

THE BROAD DIMENSION

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have been growing. Starting out as units that could build up objects from layers of plastic-like material, they can now handle a range of materials from chocolate to titanium. The uses people have been finding for the technology has similarly been expanding.

People have created flyable model air aircraft, artistic furniture, robots, parts for 3-D printers, and some are hoping to create body organs for transplant. While a 3-D printer could, say, make the case for a cellphone, it couldn't (at least at present) make the electronics inside, but people have come up with ways to do that. A team in Japan has adapted an inkjet printer so it can print electronic circuits on paper using ink containing silver nanoparticles.



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Print Me a House

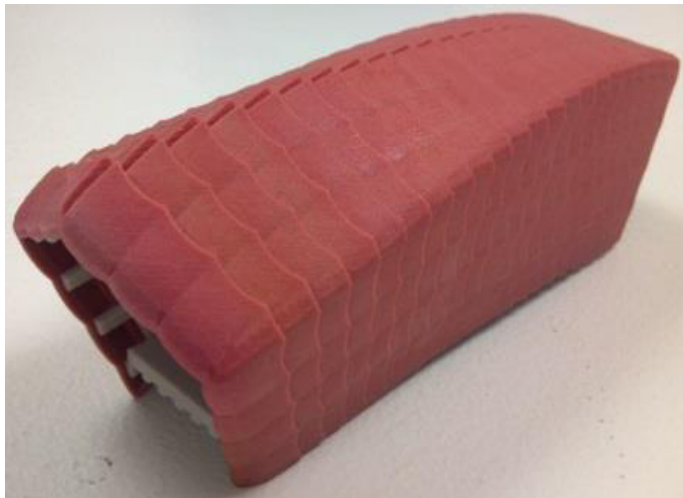
3-D printers started out as an expensive novelty, but prices have been dropping and they are now coming into the affordable bracket for many people. And the uses for them

A typical 3-D printer builds up an object by spreading a layer of whatever material is being used, fusing the required areas of the material together by means of the heat from the laser beam, then spreading another layer of the material and fusing the required areas to the lower layer, and so on. Finally the unfused material is brushed away and you have your object. The powder forming the layers might be something like polyamide plastic, stainless steel or titanium powder, and the thickness of each layer

might be around 100 micrometers (one tenth of a millimeter or one two hundred and fiftieth of an inch). To make the object stronger, the printer could use an electron beam instead of a laser, so that it melts the material completely. The strength of the final product can be adjusted by fusing different materials together.

Another method such printers may use is to build up an object from thin layers of hot extruded plastic (or similar extrudable materials). Both methods build up an object by adding layers, so it is also known as additive manufacturing.

Not everyone that wants to use a 3-D printer actually needs to have one. There are plenty of online services that will take your design and print out the object for you and mail it to you. One such company providing this sort of service is Shapeways.com, who have some very useful tutorials as well.



And you may not even have to come up with the design of your object, because a lot of ready-made plans are published on the Internet. If you do need to create a design there are simple online tools available to do so. The age of individualized objects and innovation for everyone seems to have arrived – now you don't have make something your own, you can make your own something.

Architects have made use of 3-D printers for many years for creating models of their designs, but how about printing the real thing, not just a model? People in many parts of the world are actually doing that.

Here in California, Contour Crafting is using a layered fabrication technology developed by Dr. Behrokh Khoshnevis of the University of Southern California that

automates the construction of components and whole structures. Their system can be programmed to construct a series of houses (for example), where each house is different and the system includes making provision for plumbing, air-conditioning and electrical systems. While the process works fine here on earth, they are also thinking ahead to constructing buildings on the moon and Mars.

R-O-B Technologies of Zurich, Germany, has developed a mobile robotic construction platform that builds customized and complex brick structures, adhered with epoxy resin. The computer controlled robotic arm is ideal for placing bricks in special designs without the need for extensive layout and measurements, because the robotic arm can position itself, and the bricks, precisely.

A consortium in Europe that goes by the name of Amaze (Additive Manufacturing Aiming towards Zero waste and Efficient production of high-tech metal products) is developing techniques to print metal objects, including rocket motors.

Back here in the States, MIT Media Labs is developing a similar kinds of technology using robotic arm that can 'print' buildings. One idea being developed is called the Bots of Babel using cable-suspended fabrication robots that work together to build structures bigger than themselves. Another process being developed involves a swarm of small robotic agents that exude fast setting materials that might become structures or insulation, while incorporating MEP installations.

In the UK, Loughborough University's Project Freeform uses robotics for material placement, and the project is also investigating the kinds of materials and construction techniques that work best with robot construction. They are working to produce components as well as full buildings.

Teams around the world are working to develop the technology, with a first goal of developing a 3-D printed house. Almost every building tends to be a prototype, and this blends well with robotic construction, letting designers come up with some very imaginative designs, including a two-story house resembling a mobius strip.

Thanks to VITAL Environments for the images of the 3D models

Managing Change

There is nothing as constant as change, and the flow of change orders on a project normally validates that statement well. Managing change orders is important on any project, but sometimes organizations have to manage even more challenging changes, such as those resulting from technology changes (say, the introduction of BIM), from mergers or acquisitions, or from changes in the market place. In this short article we will look at both types of change management and compare them.

With construction change orders there should be procedures for handling them laid out in the contract, which have already been agreed to and signed-off on by all parties concerned. With the changes within an organization there are seldom likely to be procedures in place for handling the change, and the first task is to establish how the change will be managed. That procedure should involve everyone, from the top management to the workers who are normally most affected by the change. All changes affect people, but change orders normally mean an adjustment to the quantity of work, while organization change normally means change to the type of work someone does or a change to the way it is carried out. These latter types of change can be stressful, and unfortunately it is often the workers who are seen as steady and reliable who have the most problems adapting to the changes.



