The Impact of Hardware-as-a-Service (Haas) on Small Laboratories

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EXECUTIVE SUMMARY

Small laboratories face unique challenges in getting their products and services on the market. The constraints and pressures of an industry that relies on research and development (R&D) to generate revenue, along with tight budgets, limit small laboratories' ability to purchase new laboratory equipment.

Used lab equipment initially costs less, but the long-term maintenance expenses and reduced energy efficiency quickly overtake the initial savings. In addition, used lab equipment requires more staff hours to monitor and maintain and increases the chances of equipment failure. If equipment failure does take place, the sample or batch loss could destroy years worth of work.

Hardware-as-a-Service (HaaS), a business model that's used by major corporations in several industries, gives small laboratories access to the latest, most up-to-date lab equipment for a monthly subscription fee. The HaaS approach provides:

- new laboratory equipment
- improved energy efficiency
- remote real-time diagnostic monitoring
- remote notifications to multiple parties
- remote control over operating criteria, including on/off control
- equipment and software updates
- cloud storage
- edge computing to create a virtual laboratory and run predictive simulations

An affordable solution puts small laboratories on a level playing field with their larger counterparts and can potentially reduce the time it takes them to get a revenue-generating product through the approval process and on the market. This solution also saves money through lowered energy use, preventative maintenance, and efficient use of personnel hours.

USED LABORATORY EQUIPMENT INTIALLY COSTS LESS, BUT THE LONG-TERM MAINTENANCE EXPENSES AND REDUCED ENERGY EFFICIENCY QUICKLY OVERTAKE THE INITIAL SAVINGS.

A HaaS model that includes new equipment and AI comes prepped for edge computing, which, when implemented, can change how researchers approach the scientific process. With edge computing, collected data can be analyzed closer to the point of origin, facilitating the use of virtual laboratories where simulations can be used to fine-tune experiments before physical testing begins.

THE LIMITATIONS OF USED LABORATORY EQUIPMENT

Small laboratories have budget limitations that may lead to the purchase of used equipment. Used equipment, like a used car, may cost less upfront, but the money spent on labor and parts, personnel, and poor energy efficiency add up over time. Beyond the budget, used equipment can take a professional and personal toll on morale in the case of equipment failure. Used equipment may also slow a small laboratory's progress towards getting a revenue-generating product on the market.

Laboratory equipment maintenance, whether the equipment is used or new, typically ranks high in a laboratory's operating budget, regularly coming in second only to personnel-related costs[2]. However, used equipment requires a larger portion of the budget to be devoted to maintenance and repairs, which continue to increase with time.

NEW EQUIPMENT CAN USE UP TO 30 TO 70 PERCENT LESS ENERGY.

In addition, each generation of new equipment becomes increasingly energy efficient. New equipment can use up to 30 to 70 percent less energy. Like the long-term costs of maintenance and repairs, used equipment's poor energy efficiency adds to the lifetime costs.

There's also a cost in time and labor. Lab managers or equipment techs may oversee maintenance and schedule repairs in a small laboratory. Lab managers' already full load may not leave adequate time, while an equipment tech may not have the training for the most complex maintenance and repairs.

Used equipment may require manual monitoring, documentation, and software updates. Some equipment may need to be updated with USB drives or integrated with data loggers or sensors to maintain adjustments and an appropriate maintenance schedule. Each of those processes may work on a different system, requiring the entry and re-entry of data from one source to another. Every time the data passes through human hands, there's a possibility of human error.

In contrast, large labs often have a team of trained technicians who perform the same duties, whereas a small lab may have one or two people monitoring equipment along with other duties in the lab.

The upfront, energy, maintenance, and personnel limitations aren't the only possible issues with used equipment. On a "clinical scale," equipment failure is the number one cause, 2.96 percent, of all batch loss in biomanufacturing[1]. Even large scale laboratories deal with equipment failure but wear and tear put used equipment at a higher risk of failure and may happen without warning.

THE LIMITATIONS OF USED LABORATORY EQUIPMENT (CONT.)

