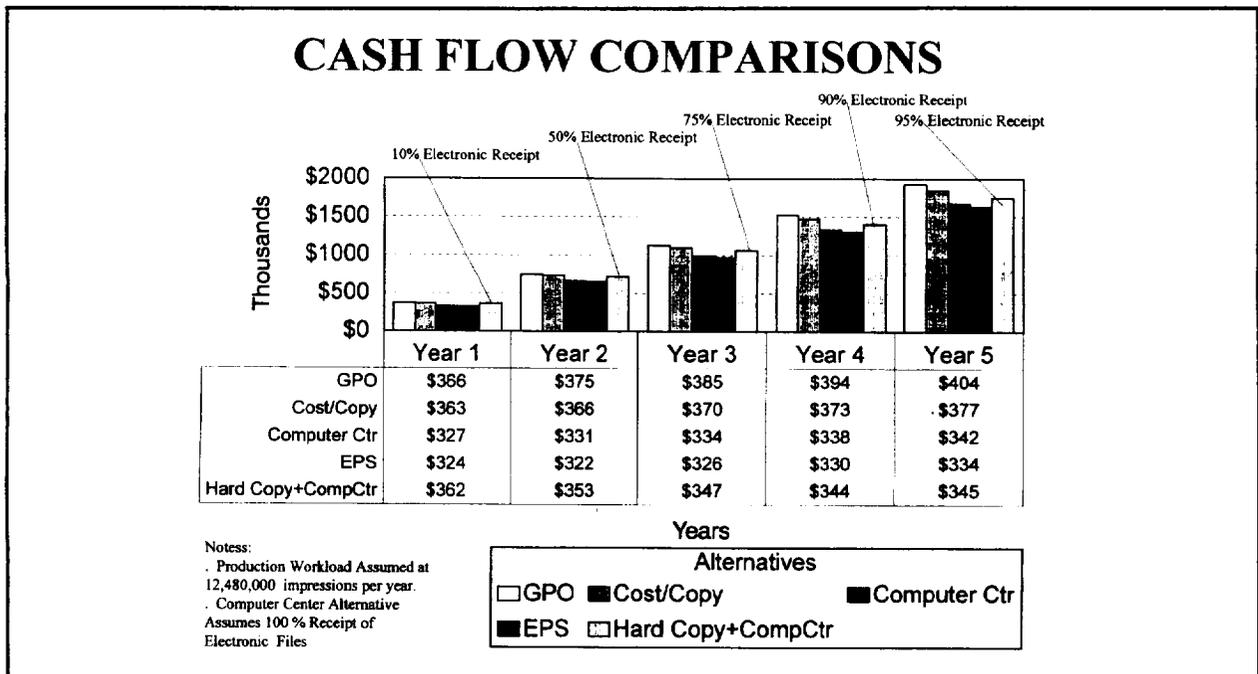


Figure 10 - Cumulative cash flow comparisons.

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

Table 7

RISK ASSESSMENT

Table 8 identifies the risk factors associated with the 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 judgements 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.

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

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) elapse 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.

