



## Modern development level of 3D printing, Advantages and Disruptive potential

Professor Chua Chee Kai Executive Director

17 October 2016

# What is 3D Printing?

A group of technologies that can automatically construct physical models directly from Computer-Aided Design (CAD) data



Other names: 3D Printing, Additive Manufacturing, Rapid Prototyping, Layered Manufacturing and Solid Freeform Fabrication

# Advantages of 3D Printing

- Prototypes are made faster and cheaper (without tooling)
- Create objects with complicated internal features that cannot be manufactured by other means
- Produce customized parts
- Make parts lightweight
- Build entire assemblies

# 3D Printing

#### **Purpose:**

Visual aids for communicating, planning purpose
Prototyped part for design testing to verify form, fit and function
Finished part for direct use

# 3<sup>rd</sup> Industrial Revolution?

# What can you print -Materials





# What can you print: Applications

food

food food food







food

sport

### sport

food



food

### sport

food

sport

food



architecture

architecture

architecture

architecture

architecture

architecture







# **Current Limitations**

- Limited range of materials
- Speed is still considered slow
- Resolution limits certain applications eg 5 major organs
- Too expensive machines and materials
- 🔶 Etc.



http://3dprint.com/60963/3d-printing-obsolete/

# Impact of 3D Printing

- Lower cost due to increased applications
- Printing on demand reduces eliminates difficulty and high cost in procuring hard-to-find parts
- Potentially revolutionize how manufacturers manage their supply chain and inventories



http://3dprint.com/60963/3d-printing-obsolete/

# **Conventional Manufacturing**

- Companies stock up on spare parts
- High-value slow-moving parts, usually obsolete parts, are gathered
- Industrial automation has accelerated the obsolescence process

# Will 3D printing make obsolescence obsolete?

http://3dprint.com/60963/3d-printing-obsolete/

# Aerospace Industry

- Demand for spare parts hard to calculate
- Spare parts require huge storage space and capital
- Benefits of 3D Printing:
  - Light weight (significant fuel savings)
  - New design features
  - Simpler design (less number of parts required)
  - Shorter manufacturing process (see <u>video</u>)



**3D Printed Jet Engine by GE** 

http://www.ge.com/stories/advancedmanufacturing

# Marine and Offshore Industry

- Spare parts not easily available in the sea
- Leads to delayed shipment, loss of productivity and money
- Benefits of 3D Printing:
  - Ability to print spare parts on board
  - Reduce lead time and costs
  - Customizable spare parts
  - Ability to print complicated joints with shorter processing time



http://3dprintingindustry.com/2015/07/08/3dprinting-sought-to-improve-spare-partsmanufacturing-for-marine-industry

# **3D Printing in Space**

- Made in Space launched the world's first zero-gravity 3D printer in 2014
- Benefits of 3D Printing:
  - Overcome environmental limitations (absence of gravity)
  - Manufacturing replacements of tools and spare parts can meet the needs of astronauts on long duration space missions
  - Overcome limitations in inventory space and shelf life



# **3D Printing of Spare Parts**

#### Kazzata: The First Marketplace for 3D Printed Spare Parts

- Variety of 3D printable files available
- Request that the part be designed or supplied by a manufacturer
- Receive the file for printing at home
- Kazzata can also set you up with the nearest 3D printer in their network to have it printed



# What's ahead?

models prototypes plastic aircraft parts

low-cost consumer medical implants batteries and custom metal aircraft parts electronics prosthetics weapons clothing food integrated **Marine and Offshore** electronics living tissue printing in construction outer space smart structures human unimaginable organs applications

#### Staying ahead of the 3D printing curve Broken

NTU Additive Manufacturing Centre focuses on research to sharpen Singapore's competitive edge

#### by suki lo

HONING Singapore's expertise in the new and powerful field of additive manufacturing (AM), commonly known as rapid prototyping or 3D printing, will help the country stay mimble to meet ever changing industrial demand, says AM ploneer Professor Chua Chee Kal.

