XEROX **Internal Memo**

To

John Shoch

From

J.M. Donohue

Electronics Engineering
Department
A2-08/823-5437

nk 3/23
c: Elkind
Schneider
Lynch
Pacco
Comments, please
(soon)

Subject

OPTICAL MOUSE

Date

9 March 1983

John, per our prior discussions, a copy of the Optical Mouse Business Plan is attached.

We have also received an RFQ from DEC for a few 100,000 mice over the next three years. This procurement alone would be sufficient to make a reasonable return from the mouse. The return would be even better if combined with sizable business from VisiCorp.

It is also well to note that the DEC RFQ was built around the Mouse Technology Device capabilities and limitations. This would indicate that DEC is planning to go the Optical Mouse route whether Xerox bids or not.

ED would certainly like to bid the DEC RFQ. DEC has requested an April 1st response but will, I believe, hold for our response if we indicate Xerox is interested in bidding. I would, therefore, appreciate an expeditious response from you.

ED continues to view the mouse as an excellent, though small, business opportunity. The margins appear to be reasonably large, even with very competitive pricing.

We would greatly value your support for this endeavor, particularly in terms of establishing marketing contacts during your multiple dealings with the external world.

J.M. Donohue

/da

Enclosure

C: A. Miller

OPTICAL MOUSE BUSINESS PLAN

9 March 1983

EXECUTIVE SUMMARY

The Optical Mouse represents a significant business opportunity for Xerox. While not earthshaking in terms of overall business impact, it could well return tens of millions of dollars to Xerox with no substantial down-side risk.

We have a clearly superior product offering cost and/or reliability advantages over any known competitor. The algorithm and sensor technique are, we believe, the best available and should be well protected by the patents already filed.

The basic market is that for the larger personal computers and other computer-driven workstations. The probabilities favor very heavy, if not total, mouse usage. The overall potential is well in excess of one million devices per year by 1985.

We believe this marketplace would best be served by driving down the large volume OEM price, while maintaining reasonable profit margins. We believe the mouse will become a commodity within three years and that only those with large volumes and low prices will be successful. This strategy will also tend to make the mouse business less attractive to those without extensive tooling and a well engineered design.

A two-pronged marketing strategy is proposed. Xerox would sell completed mice or subassemblies to the high volume OEM base. Outside sources would be licensed to make mice for the remainder of the marketplace though Xerox would remain the exclusive source for the LSI chip which is the heart of the mouse.

Manufacturing of the device would begin within ED-M. When volume requirements allow, an automated assembly cabability will be developed or the assembly/manufacture moved to an external source.

Initial LSI production will be done in the ED Microelectronics Center. As volumes grow (at the 100,000 per year level), an external second source will be brought on-board. This source will be restricted to selling only to Xerox.

All required steps are in place to initiate the endeavor. Initial tooled parts will be available in April 1983. Low Volume production will begin in mid-summer with substantial volumes achievability 1984.

DESCRIPTION OF PRODUCT

A mouse is a small device attached to a keyboard via a "tail" which is used to move a cursor on a CRT screen. As a user moves the mouse, the cursor makes corresponding moves on the screen. Buttons on top of the mouse allow the user to activate functions or make selections. A mouse usually has two or three buttons.

There are two types of mice which are currently available - optical and mechanical. Mechanical mice use balls or wheels to encode motion. They have not been reliable since the balls or wheels can get dirty and stick or slip rather than roll and dirt can get inside the mouse. There is a problem in maintaining workstations that use the mouse in an uncontrolled environment. An optical mouse detects motion optically by watching a special pad so there are no internal moving parts.

The Xerox optical mouse system involves three components: a NMOS chip, a special patterned surface (the mouse pad), and the optical system which resolve the pattern array onto the chip's sensor array. It has no mechanical parts except for the buttons. A comparison to the existing mechanical mouse is as follows:

	Mechanical	Optical
Functionality	Same	Same
Cost	>$100	≅ $30
Reliability	Electro/Mech	Solid State
Maintenance Requirement	Every 3-6 Months	Free of Maintenance

POTENTIAL MARKET

The potential user market for a mouse is in several general areas: information processors such as 860, Wang 10A, and IBM Displaywriter, personal computers through small business computers such as IBM System/32, CAD/CAM systems, and the game market. Estimates for growth in the applicable areas are in the following table. This information was supplied by Corporate Market Analysis.

