

The Cost Of Exchange Services

Disclosing the Cost of Offering Market
Data and Connectivity as a National
Securities Exchange

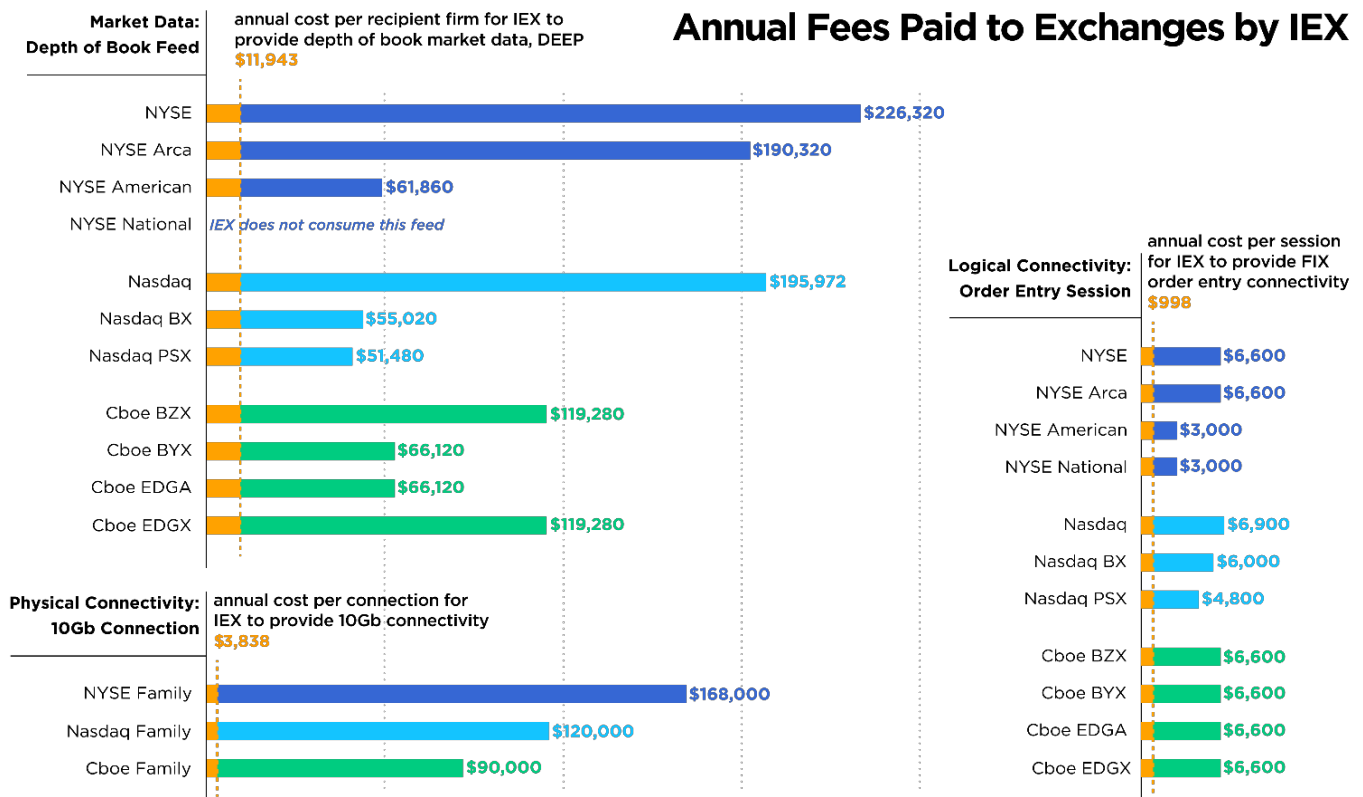


THE COST OF EXCHANGE SERVICES

Disclosing the Cost of Offering Market Data and Connectivity as a National Securities Exchange

Overview

In response to growing concerns about the costs of exchange market data and connectivity and requests for transparency by regulators and other market participants, Investors Exchange (“IEX” or the “Exchange”) has conducted a detailed review of its own costs to provide market data, as well as the physical connectivity and logical connectivity functions that are vital for trading on exchanges. Because IEX’s routing broker-dealer affiliate, like other market participants, is a member of the NYSE, Nasdaq, and Cboe exchange families, we pay the same types of fees for market data and connectivity that other participants incur. We compare the fees these other exchanges charge IEX for these products and services to the annual costs IEX incurs to provide these same services to our own members.¹ Figure 1 below compares the annual cost for IEX to provide 10 gigabit (Gb) connectivity to one physical port, order entry access to one session, and depth of book market data with the annual fees IEX is invoiced for such equivalent services by NYSE, Nasdaq, and Cboe exchanges. Many firms will require multiple physical connections, potentially dozens of logical connections, and more expensive market data services due to their size or use in trading strategies or otherwise.



¹ Note that this study does not include CHX, since ICE purchased the previously independently owned exchange in July 2018 and has yet to update the fee schedule.



Background

The Evolution of the Exchange Business Model

Our approach to allocating costs for market data and connectivity derives from our experience of operating a national securities exchange.

Fundamentally, the primary function of exchanges is to match buyers and sellers of securities at a fair price based on transparent rules. Most of IEX's costs are dedicated to this function, including sales and marketing, software development, technology infrastructure, analytics, quantitative research, operations, compliance, and other functions. We allocate resources to build products and services that allow us to do this. In performing the primary function of matching buyers and sellers, national securities exchanges operate with an exclusive government license, which gives them unique benefits and also subjects them to close oversight with the goal of ensuring they operate in ways that serve the public interest and do not unfairly discriminate or impede competition. As such, the Securities Exchange Act of 1934 requires that all fees charged by exchanges be "fair and reasonable". Exchanges charge a variety of fees, which historically have been transaction fees, to compensate them for performing this primary function.

Over the last two decades, U.S. exchanges have evolved from industry collectives to become parts of three large multi-national publicly-traded companies. At the same time, over this period they have augmented their businesses by selling speed and information in the form of "co-location" access, various connectivity options, and proprietary market data. These secondary business lines are not inherent to the core function of operating an exchange (and can actually complicate the ability of exchanges to fairly price and match trades), but as the dominant exchange operators have all come to adopt this change in business strategy, these market data and connectivity offerings have become indispensable to many market participants who must compete in a market system where trading outcomes can depend on time differences measured in millionths of a second. At the same time, these secondary business segments have come to represent a fast-growing and lucrative source of revenue for the large exchange operators as they have been able to consistently increase these revenues by regularly increasing fees and introducing product "innovations," which typically involve more expensive versions of existing products, except for small incremental differences in speed or data content that many active participants need, or feel compelled, to purchase to remain competitive. Further, these secondary products and services are charged on a subscription basis (typically monthly) which makes the revenue from these sources more predictable than transaction-related fees that fluctuate with changes in market-wide volume and market share.

Using IEX Direct Costs as a Basis of Comparison

Although there are some variations in market data and connectivity offerings among exchanges, the basic processes and components involved in providing market data and connectivity are similar for all exchanges such that new product variations do not involve significant capital investment or operating expense. In addition, each of the large exchange operators is able to spread costs it incurs across multiple exchanges (as of now, five for NYSE, four for Cboe, and three for Nasdaq). For this reason, the per unit cost to provide analogous products and services would tend to be less for exchange families that operate multiple exchanges, compared to IEX, which operates a single exchange. Further, in order to conduct its own business, IEX, like other market participants, is required to subscribe to and pay for exchange market data and connectivity.

Thus, in considering the cost to offer market data and connectivity, we believe it is appropriate to isolate IEX's direct costs to produce and offer these secondary products and services from other costs related to the primary function of



matching buyers and sellers and to compare those costs to the fees that other exchanges charge IEX for market data and connectivity. Because of the economies of scale and other factors identified in this study, we believe our calculation of IEX's costs is a conservative measure of the actual per unit or per user costs other exchanges likely incur in offering market data and connectivity.

Note on Cost Methodology

Throughout this study, we describe the expenses directly associated with offering market data and connectivity. These expenses include, but are not limited to, networking equipment, servers, fiber optic network circuits, software licenses, data center space, data center power, data center security, and IEX employees or contractors (referred to as "personnel" throughout this study).

Any invoices paid throughout the year for software licenses and leased services, such as network circuits, were included in this study. Further, infrastructure purchased for the IEX system was depreciated over three years. Therefore, the cost of each asset was divided evenly across 36 months, meaning one-third of the total cost of the asset is reflected in the annual costs discussed in this study.

Personnel costs reflect those individuals who are directly involved with the design, build, test, deployment, and operation of the product or service from a product, legal, regulatory, information security, operational, and technical perspective. We applied a specific blended rate for each service based on the personnel identified. The blended rate includes salary, stock compensation, annual cash bonus, benefits, payroll taxes, and 401(k) matching contributions.

Additional detailed breakdowns of the infrastructure and personnel costs directly associated with each of the three product and service categories are provided below in the related sections of this study.

IEX System Architecture

Throughout this study, we describe the portions of the IEX system architecture that are involved with providing the product or service. To help readers understand the cost of offering market data and connectivity in the broader context of exchange operations, the overall architecture is described below. Figure 2 shows the hardware components that process the receipt of trading messages from users (beginning at the left end of the illustration), continuing with the execution of trades, and ending with the distribution of market data to data recipients (at the right end of the illustration). The illustration shows the components, but it does not reflect the total number included in the system. For purposes of our cost calculations, however, the total number of components was taken into account.

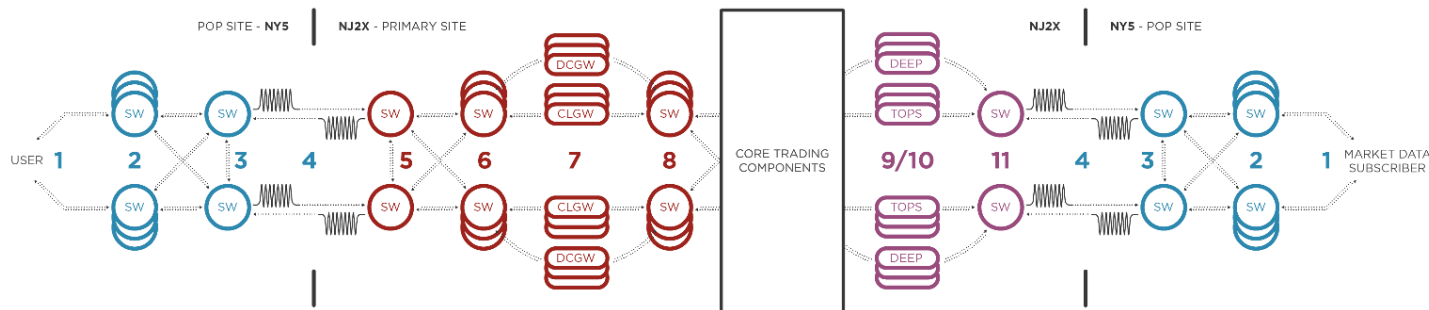


Figure 2 illustrates the physical infrastructure that comprises the Core Trading System of the Investors Exchange.



IEX uses a “leaf-and-spine” network architecture.² The “leaf layer” consists of access switches that connect to devices like servers or other switches. In the illustration, this layer includes the segments that are shown with multiple components in each half of the redundant architecture (for example, those labeled 2, 6, and 8). The “spine layer” is the backbone of the network and consists of distribution switches (including those labeled 3 and 5) that consolidate and route messages received from the leaf layer. Every leaf switch is interconnected with every spine switch.

Access layer switches acting in concert must have the capacity to accept every physical connection from end users. As more users directly connect, more access layer switches are required. Those connections are consolidated via the access layer switches so that many inputs result in just a few outputs. Therefore, many access layer switches can be supported by only two distribution switches (“SW” in the sections labeled 3 and 5). One can imagine the flow of data through the access and distribution layers as passing through a funnel, where the access layer switches (leaf layer) represent the top of the funnel and the distribution switches (spine layer) comprise the bottom of the funnel.

Note that the sections labeled 1, 2, 3, and 4 appear on both the left and right side of the illustration, because the same physical infrastructure used to receive orders is also used to distribute market data. To be clear, the physical infrastructure for order entry, order receipt (i.e., confirmation that an order has been received), receipt of drop copies and trade reporting (i.e., messages confirming whether a trade is executed or canceled), and data product dissemination (i.e., real time distribution of proprietary market data feeds) offered by exchanges is the same for all these functions. For entities operating multiple exchanges, the same physical infrastructure would be used to receive orders and distribute market data across affiliated exchanges.

The lifecycle of an order through the IEX system architecture starts on the left side with a user submitting a new order single message through the cross-connect cable provided to the user at the IEX “point of presence” (IEX POP) at a datacenter in Secaucus, NJ (NY5). The message traverses several network switches and a defined length of optical fiber coil before reaching the first piece of software in the IEX system located in Weehawken, NJ (NJ2x) 350 microseconds (μs) later. This 350 μs of intentional latency is typically referred to as the IEX “speed bump.” A client gateway (labeled CLGW in Figure 2 above) receives, validates, and transforms each user message into IEX’s internal message protocol, then sends the message to the system for further processing. The market data processes (labeled TOPS and DEEP, in Figure 2 above, for the top of book and depth of book feeds, respectively) receive messages from the system, transform the data into the format specified in those protocol specifications, then sends the messages to data recipients.

For example, assume that a user sends a new order that is intended to be displayed and that sets the best bid price on IEX. The system processes the order, posts it to the order book, and sends several messages, including a message acknowledging the receipt of the order and another updating the top of book quotation of IEX for that security. The acknowledgement is received by the client gateway and sent back to the user at the IEX POP after passing through the 350 μs speed bump. Virtually simultaneously, the quote update message is received by the IEX applications that publish IEX’s proprietary market data feeds and disseminated to each market data recipient via multicast (transmission of one message to multiple recipients simultaneously) at the IEX POP after passing through the 350 μs speed bump.

The remainder of this document is divided into three main sections that mirror the three main processes described above: Market Data (9/10 and 11 in the illustration); Physical Connectivity (1, 2, 3, 4), and Logical Connectivity, which concerns the processing of orders in order entry sessions (5, 6, 7, 8).

² See Cisco Data Center Spine-and-Leaf Architecture: Design Overview White Paper (<https://www.cisco.com/c/en/us/products/collateral/switches/nexus-7000-series-switches/white-paper-c11-737022.html>).