Prof Chua, who is the director of the NTU Additive Protochas, who is the director of the NTO Addative Manufacturing Centre (NAMC) located at Nanyang Technological University (NTU), has had a long-run-ning passion for AM — which refers to processes that produce a 3D part from a computer-aided design model by adding material successively, usually in a layer by

He says his excitement about 20 printing processe stems from their ability to produce parts with complex configurations and flexi s conveniently to meet rapid changing industrial The technology is able to do this without incurring

additional tooling costs compared to conventional manufacturing such as machining, casting and mould-

"Typically, parts can be produced within a few hours to a week, and manufacturing does not require high volume production to break even. AM is ideal for addressing dynamic technological trends and industrial demands," says Prof Chua, 54.

He leads a team of 30 professors and 100 researchers who are all involved in AM research at NAMC, which aims to be at the forefront of 3D printing technology.

Nurturing engineers In the field of AM, Prof Chua is the most published and

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National Day Special 2015

#### SG2065: The will to seize the future

Chua says: "Although

there are some tech-nical challenges, in

onclusion, additi

manufacturing helps to reduce the number of



Top prize: S\$10000 cash 國大研发三维打印技术

Prof Chua has a long-running passion for additive manufacturing

An example is its fruitful collaboration with Molex singapore, a global provider of electronic solutions, to splore 3D printed connectors and look into streamlinprint larger parts that today's 3D printers and new type of materials use. SLM is a type of 3D printing process. Explaining the rationale for the laboratory. Prof its manufacturing and assembly process. Deeming the project with Molex a success, Prof Chua says: "While the use of metal additive manufac-turing has been growing, a number of challenges con-

time to impede its more widespread adoption "For instance, the limitation of the size of the parts, use of a single material and the lack of new materi-als hinder the growth of SLM techniques for additive monotonics."

anufacturing." Building larger parts saves cost and time compared

change, and the threat that it

brings, of extreme weather patterns and rising are levels

battle with knon the US on the

entre will focus on metal AM systems and pro

The centre will focus on metal AM systems and pro-ducing alloy components for three core sectors: re-search, education and application, be says. "This will provide Singapore with the competitive advantage that will spur new opportunities in design tools development, AM knowledge propagation and manufacturing technology innovation, complement ing Singapore's existing strong manufacturing capa-

He finds that the most gratifying part about engi ering is seeing research born out of hard work bei The Sunday Times | Sunday, August 9, 2015

#### potential.

come of age, viewed askance by older generations as one with a strong series of entitlement to the Singapore is seventh worklwide and inplin Asia, in the Global Innovation Index 2014 co-published by Cornell University, Insead and the World Intellectual Good Life, with an unproven work othic, and who appear to lock a proper awareness of the Republic's sistential realities. But if we look at the future Property Organization, an agency of the United Nations.

through a longer term, and more mound lens, the future looks bright. Singapore has many things going for it. We have a competent, highly organised public administration system that is attuned to the future. Economic Community gains stear Singapore's economy will become In the pithy words of Neu Boon more regional-focused. Being plugged into the Asian hinterland can help us overcome Song who wrote Dynamic Governance, the civil service has the ability to "think ahead, think traditional constraints, Ravi Menon, in an essay in Singapore 2065, imagines a future where eross (domains) and think agai The Singapore Spirit contains a Singapore has expanded its hinterland, tapping the economic rongdose of Nietschean \*will to power": We have the drive to succeed, the ambition to excel. potential of the Iskandar region in That can be seen in the way Singapore constantly tries to shape circumstances and the environment ohor through seamless links. If Iskandar Johor - and Riau lonesia - become an economia to its ownfavour. It will be a strong asset as we enter an uncertain future and residential hinterland, and land and sea links improve, then It is our will to power that will Singapore can overcome land and help us cope with one of the big driving forces of the future: clima labour constraints, dissipating fears of congestion and high housing prices.