U.S. Market
Shipments (Thousands of Units)

	1981	1984	1987	Avg. Annual Compound Growth Rate 81-84 %	84-87 %	81-87 %
Partial/Full Page Information Processors	136.8	467.0	545.0	50.6	5.3	25.9
Personal Computers (<$1K)	217.0	914.0	1850.0	62.7	25.6	42.9
Personal Computers Prof/Scient ($1-5K)	220.0	560.0	1365.0	36.5	34.6	35.6
Very Small Business Comp ($5-15K)	90.0	225.0	390.0	35.7	20.1	27.7
Small Business Comp ($15-80K)	50.0	87.0	123.0	20.3	12.2	16.2
CAD/CAM and Other Specialized Work Stations and Terminals (ED Estimate)	30.0	60.0	120.0			

Estimates for sales of electronic games are probably in the millions.

In addition, there is an internal Xerox market.

- OSD - 2,000 to 3,000 in 1983
  - Less than 10,000 in 1984
- OPD - No significant 1983 requirement
  - Some potential for small volumes in 1984
- Other Internal
  - Replacement of existing Alto and 8010 mice - 1500 in 1983

ALTERNATIVES AND COMPETITION

The alternatives to a mouse are joysticks, step keys, text keys, styluses, light pens, and touch-sensitive screens. Research done at PARC showed that, compared to the first three alternatives on the list above, the mouse was the fastest for positioning, had the lowest error rates, and had the maximum rate of movement. Information available in various literature all conclude that a mouse is the best pointing device.

All Optical Mouse competitors appear to be at a sizable economic disadvantage for high volume opportunities. Effectively, they simply have a more complex and, therefore, more expensive product. In particular segments - the distributor channel for RS232 compatibility devices, for example - the competition may be more effective.

A well implemented mechanical mouse produced in high volume may prove to be the more significant competitor. The Apple device may well be in this class. Xerox should, however, be able to compete well on price with this class of device if we achieve similar volumes.

A large and fast growing set of suppliers are active in the mouse business.

Optical Mice

- Mouse Systems Corporation - Sunnyvale, Calif.

  A new start-up that makes a smart mouse (contains a microprocessor) utilizing an algorith that counts lines. Vertical and horizontal lines are different colors. The device can track rotation as well as cartesian position. Available with inexpensive RS-232 connection. OEM pricing in the $150 range. Samples are available with small volumes in 1Q83.

- Summagraphics - Fairchild, Conn.

  The Summa mouse is smart and provides formats and protocols widely used in the graphics input business. Summagraphics is believed to be a licensee of Mouse Systems Corp. Summagraphics is established manufacturer of graphic input devices and has full marketing capabilities. Probably not yet supplying samples. Expect product shipment in 2Q83.

- USI International - Brisbane, Calif.

  Also a smart mouse which we also believe uses a line tracking algorithm. Interfaced to an RS-232 port, it can emulate common graphics devices. Initial deliveries were projected for 1Q83 with the large quantity price "less than $200".

Mechanical Mice

- Apple Computer

  Indications are a mechanical mouse utilizing optical transducers for the ball position. Hard rubber or plastic ball. Inexpensive assembly. Rumored to be manufactured in Japan by Alp. Also rumored that Alp is free to market directly. May be a very potent implementation but sufficient data is not yet available to fully evaluate.

- Mouse House - Berkeley, Calif.

  Multiple versions based off old Xerox design. Xerox licensee. Largest and best known of present mouse suppliers. Pricing is $125 above 50,000 though Hawley has never shipped any place near such a quantity. Has had significant assistance from DEC in cleaning up present design.

- Kinetronics - Arlington, Ma.

  Mechanical mouse with optical transducers.

- Logitech Inc. - Palo Alto, Calif.

  U.S. distributor of the Swiss mouse. Rather odd looking mechanical mouse with optical transducers.

- Product Associates - Redwood City, Calif.

  Two-wheel analog mouse.

MARKETING STRATEGY

The potential mouse opportunity appears large. It is probable that it will dominate as the pointing device for personal computers and professional workstations over the next few years.

In defining the mouse opportunity, three distinct customer classes are seen:

- o High volume original equipment manufacturers
  - IBM
  - Apple
  - DEC
- o After-sale marketers
  - VisiCorp
- o Others
  - HP
  - Tektronix
  - Fortune
  - Filex

The Xerox mouse, as designed, is cost privileged in the Original Equipment Manufacturer area. The mouse is easily interfaced through keyboard controllers, and will offer a cost advantage against optical mice utilizing internal microprocessors.