Failure or performance inconsistency could destroy months or years worth of work overnight. Equipment failure creates expenses for repair or replacement as well as clean up, sanitization, and acquiring new supplies and samples. There's also time lost as resources are used towards cleaning and sanitizing rather than moving further along in the testing process. However, the financial loss of equipment failure also affects the lab's timeline towards a marketable product.

There's a human side to equipment failure, too. Months or years worth of work and data may disappear along with lost samples or data still stored in the unit. That kind of loss takes a toll on any researchers and technicians working on the project. Morale and motivation may hit a low with such a significant loss.

MOST USED EQUIPMENT HAS A LIFE EXPECTANCY OF ONLY 18 MONTHS.

Used equipment acts as one of the barriers to the survival of small labs. Considering that most used equipment has a life expectancy of only 18 months, these labs are looking at a continual cycle of breakdowns and equipment-related expenses that eat away at their already tight budgets. Any potential savings on the equipment is easily offset by the number of hours, often extending off the clock, that the lab managers spend meticulously going through equipment specifications and listings to better the odds when rolling the dice on another used equipment purchase.

Despite the challenge, small laboratories are often where innovation gains ground and drives scientific discovery in new directions. Small pharmaceutical and biotech laboratories and startups can hyperfocus their research on one area, whereas a larger lab may have to keep their research broad to assure a maximum return on investment (ROI). However, when small labs can't survive because of setbacks magnified by inefficient equipment, the scientific community as a whole suffers.

THE HEAVY PRICE OF R&D AND PRESSURES OF RETURN ON INVESTMENT

Small laboratories face unique challenges to the success of their R&D and, consequently, their financial future. Revenue and R&D's cyclical relationship presents an obstacle for the life sciences. In the pharmaceutical, biotech, and other industries where revenue relies on R&D, there are high upfront costs that may not be recovered until years down the road when the laboratory gets a viable drug or technology on the market.

"GREATER TECHNOLOGICAL COMPLEXITY IN DRUG DEVELOPMENT AND GREATER SPECIFICITY INDICES TARGETS HAS HELPED TO RAISE AVERAGE R&D COSTS..."

According to the Congressional Budget Office's report on Research and Development in the Pharmaceutical Industry, "Greater technological complexity in drug development and greater specificity indices targets has helped to raise average R&D costs. . .[3] " In addition, it can take 10 to 20 years for a pharmaceutical company to get its first product into the hands of patients. High drug prices stem from the company's need for a ROI for years worth of R&D. Drug prices also reflect the lab's need to fund current and future R&D to generate a future revenue stream. Small laboratories may have few (if any) products initially on the market to fund the R&D that's needed for revenue.

However, researchers are less likely to innovate or test drugs that have a low likelihood of providing the ROI needed to fund future research. If a drug is expensive to develop and has a small patient population, chances are they won't make the investment because they won't see the ROI when the drug hits the market. The patient population is just too small.

That, in turn, leads to fewer treatment options for patients but also slows innovation because scientific progress builds on itself. A drug that's used to treat one disease may be found to have an alternative use later down the road. Or, it could spark an idea that leads to the discovery of another treatment for another disease later on.

"SMALL LABORATORIES FILL THE GAP BETWEEN MARKETABILITY AND INNOVATION."

Instead of being able to focus on the cause, researchers are pushed to develop drugs that treat the largest patient population. Many times that puts the focus on symptoms, which can be the same across many illnesses and diseases rather than the specialized research needed to identify the cause of the symptoms. It creates a band-aid effect on human health instead of a solutions-based approach.

THE HEAVY PRICE OF R&D AND PRESSURES OF RETURN ON INVESTMENT (CONT.)

Small laboratories fill the gap between marketability and innovation. Many of these labs are laser-focused on smaller populations because their investors have a personal connection. How else could investors justify the massive upfront cost? Consequently, they can devote their resources to deep research in a specific area in ways large laboratories cannot due to regulation, policies, and low ROI. Large labs stay broad with their R&D so their products can treat the largest number of people, while small labs can use their resources to hone in on a single area of research, technology, or method.

