

Final Report

AVAILABILITY AND COST OF CONSUMER ADVANCED TELEVISION (ATV) TECHNOLOGY



HOME BOX OFFICE, INC.
New York, New York

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BOOZ • ALLEN & HAMILTON INC.

FOREWORD

This study was undertaken by Booz, Allen & Hamilton Inc. for Home Box Office Inc. (HBO), and the report has subsequently been made publicly available by HBO.

This is an exploratory study of prospective technology, costs and prices of advanced television (ATV) receivers. Uncertainties about standards and timing of introduction made it inappropriate to undertake a costing based on a detailed engineering design at this time. The study is not based on detailed consumer electronics manufacturing data for three reasons:

- . The client is a not a manufacturer**
- . Manufacturers generally appear to be still at the early stages of the design process for ATV**
- . Detailed cost data are considered by manufacturers to be competitively sensitive information**

The study is based on general engineering and costing principles, and on interviews with component manufacturers. While the findings of the study are subject to considerable uncertainty, since actual design features and introduction timing may vary considerably from what we have assumed, we believe the study provides a sound general indication of the broad levels of prices and costs that should be expected.

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I. INTRODUCTION

HBO HAS ASKED BOOZ, ALLEN TO ANALYZE THE PROSPECTIVE TECHNOLOGY, COSTS AND PRICES OF HOME RECEIVERS FOR THE INTRODUCTION OF ADVANCED TELEVISION* (ATV) SERVICES...

- . To complement the extensive work on ATV that has already been carried out in-house by HBO**
- . To gain a better understanding of likely ATV receiver technology and the implications for rollout timescales, costs and market prices for receivers**
- . To compare proposed and currently used approaches to compression technology in video transmission as well as the implications for receiver cost/complexity**

*** We have adopted the FCC terminology of "Advanced Television (ATV)" instead of the term "High Definition Television (HDTV)," which is less general.**

THE CHIEF FOCUS OF THE STUDY IS THE PROJECTION OF LIKELY ATV RECEIVER PRICES FROM A SCENARIO-DRIVEN COMPUTER MODEL BASED ON...

- . Application of the experience curve to receiver block elements**
- . Technology affecting key receiver components**
- . Estimates of technological requirements of different approaches to ATV**
- . Consumer adoption scenarios in terms of introduction and penetration rate**
- . Estimates of the amortization of R&D**
- . Estimates of value added in manufacturing and the distribution chain to derive retail price from component costs**