tech and economic frontier in Singapore, political change lags. Singapore has a political system with an incumbent party that has ruled since 1959, for 56 years, but with an electorate that hankers for more elected opposition, as the People's Action Party's declining ote share shows. Longused to consensus, we have not yet mustered, let alone mastered, the art of political ompromise or of disagreeing agreeably, a skill Kishore Mahhubaniconsiders critical for

platforms. The overall thrust is this Angapore will environmentally Singapore's future. engineerits landstate to thrive. The accord external driving force affecting our future is geopolities. Here, it is our adaptable stance that will help steer the nation. The next few decades will almost warsefully conflict incidents, and likely military skirmishes around the Ras and South China Seasas the incumbent maritime power America copes with a rising challenger in China. It is for this reason that geopolitical analyst far Bremmer last year told melie athering, which mi nleashed someday. considered this the most dangerous region in the world. What everyone fears is that a

heart? Print a patch to mend it

Singaporean taking 3-D tech a step further by 'printing' tissue, organs

sign. The 3-D printer that enables this has a built-in computer which directs a souped-up inkjet printer to lay one filmy slice of

nolten material, usually a plastic

atop another as one would stack ncakes. When these slices cool wn, they harden into a solid ob

Prof Chua 53 chairs NTU's

school of mechanical and aero-space engineering, and has distin-guished himself globally in this

field of building things up layer by layer, similar to how a plant or person grows.

person grows. His biggest idea to date has been to crack the computer formu-lae needed to direct a 3-D printer effectively to make tissue scaf-

These scaffolds are tiny biode

American industry consultant

costs and waste.

typical of traditional

manufacturing methods

costs and the need to maintain

cost-effective business models

now manufacture their own

field. These will shake up

products instead of relying on

and created opportunities for new

entrants within the manufacturing

manufacturing as we know it today

a massive product inventory



SINGAPOREAN engineer Chua Chee Kai dreams of the day when you can walk into a shop here on Valentine's Day and ask its mind-ers to print out a chocolate rose for your spouse on the spot.

Or if you need replacement soles for sneakers, you can get them to print them out pronto. Now, what if you needed a cornea, a bladder or heart tissue? Well, Professor Chua will be able to print all these out for you too by the end of the year. That is when his new mil-

These scattoids are tiny mode-gradable grids that can be implant-ed in a person so that the person's cells can latch onto the grid and grow into tissue. Once the new tis sucholds together well, the grid lion-dollar 3-D bioprinter will ar-rive at his new \$30 million centre at the Nanyang Technological Uniwill dissolve harmlessly. versity (NTU) to research the tech



folds.



For The Straits Times

Additive manufacturing (AM) or 3D printing, as it is more commonly known, is a term that is becoming more familiar, used not onlyby large corporations and institutions but also smaller enterprises and even individuals Simply put, 3D printing refers to processes that produce a 3D part from a computer-aided design model by adding materials



Prof Chua with a 3-D printed replica of a human skull he made. He will be using stem cells, proteins and other biologica material as "ink" in his new 3-D bioprinter to make corneas, skin and heart tissue. ST PHOTOS MUGLANRAASEBERAN



Some of the items that Prof Chua has made using a 3-0 printer in his laboratory. He will be getting a new 3-0 bioprinter by the end of the year.

With growing interest world-wide in 3DP today, Prof Chua says that it would be wise if the Government set up a national insti-tute soon to educate all Singapor ans on the dangerous pitfalls of 3DP, such as:

nology wasted a lot of material

"So I got to thinking: What if there was a way to build things layer by layer, just like how na-

ture grows living things?" This National University of Sin-gapore and NTU alumnus went on

claimed book on 3DP in 1995, with NTU don Leong Kah Fai and their former colleague Li

o co-author a critically ac-

Chu-Sing.

 copyright concerns, as 3DP has made ripping off another's de-signs only too easy; Security concerns, as this inhanced power to make thing



husbandry or slaughter. Bioprinting food will also minimise the risk of diseases such as mad cow disease or bird flu by

4D printing might also be useful for printing structures for transporting across dramatically different environments, such as



#### The full before the storm

In the past, thirsting for water, ingapore came up with leadination and Newater, Warried While so much is abuzz at the about water pollution and flooding, it created a canal and barrage system, redirecting riverine flows. In the face of rising sea levels, ummentators like Lim Say Bour and Peter Schwartz all expect that Singapore will build dylors to keep out the waters. If the weather becomes inhospitable, there are options to go underground, build climate-controlled domes, and even a project to build vost floating Political scientists theorise that

monolithic or author itarian sta need to go through a period of estability before they transit into stable democracies with political parties that alternate in power The PAP may want to defy all adds to remain in power through 2065. But it is far more likely that in