"... WITHOUT THE RIGHT RESOURCES, THESE SMALL LABS MAY NOT FINANCIALLY SURVIVE BEFORE THEY GET A PRODUCT TO MARKET."

However, without the right resources, these small labs may not financially survive before they get a product to market. Small laboratories need the same equipment as a large laboratory, though not in the same quantities. However, they cannot purchase the newest, fastest, most reliable equipment. Instead, they purchase used equipment that may be 10, 15, 20 years old, or even older. Like a used car, used equipment comes with higher maintenance costs, more monitoring, and a higher likelihood of leaving the lab abandoned on the roadside than speeding to the finish line.

Budgets are tight enough that some labs are willing to gamble on the 18-month life expectancy of their used equipment, hoping it will hold out long enough for them to get through vital steps in the testing process.

"SAMPLE OR BATCH LOSS DUE TO EQUIPMENT FAILURE HAPPENS FAR MORE OFTEN THAN ANYONE WOULD LIKE TO ADMIT."

Sample or batch loss due to equipment failure happens far more often than anyone would like to admit. For example, in 2012, an equipment failure wherein alarms weren't triggered when a freezer failed at Harvard-affiliated McLean Hospital led to the loss of brains used for research in Parkinson's, Alzheimer's, autism, and other psychiatric conditions. At the time, scientists projected the loss could delay autism research alone by nearly a decade. In 2018, equipment failure caused the loss of thousands of eggs and embryos in two separate fertility clinics, the loss of which affected hundreds of families. In these cases, equipment failure caused significant scientific, financial, and personal loss.

THE HEAVY PRICE OF R&D AND PRESSURES OF RETURN ON INVESTMENT (CONT.)

While equipment failure leads to direct losses, there are indirect losses that come as scientists rely on used equipment. Scientific methods vary from one lab to another, and even the process of recording information can vary. What one scientist considers a standard method may be foreign to a scientist trained at a different school or geographical location. There's no standard method of recording and monitoring, which can lead to key steps being left out of notes.

"SOME ESTIMATES PUT EXPERIMENT IRREPRODUCIBILITY AT ANYWHERE FROM 51 TO 89 PERCENT. WITHOUT THE ABILITY TO REPLICATE AN EXPERIMENT, THEORIES CANNOT BE BUILT UPON OR PROVEN."

Used equipment relies on the notes and recorded readings taken by researchers. However, those notes may not be enough to reproduce the experiment. Consequently, reproducing results, a key factor in supporting and building off of previously proven theories becomes difficult, if not impossible in most cases. Some estimates put experiment irreproducibility at anywhere from 51 to 89 percent[4]. Without the ability to replicate an experiment, theories cannot be built upon or proven.

However, today's new equipment comes with microservers and AI software ready to either reduce or eliminate many of these challenges. The key is making the equipment affordable.

"...TODAY'S EQUIPMENT COMES WITH MICROSERVERS AND AI SOFTWARE READY TO EITHER REDUCE OR ELIMINATE MANY OF THESE CHALLENGES. THE KEY IS MAKING THE EQUIPMENT AFFORDABLE."

HARDWARE-AS-A-SERVICE: NEW EQUIPMENT WITH MONITORING, MAINTENANCE, SOFTWARE, AND UPGRADES AT AN AFFORDABLE COST

The hardware-as-a-service (HaaS) model provides a fast, efficient way to update or fully equip labs. The HaaS model is used by major corporations such as General Electric, Boeing, and Rolls-Royce. Rolls-Royce, for example, offers a TotalCare® program[5] wherein jet engines are rented to an airline and Rolls-Royce monitors and maintains the engines for a fixed dollar amount per flying hour.

An Internet of Things (IoT) network along with AI produces data that the Rolls-Royce team needs to keep the engines working at peak efficiency. The data indicate when it's time for a part replacement or cleaning, preventing more costly breakdowns or repairs and improving performance.

"...HAAS CREATES A VAST NETWORK OF SERVICES WRAPPED INTO A SINGLE BUNDLE."

