

# DOES PRICE BUY PERFORMANCE OR SATISFACTION IN AN HF TRANSCEIVER?

FRANK M. HOWELL, PHD K4FMH

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# BUYING AN HF TRANSCEIVER

- Beatles made “Money can’t buy me love” famous as did the Rolling Stones with “Can’t get no satisfaction.” And, there’s the ever-popular mantra, “You get what you pay for!”
- *“You’ve finally got some cash to spend on Amateur Radio equipment, but you want to make the right choice. Ask any veteran ham and he or she will tell you about the #%&\$@ radio they’ve purchased. No one wants to throw away money, but how do you know which rig is best?”* (Steve Ford, Lab Notes: Which Rig Should I Buy? ARRL Website)
- But does this logic work in amateur radio in purchasing an HF transceiver?
- The ARRL or RSGB don’t recommend specific transceivers. But both publish bench tests of selected rigs. Rob Sherwood NCOB has published a table of his suite of bench tests for receiving. The popular website, eHam.net, has crowd-sourced, volunteered satisfaction ratings and narratives of amateur radio products.

# DOES PRICE BUY PERFORMANCE OR SATISFACTION?

- So hams are left with multiple, somewhat complicated options:
  - Ask fellow hams what they have and like and what to stay away from.
  - Go through the latest bench ratings by the ARRL, RSGB or Sherwood and try to see what's "best" on the bench.
  - Read eHam's Product Reviews and see who likes what and why?
  - Or, just buy one of the "expensive" rigs and trust that money talks!
  - But how **much** does price matter?
- This can be somewhat like a dog-tail chasing exercise although it's not those sources *per se* that are challenging. *It's putting them together in a coherent way.*

# BUT DOES THROWING MONEY AT A RIG WORK?

- I've compiled a unique dataset from three known sources to have price, receive performance, and consistent consumer satisfaction ratings for each rig in Rob Sherwood's Table. The data come from QST and other sources for prices, Sherwood's Tables, and the eHam.net Product Review section on satisfaction with HF rigs.
- The Sherwood Tables are generally the Holy Grail in rig evaluations from a workbench assessment. He's independent (no adverts), is highly trusted, and speaks his mind as an RF engineer.
- This dataset is used to investigate the relationships among price, performance and satisfaction for individual rigs. This is the first time anyone has reported such a study to my knowledge.

# DATA SOURCES & MEASUREMENT

- All are well known. For the sake of simplicity, all receivers or transceivers listed in the Sherwood Tables are referred to as “rigs”. The year of manufacturer release of these rigs cover a 50-year period. Few major or highly popular rigs are not listed.
- A few rigs in Sherwood’s Table were not reviewed on eHam.net. These were omitted from the analysis. A couple of rigs had “second” measurements due to a key upgrade or some other modification. The first review (stock rig) was used to keep measurements consistent. A final count of 126 rigs were used.



# PRICE

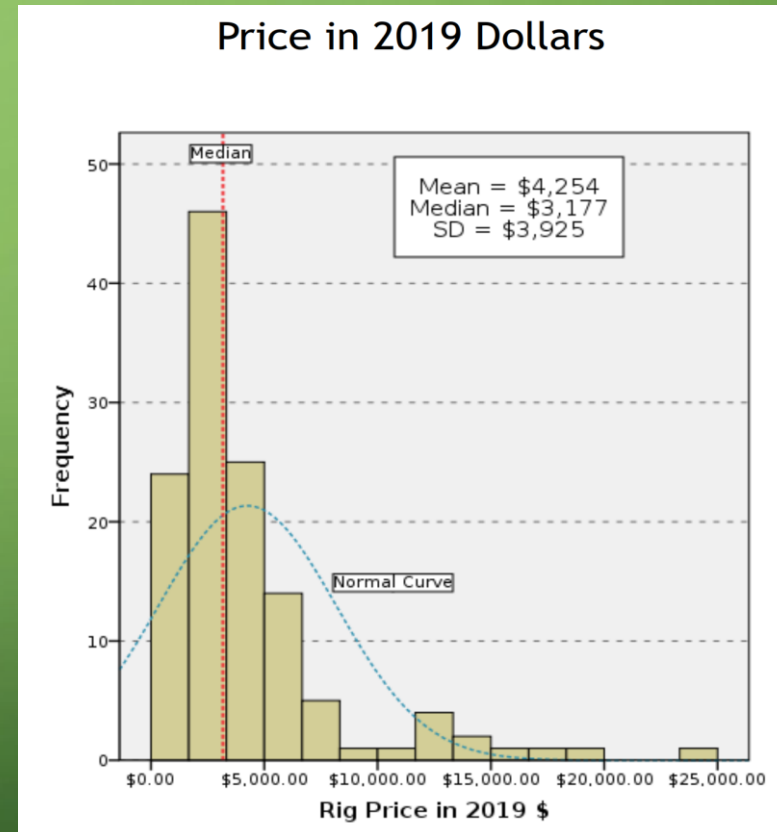
- **Price** reflects what the manufacturer states is the *suggested retail price* or the *observed retail price* circa the year of release to the marketplace. This does not track discounted retail prices, ham fest sales, or used prices. It reflects the “product value” placed on it by the manufacturer as a “signal” to the marketplace on the product. It is a consistent rig-to-rig metric for differentiating price at market-entry.
- Most price data were taken from the rig’s review in the ARRL’s QST magazine. However, some vintage rig prices had to be obtained either from manufacturer’s catalogs for the year of release, other magazine ads (CQ, Ham Radio Magazine, Monitoring Times, etc.) or rig-tracking websites. Because the dollar values over a 50 year period change substantially, I transformed the rig price data into 2019 dollar values using the BLS CPI.

# DISTRIBUTION OF PRICE IN 2019 \$

The distribution of rig prices inflated to 2019 dollar values results in an average rig price of \$4,254. There are a number of “premium” rigs ranging up to over \$20,000 which skews it to the higher end. The standard deviation of \$3,925 illustrates this spread.

A **blue dashed curve** represents what a normal curve (distribution) of prices would look like.

The median price is just over \$3,000 at \$3,177. The modal category around \$3,000 helps identify the \$3,000 mark as the central price point over the 50 year period, with inflation held constant.



# (RECEIVE) PERFORMANCE

- **Performance** reflects receiver performance as Rob NCOB measures it in his Sherwood Tables. See his website (<http://www.sherweng.com/table.html>) and my interviews with both Rob Sherwood and Bob Allison of the ARRL Test Lab in Episodes 305 and 312, respectively, on the ICQ Podcast for many details. I encourage careful study of his documentation on his website!
- Sherwood uses several bench measurements of receive performance. He ranks his table in order of best score on a **SINGLE** measurement: *narrow spaced dynamic range* in dB. His rationale is that, after years of testing, this is the *best single criterion* for the CW contest operator, which he is. I have no doubt about NCOB's rationale. But not every ham is a CW operator or contest participant so another aspect of the receiver's performance might be **more relevant.**

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## Receiver Test Data

(Terms Explained: [DOC PDF](#))

*Sorted by Third-Order Dynamic Range Narrow Spaced - or- ARRL RMDR (Reciprocal Mixing Dynamic Range) if Phase Noise Limited*

*Note: The term blocking only applies to a superhet radio. For a direct sampling radio the value in the blocking column is the ADC overload point reference receiver noise floor.*

*Updated 1 November 2019. Added Kenwood TS-2000X 2m data. 70cm and 23cm available in long form report.*