2015, Singapore is in an interlude between the status quo and reform This is a lull, with forces of change which might be What happens after? Optimists like Yeoh Lam Keong, inlis cisay for Singapore 2065, conflict incident rescalates into predicts that the next two decades will see "an unprecedented period military action. If China goes to

## ABOUT NTU

A Young and Fast Rising University



## World Wide

## ABOUT NTU

**Earth** Lee Kong Chian **Observatory** School of S.Rajaratnam of Medicine School of **Biological** Singapore International **Sciences** (EOS) Studies (RSIS) Singapore National **College of Centre on** Physical & Institute of Environmental Science **Mathematical Life Sciences** Education **Sciences College of** Engineering (SCELSE) Engineering Interdisciplinary Nanyang **Graduate School College of Humanities**, **Business Arts & Social Sciences** School **Humanities Communication &** & Social Information Art, **Sciences Design &** Media

## SCHOOL OF MECHANICAL & AEROSPACE ENGINEERING

## A Young and Fast Rising University



**Engineering – Mechanical, Aeronautical and Manufacturing** 

University	2011	2012	2013	2014	2015
University of Oxford	6	9	12	9	9
California Institute of Technology (Caltech)	9	21	19	13	11
Nanyang Technological University	33	16	11	12	17
The University of Melbourne	17	19	25	17	23
Princeton University	15	15	28	23	34
The University of Manchester	18	26	30	44	41

## PHD SCHOLARSHIP

#### Scholarship

#### Teaching Opportunities

#### Overseas Attachments

#### Overseas/ Local Conferences

Worth <u>\$\$260,000</u> for up to 4 years

(inclusive of S\$2000-S\$2500 monthly allowances for international students and tuition fees) Add value to your CV, and provide valuable exposure and teaching experience Attachments at reputable overseas universities/ institutions available Financial support to present research findings at international and local conferences

## Singapore's Economy Today



2013 GDP growth: 4.1% 2014 GDP growth forecast: 2% – 4%

Increased

Productivity

## Why Singapore Wants to Play

## AM is <u>an enabler</u> for our manufacturing industry

Speed to

market

#### AM is <u>a new growth industry</u> for Singapore



Product

Performance

Tapping on the projected global industry growth



Source: Wohlers Associates

Knowledge-intensive industrymatches Singapore's focus

## Introduction to the Global AM Ecosystem



National Institute of Standards and Technology U.S. Department of Commerce

International Organization for Standardization

Standardisation and Certification

 Terminology, materials, measurement methods etc

## Talent Landscape

Developing multi-disciplinary talent equipped with AM skills



#### **PhDs in AM-related fields**

#### Training of at least 140 PhDs in the field of AM

Focus areas of AM processes, materials & equipment. <u>Sample projects:</u> Cognitive functional model for reasoning in 3D design and AM, Fundamental study of thermal and stress fields in SLS, Cornea Bioprinting, EBM for offshore applications

MSc in Precision Engineering MSc in Manufacturing Systems & Engineering MSc in Mechanical Engineering MSc in Smart Product Design Establishment of new AM specialisations

Includes elective courses in Virtual Design & Manufacturing, Advanced Manufacturing Processes, Biofabrication, Optical Metrology & instrumentation



#### BEng and BA with AM design exposure

Collaboration of the School of Engineering and School of Design & Environment in the Engineering Design & Innovation Centre

Strengths in medical applications and surgical tools, work with National University Hospital



BEng - Engineering Product Development, Engineering Systems & Design BSc - Architecture & Sustainable Design

#### **SUTD-MIT International Design Centre**

Facilities for engineering and architectural projects have a complete range of fabrication equipment, including desktop and full-scale AM equipment.

