

# What if I Told You...

Equity Research

## Themes, Dreams and Flying Machines

### What if I Told You...

That as the terms innovation and disruption become mainstream there are still pockets of discovery value for investors in the world today. From **curing cancer with the cloud** to solving **space** to creating an alternative to fossil fuel in **lithium**, opportunities abound for those willing to look beyond today's headlines. The world is changing as a new generation (**Gen-Z**) is poised to take the mantle from Millennials while the **payback for college** becomes harder to justify.

This is all in the face of a market that remains volatile with the potential for another **flash crash** looming. Meanwhile, while the Bitcoin hype cycle has gone quiet, Silicon Valley and Wall Street are betting that the underlying technology behind it, the **Blockchain**, can change ... well everything. It is against that backdrop that we present our latest departmental thematic piece focused on seven key emerging debates we believe need to be on investors' radars. This 7 for 7 offers up insights on these key stories with a focus on framing a response to ... What if I Told You?

### Seven For Seven

#### (1) **The Blockchain Could Disrupt Everything.**

Potential use cases for the core technology behind Bitcoin abound. The VC backdrop is healthy and expectations are high, but roadblocks remain.

**(2) Space is Once Again the New Frontier.** The space race is reigniting, and we see investment opportunities.

**(3) College May Not Be Worth It.** The average return on going to college is falling, and for some the cost may no longer be justified.

#### (4) **Gen-Z Matters More than Millennials.**

America's youngest cohort will soon overshadow their predecessors in size and influence.

**(5) There will be another Flash Crash.** The Aug 24<sup>th</sup> selloff exposed the flaws of a market where regulation is not uniform across the exchanges.

**(6) Lithium is the New Gasoline.** Lithium's unique properties make it a key enabler of the electric vehicle revolution.

**(7) The Cloud Can Help Cure Cancer.** For the first time in history, physicians will have the ability to use genomic profiling for every cancer patient.

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*This is an abridged version of a report published Dec. 2, 2015. All investment recommendations have been removed.*

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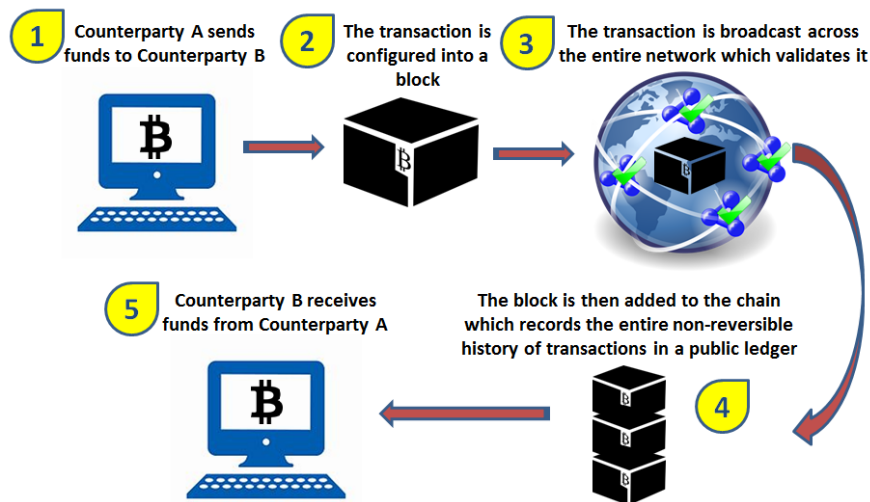
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# What if I Told You ... the Blockchain Could Disrupt ... Everything

From Silicon Valley to Wall Street, technologists and investors alike are buzzing about the potential for the Blockchain to revolutionize ... well everything. The hype is high and the potential is real but roadblocks remain. The funding backdrop is healthy and the application eco-system is growing. Once considered the underlying pipes of Bitcoin, this technology is quickly taking center stage from its crypto-currency parent promising an ushering in of a new set of tools to cut costs and challenge the profit pool of the middle-man with a promise to make centralized institutions obsolete. This solution promises to not just address consumer opportunities but also those for the far more lucrative enterprise.

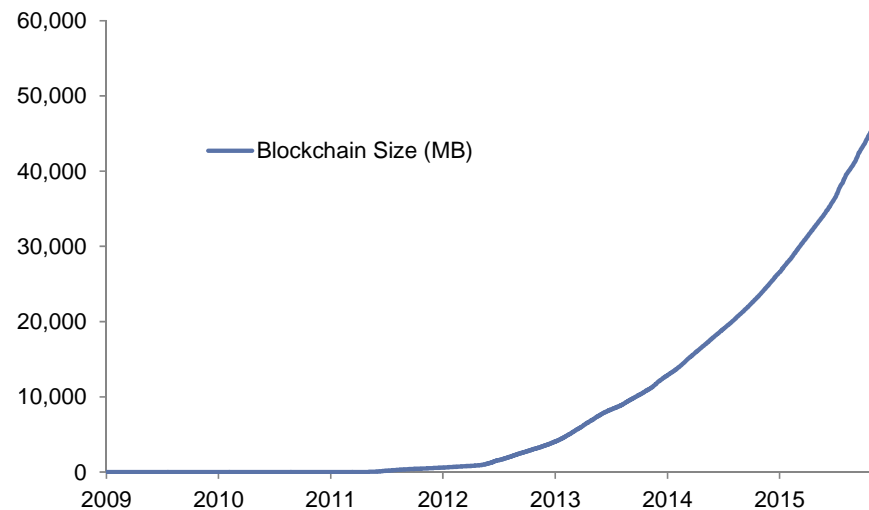
**What if I told you that Bitcoin was just the opening act ... with the Blockchain ready to take center stage.** In its purest form the **Blockchain** is a digital platform that records and verifies transactions in a tamper- and revision-proof way that is public to all (Exhibit 1). Levering the same peer-to-peer technology first developed in a dorm room at Northeastern University with Napster (and subsequently built upon by folks like Skype and Spotify) the tool was first born out of a need to track and create Bitcoin. Specifically Bitcoin and other cryptocurrencies required a way of building agreement between all parties involved in a transaction. From buying to selling to trading to storing, every transaction would be chained to each other so one could never duplicate or change the ownership of Bitcoin. This Blockchain allows information to be put in, but never deleted. This complete history ... a “shared public ledger” that a network (and the currency) relies on, if you will - made, in the user’s mind, the role of a Central Bank obsolete (Exhibit 2). The fiat of the currency, as a result, was born of the citizens of the internet, not a central clearing institution or agency. Lastly, while the Blockchain associated with Bitcoin remains the most well known, there are growing sets of private and permission-driven shared ledgers gaining traction and worth focusing on.

**Exhibit 1: The Blockchain is a distributed, public ledger, most commonly known as the core underlying technology for Bitcoin**



Source: Goldman Sachs Global Investment Research.

**Exhibit 2: The size of the Blockchain grows along with the no. of transactions**  
Aggregate size of the Bitcoin Blockchain (MB) since inception (2009)



Source: blockchain.info, Goldman Sachs Global Investment Research.

- **The Role of Cryptography.** Before any transaction is approved and added to the Blockchain it is verified by an algorithm that leverages cryptography to verify its authenticity. Each transaction that occurs in Bitcoin, for instance, has the information sent out across the network for trust and verification. By solving the algorithmic riddle behind putting a block of transactions together, individuals or groups, known as miners, receive a reward. That of more Bitcoins. This process, distributed across multiple nodes across a network, is complex, large-scale and incredibly hard to do. Persistent and reliable, in this system everyone has to agree to a transaction yet no one owns it. It allows people who don't know each other, or trust each other, to come to an agreement that is validated, trusted and held as a matter of public record.
- **Wait, I Thought Bitcoin was dead?** Granted, over the last two years ending November 30, the price of Bitcoin has fallen 67% to ~\$377 and fluctuated materially as highly publicized scandals involving digital properties such as Mt. Gox and Silk Road became mainstream fodder and global economies stabilized thus reducing the lack of confidence in central institutions. Add to this mystery of Satoshi Nakamoto, the pseudonym of a person or group who created the Bitcoin protocol and related software. Regardless, those who wrote off Bitcoin may have missed the golden egg – an underlying technology driver aimed at streamlining, potentially, a multitude of businesses. Put simply, the Blockchain can live outside a world of Bitcoin.