Market Data

In the context of this document, market data refers to the real-time data produced by an exchange to disseminate information about its order book. Exchanges contribute only a tiny fraction of the data found on such feeds.³ As illustrated by the example in the preceding section, exchange market data is derived exclusively from orders that are sent by the exchange's members. The exchange's function is simply to format and rebroadcast the data contained in these order messages back to participants and to data vendors. Even data that requires more processing by an exchange (for example, auction messages that represent indicative prices and imbalances for opening and closing auctions) is exclusively derived from a larger set of data that is supplied by its members. Unlike other subscription businesses such as Netflix, Sirius/XM Satellite radio, and newspaper publishers, exchanges produce virtually no unique content found on their real-time market data feeds.

Forms of Market Data

Exchanges provide many different types of market data, but, as detailed below, they can be divided into four generic categories: Depth of Book, Top of Book, Last Sale, and Auction Imbalance. In addition, the exchanges and FINRA jointly oversee the dissemination of the consolidated data feeds by the securities information processors (SIPs). Tables 1, 2, 3, and 4 below focus on the fees that various types of firms (principal trading, agency broker, alternative trading system (ATS), data vendor, etc.) may incur.⁴ In addition, the pricing in Table 3 also includes fees a retail trading platform, media service (e.g., website, TV, apps), or data vendor would likely incur when distributing Last Sale data to its user base.⁵ Many larger firms likely require multiple data feeds from each major exchange company based on the needs of individual trading desks within the firm or external customers of the firm.

To receive market data, a user typically pays separate fees for (i) physical connectivity to the exchange, (ii) an additional connectivity charge to receive market data through that connection, and (iii) the content of the market data itself, which varies depending on how the data is used (whether it is displayed to all other participants or non-displayed), and whether and how it is redistributed. These fee categories are described and reflected in this section or the Physical Connectivity section of this study. The per user, per platform, per device, and per logical port fees have been listed in this section and are dependent on the number of people, platforms, devices, or logical ports that have access to the data – these fees have been marked ¹, ², ³, and ⁴, respectively, in Tables 1, 2, 3, and 4 below. Please note that the fee schedules outlined in this study do not represent the full set of fees found on each exchange's price list.

³ For example, trading status (halts and resumptions), trading session transitions, and system transitions.

⁴ Pricing as of January 2019 from NYSE Market Data Pricing for NYSE, Arca, American, and National (https://www.nyse.com/publicdocs/nyse/data/NYSE_Market_Data_Pricing.pdf), Nasdaq Data Products Price List for Nasdaq, BX, and PSX (<http://nasdaqtrader.com/Trader.aspx?id=DPUSdata>), Cboe Fee Schedules for BZX, BYX, EDGA, and EDGX (https://markets.cboe.com/us/equities/membership/fee_schedule/bzx/, https://markets.cboe.com/us/equities/membership/fee_schedule/byx/, https://markets.cboe.com/us/equities/membership/fee_schedule/edga/, https://markets.cboe.com/us/equities/membership/fee_schedule/edgx/), and IEX Fee Schedule (<https://iextrading.com/trading/fees/>).

⁵ See Id.



Depth of Book

Depth of Book data shows all displayed orders at an exchange at all price levels.⁶ This data, together with data on trades that have been executed on the exchange and data showing order imbalances related to opening or closing auctions, provides the full view of an exchange's order book. Depth of Book feeds provide either (i) the aggregated number of shares available at each price within the order book (an aggregated feed) or (ii) details about each individual order that has been entered, modified, or canceled from the order book (an order-by-order feed). Note that IEX has chosen to provide only aggregated data because we believe that order-by-order data provides an unfair information advantage to recipients that can fully leverage the data, leaving other participants at a disadvantage. The Nasdaq family, NYSE Arca, and NYSE National provide an order-by-order feed but not an aggregated feed, whereas all other exchanges offer both.

Table 1 below lists the fees various types of data recipient firms may incur from the exchange fee schedules. The actual charge incurred by a firm will depend on the nature and size of its business, since many of the fees are charged per unit.

Exchange Family	Exchange	Depth Type	Feed Name	Fee Name	Monthly Fees	Annual Fees
NYSE	NYSE	Order-by-Order	NYSE Integrated	Access Fee	\$ 7,500	\$ 90,000
				Redistribution Fee	\$ 4,000	\$ 48,000
				Non-Display Fee – Category 1 (Principal) ²	\$ 20,000	\$ 240,000
				Non-Display Fee – Category 2 (Agency) ²	\$ 20,000	\$ 240,000
				Non-Display Fee – Category 3 (Matching) ²	\$ 20,000	\$ 240,000
				Professional User Fee ¹	\$ 70	\$ 840
		Non-Professional User ¹	\$ 16	\$ 192		
		Aggregated	NYSE OpenBook	Access Fee	\$ 5,000	\$ 60,000
				Redistribution Fee	\$ 3,000	\$ 36,000
				Non-Display Fee – Category 1 (Principal) ²	\$ 6,000	\$ 72,000
	Non-Display Fee – Category 2 (Agency) ²			\$ 6,000	\$ 72,000	
	NYSE Arca	Order-by-Order	NYSE Arca Integrated	Access Fee	\$ 3,000	\$ 36,000
				Redistribution Fee	\$ 3,750	\$ 45,000
				Non-Display Fee – Category 1 (Principal) ²	\$ 10,500	\$ 126,000
				Non-Display Fee – Category 2 (Agency) ²	\$ 10,500	\$ 126,000
				Non-Display Fee – Category 3 (Matching) ²	\$ 10,500	\$ 126,000
			NYSE ArcaBook	Professional User Fee ¹	\$ 60	\$ 720
				Non-Professional User ¹	\$ 20	\$ 240
				Access Fee	\$ 2,000	\$ 24,000
				Non-Professional Enterprise	\$ 40,000	\$ 480,000
Redistribution Fee				\$ 2,000	\$ 24,000	
NYSE American	Order-by-Order	NYSE American Integrated	Non-Display Fee – Category 1 (Principal) ²	\$ 6,000	\$ 72,000	
			Non-Display Fee – Category 2 (Agency) ²	\$ 6,000	\$ 72,000	
			Non-Display Fee – Category 3 (Matching) ²	\$ 6,000	\$ 72,000	
			Professional User Fee ¹	\$ 60	\$ 720	
			Non-Professional User ¹	\$ 10	\$ 120	
			Professional Enterprise	\$ 75,000	\$ 900,000	

⁶ Note that Nasdaq Level 2 is not included in this study as the feed offers only top of book data for each attributed member and aggregates a top of book collectively for all unattributed members. Nasdaq Level 2 provides some data about price levels beyond the best price, but it does not provide the same level of detail as the order-by-order or aggregated depth of book feeds described here.



Exchange Family	Exchange	Depth Type	Feed Name	Fee Name	Monthly Fees	Annual Fees
				Professional User Fee ¹	\$ 10	\$ 120
				Non-Professional User ¹	\$ 2	\$ 24
		Aggregated	NYSE American OpenBook	Access Fee	\$ 1,000	\$ 12,000
				Redistribution Fee	\$ -	\$ -
				Non-Display Fee – Category 1 (Principal) ²	\$ 2,000	\$ 24,000
				Non-Display Fee – Category 2 (Agency) ²	\$ 2,000	\$ 24,000
				Non-Display Fee – Category 3 (Matching) ²	\$ 2,000	\$ 24,000
				Professional User Fee ¹	\$ 5	\$ 60
				Non-Professional User ¹	\$ 1	\$ 12
	NYSE National	Order-by-Order	NYSE National Integrated	Access Fee	\$ -	\$ -
				Redistribution Fee	\$ -	\$ -
				Non-Display Fee – Category 1 (Principal) ²	\$ -	\$ -
				Non-Display Fee – Category 2 (Agency) ²	\$ -	\$ -
				Non-Display Fee – Category 3 (Matching) ²	\$ -	\$ -
				Professional User Fee ¹	\$ -	\$ -
				Non-Professional User ¹	\$ -	\$ -

Exchange Family	Exchange	Depth Type	Feed Name	Fee Name	Monthly Fees	Annual Fees
Nasdaq	Nasdaq	Order-by-Order	Nasdaq TotalView (ITCH)	Real-Time Data Products Administration Fee	\$ 100	\$ 1,200
				Delayed Data Products Administration Fee	\$ 50	\$ 600
				Internal Distributor	\$ 1,500	\$ 18,000
				Direct Access	\$ 3,000	\$ 36,000
				Non-Display Platform ²	\$ 5,000	\$ 60,000
				Non-Display via Direct Access ³	\$ 375	\$ 4,500
				Enterprise	\$ 30,000	\$ 360,000
				External Distribution	\$ 3,750	\$ 45,000
				FPGA Internal Distributor	\$ 25,000	\$ 300,000
				FPGA External Distributor	\$ 2,500	\$ 30,000
				FPGA Managed Data Solutions Distributor	\$ 5,000	\$ 60,000
				Managed Data Solutions License Fee	\$ 2,500	\$ 30,000
				Professional/Corporate ¹	\$ 76	\$ 912
				Web-Based Products Administration Fee	\$ 100	\$ 1,200
				Non-Professional User ¹	\$ 15	\$ 180
				Non-Professional Enterprise	\$ 500,000	\$ 6,000,000
				TCP ITCH Port ⁴	\$ 750	\$ 9,000
				Multicast ITCH (MTCH) - software ⁴	\$ 1,000	\$ 12,000
				Multicast ITCH (MTCH) - software & hardware ⁴	\$ 2,500	\$ 30,000
				DR Ports	\$ -	\$ -
				Professional Enterprise	\$ 100,000	\$ 1,200,000
	Nasdaq BX	Order-by-Order	Nasdaq BX TotalView (ITCH)	Real-Time Data Products Administration Fee	\$ 100	\$ 1,200
				Delayed Data Products Administration Fee	\$ 50	\$ 600
				Internal Distributor	\$ 750	\$ 9,000
				Direct Access	\$ 1,000	\$ 12,000
				Non-Display Platform ²	\$ -	\$ -
				Non-Display via Direct Access ³	\$ 55	\$ 660
				Enterprise	\$ 20,000	\$ 240,000
				External Distribution	\$ 1,500	\$ 18,000
				Managed Data Solutions Distribution Fee	\$ 1,500	\$ 18,000
				Managed Data Solutions License Fee	\$ -	\$ -
				Professional/Corporate ¹	\$ 40	\$ 480
				Web-Based Products Administration Fee	\$ -	\$ -
				Non-Professional User ¹	\$ 1	\$ 12
				Non-Professional Enterprise	\$ -	\$ -
				TCP ITCH Port ⁴	\$ 750	\$ 9,000
				Multicast ITCH (MTCH) - software ⁴	\$ 1,000	\$ 12,000
				DR Ports	\$ -	\$ -
				Professional Enterprise	\$ -	\$ -
	Nasdaq PSX	Order-by-Order	Nasdaq PSX TotalView (ITCH)	Real-Time Data Products Administration Fee	\$ 100	\$ 1,200
				Delayed Data Products Administration Fee	\$ 50	\$ 600
				Internal Distributor	\$ 500	\$ 6,000
				Direct Access	\$ 1,000	\$ 12,000
				Non-Display Platform ²	\$ -	\$ -



Exchange Family	Exchange	Depth Type	Feed Name	Fee Name	Monthly Fees	Annual Fees
				Non-Display via Direct Access ³	\$ 50	\$ 600
				Enterprise	\$ 17,000	\$ 204,000
				External Distribution	\$ 1,250	\$ 15,000
				Managed Data Solutions Distribution Fee	\$ 1,500	\$ 18,000
				Professional/Corporate ¹	\$ 40	\$ 480
				Web-Based Products Administration Fee	\$ -	\$ -
				Non-Professional User ¹	\$ 1	\$ 12
				Non-Professional Enterprise	\$ -	\$ -
				TCP ITCH Port ⁴	\$ 400	\$ 4,800
				Multicast ITCH (MTCH) - software ⁴	\$ 1,000	\$ 12,000
				DR Ports	\$ -	\$ -
				Professional Enterprise	\$ -	\$ -

Exchange Family	Exchange	Depth Type	Feed Name	Fee Name	Monthly Fees	Annual Fees					
Cboe	Cboe BZX	Order-by-Order	BZX Depth (PITCH)	Internal Distributor	\$ 1,500	\$ 18,000					
				External Distributor	\$ 5,000	\$ 60,000					
				Non-Display Usage by Trading Platforms	\$ 5,000	\$ 60,000					
				Non-Display Usage not by Trading Platforms	\$ 2,000	\$ 24,000					
				Professional User Fee ¹	\$ 40	\$ 480					
				Non-Professional User Fee ¹	\$ 5	\$ 60					
				Multicast PITCH Spin Server Ports (pair) ⁴	\$ 550	\$ 6,600					
				Multicast PITCH Gap Request Proxy (GRP) Port ⁴	\$ 550	\$ 6,600					
				Enterprise Fee	\$ 100,000	\$ 1,200,000					
				Internal Distributor	\$ 5,000	\$ 60,000					
	Aggregated			BZX Summary Depth	External Distributor	\$ 5,000	\$ 60,000				
					Internal Professional User Fee ¹	\$ -	\$ -				
					Internal Non-Professional User Fee ¹	\$ -	\$ -				
					External Professional User Fee ¹	\$ 5	\$ 60				
					External Non-Professional User Fee ¹	\$ 0	\$ 2				
					Enterprise Fee	\$ 30,000	\$ 360,000				
					Digital Media Enterprise Fee	\$ 7,500	\$ 90,000				
					<hr/>						
					Cboe	BYX	Order-by-Order	BYX Depth (PITCH)	Internal Distributor	\$ 1,000	\$ 12,000
									External Distributor	\$ 2,500	\$ 30,000
Non-Display Usage by Trading Platforms	\$ 2,000	\$ 24,000									
Non-Display Usage not by Trading Platforms	\$ 1,000	\$ 12,000									
Professional User Fee ¹	\$ 10	\$ 120									
Non-Professional User Fee ¹	\$ 1	\$ 12									
Multicast PITCH Spin Server Ports (pair) ⁴	\$ 550	\$ 6,600									
Multicast PITCH Gap Request Proxy (GRP) Port ⁴	\$ 550	\$ 6,600									
Enterprise Fee	\$ 25,000	\$ 300,000									
Internal Distributor	\$ 2,500	\$ 30,000									
Aggregated			BYX Summary Depth	External Distributor		\$ 2,500	\$ 30,000				
				Internal Professional User Fee ¹		\$ -	\$ -				
				Internal Non-Professional User Fee ¹		\$ -	\$ -				
				External Professional User Fee ¹		\$ 3	\$ 30				
				External Non-Professional User Fee ¹		\$ 0	\$ 1				
				Enterprise Fee		\$ 20,000	\$ 240,000				
				Digital Media Enterprise Fee		\$ 5,000	\$ 60,000				
				<hr/>							
				Cboe		EDGA	Order-by-Order	EDGA Depth (PITCH)	Internal Distributor	\$ 1,000	\$ 12,000
									External Distributor	\$ 2,500	\$ 30,000
Non-Display Usage by Trading Platforms	\$ 2,000	\$ 24,000									
Non-Display Usage not by Trading Platforms	\$ 1,000	\$ 12,000									
Professional User Fee ¹	\$ 10	\$ 120									
Non-Professional User Fee ¹	\$ 1	\$ 12									
Multicast PITCH Spin Server Ports (pair) ⁴	\$ 550	\$ 6,600									
Multicast PITCH Gap Request Proxy (GRP) Port ⁴	\$ 550	\$ 6,600									
Enterprise Fee	\$ 25,000	\$ 300,000									
Internal Distributor	\$ 2,500	\$ 30,000									
Aggregated			EDGA Summary Depth		External Distributor	\$ 2,500	\$ 30,000				
					Internal Professional User Fee ¹	\$ -	\$ -				
					Internal Non-Professional User Fee ¹	\$ -	\$ -				
					External Professional User Fee ¹	\$ 3	\$ 30				
					External Non-Professional User Fee ¹	\$ 0	\$ 1				
					Enterprise Fee	\$ 20,000	\$ 240,000				
					Digital Media Enterprise Fee	\$ 5,000	\$ 60,000				