## Talent Landscape

Developing multi-disciplinary talent equipped with AM skills



Diploma in Digital Precision Engineering Diploma in Manufacturing Engineering WSQ Diploma in Precision Engineering

Trains ~180 students yearly with basic AM skills AM skills incorporated into Master Craftmen curriculum

#### **AM Innovation Centre**

Centre to collaborate with industry on AM projects

Facility equipped with top industrial-grade AM and peripheral equipment. Centre has completed projects in aerospace, tool & die, medical devices and consumer industries.



Fabrication labs equipped with various AM equipment for fabrication of prototypes for engineering, design and digital media courses

Makerspace @ SP MAKERSPACE®SP Tinkering space for students include desktop AM equipment



#### IDA Labs @ NDC Prototyping Lab @ NDC

Work with industry and schools to build skills and invent, coupled with accelerators to spur entrepreneurship



# NTU voted one of the 15 most beautiful campuses in the world



#### Singapore Centre for 3D Printing The Singapore Story

1990 – SLA from Ministry of Flnance

1998 – SLS & SGC from Ministry of Education & NSTB (predecessor of AStar)

2003 – Polyjet from Ministry of Education

2012 – Briefing to Officials from Ministry of Finance & Ministry of Trade and Industry

2013 – Mission trips to the USA and Europe

2013 – Grants from Economic Development Board and AStar

2014 – Grant from National Research Foundation (SC3DP)

2015 – Grant from National Research Foundation (NAMIC)

## **Research Facilities**

- Selective Laser Melting (SLM), 1 large and 2 small
- Polyjet, 1 large and 1 small
- Multi-Jet Printing Machine
- Fused Deposition Modeling (FDM)
- Selective Laser Sintering (SLS), 1 large and 1 small
- Electron Beam Melting (EBM)
- Bio Printer
- Stereolithography (SLA), 2 large and 1 small
- Inkjet Printer (Dimatix)
- Chocolate Printer
- Optomec Aerosoljet
- 2 scanning devices (Artec Eva and Skyscan 1173)
- Hybrid Manufacturing Equipment











## **SC3DP** Vision

The Singapore Centre for 3D Printing aims to become a world leader in 3D Printing and a wellspring of knowledge by attracting leading researchers to the Centre and nurturing a skilled talent pool, establishing strong linkages with and delivering state of the art and innovative solutions to the industry (corporate video)





## **SC3DP Funding**

## A S\$150M Centre supported by:

- National Research Foundation (NRF)
- Economic Development Board (EDB)
- SPRING Singapore
- Agency for Science Technology and Research (A\*STAR)
- Ministry of Education (MOE)
- Nanyang Technological University (NTU)
- Industry Partners



## **Consolidating Capabilities in 3D Printing**

## **Singapore Centre for 3D Printing**



#### Future of Manufacturing

- Modeling & Prototyping
- Sustainable Manufacturing
- Precision Engineering



## Aerospace & Defence

- Lightweight UAVs
- Parts on demand
- Part certification for Quality System Management

## Building & Construction

- New printable ECCmaterials
- Modular systems for multiple build materials
- Novel robotic 3D printers for construction



## Marine & Offshore

- Novel process for large joints
- Printing of high aspect ratio structures
- Large scale laser cladding for component repair



#### Biomedical & Food

- Bioprinting bionic constructs, retina tissue, organs
- Medical Implants
- Food printing pureed food, chocolate, etc.

## NAMIC @ NTU

Innovation Cluster to perform *translation of upstream research* into applications for commercialization, and to *collaborate with key partners* for industry development

## **Broad Based Research Programmes**



## World's Top 5 Scientists in 3DP





## Where are we in the World? Top 25 Centres

#### **Number of Centres**



#### Source:

Compilation of Data from DMRC Report: Prof. Dr.-Ing. Jurgen Gausemeier, Thinking Ahead the Future of Additive Manufacturing, -Exploring the Research Landscape (2013) and various internet sources

Singapore



**Ranking Table** 

## **Number of Publications**

**3D Printing OR Rapid Prototyping OR Additive Manufacturing** 





Source: Web of Science

## **Joint Labs**

#### 1. SLM Solutions @ SC3DP

- Metal-based selective laser melting
- Next generation machines with bigger build volume, multi-material platforms and novel metals

