CALIFORNIA AND EMERGING INDUSTRIES

CAPTURING AN INDUSTRY: **3D Printing**

CAPTURING AN INDUSTRY: **Quantum Computers**

CAPTURING AN INDUSTRY: **Underwater Habitats**

Created Through the Centers for Applied Competitive Technologies Hub Grant, #13-151-001,
California Community College Chancellor's Office, Economic & Workforce Development Program

CACT
Centers for Applied Competitive Technologies
MAKING IT IN CALIFORNIA

ECONOMIC & WORKFORCE DEVELOPMENT
through the
CALIFORNIA COMMUNITY COLLEGES

BACKGROUND

This report was prepared by the Center for Applied Competitive Technologies (CACT), an advanced manufacturing initiative under the 2013-14 Hub grant from the California Community College Chancellor's Office, Economic & Workforce Development (EWD) program.

The CACT helps manufacturers compete successfully in changing markets and the global economy. Through technology education, manufacturing training and services that contribute to continuous workforce development, the CACT provides expertise in technology deployment and business development. Services include onsite training, low-or-no cost technical assistance, and educational workshops, as well as information on how to qualify for state funds to assist with retraining employees and upgrading equipment.

The CACT also provides industry-specific reports on manufacturing & emerging industries/technologies, promotes STEM education through the development of recruitment tools & educational partnerships, and provides many other resources to help industry, educators, and students succeed in California.

For more information, **visit www.makingitincalifornia.com**.

The EWD is an integral part of the California Community Colleges, investing funding and resources in key industry sectors. EWD's industry-specific programs invest in the skills of California's workforce – now and in the future – through highly specialized industry training, technical consulting and business development. The end result is the ability for businesses to better understand the trends and labor market pertaining to their industry, and make informed decisions about how to grow and compete.

For more information, **visit www.cccewd.net.**

CAPTURING AN INDUSTRY
3D PRINTING

Recommendations for Ensuring California's Dominance of the Emerging 3D Printing Industry

Created Through the Centers for Applied Competitive Technologies Hub Grant, #13-151-001,
California Community College Chancellor's Office, Economic & Workforce Development Program

CAPTURING AN INDUSTRY
3D Printing

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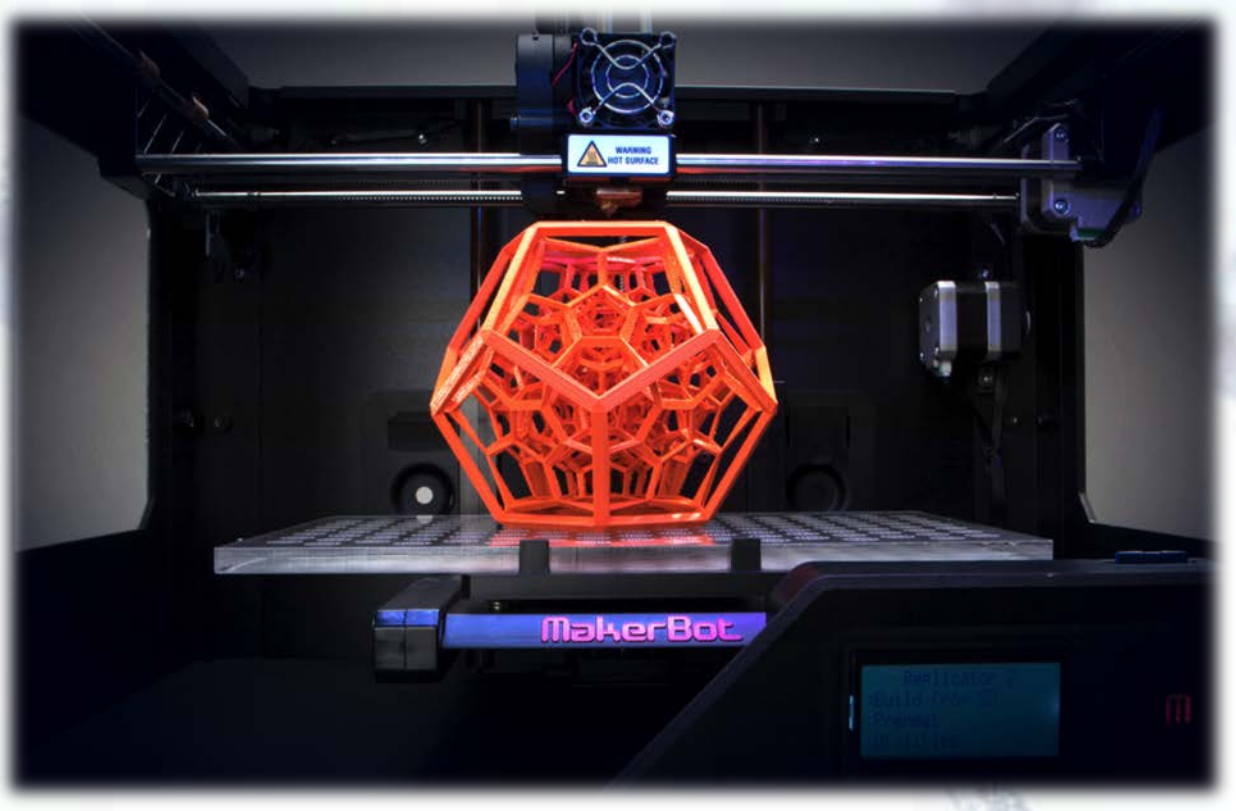
"Getting people exposed to 3D printing and what it can do will hopefully encourage people to create their own models and solve their own problems."
-- David Pastewka, Dreambox CEO



Credit: Digitaltrends.com

As its name implies, 3D printing involves the printing of three dimensional devices. This is accomplished by adding one layer on top of another, usually with the source material being plastic or metal. This process is an *additive process*, which is why 3D printing is sometimes referred to as additive manufacturing. The steps for printing a 3D object are fairly straightforward. Once the user has inputted a digital blueprint via a Computer-Aided Design (or CAD) program, the computer sends that design to the 3D printer, which in turn builds the blueprint one layer at a time until completion.

3D printers also differ from traditional machining in that they create less waste. In traditional machining, material is drilled or cut, with the leftovers generally being discarded. This is one of several advantages of 3D printing. Another is prototyping. 3D printers allow for rapid turn-around of models and usable components, saving not just time but also money.

APPLICATIONS

"We enable people to basically open up their own little company. They can design and test their products and bring them mainstream."
-- Peter Weijmarshausen, Shapeways CEO

Two-Year Old Lifting and Straightening Her Arms via 3D-Printed Prosthetics. Credit: Stratasys

There are a variety of 3D printing applications spanning numerous industries, including medical, automotive, biotechnology and aerospace. From human (and animal) limb replacements to toys, the list of applications seemingly grows each month. A Dutch company recently announced their plans to build a house made out of 3D-printed materials. NASA has begun researching the viability of using 3D printers as a means to feed future space explorers. Recently, NASA successfully tested a 3D-printed rocket component, and is currently researching the viability of using 3D printers to feed future astronauts. To that end, NASA is planning on taking a 3D printer to the International Space Station, to determine if it can perform optimally in a microgravity environment.

Recently, a 3D printed device was credited with saving the life of an infant from a respiratory disorder. A splint modeled after the infant's trachea was developed and inserted. The device is made of a benign material that will eventually be safely absorbed into the body, which is right around the time that the splint would no longer be needed. 3D printers have also been credited with giving mobility to a two-year-old girl who suffers from a rare congenital disorder (shown above).

Entrepreneurs are continually finding new applications for 3D printers. Given what has already been discovered, one can surmise that 3D printing will eventually impact nearly all facets of society, creating substantial economic activity.