Exchange Family	Exchange	Depth Type	Feed Name	Fee Name	Monthly Fees	Annual Fees
				Enterprise Fee	\$ 20,000	\$ 240,000
				Digital Media Enterprise Fee	\$ 5,000	\$ 60,000
	Cboe EDGX	Order-by-Order	EDGX Depth (PITCH)	Internal Distributor	\$ 1,500	\$ 18,000
				External Distributor	\$ 2,500	\$ 30,000
				Non-Display Usage by Trading Platforms	\$ 5,000	\$ 60,000
				Non-Display Usage not by Trading Platforms	\$ 2,000	\$ 24,000
				Professional User Fee ¹	\$ 40	\$ 480
				Non-Professional User Fee ¹	\$ 5	\$ 60
				Multicast PITCH Spin Server Ports (pair) ⁴	\$ 550	\$ 6,600
				Multicast PITCH Gap Request Proxy (GRP) Port ⁴	\$ 550	\$ 6,600
		Aggregated	EDGX Summary Depth	Enterprise Fee	\$ 100,000	\$ 1,200,000
				Internal Distributor	\$ 5,000	\$ 60,000
				External Distributor	\$ 2,500	\$ 30,000
				Internal Professional User Fee ¹	\$ -	\$ -
				Internal Non-Professional User Fee ¹	\$ -	\$ -
				External Professional User Fee ¹	\$ 5	\$ 60
				External Non-Professional User Fee ¹	\$ 0	\$ 2
				Enterprise Fee	\$ 30,000	\$ 360,000
				Digital Media Enterprise Fee	\$ 7,500	\$ 90,000
Exchange Family	Exchange	Depth Type	Feed Name	Fee Name	Monthly Fees	Annual Fees
IEX	IEX	Aggregated	IEX DEEP	External Distribution Fee	\$ -	\$ -
				Internal Distribution Fee	\$ -	\$ -
				Usage Fee ¹³	\$ -	\$ -

Table 1 above is broken into four sections (one per exchange family) that list a subset of the overall exchange market data fees that specifically relate to depth of book market data that participants of various sizes may be subject to. The monthly fee can be found on the exchange-provided fee schedule or price list, while the annual fee is twelve times the monthly fee. Note that this is not a complete list of fees for depth of book feeds. Also note that the per user, per platform, per device, and per port fees listed are dependent on the number of people, platforms, devices, or ports that have access to the data; therefore, individual invoices may reflect an amount much larger than the fee listed below – these fees have been marked ¹, ², ³, and ⁴, respectively.

Top of Book

Top of Book data only shows orders at the best bid and offer at an exchange. Orders at “worse” price levels (i.e., bids lower than the exchange’s highest priced bid and offers higher than the exchange’s lowest priced offer) are not shown. Depending on the particular feed offered, an exchange may or may not include information about trades or auctions in a Top of Book feed. For example, the NYSE BBO feed does not provide trade or imbalance data, which is provided in separate feeds for additional costs.⁷ Table 2 illustrates the fees various types of participants are charged to consume Top of Book feeds in order to calculate the NBBO. Note that an ATS or exchange that also operates a router to send orders to other venues could consume a single Depth of Book feed from each exchange and use the data both for routing as well as matching orders; however, because exchanges charge separately for each method of use, the participants would be subject to the applicable fees for each use case.

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
NYSE	NYSE	NYSE BBO	Access Fee	\$ 1,500	\$ 18,000
			Non-Display Fee – Category 1 (Principal) ²	\$ 1,500	\$ 18,000
			Non-Display Fee – Category 2 (Agency) ²	\$ 1,500	\$ 18,000
			Non-Display Fee – Category 3 (Matching) ²	\$ 1,500	\$ 18,000
			Professional User Fee ¹	\$ 4	\$ 48
			Non-Professional User ¹	\$ 0	\$ 2

⁷ See NYSE, NYSE American, NYSE Arca, NYSE National BBO feeds (<https://www.nyse.com/market-data/real-time/bbo>).



Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
			Enterprise Fee	\$ 25,000	\$ 300,000
	NYSE Arca	NYSE Arca BBO	Access Fee	\$ 750	\$ 9,000
			Non-Display Fee – Category 1 (Principal) ²	\$ 1,000	\$ 12,000
			Non-Display Fee – Category 2 (Agency) ²	\$ 1,000	\$ 12,000
			Non-Display Fee – Category 3 (Matching) ²	\$ 1,000	\$ 12,000
			Professional User Fee ¹	\$ 4	\$ 48
			Non-Professional User ¹	\$ 0	\$ 3
			Enterprise Fee	\$ 22,000	\$ 264,000
	NYSE American	NYSE American BBO	Access Fee	\$ 750	\$ 9,000
			Non-Display Fee – Category 1 (Principal) ²	\$ 500	\$ 6,000
			Non-Display Fee – Category 2 (Agency) ²	\$ 500	\$ 6,000
			Non-Display Fee – Category 3 (Matching) ²	\$ 500	\$ 6,000
			Professional User Fee ¹	\$ 1	\$ 12
			Non-Professional User ¹	\$ 0	\$ 1
			Enterprise Fee	\$ 3,000	\$ 36,000
	NYSE National	NYSE National BBO	Access Fee	\$ -	\$ -
			Non-Display Fee – Category 1 (Principal) ²	\$ -	\$ -
			Non-Display Fee – Category 2 (Agency) ²	\$ -	\$ -
			Non-Display Fee – Category 3 (Matching) ²	\$ -	\$ -
			Professional User Fee ¹	\$ -	\$ -
			Non-Professional User ¹	\$ -	\$ -
			Enterprise Fee	\$ -	\$ -

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
Nasdaq	Nasdaq	Nasdaq Basic	Internal Distributor	\$ 1,500	\$ 18,000
			External Distribution	\$ 2,000	\$ 24,000
			Nasdaq Basic with NLS	\$ 100	\$ 1,200
			Non-Professional Derived Data License	\$ 1,500	\$ 18,000
			Professional/Corporate ¹	\$ 26	\$ 312
			Professional Enterprise	\$ 100,000	\$ 1,200,000
			Non-Professional User ¹	\$ 1	\$ 12
			Non-Professional Enterprise	\$ 365,000	\$ 4,380,000
	Nasdaq BX	Nasdaq BX Basic	Internal Distributor	\$ -	\$ -
			External Distribution	\$ -	\$ -
			Non-Professional Derived Data License	\$ -	\$ -
			Professional/Corporate ¹	\$ -	\$ -
			Professional Enterprise	\$ -	\$ -
			Nasdaq Basic BX with NLS	\$ -	\$ -
			Non-Professional User ¹	\$ -	\$ -
			Non-Professional Enterprise	\$ -	\$ -
	Nasdaq PSX	Nasdaq PSX Basic	Internal Distributor	\$ -	\$ -
			External Distribution	\$ -	\$ -
			Non-Professional Derived Data License	\$ -	\$ -
			Professional/Corporate ¹	\$ -	\$ -
			Professional Enterprise	\$ -	\$ -
			Nasdaq Basic PSX with NLS	\$ -	\$ -
			Non-Professional User ¹	\$ -	\$ -
			Non-Professional Enterprise	\$ -	\$ -

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
Cboe	Cboe BZX	BZX Top	Internal Distributor	\$ 500	\$ 6,000
			External Distributor	\$ 2,500	\$ 30,000
			Internal Professional User Fee ¹	\$ -	\$ -
			Internal Non-Professional User Fee ¹	\$ -	\$ -
			External Professional User Fee ¹	\$ 4	\$ 48
			External Non-Professional User Fee ¹	\$ 0	\$ 1
			Enterprise Fee	\$ 15,000	\$ 180,000
			Digital Media Enterprise Fee	\$ 2,500	\$ 30,000
	Cboe BYX	BYX Top	Internal Distributor	\$ 500	\$ 6,000
			External Distributor	\$ 1,000	\$ 12,000
			Internal Professional User Fee ¹	\$ -	\$ -
			Internal Non-Professional User Fee ¹	\$ -	\$ -



Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
			External Professional User Fee ¹	\$ 1	\$ 12
			External Non-Professional User Fee ¹	\$ 0	\$ 0
			Enterprise Fee	\$ 10,000	\$ 120,000
			Digital Media Enterprise Fee	\$ 2,500	\$ 30,000
	Cboe EDGA	EDGA Top	Internal Distributor	\$ -	\$ -
			External Distributor	\$ -	\$ -
			Internal Professional User Fee ¹	\$ -	\$ -
			Internal Non-Professional User Fee ¹	\$ -	\$ -
			External Professional User Fee ¹	\$ 1	\$ 12
			External Non-Professional User Fee ¹	\$ 0	\$ 0
			Enterprise Fee	\$ 10,000	\$ 120,000
			Digital Media Enterprise Fee	\$ 2,500	\$ 30,000
	Cboe EDGX	EDGX Top	Internal Distributor	\$ 500	\$ 6,000
			External Distributor	\$ 1,500	\$ 18,000
			Internal Professional User Fee ¹	\$ -	\$ -
			Internal Non-Professional User Fee ¹	\$ -	\$ -
			External Professional User Fee ¹	\$ 4	\$ 48
			External Non-Professional User Fee ¹	\$ 0	\$ 1
			Enterprise Fee	\$ 15,000	\$ 180,000
			Digital Media Enterprise Fee	\$ 2,500	\$ 30,000
Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
IEX	IEX	IEX TOPS	External Distribution Fee	\$ -	\$ -
			Internal Distribution Fee	\$ -	\$ -
			Usage Fee ¹³	\$ -	\$ -

Table 2 above is broken into four sections (one per exchange family) that list a subset of the overall exchange market data fees that specifically relate to top of book market data that various types of participants would incur. The monthly fee can be found on the exchange provided fee schedule or price list, while the annual fee is twelve times the monthly fee. Note that this is not a complete list of the fees related to consuming top of book feeds. Also note that the per user, per platform, per device, and per port fees listed are dependent on the number of people, platforms, devices, or ports that have access to the data, therefore the invoice may reflect an amount much larger than the fee listed below – these fees have been marked ¹, ², ³, and ⁴, respectively.

Last Sale

Last Sale data shows only executed trades at an exchange and is the most broadly disseminated, commonly known stock exchange price data, since most retail investors equate the “price” of a security with the last trade price, not the bid or offer prices. Table 3 illustrates the fees various types of participants would incur to consume and/or display the latest stock price, percentage change, or a price chart. In addition, if a firm wished to consume top of book and last sale data it would incur Last Sale fees, in addition to Top of Book fees, for exchanges in the NYSE family, because those exchanges’ best bid and offer (“BBO”) feeds do not include trade information. IEX does not provide a separate Last Sale feed, but it does include trade information in its Top of Book data feed.

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
NYSE	NYSE	NYSE Trades	Access Fee	\$ 1,500	\$ 18,000
			Redistribution Fee	\$ 1,000	\$ 12,000
			Non-Display Fee – Category 1 (Principal) ²	\$ 3,000	\$ 36,000
			Non-Display Fee – Category 2 (Agency) ²	\$ 3,000	\$ 36,000
			Non-Display Fee – Category 3 (Matching) ²	\$ 3,000	\$ 36,000
			Professional User Fee ¹	\$ 4	\$ 48
			Non-Professional User ¹	\$ 0.20	\$ 2.40
			Enterprise Fee	\$ 25,000	\$ 300,000
			Digital Media Enterprise Fee	\$ 40,000	\$ 480,000
	NYSE Arca	NYSE Arca Trades	Access Fee	\$ 750	\$ 9,000
			Redistribution Fee	\$ 750	\$ 9,000
			Non-Display Fee – Category 1 (Principal) ²	\$ 2,000	\$ 24,000
			Non-Display Fee – Category 2 (Agency) ²	\$ 2,000	\$ 24,000



Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
			Non-Display Fee – Category 3 (Matching) ²	\$ 2,000	\$ 24,000
			Professional User Fee ¹	\$ 4	\$ 48
			Non-Professional User ¹	\$ 0.25	\$ 3.00
			Enterprise Fee	\$ 22,000	\$ 264,000
			Digital Media Enterprise Fee	\$ 20,000	\$ 240,000
	NYSE American	NYSE American Trades	Access Fee	\$ 750	\$ 9,000
			Redistribution Fee	\$ 750	\$ 9,000
			Non-Display Fee – Category 1 (Principal) ²	\$ 1,500	\$ 18,000
			Non-Display Fee – Category 2 (Agency) ²	\$ 1,500	\$ 18,000
			Non-Display Fee – Category 3 (Matching) ²	\$ 1,500	\$ 18,000
			Professional User Fee ¹	\$ 1	\$ 12
			Non-Professional User ¹	\$ 0.05	\$ 0.60
			Enterprise Fee	\$ 3,000	\$ 36,000
			Digital Media Enterprise Fee	\$ 5,000	\$ 60,000
	NYSE National	NYSE National Trades	Access Fee	\$ -	\$ -
			Redistribution Fee	\$ -	\$ -
			Non-Display Fee – Category 1 (Principal) ²	\$ -	\$ -
			Non-Display Fee – Category 2 (Agency) ²	\$ -	\$ -
			Non-Display Fee – Category 3 (Matching) ²	\$ -	\$ -
			Professional User Fee ¹	\$ -	\$ -
			Non-Professional User ¹	\$ -	\$ -
			Enterprise Fee	\$ -	\$ -
			Digital Media Enterprise Fee	\$ -	\$ -