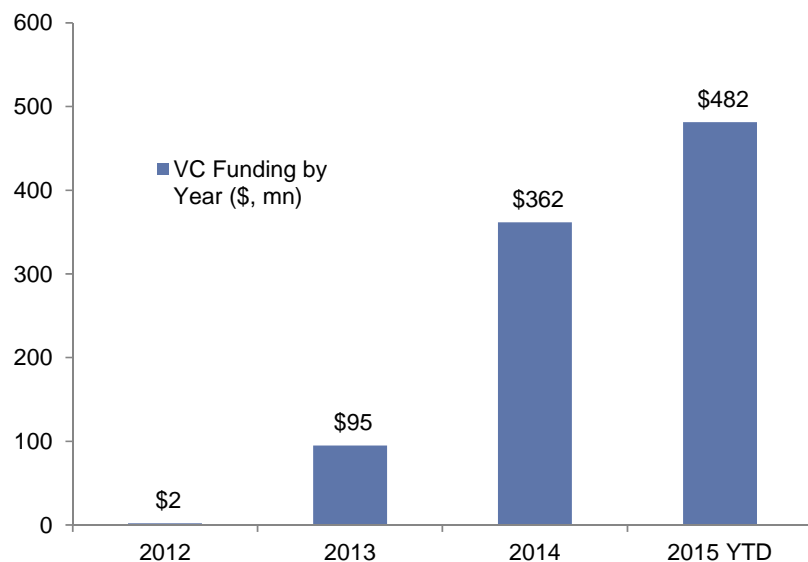
**Why It Matters?** This decentralized, cryptography-based solution cuts out the middle man. It has the potential to redefine transactions and the back office of a multitude of different industries. From banking and payments to notaries to voting systems to vehicle registrations to wire fees to gun checks to academic records to trade settlement to cataloguing ownership of works of art, a distributed shared ledger has the potential to make interactions quicker, less-expensive and safer. By removing the need for a middle man one lowers potential security concerns from hacking to corruption as well as speeding up manual processes that are antiquated and can take too long. Your counterparty risk, if processing times improve, can be near instantaneous, allowing accurate, in real-time, feedback on risks and exposures. In the world of the author, think of it from the banking side. In the face of increased capital and regulatory costs, any incremental technology that improves ROI drops to the profit line. Supervisory and technology resources as a result, could be cut.

#### **What are the Drawbacks?**

Like any new technology, the hype cycle is building with no real, at this point in time, legislative or regulatory framework. Open-source has a history of both successes and failures, thus begging the question of how open or controlled Blockchains will be. That's not to say private Blockchains can't work but fragmentation may slow adoption. Further, as with any solutions tied to technology, the key questions about the cost of development and maintenance become profound and core to scalability (as does speed). In the case of Bitcoin, for instance, VisaNet, (Visa's processing system), stated in 2013 that it could handle 47 K transactions per second (at capacity) where the Bitcoin Blockchain handles roughly 7. This is because Bitcoin software limits the size of each block to 1 MB (today, due to network compute concerns), which is created every 10 minutes. Each transaction varies in size but the smallest block size is ~224 bytes so a 1024 KB block/256 bytes = 4,096 transactions every 600 seconds which equates to 7 a second.

**Exhibit 3: Venture Capital Funding has grown exponentially**

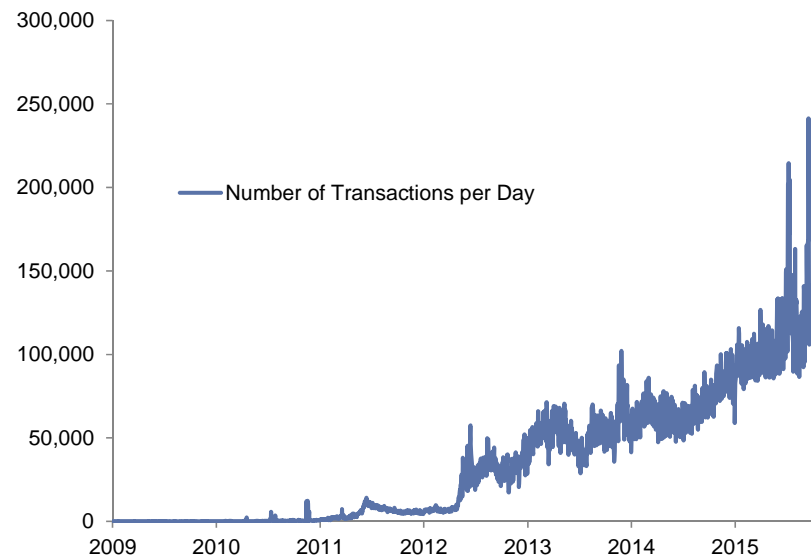
Bitcoin / Blockchain VC funding by year (\$, mn)



Source: CoinDesk, Goldman Sachs Global Investment Research.

**Exhibit 4: Bitcoin transaction volumes continue to grow**

Total number of unique Bitcoin transactions per day



Source: blockchain.info, Goldman Sachs Global Investment Research.

**Outside the Start-Ups, Examples of Use Cases ...**

The bevy of start-ups in this space are not small. From **Digital Asset Holdings** to **Coinbase** to **Ripple** to **Ethereum** (among many others) the list is long. For the purposes of this presentation we showcase three emerging applications to highlight the potential range of usage forming in corporate America today.

**R3CEV.** A consortium of 30 of the largest global banks this body is working to establish clear standards and protocols for distributed database activities. This New York based start-up has hired from Google, IBM, Barclays and others to help reduce costs in banking.

**ADEPT.** Merging IoT with the Blockchain, IBM and Samsung have developed ADEPT, or Autonomous Decentralized Peer to Peer Telemetry, which aims to leverage technology to help serve as ledgers or record-keepers for all the transactions that IoT activities will create. It can also be used to as a way for devices to understand how others work (think of linking your phone with your home heating system). This technology also borrows from BitTorrent and Telehash with promise to improve security concerns as well (another area of focus for the Blockchain).

**Nasdaq.** Has launched Nasdaq Linq, its Blockchain-enabled platform used to facilitate the issuance, cataloguing and recording of transfers of privately held companies on the NASDAQ private market. Nasdaq partnered with Chain.com leveraging its own in-house IP.

# What if I Told You ... Space Is Once Again the New Frontier

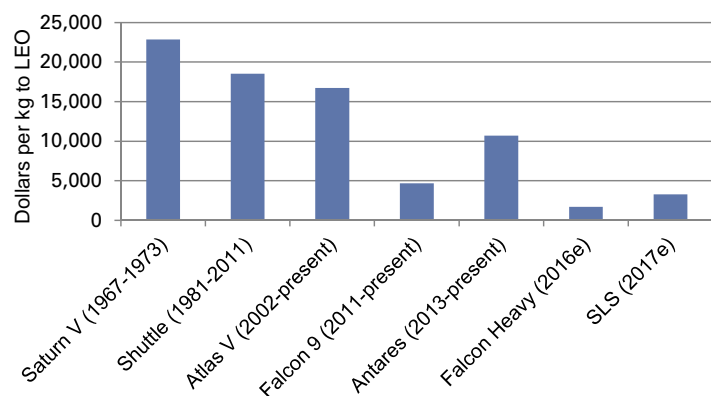
The space race is reigniting and we see investment opportunities. As the barrier and costs to deploying space technologies are lowered, we believe A&D companies will see accelerated growth in their space business lines, while commercial satellite operators may be disrupted by lower-cost alternatives. Escalating geopolitical tensions appear to be driving the US towards increased militarization of space and protection of existing assets, with growth in funding in space asset protection as a result. Space is becoming smaller, closer, and cheaper, reinventing an industry that has stagnated for decades and making room for new applications, technologies, and competitors.

**What if I told you that space launches now cost 11X less than 5 years ago and that satellites can cost 100X less.** Our ability to get to space has changed more in the last 5 years than during the entire prior period of space exploration. The new accessibility may radically change our activities in space. Low-cost launches allow for deployment of low-cost satellites with shorter life expectancies, lowering the barrier for commercial, military, and scientific space activities. Constellations of smaller satellites can now do the work of older satellites at significant cost savings. Without this high barrier to entry, the space economy may undergo an era of creative destruction. Satellite manufacturers and launch service providers must quickly respond and reinvent themselves to capitalize on what may be a high growth market.

