

# TECHNOLOGY FUTURES INC.

A vibrant, futuristic digital landscape. The scene is dominated by glowing blue and green circuitry and data lines. In the foreground, a laptop is open on the left, displaying a globe. To the right, a white rocket with a blue nose cone is positioned. In the center, a red, glowing archway structure is visible. The background features a dark blue sky with a bright, glowing horizon line, suggesting a sunset or sunrise. The overall aesthetic is high-tech and visionary.

*Your Bridge to the Future*

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# 19<sup>th</sup> Annual TFI Technology Conference

- Welcome Back to Austin! ~20 In-Person
- Welcome Online Attendees! ~50 Online
- Welcome Back to Hyatt Place!
- Thank you Sponsors!



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## Lay of the Land & Rules of the Road

- Conference room layout
- Chat and Q&A
- Screenshare and Video Feed
- Stay on schedule
- Audio is crucial - Use microphones!!!
- Have fun and be patient! 😊

## TFI 2024 Onsite Team

### Larry Vanston

Conference Director

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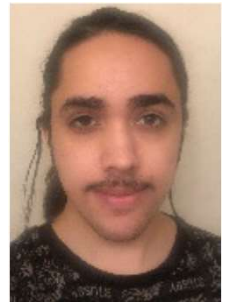


### Miguel Posadas

Audio/Video Lead

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### Luna Phillips

Audio/Video Associate

[Phillipsmakayla1023@gmail.com](mailto:Phillipsmakayla1023@gmail.com)



## TFI 2024 Keynotes



**Wireless Keynote** *Earth and Sky: Developments in 5G, 6G, and Low Earth Orbit Satellites*  
**Roger Entner** Founder  
Recon Analytics Inc.



**Broadband Keynote** *Better Broadband for More Folks: Everything's Bigger in Texas!*  
**Andrea Pacheco** Outreach Coordinator  
State of Texas Broadband Development Office



**Policy Keynote** *Communications Equipment Price Indices: Back under the Hood with the Expert*  
**Vincent Russo** Chief, Section of Durable Goods, Producer Price Index  
U.S. Bureau of Labor Statistics

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# Wireless Industry Panel



**Ruben Miranda**  
Managing Director  
Kroll



**Iain Gillott**  
President  
iGR



**Steven Ingram**  
Director – Tax  
AT&T



**Stephen Yergeau**  
Director, Property Taxes  
T-Mobile

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## Broadband Industry Panel



**Jeffrey Binkley**  
Principal,  
Ryan



**Allyssa DeCenzo**  
Senior Manager  
Comcast



**Steven Ingram**  
Director – Tax  
AT&T

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# Annual Updates

## TFI Industry Forecast Overview



**Lawrence Vanston, Ph.D.**  
President,  
Technology Futures, Inc.



**Ray Hodges**  
Senior Consultant,  
Technology Futures, Inc.

## U.S. Economic Outlook



**Michael A. Sadler, Ph.D.**  
Dept of Economics,  
Dept of Finance  
McCombs School of Business  
University of Texas at Austin

## Communications Technology Update



**August (Augie) Grant, Ph.D.**  
Professor,  
University of South Carolina

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# Feature Presentations

## Iain and Lauren's Ride Across America



**Iain Gillott**  
President  
iGR

## BEAD: From Investment to Value



**Tom Coffey**  
Senior Director, Valuation  
Systems  
CostQuest Associates

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# Special Optional Session

**Build Foundational Clarity for Success and Fulfillment**



**Carrie Vanston,**  
CEO  
Leadership Mindset Success

**Leadership  
Mindset  
Success ✓**

[leadership-mindset-success.com](http://leadership-mindset-success.com)

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# TFI Forecasts Update

Lawrence Vanston, Ph.D. President,  
Ray Hodges, Senior Associate

Technology Futures, Inc.

[lvanston@tfi.com](mailto:lvanston@tfi.com)  
[rhodges@tfi.com](mailto:rhodges@tfi.com)

**TFI Technology  
Conference 2024**

January 25-26, 2024  
Austin, Texas  
and Online

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## Technology Forecasting

- Performance Improvement
- Cost Improvement
- Adoption of New Technology
- Replacement of Old Technology
- Impacts of these changes

**Perfect for estimating lives & values  
of large capital investments**

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## Technology Forecasting Methods

- Fundamental Models of Technology Change
  - Technology Adoption and Substitution Curves
  - Performance Improvement Curves
- Analogies
- Drivers and Constraints
- Expert Opinion



## Technology Forecasting Lessons

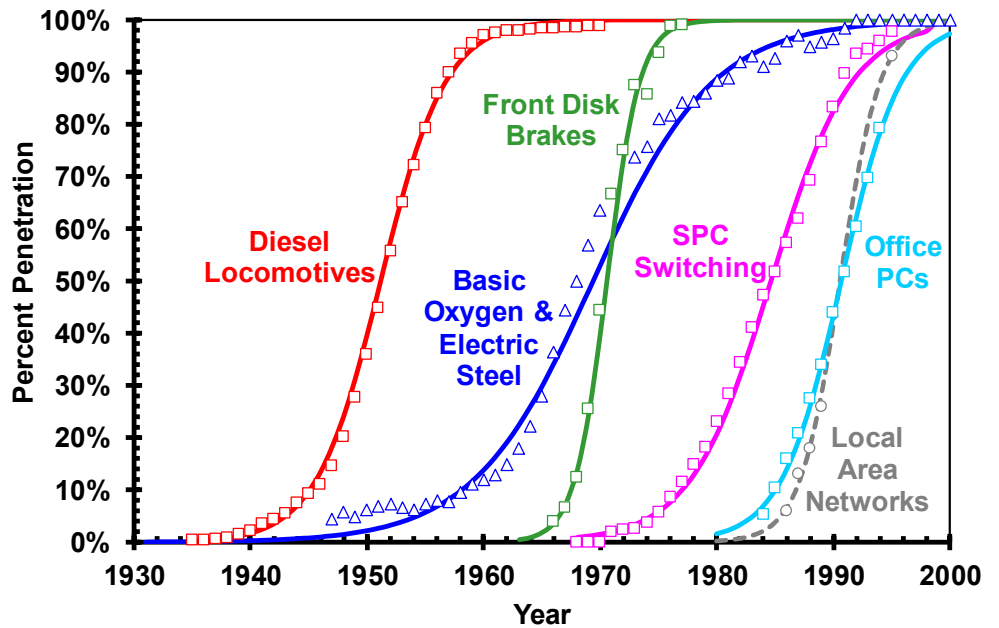
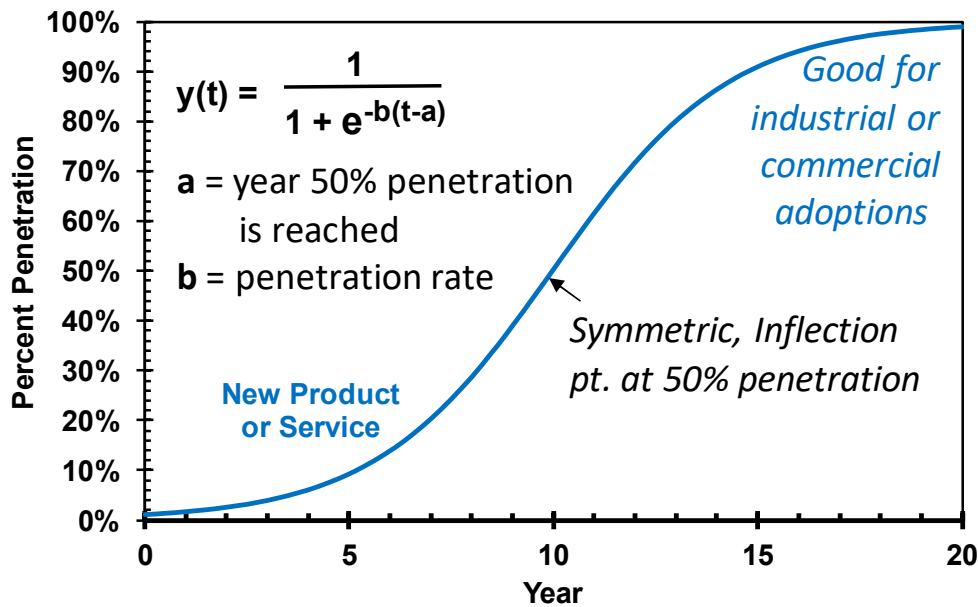
- Nothing happens overnight
- Fundamental technology trends are relentless
- Betting against fundamental technology trends is futile
- Fundamental technology trends destroy value in old technology

# Introduction to Technology Adoption and Substitution Models

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# Fisher-Pry Substitution Model (aka Logistic Model)

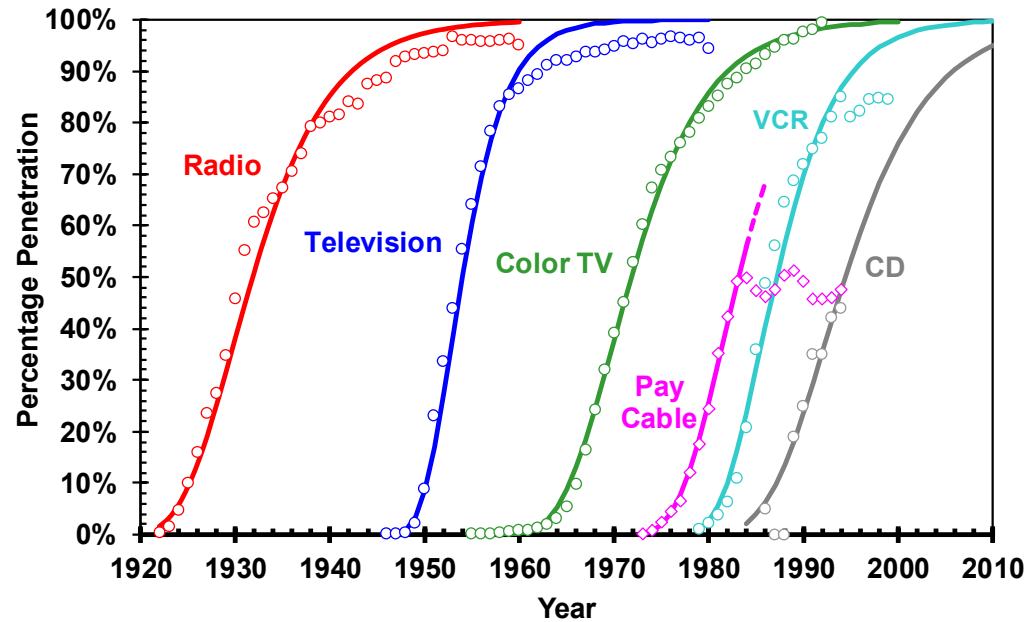
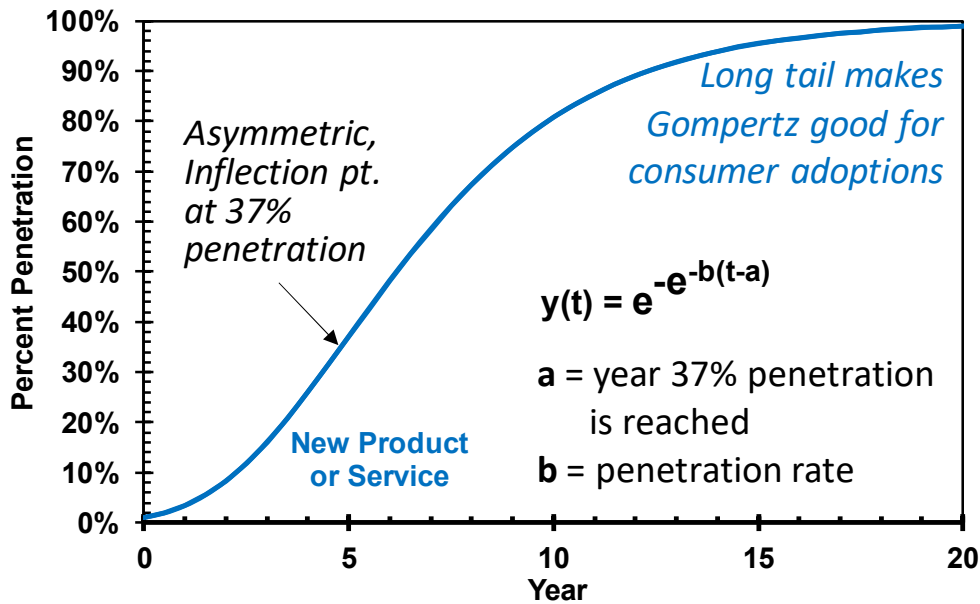


Source: Technology Futures, Inc.