Device Under Test	Noise Floor (dBm)	AGC Thrshld (uV)	dB	100kHz Blocking (dB)	Sensitivity (uV)	LO Noise (dBc/Hz)	Spacing kHz	Front End Selectivity	Filter Ultimate (dB)	Dynamic Range Wide Spaced (dB)	kHz	Dynamic Range Narrow Spaced (dB)	kHz
<i>LO Noise Corrected 05/10/19</i> Yaesu FTdx-101D	-127 -136 <sup>b</sup> -141 <sup>6</sup>	4.5 1.6 <sup>b</sup> 0.58 <sup>b1</sup>	3	>147	0.60 0.20 <sup>b</sup> 0.12 <sup>b1</sup>	154 155	10 50	A Trk Presel	>115	110	20	110	2
<i>Added 9/29/14</i> FlexRadio Systems 6700 Hardware Updated	-118 -135 <sup>b2</sup>	3.0 1.0 <sup>b2</sup>	Var	130 preamp Off	2.0 0.25 <sup>b2</sup>	145 155	10 50	B Band Pass	115	99	20&2	108 <sup>y</sup>	20&2

This screenshot is from his website for Receiver Test Data. If I used each performance measurement, they would likely give varying results which would amount to a judgment by the reader on which measurement should s/he use? Yet, it's challenging to make that judgment, especially when it's not necessary. So I used a statistical procedure to combine ALL of Sherwood's measurements into a **single index of receive performance**.

# PRINCIPAL COMPONENTS ANALYSIS

PCA is often used to create a linear composite from several measurements. The **Scree Plot** has a **red line** superimposed over the number of linear components extracted from the 9 Sherwood Table measurements. This is an eyeball test and is subjective but those above the line are most important.

The 1<sup>st</sup> component appears to be very distinguishable from the remainder so that one component score was retained. It contains about 40% of all rig differences on these 9 bench measurements.

The favorite measurement by NCOB, “close in” dynamic range, the filter’s ultimate dB, and the local oscillator’s noise spacing were the most dominant measurements whereas noise floor was the least (see “**Loadings**”).

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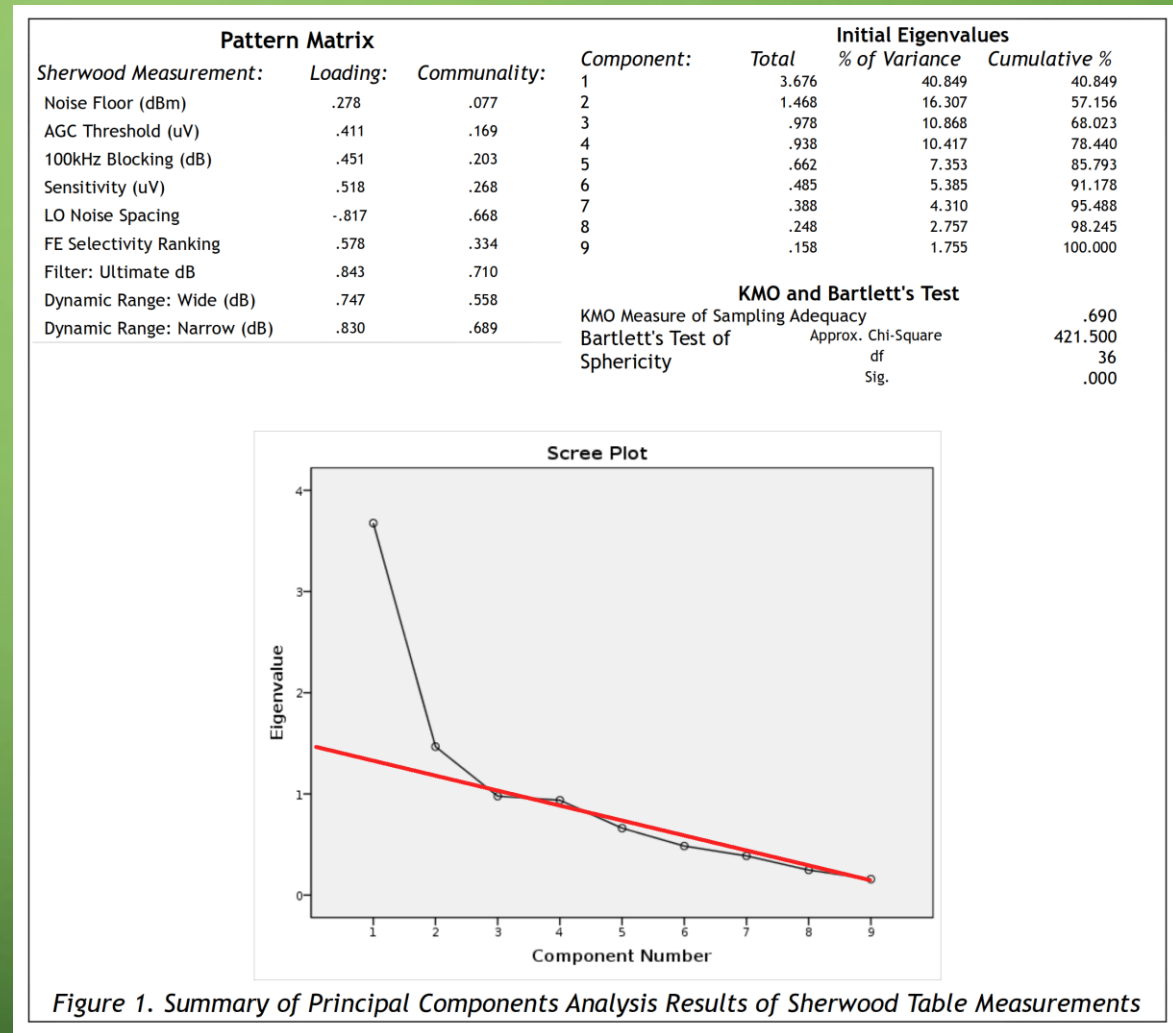


Figure 1. Summary of Principal Components Analysis Results of Sherwood Table Measurements

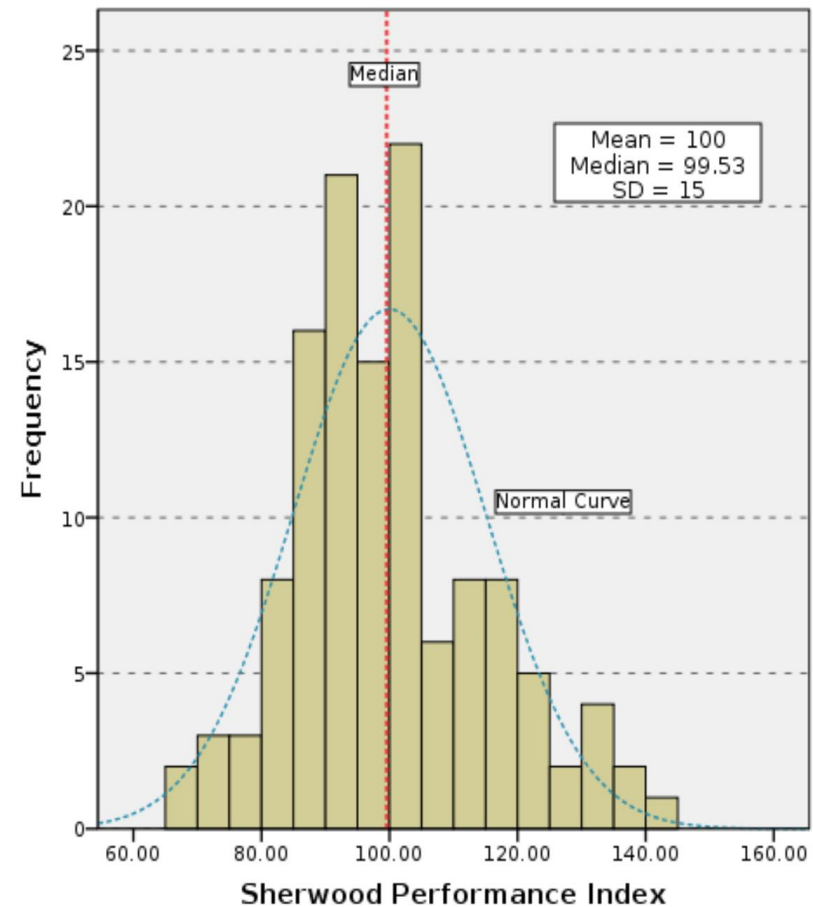
# SHERWOOD PERFORMANCE INDEX

I took the PCA's 1<sup>st</sup> component score which has a z-score metric (mean of 0, SD of 1.0) and used a common T-Score transformation so that the resulting **Sherwood Performance Index (SPI)** has a mean of 100 and a standard deviation of 15, much like IQ tests.