**Why It Matters?** Affordable access to space is a game changer. The future of exploration and the space economy is contingent on accessibility. Until now, only a handful of companies and countries were large enough to invest in space-based assets. The lower price point for both satellite technology and launch services enables access for more companies. This will likely change the competitive environment by stimulating demand for space-based assets and increasing the supply of services like GPS, satellite Internet, and precision mapping. As space becomes more crowded, tracking and protection of US assets is an increasingly important focus for the DoD that has already created new opportunity for Defense names.

**Exhibit 5: Falling launch costs open opportunity for new missions**

Launch costs per payload kg fall over time, especially recently

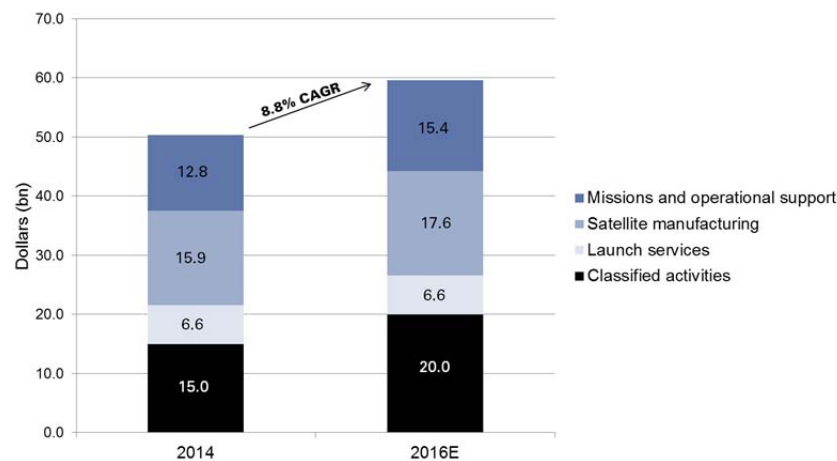


\* Antares launch costs estimated

Source: NASA, ESA, CBO, Company data, SpaceNews, Goldman Sachs Global Investment Research

**Exhibit 6: Addressable opportunity for A&D companies will be \$60bn next yr**

We see A&D space exposure growing at a 9% CAGR from 2014-2016



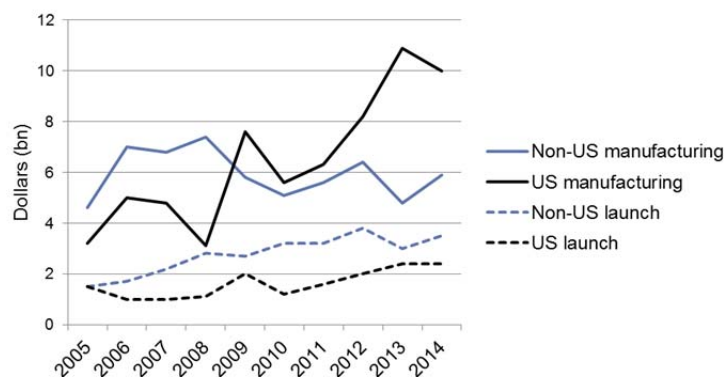
Source: NASA, DoD, NOAA, Satellite Industry Association, Goldman Sachs Global Investment Research.

**Satellite and Launch opportunities in A&D:** The decrease in launch costs offers unprecedented access to space and will create opportunity for satellite manufacturers. **With costs less than 10% of what they were 5 years ago, space investments are set to become feasible for companies without a presence there now.** Costs will likely continue falling with development of reusable rockets similar to the one successfully tested by Blue Origin last week. We think costs could fall a further 10X over the next 5 years. We expect Lockheed Martin, Alliant Techsystems, and Boeing to reduce their Antares, Atlas V, and Vulcan launch costs to compete. Low launch costs will reshape the satellite industry, since satellites can now be designed for shorter life expectancies, which disproportionately lower costs. GPS, satellite Internet, communications, imagery, and scientific research availability could increase significantly with a consequent decrease in costs for consumers and taxpayers. We see the US A&D sector continuing its above-peer manufacturing growth trajectory and gaining launch market share after years of underperformance, as shown in Exhibit 7.

We see the space economy as elastic, compounding the effects of lower cost launches and satellites. **OneWeb/Virgin Galactic/Qualcomm Inc. and SpaceX have already acted on lower launch costs, announcing deployment plans for 900 and 4,000-satellite fleets, respectively,** with Elon Musk envisioning completion in 5 years. There were 1,261 operational satellites in orbit as of the end of 2014 according to the Satellite Industry Association vs. 986 in 2011.

**Exhibit 7: Global satellite manufacturing and launch revenues (\$bn)**

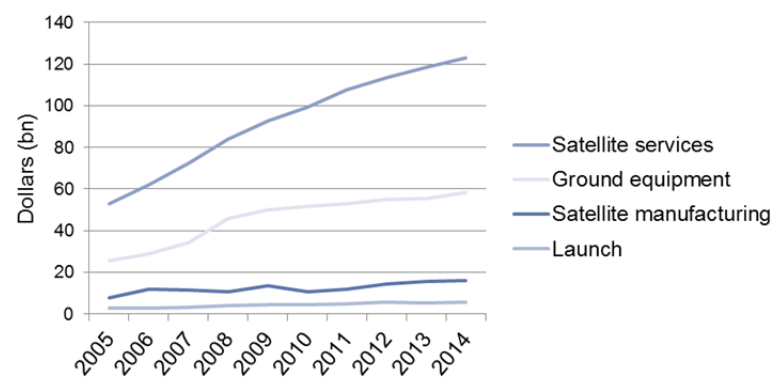
US manufacturing has taken share in this market



Source: Satellite Industry Association.

**Exhibit 8: Global satellite revenue by segment (\$bn)**

Satellite services has been, and could remain, a fast growth market



Source: Satellite Industry Association.

**Privatization of space creates near-space commercial opportunity and enables NASA to venture further out:** As NASA pushes deeper into space, firms are taking over responsibility for transport and services to low earth orbit, seen clearly in the commercial resupply and commercial crew awards. A follow-on contract to the commercial resupply services program is scheduled to be awarded by January 30, 2016 and may total more than \$5bn over 6 years. US-launched human spaceflight has halted since the last shuttle mission in 2011. **But that is set to change with the development of the Space Launch System, the next-gen exploration class rocket, which will bring Americans to asteroids by 2025 and Mars in the 2030s.**

**Space asset protection a new and growing contributor as space crowding becomes US national security threat:** Focus on space asset protection will contribute at least \$5.5bn over the next 5 years. This adds to an estimated \$25bn each year in classified and unclassified Defense space activities according to CBS. Current unclassified DoD procurement accounts for just \$7.1bn in major programs with \$1.5bn in launch costs, \$3.0bn for satellites, and \$2.6bn for support. The additional \$5.5bn for space asset protection

is likely to be allocated within the classified budget, which represents the bulk of US Defense spending for space. US Space Command has grown to roughly the same size as the Coast Guard with about 2.5X the budget. Because space spending is closely linked to national security threats from near-peer countries, we see the resurgence of Russia and rise of China as important tailwinds to Pentagon spending in space. Both countries have successfully tested anti-satellite weapons, exposing the risk to US space assets.

As the US mission in space becomes more complex and faces an increasingly competitive and crowded environment, space asset protection will become an important growth area for the DoD. While the Air Force does not comment on specific strategies for space defense, anti-jamming, maneuverability, situational awareness, and disaggregation of space assets are commonly accepted as core focus areas. In the event of the loss of space-based assets, the US is pushing for low-cost, rapidly deployable satellites that could replace downed equipment.