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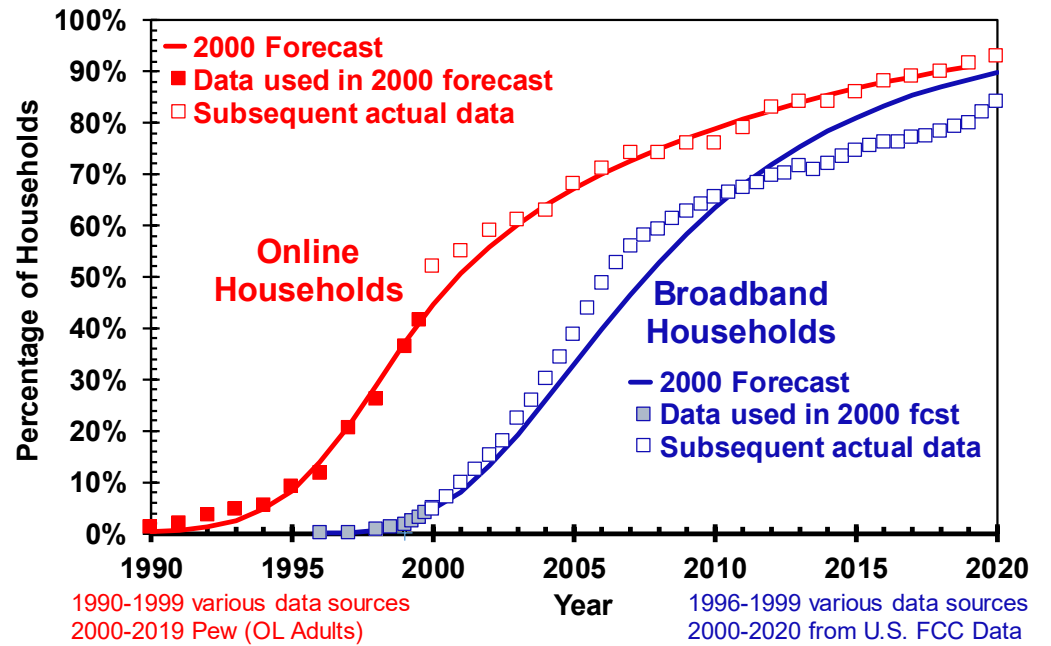
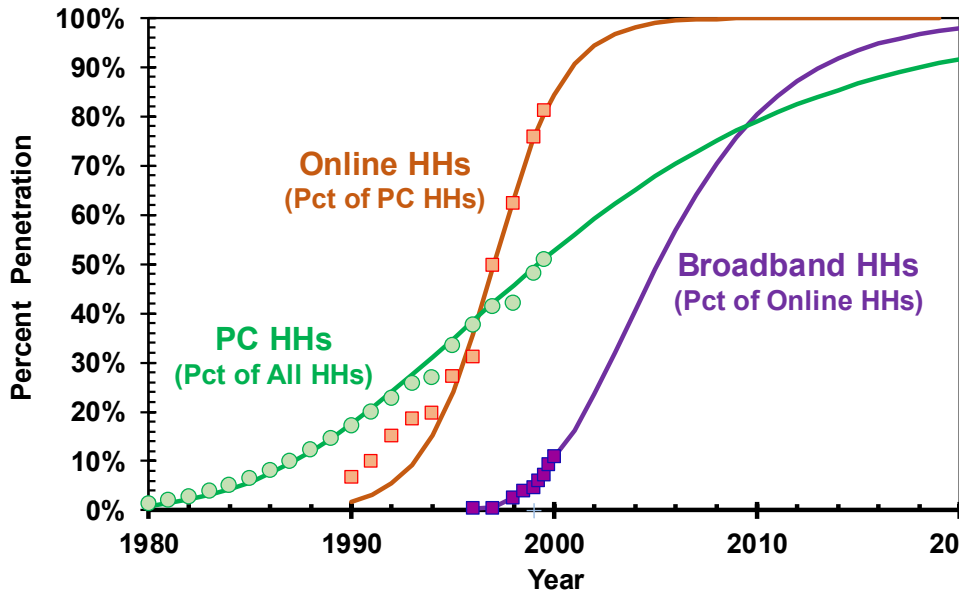
# The Gompertz Model



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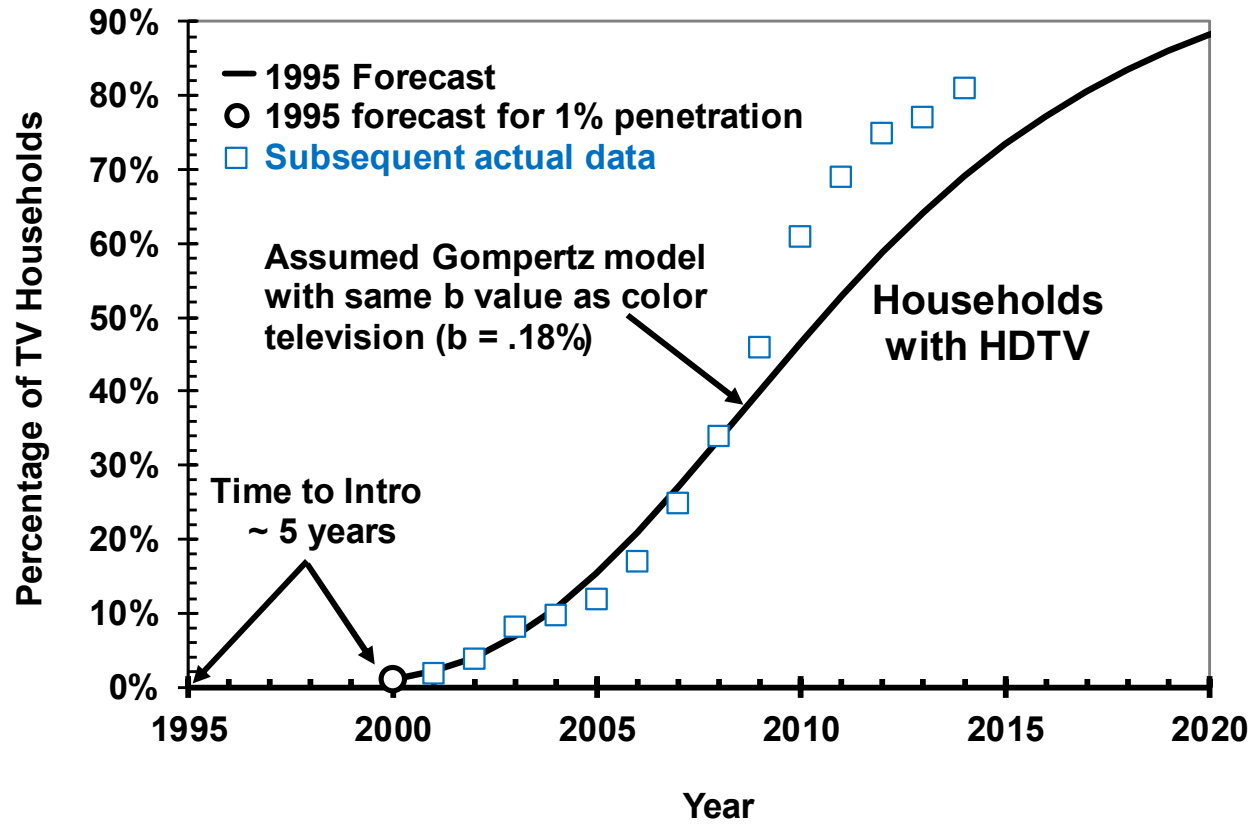
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# Early TFI Broadband Forecast (2000)



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# Early TFI HDTV Forecast (1995)



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Cross-Learning with Short Seasonal Time Series

The Limitations of Forecasts and Plans on Decision Making

Collaborative Budget Forecasting Meets the COVID-19 Pandemic

The 10 Lies Told in Consensus Meetings

Op-Eds and Minitutorial

Special Feature:

Pitfalls in Forecast Evaluation

Preview of Q4 Special Feature:

The Current State and Future Direction of Forecasting Software



2023:Q3

Issue 70

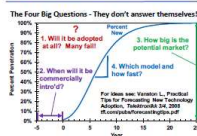
Minitutorial

## Forecasting New Product Adoption Using S-Curves

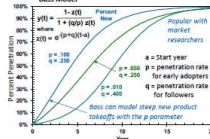
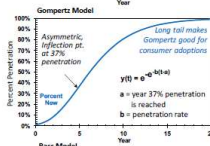
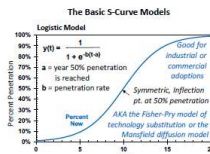
LAWRENCE VANSTON

- S-Curves reflect the fundamental nature of adoption and technology change, proven over decades of use.
- They apply to new products, services, and technologies that use a fundamentally new approach, usually substituting for an old one.
- With enough historic data, we can use linear or nonlinear regression to estimate the 2-3 curve parameters.
- Without it (the usual case), we must rely on analogies, judgment, and analysis of underlying factors to estimate them.
- We usually forecast market penetration by all firms from which sales and share can be derived.

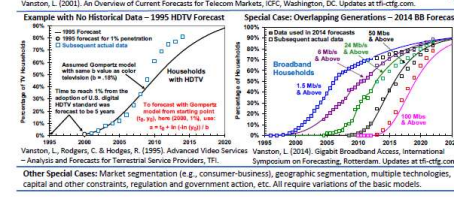
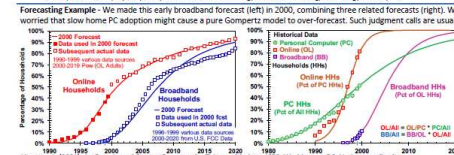
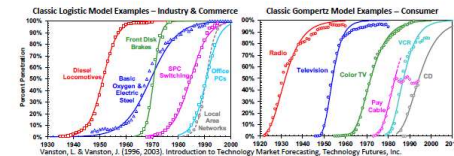
The S-shape's slow start reflects the fact that this type of new product must overcome constraints such as needed improvement, uncertainty, unfamiliarity, and high prices (due to low economies of scale, R&D costs, or lack of competition) often against entrenched existing products. Usually, a niche market or a community of innovators give the new product its start. Once improvements are made, the new product's advantages become clear and the curve steepens dramatically. It flattens out as niches favorable to the old products are reached, including late adopters in the case of consumer products.



**SELECTED CLASSIC REFERENCES**  
 Bass, F. (1969). A New-Product Growth for Model Consumer Durables, *Management Science*, Vol.15, 215-227.  
 Fisher, J. & Pry, R. (1971). A Simple Substitution Model of Technological Change, *Techn. Forecast. & Soc. Change*, 3, 75-88.  
 Mansueth, E. (1961). Technical Change and the Rate of Imitation, *Economica*, 29 (100), 741-756.  
 Martin, J. (1982). *Technological Forecasting for Decision Making*, 2nd Ed., North-Holland Publishing.



**REFERENCES ON USING ANALOGIES**  
 Owen, K. & Armstrong, J. (2007). Structural Analogies for Forecasting, *International Journal of Forecasting*, 23, 365-376.  
 Goodwin, P., Dyrasidou, K. & Moran, S. (2013). The Use of Analogies in Forecasting the Annual Sales of New Electronics Products, *IMA J. Management Mathematics*, 24, 407-422.  
 Wright, M. & Stern, D. (2015). Forecasting New Product Trial with Analogous Series, *Journal of Business Research*, 68, 1732-1738.



**REFERENCES ON EXTENSIONS AND OTHER MODELS**  
 Mahajan, V., Muller, E. & Bass, F. (1990). New Product Diffusion Models in Marketing: A Review & Directions for Research, *Journal of Marketing*, 54 (1), 1-26.  
 Meade, N. & Islam, T. (2006). Modelling and Forecasting the Diffusion of Innovation: A 20-year Review, *International Journal of Forecasting*, 22 (3), 519-545.  
 Sharif, M. & Kabir, C. (1976). System Dynamics Modelling for Forecasting Multilevel Technological Substitution, *Technology Forecasting and Social Change*, 01, 2, 89-112.

**Lawrence Vanston** is President of Technology Futures, Inc. in Austin, Texas. He holds a PhD in Operations Research and Industrial Engineering from the University of Texas at Austin and is an authority on technology forecasting for the communications and other high-tech industries. He also leads Art 84, an arts nonprofit.  
[vanston.tfi.com](http://vanston.tfi.com)

- **Minitutorial: Forecasting New Product Adoption Using S-Curves**, Lawrence Vanston, Foresight:, Q3:2023, pp. 66-67.