A similar HaaS model can provide new, state-of-the-art laboratory equipment along with monitoring, maintenance, networking (mesh WIFI and cellular data), security, data storage, software, and equipment and software upgrades for a monthly subscription fee. Like Rolls-Royce TotalCare® program, HaaS creates a vast network of services wrapped into a single bundle.

Small labs that don't have the budget to purchase a new sub-zero freezer or climate chamber, for example, can rent one via a monthly subscription that costs a fraction of the equipment's full price. In addition, the freezer or climate chamber comes equipped with the latest IoT technology, including a built-in microserver with 3g/4g/5g capabilities, allowing for real-time remote monitoring, security, and control capabilities and real-time diagnostic services and insights.

Lab managers and technicians can remotely receive recommendations, notifications, or warnings of a change in efficiency or variable long before there's an issue that would threaten the safety of a test. The technology already installed in the equipment can also control start/stop functions, change operating criteria, export data, and maintain door lock controls from a desktop or mobile device.

In addition, the lab saves money on energy efficiency on two fronts. First, each new generation of equipment becomes more energy efficient than the last due to advances in technology and efficiency standards. Second, equipment provided through a HaaS model also includes the adaptive ability of AI-generated algorithms and real-time analytics.

HARDWARE-AS-A-SERVICE: NEW EQUIPMENT WITH MONITORING, MAINTENANCE, SOFTWARE, AND UPGRADES AT AN AFFORDABLE COST (CONT.)

"IN A SIDE BY SIDE TEST COMPARING TWO DEVICES, ONE RUN BY INDUSTRY STANDARD CYCLES AND TH OTHER AN AI-GENERATED ALGORITHM, THE DEVICE RUNNING THE AI ALGORITHM IMPROVED ENERGY EFFICIENCY BY 30 PERCENT."

In a side by side test comparing two devices, one run by industry standard cycles and the other an AI-generated algorithm, the device running the AI algorithm improved energy efficiency by 30 percent. Additionally, both the HaaS provider and the researchers can use this information to assure the experiment and equipment are at peak efficiency throughout the testing process for optimum results.

As the HaaS provider monitors the equipment 24/7, their technicians also use data provided by the equipment and AI algorithms to identify indices and triggers well before an alarm sounds, even though alarms are included as a fail-safe. Essentially, the lab now has a team of highly-trained technicians ready for deployment maintaining the equipment around the clock as part of the subscription.

The latest smart equipment and AI programming also prepare labs for the next step— real-time sample monitoring and edge computing. Edge computing allows for the virtualization of the lab, where researchers can run through simulations before committing valuable resources to a physical experiment. It streamlines the scientific process and increases reproducibility by recording and reporting all changes and adjustments made at the sample level during testing.

"THE LATEST SMART EQUIPMENT AND AI PROGRAMMING ALSO PREPARE LABS FOR THE NEXT STEP—REAL-TIME SAMPLE MONITORING AND EDGE COMPUTING."

HAAS WITH AI AND EDGE COMPUTING: ENHANCED PERFORMANCE ON THE ROAD TO A VIRTUAL LABORATORY

Equipping the laboratory through a HaaS model has far-reaching benefits. The combination of new equipment with real-time analytics and operation algorithms plus preventative maintenance that's included as part of the subscription can reduce energy use by anywhere from 30 to 70 percent. Energy savings help tight budgets, while still allowing access to new equipment. Proper equipment care and maintenance will always be a strict part of laboratory procedure, but lab managers will have the added safety and security of remote monitoring and a dedicated team of trained service providers through the HaaS provider.

"...LAB MANAGERS WILL HAVE THE ADDED SAFETY AND SECURITY OF REMOTE MONITORING AND A DEDICATED TEAM OF TRAINED SERVICE PROVIDERS THROUGH THE HASS PROVIDER."

Remote monitoring and control can not only provide maintenance or equipment failure alerts, but they also reduce some manual monitoring and onsite staff. It can eliminate the need altogether, as real-time data collection and interpretation with the appropriate AI software can do much of the work performed by onsite staff, reducing personnel-related costs while dedicated facilities dispatch service personnel where necessary.