A change order normally is more or less of the same kind of thing that was already being done, but organization change often involves learning something new, requiring

training courses and developing new skills. While some people delight in that, not all do by any means. If possible, it can be best to train some of the staff in the new techniques and have them situated among the others while using the new methods on trial projects. This gives the other staff a look at the system before they have to implement it, and generates interest in it. Time can make change feel easier. That kind of implementation may also facilitate ideas and suggestions from those involved in the trials, and those who have been observing, that will help the final companywide deployment. Getting buy-in from everyone involved in a change might be wishful thinking, but trying to get as much as possible is essential. Laying down directives from on high seldom, if ever, works well.

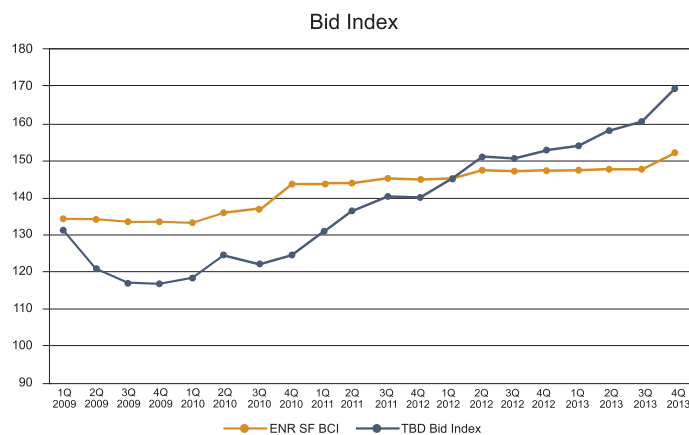
With change orders, the cost of implementing them is often the big issue, once it is determined that any change is needed. Having a clear description of the reason for the change and what the change involves is important in assessing the cost of a change order, and also in allowing those involved in organization change to assess the cost to themselves. If the reason for an organization change is not made clear, it will likely be viewed as change-for-change-sake, and that will almost certainly result in resistance.

When assessing the cost of change orders, the effects on the project schedule are often a large part, if not a major part, of the cost impact. Changes in organizational structure are also disruptive to schedules, with staff having to take out time to learn new systems, as well as the fact that they will probably not be working as efficiently as they normally might, because part of their attention is on the changes and their concerns about them. That is another reason to spread the implementation of such changes out, if possible, so that the company's production is not impacted too much at any one time. So, ideally organizational changes should be implemented over time, whereas change orders should be dealt with as quickly as possible.

While change orders do get implemented as directives for various reasons, organization changes are often a matter of choice, at least as far as when and how quickly a company decides to implement them. For instance, when technological changes are the driving force, companies are often categorized as innovators, early adopters, early majority, late majority, or laggards (popularized by Everett Roger in his book *Diffusion of Innovations*). Innovators tend to bear the development costs, so it may be tempting to think that the early adopters have the advantage. But sometimes a technology proves to have problems that don't

show up initially, or even if it does prove successful, those that take it up later may be able to learn from those that rushed ahead and end up with a smoother implementation. Or the innovators may take over the market and wipe out the others. Decisions about change management are seldom easy and intuitive. Risk management definitely comes into the equation.

A Changing Economy



Towards the end of January, Ben Bernanke's term of office expires and, at the time of writing (mid-Nov), his successor is confidently expected to be Janet Yellen. She will bear the responsibility for guiding the nation through the transition from a market supported fairly extensively by the Federal Reserve, back to a real free-market economy. Although perhaps we can hope that the financial institutions are not quite as free to play fast and loose with our money as they were before the Great Recession.

The end of the Fed's bond buying program, or 'tapering' as it's known, can be expected to start happening early in the new year, assuming it didn't start in December. But that is one change that we can definitely expect to see being spread over an extended period of time. It has certainly been talked about for long enough, and when it really does happen we can expect the usual adverse reaction by the stock market, but overall it should be good for the economy.

That program has been credited with keeping interest rates low, and even talk of tapering has caused interest rates to

start edging up, so rising interest rates is another change we can expect to see soon. But the slow tapering off of the bond-buying program should mean that we don't see too dramatic a shift.

The bond-buying program has been pumping a considerable amount of money into the economy, estimated at around \$3 trillion, with a current (Nov 2013) rate of about \$85 billion per month. But a large proportion of that money has simply ended up in bank vaults. If and when the banks actually start lending out that money, it will increase the cash flowing in the market, which could start to drive up inflation. To date, the Fed has not had to worry about inflation because the effects of the recession and fairly high unemployment have depressed the market, and avoiding deflation has been a larger concern. But that is another change we can expect to see starting this year. We have certainly already started to see construction costs rising more, but that can still largely be considered recovering from lows.

The Federal Reserve's program has been aimed mainly at building up the economy so that unemployment rates will drop. The October job growth figures showed promising results in that field, despite the government shutdown, so hopefully we are finally seeing momentum there.

With an improvement in the employment situation we should see a pickup in consumer confidence and an increase in consumer spending. With the US gross domestic product relying so much on consumer spending, that will definitely be good news for the economy.

The new year will also see a rerun of the debt-ceiling/borrowing-limits debates, and we can hope that we might see some change in political rhetoric when that happens, but that is one situation where this writer suspects major change is unlikely to happen. But we live in hope.

So, it is likely to be an interesting year ahead for us all, and if Ben Bernanke had a tough enough job seeing us through the recession, Janet Yellen could be facing an equally challenging time bringing us out of it.

Geoff Canham, Editor