ECONOMICS

"It really is a big deal and it could bring huge economic benefits."
Andrew Sessions, Work Foundation

A 3D-Printed Airplane. Credit: www.dailymail.co.uk

Given the multitude of applications for 3D printers, it's no surprise that the industry is expanding at a remarkable rate. New 3D printing companies are propping up throughout the United States and overseas. According to Wohlers Associates, in 2012 the 3D printing industry was a $2.2 billion operation, and by 2015 that estimate is projected to increase to $3.7 billion. SmarTech Markets Publishing projects that the 3D printing industry (hardware, software and services) will be a $5.1 billion market by 2018. These projections are quite realistic. For example, General Electric is expecting to use 3D printers to help build their next-generation jet engines, and projects by 2020 to have nearly 100,000 3D-printed components integrated into their jet engines.

The potential economic impact is so great that the federal government has awarded $30 million to establish the National Additive Manufacturing Innovation Institute (NAMII) in Youngstown, Ohio. NAMII is a consortium of community colleges, manufacturing firms, non-profits and universities, who have matched the award with an additional $40 million. The Institute will be tasked with several functions, including assisting small manufacturers, and training the future workforce in additive manufacturing techniques.

When attempting to estimate long-term economic projections for the 3D printing industry, it becomes difficult to quantify. When considering how many applications have already been (and yet to be) discovered, coupled with the increased affordability of 3D printers (which can now be purchased for less than a thousand dollars), it is reasonable to assume that 3D printers may eventually become a permanent fixture in both the office and home. Under this scenario, it could quite possibly become a trillion dollars industry in just a few decades. As such, California could position itself to reap huge economic benefits from the continued expansion of the 3D printing industry.

INDUSTRY FEEDBACK

"It allows us to be far more productive, efficient and innovative in designs."
-- Scott Goodman, Mattel Inc.

An Edible, 3D-Printed Cake. Credit: Evil Mad Scientists Laboratory

Through conferences and other events, the Centers for Applied Competitive Technologies (CACT) has received feedback from those working in the 3D printing industry, and two common themes have emerged. In terms of workforce issues, the most common concern was the turn-around time to train employees. Business owners indicated that it would be beneficial if incoming employees had a better technical understanding of 3D printers, which would reduce the training period and allow businesses to grow more quickly. CAD training was also highlighted as an important skill-set.

The other issue cited was California's higher cost-of-doing-business. This feedback mirrors comments by 3D Systems Corporation, one of the largest 3D printing companies that left California in 2005. In moving to South Carolina, they cited the cost-of-doing-business, investment/tax benefits, and the overall business climate as their reasons for leaving. Despite this, California can still position itself to capture a large portion of the 3D printing industry. Recently enacted sales tax exemptions on equipment and other components for manufacturers was a major step towards improving the business climate.

RECOMMENDATIONS

"We are no longer bound by economy of scale, manufacturing geometry limitations, and elite marketing and distribution channels. Consumers are afforded more product possibilities as well as options regarding who and where their products come from."
-- Josh Harker, 3D Printing Artist

Person Outfitted with a 3D-Printed Prosthetic Leg. Credit: Bespoke Innovations

Given the potential economics of this fast-emerging industry, California can position itself in such a way that it can capture a substantial economic share of the 3D printing industry, ensuring more jobs and growth in State revenue.

Workforce Training

In order to improve workforce training for the 3D printing industry, the California Community College system can provide a major role in addressing this issue. Several community colleges have already acquired a 3D printer, but the vast majority lack one. By integrating 3D printers into existing programs, students could better familiarize themselves with the software/hardware, and develop valuable skill-sets that would contribute to the industry. There is also the option to extend 3D printer use to entrepreneurs and small business, which would contribute to economic output.

One of the questions posed to industry was what price range would be best for acquiring a 3D printer that is both durable and can provide relevant skill-sets to students. Feedback was fairly uniform in stating that 3D printers below $10,000 would not have the kind of durability required for year-round use, especially if use is extended to small business and entrepreneurs. Feedback also indicated that, to a lesser extent, printers below $10,000 would not necessarily provide users with a full range of capabilities that could maximize one's skill-sets in the 3D printing industry.

Academia

Establishing a 3D printing research institute at both the UC and CSU system would ensure that California remains at the forefront of the 3D printing industry. The institutes would position the UC/CSU to receive additional federal funding, as well as transfer technology to the private sector, creating further economic prosperity. The institutes could also include shared-use functions with the private sector, enabling greater economic growth via assisting small manufacturers and entrepreneurs.

In addition to its primary function, it would also be advisable to have these institutes conduct research into 4D printing, which is 3D-developed components that can change their form via external stimuli, such as temperature or water. In other words, 4D printed materials can adapt to their environment. Initial applications being looked at are in construction industries, but will eventually impact many industries, as 3D printed materials are now starting to do.

NASA Test-Firing a Rocket with 3D-Printed Components. Credit: NASA

Industry Incentives

To expedite expansion of the industry (which includes expansion of existing companies and attracting start-ups), tax incentives for 3D printing manufacturers would go a long way, allowing them a greater capture of the market share, and thus increasing revenue to the State. Waiving the franchise tax board fee and state property tax for the first two years of operation would encourage entrepreneurs to setup a 3D printing business in California. However, for existing 3D printing businesses who stated that the cost-of-doing-business and business climate was a concern, there are so many issues within those two items that it would be arbitrary to recommend remediation. Rather, for a more complete breakdown on issues surrounding the business climate, including viable solutions for improvement, visit the CACT website, www.makingitincalifornia.com, and click on Business Climate Surveys, found under Industry Specific Reports in the Resources section.

Other options for improving the business climate are available, such as a 2011 report by Lt. Governor Gavin Newsom, entitled *An Economic Growth and Competitiveness Agenda for California*, which can be found here: http://www.ltg.ca.gov/docs/LGN_Econ_Agenda.pdf.

Child Gripping Ball with 3D-Printed Hand Prosthetic. Credit: robohand.blogspot.com

CAPTURING AN INDUSTRY
QUANTUM COMPUTERS

Recommendations for California to maximize its share of the emerging quantum computer industry.

Created Through the Centers for Applied Competitive Technologies Hub Grant, #13-151-001,
California Community College Chancellor's Office, Economic & Workforce Development Program