The distribution of the SPI is nearly normal in comparison to the dashed **blue line** shown at right. Rigs scored as low as in the 60s and as high as over 140 on this composite of all Sherwood Tests.

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## Sherwood Performance Index



# SATISFACTION

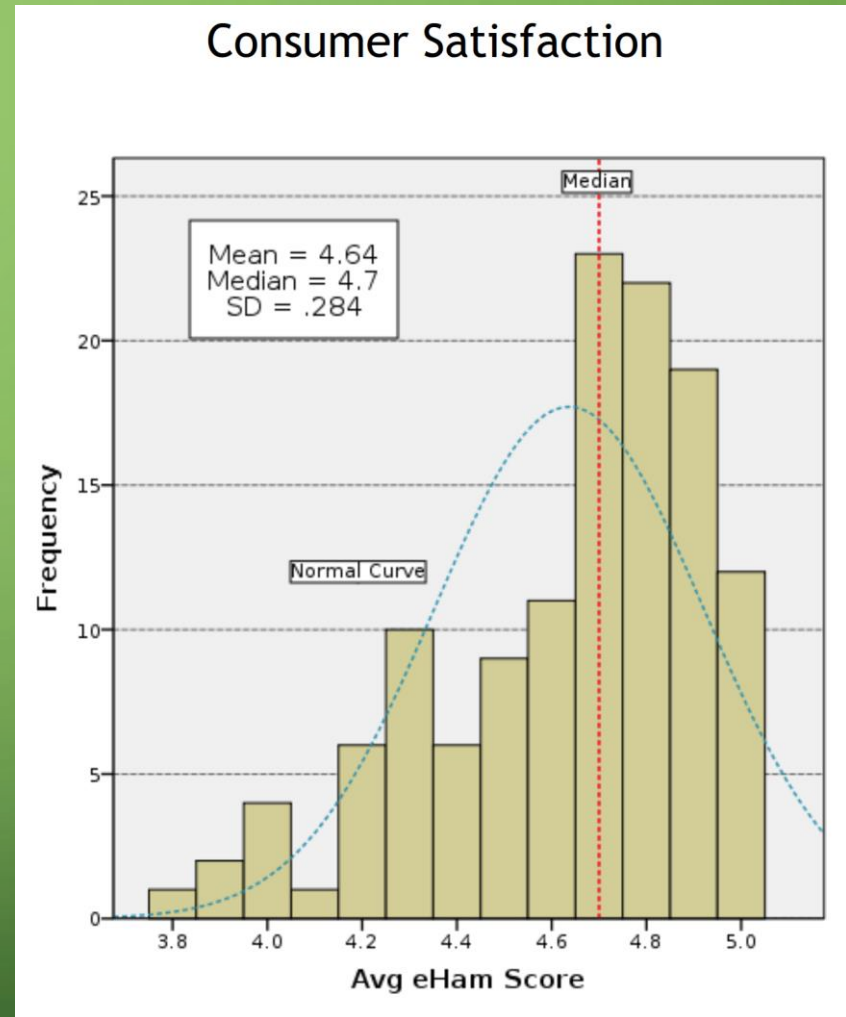
- **Satisfaction** with each rig is taken from the Product Reviews section of the eHam.net website. They are rated 1 (lowest) to 5 (highest) as a cumulative average which reflected the ratings volunteered by hams as of November 2019. Satisfaction reflects the “complete experience” with the rig, the manufacturer and, at times, the reseller.
- Note that it is the **cumulative average** over the life of the rig’s existence in the market place and is not measured only just after release.



# CONSUMER SATISFACTION

eHam satisfaction ratings for these rigs average about 4.7, reflecting the median score. There are some rigs rated below 4.0 on average. The standard deviation of 0.284 suggests that there is a smaller spread in rig satisfaction than, say, performance or price.

While this may reflect a “halo effect” among consumers of a product line, we do not observe the variation of *individual* reviews of a specific rig. Work is underway to scrape the entire corpus of individual reviews and narratives for all amateur products and services.





# TOP AND BOTTOM 10 RIGS IN PRICE

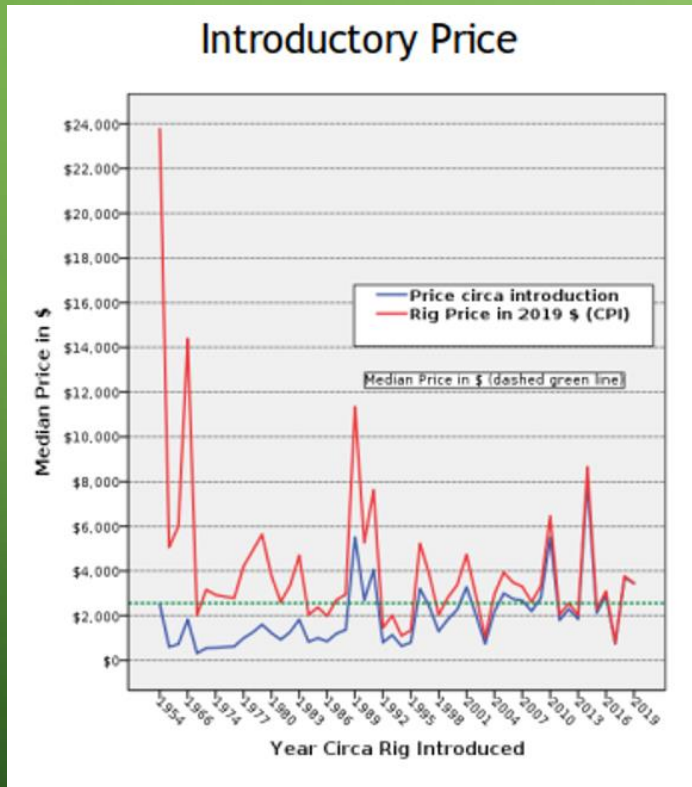
Retail Price on Market Entry					
Year of Review	Release Price \$	Top 10 Rigs	Year of Review	Price in 2019 \$	Top 10 Rigs
2014	\$17,500.00	Hilberling PT-8000A	1954	\$23,763.94	Collins R-390A
2008	\$13,500.00	Icom R9500	2014	\$18,904.73	Hilberling PT-8000A
2016	\$13,499.95	Icom IC-7851	1979	\$17,610.19	Racal 6790 GM
2007	\$10,600.00	Icom IC-7800	2008	\$16,033.21	Icom R9500
2014	\$7,999.00	Kenwood TS-990S	2016	\$14,383.07	Icom IC-7851
2008	\$7,000.00	Icom IC-7700	1966	\$14,382.14	Collins 51S1
2015	\$6,999.00	Flex Radio Systems 6700	2007	\$13,074.87	Icom IC-7800
1991	\$6,850.00	JRC NRD-93	1991	\$12,860.10	JRC NRD-93
2007	\$6,000.00	Icom IC-781	1982	\$11,923.83	Collins KWM-380
2010	\$5,500.00	Yaesu Ftdx-5000D	1990	\$11,738.33	Icom IC-781
		<i>Bottom 10 Rigs</i>			<i>Bottom 10 Rigs</i>
1981	\$550.00	Yaesu FRG-7700	2003	\$1,091.94	Ten-Tec Argonaut VI
2000	\$549.00	Elecraft K2	1994	\$1,042.26	Icom IC-703+
1974	\$500.00	Drake R-4C Stock	1994	\$1,028.23	Drake SW8
1980	\$500.00	Kenwood R-1000	1984	\$984.29	Kenwood R-600
1973	\$499.95	Drake R-4C/CF-600/6	2000	\$815.21	Elecraft K2
1999	\$499.00	Lowe HF-150	2017	\$782.44	Elecraft KX2
2002	\$495.00	Palstar R-30	1999	\$765.87	Lowe HF-150
1976	\$490.00	Heath SB-104	2011	\$737.88	Flex Radio Systems FLEX-1500
1984	\$399.95	Kenwood R-600	2017	\$729.23	Yaesu FT-891
1971	\$320.00	Heath SB-303	2002	\$703.57	Palstar R-30

