INVITED SPEAKERS

Dr. Tomy Sebastian, Director. Motor Drives Systems and President IEEE industry applications society– Halla Mechatronics, USA.

Dr. P. Sanjeevikumar, Prof / Energy Technology Alborng University, Denmark.

Dr. K. Sudhakar, CEng (India) Faculty of Mechanical Engineering, University Malaysia Pahang.

Dr. Gobbi Ramasamy, Associate Professor, Multi Media University, Malaysia.

Dr. S. Jeevananthan, Professor / EEE Pondicherry Engineering College, Puducherry.

Dr. K. Shanti Swarup, Professor / EEE Indian Institute of Technology, Madras.

Dr. S. Baskar, Professor and Dean (R&D) / EEE Thiagarajar College of Engineering, Madurai.

Dr. S. Venkatanarayan, Professor / EEE K.L.N. College of Engineering, Madurai.

Dr. B.V. Manikandan, Senior Professor / EEE MEPCO Schlenk Engineering College, Sivakasi.

KAMARAJ
COLLEGE OF ENGINEERING & TECHNOLOGY
(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)
S.P.G.Chidambara Nadar - C.Nagammal Campus
S.P.G.C.Nagar, K.Vellakulam - 625 701, (Near Virudhunagar), Madurai District.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Organizes

AICTE SPONSORED SIX DAY ONLINE STTP ON

" ELECTRIC CARS TECHNOLOGIES AND MODERN POWER SYSTEM " - SERIES-II

7^{th} – 12^{th} September, 2020

Chief Patron

Er. S. P. G. C. Srimurugan, Chairman, KCET

Patrons

Dr. Anant Achary
Principal, KCET

Dr. M.Vasanthi
Vice Principal, KCET

Convener

Dr. S.Kalyani, HoD/EEE, KCET

Coordinator

Dr. D.Prince Winston, Professor/EEE

Co-coordinators

Mr.D.Mariappan
Asst. Prof/EEE

Mr.S.Jegan
Asst. Prof/EEE

Join us at Microsoft Teams

- ***REGISTRATION IS FREE!!!!***
- **Link: https://bit.ly/kamarajSTTP2**
- **Visit www.kamarajengg.edu.in**
- ***Session Timings: FN (10.00 am to 12.00 pm) & AN (02.00 pm to 04.00 pm)***
- ***Certificate will be provided to participants who attend all sessions***

For more details: 9976799833 / 9524924704 / 8807887933

BACKGROUND OF THE INSTITUTION

Kamaraj College of Engineering and Technology (KCET), Virudhunagar is a self-financing autonomous institution established in the year 1998 by a group of philanthropists at Virudhunagar in Tamil Nadu, named after the great leader and son of the soil, "Karmaveerar K. Kamarajar". The Institute is accredited by National Assessment and Accreditation Council (NAAC), Bangalore with 'A' grade. KCET offers 11 UG Programs and 6 PG programs. Five departments (ECE, CSE, PT, MECH & BT) are provisionally accredited by NBA, New Delhi. Seven departments (BT, PT, EEE, ECE, MECH, PHYSICS & CHEMISTRY) have been recognized as Research centers by Anna University, Chennai. In 2020, National Institutional Ranking Framework (NIRF) Ministry of Human Resource Development ranked Kamaraj College of Engineering and Technology in the rank band of 251 – 300. As per the AICTE initiative of conducting survey on Industry Linked Technical Institutes 2018, the Confederation of Indian Industry (CII) rated our Institute with GOLD category in score band of 10 - 30.

ABOUT THE DEPARTMENT

Vision "To make the Department of Electrical and Electronics Engineering of this Institution the unique of its kind in the field of Research and Development activities in this part of world".

Mission "To impart highly innovative and technical knowledge in the field of Electrical and Electronics Engineering to the urban and unreachable rural student folks through Total Quality Education".

The Department of Electrical & Electronics Engineering was established in the year 2002. It offers UG programme in Electrical and Electronics Engineering and PG programme in Power Systems Engineering. The Department has Research Center approved by Anna University, Chennai and offers Ph.D. programme. The Department has obtained Permanent Affiliation from Anna University, Chennai for the UG program. The department has recently received funds worth 49 lakhs for Research projects, MODROBS, STTPs from funding agencies such as AICTE, DST, IE (India), TNSCST etc.

OBJECTIVE OF THE PROGRAM

The program focusses on imparting knowledge to participants in the evolution and design of Electric Vehicles (EVs), especially in Indian Context with real time experience from academic experts of Indian and Foreign Universities. This program will concentrate technology associated with each component of EV drive train and economics of EVs and battery systems.

EXPECTED OUTCOME

At the end of this program, participants will be able to teach the courses like electric vehicles, smart grid, etc. Further, they will be equipped with the skills to undergo research projects related to EVs and also guide students.

TOPICS TO BE COVERED

- ✓ Introduction & Working Principle of Different Types of Electric Vehicles
- ✓ Different types of Charging Technologies in Electric Vehicles
- ✓ Battery Technologies in EV
- ✓ Motors for Electric Vehicles
- ✓ Power Converters for Electric Vehicles
- ✓ Energy Management in Electric Vehicles
- ✓ Optimization Techniques for plug-in hybrid Electric Vehicle (PHEV)
- ✓ Introduction to Smart Grid and Micro Grid Technology
- ✓ Challenges in Modern Power System
- ✓ Future Trends in Electric Vehicles

ELIGIBILITY (Who can attend?)

All teachers in areas of technical education in AICTE approved institutions and industrialists are eligible to participate. Selections will be based on First Come First Serve.

IMPORTANT DATES

- ➢ Last date for registration: 2nd September, 2020
- ➢ Intimation for selection: 4th September, 2020

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S.P.G.C.Nagar, K.Vellakulam - 625 701, (Near Virudhunagar), Madurai District.
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
(Accredited by NBA, New Delhi)

Dr.R.Suresh Babu Ph.D.,
Professor and Head

Phone No:+91-9486534819
Email: hodece@kamarajengg.edu.in.

Ref : KAMARAJ/ECE/2020-21

23.04.2021

To

Dr. Sankara Narayanan
Vajendra Microwave products,
Chengalpattu.

Dear Sir.