CAPTURING AN INDUSTRY: **3D Printing**

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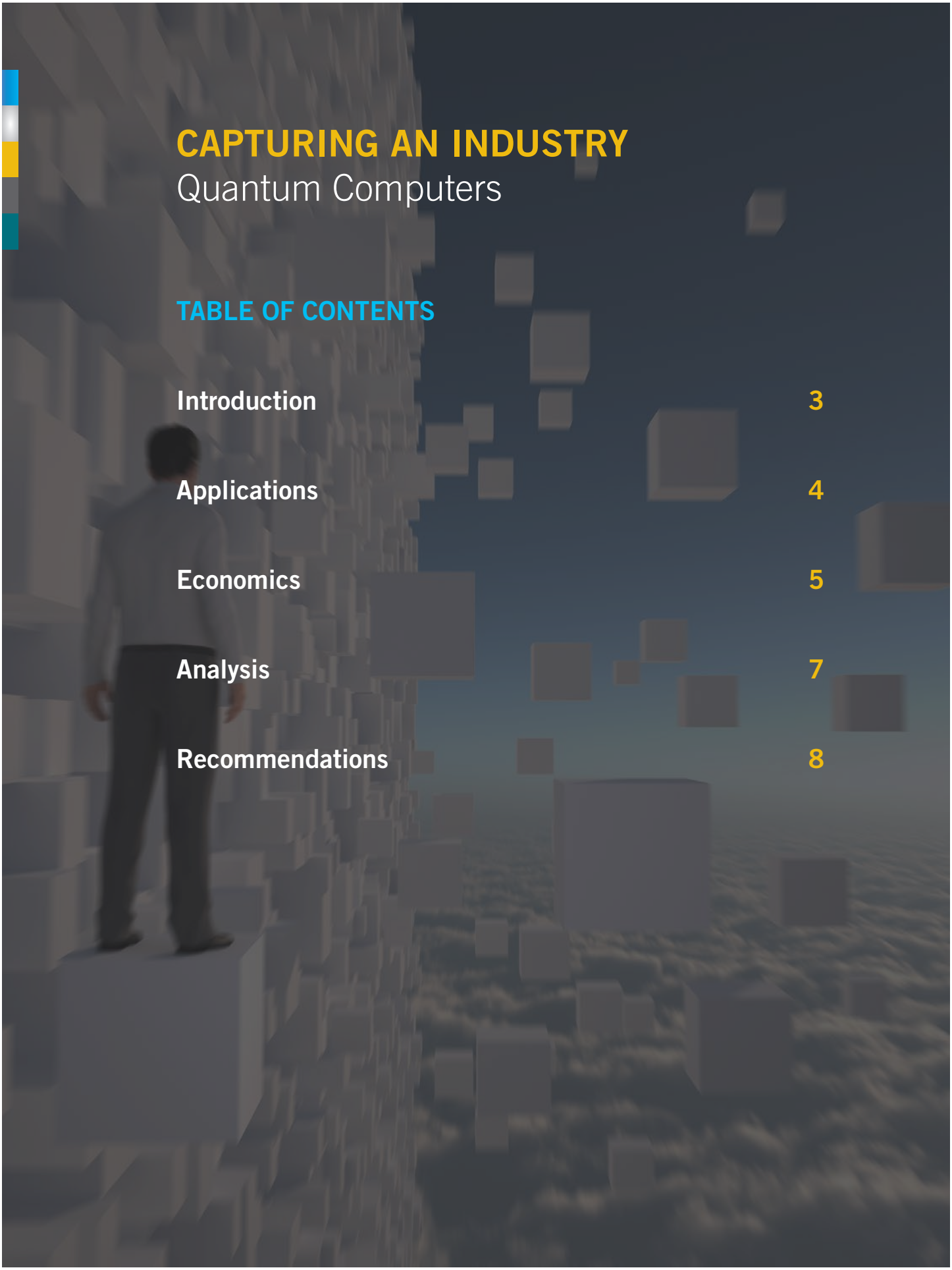
CAPTURING AN INDUSTRY: **Underwater Habitats**



CAPTURING AN INDUSTRY
Quantum Computers

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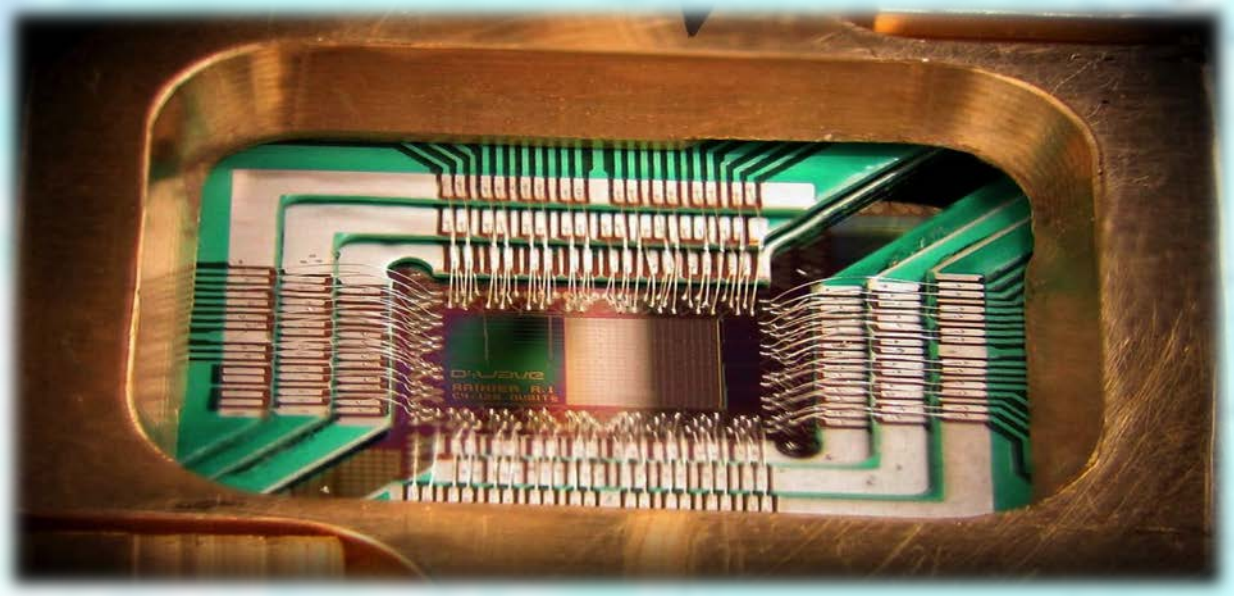
"This technology will have a bigger impact on solving the universes most challenging problems than any other technology that has come along so far."
-- Bo Ewald, D-Wave Systems



Credit: D-Wave Systems

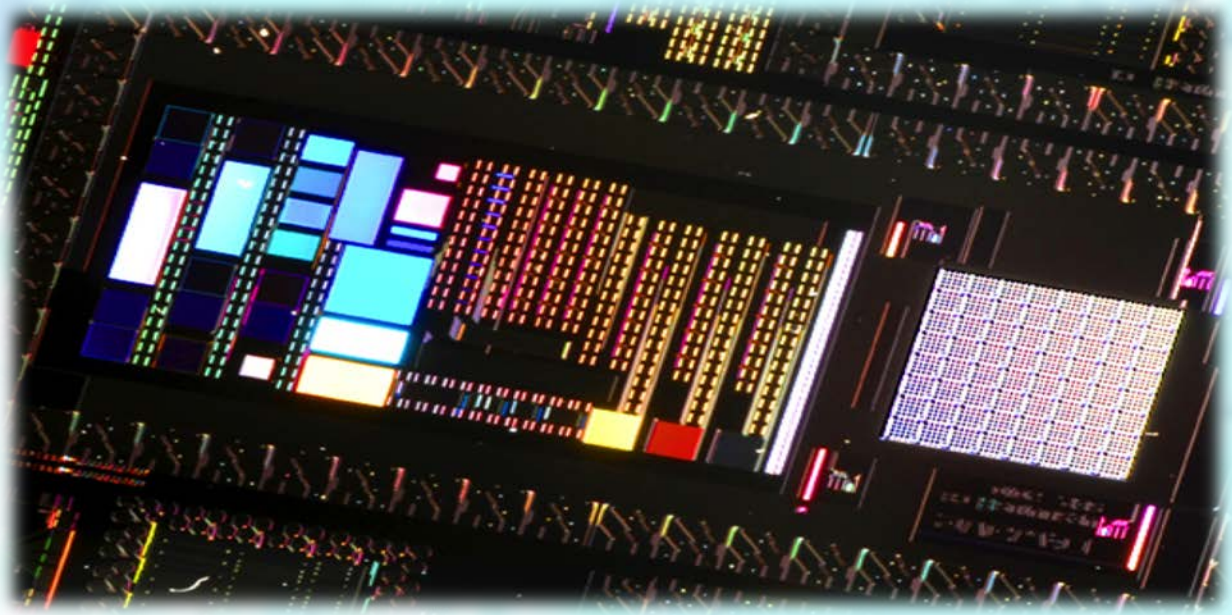
Quantum computing involves controlling quantum phenomena for both storing and manipulating computer data. While existing (traditional) computers operate with zeros or ones, quantum computers can operate with zeros and ones simultaneously. As a result, they can out-perform supercomputers, as well as have the capacity for unprecedented data storage.