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
Nasdaq	Nasdaq	Nasdaq Last Sale	Distributor	\$ 1,500	\$ 18,000
			Query Fee	\$ 0.003	\$ 0.04
			User Fee ¹	\$ 0.90	\$ 10.80
			Device Fee ³	\$ 0.04	\$ 0.43
			Enterprise Fee	\$ 41,500	\$ 498,000
	Nasdaq BX	Nasdaq BX Last Sale	Distributor	\$ -	\$ -
			Query Fee	\$ -	\$ -
			User Fee ¹	\$ -	\$ -
			Device Fee ³	\$ -	\$ -
			Enterprise Fee	\$ -	\$ -
	Nasdaq PSX	Nasdaq PSX Last Sale	Distributor	\$ -	\$ -
			Query Fee	\$ -	\$ -
			User Fee ¹	\$ -	\$ -
			Device Fee ³	\$ -	\$ -
			Enterprise Fee	\$ -	\$ -

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
Cboe	Cboe BZX	BZX Last Sale	Internal Distributor	\$ 500	\$ 6,000
			External Distributor	\$ 2,500	\$ 30,000
			Internal Professional User Fee ¹	\$ -	\$ -
			Internal Non-Professional User Fee ¹	\$ -	\$ -
			External Professional User Fee ¹	\$ 4	\$ 48
			External Non-Professional User Fee ¹	\$ 0.10	\$ 1.20
			Enterprise Fee	\$ 15,000	\$ 180,000
			Digital Media Enterprise Fee	\$ 2,500	\$ 30,000
	Cboe BYX	BYX Last Sale	Internal Distributor	\$ 500	\$ 6,000
			External Distributor	\$ 1,000	\$ 12,000
			Internal Professional User Fee ¹	\$ -	\$ -
			Internal Non-Professional User Fee ¹	\$ -	\$ -
			External Professional User Fee ¹	\$ 1	\$ 12
			External Non-Professional User Fee ¹	\$ 0.03	\$ 0.30
			Enterprise Fee	\$ 10,000	\$ 120,000
			Digital Media Enterprise Fee	\$ 2,500	\$ 30,000
	Cboe EDGA	EDGA Last Sale	Internal Distributor	\$ -	\$ -
			External Distributor	\$ -	\$ -
			Internal Professional User Fee ¹	\$ -	\$ -
			Internal Non-Professional User Fee ¹	\$ -	\$ -



Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
			External Professional User Fee ¹	\$ 1	\$ 12
			External Non-Professional User Fee ¹	\$ 0.03	\$ 0.30
			Enterprise Fee	\$ 10,000	\$ 120,000
			Digital Media Enterprise Fee	\$ 2,500	\$ 30,000
	Cboe EDGX	EDGX Last Sale	Internal Distributor	\$ 500	\$ 6,000
			External Distributor	\$ 1,500	\$ 18,000
			Internal Professional User Fee ¹	\$ -	\$ -
			Internal Non-Professional User Fee ¹	\$ -	\$ -
			External Professional User Fee ¹	\$ 4	\$ 48
			External Non-Professional User Fee ¹	\$ 0.10	\$ 1.20
			Enterprise Fee	\$ 15,000	\$ 180,000
			Digital Media Enterprise Fee	\$ 2,500	\$ 30,000

Table 3 above is broken into three sections (one per exchange family that offers a separate Last Sale feed) that lists a subset of the overall exchange market data fees that specifically relate to last sale market data that various types of participants would incur. The monthly fee can be found on the exchange provided fee schedule or price list, while the annual fee is twelve times the monthly fee. Note that this is not a complete list of the fees related to consuming last sale feeds. Also note that the per user, per platform, per device, and per port fees listed are dependent on the number of people, platforms, devices, or ports that have access to the data, therefore the invoice may reflect an amount much larger than the fee listed below – these fees have been marked ¹, ², ³, and ⁴, respectively.

Auction Imbalance

Auction Imbalance data shows only order imbalance and potential clearing prices prior to a primary listing exchange's auction. NYSE Integrated, NYSE Arca Integrated, NYSE ArcaBook, NYSE American Integrated, Nasdaq TotalView, Cboe BZX Depth, IEX DEEP, and IEX TOPS all include imbalance data as part of those data feeds. To obtain auction imbalance data, a participant would need to buy either the data feeds listed above or the individually listed Imbalance feeds below in Table 4. Exchange auction imbalance data is not provided to the SIPs that disseminate consolidated market data. IEX believes that disseminating such data through the SIPs would allow the broadest number of market participants to benefit from a better understanding of the opening and closing auction, thus leading to more robust price discovery leading into an auction.

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
NYSE	NYSE	NYSE Order Imbalances	Access Fee	\$ 500	\$ 6,000
			Redistribution Fee	\$ -	\$ -
			Non-Display Fee – Category 1 (Principal) ²	\$ 2,000	\$ 24,000
			Non-Display Fee – Category 2 (Agency) ²	\$ 2,000	\$ 24,000
			Non-Display Fee – Category 3 (Matching) ²	\$ 2,000	\$ 24,000
			Professional User Fee ¹	\$ -	\$ -
			Non-Professional User ¹	\$ -	\$ -
	NYSE Arca	NYSE Arca Order Imbalances	Access Fee	\$ 500	\$ 6,000
			Redistribution Fee	\$ -	\$ -
			Non-Display Fee – Category 1 (Principal) ²	\$ 500	\$ 6,000
			Non-Display Fee – Category 2 (Agency) ²	\$ 500	\$ 6,000
			Non-Display Fee – Category 3 (Matching) ²	\$ 500	\$ 6,000
Professional User Fee ¹			\$ -	\$ -	
		Non-Professional User ¹	\$ -	\$ -	
NYSE American	NYSE American Order Imbalances	Access Fee	\$ 500	\$ 6,000	
		Redistribution Fee	\$ -	\$ -	
		Non-Display Fee – Category 1 (Principal) ²	\$ 500	\$ 6,000	
		Non-Display Fee – Category 2 (Agency) ²	\$ 500	\$ 6,000	
		Non-Display Fee – Category 3 (Matching) ²	\$ 500	\$ 6,000	
		Professional User Fee ¹	\$ -	\$ -	
		Non-Professional User ¹	\$ -	\$ -	

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
Nasdaq	Nasdaq	Nasdaq NOIView	Direct Access	\$ 750	\$ 9,000

Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
Cboe	Cboe BZX	BZX Auction Feed	Internal Distributor	\$ -	\$ -



Exchange Family	Exchange	Feed Name	Fee Name	Monthly Fees	Annual Fees
			External Distributor	\$ -	\$ -
			Non-Display Usage by Trading Platforms	\$ -	\$ -
			Non-Display Usage not by Trading Platforms	\$ -	\$ -
			Professional User Fee ¹	\$ -	\$ -
			Non-Professional User Fee ¹	\$ -	\$ -
			Enterprise Fee	\$ -	\$ -

Table 4 above is broken into three sections (one per exchange family that offers a separate Auction Imbalance feed) that lists a subset of the overall exchange market data fees that specifically relate to imbalance market data that various types of participants would incur. The monthly fee can be found on the exchange provided fee schedule or price list, while the annual fee is twelve times the monthly fee. Also note that the per user, per platform, per device, and per port fees listed are dependent on the number of people, platforms, devices, or ports that have access to the data, therefore the invoice may reflect an amount much larger than the fee listed below - these fees have been marked ¹, ², ³, and ⁴, respectively.

How is Market Data Provided by an Exchange?

Market data is provided via network switch and cabling infrastructure, as well as the server infrastructure that runs the processes responsible for producing such messages for external consumption (market data process). Depending on the type of market data feed, the market data process performs a varying amount of logic. As an example, order-by-order depth of book market data processes perform the least amount of logic on the messages received by the system, even though they involve more granular data. This is because each incoming order-related message produces an analogous output message on the data feed (i.e., a feed's add order, update order, remove order messages correspond directly with each user's new order single, replace, or cancel message, respectively). In contrast, aggregated depth of book feeds must perform additional logic on each order-related message received from the system to calculate the total shares at a given price level and, in some cases, the total number of orders at such price, before publishing an output message on the data feed. However, order-by-order data feeds are priced more expensively than aggregated products by exchanges that offer both, which results primarily from the fact that order-by-order feeds are generally faster and contain more information that is actionable by many trading firms, compared to aggregated feeds. Further, firms consuming order-by-order feeds incur additional expense because they are required to perform the book building logic themselves (i.e., they must manage each order in the book based on the inputs from the order-by-order feed), while customers of aggregated feeds simply update their view of the market with the latest data the exchange provides at a given price level.⁸

Customers of an order-by-order depth of book feed are likely to need or desire faster access to the data, and therefore those feeds typically are optimized for speed, which can include delivery through a different architecture than is used for the aggregated depth of book or top of book feeds offered by the same exchange. For example, Nasdaq offers a field-programmable gate array (FPGA) solution on dedicated hardware for Nasdaq TotalView customers that are particularly latency-sensitive. Additionally, NYSE Arca offers order-by-order depth of book via two competing products

⁸ While 500 shares are displayed on the bid, an order-by-order feed requires that the data recipient calculated that value by processing that 300 shares arrived in order 1, then 300 shares arrived in order 2, then 200 shares canceled from order 1, then 100 shares arrived in order 3. Alternatively, an aggregated feed will disseminate the total shares available with each update, therefore 300 shares, then 600 shares, then 400 shares, and finally 500 shares. The latest message will provide an aggregated feed user the current state of the order book, while order-by-order users must understand each action in the proper sequence to have an accurate view of the order book.



– NYSE ArcaBook and NYSE Arca Integrated – where the latter, newer feed is 75% more expensive than the older version of the same data for the same non-display use.⁹

Market data processes may distribute data via different protocols that either provide no guarantee of delivery (UDP) or guarantee delivery of the data to the recipient (TCP). When offering market data via a UDP protocol, an exchange also offers one or more services for a participant to recover data that has been lost during transmission, usually referred to as “gap fill” or “snapshot” services (collectively known as retransmission services) that re-send missed (i.e., dropped) messages or send the current state of the exchange’s order book, respectively. One market data process utilizing UDP may publish to any number of participants (the number is limited by the exchange’s ability to connect more participants to its network). One market data process utilizing TCP may publish to many participants, in the same way that one client gateway process can support many order entry sessions, although each process would be limited to some maximum number of connections specified by the exchange.

IEX Market Data Calculation Considerations

To calculate IEX’s costs to produce market data, we considered all the requisite infrastructure in the primary data center, secondary (Disaster Recovery or “DR”) data center, and public facing testing facility (called the IEX Testing Facility or “ITF”). IEX specifically considered the following physical assets when calculating the cost of offering market data to participants:

- Market Data Servers: the server running a market data process that either publishes data or responds to retransmission requests
- Market Data Feeds Switches: data formatted by a market data process is distributed to participants via an initial array of top of rack access layer switches
- ITF Infrastructure: hardware and software to facilitate market data testing
- Space, Power, and Security: physical space, electrical power, and security at the data centers considered for the physical assets in scope
- Administrative Access: command and control infrastructure for operations teams to administer the exchange services
- Monitoring: servers, switches, and software licenses to monitor the physical assets in scope as well as the resiliency of the market data product provided by such assets

⁹ Per the NYSE Market Data Price List (https://www.nyse.com/publicdocs/nyse/data/NYSE_Market_Data_Pricing.pdf), NYSE ArcaBook Non-Display Fees for Category 1, 2, and 3 are \$6,000 each, while NYSE Arca Integrated Non-Display Fees for Category 1, 2, and 3 are \$10,500 each.

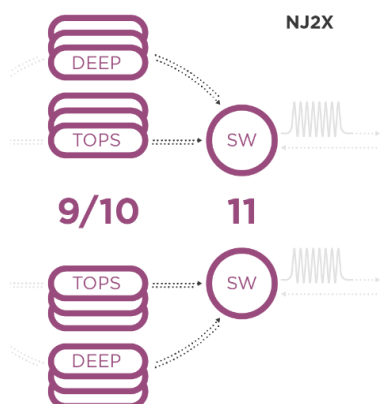


Figure 3 illustrates the physical assets in the primary data center that are directly responsible for producing and transmitting market data.

- "9/10" represents the Market Data Process Servers
- "11" represents the Market Data Feeds Switches

IEX did not consider the physical connectivity assets that are used to provide both order entry and market data in this calculation. IEX treated these physical assets as supporting "physical connectivity" to the exchange, which can be used for multiple purposes (for example, one physical connection can support the entry of orders and receipt of executions, as well as the receipt of market data and request for retransmission of market data). Therefore, IEX did not allocate costs directly related to physical connectivity to either market data or order entry services. Instead, IEX allocated those costs separately, as described below under the heading "Physical Connectivity".

In addition, IEX included the following personnel when calculating the cost of offering market data to participants:

- Product Management: resources responsible for managing the Exchange offering
- Legal and Regulatory: resources responsible for the Exchange's compliance with applicable laws and regulations
- Information Security: resources responsible for maintaining and surveilling for information security
- Development and Quality Assurance: resources responsible for building and testing new Exchange functionality
- Operations: resources responsible for supporting participants and maintaining the IEX system
- Infrastructure: resources responsible for installing and maintaining the physical infrastructure
- ITF Operations: resources responsible for supporting participants and maintaining the IEX Testing Facility

Capacity and Expansion

The capacity of an exchange's market data offering is limited by the total number of usable physical ports available via its physical connectivity architecture and, in the case of a TCP process, the total number of simultaneous connections the market data processes can support. The layer that supports the least number of connections (whether physical or logical) limits the total capacity of the entire platform. However, market data is primarily distributed through UDP-based protocols, which allow the exchange to scale distribution to many participants with a small number of market data processes. Therefore, the cost of scaling this infrastructure is not high in relation to the initial investment. Further, the cost of offering an additional feed is relatively small in relation to the initial investment for offering the first market data feed. For more details on capacity and expansion of the physical connectivity infrastructure, see the "[Physical Connectivity](#)" section below.



Calculating the Costs of Offering Market Data

To calculate the total annual cost of offering market data to participants, we depreciated the cost of each purchased physical asset over three years, and included any lease, license, or recurring charges for the year. For personnel, we took into account 33 employees who directly impact market data and used a blended rate of \$272,839 to reflect the total annual compensation per person. Since the market data offering, once established, requires little daily intervention, and all of the identified employees have other responsibilities in addition to market data, we then determined the percentage of time each employee spent on market data to arrive at a full time equivalent of 4.05 across all the identified personnel.

The costs for offering market data via the primary and secondary site were combined for this exercise. Additionally, the ITF costs were included in the overall cost calculation.