The Xerox Optical Mouse does not have as large a privilege in the after-sales market. Here the cost advantage, due to the lack of an in-mouse microprocessor, is minimized by the need to add an external microprocessor for RS232 or buss compatibility. Xerox appears to have a remaining advantage in terms of a superior sensor and algorithm though this may manifest itself as a performance advantage rather than in UMC.

We propose to attack this market on a two-pronged basis:

- o Directly market to major manufacturers (volume larger than 25,000 per year)
- o License external sources to manufacture and market the mouse

Direct marketing to the large OEMs is an attempt to achieve sizable volumes and revenues with a minimum and focused marketing endeavor. Direct contacts will be made through any available Xerox channel and initial marketing contacts will be made by ED Forward Business Planning.

Licensing of sources outside Xerox is to provide penetration in all other markets. We propose to allow such sources to compete with Xerox on any order. It is also likely that some of the outside sources will develop value added additions such as an RS232 interface.

The major factor in Xerox revenues is planned to be the Optical Mouse LSI chip. The chip is well protected by patents and will not be externally licensed. Our approach is to make the large part of our profit on the chip giving Xerox a significant return whether marketed by Xerox or an outside source.

Xerox will then be willing to provide:

- The LSI chip
- The LSI chip and optical assembly
- The complete internals of the mouse
- Fully assembled and tested mice

The exact configuration sold will be based upon a customer-by-customer negotiation.

Customers with less than 25,000 annual volume will be directed to external licensees.

Volumes

To arrive at a mouse placement potential, we presume that all of the larger personal computers, small business computers and specialized workstations, are eligible. We further assume half of the partial/full page information processors and a small but growing fraction of the low cost PCs are potentials.

This gives a potential of:

U.S. Market
Placements (Thousands of Units)

	1983	1984	1985	1986	1987
Partial/Full Page Information Processors	155	233	245	257	272
Personal Computers (<$1K)	50	91	150	300	400
Personal Computers Prof/Scient ($1-5K)	399	560	754	1014	1365
Very Small Business Comp ($5-15K)	166	225	270	325	390
Small Business Comp ($15-80K)	72	87	97	108	123
CAD/CAM and Other Specialized Workstations and Terminals (ED Estimate)	50	60	80	100	120
	892	1256	1596	2104	2670

To arrive at our projection of mouse volumes, we define two cases:

- Case I - Optimistic - The Xerox mouse is reasonably dominant in the marketplace and the marketplace goes heavily to mouse.
- Case II - Pessimistic - The Xerox mouse is one of several or the mouse usage fails to develop.

For Case I, we assumed that we achieved 50% of the available 1985 market. For Case II, we assumed that we achieved 25% of the available 1985 market.

The mice placements would then be:

	1983	1984	1985	1986
Total Available Placements (000)	892	1256	1594	2104
Xerox Optical Mice - Case I (000)	30	320	800	800
Xerox Optical Mice - Case II (000)	10	140	400	500

To achieve either of these cases, we have assumed that 67% of the mice will be sold as finished or mostly finished mice and 33% as Optical Mouse chips or chips and optics assembly.

Profit Projections

Our financial assessments bracket a gross profit potential between $5 million and $14 million through 1985. While profits could potentially continue into the second half of the decade, it is possible that the environment will become fiercely competitive or go off in other directions. Thus, cutting off the analysis in 1985 appears prudent. The following pages detail our financial projections.

ELECTRONICS DIVISION
OPTICAL MOUSE PROPOSAL

CHIP/MOUSE PRODUCTION (THOUSANDS)

		CASE I		CASE II		UMC		SALES PRICE	
		CHIPS	MICE	CHIPS	MICE	CHIP	MOUSE	CHIP	MOUSE
1983 -	1Q	-	-	-	-				
	2Q	-	-	-	-				
	3Q	10	8	4	3				
	4Q	20	12	6	4				
	TOTAL	30	20	10	7	12.50	37.00	25.00	74.00
1984 -	1Q	40	26	15	10				
	2Q	60	40	25	16				
	3Q	90	60	40	26				
	4Q	130	88	60	40				
	TOTAL	320	214	140	92	9.00	23.50	19.00	47.00
1985 -	1Q	200	135	80	54				
	2Q	200	135	100	68				
	3Q	200	135	110	75				
	4Q	200	135	110	75				
	TOTAL	800	540	400	272	3.00	12.00	11.00	24.00

ELECTRONICS DIVISION
OPTICAL MOUSE PROPOSAL

PROFIT/LOSS STATEMENT ($000)