# TOP AND BOTTOM 10 RIGS IN PERFORMANCE AND SATISFACTION

Consumer Satisfaction			Performance		
Year of Review	Avg eHam Score	Top 10 Rigs	Year of Review	Performance Index	Top 10 Rigs
1973	5.00	Drake R-4C/CF-600/6	2019	143.83	FlexRadio 6600M
1996	5.00	AOR 5000	2019	137.57	Yaesu Ftdx-101D
1979	5.00	Kenwood R-820S	2019	137.52	FlexRadio 6400
2019	5.00	Apache ANAN-200D	2016	133.73	Icom IC-7851
2019	5.00	Yaesu Ftdx-101D	2019	131.76	Kenwood TS-890S
2018	5.00	Apache ANAN-7000DLE	2012	131.46	Elecraft KX3
1962	5.00	Collins 75-S3 Wing	2015	130.52	Flex Radio Systems 6700
2001	5.00	Ten-Tec 340	2014	127.42	Hilberling PT-8000A
1991	5.00	JRC NRD-93	2016	126.04	Elecraft K3S
2016	5.00	Icom IC-7851	2017	124.49	Elecraft KX2
		<i>Bottom 10 Rigs</i>			<i>Bottom 10 Rigs</i>
1971	4.20	Heath SB-303	1999	80.57	Lowe HF-150
1984	4.20	Yaesu FT-757	1984	80.25	Kenwood TS-430S
1981	4.10	Yaesu FRG-7700	1974	79.22	Kenwood TS-520
2015	4.00	Yaesu FT-991	1971	76.98	Heath SB-303
1982	4.00	Icom IC-720A	1980	75.38	Kenwood R-1000
1979	4.00	Icom IC-701	1981	74.97	Yaesu FRG-7700
2014	4.00	Hilberling PT-8000A	1976	74.93	Yaesu FT-101E
1985	3.90	Yaesu FRG-8800	1984	71.15	Kenwood R-600
1977	3.90	Atlas 350-XL	1984	68.09	Kenwood R-2000
1993	3.80	Icom IC-R72	1996	67.39	AOR 5000

Figure 3. Top Ten and Bottom Ten Rigs on Price, Sherwood Table Index Performance and eHam Satisfaction Score

# TRENDS IN PRICE...



The line chart at left shows how the original nominal median price and adjusted for inflation to 2019 dollars over the 50 year horizon.

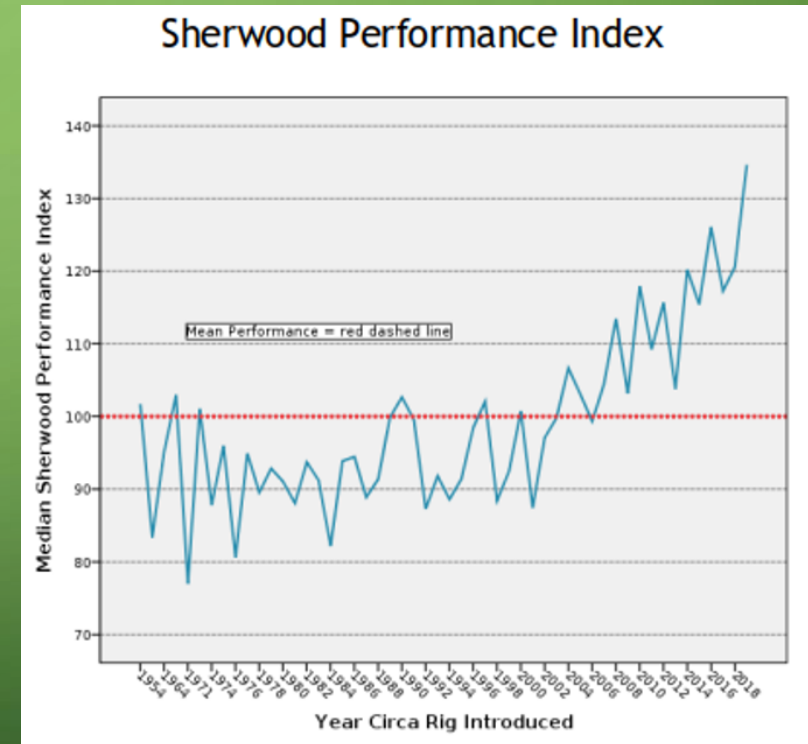
The earliest spike to over \$20,000 was for specific Collins rigs: expensive then in nominal price and **very** expensive in today's dollar!

There are really two periods where adjusted “real” prices have spiked: around 1990 and again around 2010. The price of parts and rig production in Japan and in the US post-1980s recession period of the late 1980s and the introduction of “premium” HF rigs introduced around 2010 are noteworthy.

# TRENDS IN PERFORMANCE...

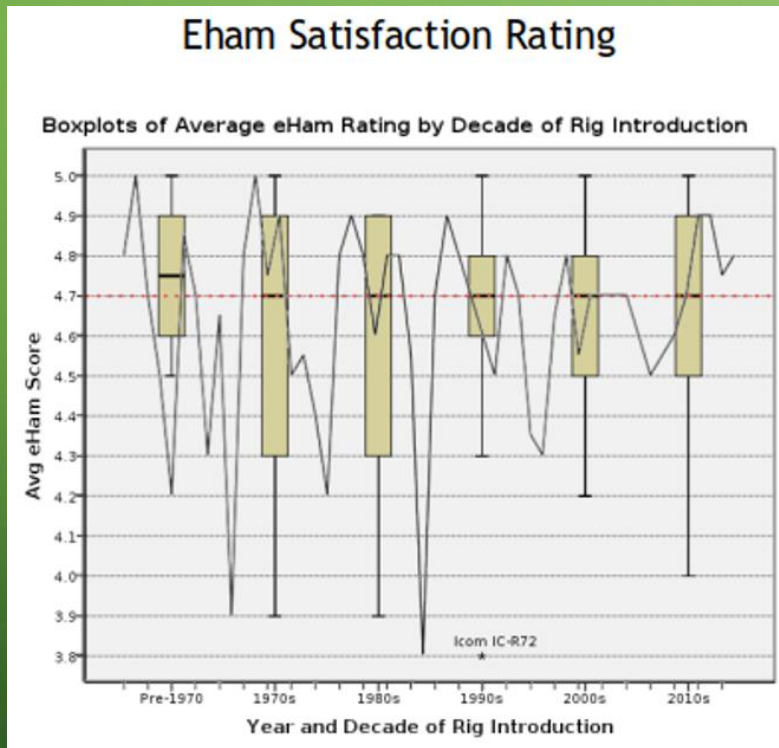
There is a very significant trend in HF rig performance illustrated in the line chart for the Sherwood Performance Index on the right. The **median** performance score for the entire period is 100. For the decades of the 1950s through the 1990s, measured rig receive performance was mostly averaging around 90.