II. DESCRIPTION OF THE RECEIVER COST MODEL

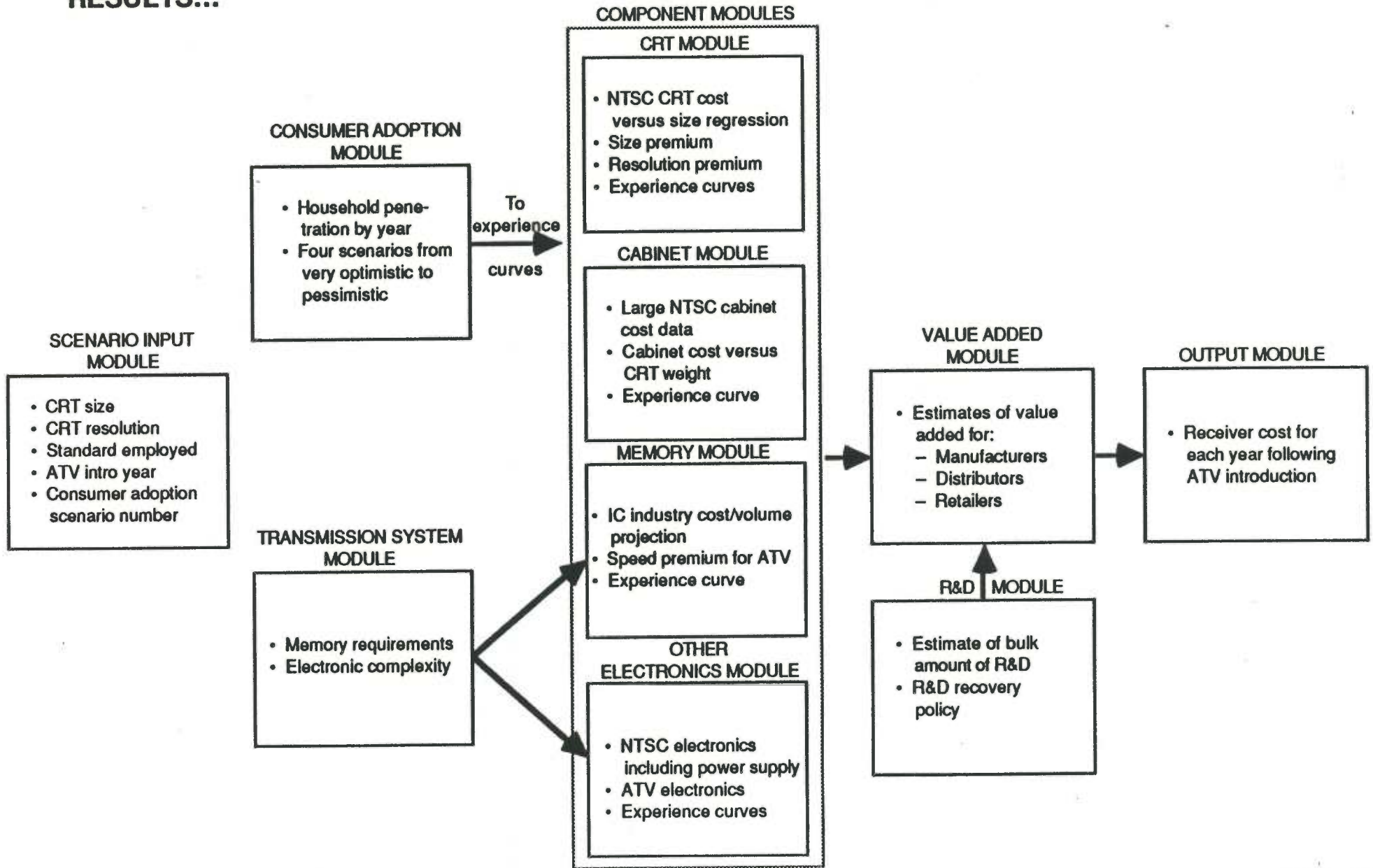
Overview...

THE ATV RECEIVER COST MODEL PROJECTS RETAIL PRICES BY BUILDING A CRT-BASED UNIT FROM THE GROUND UP...

	<u>Year 1</u>	<u>Year 2</u>	<u>Year 3</u>
Components costs			
CRT display			
Memory			
Other electronics			
Cabinet			
	_____	_____	_____
Subtotal			
R&D Costs			
Manufacturer value added			
Distributor value added			
Retail value added			
	_____	_____	_____
Retail List Price			

Overview...

THE MODEL IS STRUCTURED ACCORDING TO MODULES THAT ACCEPT SCENARIO PARAMETERS, PROJECT COSTS OF MAIN COMPONENTS, R&D, AND VALUE-ADDED AND GENERATES OUTPUT RESULTS...