Quantum computers have applications in a variety of fields, including aerospace, medicine, and cyber-security, with many more yet to be realized. The most immediate area of use will likely be computer modeling & simulation, as quantum computing allows for highly realistic modeling/simulations scenarios, greater predictive accuracy for real-world applications are achieved.

To-date, only two quantum computers have been built, but a growing number of research efforts from academia, industry and government are investigating quantum computing viability, including MIT, IBM, Lockheed-Martin, Google, and NASA. Since quantum computers are the eventual replacement to current computers, their projected economic impact is substantial. As such, various government around the world are investing in research and development efforts, hoping to capture a large share of the emerging quantum computer industry.

APPLICATIONS

"We believe quantum computing may help solve some of the most challenging computer science problems, particularly in machine learning."
-- Hartmut Neven, Google



Credit: D-Wave Systems

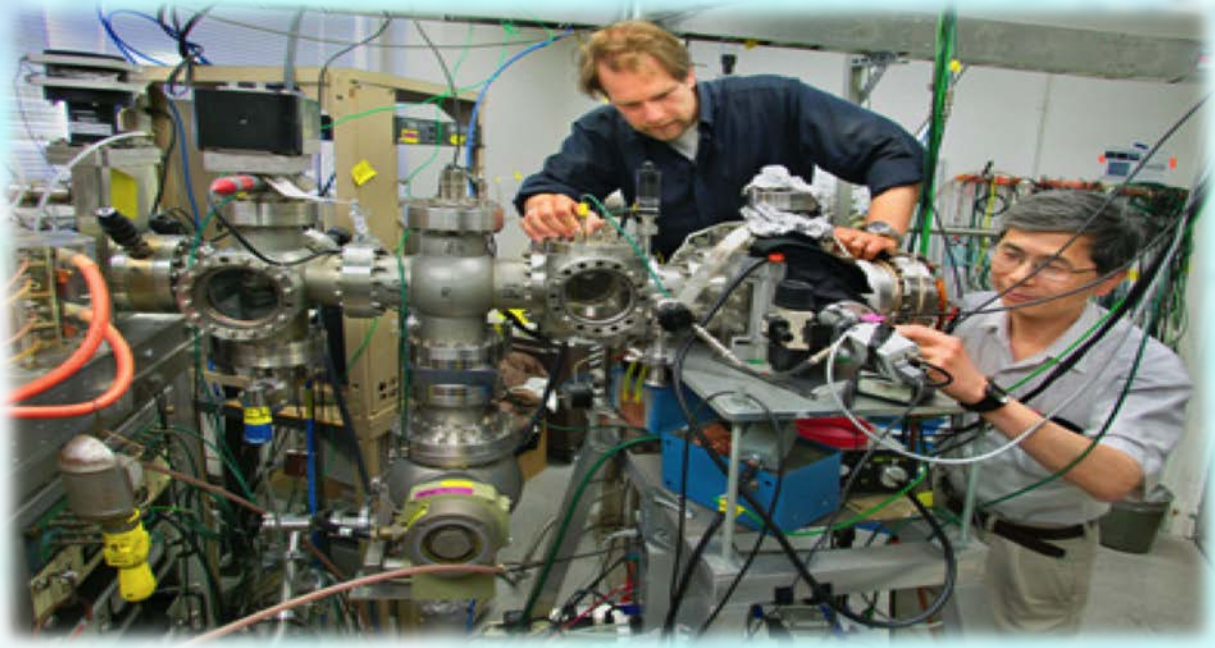
Potential applications for quantum computers are numerous, and additional applications will undoubtedly follow as the industry develops. One of the applicable areas is in medicine. Medical research is growing in terms of how much data is generated. Through the advancements of medical technologies, researching areas like protein folding, drug delivery, magnetic imaging or genetic programming generates large volumes of data, which is problematic in having to crunch the data to draw conclusions. Quantum computers would serve these areas by being able to process the data with expediency, benefitting medicine on several levels.

Quantum computers are also applicable to the aerospace industry. The modeling of new aircraft/spacecraft (which can have incredible complexity) would be significantly improved with quantum computing. In fact, modeling with quantum computers would benefit many areas, such as the simulation of weather systems and chemical reactions.

Quantum computers will also advance cryptology. The encryption capabilities of quantum computing would far exceed that of traditional encryption sequencing, which would vastly improve the security of cyberspace and business finance security, among other things. As quantum computers become more viable, additional applications will undoubtedly be discovered.

ECONOMICS

"This is a revolution not unlike the early days of computing...It is a transformation in the way computers are thought about."
-- Ray Johnson, Lockheed Martin



Credit: Lawrence Berkeley National Laboratory

Quantum computers will eventually replace current computers, which will translate into off-the-chart economics. As it currently stands, for one computer electronics manufacturing job, that translates into 16 other jobs created as a result. Consequently, substantial economic activity will follow. According to *MarketsandMarkets*, between 2017 and 2022 the quantum computing industry is projected to grow nearly 140%.

Currently, only one company exists: D-Wave Systems. They are based in Canada, and have so far sold two quantum computers, with a reported cost of around $15 million per. The first sale was to Lockheed-Martin, which has partnered with USC, and plans to utilize their computer for satellite system reliability testing & jet aircraft design testing. The other sale was to a consortium made up of Google, NASA and the Universities Space Research Association. Together, they have created the Quantum Artificial Intelligence Lab, located at NASA Ames.

Private industry, academia and governments are putting forth major research efforts into quantum computing, including IBM, Los Alamos National Laboratory, MIT, UC Berkeley, UC Santa Barbara, Oxford University and others. The Canadian government has invested nearly

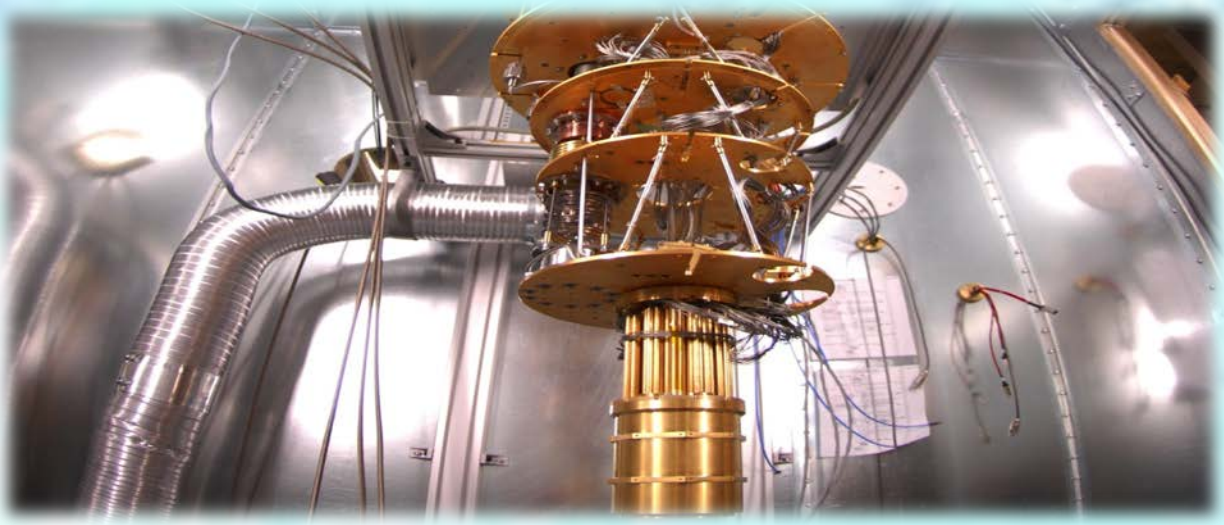
$500 million. Australia and the UK have also provided funds for conducting quantum computing research. Even individuals have contributed. The founder of BlackBerry, Mike Lazaridis, has invested more than $250 million at the University of Waterloo's Institute of Quantum Computing, with the intent of commercializing quantum computers.