With the dawn of 2000, rig performance began a consistent upward trend. During the 2010s, measured receive performance reached levels that have never been measured previously, over 120 and a high of over 130. This is two standard deviations above the series average!





# TRENDS IN SATISFACTION...



Satisfaction trends are more dynamic than price or performance. To fully examine this pattern of change, I've combined a line chart with a box-and-whisker diagram on the left. The B&W plot has the **median score** on the line of the box with the upper and lower "hinge" reflecting the tails of the distribution. Two observations about rig satisfaction are clear.

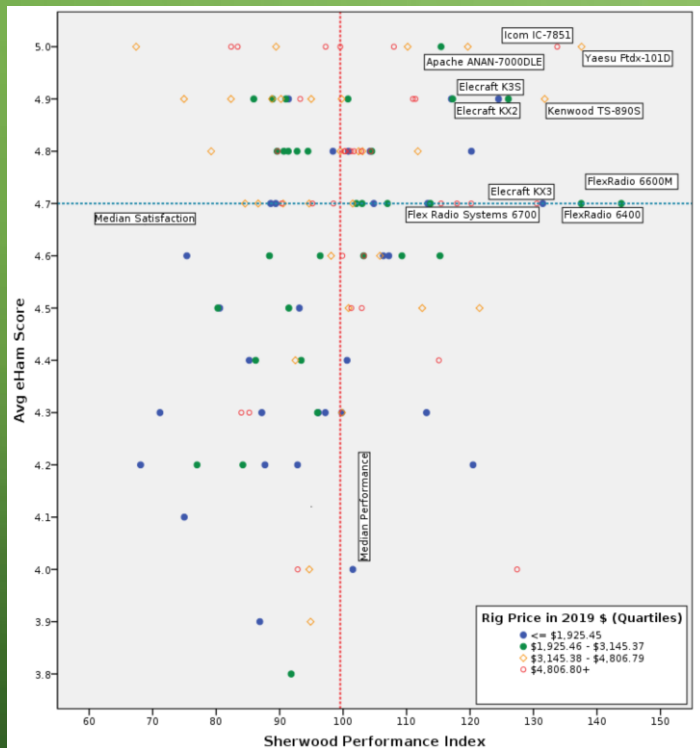
One is that the **median** satisfaction rating has been **constant** for rigs released to the market over the 50 year horizon. However, some poorly rated rigs (note the Icom R72) occurred in the pre-1970s era and in the 1980s. Analysis not shown verifies that these *are not* due to a small number of review on eHam.



# FINDING NEMO...ER, THE OPTIMAL HF RIG

- These results are about what the typical ham in the market has to work with. Aggregate information that is not easily linked to specific rigs so as to optimize on price, performance and what others say their satisfaction is on them. This is a major impediment to finding the “right” HF rig for a given ham operator.
- I use a form of **Quadrant Analysis** which is a frequent business analytics tool. Comparing performance and satisfaction at various price points helps reduce the number of rigs to a much smaller number for further consideration.
- The following analysis examines these three aspects of HF rigs as well as the “bang for the buck” **and** the relative optimization of major manufacturers over the 50 year period.

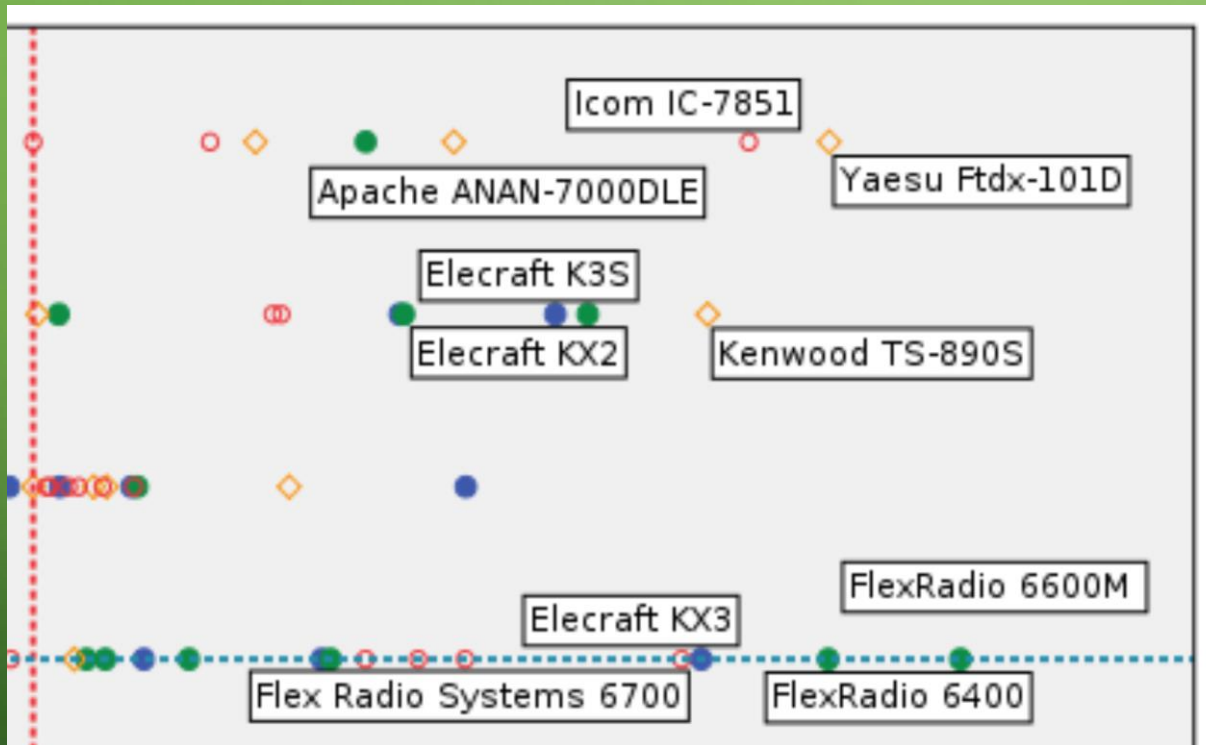
# SCATTERPLOT IN QUADRANTS: PERFORMANCE BY SATISFACTION AT PRICE POINTS



The scatterplot at left uses the data for each rig to plot four quadrants. On the vertical axis there is the below and above **median** Satisfaction score and on the horizontal axis there is the same **median** split for the Sherwood Performance Index. The four quartiles are of the Price in 2019 \$. These Price quartiles are shown with different symbols and colors.

The four quadrants represent low-satisfaction, low-performance; high-satisfaction, low-performance; low-satisfaction, high-performance; and the **optimal quad** of *high-satisfaction, high-performance*. Let's focus on that in the next slide.

# FOCUS ON OPTIMAL QUADRANT



The rigs annotated at left are in the optimal Performance-Satisfaction quadrant.