• <https://tfi-ctfg.com/technology-forecasting-resources/>



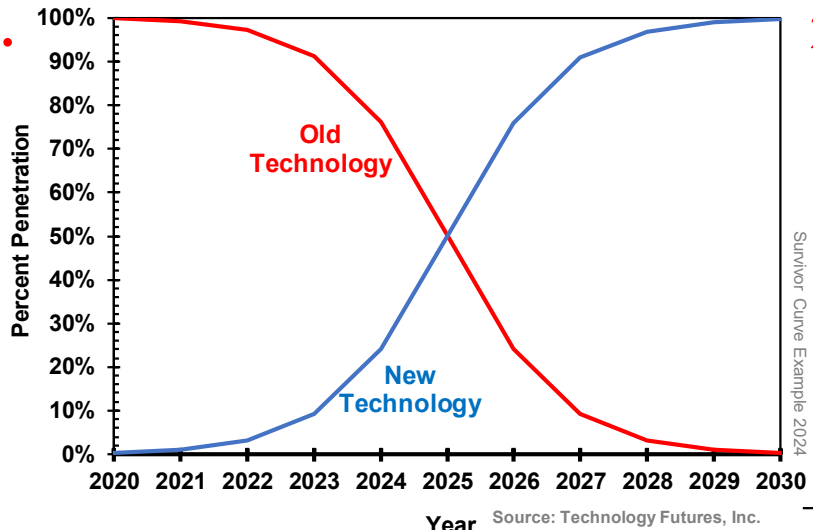
# Application to Valuation

## Simplified Example

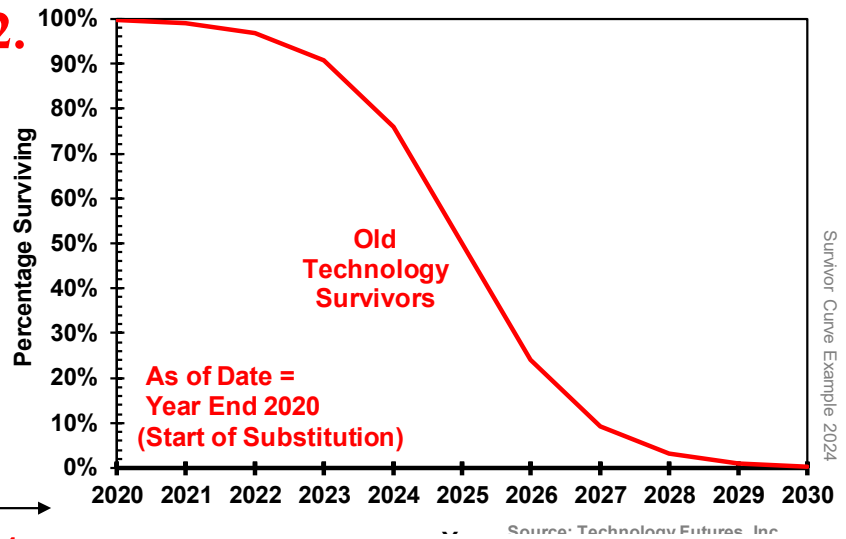
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1.



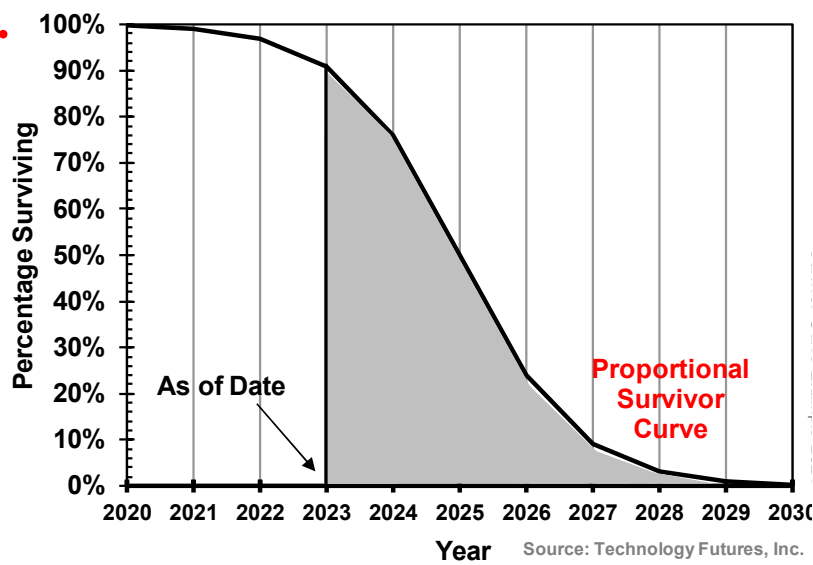
2.



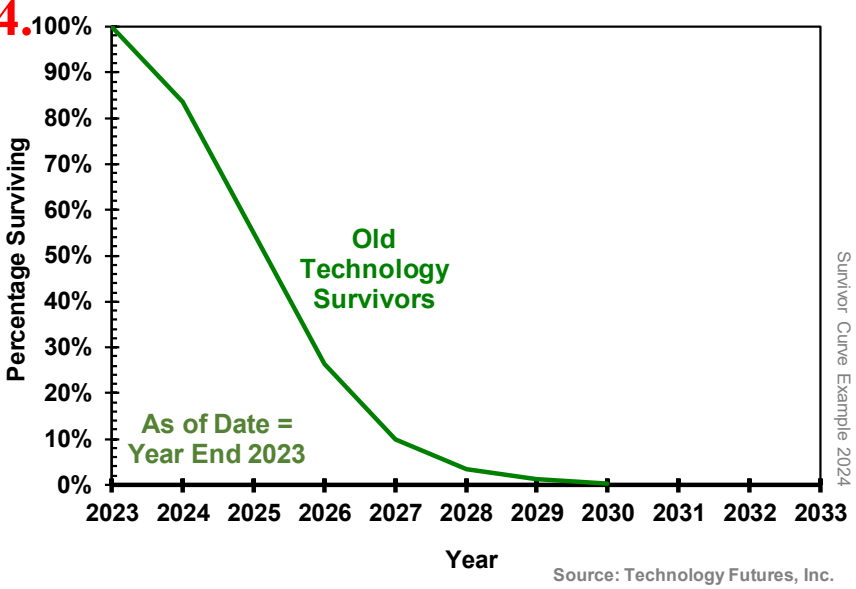
5.

Year End	Survs
2023	100%
2024	84%
2025	55%
2026	26%
2027	10%
2028	3%
2029	1%
2030	0%
<b>Sum =</b>	<b>2.8</b>
1/2 yr	-0.5
<b>RL =</b>	<b>2.3</b>

3.



4.



6.

$$\text{Pct Good} = \frac{\text{RL}}{\text{Age} + \text{RL}}$$

Year	Age	Pct Good
2023	0.5	82%
2022	1.5	61%
2021	2.5	48%
2020	3.5	40%
2019	4.5	34%
2018	5.5	29%
2017	6.5	26%
2016	7.5	23%

# Prospects for using AI in Product Forecasting

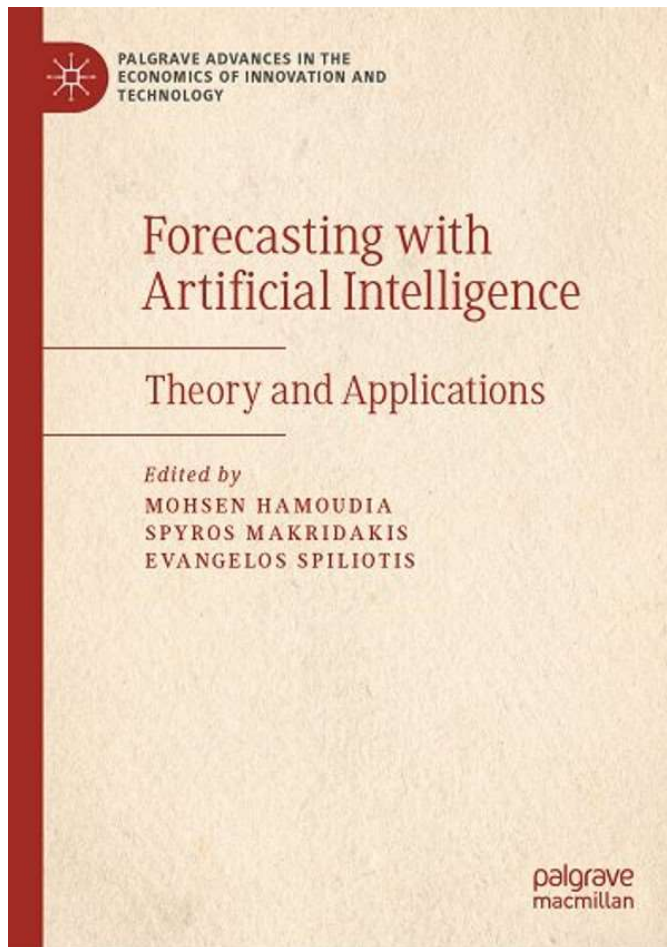
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# AI for Product Forecasting

	Existing Products	Routine New Products	Truly New Products
AI Literature	Broad	Minimal	Scant
Historical Data	Lots of historical data	Lots of historical data for similar products	Some historical data for analogous products
Time Horizon	Short-term	Short-term	Long-term
AI Status	Proven superior to statistical methods in many cases	Appears to be useful in improving accuracy over customary methods	Pre-Exploratory

# For Forecasting Routine New Products



*Machine Learning for New Product Forecasting*,  
Mohsen Hamoudia and Lawrence Vanston, Chapter  
in **Forecasting with Artificial Intelligence: Theory  
and Applications**, Springer, 2023.

<https://link.springer.com/book/10.1007/978-3-031-35879-1>

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# Prospects of AI for Long-Term New Product Forecasting

Lawrence Vanston, Ph.D. President,

Technology Futures, Inc.  
& TFI Projects

[lvanson@tfi.com](mailto:lvanson@tfi.com)

International Symposium  
on Forecasting 2023

June 25-28, 2023  
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# Prospects of AI for Long-Term New Product Forecasting

## Conclusions

- AI very promising for parts of the process (research, drivers & constraints, adoption curves, analogies)
- Somewhat promising for other parts
- Comprehensive forecasts (beyond quoting existing forecasts) is an open question.
- More research is needed.

# TFI Forecasts 2024

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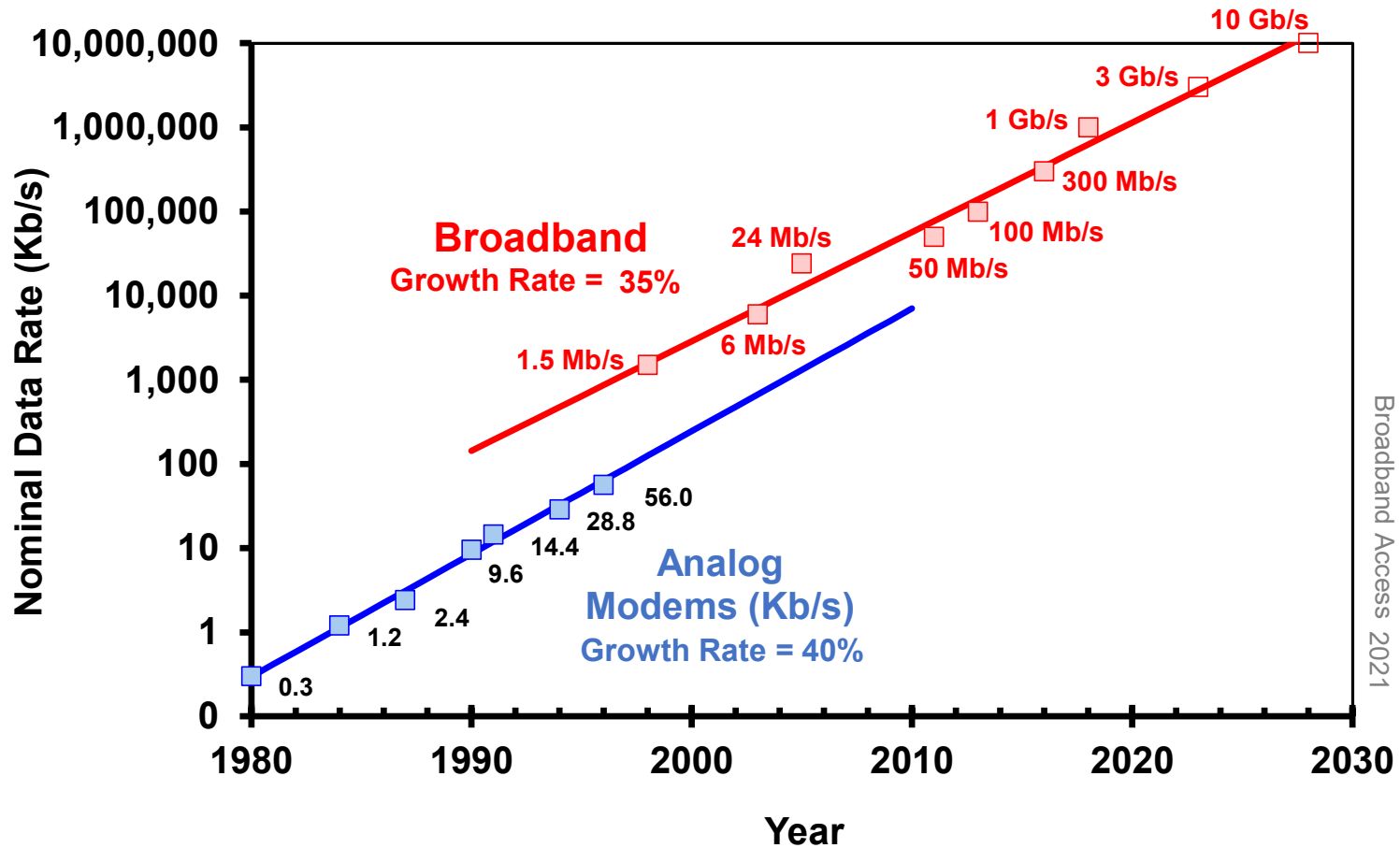
# Broadband Forecasts