When considering the economic impact of quantum computers, it's important to take into account the potential impact on Silicon Valley. Numerous countries, including Russia, China, India and England, have copied the Silicon Valley model, and some with great success. As a result, competition has increased, and Silicon Valley is slowly continuing to lose its unmatched supremacy that it once enjoyed. If California can position itself to dominate the quantum computing industry before it fully emerges, then Silicon Valley would be guaranteed to continue its technology dominance for many decades to follow.

Credit: D-Wave Systems

ANALYSIS

"This [quantum theory] is the most basic thing that should be taught in school. Kids need to know," he said. "It's leading us into an incredible future where we will be able to do things we could only dream of."
-- Neil Turok, Perimeter Institute for Theoretical Physics



Credit: D-Wave Systems

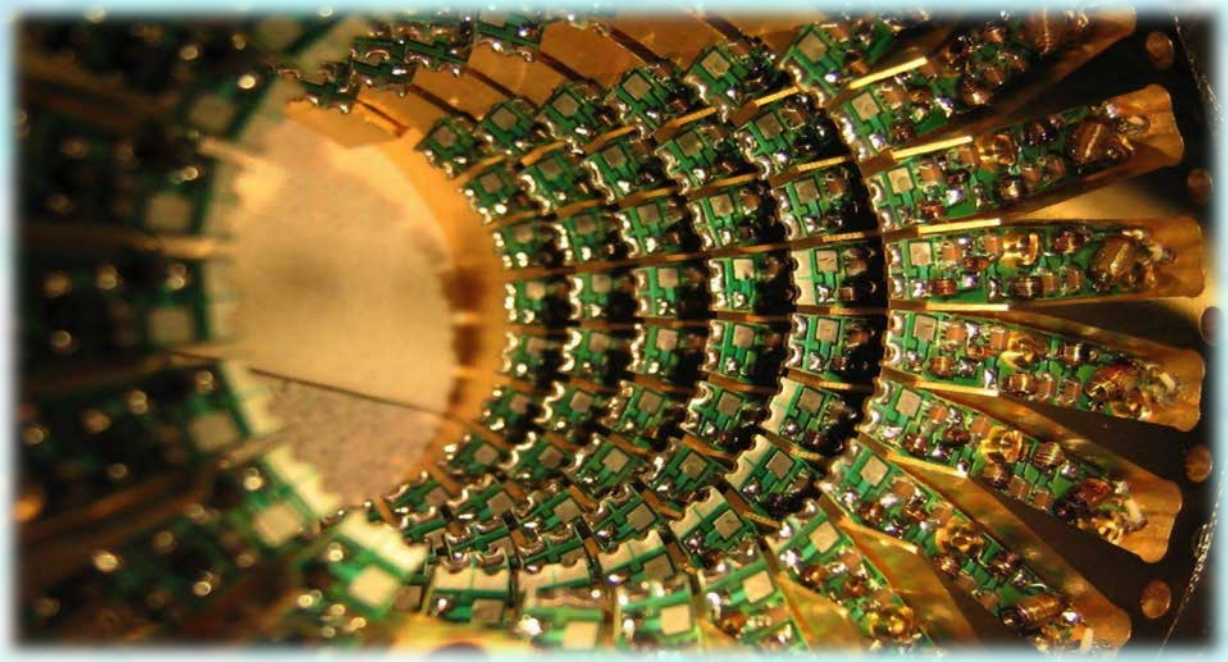
There is substantial economics to be gained for state governments than can attract start-ups (and existing businesses) involved in the production of quantum computers. Although only one company is currently in existence, more will undoubtedly follow. Overseas entities may also be looking to establish a physical presence within the United States, as a means to overcome possible International Traffic in Arms Regulations (ITAR) restrictions, and/or for expanding sales opportunities to the American market, which likely will have the most demand.

Given the specialized equipment and controlled environments that would be required for manufacturing such computers, start-up costs will be higher than standard manufacturing operations. As such, start-ups and existing companies entering the quantum computing market will look to establish operations in States that can provide some level of assistance to offset costs.

Academia is currently playing an integral role in working with industry to overcome limitations that impede mass production of quantum computers. They are in a position to not only overcome those limitations but transfer technology to the private sector. In addition, academic institutions that are actively pursuing research and development of quantum computers have positioned themselves to acquire greater federal funding and develop partnerships with industry, both of which benefit California's economy.

RECOMMENDATIONS

"Organizations that depend on leading-edge technology would do well to begin exploring the possibilities for quantum computing."
-- Steve Conway, International Data Corporation



Credit: D-Wave Systems

There are several actions that can be taken to maximize California's share of the emerging quantum computer industry.

Academia

Establishing a quantum computing institute would provide a significant boost to advancing quantum computing viability. Not only would it position the UC system to receive additional federal funding, but would also increase the possibility of technology transfer to California's private sector, further boosting economic output.

Academia would also benefit from the acquisition of a quantum computer, which would improve the quality of research & education for those pursuing a Masters or PhD in a related field. By expanding research capabilities, opportunities for outside funding via joint partnerships and grants would also be increased. The acquisition could also serve as an impressive marketing tool for recruiting both students and professors to the UC system, as no other public university system currently has a quantum computer.

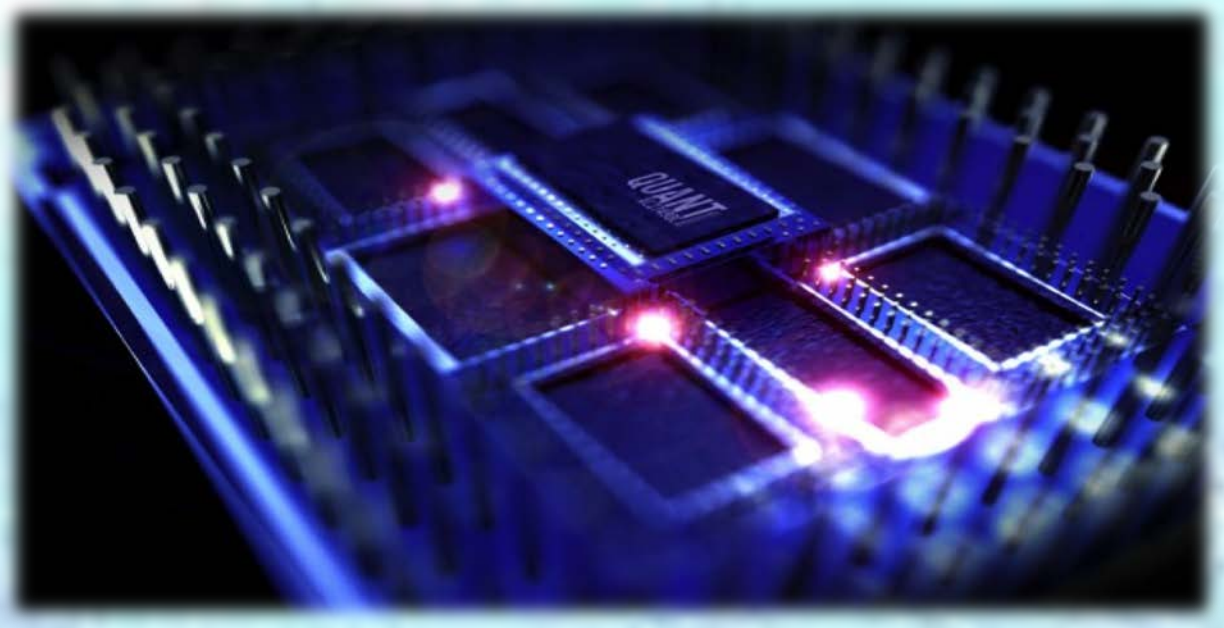
Workforce

Once quantum computers can be manufactured at a high volume, technical education would come into play. Currently, those involved in the quantum computer industry generally have a PhD or Masters (at a minimum). As such, the immediate focus would be on maintaining a pipeline of researchers who are pursuing advanced degrees in quantum physics, computational mathematics, electrical engineering & computer science, and other related degrees.