#### 2. NTU-SUTD Joint Lab

- 3D design and printing, visualization and prototyping
- Large-scale prototyping, multi-material 3D printing and embedded sensor technology

#### 3. SIMTech Joint Lab

• Remanufacturing technologies and sustainable manufacturing

#### 4. Underwriters Laboratories Joint Lab

• Safety and quality of 3D printed parts and products

#### 5. DMG MORI Joint Lab

• Hybrid manufacturing technology for complex part fabrication

#### 6. Emerson-NTU Joint Lab

• Next generation control valve solutions



## Blacksmith Group – Spin-off from SC3DP

#### **BLACKSMITH GENESIS**

- Invented by the Blacksmith Group, a spin-off from SC3DP
- Singapore's first All-in-One 3D scanner + printer + copier
- Crowdfunding campaign on Indiegogo.com from 11 Aug to 10 Sep 2014
- \$81,935usp raised (109%)











2017

International

Printing

http://sc5dp.nbu.edu.ag/Pages/Home.espa.

5th Singapore

Competitions

# 2017 SingaporeInternational3D PrintingCompetitions

#### Hat

A symbol of functionality, style, elegance, and personality. With 3D printing, we can now produce unique hat designs with tailored fittings that are hitherto difficult to achieve with older manufacturing techniques. This year, we challenge aspiring hat designers to 3D print fashionable, creative and yet functional hats that celebrate the human spirit.

#### Clock

A device that is immemorial as time itself. Clocks chart our time and orientate our lives. 3D printing enhances: the development of this age-old device by allowing clock makers to create innovatively unique designs. We challenge aspiring clock makers of this technological age to 3D print clocks, which feature an innovatively unique design that will enthrall and excite.

#### Submission

These competitions only accept printed physical PORTS as submissions. The design should be submitted to: Singapore Centre for 3D Printing by 31" March 2017.

Singapore Tertiary Student Category Top Prize:

S\$5,000

Open Category Top Prize by CoE:

S\$10,000

Singapore School Student Category Top Prize:

S\$5,000

Pull Details:

⊭ \_\_\_\_\_kokwe⊛ntu edu ag

+65 6790 5543

The competitions are

Sponsored by: NTU College of Engineering (CoE) Co-organized by: National Additive

Manufacturing Innovation Cluster (NAMIC) & IMDA Labs

## **Pro-AM 2016**

# PROGRESS IN ADDITIVE MANUFACTURING

16 - 19 MAY 2016 • NANYANG EXECUTIVE CENTRE NTU, SINGAPORE

#### WELCOME TO PRO-AM 2016

Riding on the success of the 1<sup>st</sup> Pro-AM Conference in 2014, the biennial conference will be held in Singapore for the 2<sup>nd</sup> time from 16 to 19 May 2016. In this **conference cum exhibition**, Pro-AM 2016 brings to you the latest commercial and scientific progress in Additive Manufacturing. Learn about scientific breakthroughs and technological advances in Additive Manufacturing from global subject matter experts and researchers. Witness the latest technologies and applications that will be displayed by commercial market players at the trade exhibition.

Be part of this international event now!

#### **GUEST OF HONOUR**

#### **KEY DATES**



Mr S Iswaran

Minister (Industry) Ministry of Trade and Industry

## **Publicity & Outreach**

#### **Industry Conferences**

e.g. Quality & Standards Conference 2016 (Singapore), The International Conference on Sustainable Smart Manufacturing (S2M) (Lisbon, Portugal) and Additive technologies in Russian market: from scientific developments to manufacturing of the future (Moscow, Russia)









Industry Seminars by World-renowned Academics Industry Visits >180 per year

**Talks at Junior Colleges** e.g. Hwa Chong Institution and Raffles Junior College & Internship Opportunities

## Visits by VVIPs



Visit by Mr Stanislaw Tillich, President of the German Federal Council (Bundesrat) and Prime Minister of the Free State of Saxony, Germany and Delegation 30 April 2016