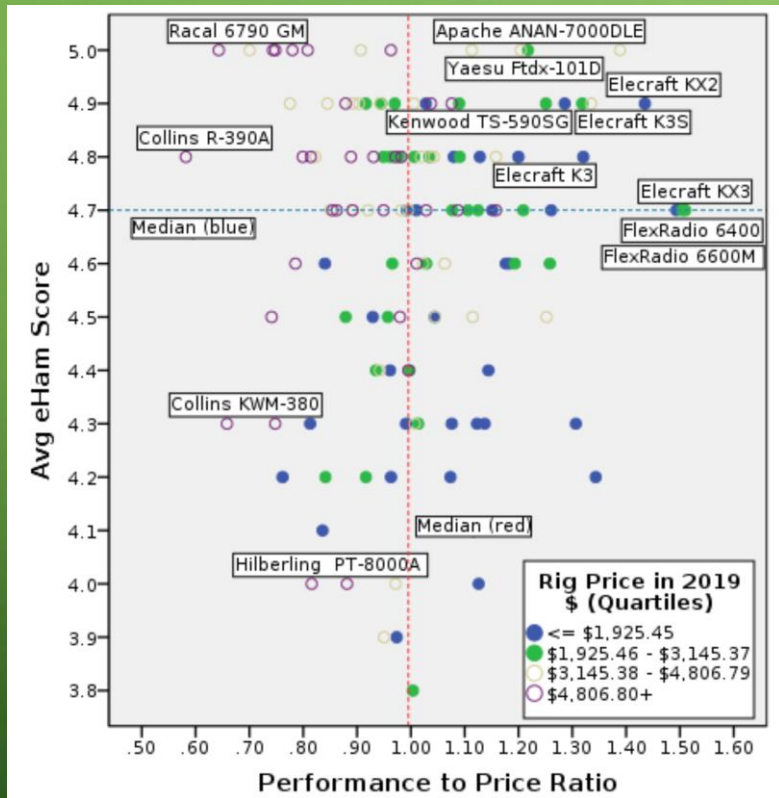
Some are significantly more expensive than similarly performing and well-liked rigs. The top performer, Flex 6600M, is on the bubble for Satisfaction but in the 2<sup>nd</sup> quartile on price. The next rig on performance, Yaesu Ftds-101D, is more expensive but higher in average satisfaction.

Rig Price in 2019 \$ (Quartiles)	
●	<= \$1,925.45
●	\$1,925.46 - \$3,145.37
◇	\$3,145.38 - \$4,806.79
○	\$4,806.80+

# PERFORMANCE BANG-FOR-THE-BUCK COMPARISON

- This “you get a lot of rig for the money” is a very common theme in the narratives published in the eHam HF rig reviews. I read all of them for these rigs! To examine that specifically, I added a new variable.
- The Price in 2019 \$ was transformed into a T-Score (mean of 100, SD of 15) like the Sherwood Performance Index. The Performance-to-Price Ratio is the SPI divided by the T-Score version of Price. Higher than 1.0 means more bang for the buck while less than 1.0 is less the case. The same Quadrant Analysis is used but with absolute price quartiles so the PPR at the price is revealed.

# PERFORMANCE-TO-PRICE QUADRANT ANALYSIS



The scatterplot is in the same quadrant style as before. I'll focus on the optimal upper right quad in the next slide. But here are a few key observations.

Note that the **solid blue circles** are the lowest quartile rigs in terms of absolute price in 2019 \$. Quite a number of them have a good performance-to-price ratio (lower right quad). But they are not well-received on average in the eHam reviews.

Some beloved rigs---Racal, Collins---just don't perform well in terms of receiving relative to their price AND are in the highest price quartile. **Money might not buy love but love can cost a lot!** Note that the contemporary high-priced rig offered by Hilberling is among the lowest rated on eHam and is below the median PPR.

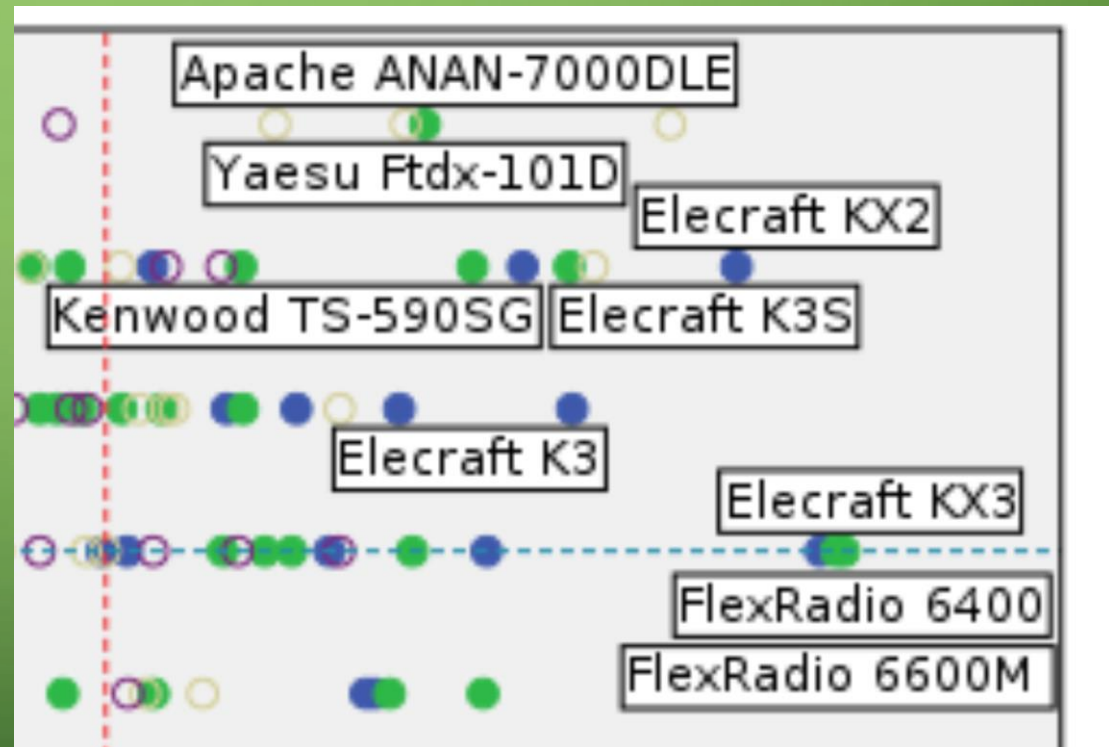


# FOCUS ON OPTIMAL PPR QUADRANT

This upper right quad shows the rigs that both perform very well for the price and several of them are below the median price in absolute dollars.

Both the Flex and Elecraft rigs annotated here fit that description. The Yaesu flagship (Ftdx-101D) and the Apache Anan-7000DLE fall just behind these rigs.

Note in particular that the Kenwood TS-590G falls into the “sweet spot” in terms of measured receive performance for the money and is at a lower price point, too.