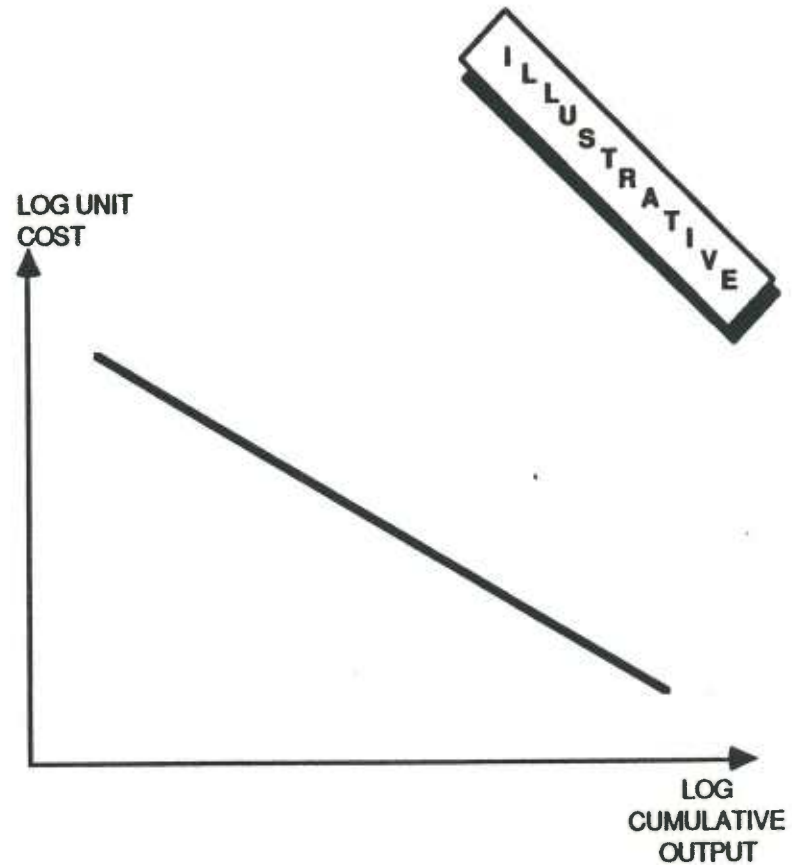
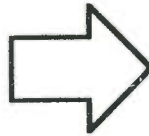


Overview...

CENTRAL TO THE METHODOLOGY IS THE EXPERIENCE CURVE, THE GENERAL EMPIRICAL OBSERVATION THAT FOR EACH DOUBLING OF CUMULATIVE OUTPUT, UNIT COSTS FALL BY A CONSTANT PERCENTAGE...

For an experience curve of 0.8*, every doubling of cumulative output causes unit cost to fall by 20%

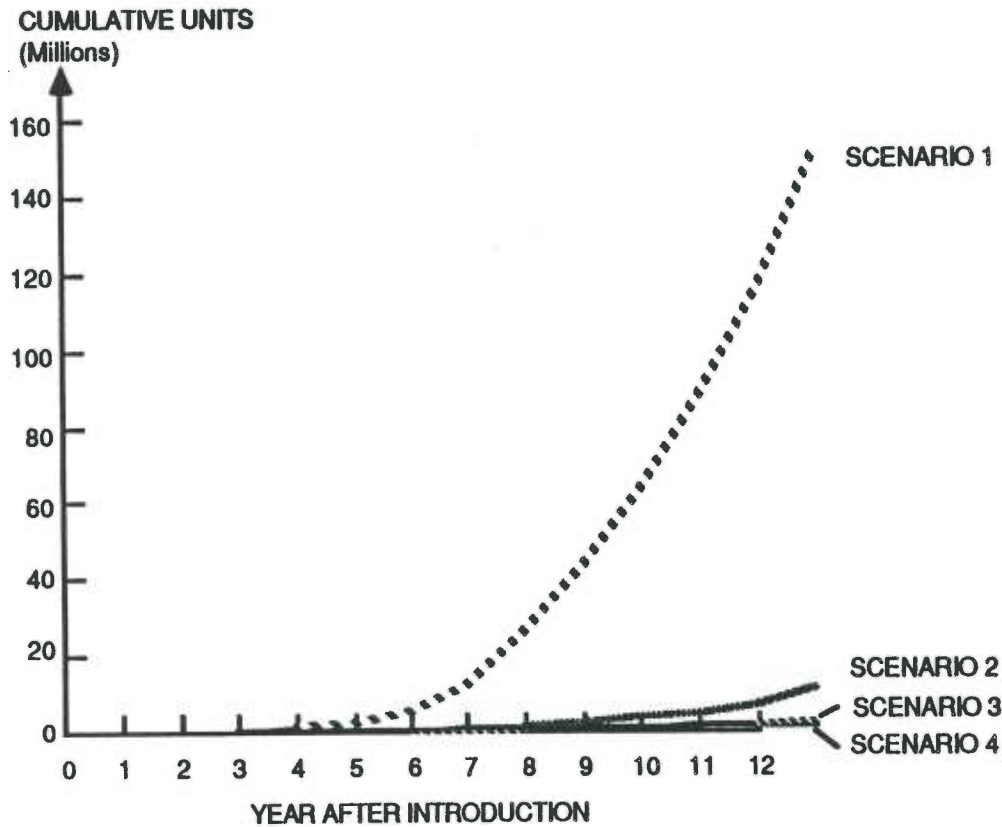
<u>CUMULATIVE OUTPUT</u>	<u>UNIT COST</u>
1	100
2	80
4	64
8	51
16	41