To ensure a continuous supply of workers, increasing K-12 science, technology, engineering and mathematics (STEM) education would be an appropriate starting point. It would put the UC/CSU in a position to continue to receive students who have the knowledge/skill-sets to continue quantum computing research and development efforts. This could be achieved through a variety of actions, such as expanding Project Lead The Way (a non-profit that integrates STEM education into middle and high schools), or increasing the number of computer science/programming courses at the high school level, among many other available options.

Industry Incentives

While there is only one quantum computing company in existence, others will undoubtedly follow. Offering tax credits related to facility construction and equipment purchases specific for quantum computing R&D would entice future start-ups to setup in California. It would also encourage high-tech California companies to pursue research and development efforts. In either case, California would be well-positioned to maximize its share of the emerging quantum computer industry.



Credit: welcomia/Shutterstock

CAPTURING AN INDUSTRY
UNDERWATER HABITATS

The recommendation to establish a pathway for the development of underwater habitats.

Created Through the Centers for Applied Competitive Technologies Hub Grant, #13-151-001,
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CAPTURING AN INDUSTRY
Underwater Habitats

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INTRODUCTION

"Water Discus Hotel project opens many new fields of development for the hotel and tourism sector, housing and city sector in the coastal off-shore areas, as well as new opportunities for ecology support by creation of new underwater ecosystems and activities on underwater world protection"
-- Bogdan Gutkowski, BIG InvestConsult

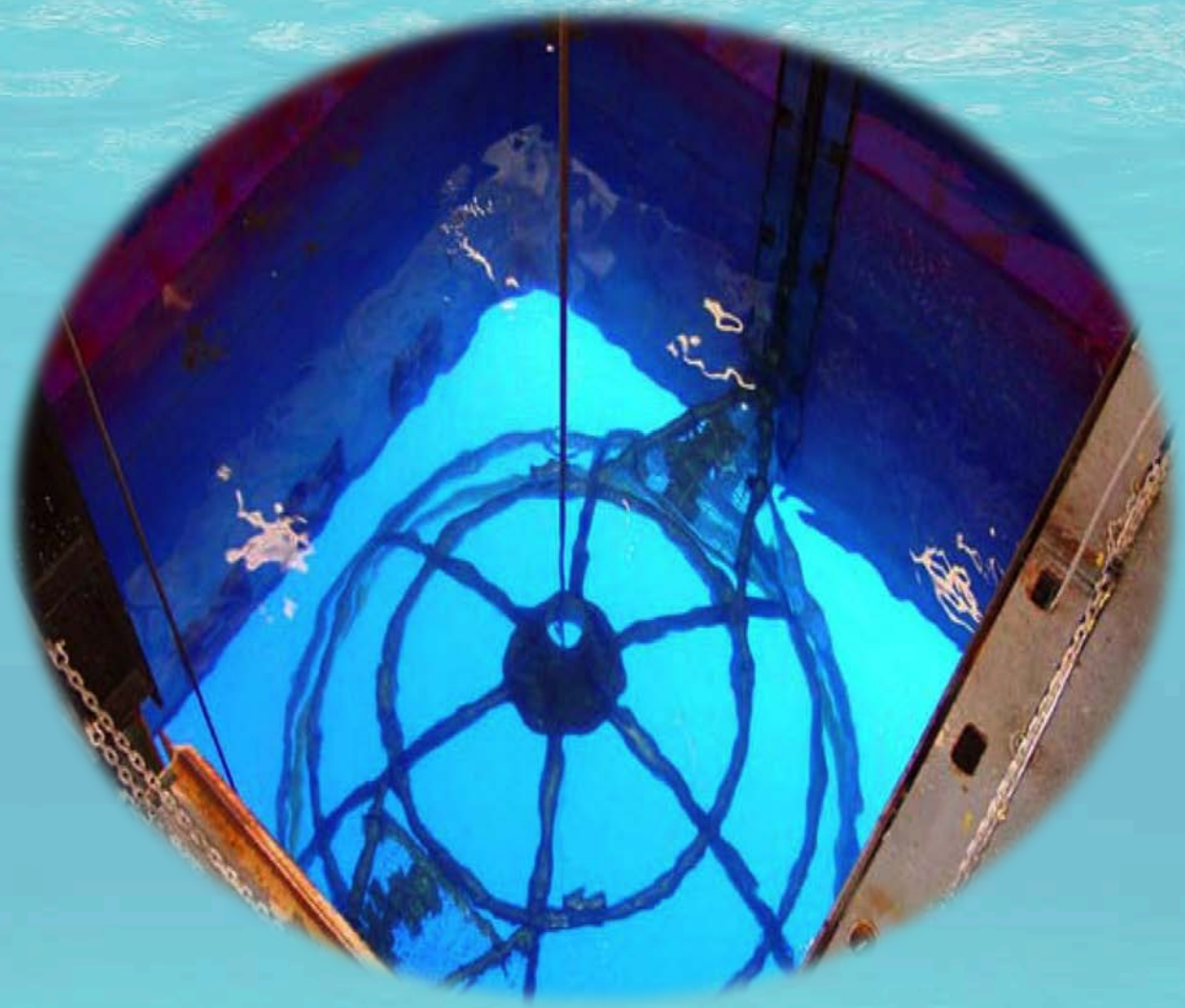
Credit: Deep Ocean Technology

There are a growing number of entrepreneurs who are looking to expand a human presence beneath the ocean's surface. Some want to permanently live there, while others are looking for more commercial functions. In either case, this unique endeavor provides several economic possibilities, as well as serving as a place of unmatched inspiration and education.

While technology to support humans living in underwater habitats has been around for more than 50 years, it is only within the last decade that a growing number of developments & proposals have begun to emerge, some of which include permanent living quarters, hotels, restaurants, and ocean research labs. Some facilities are designed for partial immersion, while others are fully immersed. This lends itself to the way in which facilities would be accessed. Whereas partially

immersed facilities could be accessed by simply walking to the structure via a platform, fully submersed facilities may require visitors to swim below to access a moon pool.

Given the ocean's importance for all life on Earth, one naturally considers how underwater infrastructure would impact the ocean environment. It is natural to initially assume that these projects would have some kind of negative impact on the ocean environment. Quite the contrary, these underwater facilities have the potential to make a substantially positive impact on ocean protection and conservation.



A Moon Pool. Credit: Oceaneering

UNDERWATER PROJECTS

"We are thinking of constructing a Hydropolis that would serve like a research institute and would give people a chance to come and study sea-life in a unique environment."
-- Mansoor Ijaz, Chief executive of Crescent Hydropolis Resorts

Underwater Lodge in Florida. Credit: Jules Undersea Lodge

There have been a slow-growing number of ocean infrastructure projects, but there appears to be an acceleration in future planning for underwater infrastructure. Some facilities are partially submerged while others are fully submerged. A select number of current and proposed underwater projects are discussed below.

Jules Undersea Lodge

Originally a marine research lab, the Jules Undersea Lodge opened in 1986 in Key Largo, Florida. It is accessed by scuba-diving 21 feet below the ocean surface. It is comprised of two bedrooms and one bath. Meals are delivered by hotel staff scuba-diving down to the undersea lodge.