To calculate the cost per user, we divided the total annual cost of offering market data by the total number of firms that receive IEX proprietary market data (TOPS or DEEP) that are classified as a data recipient or data subscriber per the IEX Data Agreement, excluding natural persons, over the trailing six months, and rounded up to the nearest dollar. Thus, the sum of the annual market data costs for the primary site, secondary site, and ITF, \$1,791,403, was divided by 150 to determine the cost per data recipient or data subscriber, which is an annual cost of \$11,943 per data recipient firm.

Firms that consume both TOPS and DEEP, and firms that consume TOPS or DEEP via two different providers, are counted once, not twice, for purposes of our analysis. The size of the firm – reflected by the number of platforms consuming IEX data, number and type of non-display uses for IEX data, number of servers consuming IEX data, or number of professional or non-professional users viewing IEX data – was not factored into the calculation. Because any higher consumption of data based on these factors does not increase IEX's costs to produce market data, they were not factored into our calculation of per recipient costs.¹⁰ However, if included, the per recipient cost would decline by a potentially substantial margin. As noted elsewhere in this study, many types of exchange fees vary depending on these factors, and thus the decision not to “over count” the number of users results in a more conservative (higher) estimate of per user costs than would otherwise be the case.

¹⁰ Increased volume of usage based on these factors by each user that connects directly to IEX would be captured in the section of this document labeled “[Physical Connectivity](#)” below.



Annual IEX Market Data Infrastructure	(\$1,791,403)
9. Top of Book Servers (TOPS) (5)	(\$12,833)
10. Depth of Book Servers (DEEP) (5)	(\$12,833)
11. Market Data Feeds Switches (2 x 24 port)	(\$13,333)
ITF Market Data	(\$7,333)
Data Center Space, Power, Security	(\$10,605)
Administrative Access	(\$33,333)
Monitoring	(\$596,135)
Personnel	(\$1,104,998)

Total Users (Trailing 6 months)	150
Annual Cost per Data Recipient / Subscriber for TOPS	(\$11,943)
Annual Cost per Data Recipient / Subscriber for DEEP	(\$11,943)

Figure 4 shows the annualized costs for IEX to offer top of book (TOPS) and depth of book (DEEP) market data feeds using the above described methodology.

Comparing IEX Costs with Other Exchange Market Data Fees

Table 5 below compares IEX’s annual costs to produce its depth-of-book feed (DEEP) to IEX’s cost to purchase similar feeds from other exchanges.¹¹ In calculating IEX’s costs to offer its proprietary market data products, we have not attempted to define what would constitute an appropriate mark-up in selling these services to our members. Further, different system architectures may require more or less infrastructure and/or personnel to support the products and services discussed. Therefore, the absolute difference between IEX’s annual cost per data recipient firm to offer DEEP versus the annual fees IEX is charged by other exchanges to purchase proprietary depth of book market data feeds may not be representative of the precise margins earned by other exchanges on market data products. However, this comparison serves to illustrate the stark differences between the costs to produce market data by one exchange and the revenues earned by other exchanges from similar market data products and services.

¹¹ IEX has direct access to multicast depth of book market data from each exchange by one internal IEX network. IEX subscribes to the following direct market data feeds: NYSE OpenBook, NYSE Arca ArcaBook, NYSE American OpenBook, Nasdaq family TotalView (ITCH) feeds, and Cboe family Depth (PITCH) feeds. NYSE National is consumed via the SIP. IEX distributes such market data internally and does not distribute the data externally. IEX has 9 servers that have access to process the various market data feeds. IEX has 31 “professional” users (i.e., employees) that have access to view the market data via IEX proprietary tools. IEX has access to 4 pairs of Spin Server Ports at each Cboe exchange. IEX uses market data for matching orders, and routing orders in an agency capacity. While Table 5 summarizes annual fees per exchange, [Appendix A: Market Data Fees Paid by IEX](#) details the individual fees.



Exchange Family	Exchange	IEX Purchased Feed	Depth Type	Annual Fees	Analogous Annual IEX Cost	Markup Over IEX Cost
NYSE	NYSE	NYSE OpenBook	Aggregated	\$226,320	\$11,943	1,795%
	NYSE Arca	NYSE ArcaBook	Order-by-Order	\$190,320	\$11,943	1,494%
	NYSE American	NYSE American OpenBook	Aggregated	\$61,860	\$11,943	418%
NYSE Total				\$478,500		
NASDAQ	Nasdaq	Nasdaq TotalView (ITCH)	Order-by-Order	\$195,972	\$11,943	1,541%
	Nasdaq BX	Nasdaq BX TotalView (ITCH)	Order-by-Order	\$55,020	\$11,943	361%
	Nasdaq PSX	Nasdaq PSX TotalView (ITCH)	Order-by-Order	\$51,480	\$11,943	331%
Nasdaq Total				\$302,472		
CBOE	Cboe BZX	BZX Depth (PITCH)	Order-by-Order	\$119,280	\$11,943	899%
	Cboe BYX	BYX Depth (PITCH)	Order-by-Order	\$66,120	\$11,943	454%
	Cboe EDGA	EDGA Depth (PITCH)	Order-by-Order	\$66,120	\$11,943	454%
	Cboe EDGX	EDGX Depth (PITCH)	Order-by-Order	\$119,280	\$11,943	899%
Cboe Total				\$370,800		

Table 5 compares the annual fees IEX is invoiced from each exchange for proprietary depth of book market data with the annual cost for IEX to offer its comparable product, DEEP, which is \$11,943 per data recipient or data subscriber that is not a natural person.

Note that, when IEX purchases the newer, faster order-by-order feeds offered by the NYSE family (a scheduled technology project), the annual fees we pay will approximately double, as shown in Table 6 below.

Exchange Family	Exchange	Feed Name	Depth Type	Annual Fees	Analogous Annual IEX Cost	Markup Over IEX Cost
NYSE	NYSE	NYSE Integrated	Order-by-Order	\$596,040	\$11,943	4,891%
	NYSE Arca	NYSE Arca Integrated	Order-by-Order	\$310,320	\$11,943	2,498%
	NYSE American	NYSE American Integrated	Order-by-Order	\$153,720	\$11,943	1,187%
NYSE Total				\$1,060,080		

Table 6 identifies the annual fees IEX would be invoiced by NYSE for the proprietary "integrated" order-by-order depth of book market data from NYSE, NYSE Arca, and NYSE American.



Physical Connectivity

Receipt of market data or order entry must occur through a physical connection to an exchange. Therefore, in addition to the fees charged for the use of or access to these services, participants must also pay for physical connectivity to the exchange or exchange family either directly or through a third party that has purchased such direct connectivity. In general, participants that are actively engaged in electronic trading seek to obtain direct connections in the data centers of each of the three major exchange operators.

Forms of Physical Connectivity

Exchanges provide several forms of physical connectivity that offer increasing amounts of bandwidth to the exchange system's network. This is akin to the bandwidth an internet service provider sells to its customers. Lower bandwidth connections have inferior performance when there is a need to push large amounts of data through the connection. Compare, for example, the lag that personal computer users once experienced loading an image on a 56k dial-up connection to the instantaneous experience of today's fiber optic connectivity.

A participant may access all exchanges in an exchange family through a single physical connection. For example, via one physical 10Gb connection to NYSE at Mahwah, one may access NYSE, NYSE Arca, NYSE American, and NYSE National. Through the single physical connection, the same participant is then required to buy logical connectivity to each exchange to segregate order flow for its own purposes, or for its clients, which is discussed separately below (see the "Logical Connectivity" section of this study).

For simplicity, the pricing listed in Table 7 below focuses on the fees associated with purchasing the right to use a single physical connection to the exchange family's trading network.¹² In other words, the connectivity options listed below are the options for a member, data recipient, or extranet provider to physically connect its fiber optic cable to the exchange's network to send orders and receive executions, drop copies, or market data. Even participants that use wireless communication methods to transmit messages to an exchange data center must ultimately transmit the message via one of the physical connectivity options described in this section in order to access the exchange system. In order to mitigate the risk of an outage, participants typically implement redundant architectures that require the purchase of at least two physical connections to each exchange family's network. In the event of a failure on one physical connection, the secondary connection(s) will allow the participant to avoid an interruption. Further, participants may need to purchase more than two connections in order to meet their individual trading or other business needs. Note that NYSE uniquely provides connectivity to co-location customers via two networks, SFTI Liquidity Center Network (LCN) and SFTI IP Liquidity Center (SLC), each with its own connectivity options that offer varying amounts of bandwidth (e.g., 1Gb, 10Gb, etc.).¹³

¹² Pricing as of January 2019 from NYSE Price List (https://www.nyse.com/publicdocs/nyse/markets/nyse/NYSE_Price_List.pdf), Nasdaq Price List (<http://nasdaqtrader.com/Trader.aspx?id=PriceListTrading2>), Cboe Fee Schedule (https://markets.cboe.com/us/equities/membership/fee_schedule/bzx/), and IEX Fee Schedule (<https://iextrading.com/trading/fees/>).

¹³ See ICE Data Services Connectivity: SFTI & Colocation pg. 9 - 11 (https://www.nyse.com/publicdocs/nyse/data/SFTI_and_Colocation_US_Customer_Guide.pdf).



We did not include an analysis of co-location, as distinct from connectivity, fees. Co-location services include, but are not limited to, secure cages to house equipment, entire cabinets or partial cabinets to rack equipment, installation, and connection to a time protocol feed. IEX does not offer co-location services, and thus has not attempted to separately calculate the costs of providing those additional services.

Exchange Family	Physical Connection Type	Installation Fees	Monthly Fees	Annual Fees
NYSE	1Gb Fiber IP Network Access	\$ 2,500	\$ 2,500	\$ 30,000
	1Gb Fiber LCN Access	\$ 6,000	\$ 5,000	\$ 60,000
	10Gb Fiber IP Network Access	\$ 10,000	\$ 11,000	\$ 132,000
	10Gb Fiber LCN Access	\$ 10,000	\$ 14,000	\$ 168,000
	10Gb LX Fiber LCN Access	\$ 15,000	\$ 22,000	\$ 264,000
	40Gb Fiber IP Network Access	\$ 10,000	\$ 18,000	\$ 216,000
	40Gb Fiber LCN Access	\$ 15,000	\$ 22,000	\$ 264,000

Exchange Family	Physical Connection Type	Installation Fees	Monthly Fees	Annual Fees
Nasdaq	1Gb Fiber	\$ 1,000	\$ 2,500	\$ 30,000
	1Gb Ultra Fiber via POP	\$ 1,500	\$ 2,500	\$ 30,000
	1Gb Ultra Fiber	\$ 1,500	\$ 2,500	\$ 30,000
	10Gb Fiber	\$ 1,000	\$ 10,000	\$ 120,000
	10Gb Ultra Fiber via POP	\$ 1,500	\$ 7,500	\$ 90,000
	10Gb Ultra Fiber	\$ 1,500	\$ 15,000	\$ 180,000
	40Gb Ultra Fiber	\$ 1,500	\$ 20,000	\$ 240,000

Exchange Family	Physical Connection Type	Installation Fees	Monthly Fees	Annual Fees
Cboe	1Gb Fiber	\$ -	\$ 2,500	\$ 30,000
	1Gb Fiber (Disaster Recovery)	\$ -	\$ 2,000	\$ 24,000
	10Gb Fiber	\$ -	\$ 7,500	\$ 90,000
	10Gb Fiber (Disaster Recovery)	\$ -	\$ 6,000	\$ 72,000

Exchange Family	Physical Connection Type	Installation Fees	Monthly Fees	Annual Fees
IEX	1Gb Fiber	\$ -	\$ -	\$ -
	10Gb Fiber	\$ -	\$ -	\$ -

Table 7 above lists the installation and monthly fees found in the exchange fee schedules and price lists associated with a variety of physical connectivity options to NYSE, Nasdaq, Cboe, and IEX. The fees above are charged monthly and provide access to a single physical connection. The monthly fee can be found on the exchange provided fee schedule or price list, while the annual fee is twelve times the monthly fee. Note that this is not a complete list of the connectivity options.

How is Physical Connectivity Provided by an Exchange?

Physical Connectivity is provided by an exchange via network switch and cabling infrastructure that allows participants to “plug into” an exchange’s system for market data receipt, order entry, execution receipt, and other messaging. Participants may either connect to the exchange directly at the data center where its trading system is housed, or at a point-of-presence (POP) facility that is in a different physical location from the exchange’s trading system (the IEX POP is in Secaucus, NJ, while its trading system is located in Weehawken, NJ). IEX requires that all members access its systems through its POP.

IEX Physical Connectivity Calculation Considerations

We considered the infrastructure in the IEX POP, primary data center, secondary (DR) data center, and public facing testing facility (ITF) for purposes of this calculation. IEX specifically considered the following physical assets when calculating the cost of offering physical connectivity to participants:



- Cross Connect via Patch Panel: the physical point at which a participant plugs its cable into the IEX system
- Access Layer Switches (the “leaf layer”): each connection at the patch panel from a participant has a corresponding connection at this initial array of switches
- Distribution Switches (the “spine layer”): connections from access layer switches are aggregated at distribution switches
- Equidistant Cabling and POP Networking Equipment: IEX uses a fiber spool, optics equipment, and fiber lines between two data centers to implement the 350µs “speed bump” of designed latency experienced by each message to/from participants¹⁴
- ITF System: specific internet facing switches and firewalls to allow access for FIX certification via the internet
- Space, Power, and Security: physical space, electrical power, and security at the data centers considered for the physical assets in scope
- Monitoring: servers, switches, and software licenses to monitor the physical assets in scope as well as the health of the connectivity service provided by such assets

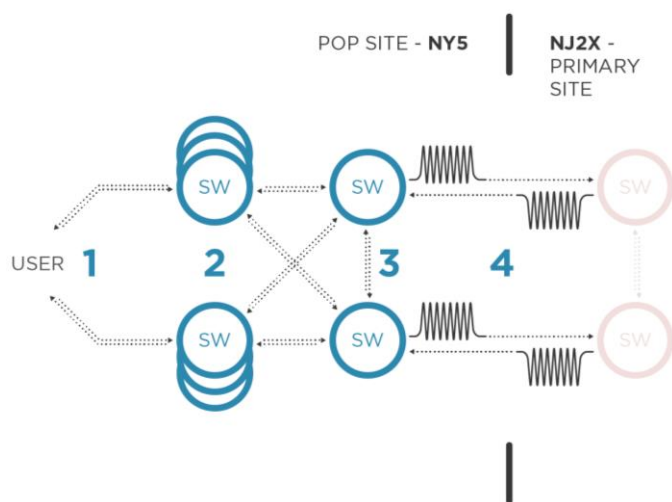


Figure 5 illustrates the physical assets in the IEX POP and primary data center that are directly responsible for offering physical connectivity.