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# Broadband Performance Milestones



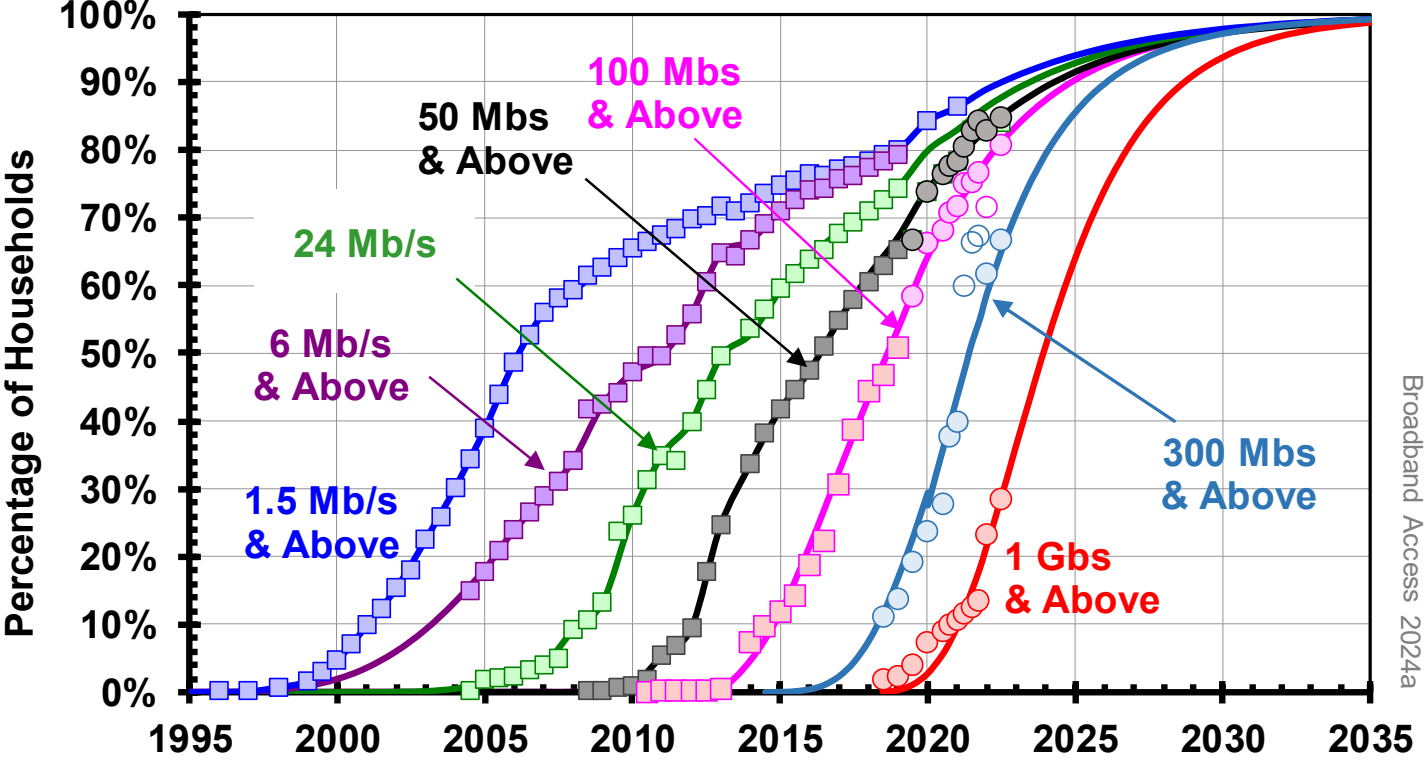
Broadband Access 2021

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# U.S. Broadband Households – 2024 TFI Forecast

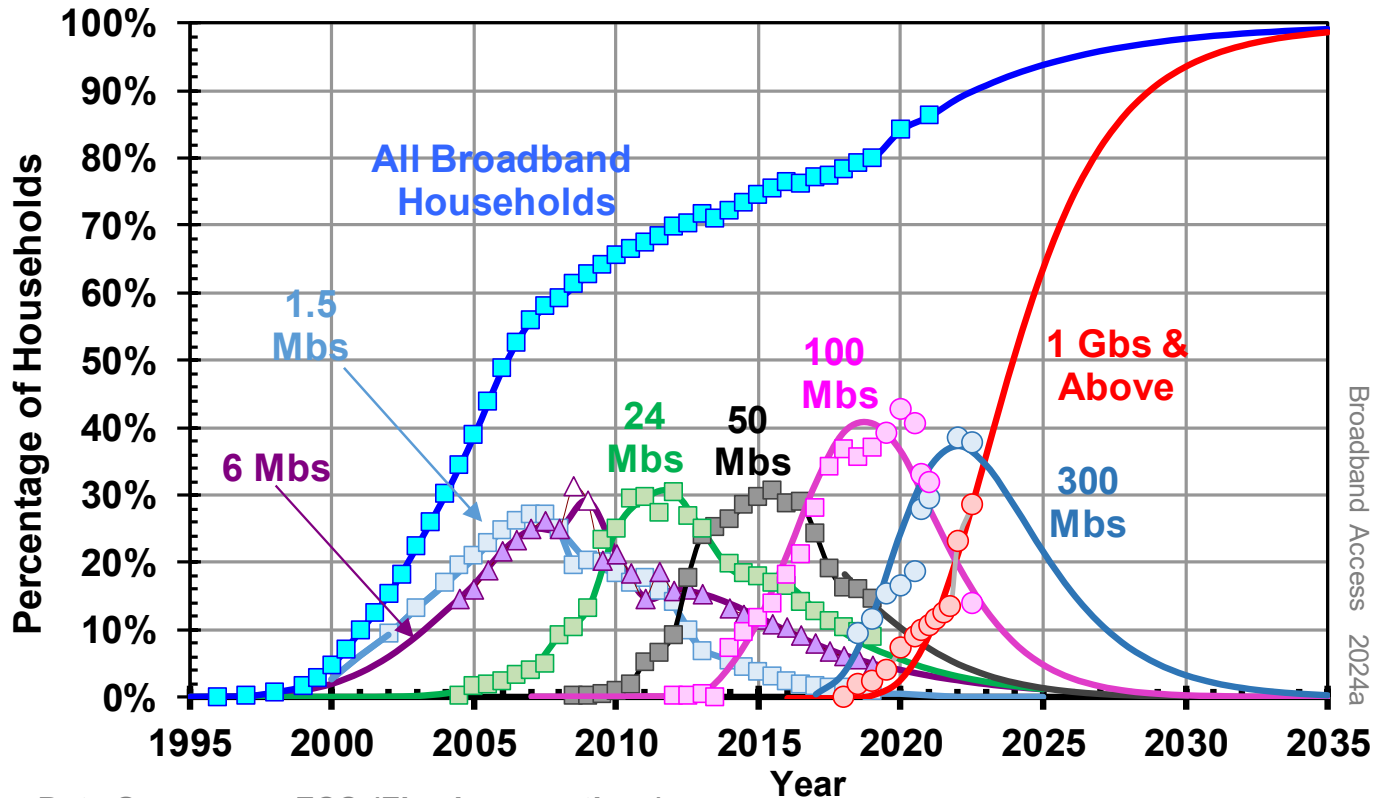


Data Sources: □ FCC (Fixed connections)      Year  
 ○ Openvault OBVI quarterly reports

Source: Technology Futures, Inc. **TECHNOLOGY FUTURES INC.**

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# U.S. Broadband Households – 2024 TFI Forecast



Broadband Access 2024a

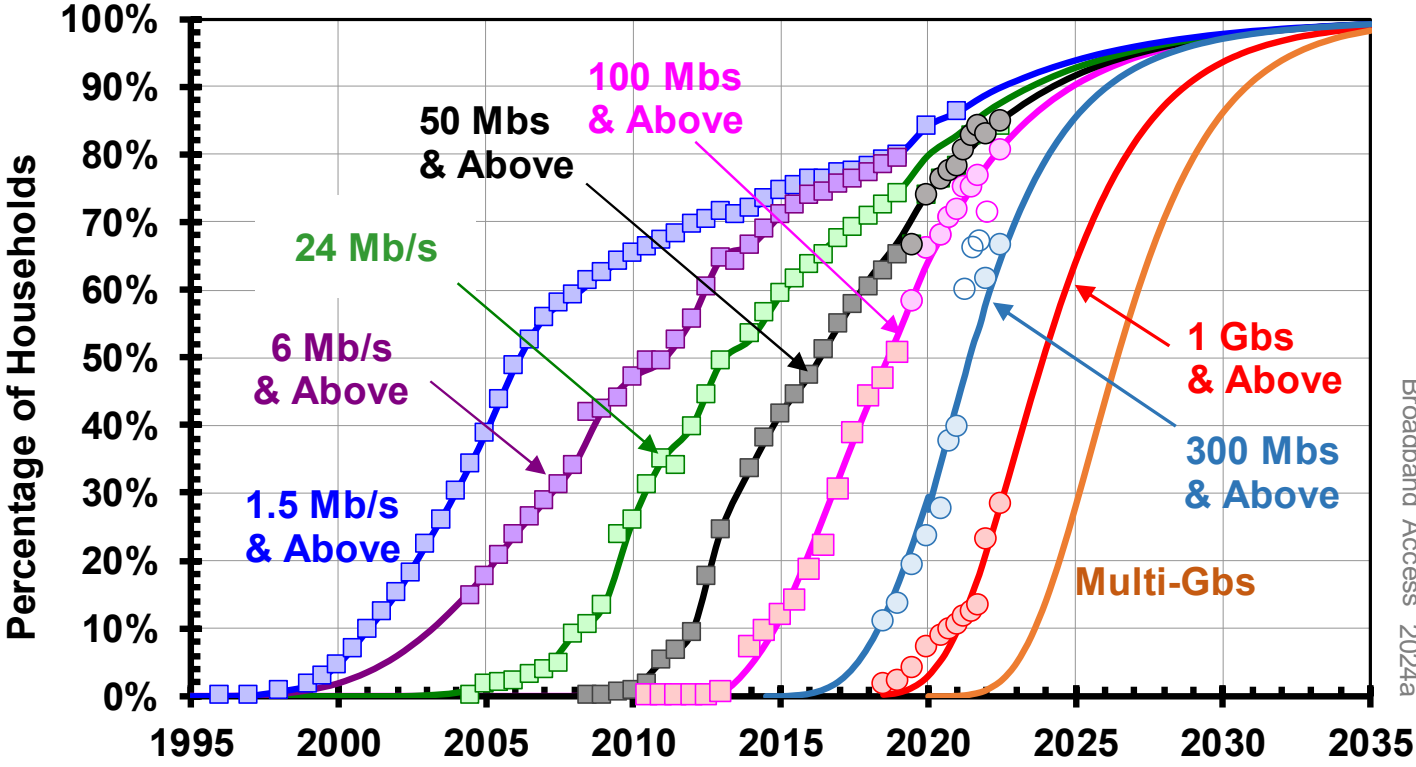
Data Sources: □ FCC (Fixed connections)  
 ○ Openvault OBVI quarterly reports

Source: Technology Futures, Inc.



$$\text{Lifecycle (t)} = \text{Substitution (t)} - \text{Next Substitution (t)}$$