* Extensive research has shown that 0.8 is a typical value for general manufacturing. For instance, the experience slope for VCR manufacturing is 0.78.

Consumer Adoption...

THE CONSUMER ADOPTION MODULE PROVIDES FOUR SCENARIOS PROJECTING HOUSEHOLD PENETRATION AND CUMULATIVE UNITS OF ATV RECEIVERS SINCE INTRODUCTION AND SERVES AS AN INPUT TO THE EXPERIENCE CURVES...



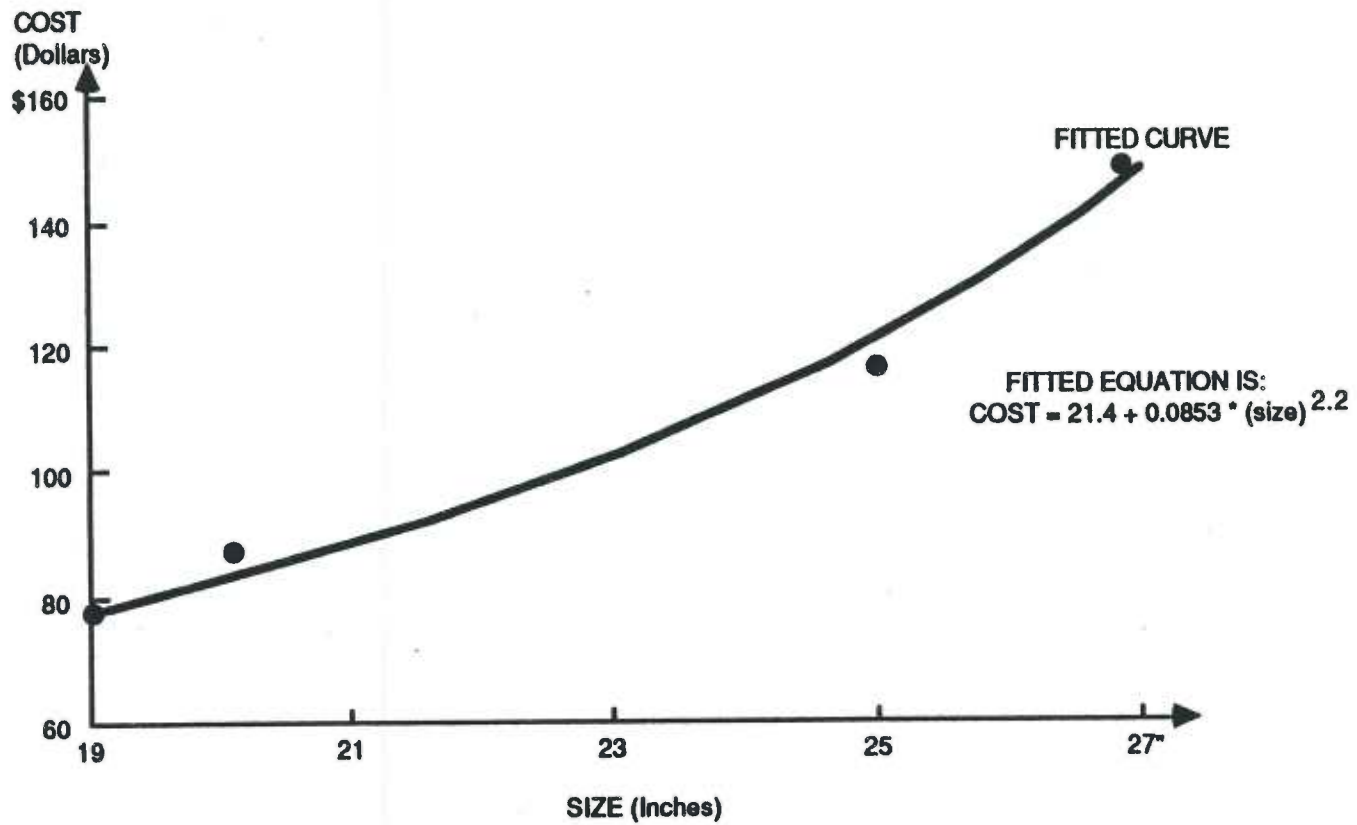
LEGEND	
<i>Scenario 1</i>	<i>Very Optimistic (CD)</i>
<i>Scenario 2</i>	<i>Optimistic (Color TV)</i>
<i>Scenario 3</i>	<i>Cautious Adoption</i>
<i>Scenario 4</i>	<i>Pessimistic</i>