- “1” represents the Cross Connect via a Patch Panel
- “2” represents the Access Layer Switches
- “3” represents the Distribution Switches
- “4” represents the Equidistant Cabling and POP Networking Equipment

IEX considered the following personnel when calculating the cost of offering physical connectivity to participants:

- Product Management: resources responsible for managing the Exchange offering
- Infrastructure: resources responsible for installing and maintaining the physical infrastructure
- Operations: resources responsible for supporting participants and maintaining the IEX system
- Legal and Regulatory: resources responsible for the Exchange’s compliance with applicable laws and regulations
- Information Security: resources responsible for maintaining and surveilling for information security

Capacity and Expansion

The capacity of an exchange’s physical connectivity is limited by the total number of usable physical ports available at the patch panel, access layer switches, or distribution switches. Expanding capacity is an interdependent process, as the expansion of one layer may trigger the need to expand another layer. Capacity may be added in the form of an additional switch or a larger patch panel. However, if a larger patch panel is installed, it may also require the installation of additional switches. Similarly, when the capacity of the distribution switches is exhausted, additional distribution

¹⁴ See “[IEX System Architecture](#)” above.



switches or greater density switches must be integrated into the platform. Further, when the capacity of a data center rack is exhausted, a new rack or set of racks must be built out to provide both capacity and redundancy. Because of the economics of adding to exchange infrastructure, exchanges often choose to add capacity as a “step-function” of demand and not on a per user basis.

Calculating Physical Connectivity Costs

To calculate the total annual cost of offering Physical Connectivity to participants, we depreciated the cost of each purchased physical asset over three years, and included any lease, license, or recurring charges for the year. For personnel, we took into account 20 employees who directly impact physical connectivity and used a blended rate of \$239,955 to reflect the total annual compensation per person. Since the physical connectivity offering, once established, requires little daily intervention, and all of the identified employees have responsibilities in addition to physical connectivity, we then determined the percentage of time each employee spent on physical connectivity to arrive at a full time equivalent of 2.087 across all the identified personnel.

We separately identified the costs for connecting to the primary and secondary (Disaster Recovery, or “DR”) sites, given that participants can choose to physically connect to the secondary site, but relatively few do so voluntarily. To determine the per port fees for each site, the cost of physical infrastructure was allocated to either the primary site or secondary site. The ITF costs were included in the primary site costs. The costs for monitoring and personnel were divided by the proportion of total usable physical ports at the access layer in each site to the total usable ports across both sites. Each access layer switch in the primary and secondary site has 18 usable ports. There are currently 9 access layer switches at the primary site and 3 access layer switches at the secondary site. Therefore, the number of usable ports at the primary site is 162, and the number of usable ports at the secondary, DR, site is 54. Thus, monitoring and personnel costs were allocated 75% to the primary site ($\frac{162}{162+54} = 0.75$) and 25% to the secondary site ($\frac{54}{162+54} = 0.25$).

To calculate the cost per physical connection, we divided the sum of all annual costs for each site by the total number of available ports at the access layer switches for such site and rounded up to the nearest dollar. Thus, the sum of the annual Physical Connectivity costs for the primary site and ITF, \$621,599, was divided by 162 to determine the cost per physical connection at the primary site, which is an annual cost of \$3,838 per physical connection. Similarly, the sum of the annual Physical Connectivity costs for the secondary site, \$173,849, was divided by 54 to determine the cost per physical connection at the secondary site, which is an annual cost of \$3,220 per physical connection.



Annual IEX Physical Connectivity Infrastructure **(\$795,448)**

1. Cross Connect via Patch Panel	\$0
2. POP Access Layer Switches (9 x 24 port)	(\$60,000)
a. DR Access Layer Switches (3 x 24 port)	(\$20,000)
3. POP Distribution Switches (2 x 52 port)	(\$16,667)
a. DR Distribution Switch (1 x 52 port)	(\$8,333)
4. POP Networking Equipment	(\$44,000)
a. DWDM Filter	
b. DWDM Optics	
c. Spools	
d. Fiber	
ITF Physical Connectivity	(\$56,667)
POP Data Center Space, Power, Security	(\$22,009)
DR Data Center Space, Power, Security	(\$10,319)
POP Administrative Access	(\$16,667)
Monitoring	(\$40,000)
Personnel	(\$500,786)
Total Available Physical Ports (Primary)	162
Total Available Physical Ports (Secondary)	54
Annual Cost per Port (Primary)	(\$3,838)
Annual Cost per Port (Secondary)	(\$3,220)

Figure 6 shows the annualized costs for IEX to offer physical connectivity to the Exchange using the above described methodology.

Note that since IEX does not manage its own data center, the cost to install and maintain cross-connects is paid by users to the data center operator. For reference, the cost to install a cross-connect presently is approximately \$500, and the monthly maintenance fee is approximately \$350 in most third-party data centers in the NY/NJ area. We have not included this monthly maintenance fee in the above calculation since these maintenance costs are incurred by users and not by IEX.

Comparing IEX Costs with Other Exchange Physical Connectivity Fees

In calculating IEX's costs to offer physical connectivity services, we have not attempted to define what would constitute an appropriate mark-up in selling these services to our members. Further, different system architectures may require more or less infrastructure and/or personnel to support the products and services discussed. Therefore, the absolute difference between IEX's annual cost per physical port in the primary and secondary (DR) data center and the annual fees IEX is charged by other exchanges for physical connectivity to similar types of data centers may not be



representative of the precise margins earned by other exchanges on their physical connectivity offerings. However, Table 8 below serves to illustrate the stark differences between the costs to provide physical connectivity and the revenues earned by other exchanges from similar connectivity products and services.

Exchange Family	IEX Purchased Physical Connection Type	Quantity	Installation Fees	Annual Fees	Analogous Annual IEX Cost	Markup Over IEX Cost
NYSE	10Gb Fiber LCN Access	2	\$20,000	\$336,000	\$7,676	4,277%
	10Gb Fiber IP Network Access	1	\$10,000	\$132,000	\$3,220	3,999%
NYSE Total			\$30,000	\$468,000		
NASDAQ	10Gb Fiber	2	\$2,000	\$240,000	\$7,676	3,027%
	10Gb Ultra Fiber via POP (Disaster Recovery)	1	\$1,500	\$90,000	\$3,220	2,695%
Nasdaq Total			\$3,500	\$330,000		
CBOE	10Gb Fiber	2	-	\$180,000	\$7,676	2,245%
	10Gb Fiber (Disaster Recovery)	1	-	\$72,000	\$3,220	2,136%
Cboe Total			-	\$252,000		

Table 8 compares the annual fees IEX is invoiced from each exchange for physical ports with the annual cost for IEX to offer its comparable service, which is \$3,838 per port at the primary data center and \$3,220 per port at the secondary data center.



Logical Connectivity for Order Entry

Entry of orders, as well as the receipt of trade reports for executions and drop copies must occur through a logical connection to an exchange. Multiple logical ports, also known as “sessions”, may exist through one physical connection. By using multiple sessions, participants can segregate the order flow from different internal desks, business lines, or customers, which mitigates exposure in the case of a disruption and reduces the likelihood of performance impacts if one strategy, desk, or customer sends a high volume of orders simultaneously.

Multiple sessions can exist on one server and/or process. To mitigate exposure in the case of a disruption, a participant’s sessions do not all exist on the same process/server. The maximum number of sessions per process/server differs depending on individual exchange architecture and risk tolerance.

Forms of Logical Connectivity

Exchanges usually offer logical connectivity in the form of FIX order entry, binary order entry, and drop copy service. Some exchanges offer specialty methods of access, such as the QIX or RASH protocols offered by Nasdaq, or sell segregated hardware where the logical connectivity for one and only one participant terminates, e.g., a dedicated OUCH server on Nasdaq.¹⁵ Each order entry protocol may offer slightly different functionality based on either the limitations of the underlying protocol or design choices of the exchange.¹⁶

NYSE, NYSE Arca, Nasdaq, and Nasdaq BX require that members pay an additional membership fee, in the form of a trading rights, trading license, or ETP membership fee, to gain access to the exchange system. Without paying for membership, a firm would not be eligible to submit orders to the exchange. Nasdaq also charges a fee per market participant identifier (MPID). Similarly, without paying the MPID fee, a firm would not be eligible to submit orders to the exchange through that particular MPID. Since these fees are directly related requirements for order entry, we have included them in assessing costs for logical connectivity.

In selling depth of book market data and related retransmission services, Nasdaq and Cboe impose an additional fee related to logical connectivity for purposes of receiving that data or service. Accordingly, to receive market data, a participant may pay separate fees for (i) physical connectivity to the exchange, (ii) an additional logical connectivity charge for the privilege of receiving market data through that connection, and (iii) the content of the market data itself, which itself varies depending on how the data is used (display or non-display) and whether and how it is redistributed. These fee categories are described and reflected in the Market Data or Physical Connectivity sections of this study. Therefore, the fees listed below in Table 9 focus on the fees per port solely for logical connectivity to send orders to each exchange and receive executions or receive drop copy information from each exchange and do not include any additional logical connectivity fees that may be charged for market data.¹⁷

¹⁵ See Nasdaq’s OUCH page for Dedicated OUCH server benefits and features (<http://www.nasdaqtrader.com/Trader.aspx?id=ouch>).

¹⁶ See Nasdaq’s Protocol Quick Reference for an overview of different attributes and functionality available on each protocol (https://www.nasdaqtrader.com/content/ProductsServices/Trading/Protocols_quickref.pdf).

¹⁷ Pricing as of January 2019 from NYSE Price Lists for NYSE, Arca, American, and National (https://www.nyse.com/publicdocs/nyse/markets/nyse/NYSE_Price_List.pdf, https://www.nyse.com/publicdocs/nyse/markets/nyse-american/NYSE_America_Equities_Price_List.pdf, https://www.nyse.com/publicdocs/nyse/markets/nyse-american/NYSE_America_Equities_Price_List.pdf).



Exchange Family	Exchange	Port Type	Port Name	Installation Fees	Monthly Fees per Port
NYSE	NYSE	Order Entry	FIX or Binary	\$ -	\$ 550
		Drop Copy	DROP	\$ -	\$ 550
	NYSE Arca	Order Entry	FIX or Binary	\$ -	\$ 550
		Drop Copy	DROP	\$ -	\$ 550
	NYSE American	Order Entry	FIX or Binary	\$ -	\$ 250
		Drop Copy	DROP	\$ -	\$ 250
	NYSE National	Order Entry	FIX or Binary	\$ -	\$ 250
		Drop Copy	DROP	\$ -	\$ 250

Exchange Family	Exchange	Port Type	Port Name	Installation Fees	Monthly Fees per Port
Nasdaq	Nasdaq	Order Entry	FIX or Binary (OUCH)	\$ -	\$ 575
			Dedicated OUCH Server	\$ 5,000	\$ 5,000
			Chicago DR Ports	\$ -	\$ 25
		Drop Copy	NTF Port	\$ -	\$ 300
			DROP	\$ -	\$ 550
			Chicago DR Ports	\$ -	\$ 25
	Nasdaq BX	Order Entry	FIX or Binary (OUCH)	\$ -	\$ 500
			Chicago DR Ports	\$ -	\$ 25
			NTF Port	\$ -	\$ 300
		Drop Copy	DROP	\$ -	\$ 500
			Chicago DR Ports	\$ -	\$ 25
			Chicago DR Ports	\$ -	\$ 25
	Nasdaq PSX	Order Entry	FIX or Binary (OUCH)	\$ -	\$ 400
			Chicago DR Ports	\$ -	\$ 25
			NTF Port	\$ -	\$ 300
		Drop Copy	DROP	\$ -	\$ 400
			Chicago DR Ports	\$ -	\$ 25
			Chicago DR Ports	\$ -	\$ 25

Exchange Family	Exchange	Port Type	Port Name	Installation Fees	Monthly Fees per Port
Cboe	Cboe BZX	Order Entry	FIX or Binary	\$ -	\$ 550
		Drop Copy	DROP	\$ -	\$ 550
	Cboe BYX	Order Entry	FIX or Binary	\$ -	\$ 550
		Drop Copy	DROP	\$ -	\$ 550
	Cboe EDGA	Order Entry	FIX or Binary	\$ -	\$ 550
		Drop Copy	DROP	\$ -	\$ 550
	Cboe EDGX	Order Entry	FIX or Binary	\$ -	\$ 550
		Drop Copy	DROP	\$ -	\$ 550

Exchange Family	Exchange	Port Type	Port Name	Installation Fees	Monthly Fees per Port
IEX	IEX	Order Entry	FIX	\$ -	\$ -
		Drop Copy	DROP	\$ -	\$ -

https://www.nyse.com/publicdocs/nyse/regulation/nyse/NYSE_National_Schedule_of_Fees.pdf),

Nasdaq Price Lists for Nasdaq, BX, and PSX

(<http://nasdaqtrader.com/Trader.aspx?id=PriceListTrading2>,

http://nasdaqtrader.com/Trader.aspx?id=bx_pricing,

http://nasdaqtrader.com/Trader.aspx?id=PSX_Pricing),

Cboe Fee Schedules for BZX, BYX, EDGA, and EDGX

(https://markets.cboe.com/us/equities/membership/fee_schedule/bzx/,

https://markets.cboe.com/us/equities/membership/fee_schedule/byx/,

https://markets.cboe.com/us/equities/membership/fee_schedule/edga/,

https://markets.cboe.com/us/equities/membership/fee_schedule/edgx/),

and IEX Fee Schedule

(<https://iextrading.com/trading/fees/>).



Exchange Family	Exchange	Membership Fee Type	Monthly Membership Fees	Annual Membership Fees
NYSE	NYSE	Trading License	\$ 4,167	\$ 50,000
	NYSE Arca	ETP Membership Fee	\$ 1,250	\$ 15,000

Exchange Family	Exchange	Membership Fee Type	Monthly Membership Fees	Annual Membership Fees
Nasdaq	Nasdaq	MPID Fees	\$ 550	\$ 6,600
		Trading Rights	\$ 1,250	\$ 15,000
	Nasdaq BX	Trading Rights	\$ 1,000	\$ 12,000

Table 9 lists the installation and monthly fees associated with a variety of logical connectivity options to NYSE, Nasdaq, Cboe, and IEX, as well as the various membership fees for the applicable NYSE and Nasdaq exchanges. The monthly fee can be found on the exchange provided fee schedule or price list, while the annual fee is twelve times the monthly fee. Note that this is not a complete list of the logical connectivity options.

How is Logical Connectivity Provided by an Exchange?

Logical connectivity for order entry is provided via network switch and cabling infrastructure that delivers order, execution, and drop copy messages, as well as server infrastructure that runs software processes responsible for validating and formatting such messages for either internal or external consumption. These software processes may be developed to offer a range of different protocols, e.g., FIX or binary.