# U.S. Broadband Households – 2024 TFI Forecast



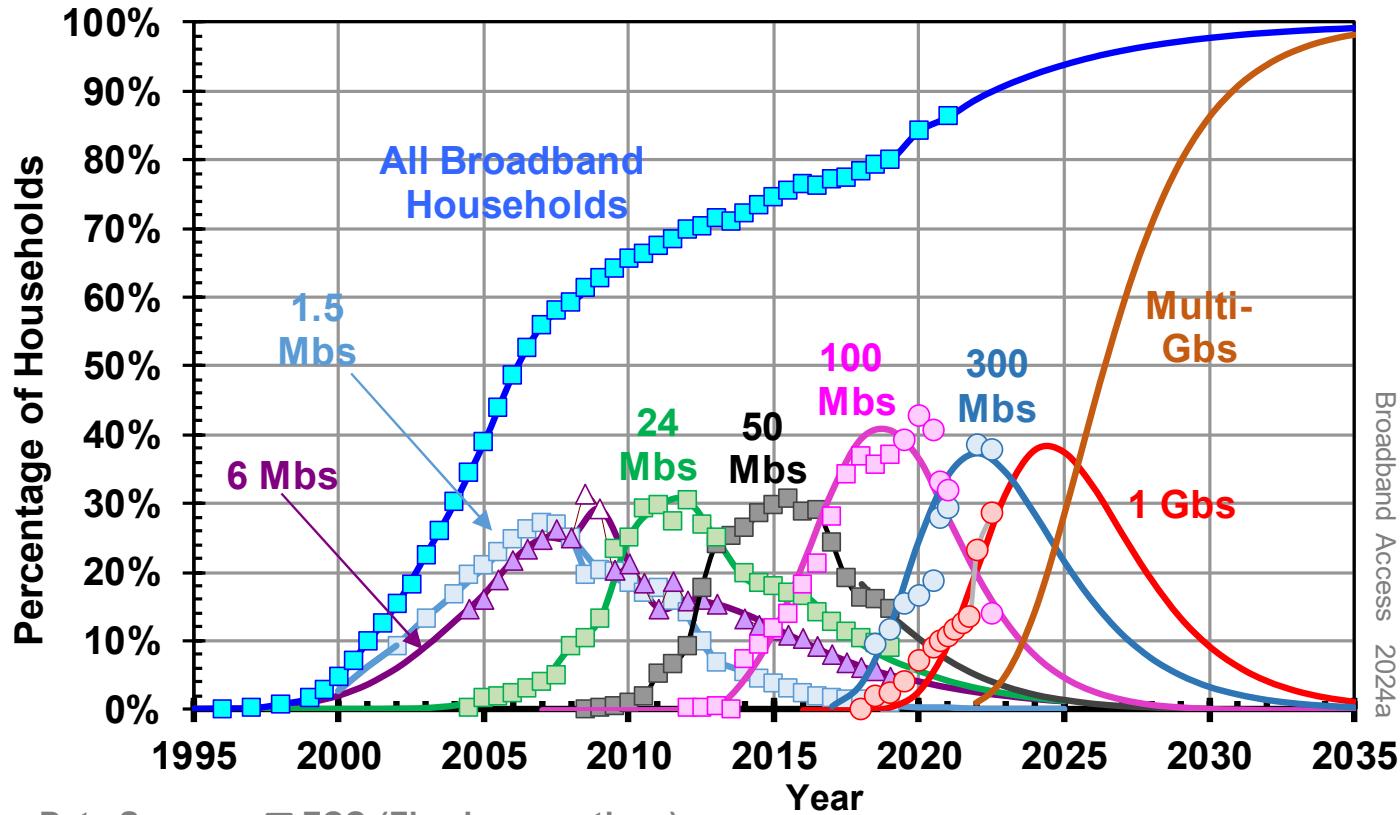
Broadband Access 2024a

Data Sources: □ FCC (Fixed connections)      Year  
 ○ Openvault OBVI quarterly reports

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# U.S. Broadband Households – 2024 TFI Forecast



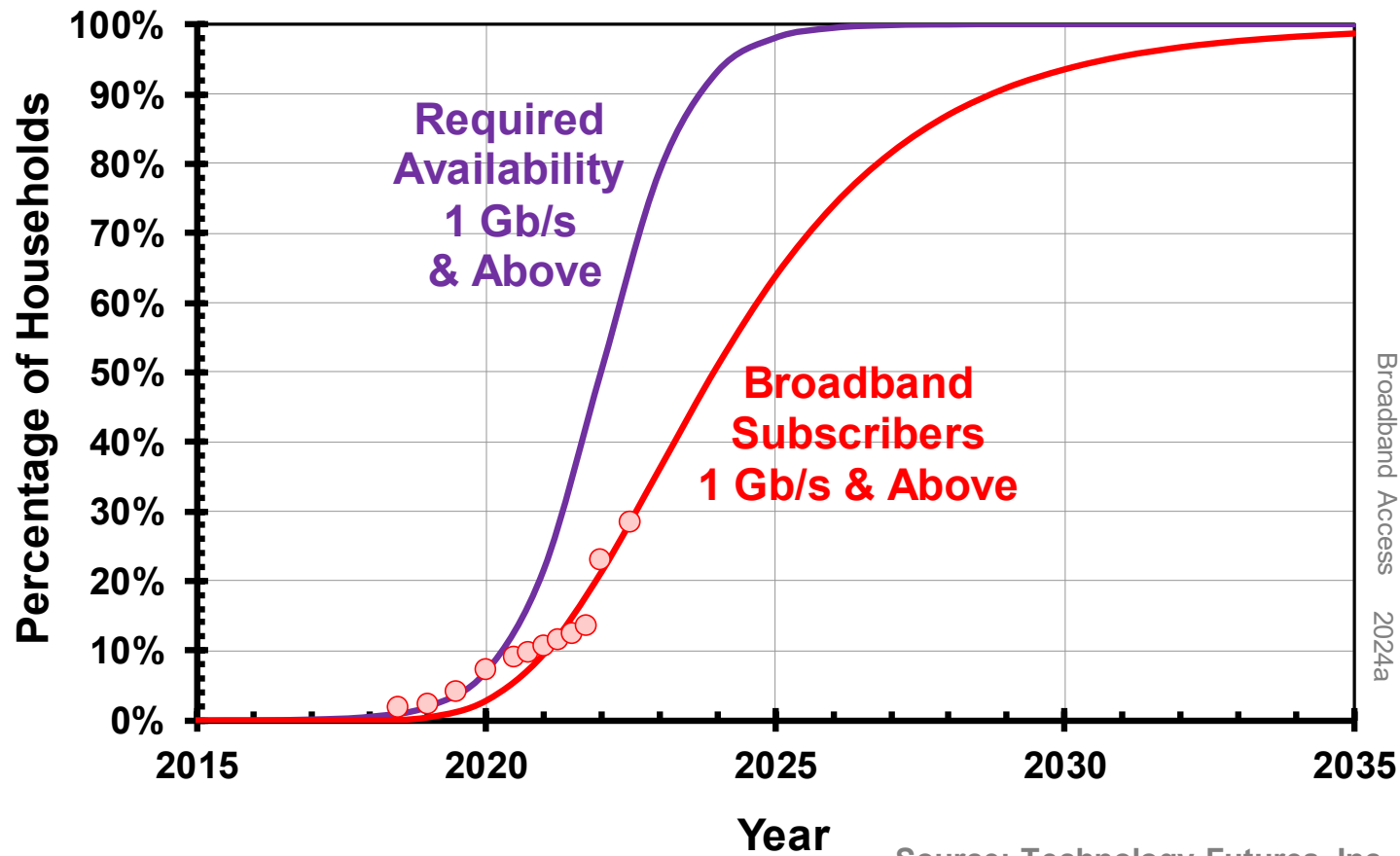
Data Sources: □ FCC (Fixed connections)  
 ○ Openvault OBVI quarterly reports

Source: Technology Futures, Inc.



$$\text{Lifecycle (t)} = \text{Substitution (t)} - \text{Next Substitution (t)}$$

# Availability vs Subscribers, 1 Gb/s & Above



Source: Technology Futures, Inc.



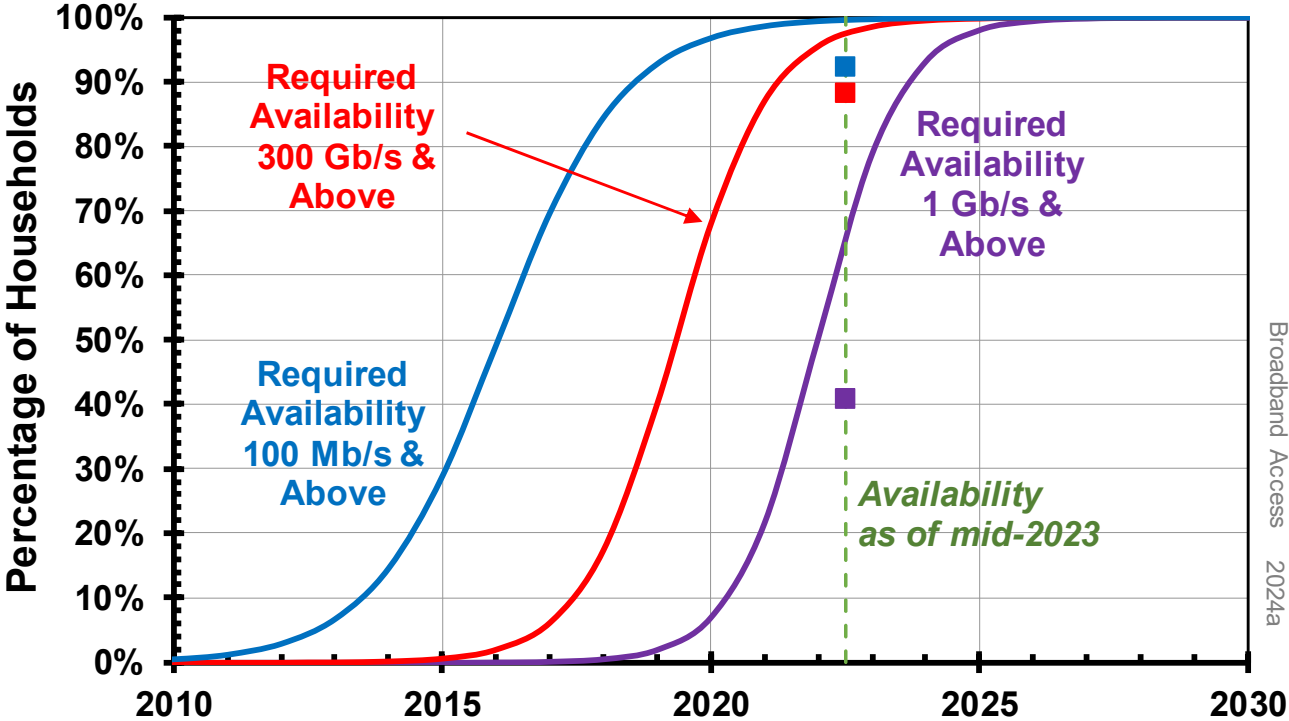
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Speed (Down/Up)	Fiber	Cable	Fixed Wireless	Copper	All Terrastrial
<b>25M / 3M</b>	40%	83%	61%	23%	95%
<b>100 / 20M</b>	40%	83%	40%	5%	92%
<b>250M / 20M</b>	40%	81%	8%	0%	88%
<b>1G / 100M</b>	32%	12%	0%	0%	41%

# Actual Availability as of Mid 2023

FCC National Broadband Map  
<https://broadbandmap.fcc.gov/area-summary/fixed>

Accessed 1/21/2024



## Broadband Summary

- Broadband speeds continue to increase, 300 Mb/s standard. 1 Gb/s optimal. Future: Multi Gb/s
- Relentless bandwidth demand means deploying fiber and upgrading / replacing equipment constantly.
- Competition from wireless, especially 5G
- Telco copper is doomed. Has been for years.



# How Long Will Broadband Speeds Increase?

## Key Technology Forecasting Principle:

- Performance improvement will continue as long as it's:
  - Technically feasible AND
  - Useful
- The rate may change if the technology approach changes.
- 10 Gb/s for sure – after that, who knows?