Remote monitoring also reduces the number of times data passes through human hands. With used equipment, staff may transfer information from the equipment using a USB device or through a third party data-logging system. Data may be entered and re-entered three or four times before going through analysis. Smart equipment reduces the number of times data passes through human hands before analysis, reducing instances of human error. When edge-computing is deployed, the AI will generate insights without human intervention, eliminating all risk of human error. In the future, the equipment may increase the temperature and/or gas concentration, for example, to increase experimental outcome probabilities based on real-time feedback instead of simply setting an incubator at 37C as a blanket "catch-all" standard.

"...THE BENEFITS OF A HAAS MODEL CAN LEAD TO A 40 PERCENT INCREASE IN MANAGER TIME THAT WOULD BE AVAILABLE FOR OTHER TASKS."

A HaaS model also has implications for lab managers. Bundling so many services into a single subscription eliminates the need for a separate subscription or provider for monitoring, security, software, and equipment. They're one and the same, which makes it easier to access services. Together, the benefits of a HaaS model can lead to a 40 percent increase in manager time that would be available for other tasks.

HAAS WITH AI AND EDGE COMPUTING: ENHANCED PERFORMANCE ON THE ROAD TO A VIRTUAL LABORATORY (CONT.)

HaaS also addresses data storage needs. Smart equipment produces vast amounts of data that, traditionally, would be stored locally where there's limited space. However, a HaaS solution with cloud storage allows researchers access to data for the lifetime of the equipment. Patterns from years past or changes that could only be recognized after years of data will be available rather than lost due to a lack of storage. Digital information is also more easily accessed than lab journals, which may be locked away in a hall closet collecting dust.

"...A HAAS SOLUTION WITH CLOUD STORAGE ALLOWS RESEARCHERS ACCESS TO DATA FOR THE LIFETIME OF THE EQUIPMENT."

However, the growing sophistication of AI presents an issue with cloud storage that a HaaS model is already prepped to solve. Cloud computing requires data to travel far from the data source. The further the data has to travel for analysis, the longer it takes for the final results. It's like multiple lanes of traffic merging at a major city center. AI requires a quick analysis of real-time data to make predictions.

The microservers built into new equipment included with a HaaS model has increased potential because it's ready for the next step in AI—edge computing.

While cloud storage works wonderfully to store high volumes of data, it has limits, namely, its ability to keep up with AI. Edge computing moves the point of analysis and processing closer to the data source. What does that mean for the future of scientific work in the laboratory—a virtual laboratory.

Smart equipment, AI, and edge computing create the potential for researchers to run through hundreds of permutations overnight. Within a few days, they can determine the equipment and supply needs as well as narrow down possible reagents, buffers, and other variables before testing begins.

That kind of predictive power can straighten the sometimes zigzagging road that small laboratories take on their way to getting their products on the market. When researchers can run onsite simulations to narrow down the parameters of the experiment, they can save time that would have been spent in multiple rounds of testing.