To send an order to an exchange, the exchange must create a logical port (also referred to as an order entry session) for the participant. One client gateway or drop copy gateway process may support one or more order entry sessions or drop copy sessions from one or more members.

IEX Logical Connectivity for Order Entry Calculation Considerations

IEX considered costs for infrastructure in the primary data center, secondary (DR) data center, and public facing testing facility (ITF) for purposes of this calculation. Specifically, we considered the following physical assets when calculating the cost of offering logical connectivity for order entry to participants:

- Order Entry Distribution Switches: data from the distribution switches at the POP traverses the POP networking equipment to the order entry distribution switches in the primary data center
- Order Entry Access Layer Switches: data from the distribution switches is distributed into a specific top of rack access layer switch
- Client Gateway & Drop Copy Servers: the servers running either client gateway or drop copy process that either receive order or send execution/drop copy messages
- System Access Layer Switches: data validated and formatted by a client gateway process is distributed via an initial array of top of rack switches to the IEX system
- ITF System: hardware and software to facilitate FIX certification and order entry testing
- Space, Power, and Security: physical space, electrical power, and security at the data centers considered for the physical assets in scope
- Administrative Access: command and control infrastructure for operations teams to administer the exchange services
- Monitoring: servers, switches, and software licenses to monitor the physical assets in scope as well as the health of the connectivity service provided by such assets



NJ2X -
PRIMARY
SITE

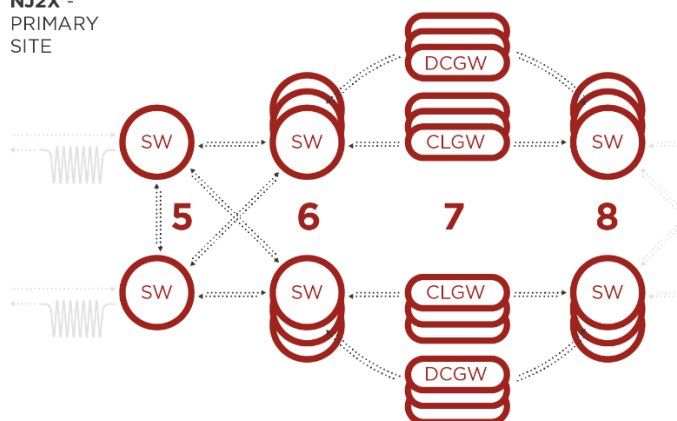


Figure 7 illustrates the physical assets in the primary data center that are directly responsible for offering logical connectivity.

- "5" represents the Order Entry Distribution Switches
- "6" represents the Order Entry Access Layer Switches
- "7" represents the Client Gateway & Drop Copy Process Servers
- "8" represents the System Access Layer Switches

IEX considered the following personnel when calculating the cost of offering logical connectivity for order entry to participants:

- Product Management: resources responsible for managing the Exchange offering
- Legal and Regulatory: resources responsible for the Exchange's compliance with applicable laws and regulations
- Information Security: resources responsible for maintaining and surveilling for information security
- Development and Quality Assurance: resources responsible for building and testing new Exchange functionality
- Operations: resources responsible for supporting participants and maintaining the IEX system
- Infrastructure: resources responsible for installing and maintaining the physical infrastructure
- ITF Operations: resources responsible for supporting participants and maintaining the IEX Testing Facility

Capacity and Expansion

The capacity of an exchange's logical connectivity for order entry is limited by the total number of order entry sessions the client gateway processes can support, client gateway servers, and access layer switches. As is the case with expanding physical capacity, expanding capacity to support additional logical connectivity is an interdependent process, as each layer cannot be considered in isolation, and an expansion of one layer may trigger the need to expand another layer. An exchange sets an acceptable tolerance of sessions per process/server. When the capacity across client gateway process servers is exhausted, capacity may be added in the form of an additional client gateway process server. However, adding a server uses capacity of the access layer switches and, when the capacity of the access layer switches is exhausted, an additional access layer switch must be added. Moreover, as described above, when the capacity of distribution switches is exhausted, additional distribution switches or greater density switches must be integrated into the platform. Finally, when the capacity of a data center rack is exhausted, a new rack or set of racks must be built out to provide both capacity and redundancy.

Calculating Logical Connectivity Costs for Order Entry

To calculate the total annual cost of offering logical connectivity to participants, we depreciated the cost of each purchased physical asset over three years, and included any lease, license, or recurring charges for the year. For personnel, we took into account 28 employees who directly impact logical connectivity and used a blended rate of \$249,386 to reflect the total annual compensation per person. Since the logical connectivity offering, once established, requires little daily intervention, and all of the identified employees have other responsibilities in addition to logical



connectivity, we then determined the percentage of time each person spent on logical connectivity to arrive at a full time equivalent of 3.34 across all the identified personnel.

The costs for offering logical connectivity via the primary and secondary site were combined for this exercise. The ITF costs were also included in the overall cost calculation.

In evaluating logical connectivity costs, we took account of the fact that, although most of the infrastructure, personnel, and software costs are common to both order entry and drop copy services, these services each ultimately run on separate, dedicated servers. Therefore, we separated the costs for providing order entry from those providing drop copy dissemination, by the proportion of logical ports available for each service. IEX's system architecture provides for 27 order entry or drop copy sessions per server. To calculate the proportion of logical connectivity costs for order entry, we multiplied the total logical connectivity costs by the proportion of order entry sessions available on the existing infrastructure to the total number of logical order entry and drop copy sessions. Similarly, to calculate the proportion of logical connectivity costs for drop copy services, we multiplied the total logical connectivity costs by the proportion of drop copy sessions available on the existing infrastructure to the total number of logical order entry and drop copy sessions.

Given a population of 56 client gateway servers for order entry and 4 servers for drop copy services, the maximum number of order entry sessions the current infrastructure in the primary site can support is 1,512 and the maximum number of drop copy sessions the current infrastructure in the primary site can support is 108. Thus, annual logical connectivity costs were allocated 93.3% to order entry ($\frac{1,512}{1,512+108} = 0.933$) and 6.7% to drop copy dissemination

($\frac{108}{1,512+108} = 0.067$).

To calculate the cost per session, we divided the proportion of the annual costs by the total number of available sessions and rounded up to the nearest dollar. The sum of the annual logical connectivity costs for order entry, \$1,508,649, was divided by 1,512 to determine the cost per order entry session. Similarly, the sum of the annual logical connectivity costs for drop copy dissemination, \$107,761, was divided by 108 to determine the cost per drop copy session. Due to the IEX system architecture and configuration, the annual cost for either an order entry or drop copy session is \$998.



Annual IEX Order Entry Infrastructure	(\$1,616,409)
5. Order Entry Distribution Switches (2 x 52 port)	(\$16,667)
6. Order Entry Access Layer Switches (6 x 24 port)	(\$40,000)
7. Client Gateway & Drop Copy Servers (CLGW / DCGW) (84/6)	(\$165,000)
a. Software Licensing	(\$48,000)
8. Sequencing Access Layer Switches (6 x 24 port)	(\$50,000)
ITF Order Entry	(\$95,333)
Space, Power, Security	(\$14,560)
Administrative Access	(\$33,333)
Monitoring	(\$320,567)
Personnel	(\$832,949)

Max Order Entry Sessions (Logical Sessions)	1,512
Max Drop Copy Sessions (Logical Sessions)	108
Annual Cost per Order Entry Session	(\$998)
Annual Cost per Drop Copy Session	(\$998)

Figure 8 shows the annualized costs for IEX to offer logical connectivity for order entry on the Exchange using the above described methodology.

Comparing IEX Costs with Other Exchange Logical Connectivity Fees

In calculating IEX's costs to offer logical connectivity services, we have not attempted to define what would constitute an appropriate markup to produce a profit or cover the cost of unused logical port capacity. Further, different system architectures may require more or less infrastructure and/or personnel to support the products and services discussed. Therefore, the absolute difference between IEX's annual cost per logical port and the annual fees IEX is charged by other exchanges for order entry sessions may not be representative of the precise margins earned by other exchanges on their logical connectivity offerings. However, this study illustrates the stark differences between the costs to provide logical connectivity and revenues earned by other exchanges from providing logical connectivity services.



Exchange Family	Exchange	Production Ports	Annual Port Fees	Annual Membership & MPID Fees	Total Annual Fees	Analogous Annual IEX Cost	Markup Over IEX Cost
NYSE	NYSE	4	\$26,400	\$50,000	\$76,400	\$3,992	1,814%
	NYSE Arca	4	\$26,400	\$15,000	\$41,400	\$3,992	937%
	NYSE American	2	\$6,000	-	\$6,000	\$1,996	201%
	NYSE National	2	\$6,000	-	\$6,000	\$1,996	201%
NYSE Total			\$64,800	\$65,000	\$129,800		
NASDAQ	Nasdaq	4	\$27,600	\$21,600	\$49,200	\$3,992	1,132%
	Nasdaq BX	2	\$12,000	\$12,000	\$24,000	\$1,996	1,102%
	Nasdaq PSX	2	\$9,600	-	\$9,600	\$1,996	381%
Nasdaq Total			\$49,200	\$36,600	\$85,800		
CBOE	Cboe BZX	2	\$13,200	-	\$13,200	\$1,996	561%
	Cboe BYX	2	\$13,200	-	\$13,200	\$1,996	561%
	Cboe EDGA	2	\$13,200	-	\$13,200	\$1,996	561%
	Cboe EDGX	2	\$13,200	-	\$13,200	\$1,996	561%
Cboe Total			\$52,800	-	\$52,800		

Table 10 compares the annual fees IEX is invoiced from each exchange for order entry ports (i.e., sessions) with the annual cost for IEX to offer its comparable service, which is \$998 per port.



Economies of Scale

One might think that an exchange would incur higher costs when supporting more participants or offering more products or services. In reality, because of the economies of scale that are inherent in operating an exchange (or family of exchanges), the incremental per unit cost for additional products and services for each exchange should be lower than the per unit costs incurred by IEX as the operator of a single exchange. Consider the following example illustrating the change in cost per user as an exchange adds physical connectivity capacity and increases its market data offerings.

ABC Exchange offers two market data products: aggregated Depth of Book and Top of Book. Each product is disseminated to participants via a single channel over an A-line and B-line. For illustration purposes, ABC Exchange has 150 data recipient firms (companies, not natural persons) of its market data products. Also, the access layer switches at ABC Exchange support a total of 180 physical port connections, assuming 10 switches that have 18 usable ports each. Assume that the exchange's overall cost of providing market data and physical connectivity is \$500,000 per month, where the exchange's costs of providing connectivity are \$200,000 per month, and its costs of providing market data are \$300,000 per month. Therefore, in the current configuration, each physical port costs the exchange \$1,112 per month (\$200,000 divided by 180 ports) and the market data feeds provided through such connections to each data recipient cost the exchange \$2,000 per month to produce (\$300,000 divided by 150 data recipient firms).

If ABC Exchange were near capacity in access layer switches and decided to *double* its capacity, it could do so by adding another 10 access switches, which would increase the capacity of the access layer to 360 total physical ports. For this increase in capacity, assuming a cost of \$30,000 per switch depreciated across three years, the exchange would incur only roughly \$8,333 in additional monthly cost (\$30,000 per switch * 10 switches / 36-month depreciation = \$8,333 per month), increasing the total physical connectivity costs for ABC Exchange from \$200,000 per month to \$208,333 per month. Therefore, in the updated configuration, each physical port would cost the exchange \$579 per month, compared with the \$1,112 per port cost prior to the expansion. There would be no change to the cost of providing market data, but the exchange would have doubled the number of direct market data customers it could support.

Physical Connectivity Metric	Baseline	Double Capacity
Access Layer Switches	10	20
Total Usable Ports	180	360
Monthly Cost of Physical Connectivity	\$ 200,000	\$ 208,333
Monthly Cost Per Port	\$ 1,112	\$ 579

Figure 9 illustrates how doubling physical connectivity capacity for ABC Exchange brings down the monthly cost per port.

To continue the example, assume the exchange decided to double its portfolio of market products by offering two new market data feeds over this expanded infrastructure: order-by-order Depth of Book and Last Sale. Each product is disseminated to participants via a single channel over an A-line and B-line. To deliver this functionality, assume that the exchange requires 5 additional servers per market data service. For this new product offering, assuming a cost of \$6,000 per server depreciated across 3 years, the exchange would incur only roughly \$1,667 in additional monthly cost (\$6,000 per server * 10 servers / 36-month depreciation = \$1,667 per month), increasing the total market data costs for ABC Exchange from \$300,000 per month to \$301,667 per month, which equates to \$2,012 per data recipient firm for the existing 150 firms. Therefore, if the new product offerings were able to attract just 100 new customers to the exchange, for a total of 250 data recipients, the costs to the exchange per data recipient would equal about \$1,207 per month, compared with the \$2,000 per recipient cost prior to the introduction of the new feeds.



Market Data Metric	Baseline	Double Products	Customer Growth
Market Data Users	150	150	250
Market Data Feeds	2	4	4
Monthly Cost of Market Data	\$ 300,000	\$ 300,000	\$ 301,667
Monthly Cost Per User	\$ 2,000	\$ 2,012	\$ 1,207

Figure 10 illustrates how increasing the number of market data feeds and subsequently the number of market data customers for ABC Exchange brings down the monthly cost per user.

As seen in these examples, increasing scale (for example, by providing more physical ports) or differentiation (for example, by introducing new market data products) can substantially increase the potential revenue while only marginally increasing the exchange's costs. Further benefits of the same type can arise by increasing the number of exchanges operated by the same company. Once an exchange operator makes the necessary upfront investment to offer a product or service, adding another exchange further leverages available personnel, research, software and infrastructure across multiple platforms and keeps the marginal cost of expansion low.

It is also important to note that the single highest cost category for IEX is its personnel. In fact, over 50% of the costs for all three areas discussed in this study relate to personnel. Firms that operate multiple exchanges can spread these costs across multiple exchanges by leveraging the same personnel across multiple exchanges.

Conclusion

The controversy over the cost to the industry and investors for market data and connectivity will never be settled without additional transparency by exchanges. In response to calls by market participants and regulators for transparency, IEX has voluntarily undertaken this study, which provides to the public an unprecedented view of the inner workings of a national securities exchange. This study also presents a logical and coherent methodology to identify and quantify exchange costs to produce these necessary products and services.