# What if I Told You ...College May not Be Worth it?

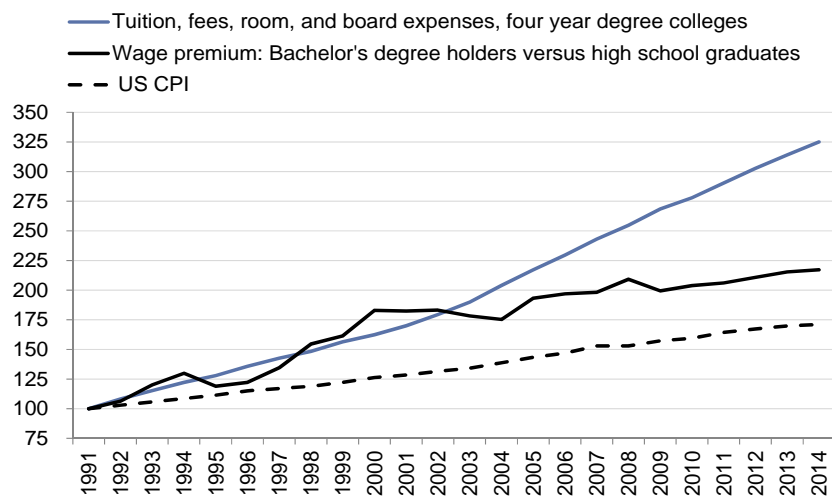
The average return on going to college is falling. For the typical student the number of years to break even on the cost of college has grown from 8 years in 2010 to 9 years today. If current cost and wage growth trends persist then students starting college in 2030/2050 will have to wait 11/15 years post college to break even. 18 year olds starting college in 2030 with no scholarship or grants will only start making a positive return when they turn 37.

**What if I told you college may not be worth it.** These are averages though. The distribution of wages is changing though – using SAT scores as a proxy, the gap in alumni earnings between colleges in the 99<sup>th</sup> percentile of scores and the 99.9<sup>th</sup> is as big as the gap between the 1<sup>st</sup> percentile and the 20<sup>th</sup>. If future wages for an individual joining college today were 30% below the average wages expected for college graduates, they wouldn't break even until they were over 50. Graduates studying lower paying majors such as Arts, Education and Psychology face the highest risk of a negative return. For them, college may not increasingly be worth it.

**Why It Matters?** The choice of college and major are more important than ever to students given the changing return profile. (US student debt is now more than \$1tn). The still high levels of skilled vacancies shown in Exhibit 10 despite record numbers of undergraduates points to a demand and supply mismatch (linked to this is the shortages in trade jobs; skilled trade vacancies screened as the most difficult job to fill in Manpower's annual survey for the sixth consecutive year in 2015). Corporates may have to do more themselves and develop their own talent identification systems. New entrants and business models are emerging to meet some of these challenges.

## Exhibit 9: The inexorable rise in the cost of college

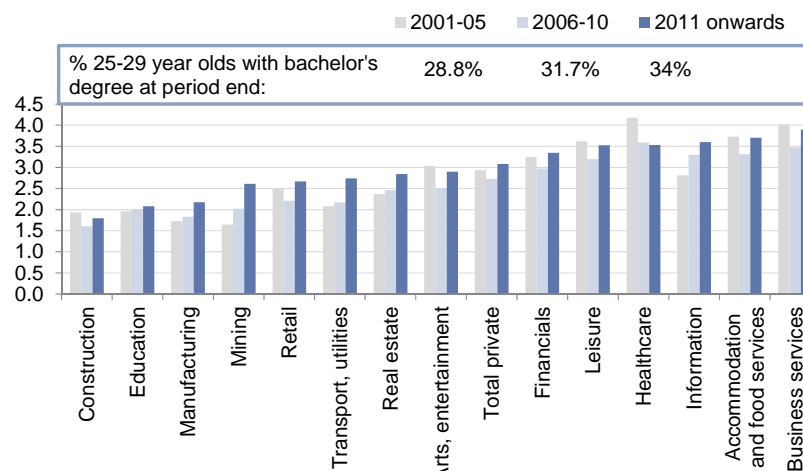
Average fee of 4 yr degree colleges, US CPI and difference in mean earnings of high school graduates and bachelor's degree holders, US (1991 indexed to 100)



Source: US Census Bureau, NCES, BLS, Goldman Sachs Global Investment Research.

## Exhibit 10: Unmet demand

Average vacancy rate by sector and % 25-29 year olds with bachelor's degree, US



Source: BLS, NCES, Goldman Sachs Global Investment Research.

### Studying the cost of studying

We calculate the economic return on college education as the total all-in cost of college (net of grants and scholarships) and the wages foregone during the 4 years of study versus the wage premium that undergraduate degree holders enjoy versus high school graduates over their working life. **Since 2009, college fees have risen by 10.6% in real terms**, versus a 0.9% and -0.1% change in high school and college graduates' wages. This calculation is just the economic return and of course there are other broader factors which matter greatly.

### For whom the bell-curve tolls

Choices matter – median wages of recent college graduates in architecture / engineering are 51% higher while wages of Arts graduates are 15% lower than the median across majors. A recent Economist study of US colleges based on US Department of Education data shows that the median annual earnings of MIT graduates ten years post college is \$91,600 (almost twice the national median earnings). **At the other end of the scale graduates from the bottom 25% colleges earn less, on average, than high school graduates.** Another way to think about the changing shape of the labor market is that graduates of colleges with a 90<sup>th</sup> percentile SAT score entrance requirement make \$11,700 more per year than those from universities in the 10<sup>th</sup> percentile.

### Skills sought versus skills taught

With more graduates than ever, it is an interesting paradox that skilled vacancies in many industries are high. Take the example of the IT industry; as evident in Exhibit 10, the sector has a high and growing vacancy rate (3.6% since 2011, up from 2.8% between 2001- 05) but less than 3% of degrees conferred are in computer science (vs. 6% in education and 10% in social sciences and history). More people graduating has blunted the signaling power of an undergraduate degree contributing to a rise in the number of masters degrees (now 7.6% of population versus 5.4% in 2000) which adds to the cost of education. But the vacancy rate does imply that the increased need for specialization is a factor and that the labor market is moving faster than education can respond. Arguing against this is the threat from artificial intelligence to pattern recognition and human decision making jobs (**47% of total US employment is at risk from computerization according to a recent Oxford University study**). This hollowing out of the labor market risk makes future-proofing very difficult, but there is a clear growth opportunity in professional training.

### What could change?

Two things in particular stand out as potentially disruptive to universities. First if employers changed their attitude toward non-traditional sources of degree awards. Massive open online courses (MOOCs) are the most obvious threat (**30% of undergraduates already take some classes on line**), but it could also be companies creating their own *de facto* degrees. Udacity for example offers nanodegree programs where curricula are designed in partnership with companies like Google, AT&T, Facebook, Salesforce and Cloudera. Second, for a broader new system of signaling and talent identification, look again to the tech sector; an increasing numbers of companies are using GitHub (a software development tool used for writing, storing and collaborating on code) to view coders' portfolios of work as a better talent indicator than their academic resume. Consulting firms EY and PWC have both said they will use their own testing systems for recruitment rather than relying on academic grades.

**Did you know?** College costs in the US have risen by 19.2x in nominal terms and 2.52x in real terms since 1964.

More broadly, education price increases have exceeded the overall CPI in every single month since 1994.



## Gen-Z is America's most diverse to date

It's clear that diversity will be one of the defining attributes of Gen-Z. To start, the rise of multi-racial marriages in the US has led to a 50% increase in America's multi-racial youth in the last ten years alone. In fact, by the year 2020, 50.2% of children under the age of 18 are expected to be part of a minority race or ethnic group (Census Bureau). Importantly, Gen-Z is not just diverse by a matter of fact, but they also hold a more positive view of the rising ethnic diversity in America than prior generations (Magid Generational Strategies).

**Did you know?** While throughout this report we use the name "Gen-Z", this cohort has already garnered a number of other nicknames, including:

- Homeland generation
- Plurals
- Centennials
- iGen
- Post-Millennials
- Digitals
- Screeners
- Tweenials

Diversity for Gen-Z transcends race, gender and sexual orientation. Take fashion, for example, where "normcore" has emerged as one the prominent style trends. Bland, boring, basic and in most cases absent of brand logos, this style leans more towards blending in than standing out. And for Gen-Zer's, not relying on a designer brand's latest fashion trends to establish their identities is exactly the point. For the retailers, this presents a new challenge should this trend hold.

## Digital to the core, it all happens online

Never before has there been a generation incapable a remembering a world without the internet. Sometimes called "digital-natives", the overwhelming majority of Gen-Z is connected online for at least an hour per day and nearly half are connected for 10 or more hours per day (Wikia). However, unlike their Millennial predecessors, Gen-Z appears more conscious of protecting their reputations online. More than half (57%) have abstained from posting something because they felt it would "reflect badly on them in the future" (Pew Research). As members of this generation mature, their views and preferences on social media are evolving, and no platform is insulated from that reality.