The Water Discus

Planned for Dubai, this proposed development would be the world's largest underwater hotel. It

would include 21 rooms, sit 33 feet below the ocean surface, and include a restaurant, spa, and other standard hotel accommodations. Hotel rooms would be located beneath the ocean surface, while all other hotel facilities located above water.

Proposed Water Discus. Credit: Deep Ocean Technology

Red Sea Star Restaurant

Located 16 feet beneath the water's surface in Israel, this 105 guest-capacity restaurant opened in 1998. The restaurant has taken measures to preserve and nurture the surrounding coral reef, done with the intent of providing an enhanced viewing experience for visitors.

Red Sea Star Restaurant. Credit: Aqua Creations

Poseidon Undersea Resort

To be located in Fiji, this planned 22-room resort would have standard hotel amenities, including a bar & restaurant, spa and conference room. It would also have non-standard hotel amenities, such as a library and wedding chapel.

Credit: Poseidon Undersea Resort

Ithaa Undersea Restaurant

Located in the Maldives, this fully submerged restaurant opened in 2005. With a capacity of 14 people, it is also used for private parties and weddings. This 16 by 30 foot structure is projected to have a life-span of 20 years.

Credit: Conrad Hotels & Resorts

Atlantica Undersea Colony

Planned for this year, the Atlantica Undersea Colony will begin its first phase in establishing a permanent human presence underneath the ocean surface. Unlike the aforementioned underwater projects, this is the only one with the intent of eventually allowing humans to permanently live underwater.

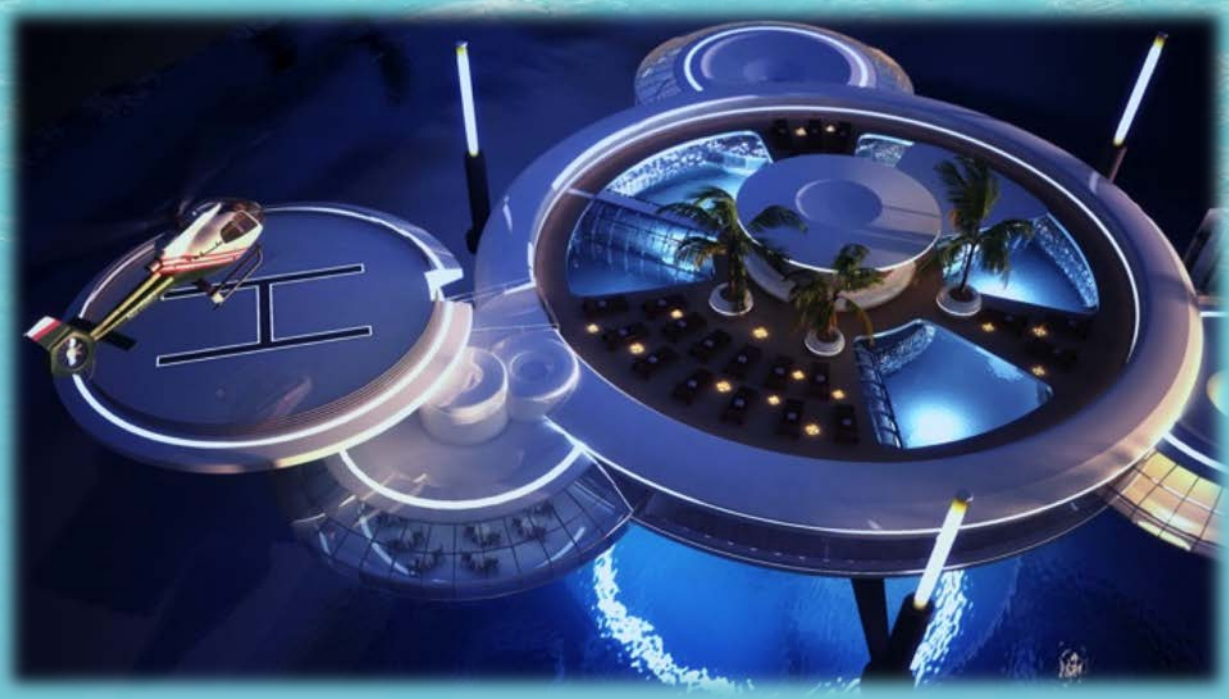
Credit: Poseidon Undersea Resort

NAME	LOCATION	TYPE	YEAR BUILT/PLANNED
MarineLab	Florida	Research Lab	1984
Jules Undersea Lodge	Florida	Hotel	1986
Aquarius	Florida	Research Lab	1986
The Red Sea Star	Israel	Restaurant/Bar	1998
Utter Inn	Sweden	Hotel	2000
Ithaa Undersea Restaurant	Maldives	Restaurant	2005
Atlantica Undersea Colony	Florida	Residence	N.A.
The Water Discus	Dubai	Hotel	N.A.
Poseidon Undersea Resort	Fiji	Hotel	N.A.
Apeiron Hotel	Dubai	Hotel	N.A.
Hydropolis Hotel	Dubai	Hotel	N.A.

A select number of built/planned underwater infrastructures, including the name, location, type of use, and year built/planned.

ECONOMIC BENEFITS

"Our expertise lies in developing future strategies aimed at advancing the construction of technology-driven pioneering projects in the maritime sector."
-- Khamis Juma Buamim, Drydocks World



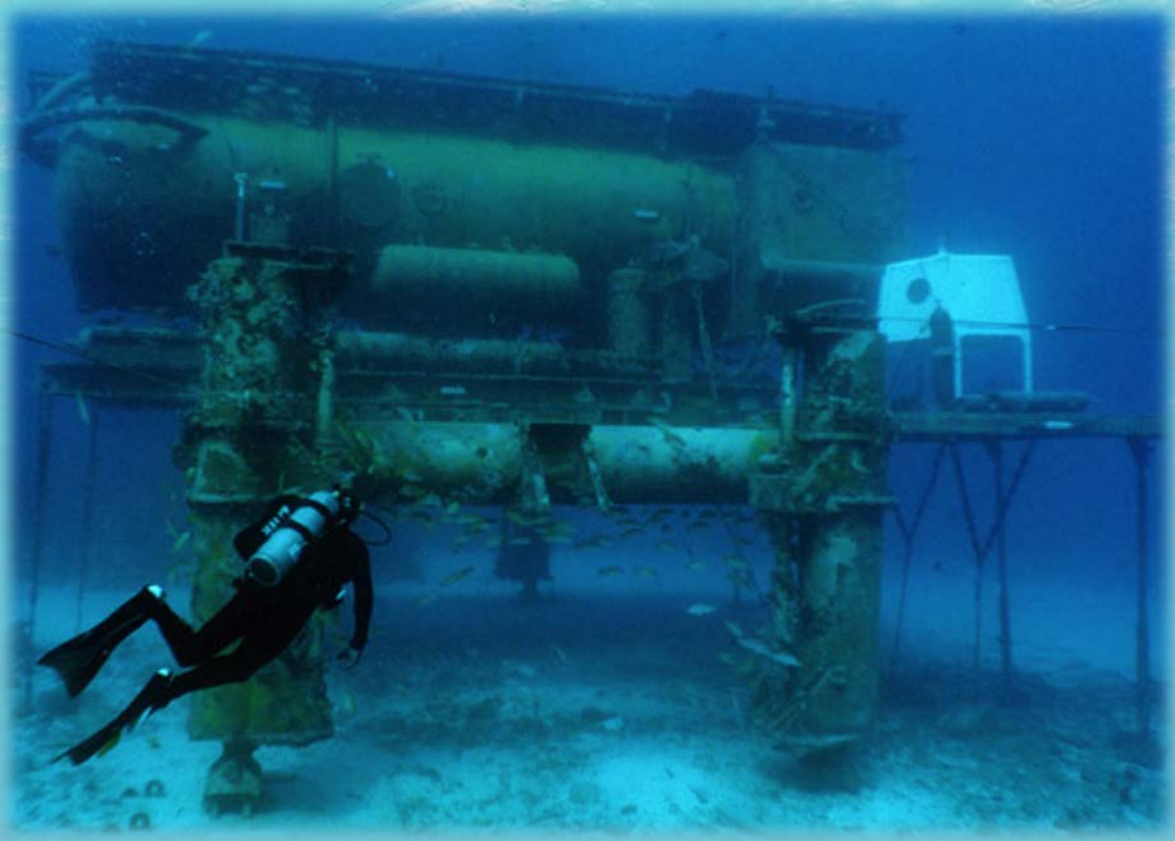
Credit: Deep Ocean Technology

There are many economic benefits that can be garnered from the development of underwater habitats. For example, the manufacturing of underwater facilities would take substantial investments over several years or decades, creating long-term, highly skilled jobs. Both the type of engineering and technology utilized for these projects would generate high amounts of economic activity, which means more revenue to the State. Obviously, the activities taking place inside an underwater hotel or restaurant would also contribute to the economy. Given the uniqueness of such facilities, one would expect substantial economic activity, with a large part coming from tourism.