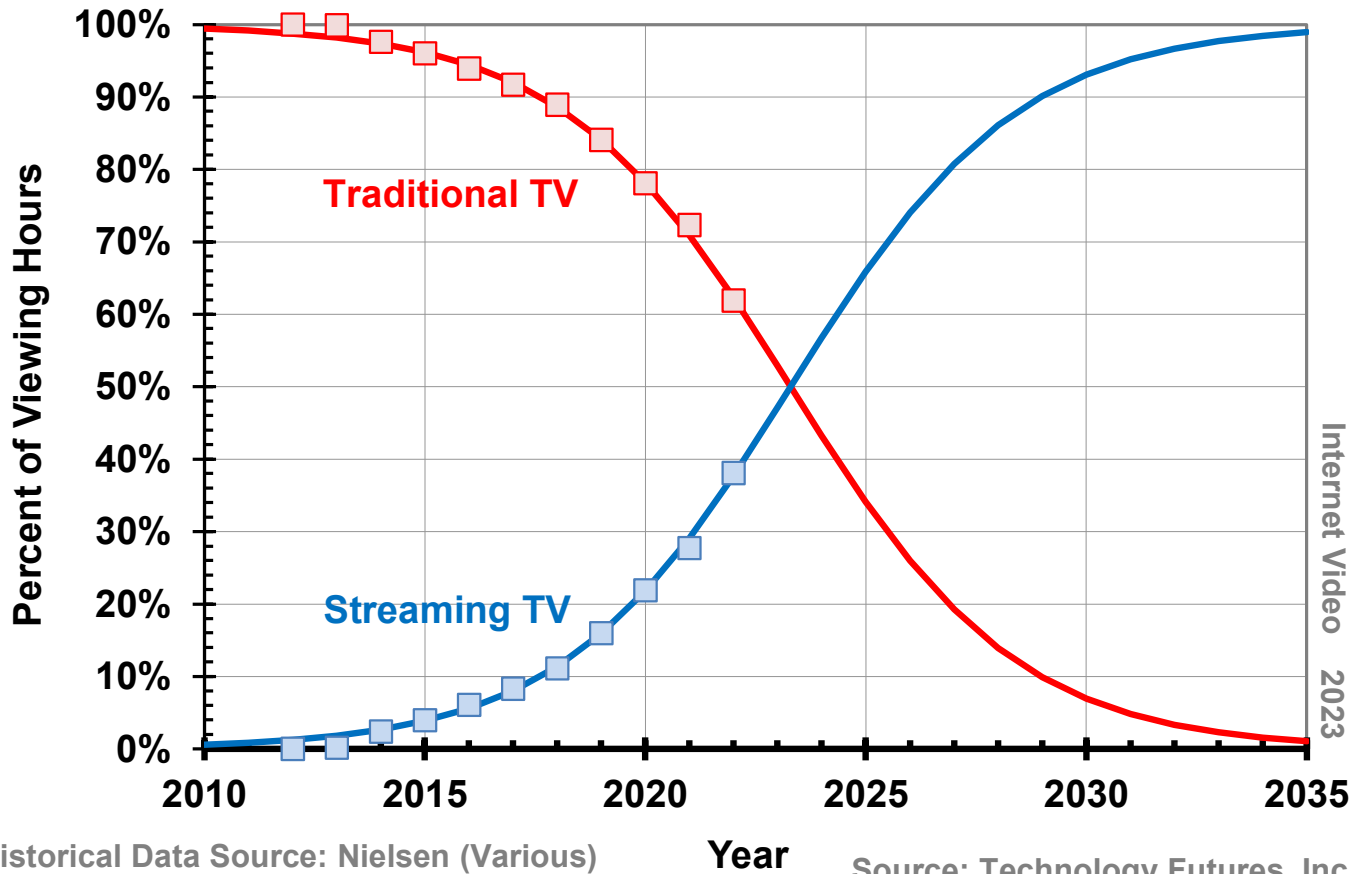
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# Online Video Forecasts

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# Traditional TV vs Streaming TV – 2023 TFI Forecast



Historical Data Source: Nielsen (Various)

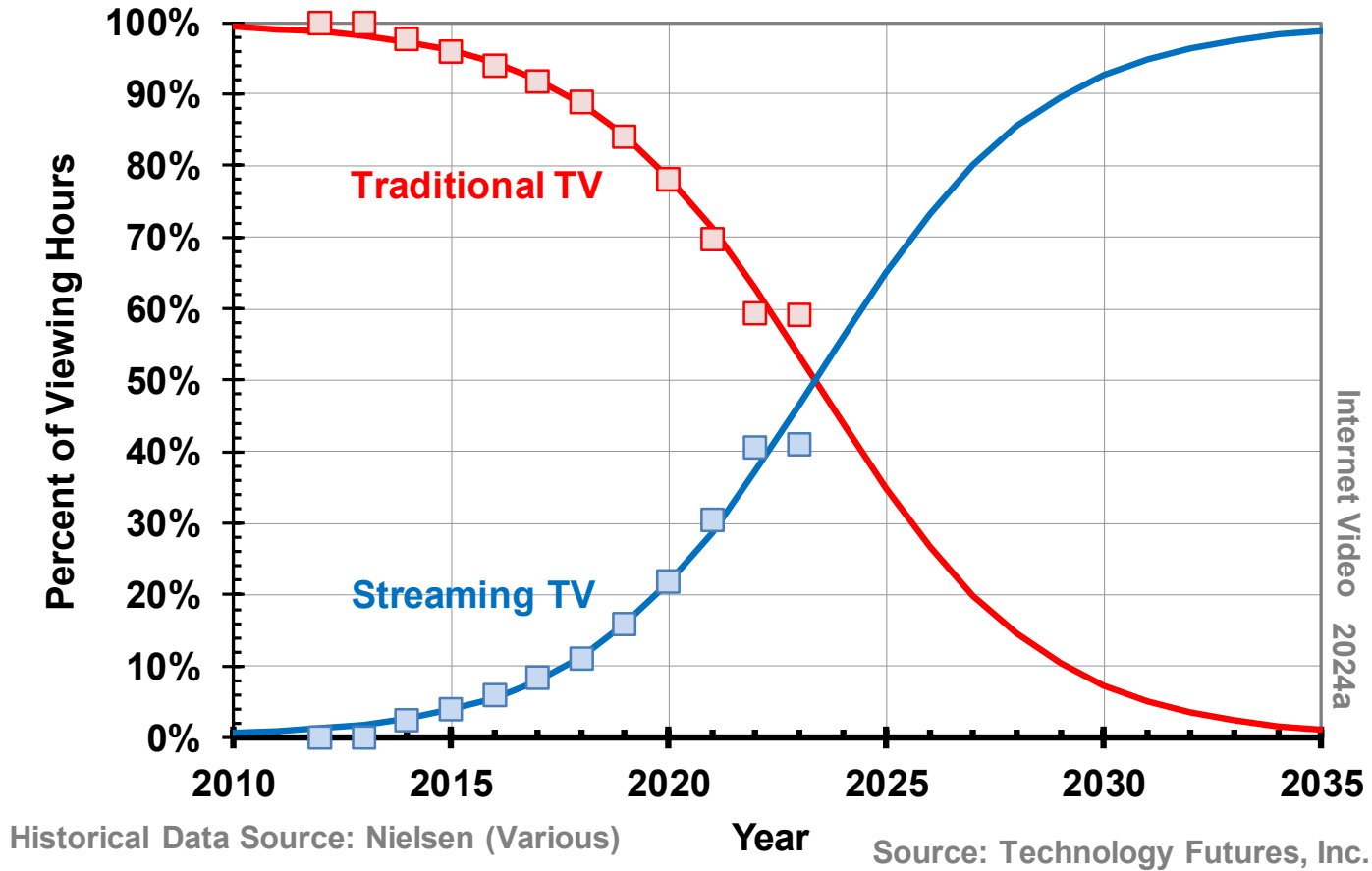
Year

Source: Technology Futures, Inc.

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# Traditional TV vs Streaming TV – 2024 TFI Forecast

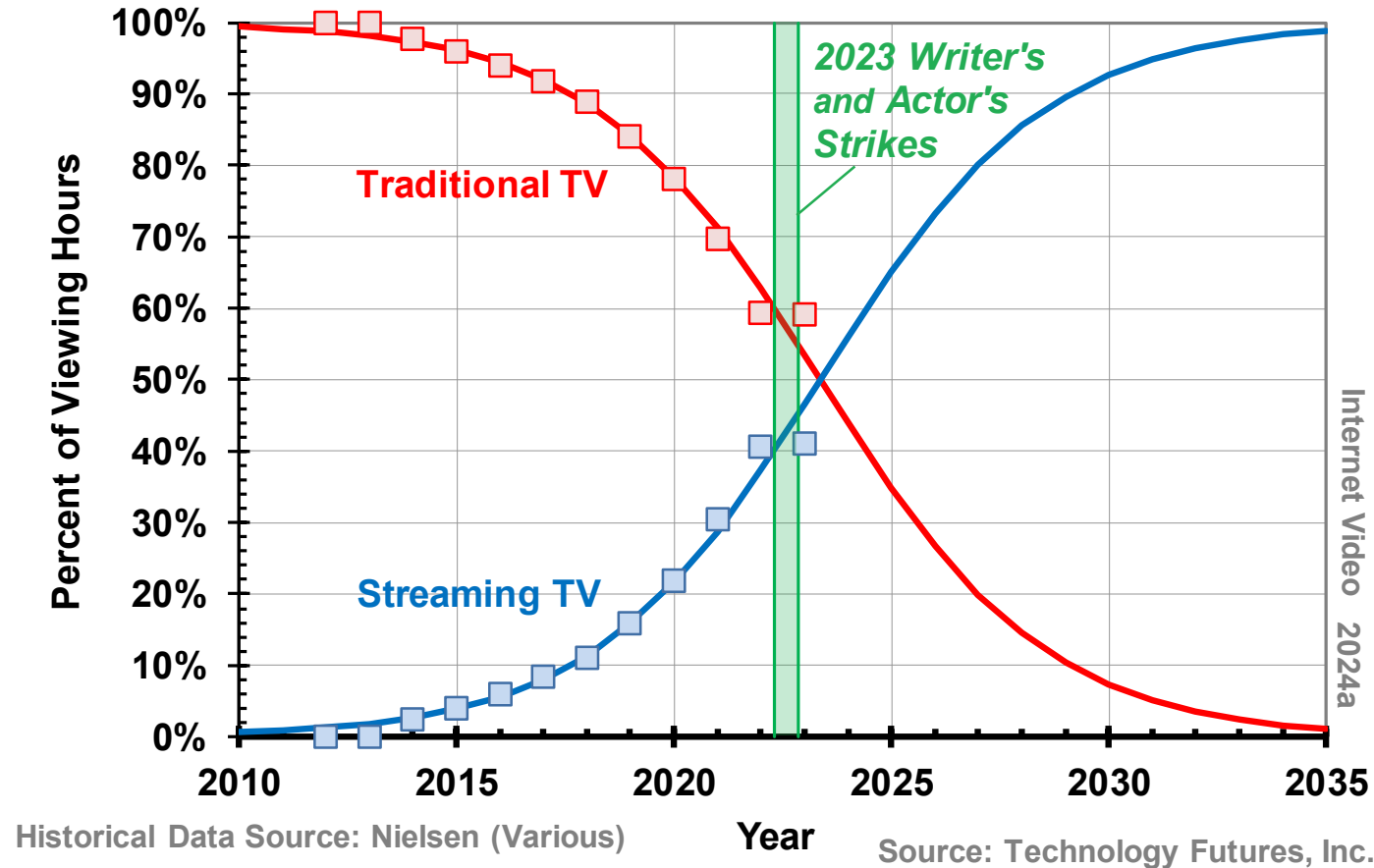


Internet Video 2024a



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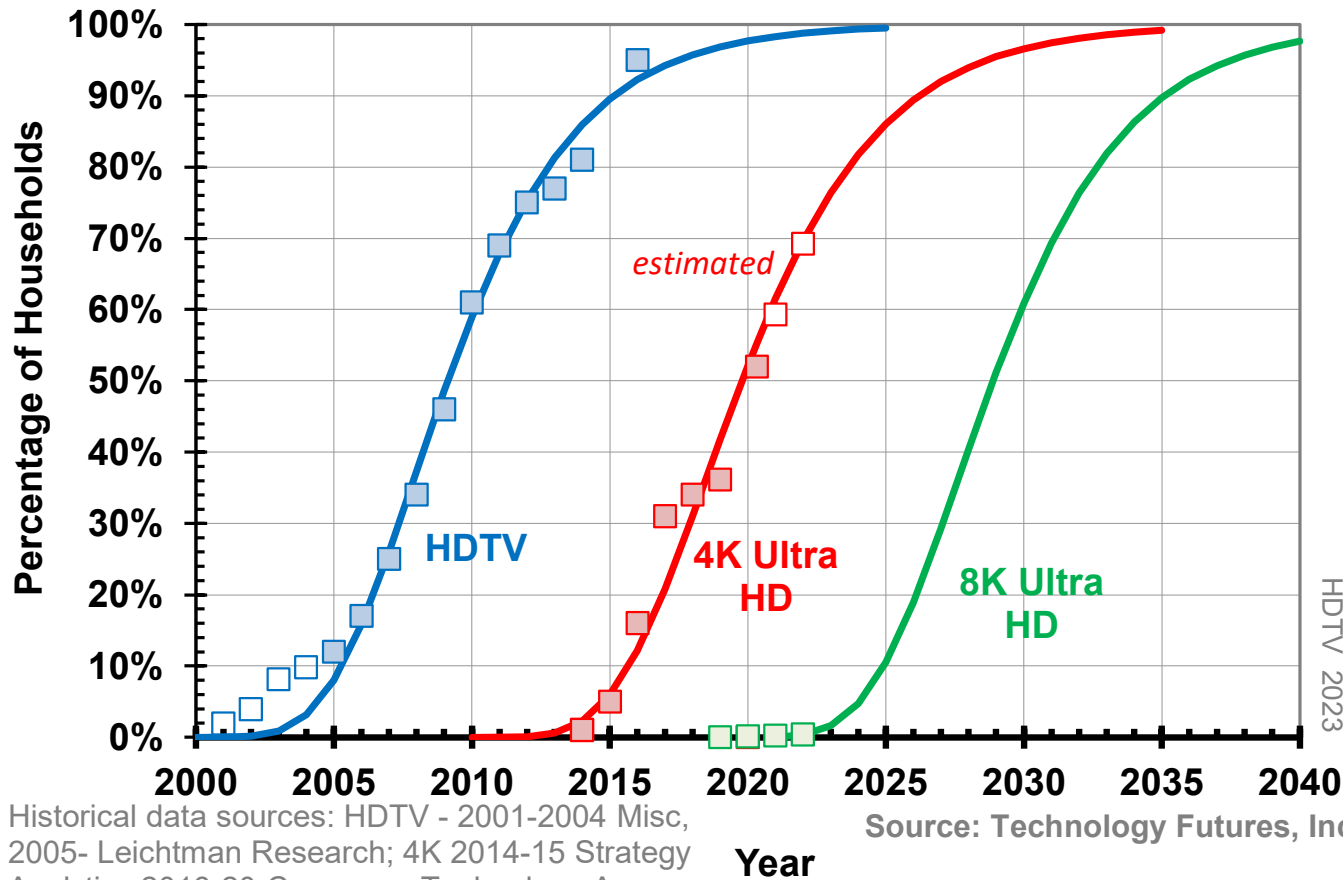
# Traditional TV vs Streaming TV – 2024 TFI Forecast