When it comes to spending habits, naturally this cohort is accustomed to online shopping. Further, their ability to navigate online, coupled with a thrifty mindset, has created an army of deal hunters for whom online word-of-mouth matters greatly.

## Financially, Gen-Z is decidedly conservative

When it comes to money and finances, Gen-Z and Millennials hardly resemble one another. While Millennials are often cast as the "follow your dreams at all costs" generation, Gen-Z appears acutely focused on the financial consequences of their decisions. TD Ameritrade's 2<sup>nd</sup> Annual Generation Z survey, for example, revealed that 46% are worried about accruing student loan debt while a study by Adecco showed that Gen-Z'ers are more concerned about the cost of education than Millennials. Meanwhile, sixty percent of Gen-Z believes that "a lot of money" is evidence of success, while only 44% of Millennials believe the same (Cassandra Report).

In combination with their financial conservatism, Gen-Z is also entrepreneurial. Although referring to a presumably small sample size, a recent Harvard Business Review article suggested that nearly 70% of Gen-Z teens were "self-employed" (e.g., teaching piano lessons, selling goods on eBay) vs. just 12% that held a "traditional" teen job (e.g., waiting tables). This ability and ingenuity to turn coveted skillsets into earnings power will likely serve Gen-Z well as they enter the labor force. In fact, a survey by Northeastern University showed that 42% expect to work for themselves one day, far more than the 1-in-9 that are actually self-employed today.

## A voice and a microphone

Today's era of social media, crowd funding and Ted Talks has provided Gen-Z'ers with a platform for expression and an avenue for being discovered, both of which are occurring earlier in life and at a scale unthinkable to generations past. Consider *Time Magazine's* list of "The 30 Most Influential Teens of 2015". By our count, all but three on that list maintain an active social media presence with thousands, if not millions of followers. For many of them, social media was either instrumental in, or rapidly accelerated, their rise to stardom. While not the first generation of youths with a desire to be heard, Gen-Z is arguably the first with the means.

# What If I Told You ... August 24<sup>th</sup> Won't Be the Last Flash Crash

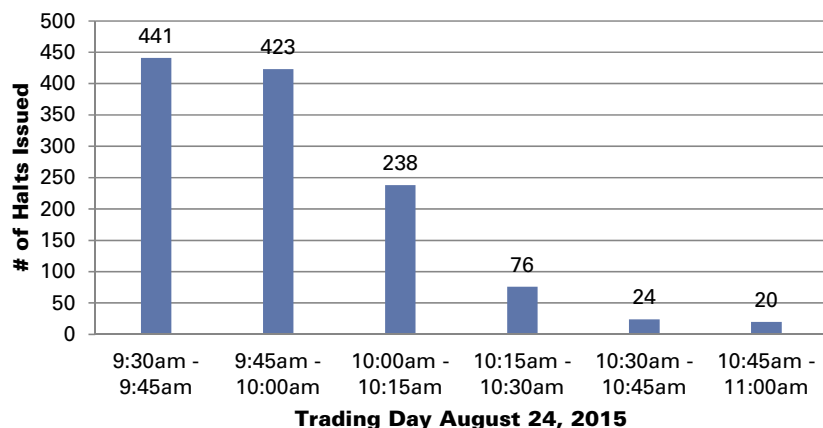
On August 24<sup>th</sup> the equity market went haywire. While many pointed the finger at ETFs as the driver of volatility, that was not the case. Specifically a series of new rules and procedures born out of the 2010 Flash Crash coupled with the lack of harmonization across markets paved the way for an eventful morning. The impact to institutional P&Ls were largely limited (beyond a collective, "what just happened?") but many individual investors were bruised and suffered material losses as their market and limit orders were executed at prices that were impacted by the volatility. Regardless, in both cases confidence was undermined. Indeed while investors have increasingly gotten used to higher volatility, exacerbated by diminished liquidity and the rise of automation the specter of this happening again is top of mind for investors across all markets. One need not look any farther than October 15, 2014 when the US Treasury market suffered its own flash crash moving nearly 40 bps in a day or as the CEO Of JP Morgan put it "statistically 7 to 8 standard deviations [beyond normal] – an unprecedented move – an event that is supposed to happen only once in every 3 billion years or so ..." To that end we answer what happened on August 24<sup>th</sup> and why it likely won't be the last time we see this.

What if I told you to get used to the volatility.

**Anatomy of August 24, 2015.** Concerns around China growth were high, and selling pressure was in full effect heading into the open. Futures traded down 7% and were halted before the market opened. As many risk management and cross asset models rely on futures as a proxy for other markets and securities, this liquidity / selling demand spilled over into other securities.

**Exhibit 13: The vast majority of trading halts on August 24, 2015 occurred around the open**

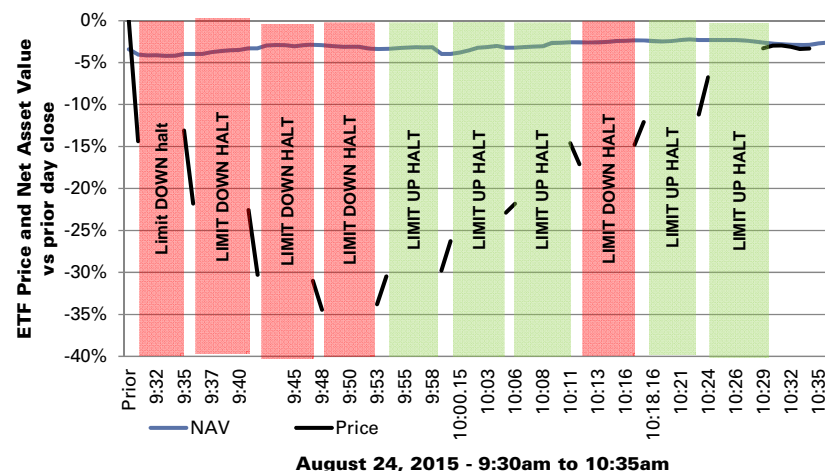
Number of trading halts issued by time period



Source: Nasdaq, Goldman Sachs Global Investment Research.

**Exhibit 14: More than half of the halts on August 24 were limit up halts**

An example of an ETF that was halted 10 times on August 24, half of which were on limit up halts and maybe slowed the recovery from the Flash Crash



Source: Nasdaq, Goldman Sachs Global Investment Research.

- Specialists on the exchange, as a result, invoked NYSE Rule 48 which suspends the requirement to provide indications of equity prices and to obtain approval from floor officials before opening up a stock. With Rule 48 invoked, the market did not fully open at 9:30am. Indeed, once that occurred many securities traded off sharply, when they did open, given the lack of paired off trading and the restricted number of securities that were available to sell, with select stocks like GE and Ford declining by over 20%.
- This triggered the largest number of Limit Up Limit Down (LULD) halts seen in the market to date. The LULD rules were enacted after the 2010 Flash Crash, halting a security when it trades outside of predefined bands, both to the upside and downside. That day, there were over 1,200 halts triggered across 470 securities (Exhibit 13). ETFs represented 80% of the LULD halts that morning as the arbitrage mechanism that makes them work was temporarily impaired. This was especially pronounced in headlines as nearly 40% of the consolidated tape traded that day was ETFs – up from an average of 25% of volume since 2010. Even futures, one of the most liquid markets in the world, traded at approximately a 170 bps discount to net asset value that morning.
- As stocks gapped lower, stop loss orders were triggered, exacerbating selling pressure in many securities. Many market participants, including High Frequency Traders, were reluctant to act around the open as they were not clear if the trades would be cancelled – if they were allowed to trade at all.