There are other economic benefits through academia. If the UC/CSU were to have access to an underwater research facility, it would open up three potential funding sources. First, by having a very unique capability, this would allow for greater federal funding opportunities in the form of research grants. Second, these research facilities would also serve as a robust tourist destination. Third, a public-private partnership would yield yet another revenue stream, thereby offsetting operational costs.

ENVIRONMENTAL CONSIDERATIONS

"We are currently planting a coral garden on the reef to add to the spectacular views of the rays, sharks and many colorful fish that live around the reef near the restaurant."
-- Carsten Schieck, Hilton Maldives Resort & Spa



Aquarius Habitat. Credit: NOAA

Contrary to initial assumptions, the environmental impacts of these underwater facilities would be surprisingly negligible. There are several reasons for this. First, construction is not actually taking place underwater. Rather, an underwater structure is built on land, transported to its designation, and then submerged. Second, the habitats would still be connected to the land. That means byproducts of, for example, generating electricity, would still be taking place on the surface. Third, these underwater facilities are not being located in areas that are sensitive to slight changes, nor are they being dropped onto sensitive habitats. The site selection takes into account the surrounding ocean environment. As such, these facilities would not damage parts of the marine ecosystem.

There are several potential environmental benefits with these types of facilities. First, as it relates to electricity generation, these underwater structures could eventually be powered by capturing the kinetic energy of waves and tidal forces. At the very least, these facilities would provide a platform to explore this type of renewable energy. Second, these facilities could serve as marine monitoring stations. Through the expansion of underwater habitats, California could eventually setup a large underwater sensor grid that monitors a variety of marine issues, such as total particulate matter and water chemistry (among other measurables). Third, by visiting these underwater facilities, a new level of ocean conservation awareness would be established. Being able to view the ocean from an underwater perspective is a substantially powerful tool in showcasing the need for protecting the oceans. Fourth, underwater infrastructures allow for an enhanced research capability that would advance the areas of marine biology and related fields. There are other research implications as well, including the R&D of beneficial technologies. Fifth, as demonstrated by the Red Sea Star Restaurant, those operating underwater facilities are helping to nurture coral reef growth, which not only enhances the ocean environment, but provides a nicer viewing experience for visitors. Hence, there is a vested interest in ensuring that the ocean environment is thriving around a given underwater habitat.

Credit: California Academy of Sciences

RECOMMENDATIONS

"We are expecting around 3,000 visitors a day in addition to the hotel guests."
-- Joachim Hauser, Hydropolis Underwater Hotel & Resort

Credit: Poseidon Undersea Resort

Regulatory Framework

A regulatory framework needs to be established in order to ensure environmental protection by way of location and operational processes. From a location perspective, it would be expected that these underwater facilities are not to supplant existing ocean habitats, such as coral reefs. From an operational perspective, there is little to be done for the aforementioned reasons (primarily that these facilities are still connected to the surface). However, it is feasible that an underwater facility would want to put in their own waste processing capability for direct release. For that scenario, a regulatory framework would have to specify the treatment procedures and minimum water quality thresholds to ensure an acceptable environmental impact. This scaled-down version of a waste processing unit may ultimately yield some new technologies that could have a profound impact in addressing pollution runoff. Regardless, it is clear that sewage should not go directly into the ocean without being treated, as is the case for land operations.

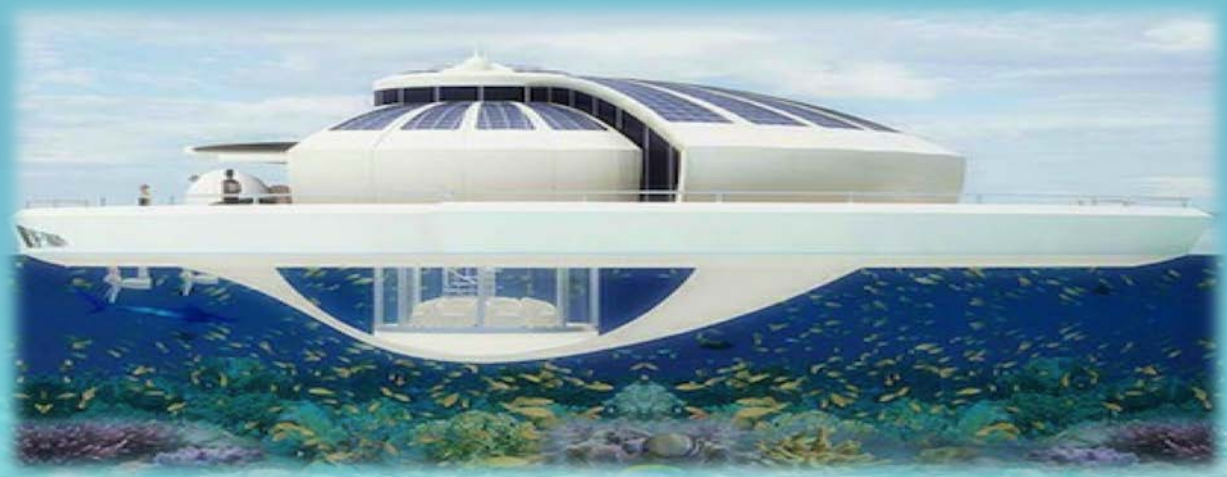
Industry Incentives

Given the potential economic revenue for this emerging industry, it would be advisable for California to offer various tax incentives to manufacture these underwater facilities in-state. These manufacturers would be receiving orders not just from California, but other coastal states and nations around the world, generating high-skilled, permanent jobs, and a robust revenue stream for decades to come. Consequently, it is highly advisable for California to capture this emerging industry, which will contribute to a strong future economy, and raise a new level of environmental awareness.

Academia

It also would be advisable for the State of California to identify funding for establishing three joint UC/CSU underwater research laboratories. One would be located off of the Northern California coastline, while the other two off the Central and Southern California coastline. This would provide several benefits, including: 1) a unique research capability that further solidifies the reputation of California's universities and opens up new opportunities for federal funding, 2) three new tourist destinations that would yield substantial increases in tax revenue, 3) an unmatched conservation platform to educate numerous generations on the importance of our oceans, and 4) inspiring youth to pursue a better tomorrow. One option for financing this development would be to put forth a bond proposal for the establishment of these underwater research facilities. Another strategy would be for the UC/CSU to begin a long-term fundraising campaign, of which all schools within both systems would be required to participate. In either case, additional funding from the federal government would likely be available to help offset costs.

By pursuing an aggressive campaign to capture this industry, California would gain a substantial head-start on this emerging industry, thereby reaping the unchallenged economic rewards for decades before other states (or countries) could pose any serious competition.



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