Greetings! We express our sincere thanks for the time and effort you took to share your thoughts and experiences with our faculty members in the topic "**Microwave products demonstration**" on 09th April, 2021 in digital platform organized by the Department of Electronics and Communication Engineering, Kamaraj College of Engineering and Technology, Near Virudhunagar, Madurai-625701. Your enthusiasm is amazing and we hope to use your suggestions in training our students for the microwave experiments and research purpose.

Thank you again for your valuable contribution. We hope that our bonding will bear fruitful solutions in the future.

Thank you,

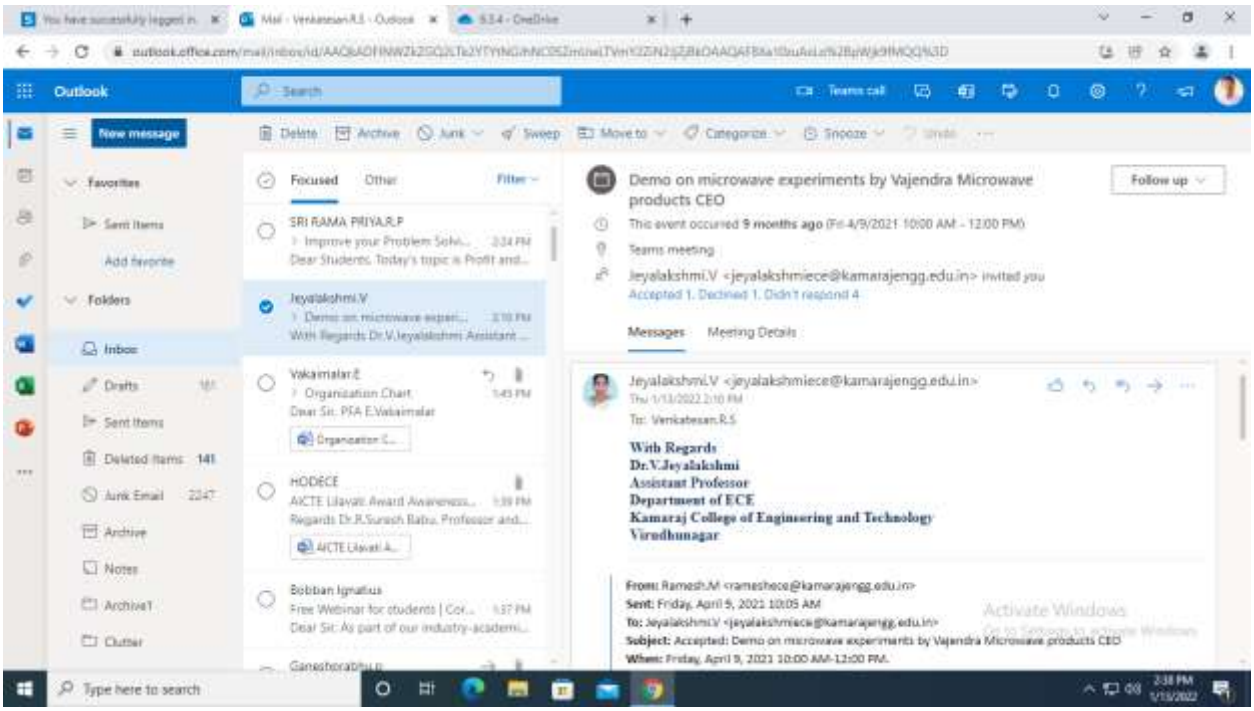
Yours Sincerely,

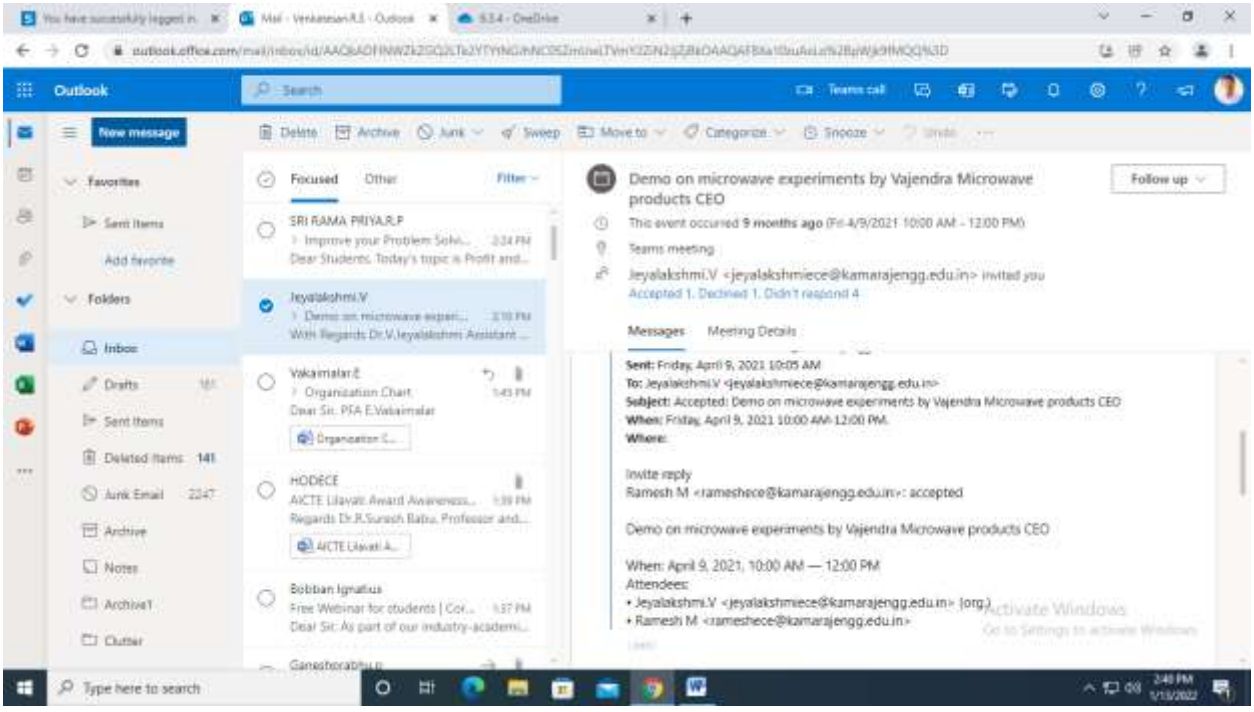
R.S — Bar
23/4/2021

HOD/ECE

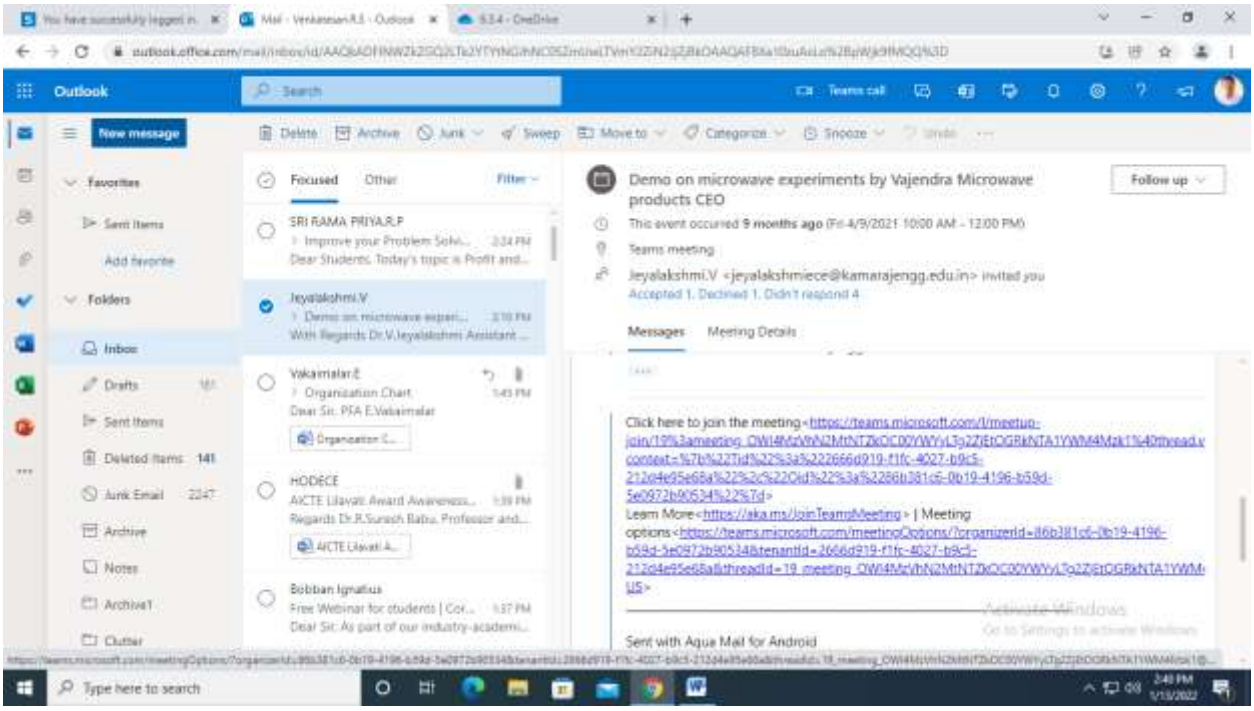
Dr. R. SURESH BABU, M.E., M.B.A., Ph.D.
Professor and Head
Department of Electronics and Communication Engineering
Kamaraj College of Engineering and Technology
K. Vellakulam - 625 701.
Near Virudhunagar