### Why It Matters?

Another Flash Crash can and likely will happen again, but consider:

- **What are the merits of enacting Rule 48?** Rule 48's goal is to allow market makers the ability to open stocks quicker and more efficiently than pairing off orders and providing a clearing price. Rules that delay the open might have not stemmed volatility, but rather liquidity likely rushed to open markets. When the exchanges delay openings in stocks, transparency is severely impaired. But even with Rule 48 the New York Stock Exchange was not fully opened until after 9:40am, whereas NASDAQ and BATS fully opened at 9:30am.
- **More transparency in the market around order imbalances and prices pre-market.** The NYSE Order Imbalances data feed publishes real-time auction imbalances, but it stops at 9:35am, so any stocks that are opened after this time, the market has to digest a sizeable information gap. Less transparency limits market maker's ability to provide liquidity broadly.
- **Revisiting the LULD rules.** LULD rules were enacted after the 2010 Flash Crash in a bid to build stronger circuit breakers in individual names when unexpected news or erroneous orders hit the tape. While LULD appears to have been helpful in helping the market level out before August 24th, most of the 1,200 halts on that day were on securities that had traded sharply lower but then were recovering. This dried up liquidity and delayed a recovery. Keep in mind, again, that LULD was enacted for stock moves down as well as up (Exhibit 14).
- **Harmonize the exchange rules.** Most financial assets/markets (e.g., equities, ETFs, futures, derivatives) have their own unique openings, halts, trade cancellations and regulators. Thus when products that are not "harmonized" are tied to each other (e.g. ETFs that use futures) or more liquid (e.g., futures versus derivatives) price and liquidity imbalances can quickly form.
  - **Erroneous trade rules do not match LULD bands for certain securities.** Consider the erroneous trade policies that were instituted by the exchanges in the wake of the 2010 Flash Crash. The bands here for erroneous trades can be out of alignment with the LULD bands, leaving investors concerned that a trade that happens within the LULD bands might

- be cancelled due to erroneous trade guidelines. This also affects the market's ability to pursue arbitrage on products across the market. LULD bans, as well, are wider at the open and close than during the day.
- **Timing of trading halts varies across exchanges.** Consider that a stock is halted for 5 minutes under the LULD plan, but CME futures are halted for two minutes.
  - **How a security trades coming out of a trading halt.** The auction procedures following a trading halt vary by exchange. With over 85% of the US Exchange Traded Products (ETPs) listed on NYSE Arca, rules on this exchange can have a broader impact on ETFs. After a security is halted, the asset then goes to an auction period with specified collars before it can trade in the market. On August 24<sup>th</sup>, the auction collars in effect for NYSE Arca were 5% for securities priced from \$0.01 to \$25.00, 2% for securities priced from \$25.01 to \$50.00 and 1% for securities priced greater than \$50.00. These collars are in place to help prevent securities from opening materially different from the last trade. But, in Flash Crashes, when there is a material imbalance of buy and sell orders, these tight collars can increase the chances that the auction process itself will generate another LULD halt. This helps to explain how some ETFs were halted many times that morning.
  - **Trading with Stop-Loss orders can accelerate a sell-off.** Consider that retail investors tend to trade around the open and can often trade with stop-loss orders. A stop-loss order is triggered when a security trades below a certain threshold, and prioritizes the speed of execution. In other words, it sells agnostic of price. In a Flash Crash, stop loss orders can be triggered, and this second wave of automated selling can worsen the sell-off, and can trigger sales of securities sharply below the threshold if liquidity dries up. Some have argued to place limits on individual trading of ETFs if the discount or premium to the NAV is greater than, for instance, 5%. Increased investor education, regardless, seems key.

# What if I Told You ... Lithium is the New Gasoline

**Lithium is the lightest solid element on earth with double the energy density of the next closest alternative; it is also one of the most abundant elements on earth. These unique properties ideally position it for portable energy storage applications that will be a key enabler of the electric car revolution and replace gasoline as the primary source of transportation fuel.**

**Lithium carbonate**

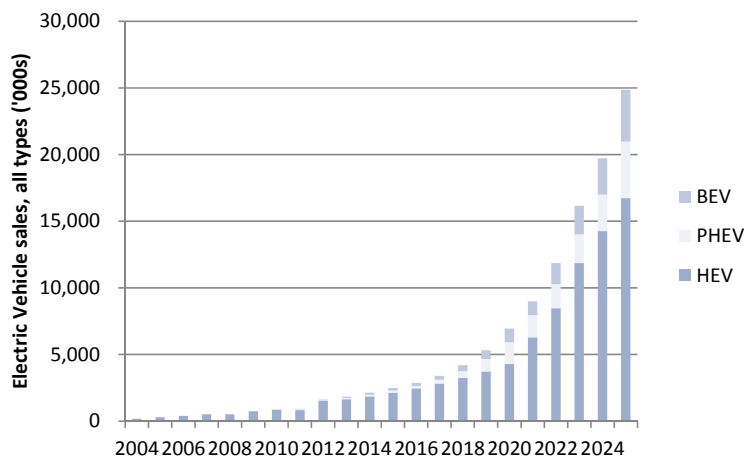
**equivalent (LCE):** Lithium carbonate is the largest lithium product by volume and is quoted by industry players to normalize for the various lithium containing byproducts and derivatives. There is 1kg of pure lithium content in 5.3kg of lithium carbonate.

**What if I told you that lithium is the new gasoline.** Oil derivatives have been the primary source of transportation energy since the commercialization of the internal combustion engine. However, thanks to technology breakthroughs, favorable policy and supportive public opinion, electric vehicles (EVs) appear poised for a sustained period of superior growth with our autos team estimating 22% EV penetration (BEV, PHEV, and HEV combined) in 2025 from under 3% today.

Despite its almost universal acceptance in portable electronic devices today, we believe that the greatest opportunity for lithium-ion batteries lies ahead in the form of transportation applications. In 2014 alone, more than 70 million cars were sold globally, providing an enormous available market for lithium-based batteries. The core material that enables lithium-ion batteries to function is lithium. Today, lithium is commercially recovered from underground brine deposits not too dissimilar to the way oil is extracted from the ground via a well. Similar to converting oil to usable fuels, lithium requires substantial above-ground “refining,” which substantially extends the time from extraction to a commercial product.

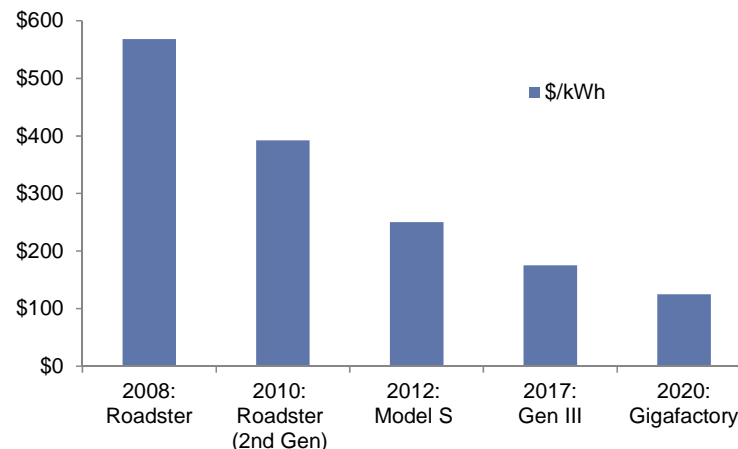
**Why It Matters?** Total lithium demand today is 160,000mt of lithium carbonate equivalent (LCE) per year. **We estimate that a 1% increase in battery electric vehicle (BEV) penetration would increase lithium demand by 70,000mt of LCE/year (or roughly half of current global demand for lithium).** In order for electric vehicle penetration rates to hit industry forecasts, significant capital investments to expand commercial lithium capacity will be needed, particularly from producers and/or EV OEMs.

**Exhibit 15: Electric vehicles powered by lithium-ion batteries will become an increasing portion of the transportation mix over the next decade**  
Electric vehicle sales by type, GS estimates



Source: Goldman Sachs Global Investment Research.

**Exhibit 16: Declining battery costs are key, and could be achieved with scale**  
Battery costs per kWh



Note: Battery costs referenced above are Tesla specific

Source: Company data, Goldman Sachs Global Investment Research.



**EV adoption is the key to lithium battery growth:** Electric vehicles are critically important to the growth in lithium demand due to the much higher per-unit content in car batteries than in traditional consumer electronic battery applications. A typical cell phone uses 5-7 grams of lithium carbonate equivalent (LCE) in its battery. A TSLA model S with a 70kWh battery uses 63 kilograms – an equivalent content of more than 10,000 cell phones. Range anxiety and battery costs are the two primary headwinds to adoption of EVs, in our view, and are heavily related due to the direct relationship between battery capacity and usable range. Should demand for hybrid electric vehicles (HEVs), plug-in electric vehicles (PHEVs) and BEVs follow the GS auto team forecast, we believe lithium demand for all EV applications could grow more than 11x by 2025, adding more than 310,000mt of LCE demand. This compares to current EV demand that represents only 27,000mt of LCE (17% of the current overall lithium market). In short, growth in EV applications alone could triple the size of the entire lithium market from 160,000mt today to 470,000mt by 2025.