CASE I

	1982	1983	1984	1985
REVENUE				
- MOUSE	0	1480	10058	12960
- CHIPS	0	250	2014	2860
TOTAL	0	1730	12072	15820
EXPENSES				
- DEVELOPMENT	320	65	0	0
- MOUSE	0	740	5029	6480
- CHIPS	0	125	954	780
- COST REDUCTION	0	0	545	300
- ADMINISTRATION	0	53	136	144
TOTAL	320	983	6664	7704
PROFIT/-LOSS	-320	747	5408	8116

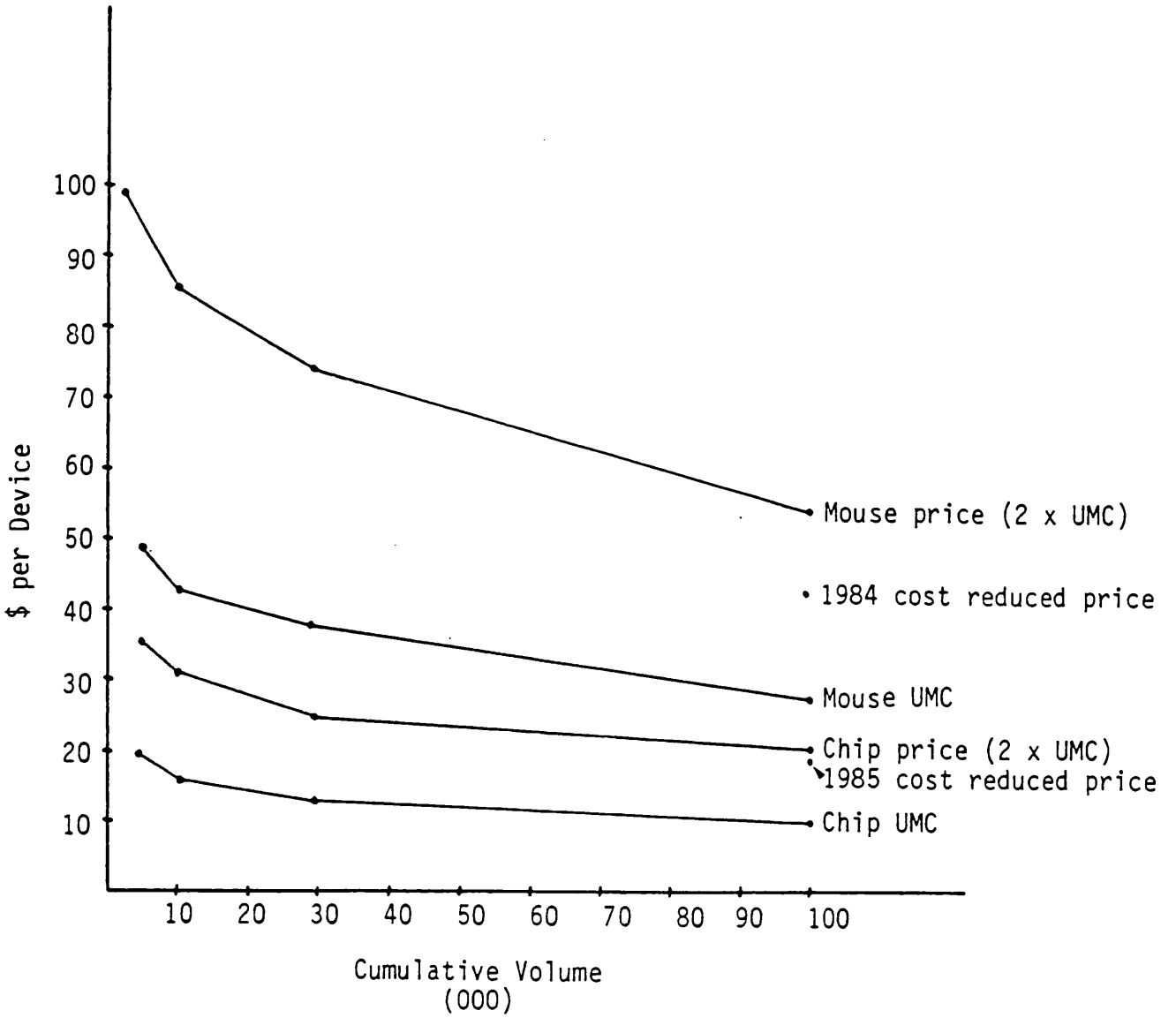
ELECTRONICS DIVISION
OPTICAL MOUSE PROPOSAL