6.3.3 Demo on microwave experiments by Vajendra Microwave products CEO 09-04-2021

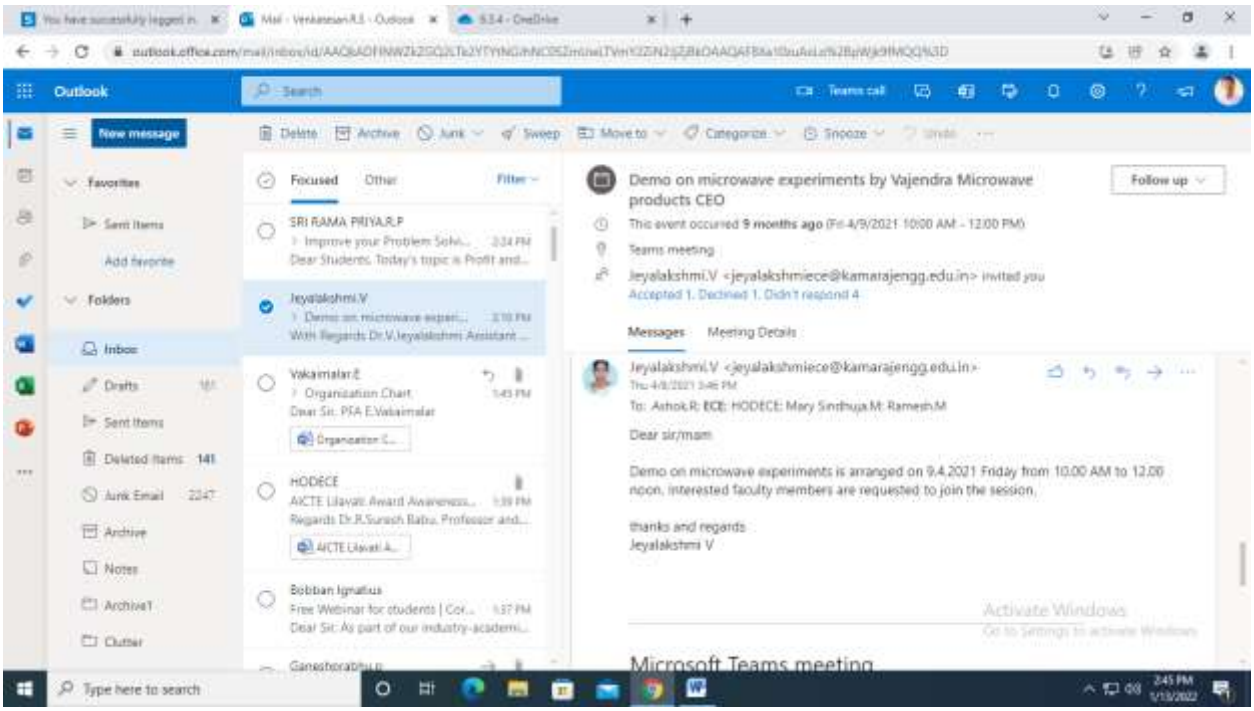


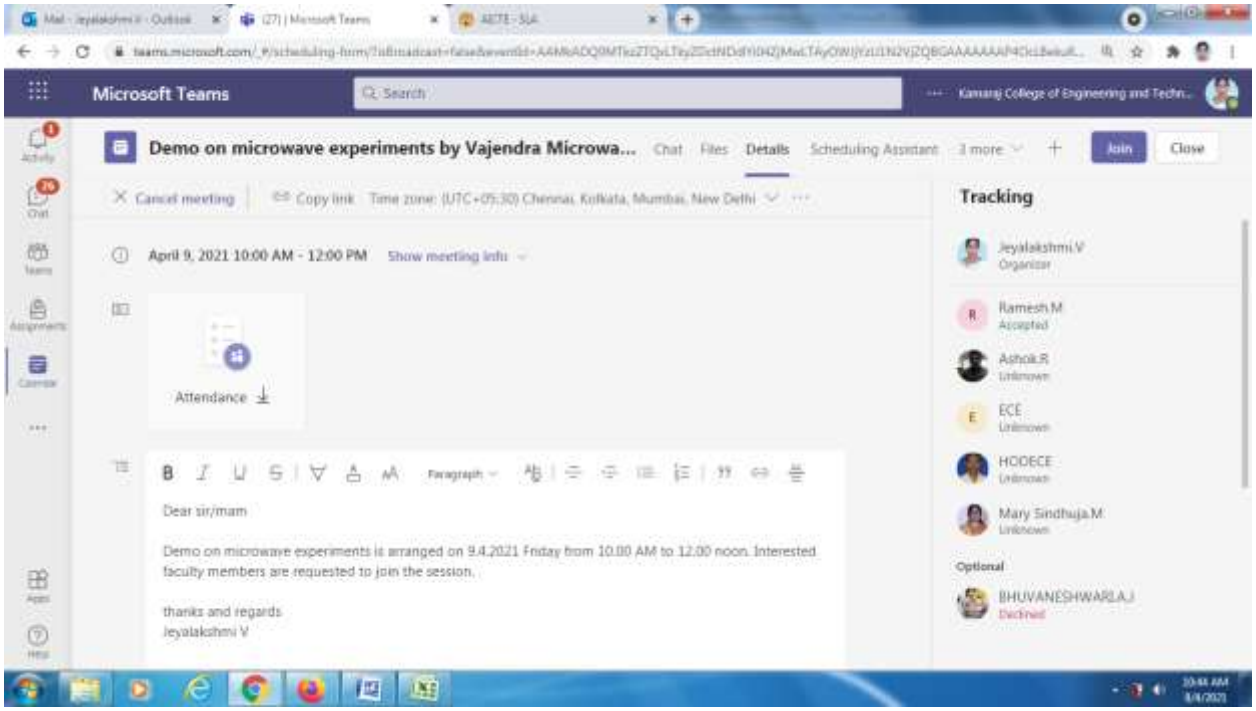


6.3.3 Demo on microwave experiments by Vajendra Microwave products CEO 09-04-2021



6.3.3 Demo on microwave experiments by Vajendra Microwave products CEO 09-04-2021

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April 9, 2021 10:00 AM - 12:00 PM
Show meeting info
Attendance
Paragraph
Dear sir/mam
Demo on microwave experiments is arranged on 9.4.2021 Friday from 10.00 AM to 12.00 noon. Interested faculty members are requested to join the session.
thanks and regards
Jeyalakshmi V
Tracking
Jeyalakshmi.V
Organizer
Ramesh.M
Accepted
Ashok.R
Unknown
ECE
Unknown
HODECE
Unknown
Mary Sindhuja.M
Unknown
Optional
BHUVANESHWARI.A.I
Declined

We Cordially Invite

Inaugural Function on 12th October, 2020 @ 09.30 am

Dr. D.P. Kothari, Director Research & Professor,

S B Jain Institute of Technology, Management and Research, Nagpur, (Former Director, IIT Delhi).

Will deliver the Inaugural Address

Felicitations by

Er. S. P. G. C. SRIMURUGAN, B.E., M.Sc., (Engg)
Chairman, KCET

Dr. ANANT ACHARY, M.Tech., Ph.D.,
Principal

Dr.M.VASANTHI, M.Sc., Ph.D.,
Vice Principal

Dr.D.PRINCE WINSTON, M.E., Ph.D.,
HoD / EEE

Platform: Microsoft Team App

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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

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Six Day Online STTP
On

"ELECTRIC CARS TECHNOLOGIES AND MODERN POWER SYSTEM" - SERIES-III

(12th- 17th October, 2020)

Sponsored by

All India Council for Technical Education

Coordinator

Dr.D.Prince Winston, Prof & Head / EEE.