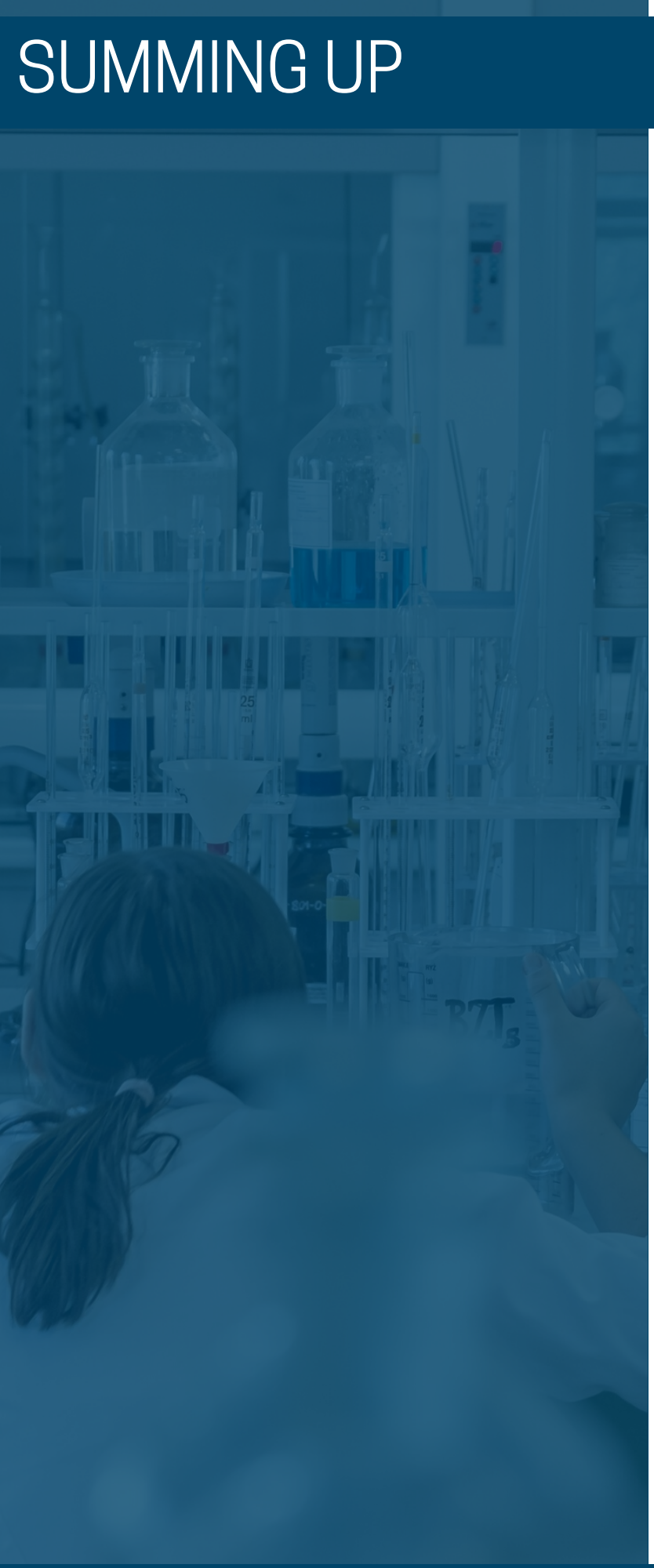
It doesn't mean every test will be a success, but eliminating some of the variables beforehand could shorten the time it takes for a small lab to get a ROI. A shortened time to a ROI could potentially lower drug prices as the time it takes to go from idea conception to viable product gets streamlined. For both small and large companies, this means bigger profit potentials by selling at a price more patients can afford. Greater margins + higher volume = more profits and loyal customers.

HAAS WITH AI AND EDGE COMPUTING: ENHANCED PERFORMANCE ON THE ROAD TO A VIRTUAL LABORATORY (CONT.)

A HaaS model furthers the scientific community as a whole. Smart equipment records the entire process, allowing scientists to export step-by-step information. Suddenly, the potential for reproducing an experiment drastically increases. There may not be a “standard” lab procedure, but when the whole process has been electronically recorded and monitored, anyone with whom the scientists want to share the process or results can replicate the data. That includes regulatory agencies as well as other scientists looking to take the results to the next step or in another direction.

Orphaned pharmaceuticals and molecules now create a new marketplace where companies can recover some of their expenses. In this way, detailed procedures and experiments can be bought and sold, further reducing the costs and time of R&D.

SUMMING UP



A HaaS model gives small labs access to new equipment while providing them with monitoring, security, storage, and network to dynamically transition into the next stage of technology and science. It's an efficient way for small biotech and pharmaceutical laboratories to gain equal footing in the race to get products on the market or hospitals and diagnostic laboratories to update their equipment and to improve productivity and safety while staying within budget.

"HAAS STREAMLINES THE SCIENTIFIC PROCESS SO NEEDED DRUGS AND TECHNOLOGY ENTER THE MARKET AT AFFORDABLE PRICES."

While scientific research has to make a profit, it's also about furthering human health and knowledge. HaaS streamlines the scientific process so needed drugs and technology enter the market at affordable prices. It encourages discovery and innovation, leaving the door open for others to build on a growing foundation of knowledge.

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