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

Table 9

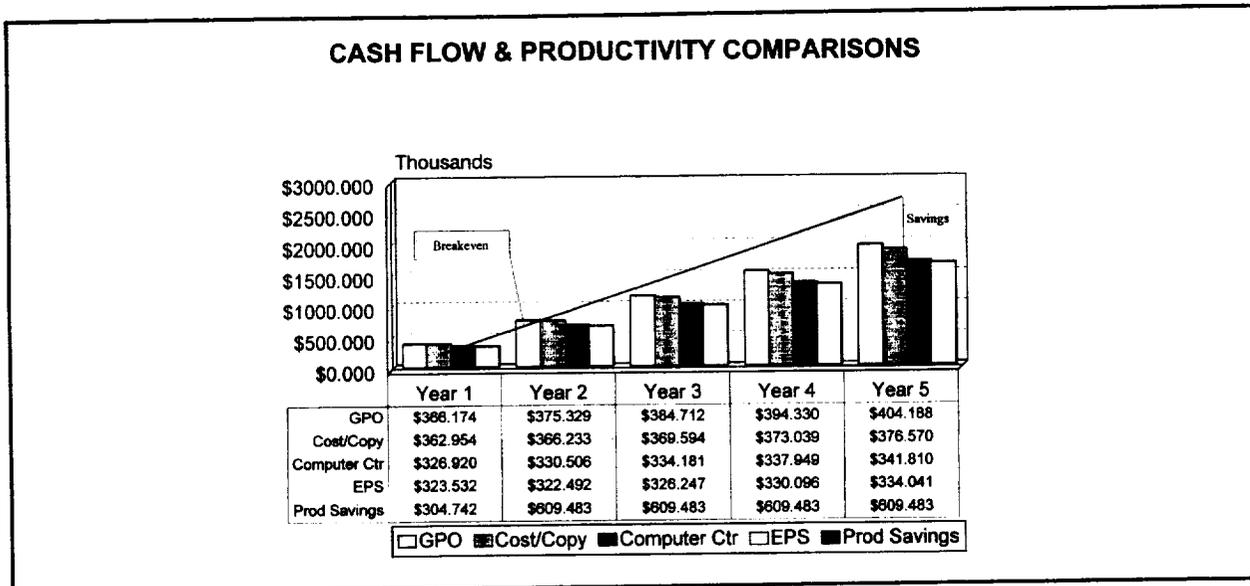


Figure 11 - Productivity versus cash outflow.

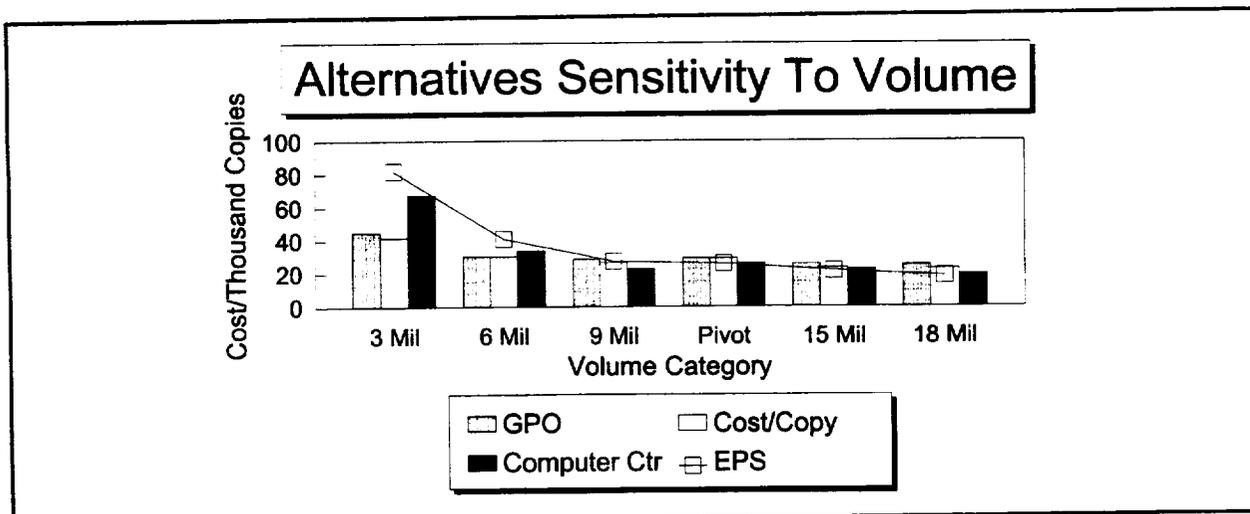


Figure 12 - Sensitivity to volume.

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).

Alternative 1 Vs 4

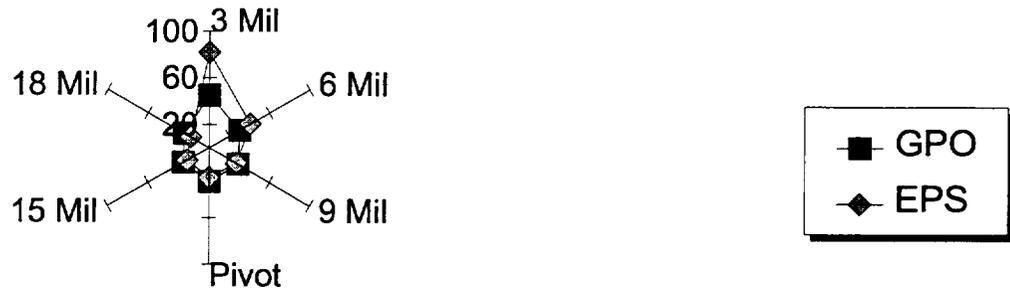


Figure 13- Relative cost per thousand (alternatives 1 versus 4).