PROGRAM SCHEDULE

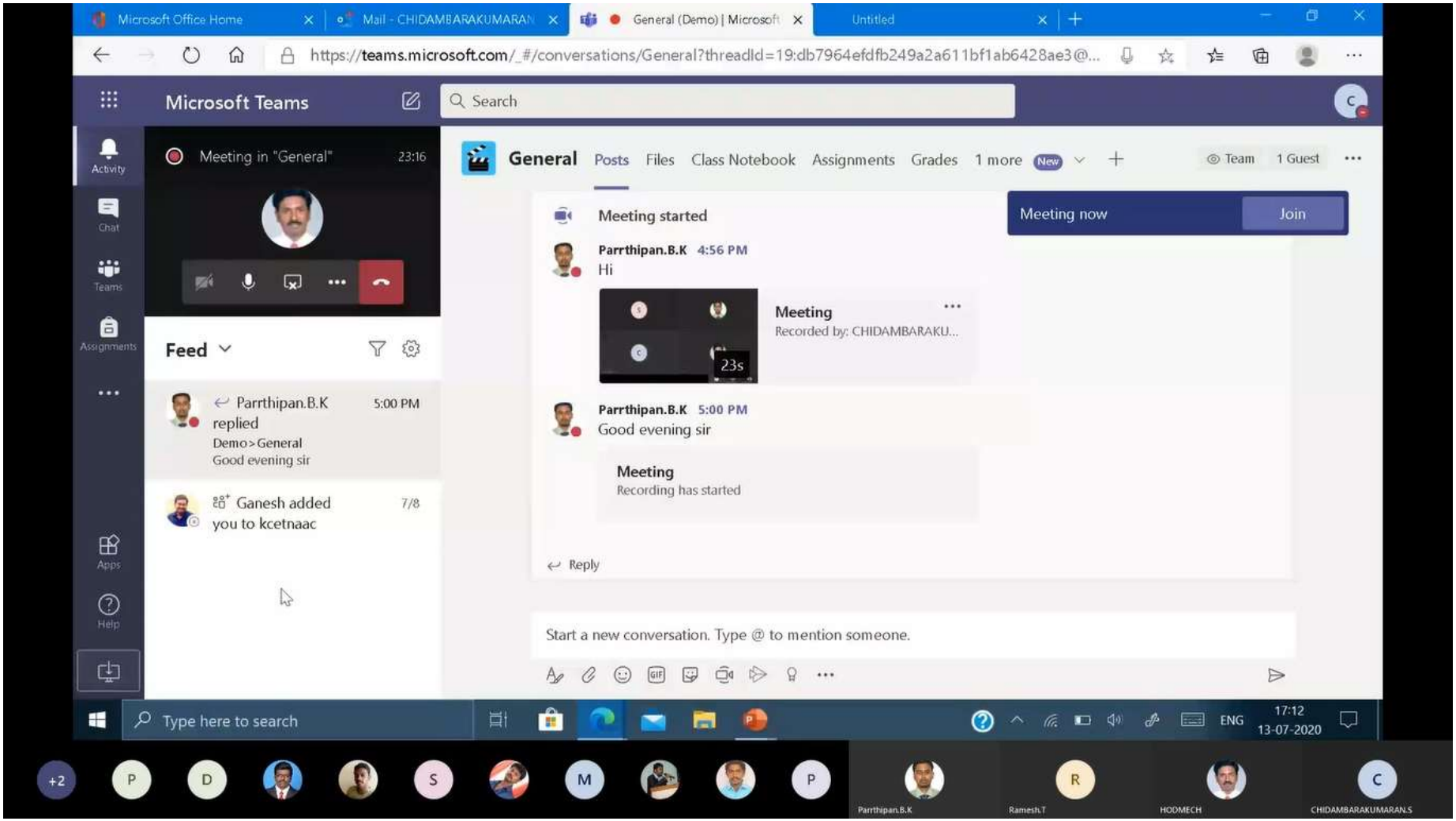
12th October 2020, Monday		
09.30 am - 10.00 am	INAUGURAL FUNCTION	
10.00 am - 11.00 pm	Energy and Environment problems, the solutions for sustainable development and Electric cars	Dr. D.P. Kothari, Professor / EEE, (Former Director, IIT Delhi).
11.00 am - 12.00 pm	Application of Machine Learning Techniques in E - vehicles	Dr.S.Kalyani, Dean (Examinations) / Professor, EEE, KCET
02.00 pm - 04.00 pm	Distributed Generators for Micro grids	Dr. M. M. Rajan Singaravel, AP / EEE, NIT, Puducherry
13th October 2020, Tuesday		
09.30 am - 11.00 am	G2V & V2G Technologies in Electric Vehicles	Dr. S. Sreejith, AP/EEE, NIT, SILCHAR
11.15 am - 12.30 pm	Wide area monitoring and control in Smart Grid System	Dr. Devaraj, Dean Academics, Kalasalingam University, Krishnankoil.
02.00 pm - 04.00 pm	Challenges in EV design and modeling - KAL story	Er. Shajahan Ahamad Kunju Director, Kerala Automobiles
14th October 2020, Wednesday		
10.00 am - 12.00 pm	Electric Vehicle Infrastructure	Mr. S. Selva Kumar, Head Engineering &Design at M/s Power Projects, Chennai.
02.00 pm - 04.00 pm	Hybrid Electric Vehicles	Mr. S. Badri Narayanan, Deputy Manager, Lucas TVS Ltd., Padi, Chennai.
15th October 2020, Thursday		
10.00 am - 12.00 pm	Power Converters for Electric Vehicles	Dr.C. Ponmani Professor, (CAS), EEE, Government College of Engineering, Tirunelveli .
02.00 pm - 04.00 pm	Modeling and design of Battery powered vehicles - Case study at Pi Beam Labs	Mr. Visakh Sasikumar, Founder & CEO, Pi Beams Pvt Ltd, IIT Madras, Perungudi, India
16th October 2020, Friday		
10.00 am - 12.00 pm	Hands on session for battery energy storage technology using MATLAB	Dr. D. Prince Winston, Prof & Head /EEE, KCET, Madurai
07.00 pm - 09.00 pm	Circuit design using beyond CMOS technology - QCA	Dr.R.Marshal, Scientist 'C' Indian Computer Emergency Response Team (ICERT), Ministry of Electronics and Information Technology, New Delhi.
17th October 2020, Saturday		
10.00 am - 12.00 pm	Automotive cyber security	Dr. B. Chandra Sekhar, Technical Lead, TATA Consultancy Services, Bengaluru.
01.30 pm - 03.30 pm	Introduction to batteries technology, classification, types and improvements over time	Dr. Debmalya sen, Senior Consultant, Emerging Technologies, Customized Energy Solutions, Pune.
04.00 pm - 04.30 pm	Online Test by Program Evaluation committee	

PROOF FOR ACADEMIC YEAR 2020 – 2021

- Orientation to Microsoft Teams for Online teaching. Conducted through online. **Dated: 13-07-2020**

Participant's list:

1. **Dr.S.Senthil/HoD/Mech**
2. Dr.S.S.Saravanakumar
3. Dr.P.Narayanasamy
4. Mr.T.Ramesh
5. Mr.S.Thangakasirajan
6. Mr.S.Chidambarakumaran
7. Mr.D.Palanikumar
8. Mr.P.Sivasubramanian
9. Mr.B.Prabhu
10. Mr.B.Balavairavan'
11. Mr.R.SakthivelMurugan
12. Mr.B.K.Parthiban
13. Mr.N.R.Madhan
14. Mr.S.Devaraj
15. Mr.M.Prithiviraj
16. Mr.T.Suresh
17. Mr.A.Sankaranarayanamurthy
18. Mr.K.Murugananthan
19. Mr.P.Senthamarai Kannan
20. Mr.S.David Blessley
21. Mr.L.Loganathan
22. Mr.S.Muthunatarajan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Feed
Parrthipan.B.K replied
Demo > General
Good evening sir
5:00 PM
Ganesh added you to kcetnaac
7/8
General
Posts
Files
Class Notebook
Assignments
Grades
1 more
New
Team
1 Guest
Meeting started
Meeting now
Join
Parrthipan.B.K 4:56 PM
Hi
Meeting
Recorded by: CHIDAMBARAKU...
23s
Parrthipan.B.K 5:00 PM
Good evening sir
Meeting
Recording has started
Reply
Start a new conversation. Type @ to mention someone.
Type here to search
ENG
17:12
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+2
Parrthipan.B.K
Ramesh.T
HODMECH
CHIDAMBARAKUMARAN.S

We Cordially Invite

Inaugural Function on 18th January, 2021 @ 09.30 am

Mr. Malay Rout,

Senior Data Scientist, Senior Consultant, Data Science at Verizon Data Services, Chennai.