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# Ultra HD Households (4K and 8K) - 2023 TFI Forecast



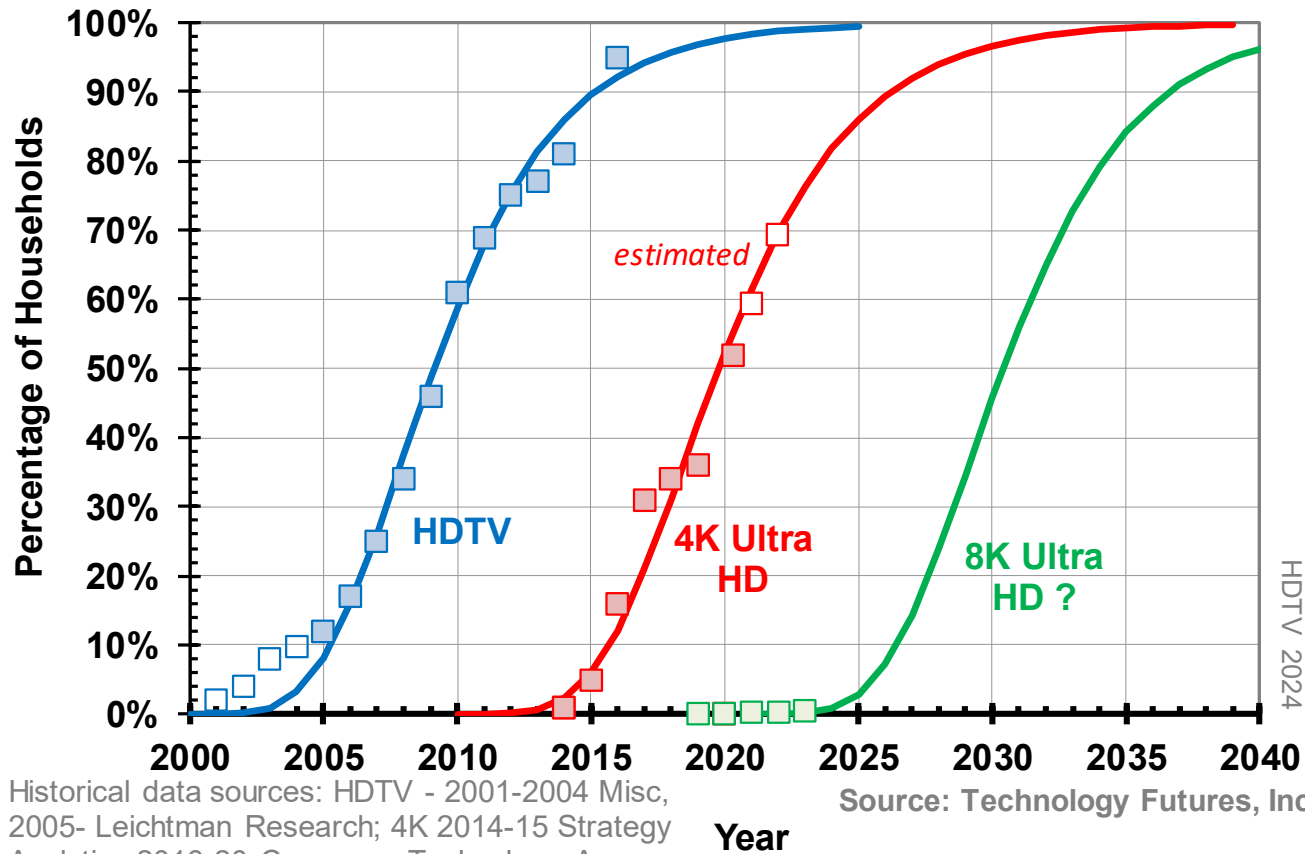
Historical data sources: HDTV - 2001-2004 Misc, 2005- Leichtman Research; 4K 2014-15 Strategy Analytics, 2016-20 Consumer Technology Assc 8K - 2019-20 Strategic Analytics, 2021-23 Trendforce

Source: Technology Futures, Inc.



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# Ultra HD Households (4K and 8K) - 2024 TFI Forecast



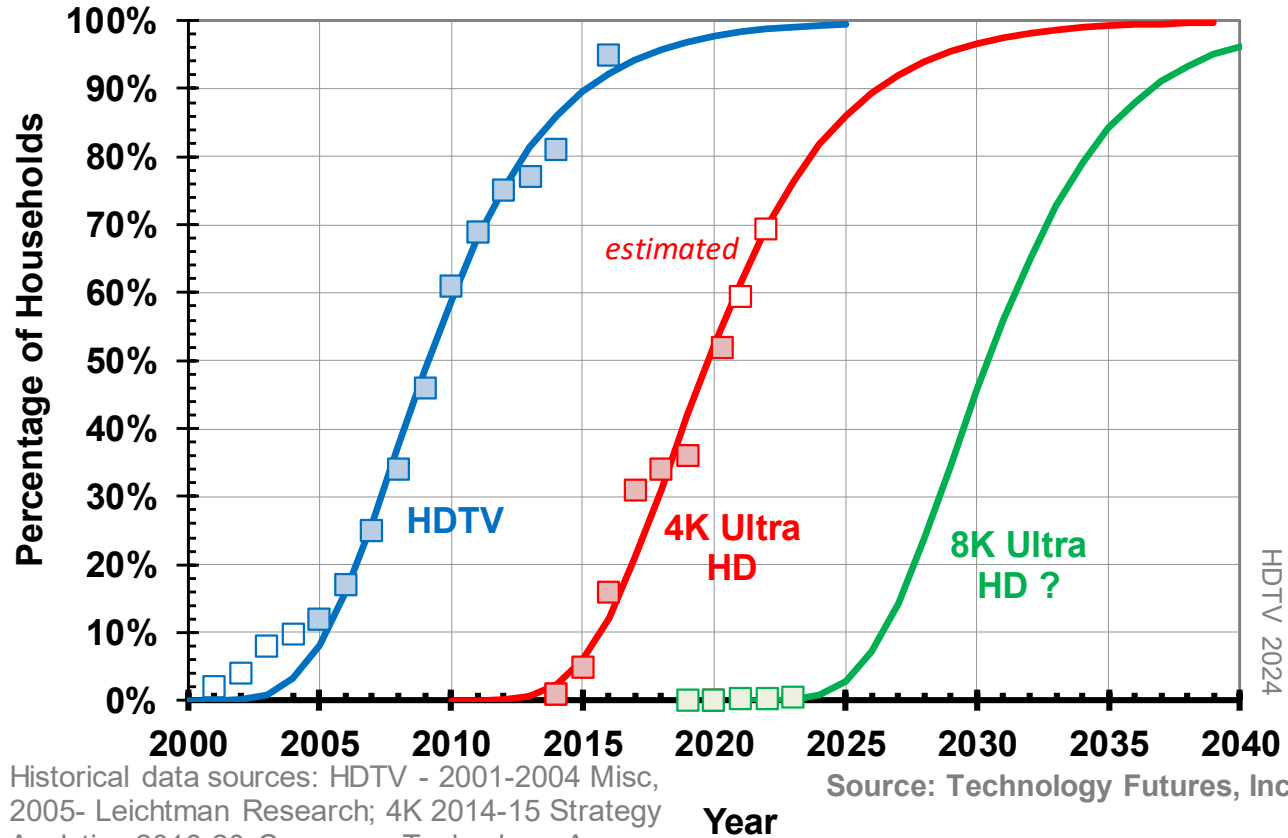
Historical data sources: HDTV - 2001-2004 Misc, 2005- Leichtman Research; 4K 2014-15 Strategy Analytics, 2016-20 Consumer Technology Assc 8K - 2019-20 Strategic Analytics, 2021-23 CTA

Source: Technology Futures, Inc.

HDTV 2024



# Ultra HD Households (4K and 8K) - 2024 TFI Forecast



Historical data sources: HDTV - 2001-2004 Misc, 2005- Leichtman Research; 4K 2014-15 Strategy Analytics, 2016-20 Consumer Technology Assc 8K - 2019-20 Strategic Analytics, 2021-23 CTA

Source: Technology Futures, Inc.

## Typical Streaming Data Rates

Std TV = ~ 2 Mb/s

HDTV = ~ 4 Mb/s

4K UHD = ~ 18 Mb/s

8K UHD = ~ 60 Mb/s





## Implications for Cable Companies

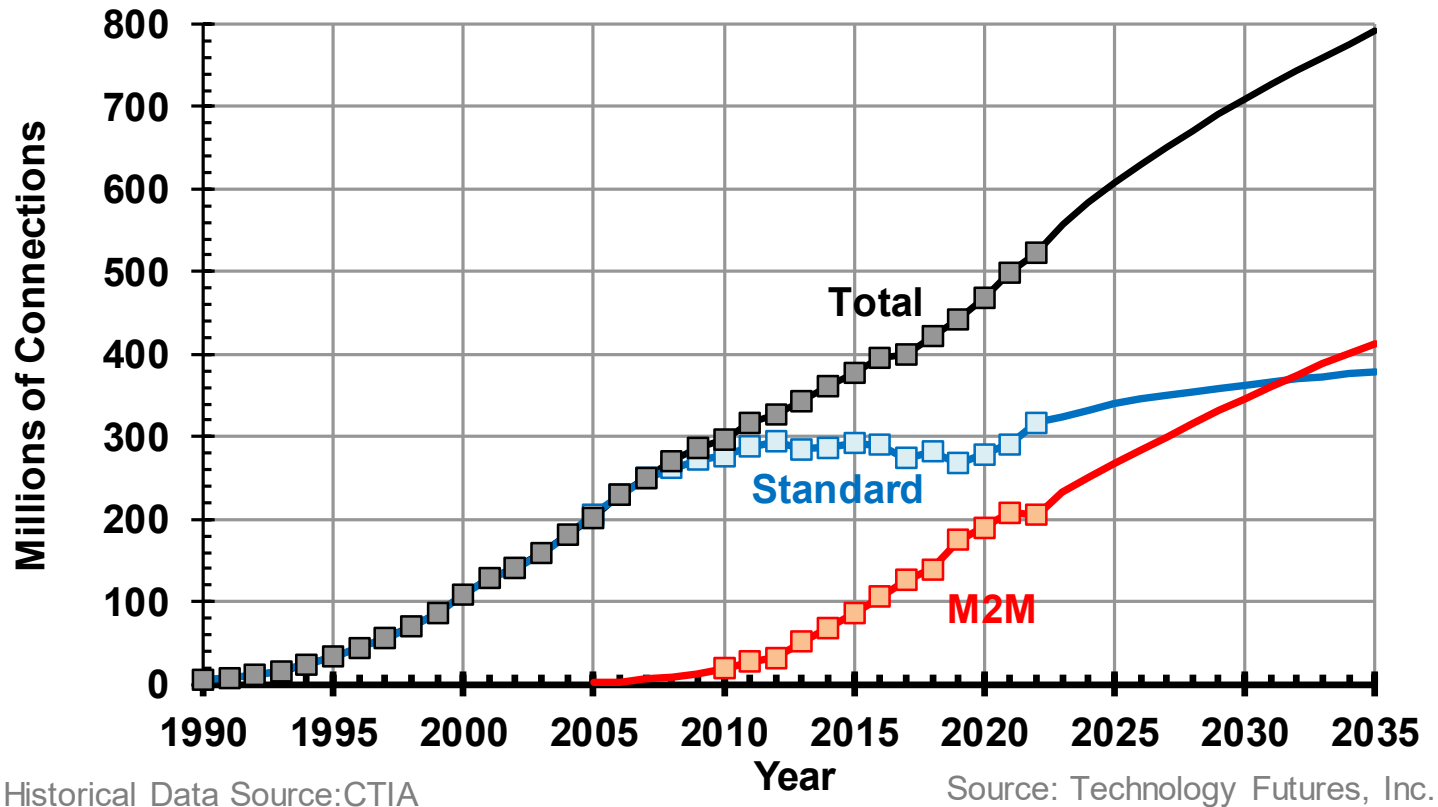
- Continued losses in multichannel TV subscriptions
- Continued need to provide multichannel and enhance broadband service simultaneously
- Competition from wireless, especially 5G
- Telcos have stepped up their game
- HFC networks are less energy efficient
- Increased investment without commensurate increase in revenue