**Exhibit 17: Lower battery costs and range anxiety will drive adoption of higher lithium content car batteries**

Lithium content scales with company reported range

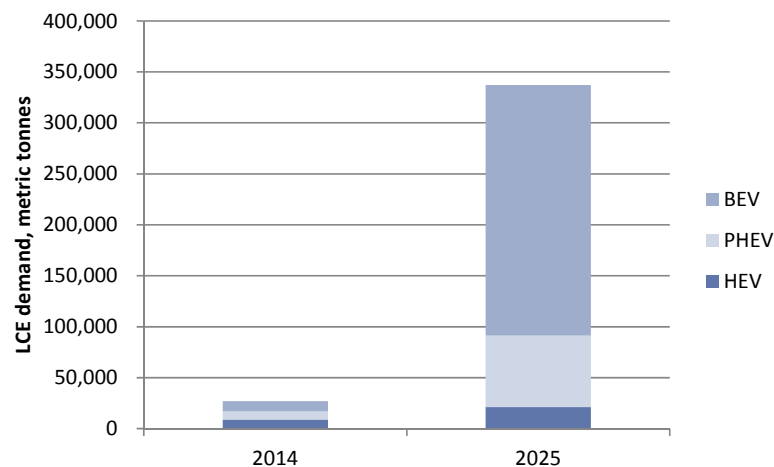
Model	Type	Battery		Range
		Size	LCE Required	
2016 Ford Fusion Hybrid	HEV	1.4 kWh	1.3kg	-
2016 Chevy Volt	PHEV	18.4 kWh	16.6kg	53 mi
2016 Nissan Leaf S	BEV	24.0 kWh	21.6kg	84 mi
2016 Tesla Model S	BEV	70.0 kWh	63.0kg	240 mi

Assumes 0.9kg LCE per kWh for all batteries. Actual ranges generally vary from 0.7-1.3kg per kWh  
HEVs usually do not guarantee electric only range

Source: Goldman Sachs Global Investment Research.

**Exhibit 18: Lithium for EV use could grow 11x by 2025**

Lithium demand in 2014 was just 27,000mt



Note: Assumes 70kWh batteries in all BEVs and 3.5% global BEV adoption in 2025

Source: Albemarle, Goldman Sachs Global Investment Research.

**Battery cost:** Average battery costs have declined approximately 14% per year over the period from 2007-2014 from over \$1,000/kWh to \$410/kWh. Costs for the leading BEV manufacturers are even lower at \$300/kWh. However, even at leading manufacturer rates, the implied cost of a 70kWh battery pack in a Tesla Model S is still well above \$20,000, a level that likely prohibits usage in mass market automobiles. According to *Nature*, \$150 kWh is the level widely perceived as the point of mass-market commercialization for BEV. If costs continue to fall to the \$125 kWh level targeted by TSLA in 2020, then 70kWh battery packs become more manageable at around \$9,000. We believe this is key to adoption, both by bringing down the cost of EV production and by increasing range to combat consumer range anxiety. Importantly, we do not expect lithium itself to be part of the cost solution, as it is critical to functionality yet represents only 2% of total lithium-ion battery costs, thereby providing limited cost savings opportunities for battery makers.

### **Types of Electric Vehicles (EV):**

**Plug-in Hybrid Electric Vehicle (PHEV):** Have both electric and conventional motors, but are distinct from HEVs in that they can be recharged from an electric outlet via a plug (e.g. Chevy Volt).

**Hybrid Electric Vehicle (HEV):** Capable of storing charge (usually only in small amounts). Do not plug into an electric outlet, but instead are recharged by a separate internal combustion engine which is the principal power source (e.g. Toyota Prius).

**Battery Electric Vehicle (BEV):** Fully electric vehicles that do not contain a combustion engine. Their battery packs and driving ranges between recharges tend to be much larger than other EVs since they do not have auxiliary power sources such as an internal combustion engine. Example: Tesla Model S.

**Is there enough Lithium?** Yes, but more infrastructure investments are needed to extract and “refine” it. At current production rates, producing resources have more than 70 years of reserves available with roughly triple that capacity available in proved undeveloped resources. Similar to oil, more lithium deposits will become economical at higher prices (i.e. there is a steep cost curve) to serve new demand. Lithium recycling is also possible in the future although it is not currently practiced on a large scale.

### **Key investor signposts**

**1) Battery costs** – driving further battery efficiencies towards the targeted \$150/kWh level widely seen as the tipping point for broad commercialization. We believe this is feasible by 2020 based on progress trendlines in recent years. **2) EV adoption** – EV adoption represents not only an enormous and largely untapped market, but its development may also pave the way for further applications such batteries for heavy trucks, trains and airplanes that could provide further lithium demand sources. **3) Energy storage** – the ultimate winner in the race for grid storage applications is unclear today, but incumbent battery technologies like lithium-ion have a competitive advantage due to their scale. In small use applications such as Tesla’s powerwall pack, we expect lithium-ion batteries to remain competitive.

### **Key Risks**

**1) Lower oil prices** – costs still favor incumbent internal combustion engines and low oil prices will widen the gap EVs need to close, with additional possible risks to the current favorable policy environment. Higher truck and SUV sales in 2015 vs. 2014 (when oil prices were higher) are an example. **2) Other technologies** – lithium-ion batteries are not the only types of batteries being discussed, but they are furthest along in development. We believe other technologies are more likely to impact grid storage than transportation applications in the foreseeable future. **3) Policy** – favorable policy including tax credits have aided the adoption of EVs, as have pollution regulations such as caps on carbon emissions and CAFÉ standards. There is a substantial risk that less favorable policy could slow EV adoption.

# What if I Told You ... the Cloud Can Help Cure Cancer

Rapid reductions in cloud storage costs and DNA sequencing technology will soon merge with the proliferation of electronic medical records to enable a new paradigm in cancer treatment. Here we explore the key enabling technologies, identify early players, and discuss key considerations as personalized medicine finally becomes a reality in cancer.

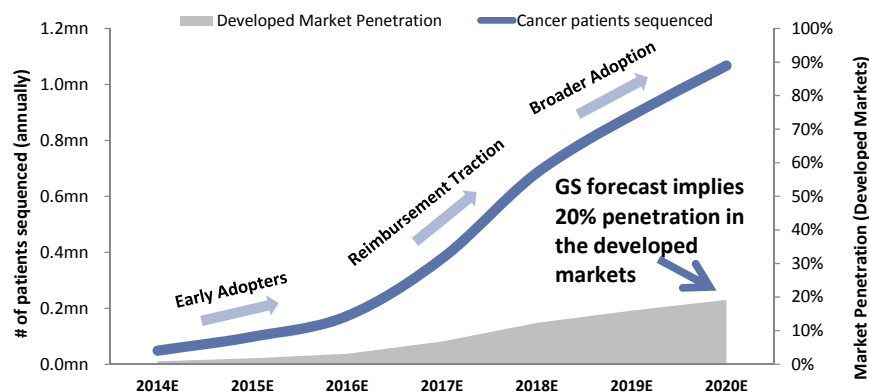
**For the first time in history, physicians will soon have the ability to use genomic profiling for every cancer patient**

**What if I told you the cloud can help cure cancer.** At \$90 billion annually, the direct medical costs of cancer are among the highest of all conditions. However, rapid advances in cloud computing, next-gen DNA sequencing (NGS), and electronic medical records (EMR's) are forming a powerful trifecta that could change the paradigm over the next decade. **We think it is feasible to assume that 20% of all new cancer patients in the US will receive genomic profiling by the year 2020. If cost curves play out as expected, it will cost just \$30 million annually to store all of this data.** For the first time in history, physicians will soon have the ability to use genomic profiling for every cancer patient.

**Why It Matters?** Since cancer is a disease rooted in genetics, we believe physicians will find great utility in the ability to gather NGS data across large populations, analyze the data over time as the DNA mutates, and then compare it to a single patient to assess that person's treatment options. At the same time, these data can be used by drug companies and scientists to develop better drugs faster and cheaper than ever before. Taken together with the emergence of EMR's, we think payers will likewise be able to translate this data into more efficient allocation of Healthcare spend both for preventative and ongoing treatment-based applications.