CRT Module...

ATV CRT COSTS ARE MODELLED AS THE COST OF AN NTSC CRT PLUS PREMIA FOR LARGE SIZE AND HIGH RESOLUTION...

- . **Interviews of CRT manufacturers regarding cost of NTSC CRTs and subsequent regression analysis of size versus cost indicated:**
 - **CRT costs vary linearly with (size)^{2.2}**
 - **There is a premium for both large size and high resolution**
- . **The size premium is estimated by noting the difference in actual cost between large CRTs and the value predicted by the regression equation**
- . **The resolution premium reflects the additional cost of adding higher resolution to current CRTs**
 - **For medium resolution (about 500 to 600 lines) the initial premium is 80% of the baseline NTSC cost**
 - **For high resolution (about 1,000 lines) the initial premium is 250% of the baseline NTSC cost**

CURRENT NTSC CRT COSTS

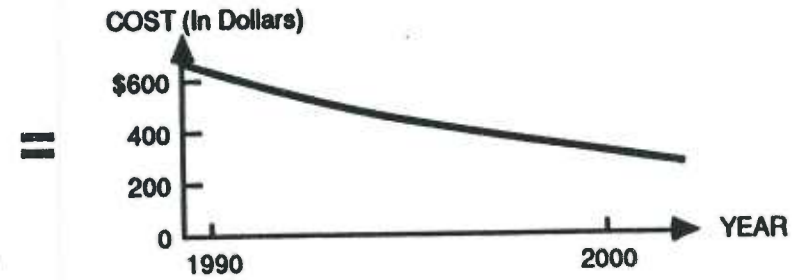
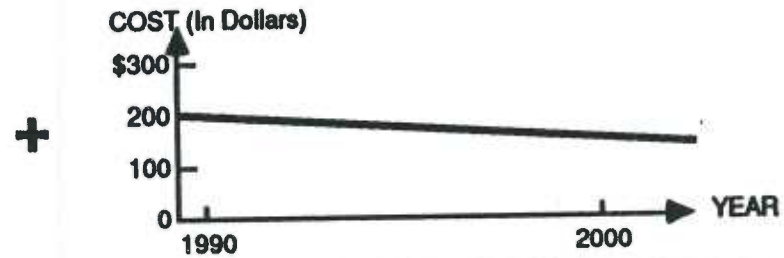
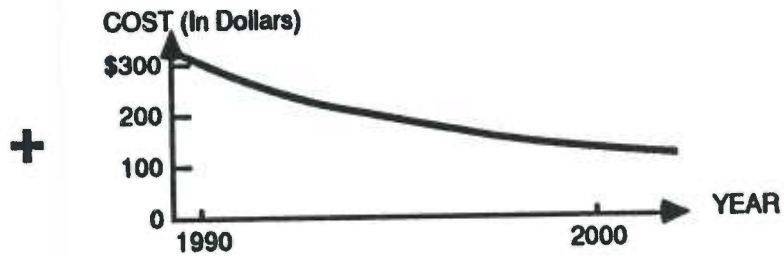
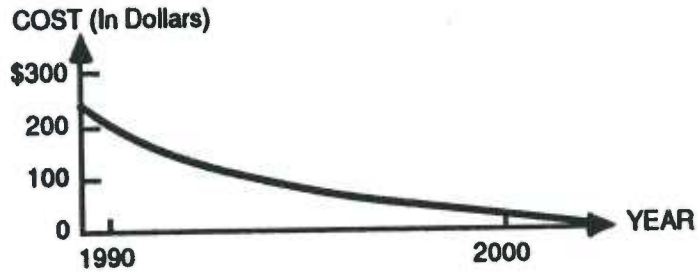
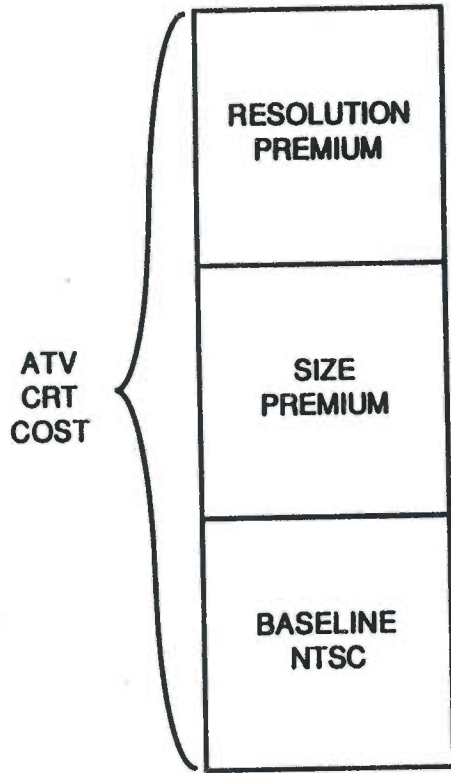


