

## 3D printing

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3D printing [or Additive Manufacturing (AM)] allows the construction of three-dimensional objects on demand. 3D printing technologies is now widely used in healthcare, aerospace, design, and the automotive industry. Additive Manufacturing (AM) had first been launched over three decades ago as Charles Hull's first introduced the SLA (Stereolithography) patent in 1986. This technological innovation requires a variety of stages which shift from the definition of the simulated CAD (computer aided design) to the physical component arising from it. Additive manufacturing inserting layers of raw materials upon layer. Each layer is composed of a thin cross-section of the portion obtained directly from the CAD files. This allows the production of materials on demand that can be easily printed where the 3D printer allowing the production of artifacts at tourism facilities. For example, a 3D printer can print materials on board a cruise ship on demand, rather than wait for reaching a port and order them through suppliers.

There are a number of important differences between traditional production and AM processes. This can be seen in terms of freedom in design, minimal waste of materials, less equipment, less machining, fast prototyping, and manufactured complex parts on demand. Another major advantage of the AM process is that various materials can be applied, for instance, polymeric materials, composite, metallic, and ceramics. The final product obtained from 3D printing could have high surface quality. The raw materials in this process, such as powder, can be reused and recycled many times, as long as the powder properties do not change. 3D machines are safe, simple, inexpensive, and easily accessible for consumers. Therefore, in terms of domestic use, consumers are widely able to construct desirable objects by using additive manufacturing techniques. However, there are some drawbacks of AM which need to be considered. For example, the raw materials (powder) used in AM processes should not have excessive moisture, any contamination, or being exposed to extreme light ([Gibson et al. 2014](#)). The AM technology has made a new revolution by changing the design concept and improvements in many industrial applications. Therefore, identifying the great potential of AM technology by stakeholder and decision makers requires careful consideration of their ability prior to impact of this technology on the tourist industry.

3D printing has great potential and offers capabilities for the tourism and hospitality industries. 3D printing can support maintenance and sustainability especially in cultural heritage. Artifacts such as pottery, tiles, roof tiles of historical buildings, weapons, and ceramics are frequently destroyed by natural and artificial causes. As a consequence, it is important to rebuild the destroyed objects and preserve them to illustrate these objects to the next generation and exhibition purposes. Historically, natural materials were predominantly used for fixing and preserving such items. Traditionally in this process, hand repairs resulted in possible damage once the preservation materials get into close touch with the objects, leading to the removal of the materials from the objects due to insufficient preservation. New materials such as epoxy resin have just been developed for these intentions. This allows conservator-restorers to print the missing or repair parts by (3D) with highest shape accuracy, thickness as well as a well-suited surface with the minimum human contact ([Jo and Hong 2019](#)). Another advantage of using 3D scanning and printing is that it can be used for educational and restoration purposes. They can create scale models of ancient artifacts and restoring historical buildings for educational and training purposes.

Organisations can print on demand material and replace materials when damaged or they can 3D print equipment such as tableware and cutlery using a variety of additive manufacturing techniques (Lipton, et al 2015). 3D printing allows not only the replacement of broken artefacts on machinery and equipment for example in rooms or food and beverage outlets but also provides the advantage of customisation for tourism and hospitality businesses adding to the customer experience. This is particularly useful if suppliers of these artifacts are remote and require considerable time to deliver. It also very useful when there is a need to produce a unique design that fits a particular occasion, such as a personalised cake or an individual artefact for a wedding reception. It can also be used to 3D print artefacts, souvenirs and other items connected to a unique occasion, at relatively short notice and cost effectively. The advantages of AM technology give great opportunities for the tourism and hospitality industries to be creative and adaptive and at the same time cost efficient. Figure 1 provides an illustration of AM capabilities in the travel and hospitality market ([Ayad and Shehata 2014](#)).

Fig1. Schematic of the additive manufacturing (3D) products

**FIGURE HERE**

Source: Anastasiadou and Vettese 2019 and Mearian 2015

Souvenir and gift shops are great places for visitor attractions as well as for generating revenue for local people. One of the AM applications in this sector would be the manufacturing of souvenirs and symbolic objects such as unicorn head, Eiffel Tower, Chinese dragon perhaps with an element of personalization. Seeing 3D object being printed in real time also creates unforgettable moments and individually experiences for tourists in specific places during vacations. Therefore, not only purchasing 3D printed souvenirs by visitors could generate significant income for local residents, it also can be of great gravity for tourist attractions (Anastasiadou and Vettese 2019). It has also been claimed by the designer Héctor Serrano, that manufacturing souvenirs by 3D techniques can result in reduced carbon footprint as transport and mass manufacturing are minimized [<https://hectorserrano.com/works/carbon-footprint-reduced-souvenirs/>]. To reduce environmental impact, they designed specific souvenirs in CAD files and then sent via email to be printed where they will be used. Therefore, no transportation or normal manufacturing methods were needed and resulted in reducing their effect on the climate. These results suggest that manufacturing physical objects such as souvenirs by 3D is environmentally sustainable and can support decrease carbon footprint and global warming ([Anastasiadou and Vettese 2019](#)).

AM is also a major area of interest within the field of food and hospitality industries. This is the case of cutlery and other material 3D printing to make complicated usable components with lowest cost. AM is expected to be a key factor in the future of the hotel industry and green tourism. A notable example is the Lewis Grand Hotel located in Philippines, which created a villa in the hotel by 3D printers. The hotel includes a 3D printed spa bath that used local materials, such as sand and volcanic ash, to give the printed component attractive features. Another example of 3D application in the hotel industry is office space made in Dubai's Emirates Towers complex. Printing symbolic objects and cultural artifacts can generate tourism revenues. However, there are challenges due to low production rates and safety issues for 3D parts. Fabricating parts, where layer is inserted upon layer and can cause internal void. These internal pits can allow bacteria to grow and it is difficult to clean with chemical materials. This can be solved by correct design.

The AM process is fast becoming a key manufacturing technique in the 21 centuries. This new technology will enable businesses, to improve their final products and their revenue by prototyping, dynamic designing and personalization. Eventually, this modern technology can contribute to developing cheap homes to tackle poverty around the world, by creating efficient and sustainable place to live (Holt et al. 2019). 3D printing also can be used to restore ancient artifacts or historical buildings with less human interference and preserve them for the next generation. 3D printing can be a great attraction for shoppers, support maintenance and repairs in remote areas, and reduce the carbon footprint. It also can play a crucial role in green tourism and building affordable homes. However, this process is facing some challenges such as mass production, building orientation, materials reliability, professional standardization. Despite the obvious drawbacks, this exciting technology has enormous potential for the tourism sector and will be developed further with new procedures, materials and standards.

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