# Wireless Forecasts

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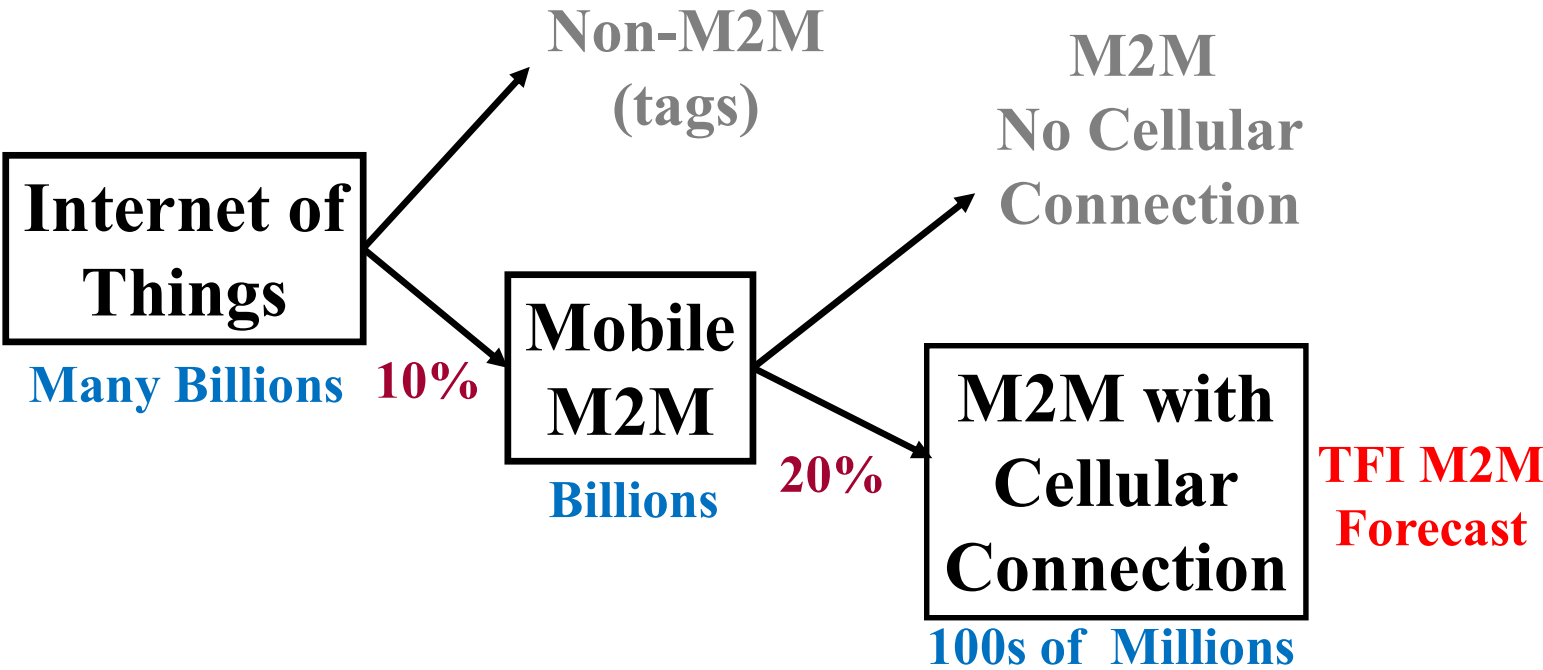
# Wireless Connections – 2024 TFI Forecast



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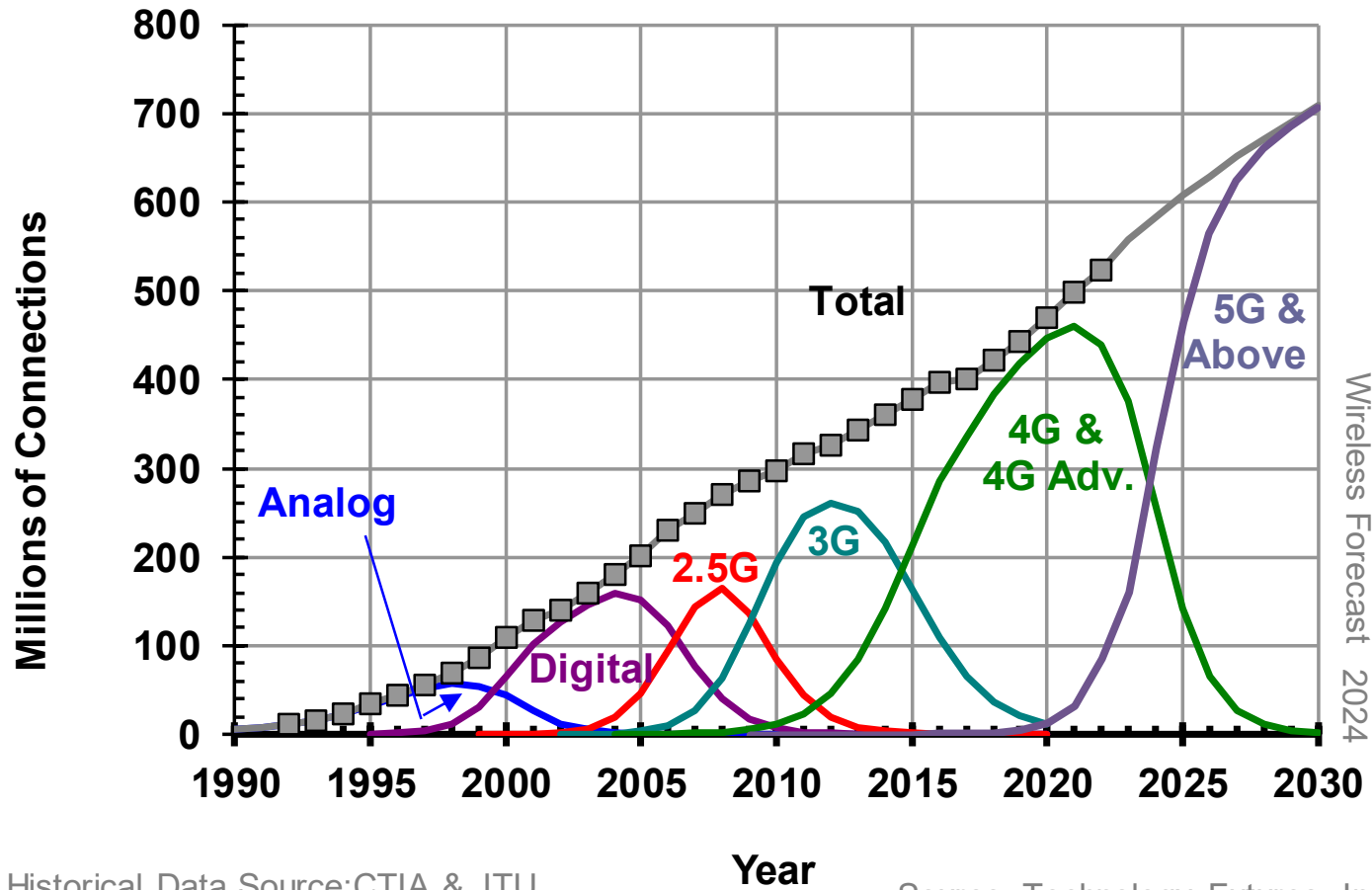
# The IoT will include many items unconnected to the cellular network



*Based on GSMA estimates*



# Wireless Generations – 2024 TFI Forecast



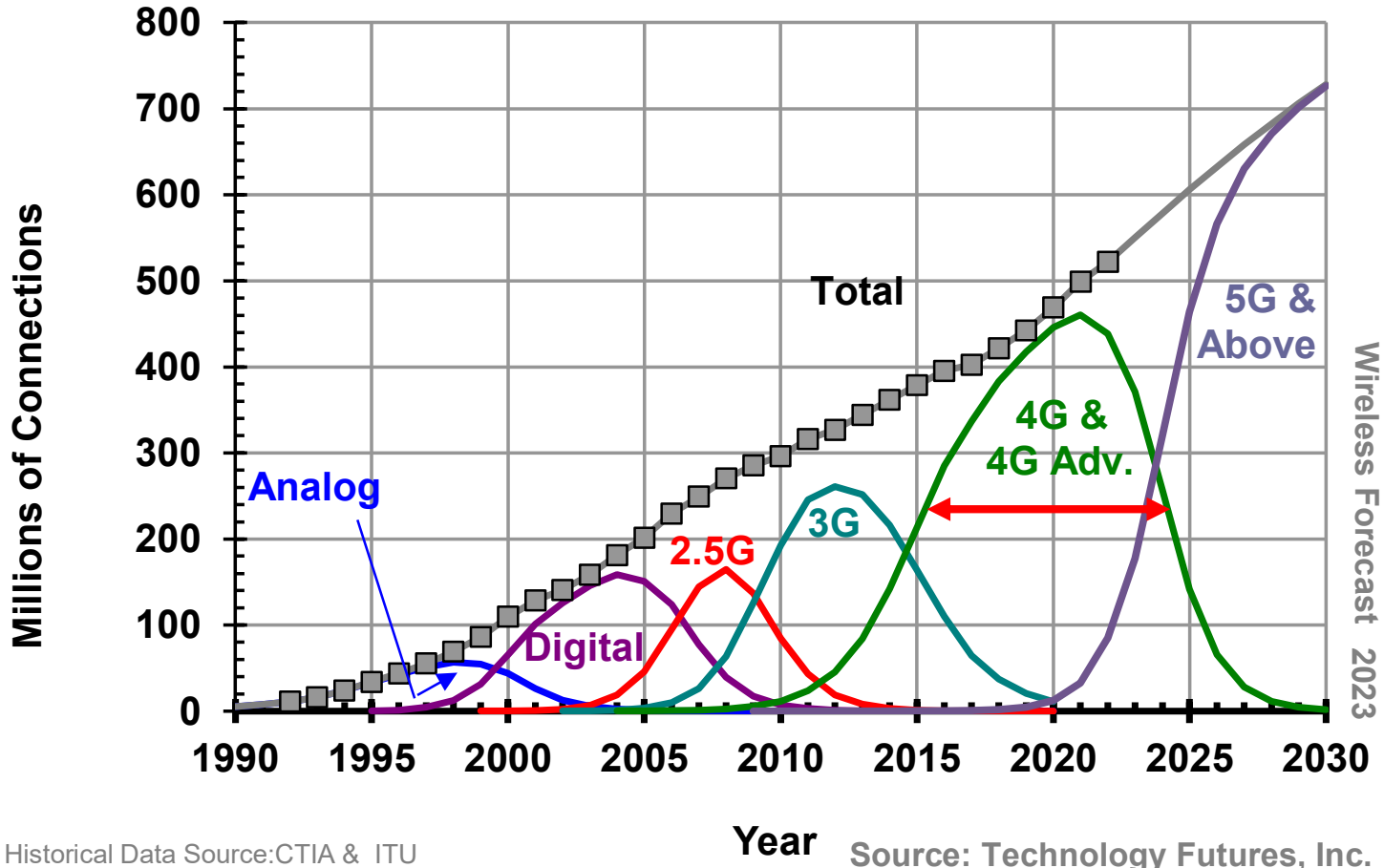
Historical Data Source: CTIA & ITU

Source: Technology Futures, Inc.



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# Wireless Generations – 2023 TFI Forecast



Historical Data Source: CTIA & ITU

Year Source: Technology Futures, Inc.

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## Implications for Wireless Providers

- Never ending appetite for more bandwidth and performance
- Now seriously competing with wireline broadband in some cases
- More focus on M2M than before
- Greatly improving cost/performance of newer technology
- Continuous investment in new technology and spectrum

## Overall Industry Assessment

- Continued increases in demand for bandwidth and higher performance
- Continued delivery of those increases – No rest for the wicked
- Continued investment in technology to make them happen
- All in a highly competitive environment
- And still central to our future!





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