# OPTIMAL RIG LIST

No.	Rig Name	Introduction Year	Performance-to-Price Ratio (Top Quartile)	Sherwood Performance Index	eHam Average	Introduction Price	Price in 2019 \$	eHam Quartile	Price in 2019 \$ Quartile
1	Flex 6600M	2019	1.51	143.83	4.7	\$2,999.00	\$2,999.00	2nd	2nd
2	Flex 6400	2019	1.50	137.52	4.7	\$1,999.00	\$1,999.00	2nd	2nd
3	Elecraft KX3	2012	1.49	131.46	4.7	\$999.95	\$1,113.62	2nd	1st
4	Elecraft KX2	2017	1.43	124.49	4.9	\$750.00	\$782.44	4th	1st
5	Yaesu Ftdx-101D	2019	1.39	137.57	5.0	\$3,995.00	\$3,995.00	4th	3rd
6	Perseus	2008	1.34	120.47	4.2	\$1,299.00	\$1,542.75	1st	1st
7	Kenwood TS-890S	2019	1.33	131.76	4.9	\$3,900.00	\$3,900.00	4th	3rd
8	Elecraft K3	2008	1.32	120.21	4.8	\$1,599.95	\$1,900.17	3rd	1st
9	Elecraft K3S	2016	1.32	126.04	4.9	\$2,900.00	\$3,089.71	4th	2nd
10	Flex FLEX-1500	2011	1.31	113.14	4.3	\$649.00	\$737.88	1st	1st
11	Kenwood TS-590SG	2015	1.29	117.06	4.9	\$1,759.00	\$1,897.79	4th	1st
12	Icom IC-7300	2016	1.26	113.32	4.7	\$1,500.00	\$1,598.13	2nd	1st
13	Kenwood TS-590S	2011	1.26	115.26	4.6	\$1,800.00	\$2,046.51	2nd	2nd
14	Icom IC-7610	2018	1.25	121.49	4.5	\$3,400.00	\$3,462.29	1st	3rd
15	Icom IC-R8600	2017	1.25	117.27	4.9	\$2,499.00	\$2,607.08	4th	2nd
16	Drake R-4C/CF-600/6	1973	1.22	115.43	5.0	\$499.95	\$2,879.22	4th	2nd
17	Flex 6300	2015	1.21	113.76	4.7	\$2,499.00	\$2,696.18	2nd	2nd
18	Apache ANAN-7000DLE	2018	1.20	119.64	5.0	\$3995.00	\$4,068.19	4th	3rd

**Color Coding:** All rigs are in the top quartile (75% and above) of Performance-to-Price Ratio and ranked in this table by the Ratio. Three classes of rigs are highlighted based upon the quartiles of Average eHam Satisfaction Score and Price in 2019 dollars. **Sweet Spot** rigs are in the highest consumer satisfaction quartile and in the lowest half of price rankings (i.e., cheaper). **Hot Rod** rigs are in the second quartile of consumer satisfaction and in the lowest half of price rankings. **Contender** rigs are in the top quartile of consumer satisfaction but in the third quartile of price rankings.

<b>Sweet Spot:</b> Top eHam, 1 <sup>st</sup> or 2 <sup>nd</sup> Quartile Price	<b>Hot Rod:</b> 2 <sup>nd</sup> eHam, 1 <sup>st</sup> or 2 <sup>nd</sup> Quartile Price	<b>Contender:</b> Top eHam, 3 <sup>rd</sup> Quartile Price
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This list is mildly subjective but it is based upon this Quadrant Analysis of objective data. These rigs are **ALL** in the highest quartile (75 percentile and above) in Performance-to-Price Ratio. (The full list is available on [foxmikehotel.com](http://foxmikehotel.com))

**Sweet Spot:**  
 Top eHam, 1<sup>st</sup> or 2<sup>nd</sup> Quartile Price

Elecraft KX2, Elecraft K3S, Kenwood TS-590SG,  
Icom IC-8600, Drake R-4C

**Hot Rod:**  
 2<sup>nd</sup> eHam, 1<sup>st</sup> or 2<sup>nd</sup> Quartile Price

Flex 6600M, Flex 6400, Elecraft KX3

**Contender:**  
 Top eHam, 3<sup>rd</sup> Quartile Price

Yaesu Ftdx-101D, Kenwood TS-890S, Apache  
ANAN-7000DLE

# HOW MUCH EFFECT DOES PRICE HAVE ON PERFORMANCE AND SATISFACTION?

- There is an inconsistent pattern of the role of price thus far in the analysis. I illustrated that this is asymmetric: buying a “random” high-priced rig does **NOT** guarantee measured receive performance or collective satisfaction.
- Can we put a finer point on the relationship of price to performance and typical satisfaction?
- In the next slide, the results of a **linear regression model** does this. It also includes the decade of release to the market, whether the rig is from one of the major manufacturers, and, for Satisfaction, the number of eHam reviews.

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# REGRESSION MODEL RESULTS

## Regression Model Summary for Rig Performance Index and Satisfaction

Dependent Variable:	<u>Rig Performance Index</u>		<u>eHam Satisfaction</u>	
	<u>Coefficients</u>		<u>Coefficients</u>	
	B	Beta	B	Beta
Intercept	60.203***		3.371	
(LN) Rig Price in 2019 \$	6.888***	.341	.110***	.289
Decade: Pre-1970s (1=yes)	-27.910***	-.326	.060 <sup>ns</sup>	.085
Decade: 1970s (1=yes)	-25.473***	-.534	.004 <sup>ns</sup>	.188
Decade: 1980s (1=yes)	-24.800***	-.688	-.013 <sup>ns</sup>	-.015
Decade: 1990s (1=yes)	-20.555***	-.547	.017 <sup>ns</sup>	.024
Decade: 2000s (1=yes)	-13.715***	-.365	.096 <sup>ns</sup>	.136
Elecraft Rig (1=yes)	17.022***	.222	.029 <sup>ns</sup>	.018
Flex Rig (1=yes)	12.085*	.185	.260 <sup>ns</sup>	.179
Icom Rig (1=yes)	-.264ns	-.008	-.003 <sup>ns</sup>	-.003
Kenwood Rig (1=yes)	-2.808ns	-.071	-.044 <sup>ns</sup>	-.067
Yaesu Rig (1=yes)	-3.715ns	-.091	.157 <sup>ns</sup>	.210
Number of eHam Reviews	NA	NA	-.047 <sup>ns</sup>	-.061
<i>Legend:</i>				
*** $p < .001$				
* $p < .05$				
ns not sig.				
	R <sup>2</sup> = .688***		R <sup>2</sup> = .199*	
	F=30.03***	MSE=9.72	F=2.15*	MSE=0.27

*Note:* The list of decade and major manufacturer rows are measured as 0,1 where 1 = Yes versus an omitted category. For decade, 2010 is the reference category whereas Other manufacturer is the omitted reference for that set of variables. These are commonly referred to as dummy or indicator variables in multiple regression models.

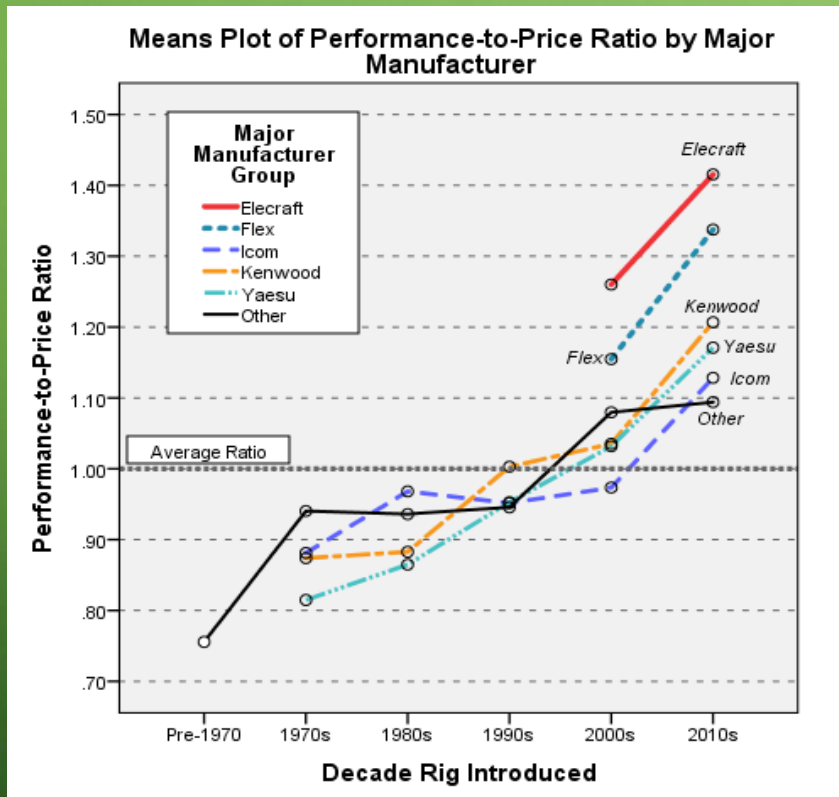
*Multiple Regression Models for Rig Performance Index and eHam Satisfaction Rating*

The two models on the left are for **Performance** and **Satisfaction**. The predictor (independent) variables are in the first column, followed by the unstandardized (B) and standardized (Beta) partial regression coefficients. The model summary is at the bottom. The R<sup>2</sup> indicates the percent of all differences in Performance or Satisfaction associated with the set of independent variables. The regression coefficients (B, Beta) are the unique association to the dependent variable with other variables held constant.