PROFIT/LOSS STATEMENT ($000)

CASE II

	1982	1983	1984	1985
REVENUE				
- MOUSE	0	518	4324	6528
- CHIPS	0	75	912	1408
TOTAL	0	593	5236	7936
EXPENSE				
- DEVELOPMENT	320	65	0	0
- MOUSE	0	259	2162	3264
- CHIPS	0	37.5	432	384
- COST REDUCTION	0	0	545	300
- ADMINISTRATION	0	53	136	144
TOTAL	320	414.5	3275	4092
PROFIT/-LOSS	-320	178.5	1961	3844

PRICE VOLUME PRODUCTIONS
1983-84
(NO COST REDUCTION)



FACT SHEET

Hardware Interface

- Requires 5V at 250mA.

- D serial connector, 8 conductor interface, 2 Y-axis signals, 2 X-axis signals, gnd, +5, SW #1, and SW #2.

Standard Protocol

This Optical Mouse uses a single chip NMOS device which detects motion across a defined pattern by means of light passing through a straight-through Optical Mouse system to the optical sensors (imager). Then, the IC device converts the motion into X and Y direction pulse train outputs.

The phase and frequency of the X-signal pair and the Y-signal pair will determine the cursor's moving or staying speed, and direction. Because this mouse does not have moving parts, except the switches, it does not have the limitations of acceleration. The nominal count rate of this Optical Mouse is 200 counts/inch.

Miscellaneous

- The imager contains a 4x4 array of photo diodes.
- Two buttons (three buttons optional).
- Uses specially designed mouse pad (8x11).
- Size: 90 x 58 x 32 mm
- Wire length: 760 mm (2.5 ft.)
- Beige body with grey buttons

STATUS

- Fifty prototype mice completed in November, 1982, and distributed internally for evaluation. Feedback all positive.
- Pad design completed and sample quantities available. Continuing to work on slick coating on top of paper, sticky coating on bottom.
- PARC chip masks transferred to MEC and sample chips manufactured.

Engineering Status

- Awaiting parts from tooling - expect no problems
- Safety agency approval underway - complete May 15, 1983
- Only remaining Engineering task
  - Validation of tooled parts - complete April 15, 1983

Manufacturing

- Test equipment well along - complete April 1, 1983
- Start-up in EDM/SPG - Pilot run of additional 50 - complete April 15, 1983
- Coated pads available March 1

Effectively a go for up to 10,000/quarter

MANUFACTURING PLAN

The Optical Mouse will be sold by Xerox in four forms:

1. Chip only
2. Chip and optics system. The optics system consists of three elements: the baseplate, the lens and the lens cap
3. All internals without case
4. Complete mouse

The MEC will be responsible for the production of the chip. 1983 production will be produced on the present MEC volume line. As volumes increase in the first half of 1984, the MEC will be responsible for developing chip off-load vendors and establishing/maintaining an appropriate mix of in-house production and vendor off-load.

The optics system is presently off-loaded to MU Engineering. They have been funded for a single cavity mold. The capacity of this mold is 10,000 systems/month. This mold capacity is sufficient for 1983 production. As volumes increase in 4Q83/1Q84, the molds should be retooled to two or four cavity systems so that unit costs can be lowered. There is not a need to establish a second source for the optics system.

EDM will be responsible for production of the complete mouse. 1983 production will be built by EDM/SPG. One of two strategies will be adopted.

- Automatic assembly and test with a robotics system. Some level of mouse redesign may be needed to achieve full automated assembly and test.

- An off-load vendor, likely in the Far East, will be brought up if automated assembly is found deficient.

QUALITY PLAN

The quality plan for the Optical Mouse is based upon the assumption that as the volumes build up, Xerox will both establish outside vendors to take over primary manufacturing responsibilities, such as the mouse assembly and establish second sources to augment internal production, such as the manufacturing of chips.

This quality plan requires the establishment of a start-up protection plan and tracking activity for all initial production, whether in-house or at an outside vendor. This start-up protection plan will follow the standard Xerox format.

If the outcome of automating the assembly and the required volumes dictate that we assemble/manufacture outside Xerox, we must do the following:

1. Determine potential vendors, conduct surveys determining capabilities, processes and potential reliability, quality and ability to meet schedules.