Will deliver the Inaugural Address

Felicitations by

Er. S. P. G. C. SRIMURUGAN, B.E., M.Sc.,(Engg)
Chairman, KCET

Dr. ANANT ACHARY, M.Tech., Ph.D.,
Principal

Dr.M.VASANTHI, M.Sc., Ph.D.,
Vice Principal & Dean Academic Courses

Dr.C.T.VIJAYAKUMAR, Ph.D.,
Dean Research

Dr.D.PRINCE WINSTON, M.E., Ph.D.,
HoD / EEE

Platform: Microsoft Team App
Link: https://bit.ly/35sl9vt

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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Proudly hosts

Two Week Online FDP

On

"APPLICATIONS OF MACHINE LEARNING & DEEP LEARNING IN ELECTRICAL ENGINEERING" - *SERIES-I*

(18th- 30th JANUARY, 2021)

Sponsored by

All India Council for Technical Education

Coordinator

Dr.S.Kalyani, Prof. / EEE

Co-coordinators

Mrs.B.Noorul Hamitha, AP / EEE

Mrs.V.Chandra, AP / EEE

Ms.R.Reenu, AP / EEE

PROGRAM SCHEDULE

18th January 2021, Monday		
09.30 am –10.00 am	**INAUGURAL FUNCTION**	
10.00 am –12.00 pm	Is Machine Learning relevant for me?	Mr. Malay Rout, Senior Data Scientist, Senior Consultant-Data Science at Verizon Data Services, Chennai.
01.30 pm –03.30 pm		
19th January 2021, Tuesday		
10.00 am –12.00 pm	Online optimization techniques in Electrical Engineering	Dr.V. Vignesh Kumar Assistant Professor / Department of Electrical and Electronics Engineering, National Institute of Technology, Karnataka, Surathkal, Manglore.
01.30 pm –03.30 pm	Fundamentals of machine learning techniques	Dr. A.Meenakshi, Professor & Head / Department of Computer Science Engineering, KCET, Madurai.
20th January 2021, Wednesday		
10.00 am –12.00 pm	Applications of ANN in Engineering	Dr.S.Kumaravel, Department of EEE, National Institute of Technology, Calicut, Kerala.
01.30 pm –03.30 pm	Introduction to Deep Learning and its types	Dr. P. Subathra, Professor & Head / IT, KCET, Madurai.

21st January 2021, Thursday		
10.00 am - 12.00 pm	Supervised and Unsupervised Machine Learning Algorithms	Dr.Merugu Suresh, Dean R&D , CMR College of Engineering & Technology, Hyderabad.
01.30 pm - 03.30 pm	Applications of Artificial Intelligence and Machine Learning in Electrical Engineering	Dr.M. Indra Devi, Professor / CSE, KCET, Madurai.
22nd January 2021, Friday		
10.00 am – 12.00 pm	IoT Applications for harnessing solar power	Dr.Rajasekar, Vellore Institute of Technology, Vellore
01.30 pm – 03.30 pm	ANN based fault classification	Dr.D.Ganga, Assistant Professor, National Institute Technology, Nagaland.
23rd January 2021, Saturday		
10.00 am – 12.00 pm	Fuzzy logic and its applications to Renewable Energy System	Dr. C.K.Babulal, Professor / EEE, Thiagarajar College of Engineering, Madurai.
01.30 pm – 03.30 pm	Machine Learning in Cyber security	Dr. S.Shitharth, Assistant Professor / CSE, Vardhaman College of Engineering, Hyderabad.

PROGRAM SCHEDULE

25th January 2021, Monday		
10.00 am – 12.00 pm	Big Data Analytics	Dr. G S R Emil Selvan, Professor / CSE, Thiagarajar College of Engineering, Madurai.
01.30 pm – 03.30 pm	Text Classification using Tensor flow APIs	Dr. V.Sathiesh Kumar, Assistant Professor, Department of Electronics Engineering, Madras Institute of Technology- Anna University, Chennai.
26th January 2021, Tuesday		
10.00 am – 12.00 pm	Arduino and IoT based Machine Learning	Dr.M.Sudalaimani, Assistant Professor / Department of EEE, KCET, Madurai.
01.30 pm – 03.30 pm	Applications of Machine Learning Techniques in Electrical Engineering	Dr. S.Rajesh Babu, Assistant Professor / Department of EEE, KCET, Madurai.
27th January 2021, Wednesday		
10.00 am – 12.00 pm	Hands on training in Applications of Machine Learning & Deep Learning in Electrical Engineering	Mr.P.Sudhakar, Senior Scientific officer, Advanced Technology Development Centre, Indian Institute of Technology, Kharagpur
01.30 pm – 03.30 pm		

28th January 2021, Thursday		
10.00 am - 12.00 pm	Hands on training in Applications of Machine Learning & Deep Learning in Electrical Engineering	R.Kishore Kumar, Research Scholar, Department of CSE, Indian Institute of Technology, Kharagpur
01.30 pm - 03.30 pm		
29th January 2021, Friday		
10.00 am - 12.00 pm	Image classification using Tensorflow APIs	Dr. V.Sathiesh Kumar, Assistant Professor, Department of Electronics Engineering, Madras Institute of Technology- Anna University, Chennai.
01.30 pm - 03.30 pm	Deep Learning in Object Labeling	Dr.Prakash Choudhary Assistant Prof & Head / CSE, National Institute of Technology, Manipur.
30th January 2021, Saturday		
10.00 am - 12.00 pm	Applications of Deep Learning in Electrical Engineering	Dr. R. Muthuselvi, Professor / CSE, KCET, Madurai.
01.00 pm - 03.00 pm	Transfer Learning based CNN models	Dr. V.Sathiesh Kumar, Assistant Professor, Department of Electronics Engineering, Madras Institute of Technology- Anna University - Chennai.
03.00 pm – 03.30 pm	Online Test by Program Evaluation committee	
03.30 pm – 04.00 pm	VALEDICTORY FUNCTION	