Visit by Minister for Trade and Industry (Industry), Mr S Iswaran 17 May 2016



Visit by Deputy Prime Minister Teo Chee Hean 16 June 2016

## **Undergraduate Innovative Projects**

#### NTU's 3D Printed Car!

THE STRAITS TIMES, TUESDAY, 3 FEBRUARY 2015, PAGE A6

#### **3D-printed** green car to blaze a trail

#### By AUDREY TAN

THE future of green car technolo gy could lie in 3D printing. Two eco-friendly cars, one of

which is the first in Singapore to be made using 3D-printed parts, were unveiled yesterday by Nanyang Technological University. The 3D-printed prototype,

called the NTU Venture 8, has a cabin made of printed components glued together using epoxy adhesive. A total of 150 panels were used in its construction the largest assembly of 3D-printed parts to be put together here. Each of the 3D-printed compo-

nents is made from acrylonitrile butadiene styrene, a lightweight plastic. Coupled with the aerodynamic design of the vehicle, it reduces drag, which makes the 120kg car more energy-efficient. While the plastic shell is only

Imm thick, it is strong enough to handle the weight of the vehicle and the driver, because of the honeycomb structure used by the student designers from NTU's College of Engineering.

The structure's properties provide the strength and stiffness required, said student Ng Jun Wen, 24, part of a team of 16 that built the cars.

Said Associate Professor Ng Heong Wah, who mentored the students: "We are extremely proud to have designed and assembled a 3D-printed body shell for the electric car, which is Singapore's first and probably Asia's first. The 3D-printed car body was pushing existing technology to the limits."





Currently, 3D-printing technolmotorcycle racing, where racers ogy is used for smaller items such as architectural models. The second car is a three-

and speed." wheeled vehicle that, with a sleek shape resembling a bullet, has a unique tilting ability. Team member Winston Tan. 27, said: "We took our inspiration

for the tilting mechanism from tion that challenges student teams from around the world to design, lean left or right during sharp build and test energy-efficient veturns to maintain their handling hicles. Another Singapore team, from ITE College West, will also

Both cars are powered partially be taking part. by solar cells mounted atop their audreyt@sph.com.sg frames, and will race at month's SEE WORLD A12 end in the Shell Eco-marathon

Manila at month's end. ST PHOTOS: ONG WEE JIN Asia in Manila, an annual competi-

edition of the







## **Upcoming Courses**

#### WSQ 3D Printing for Rapid Product Development

13, 16, 17 & 18 January 2017 17, 20, 21 & 22 March 2017

**Upcoming run:** Jan – 13, 16, 17 & 18 January 2017 Mar – 17, 20, 21 & 22 March 2017

Time: 9:00am to 5:00pm

**Venue:** Fusion @ MAE Seminar Room, Nanyang Technological University, Singapore Centre for 3D Printing Labs

**Registration Deadline:** 2 weeks before course starts

Learn about 3D Printing, from the world's most published and most cited researcher in 3D printing, Dr Chua Chee Kai, over a 4-day course conducted at the Singapore Centre for 3D Printing, Nanyang Technological University. The course includes a 1-day workshop where you will get to watch and understand 10 3D Printing systems.

#### **Course Objectives**

- To understand the motivation behind 3D Printing, Rapid Prototyping (RP) or Additive Manufacturing (AM)
- To familiarise with the various 3D Printing techniques so as to compare their strengths and limitations
- To be acquainted with STL (StereoLithography), its format, problems and repair
- To know the application areas and be exposed to industrial case studies
- To learn about bureau service, benchmarking methodology, growth and trends

Visit the website http://sc3dp.ntu.edu.sg for more details and to register now!







## Books



#### Book Title: 3D Printing and Additive Manufacturing

Principles and Applications (with Companion Media Pack) Fourth Edition of Rapid Prototyping 4th Edition, Published in 2014

By (author):

Chua Chee Kai (Nanyang Technological University, Singapore), Leong Kah Fai (Nanyang Technological University, Singapore)





**Book Title:** Bioprinting: Principles and Applications Published in 2014 By (author):

Chua Chee Kai (Nanyang Technological University, Singapore), Yeong Wai Yee (Nanyang Technological University, Singapore) Price (direct from author): <u>S\$55 (2500 RUB)</u>