**Exhibit 19: We expect a material ramp in cancer sequencing...**

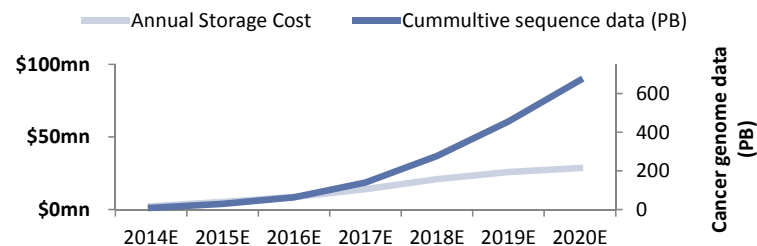
GS forecasts over 1 million patients will be sequenced annually, or 20% of the new cancer cases in the developed markets by 2020



Source: Goldman Sachs Global Investment Research, Cancer.org

**Exhibit 20: ...helped by the declining cost of NGS and cloud storage**

Hypothetical cost if 20% of all US cancer patients have their genomic profiles stored in the cloud = less than \$30 million annually



Cloud storage cost (whole genomes, raw data)							
	2014E	2015E	2016E	2017E	2018E	2019E	2020E
# cancer of sequences (annually,mn)	0.05	0.10	0.17	0.38	0.68	0.89	1.07
Data generated per sequence (GB)	200	200	200	200	200	200	200
Annual sequence data produced (PB)	10	20	35	76	137	178	213
Cummulative sequence data (PB)	10	29	64	140	276	454	668
Annual reduction in storage costs	25%	25%	25%	25%	25%	25%	25%
Cost per (GB, annual)	\$0.24	\$0.18	\$0.14	\$0.10	\$0.08	\$0.06	\$0.04
Annual Storage Cost	\$2mn	\$5mn	\$9mn	\$14mn	\$21mn	\$26mn	\$29mn

Source: Goldman Sachs Global Investment Research, Company data

## Key catalysts and themes

**We look for continued reduction in the cost of NGS, improved ease-of-use, and better connectivity with EMRs.**

**Internet/Software:** We look for continued reductions in cloud storage costs (20-30% annually) and improved virtualization capabilities for research scientists seeking to harness the cloud.

**Life Science Tools and Diagnostics:** We look for continued reduction in the cost of NGS technology, improved ease-of-use, and better connectivity with EMRs. We also think Diagnostics companies need to broaden their testing platforms to acquire more outcomes data to enhance the value of their databases.

**Healthcare IT:** EMRs are increasingly mining the clinical workflow for insights that can be used by clinicians and researchers. In this vein, we have seen EMR vendors announce software integration development collaborations with Diagnostics companies. Successful integration would provide average clinicians with the tools to provide precision medicine.

**Biotechnology:** Cancer is moving away from organ specific diagnosis to a pathway specific diagnosis. This is best represented by non-small cell lung cancer (NSCLC) where there are drugs targeting a number of driver and/or resistance pathways such as EGFR and ALK. Unfortunately, patients often develop resistance to targeted drugs. In our view, serial sequencing could play an important role in understanding how mutations evolve and which pathways are most important. Sequencing is also likely to help identify new drug targets. For example, Regeneron formed the REGN Genetics Center which combines exome sequencing and cloud based informatics (utilizing AMZN web services) to help elucidate genetic causes of disease to facilitate drug discovery.

**Current databases lack harmonization, a critical component to enable a functional cloud infrastructure.**

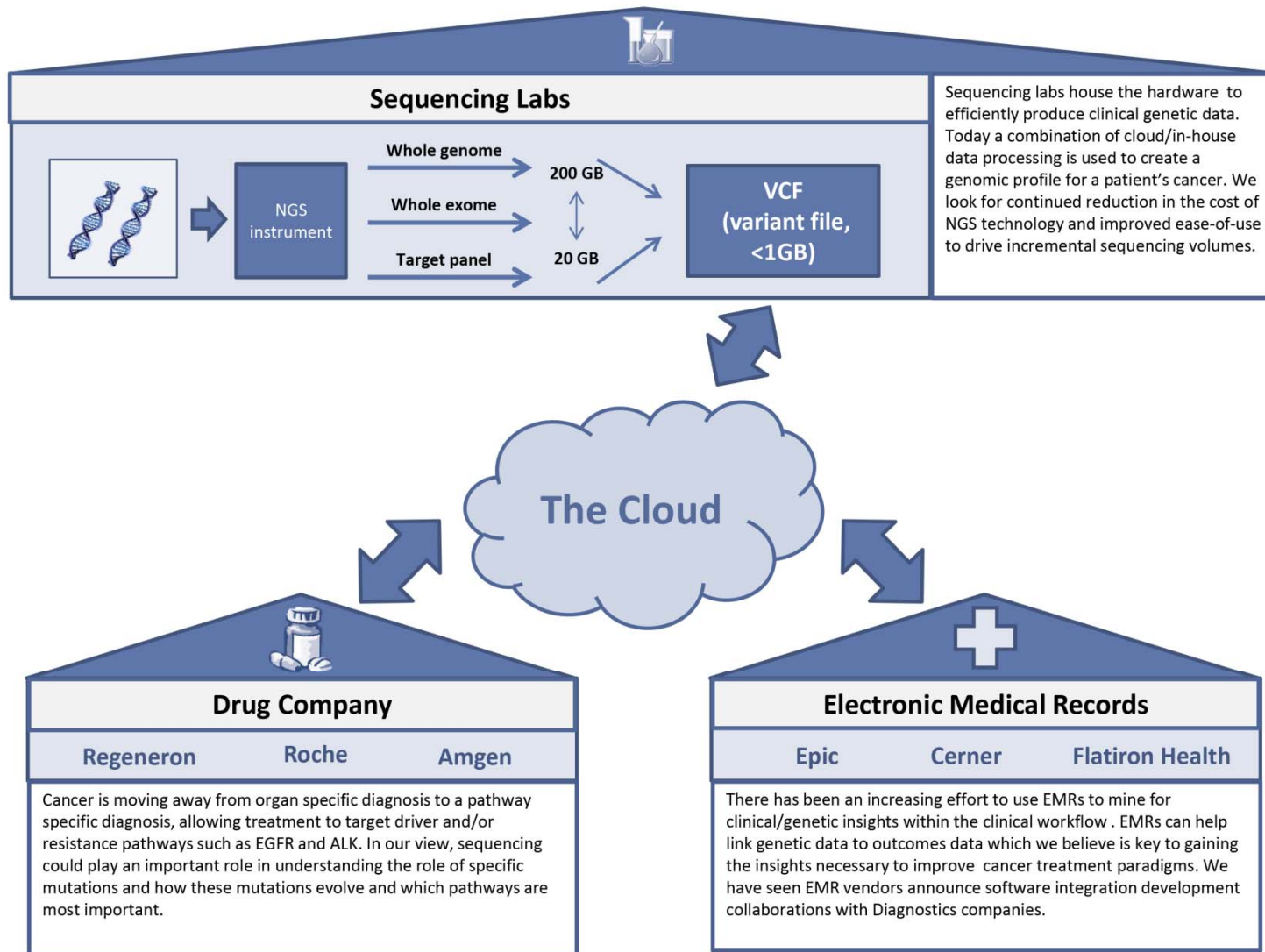
## Regulatory considerations

**What we should be storing:** Today, most labs only retain basic gene variant data on file, not the entire genome. However, it is well established that most cancers involve multiple genes and future variant calling software tools are likely to show good improvement, so regulators have stated it is better to have an individual's full sequence profile stored.

**Harmonization between databases is critical:** Today, most genetic databases exist in silos with little in the way of data standardization and interconnectivity between institutions. We believe regulators and governing bodies such as the Actionable Genome Consortium will work to develop standard nomenclatures for variant calling, standard operating procedures for data collection, and training for curators. All of this should help reduce discordance between databases.

**Automation too soon is dangerous:** Currently, bioinformatics platforms require human oversight, including manual curation. Regulators desire improved partnerships with the private sector where platforms are updated and validated for clinical use.

**Exhibit 21: The current Cloud landscape for clinical cancer genetics**



Source: Goldman Sachs Global Investment Research

## Reg AC

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