We Cordially Invite

Inaugural Function on 24th May, 2021 @ 09.30 am

Dr. M. Venkatesh Kumar, M.E., Ph.D.,
Assistant Professor (Sr.G), Amrita School of Engineering, Chennai campus.
Will deliver the Inaugural Address

Felicitations by

Er. S. P. G. C. SRIMURUGAN, B.E., M.Sc.(Engg)
Chairman, KCET

Dr. ANANT ACHARY, M.Tech., Ph.D.,
Principal

Dr. M.VASANTHI, M.Sc., Ph.D.,
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Dr. C.T.VIJAYAKUMAR, M.Sc., Ph.D.,
Dean (Research)

Dr. D.PRINCE WINSTON, M.E., Ph.D.,
HoD / EEE

Platform: Microsoft Teams App

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"APPLICATIONS OF MACHINE LEARNING & DEEP LEARNING IN ELECTRICAL ENGINEERING" - *SERIES-II*

(24th May - 05th June, 2021)

Sponsored by

All India Council for Technical Education

Coordinator

Dr. S.Kalyani, Prof. / EEE

Co-coordinators

Mrs.B.Noorul Hamitha, AP / EEE

Mrs.V.Chandra, AP / EEE

Ms.R.Reenu, AP / EEE

PROGRAM SCHEDULE

24th May 2021, Monday		
09.30 am -10.00 am	INAUGURAL FUNCTION	
10.00 am -12.00 pm	AI for Smart grid applications	Dr. M.Venkateshkumar, Assistant Professor (Sr.G) , Amrita School of Engineering, Chennai Campus.
01.30 pm -03.30 pm	Hands on training in Applications of Machine Learning & Deep Learning in Electrical Engineering	Mr. P.Sudhakar, Senior Scientific officer, Advanced Technology Development Centre, Indian Institute of Technology, Kharagpur.
25th May 2021, Tuesday		
10.00 am -12.00 pm	Solar Power Forecasting with Machine Learning Techniques	Dr. R.Sathishkumar, R & D Engineer, Quantanics Tech Serv Pvt Ltd, Madurai.
01.30 pm -03.30 pm	Real time implementation of Machine Learning in solar power with practical demos	Mr. R.Vignesh, CTO, Quantanics Tech Serv Pvt Ltd, Madurai.
26th May 2021, Wednesday		
10.00 am -12.00 pm	Hands on Training in Machine Learning Tools using MATLAB	Dr.S.Kalyani, Professor/EEE, Dean (Examinations), Kamaraj College of Engineering and Technology, Madurai
01.30 pm -03.30 pm	Pedagogical Initiatives in Outcome Based Education	
27th May 2021, Thursday		
10.00 am -12.00 pm	Multi-Objective Evolutionary Algorithms for Solving Power System Problems	Dr. S. Ramesh, Prof/EEE, Vel Tech Rangarajan Dr. Sagunthala R & D Institute of Science and Technology, Avadi, Chennai.
01.30 pm -03.30 pm	Hands on training in Applications of Machine Learning & Deep Learning in Electrical Engineering	Mr.P.Sudhakar, Senior Scientific officer, Advanced Technology Development Centre, Indian Institute of Technology, Kharagpur.
28th May 2021, Friday		
10.00 am -12.00 pm	Machine Learning in High Voltage Engineering	Dr.B.GuruKarthik Babu Assistant Professor / EEE, KCET, Madurai
02.00 pm -03.00 pm	Machine learning and IoT in Microgrid	Dr.J.Jeslin Drusila Nesamalar, AP / EEE, KCET, Madurai
29th May 2021, Saturday		
10.00 am -12.00 pm	Fuzzy logic and its applications to Renewable Energy System	Dr.A.Venkadesan, Assistant Professor and Head / EEE, National Institute of Technology, Puduchery Karaikal.
01.30 pm -03.30 pm	Machine Learning in Cyber security	
06.00 pm - 07.00 pm	Artificial Intelligence techniques in Battery Management system	Dr.Sridhar Swaminathan, Assistant Professor / CSE, Bennett University, Greater Noida, India

PROGRAM SCHEDULE

31st May 2021, Monday		
10.00 am -12.00 pm	Fundamentals of Digital Image Processing	Dr.G.Sasi Professor, Department of BME,Vel Tech Multitech Dr.RR Dr.SR Engineering College, Avadi, Chennai.
01.30 pm -03.30 pm	Time series learning and python wavelets package	Mr. C.I.Johnpaul, Assistant Professor, Department of Information Science and Engineering, The National Institute of Engineering, Mysuru, Karnataka
01st June 2021, Tuesday		
10.00 am -12.00 pm	Solar data analysis using machine learning	Dr. D. Roja Ramani Assistant Professor, Department of Information Technology, Sethu Instituteof Technology, Madurai
01.30 pm -03.30 pm	Reinforcement Learning for Nonlinear Control Applications- I	Dr. B. Jaganatha Pandian, Associate Professor, Department of Control and Automation, School of Electrical Engineering, VIT, Vellore.
02nd June 2021, Wednesday		
10.00 am -12.00 pm	National Education Policy	Mr. K. Ganesan AP / EEE, Kamaraj College of Engineering and Technology, Madurai.
01.30 pm -03.30 pm	Activity in National Education Policy	Mrs. B. NoorulHamitha, AP / EEE & Mrs. V. Chandra, AP / EEE, Kamaraj College of Engg and Tech, Madurai
03rd June 2021, Thursday		
10.00 am -12.00 pm	Machine Learning in Smart Grid System	Dr. Sishaj P Simon, ASP/EEE, National Institute of Technology, Trichy.
01.30 pm -03.30 pm	Application of Machine learning techniques in Renewable Energy Systems	Dr. D. Prince Winston Professor and Head /EEE, KCET, Madurai.
04th June 2021, Friday		
10.00 am -12.00 pm	Application of artificial intelligence to Solar PV systems	Dr.K.Premkumar, ASP / EEE, Rajalakshmi Engg, College, Chennai.
01.30 pm -03.30 pm	Reinforcement Learning for Nonlinear Control Applications - II	Dr. B. Jaganatha Pandian, ASP/ Department of Control and Automation, School of Electrical Engineering, VIT, Vellore.
05th June 2021, Saturday		
10.00 am -11.00 am	Impact of Weather conditions in energy forecasting using deep learning and Big data Analytics	Mrs.D.Jayanthi, AP / IT, Sri Venkateswara College of Engg, Chennai.
11.00 am -12.00 pm	Transforming the energy industry using Deep learning and Big Data Analytics	Mr.Rajvikram Madurai Elavarasan, Visiting Research Scholar, Clean and Resilient Energy Systems Laboratory, Texas A&M University, Galveston, USA.
01.30 pm -03.30 pm	Recent Optimization Techniques used to Solve Electrical Engineering Problems	Dr. S. Sreejith, AP / EEE, National Institute of Technology Silchar Cachar, Assam.
03.30 pm - 04.00 pm	Online Test by Program Evaluation committee	
04.00 pm - 04.30 pm	Valedictory Function	