2. Select vendor and have sample parts made and then evaluated.

3. Determine test and tester requirements.

4. Establish first article verification, in essence, a vendor start-up protection system.

5. Establish vendor buy-off procedures so that we do not have to have a receiving inspection system at Xerox.

6. Initiate source quality assurance (SQA).

7. Monitor performance so that mutually agreed reliability and quality targets are being met. If targets are not being met, work with vendor to determine and correct problems(s).

8. Requalify vendor periodically - every six to twelve months.

RELIABILITY PLAN

1. Reliability Prediction

   a. Reliability Engineering (ED) shall make a reliability prediction for the Optical Mouse assembly using standard failure rates, from their database, for the various components comprising the assembly.

   b. Reliability prediction shall be modified based on reliability established for (1) the mouse IC, (2) the optical system, and (3) the LED

2. Reliability - Mouse Components

   a. Mouse IC - LSI Component Engineering will be responsible for establishing the failure rate of the mouse IC. This will be accomplished as part of device qualification using accelerated life tests such as high temperature operating life, temperature cycle, humidity bias life, and pressure temperature humidity life.

   b. Optical System - EOS and EED will establish the failure rate of the optical system. This will be accomplished by accelerated testing such as lens aging test, shock and vibration tests, housing feet wearing test, and lens wearing test.

   c. LED - Component Engineering will establish the failure rate of the LED. This will be accomplished by running light intensity degradation tests and various package accelerated life tests.

   d. Other Mouse Components - No testing.

3. Mice Field Tests - Fifty Prototypes

   EED will establish fifty mice test sites and be responsible for tracking use time of each mouse, failures on which mouse at which time, and obtaining failed mice for failure analysis.

4. Mice Field Data - Production

   Reliability Engineering shall be responsible for monitoring the reliability of the Optical Mouse in the field. Emphasis will be on mice for in-house use.

COST REDUCTION OPPORTUNITIES

As volumes increase with firm orders, there are cost reduction opportunities which will be considered. Each UMC cost reduction will be considered separately and undertaken only if there is sufficient payback.

ITEM NAME	PROPOSED CHANGE	ESTIMATED COST SAVING ($/DEVICE)	RESOURCE REQ.	CAPITAL REQ.
Switches	Dome Switch	$1.0	$15K	--
IRLED	Remove 1	$1.0	6K	10K
CABLE	Use Low Cost Ones	$1.5	12K	--
IC Device Package	Use Plastic Package	$1.5	57K	--
Optical System	Use Multi-Cavity Mold & Welding Process to Delete 3 Screws	$1.2	15K	100K
Mouse Cover	Use Snap-In Device to Replace 2 Screws	$1.0	9K	10K
Low Cost PWB	Use Single-Side Low Cost Material PWB	$0.5	21K	--
	TOTAL COST SAVING	$8.7		

MAJOR FUTURE MILEPOSTS

- Orders in-hand for 25,000 mice per quarter - 4Q83
  - Major constraint for further development/tooling activity.
- License of initial external source - 2Q83
- Upgrade of tooling for higher volumes - 1Q84
- Selection of outside manufacturing source - 3Q83
- Selection of chip offloard vendor - 1Q84

POTENTIAL FOLLOW-ON PRODUCTS

- Optical/mechanical hybrid - utilize a ball with optical sensing of position. Potentially a PAD-less device at a small premium.

- Tail-less mouse - small RF transmitter with NiCad battery. Somewhat more complex device requiring CMOS and pulsed light source.

- Serial I/O device - lower cost version simplifying the interconnect cable. Requires chip redesign.

- RS 232 I/O device - Incorporate RS 232 interface in mouse, allowing direct connection to PC RS 232 port.

RISKS

- Xerox may elect to maintain the Optical Mouse as an internal product. It is very doubtful that internal volumes will be sufficient to sustain a viable business.

- A well tooled, well engineering mouse may appear - Japan is a likely source. Our opinion is that such a device may well be mechanical rather than optical.

- Over the next year or two, a new device or a substantial improvement to the mouse may occur. We see nothing in the immediate future but the art develops quickly.

RESOURCE REQUIREMENTS

- Expenditures:

  1982 - $320K (Actuals)

  $100K Engineering Support

  70K Component Qualification

  13K Documentation

  137K Optics (EOS)

  1983 - $65K (Plan)

  $50K Engineering Support

  15K Optics (EOS)

- Staffing Level:

	1983	1984	1985
Manager	5 mm	12 mm	12 mm
Clerk 1	5 mm	12 mm	12 mm
Clerk 2	----	6 mm	12 mm