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

B/C	Benefit/cost
COTS	Commercial off the shelf
EDS	Electronic duplicating system
FIP	Federal information processing
FTE	Full time equivalent
FRDD	Federal Information Processing Resource Decision Document
GPO	Government Printing Office
GSA	General Services Administration
JCP	Joint Committee on Printing
NPMO	NASA Printing Management Officer
NPV	Net present value
PV	Present value

APPENDIX B - REFERENCES

1. Tuey, Richard C.: NASA Electronic Publishing System -- Electronic Printing and Duplicating Evaluation Report. NASA TM 106242, Jun. 1993.
2. Tuey, Richard C.: NASA Electronic Publishing System -- Stage 1 Evaluation Report. NASA TM 106510, Feb. 1994
3. NASA STI Program Coordinating Council: NASA STI Modernization Plan. NASA TM 109415, Sep. 1993.
4. Sassone, Peter G.; and Schaffer, William A.: Cost-Benefit Analysis A Handbook, Academic Press, New York, 1978.
5. Kendall, M. G.: Cost-Benefit Analysis, American Elsevier Publishing Co., Inc., New York, 1971.
6. General Services Administration Federal Supply Service, FSC Group 36, Part IV, FSC Class 3610, Contract GS-26F-1001B, Period 10/1/93 to 9/30/94.
7. General Services Administration Authorized ADP Schedule Price List, FSC Group 70, Part I, Section A, FSC Class 70215-0004, Contract GSOOK94AGS5816, 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.

1	A	B	C \$ Sensitivity To # Of Copies				D	E	F	G	H	I	J
2	Per Year	Copies-Yr1	GPO	Cost/Copy	Computer Ctr	EPS				Bind	Stitches	Saddle	
3	3,000,000	3 Mil	\$134,850	\$125,165	\$202,968	\$245,756				240	721	3,606	
4	6,000,000	6 Mil	\$182,928	\$181,565	\$202,968	\$245,756				481	1,442	7,212	
5	9,000,000	9 Mil	\$258,053	\$237,965	\$202,968	\$245,756				721	2,163	10,817	
6	12,480,000	Pivot	\$366,174	\$362,954	\$326,920	\$323,532				1,000	3,000	15,000	
7	15,000,000	15 Mil	\$383,292	\$350,765	\$336,548	\$325,041				1,202	3,606	18,029	
8	18,000,000	18 Mil	\$450,541	\$407,165	\$347,709	\$331,103				1,442	4,327	21,635	
9													
10			Alternatives Sensitivity To Volume										
11			GPO	Cost/Copy	Computer Ctr	EPS							
12		3 Mil	\$44.95	\$41.72	\$67.66	\$81.92							
13		6 Mil	\$30.49	\$30.26	\$33.83	\$40.96							
14		9 Mil	\$28.67	\$26.44	\$22.55	\$27.31							
15		Pivot	\$29.34	\$29.08	\$26.20	\$25.92							
16		15 Mil	\$25.55	\$23.38	\$22.44	\$21.67							
17		18 Mil	\$25.03	\$22.62	\$19.32	\$18.39							
18													
19			Alternatives										
20			GPO	Cost/Copy	Computer Ctr	EPS							
21		Min Cost	NA	68765	202968	245756							
22		Cost/Copy	Variable	\$0.0138	\$0.0037	\$0.0020							
23		Binding	\$0.0000	\$0.2300	\$0.2090	\$0.2090							
24		Stapling	\$0.0000	\$0.0012	\$0.0015	\$0.0015				9.62%			
25		Saddle	\$0.0000	\$0.0012	\$0.0029	\$0.0029				18.27%			
26										72.12%			
										100.00%			

Source Data For Sensitivity Calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
	Req'ts	Qty	Jobs	Pages		Cost	Cost	Cost	Total	Cost	Qty						
						inc in Saddle											
1	Electronic	5,000	10	50	250,000	250,000	250,000	250,000	250,000	250,000	325,000	375,000	375,000	375,000	375,000	0	0
2	1 sided	12,000	3	5	60,000	60,000	60,000	60,000	60,000	60,000	80,000	100,000	100,000	100,000	100,000	80,000	12,000
3	2 sided	4,000	4	20	0	0	0	0	0	0	0	0	0	0	0	0	4,000
4	Scans	100,000	0	20,000	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Blinds	1,000	4	100	100,000	100,000	100,000	100,000	100,000	100,000	125,000	200,000	200,000	200,000	200,000	100,000	1,000
6	Single S	1,000	1	25	25,000	25,000	25,000	25,000	25,000	25,000	50,000	100,000	100,000	100,000	100,000	50,000	1,000
7	Double S	1,000	1	25	25,000	25,000	25,000	25,000	25,000	25,000	50,000	100,000	100,000	100,000	100,000	50,000	1,000
8	Saddle	10,000	20	50	40,000	40,000	40,000	40,000	40,000	40,000	50,000	125,000	125,000	125,000	125,000	50,000	10,000
9	Totals				500,000	15,244.03	760,000	21,504.38	1,040,000	27,204.60	1,250,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	250,000
10	Monthly Copies					500,000	750,000	1,040,000	1,040,000	1,040,000	1,250,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	250,000
11	Annual \$					182,928	258,053	328,455	328,455	328,455	383,292	450,541	450,541	450,541	450,541	450,541	134,850
12	Annual Copies					6,000,000	9,000,000	9,000,000	9,000,000	9,000,000	12,460,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	3,000,000
13																	
14																	
15																	