CRT Module...

EACH OF THE COMPONENTS OF CRT COSTS FOLLOWS A SEPARATE EXPERIENCE CURVE IN ORDER TO ARRIVE AT THE TOTAL CRT COST FOR EACH YEAR OF THE SCENARIO...

<u>CRT Cost Components</u>	<u>Applicable Experience</u>	<u>Data Source</u>	<u>Experience Slope</u>
. Baseline NTSC	NTSC CRTs	Historical NTSC production	0.8
. Size premium	Experience with large NTSC CRTs (>30 in) and ATV	Philips data on market for large CRTs and adoption scenario	0.8
. Resolution premium	ATV	Adoption scenario	0.8

ATV CRT COSTS ARE MODELLED AS THREE SEPARATE COMPONENTS...



TOTAL ATV CRT COST

Cabinet Module...

CABINET COSTS ARE BASED ON DISCUSSIONS WITH ZENITH AND OTHER INDUSTRY SOURCES...

- . The main factor driving the cost of the cabinet is the size and the weight of the CRT**
- . For large CRT sizes, a good approximation is that the cost of the cabinet grows linearly with CRT weight**
- . Paper published by Matsushita engineers shows that CRT weight grows exponentially with size**
- . Experience curve used is that of NTSC**

Memory Module...

MEMORY COSTS ARE BASED ON EXPERIENCE CURVE PARAMETERS AND VOLUME PROJECTIONS FROM AUTHORITATIVE SEMICONDUCTOR INDUSTRY SOURCES...

- . **The Integrated Circuit Engineering Corporation publishes an annual IC industry status report showing historical costs and volumes for memory on a per bit basis**
 - **Memory costs very closely conform to a 68% experience curve**
 - **Present memory costs are .77 millicents per bit (\$62 per megabyte)**
- . **Status report also publishes future volume projections so that experience curve can be used to derive implied future costs**
- . **Memory costs used in the receiver model employ a speed premium**
 - **Interviews with TV industry sources indicate that ATV receivers will require faster than average memory**
 - **A two year cost premium was established - e.g., ATV memory costs for 1991 correspond to baseline costs in 1989**

Other Electronics Module...