The results show that 68% of the Performance differences are linked to these variables but only 20% of typical Satisfaction. Price has a **positive** effect but **much smaller** (Beta = .341, .289) than expected! Decade of introduction and being an Elecraft or Flex rig have significant effects.



# BANG-FOR-THE-BUCK, MAJOR MANUFACTURER AND DECADE OF RELEASE

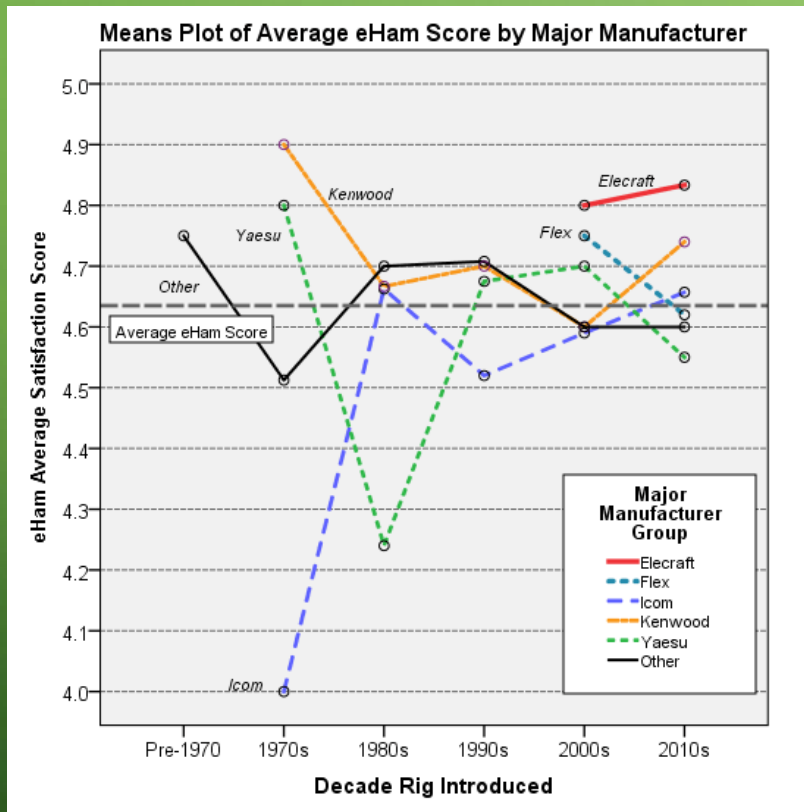


The plot of mean scores on PPR by decade and major manufacturer is shown on the left. Both decade and manufacturer differences are very significant with just these two variables explaining 63% of the rig-to-rig differences in PPR!

All rigs got better PPR over time. This was especially the case from the 1990s onward but particularly after 2010. This includes rigs NOT from these major manufacturers. While the Big Three (Icom, Kenwood, Yaesu) all improved PPR from 2000 onward, the newcomers of Elecraft and Flex entered at higher points (one standard deviation above) and made a dramatic leap higher by the 2010 years. The relative order is Elecraft, Flex, Kenwood, Yaesu, Icom, and the others.



# SATISFACTION, MAJOR MANUFACTURER AND DECADE OF RELEASE



The same analysis is shown on the left for the typical eHam Satisfaction rating. As the simple trends plot for Satisfaction showed above, the **decade** average over all rigs was quite stable while the **year-to-year** means jumped around wildly. The graph at left actually reflects this basic descriptive pattern for all the manufacturers, whether major or not.

The statistical effects of decade and major manufacturer are not significant suggesting that these fluctuations are most likely due to chance across manufacturers as well as decade (but not necessarily year-to-year).

# CONCLUSIONS

- I've found no study of this kind so these data and results are new. It's a unique opportunity to investigate the question Steve Ford at the ARRL asked: How do you know which rig is best without throwing away money?
- **Let me state clearly:** best is somewhat idiosyncratic to the individual ham. Read the eHam rig rating narratives. The top rated rig will inevitably have a few hams who give it low ratings for particularistic reasons. Yet, their satisfaction is valid. To *them*. To *you*? You have to consider what's best for you.
- But these results *do* help the reader to ***narrow down*** the scope of HF rigs to consider.

# CONCLUSIONS...

- Price *is* positively related to better receive performance and the consumer's satisfaction with this set of well-known rigs included in the Sherwood Tables. The relationship is **just smaller** than our conventional logic would expect.
- The receive performance as measured through a composite index of the key metrics published in the Sherwood Tables is *better in recent years than it has ever been and it isn't even close*.
- Typical satisfaction with a transceiver depends on a number of things, receive performance only being **one** of them. Price is only moderately related to typical satisfaction. Features? Ergonomics? These elements of rig design and performance are not directly observed here.
- Major name-brands do not seem to have much broad or long-term sway with overall average satisfaction. The jury may still be out on this but my results do not detect evidence for it per se when all of the eHam reviews are tallied and evaluated by major manufacturer.

# CONCLUSIONS...

- While the major manufacturers all shared in this dramatic improvement in this aspect of rig performance, as did the others, two recent ones entered at the top quartile of the Sherwood Performance Index and continued to improve, even more than their competitors. These were **Elecraft** and **Flex Radio Systems**.
- I used the top quartile Performance-to-Price Ratio rigs in addition to their absolute price and typical satisfaction to identify **three groups** that distinguish themselves: **Sweet Spot**, **Hot Rods**, and **Contenders**. They are all high performing, especially relative to their introductory price, and stand out for different reasons. Buyers should evaluate those reasons based on their own preferences as priorities.

# CONCLUSIONS...

- The results help readers juggle these three sources of information in an objective way. While the statistical analysis may not be every reader's cup of tea (and I'm told not every ham enjoys plowing through RF measurements), the results themselves do identify a number of rigs that appear to have the "most for the least" investment and high typical consumer satisfaction.
- While it is important for any consumer to carefully evaluate specific aspects of a product in terms of their own preferences and priorities, and this is clearly the case for a new HF rig, my results help the reader hone in to a smaller subset and their desired price point. This subset will be with a high measured receive performance, and with the knowledge that other hams have rated them very highly. But it's always *caveat emptor!*
- More details on the Sherwood Performance Index with a complete listing by rig can be found at my companion website, [foxmikehotel.com](http://foxmikehotel.com). A two-part article on this research will be appearing in the ARRL *National Contesting Journal* in early 2021.



# THANKS FOR WATCHING!

Frank M. Howell, PhD K4FMH

Good on QRZ.com

ARRL Assistant Director, Delta Division

Presenter, ICQ Podcast

Blog: [k4fmh.com](http://k4fmh.com) and [FoxMikeHotel.com](http://FoxMikeHotel.com)

President, Magnolia Intertie Inc.

Chair, Fox Mike Hotel Portable Ops Challenge

Chair, Homebrew Heroes Awards Program