GPO cost profile for designated production volumes.

Alternative 3 and 4 Plus Other Options			
Specs	Alt 4 - Network DocuTech (Copier/Central Printer)	Alt 3 - 4135 (Central Printer)	4090 (Central Printer)
Speed	135 ppm	135 ppm	92 ppm
Resolution	600 dpi	600 dpi	300 dpi
Imaging	laser	laser	laser
Max Paper Size	11" x 17"	11" x 17"	8.5" x 14"
Stock Binns	3	4 (+1 roll feed opt.)	3
Stock Capacity	3,300	6,900 (+ roll feed opt.)	3,300
Duplexing	yes	yes	yes
Stacker	8" x 10" to 9" x 14", 3,000 max	2 @ 2,500 ea.	2 @ 750 ea. (opt. 1 @ 2,000)
Stitcher	8x10-9x14", 2-70 sheets (32K /spool)	opt. (finishing partner)	opt. stitcher (2-50 pgs.)
Saddle Stitch	5.5x8.5 & 11x17 in line (opt. sign book maker)	opt. (finishing partner)	opt. (finishing partner)
Thermal Binder	8.5x11" 15-125 sheets, 425 binds /reel	opt. (finishing partner)	opt. (finishing partner)
Duty Cycle	1,000,000 per month	4,000,000 per month	2,000,000 per month
CPU	6 Xerox CPU's	DEC J-11	DEC J-11
RAM	16 mb	n/a	n/a
Hard Drive	1,140 mb	2 @ 182mb ea. std (1,124 mb opt.)	2 @ 170mb ea. std (1,123 mb opt.)
Interface	Ethernet XNS	Ethernet XNS	Ethernet XNS
Resident PDL	Interpress	Interpress	Interpress
Emulations	None	None	None
Print Manager	80386 PC	Functionality in Network Server	Functionality in Network Server
Network Server - HW	80386 PC	Sun Sparc 10	Sun Sparc 10
Network Server - SW	PS or HP/PCL, Novell, TCP/IP, Appletalk	PS or HP/PCL, Novell, TCP/IP, Appletalk	PS or HP/PCL, Novell, TCP/IP, Appletalk
Media Server - HW	80386 PC	n/a	n/a
Media Server - SW	DOS, OS2, Mac, SUN, PostScript or HP/PCL	n/a	n/a
RAM	8 mb std, 16 mb optional	32 mb standard	32 mb standard
Hard Drive	650 mb	424 mb standard	424 mb standard
PDL's	Postscript level 2 - Adobe, PCL 4 & 5	PS 1&2, HP PCL 4 & 5, TIFF, ASCII, CCITT gcp 4	PS 1&2, HP PCL 4 & 5, TIFF, ASCII, CCITT gcp 4
Client Support	IBM PC, Apple Macintosh, Unix Workstation	IBM PC, Apple Macintosh, Unix Workstation	IBM PC, Apple Macintosh, Unix Workstation
Scanner	Scan rate @ 2.5 sec per document, 23 ppm	n/a	n/a
Supply yields	Dry ink = 220k, developer = 750k, fuser agent = 250k	Dry ink = 260k, developer = 600k, fuser agent = 250k	Dry ink = 105k, developer = 300k, fuser agent = 140k
Administration (Accounting)	Stores up to 10,000 accounts	Not applicable, internal to computer complex (job control system)	Not applicable, internal to computer complex (job control system)

Note: Alternative 3 - Central Printer @ Computer Center & Alternative 4 - Copier @ Duplicating Facility (Data Source from: Xerox Corporation, Mr. Bob Sullivan, Federal District Operations)

Comparative printing & duplicating system specifications.

REPORT DOCUMENTATION PAGE

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13. ABSTRACT (<i>Maximum 200 words</i>) 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.			
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