ATV ELECTRONICS COSTS ARE MODELLED AS THE COST OF BASIC NTSC COMPONENTS, PREMIA FOR HIGHER POWER AND BANDWIDTH REQUIREMENTS, AND COMPLETELY NEW ATV SIGNAL PROCESSING HARDWARE...

- . Approach based on interviews with Motorola and National Semiconductor**
- . Current price of NTSC electronics is about \$40**
- . High-power CRT deflection circuits and wide-bandwidth video amplifiers will add approximately \$40 more**
- . Signal processing chips required for ATV will cost about \$25 "at volume"; we have interpreted "at volume" as a cumulative production of 2 million**
- . Experience curve for NTSC is used for NTSC and basic enhancements; ATV semiconductor experience curve is used for new signal processing ICs**

R&D Module...

R&D COSTS ARE DISTRIBUTED ACROSS RECEIVERS PRODUCED DURING THE TEN YEARS FOLLOWING INTRODUCTION...

- . Bulk amount of R&D of \$300 million is based on budgets for HDTV development of several organizations
 - NHK
 - David Sarnoff Research Center
 - Sony
 - Eureka project participants

- . This bulk amount is recovered across 10 years
 - 80% is recovered equally across each set produced during these 10 years
 - 20% is recovered equally across each year of this period

- .
$$\begin{aligned} & 80\% * \text{Bulk Amount} / (\text{cumulative production in first 10 years}) \\ & + 20\% * (\text{Bulk Amount} / 10) / (\text{annual production in year } x) \\ & \hline & = \text{Total R\&D cost per set in year } x \end{aligned}$$

Value Added Module...

THE VALUE ADDED MODULE APPLIES ESTIMATES OF VALUE ADDED BY MANUFACTURER, DISTRIBUTOR AND RETAILER IN BUILDING UP THE RETAIL PRICE FROM THE COST OF COMPONENTS AND R&D...

- . **Manufacturer value added of 100% of components costs is based on interviews with industry sources and analysis of NTSC prices**
- . **Distribution and retail value added of 15% and 40% respectively are based on a recent EIA report on consumer electronics prepared by Arthur D. Little**
 - **These margins correspond to "suggested retail price"**
 - **We understand that in mature stage there could be heavy discounting but probably not in early stages of product life**
- . **(Components cost * (1 + 100%) + R&D costs) * (1 + 15%) * (1 + 40%) =
Retail Price**

III. ATV RECEIVER COSTS

**AS A MEANS OF STRUCTURING THE MODELLING PROCESS WE HAVE ADOPTED A
BASELINE SCENARIO...**

- . ATV introduction in 1991**
- . Consumer adoption based on optimistic (color-TV) scenario**
- . CRT size of 35 inches, medium resolution**
- . ATV transmission system: ACTV***
- . All dollar figures are current (1988) dollars**

*** Cost impact of other transmission systems is also addressed in this section.**

FOR THIS BASELINE SCENARIO, INTRODUCTION PRICE IS APPROXIMATELY \$4,300 FALLING TO \$2,300 AFTER FIVE YEARS, WITH CRT COST BEING THE DRIVING COMPONENT COST...

	1991 \$ COST	1992 \$ COST	1993 \$ COST	1994 \$ COST	1995 \$ COST	1996 \$ COST
MANUFACTURING COSTS						
Component Costs:						
• CRT Display	670	592	540	497	462	432
• Memory	75	57	42	31	23	17
• Other Electronics	354	254	204	170	147	130
• Cabinet	121	118	114	111	108	105
SUBTOTAL	1,221	1,021	900	809	739	684
R&D COSTS	255	205	122	98	79	71
OTHER MANUFACTURING COSTS AND MARGIN	1,221	1,021	900	809	739	684
TOTAL FACTORY PRICE	2,697	2,248	1,922	1,717	1,558	1,438
DISTRIBUTION CHAIN MARKUP						
Distribution Markup	405	337	288	258	234	216
Retail Markup	1,240	1,034	884	790	717	661
RETAIL LIST PRICE	4,342	3,620	3,095	2,764	2,509	2,315