We believe this study clearly demonstrates the existence of dramatic, and at times egregious, differences between the costs of providing market data and connectivity, and the fees charged by NYSE, Nasdaq, and Cboe. The size of these differences on their face gives strong support to industry complaints that the power of exchanges to set prices for these products and services is unfair, unreasonable, and not subject to competitive forces. In addition, the fact that exchanges are granted a regulatory quasi-monopoly in providing these services further justifies additional scrutiny to the prices charged for them.

Although we do not expect that publishing this study will end the debate of these issues, we think it justifies further regulatory action to force comparative disclosure about these matters from all exchanges. In the meantime, we challenge other exchanges to provide similar disclosures that illuminate their own costs for providing market data and connectivity and/or better justify the markups suggested by our study.

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Adrian Facini - Head of Product

John Ramsay - Chief Market Policy Officer



Appendix A: Market Data Fees Paid by IEX

Exchange Family	Exchange	Feed Name	Fee Name	Base Fee	Quantity	Monthly Fees	Annual Fees	
NYSE	NYSE	NYSE OpenBook	Access Fee	\$ 5,000	1	\$ 5,000	\$ 60,000	
			Non-Display Fee – Category 2 (Agency) ²	\$ 6,000	1	\$ 6,000	\$ 72,000	
			Non-Display Fee – Category 3 (Matching) ²	\$ 6,000	1	\$ 6,000	\$ 72,000	
			Professional User Fee ¹	\$ 60	31	\$ 1,860	\$ 22,320	
	NYSE Total						\$ 18,860	\$ 226,320
	NYSE Arca	NYSE ArcaBook	Access Fee	\$ 2,000	1	\$ 2,000	\$ 24,000	
			Non-Display Fee – Category 2 (Agency) ²	\$ 6,000	1	\$ 6,000	\$ 72,000	
			Non-Display Fee – Category 3 (Matching) ²	\$ 6,000	1	\$ 6,000	\$ 72,000	
			Professional User Fee ¹	\$ 60	31	\$ 1,860	\$ 22,320	
	NYSE Arca Total						\$ 15,860	\$ 190,320
	NYSE American	NYSE American OpenBook	Access Fee	\$ 1,000	1	\$ 1,000	\$ 12,000	
			Non-Display Fee – Category 2 (Agency) ²	\$ 2,000	1	\$ 2,000	\$ 24,000	
			Non-Display Fee – Category 3 (Matching) ²	\$ 2,000	1	\$ 2,000	\$ 24,000	
Professional User Fee ¹			\$ 5	31	\$ 155	\$ 1,860		
NYSE American Total						\$ 5,155	\$ 61,860	
NYSE Total						\$ 39,875	\$ 478,500	
Nasdaq	Nasdaq	Nasdaq TotalView (ITCH)	Real-Time Data Products Administration Fee	\$ 100	1	\$ 100	\$ 1,200	
			Internal Distributor	\$ 1,500	1	\$ 1,500	\$ 18,000	
			Direct Access	\$ 3,000	1	\$ 3,000	\$ 36,000	
			Non-Display Platform ²	\$ 5,000	1	\$ 5,000	\$ 60,000	
			Non-Display via Direct Access ³	\$ 375	9	\$ 3,375	\$ 40,500	
			Professional/Corporate ¹	\$ 76	31	\$ 2,356	\$ 28,272	
	Multicast ITCH (MTCH) - software ⁴	\$ 1,000	1	\$ 1,000	\$ 12,000			
	Nasdaq Total						\$ 11,731	\$ 195,972
	Nasdaq BX	Nasdaq BX TotalView (ITCH)	Real-Time Data Products Administration Fee	\$ 100	1	\$ 100	\$ 1,200	
			Internal Distributor	\$ 750	1	\$ 750	\$ 9,000	
			Direct Access	\$ 1,000	1	\$ 1,000	\$ 12,000	
			Non-Display via Direct Access ³	\$ 55	9	\$ 495	\$ 5,940	
			Professional/Corporate ¹	\$ 40	31	\$ 1,240	\$ 14,880	
	Multicast ITCH (MTCH) - software ⁴	\$ 1,000	1	\$ 1,000	\$ 12,000			
	Nasdaq BX Total						\$ 3,735	\$ 55,020
	Nasdaq PSX	Nasdaq PSX TotalView (ITCH)	Real-Time Data Products Administration Fee	\$ 100	1	\$ 100	\$ 1,200	
			Internal Distributor	\$ 500	1	\$ 500	\$ 6,000	
			Direct Access	\$ 1,000	1	\$ 1,000	\$ 12,000	
			Non-Display via Direct Access ³	\$ 50	9	\$ 450	\$ 5,400	
Professional/Corporate ¹			\$ 40	31	\$ 1,240	\$ 14,880		
Multicast ITCH (MTCH) - software ⁴	\$ 1,000	1	\$ 1,000	\$ 12,000				
Nasdaq PSX Total						\$ 3,690	\$ 51,480	
Nasdaq Total						\$ 19,156	\$ 302,472	
Cboe	Cboe BZX	BZX Depth (PITCH)	Internal Distributor	\$ 1,500	1	\$ 1,500	\$ 18,000	
			Non-Display Usage by Trading Platforms	\$ 5,000	1	\$ 5,000	\$ 60,000	
			Professional User Fee ¹	\$ 40	31	\$ 1,240	\$ 14,880	
			Multicast PITCH Spin Server Ports (pair) ⁴	\$ 550	4	\$ 2,200	\$ 26,400	
	Cboe BZX Total						\$ 8,440	\$ 119,280
	Cboe BYX	BYX Depth (PITCH)	Internal Distributor	\$ 1,000	1	\$ 1,000	\$ 12,000	
			Non-Display Usage by Trading Platforms	\$ 2,000	1	\$ 2,000	\$ 24,000	
			Professional User Fee ¹	\$ 10	31	\$ 310	\$ 3,720	
			Multicast PITCH Spin Server Ports (pair) ⁴	\$ 550	4	\$ 2,200	\$ 26,400	
	Cboe BYX Total						\$ 4,510	\$ 66,120
	Cboe EDGA	EDGA Depth (PITCH)	Internal Distributor	\$ 1,000	1	\$ 1,000	\$ 12,000	
			Non-Display Usage by Trading Platforms	\$ 2,000	1	\$ 2,000	\$ 24,000	
			Professional User Fee ¹	\$ 10	31	\$ 310	\$ 3,720	
			Multicast PITCH Spin Server Ports (pair) ⁴	\$ 550	4	\$ 2,200	\$ 26,400	
	Cboe EDGA Total						\$ 4,510	\$ 66,120
	Cboe EDGX	EDGX Depth (PITCH)	Internal Distributor	\$ 1,500	1	\$ 1,500	\$ 18,000	
			Non-Display Usage by Trading Platforms	\$ 5,000	1	\$ 5,000	\$ 60,000	
Professional User Fee ¹			\$ 40	31	\$ 1,240	\$ 14,880		
Multicast PITCH Spin Server Ports (pair) ⁴			\$ 550	4	\$ 2,200	\$ 26,400		
Cboe EDGX Total						\$ 8,440	\$ 119,280	
Cboe Total						\$ 25,900	\$ 370,800	



Appendix B: Physical Connectivity Fees Paid by IEX

Exchange Family	Physical Connection Type	Installation Fees	Base Fee per Port	Quantity	Monthly Fees	Annual Fees
NYSE	10Gb Fiber LCN Access	\$ 10,000	\$ 14,000	2	\$ 28,000	\$ 336,000
	10Gb Fiber IP Network Access	\$ 10,000	\$ 11,000	1	\$ 11,000	\$ 132,000
NYSE Total					\$ 39,000	\$ 468,000
Nasdaq	10Gb Fiber	\$ 1,000	\$ 10,000	2	\$ 20,000	\$ 240,000
	10Gb Ultra Fiber via POP	\$ 1,500	\$ 7,500	1	\$ 7,500	\$ 90,000
Nasdaq Total					\$ 27,500	\$ 330,000
Cboe	10Gb Fiber	\$ -	\$ 7,500	2	\$ 15,000	\$ 180,000
	10Gb Fiber (Disaster Recovery)	\$ -	\$ 6,000	1	\$ 6,000	\$ 72,000
Cboe Total					\$ 21,000	\$ 252,000

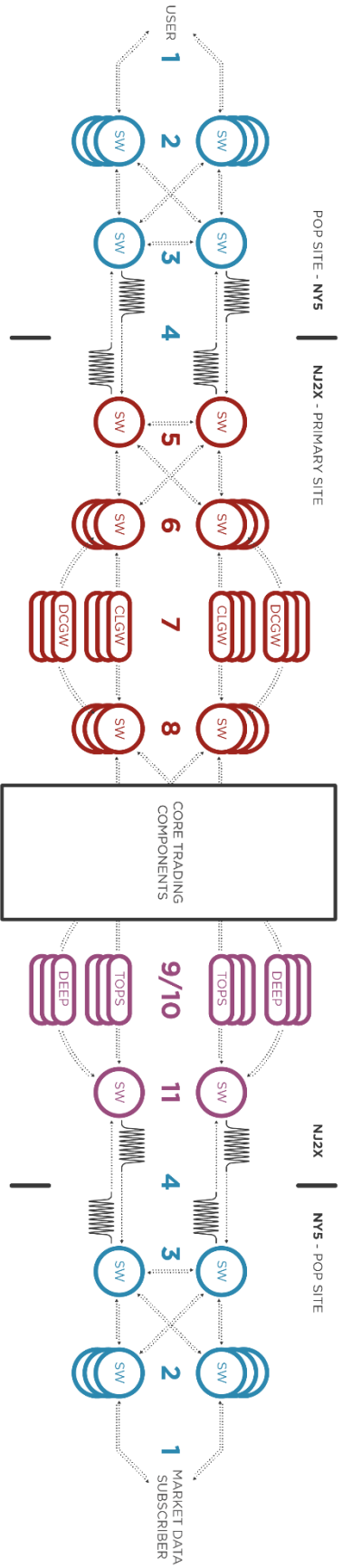


Appendix C: Logical Connectivity Fees Paid by IEX

Exchange Family	Exchange	Port Type	Port Name	Base Fee per Port	Quantity	Monthly Fees	Annual Fees
NYSE	NYSE	Order Entry	FIX or Binary	\$ 550	4	\$ 2,200	\$ 26,400
	NYSE Arca	Order Entry	FIX or Binary	\$ 550	4	\$ 2,200	\$ 26,400
	NYSE American	Order Entry	FIX or Binary	\$ 250	2	\$ 500	\$ 6,000
	NYSE National	Order Entry	FIX or Binary	\$ 250	2	\$ 500	\$ 6,000
NYSE Total						\$ 5,400	\$ 64,800
Nasdaq	Nasdaq	Order Entry	FIX or Binary (OUCH)	\$ 575	4	\$ 2,300	\$ 27,600
			Chicago DR Ports	\$ 25	4	\$ 100	\$ 1,200
			NTF Port	\$ 300	1	\$ 300	\$ 3,600
	Nasdaq BX	Order Entry	FIX or Binary (OUCH)	\$ 500	2	\$ 1,000	\$ 12,000
			Chicago DR Ports	\$ 25	2	\$ 50	\$ 600
			NTF Port	\$ 300	1	\$ 300	\$ 3,600
	Nasdaq PSX	Order Entry	FIX or Binary (OUCH)	\$ 400	2	\$ 800	\$ 9,600
			Chicago DR Ports	\$ 25	2	\$ 50	\$ 600
			NTF Port	\$ 300	1	\$ 300	\$ 3,600
	Nasdaq Total						\$ 5,200
Cboe	Cboe BZX	Order Entry	FIX or Binary	\$ 550	2	\$ 1,100	\$ 13,200
	Cboe BYX	Order Entry	FIX or Binary	\$ 550	2	\$ 1,100	\$ 13,200
	Cboe EDGA	Order Entry	FIX or Binary	\$ 550	2	\$ 1,100	\$ 13,200
	Cboe EDGX	Order Entry	FIX or Binary	\$ 550	2	\$ 1,100	\$ 13,200
Cboe Total						\$ 4,400	\$ 52,800



Appendix D: Costs for IEX to Provide Connectivity, Order Entry, and Market Data



Annualized cost of providing connectivity, order entry, and market data services in Prod, DR, and ITF:

Annual IEX Physical Connectivity		Annual IEX Order Entry		Annual IEX Market Data	
Direct Costs	(\$795,448)	Direct Costs	(\$1,616,409)	Direct Costs	(\$1,791,403)
1. Cross Connect via Patch Panel	\$0	5. Order Entry Distribution Switches (2 x 52 port)	(\$16,667)	9. Top of Book Servers (TOPS) (5)	(\$12,833)
2. Primary Access Layer Switches (9 x 24 port)	(\$60,000)	6. Order Entry Access Layer Switches (6 x 24 port)	(\$40,000)	10. Depth of Book Servers (DEEP) (5)	(\$12,833)
a. Secondary Access Layer Switch (3 x 24 port)	(\$20,000)	7. Client Gateway & Drop Copy Servers (CLGW/DCGW) (84/6)	(\$165,000)	11. Market Data Feeds Switches (2 x 24 port)	(\$13,333)
a. Primary Distribution Switches (2 x 52 port)	(\$16,667)	a. Software Licensing	(\$48,000)		
3. Primary Distribution Layer Switch (3 x 24 port)	(\$8,333)	8. Sequencing Access Layer Switches (6 x 24 port)	(\$50,000)		
4. Primary Networking Equipment	(\$44,000)				
a. DWDM Filter & Optics					
b. Spools					
c. Fiber					
ITF Physical Connectivity	(\$56,667)	ITF Order Entry	(\$95,333)	ITF Market Data	(\$7,333)
Primary Data Center Space, Power, Security	(\$22,009)	Data Center Space, Power, Security	(\$14,560)	Data Center Space, Power, Security	(\$10,605)
Secondary Data Center Space, Power, Security	(\$10,319)	Administrative Access	(\$33,333)	Administrative Access	(\$33,333)
Primary Administrative Access	(\$16,667)	Monitoring	(\$320,567)	Monitoring	(\$596,135)
Monitoring	(\$40,000)	Personnel	(\$832,949)	Personnel	(\$1,104,998)
Personnel	(\$500,786)				
Total Available Physical Ports (Primary)	162	Max Order Entry Sessions (Logical Sessions)	1,512	Total Users (Trailing 6 months)	150
Total Available Physical Ports (Secondary)	54	Max Drop Copy Sessions (Logical Sessions)	108	Annual Cost per Data Recipient / Subscriber for TOPS	(\$11,943)
Annual Cost per Port (Primary)	(\$3,838)	Annual Cost per Order Entry Session	(\$998)	Annual Cost per Data Recipient / Subscriber for DEEP	(\$11,943)
Annual Cost per Port (Secondary)	(\$3,220)	Annual Cost per Drop Copy Session	(\$998)		