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INVITED SPEAKERS

Dr.Sukumar Mishra, Professor / EEE
Indian Institute of Technology , Delhi.

Dr.V.Sankaranarayan, Professor & Head / EEE
National Institute of Technology, Trichy.

Dr.Zakir Hussain Rather, Associate Professor/EE
Indian Institute of Technology, Bombay.

Dr. S. Senthil Kumar, Associate Professor / EEE
National Institute of Technology, Trichy.

Dr. S.Kumaravel, Assistant Professor/ EEE
National Institute of Technology, Calicut.

Dr. M.P.Selvan, Associate Professor / EEE
National Institute of Technology, Trichy.

Dr. M.Saravanan, Professor / EEE
Thiagarajar College of Engineering, Madurai.

Dr. B.Chitti Babu, Assistant Professor / ECE
IIITDM, Kanchepuram.

Mr.K.Pradeep Kumar, General Manager
Robert Bosch Engineering
& Business Solutions, Bangalore.

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AICTE SPONSORED SIX DAY ONLINE STTP ON

" ELECTRIC CARS TECHNOLOGIES AND MODERN POWER SYSTEM " - SERIES-I

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DEPARTMENT OF
MECHANICAL ENGINEERING
(ACCREDITED BY NBA, NEW DELHI)

Organizes

AICTE SPONSORED
SHORT TERM TRAINING PROGRAMME
on

MAKE IN INDIA:
THROUGH 3D PRINTING & INDUSTRY 4.0 FOR INDIAN INDUSTRIES

PHASE I	01.02.2021 TO 06.02.2021
PHASE II	12.04.2021 TO 17.04.2021
PHASE III	03.05.2021 TO 09.05.2021
PHASE IV	14.06.2021 TO 19.06.2021

STTP PROCEEDINGS

COORDINATORS
DR.S.SENTHIL, PROF & HEAD, MECH
MR.D.PALANIKUMAR & MR.S.DEVARAJ, AP/MECH

Need & Objective of STTP

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Department of Mechanical Engineering

AICTE sponsored STTP

"MAKE IN INDIA THORUGH 3D PRINTING AND INDUSTRY 4.O FOR THE INDUSTRIES"

Phase I - 1st February to 6th February, 2021

Phase II - 12th April to 17th April, 2021

Phase III - 3rd May to 9th May, 2021

Phase IV - 14th June to 19th June, 2021

Intended Participants : Faculties of AICTE approved Institutions and Industry Professionals

No. of Participants : Minimum 40

Need of the Program :

World is in the midst of a significant transformation regarding the way we produce products. Digitization of manufacturing process has affected many industries. This transition is so compelling that it is being called Industry 4.0 to represent the fourth revolution that has occurred in manufacturing. The STTP focuses on the emerging advances in the area of 3D Printing and Industry 4.0 which is funded by AICTE.

Objective of the Program :

- To provide an exposure to the participants in the field of 3D Printing and Industry 4.0.
- To promote various research initiatives and make in India projects related to the proposed topics.
- To provide opportunity to the participants to get interactions with experts from IIT, NIT, Industries and Research Organization.

Expected Outcome :

Empowerment of faculty members and industry professionals in Recent Trends in 3D printing and Industry 4.0 will make them to guide students in recent technologies. It will create awareness among students about 3D printing.

PROGRAM SCHEDULE

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Department of Mechanical Engineering

Six Days

Short term Training Programme

on

"MAKE IN INDIA: THROUGH 3D PRINTING & INDUSTRY 4.O FOR INDIAN INDUSTRIES" - Phase I

01.02.2021 to 06.02.2021

PROGRAMME SCHEDULE

Date / Day	09:30 am to 10:30 am		11:00 am to 12:00 pm			01:30 pm to 02:30 pm		03:00 pm to 04:00 pm
Day 1 (01.02.2021) Monday	**Session 1**		**Session 2**			**Session 3**		**Session 4**
	Inauguration - 3D Printing and Rapid Product Development Dr.S.Vinodh, Assosiate Professor, Dept of Production Engineering, NIT-Tiruchirapalli.	**Break**	**Research in Process planning for 3D printing** Dr. Senthilkumaran Kumaraguru, Associate Professor, Dept. of Mechanical Engineering, IIITDM, Kancheepuram.	**Lunch**		**Generative Design** Dr. Ramesh Shankar Program Manager Autodesk India Pvt. Ltd.	**Break**	**3D Printing the Future of Manufacturing** Dr. Ramesh Shankar Program Manager Autodesk India Pvt. Ltd.
Day 2 (02.02.2021) Tuesday	**Session 1**		**Session 2**			**Session 3**		**Session 4**
	3D Printing: A Disruptive Technology of This Era Dr. K. P. Karunakaran, Professor, Dept of Mechanical Engineering, IIT Mumbai.	**Break**	**Industry 4.0 and Sustainable Manufacturing** Dr.S.Vinodh, Associate Professor, NIT-Tiruchirapalli.	**Lunch**		**Additive Manufacturing Technologies and its application in various industries** E.Sreedhar Kumar, Senior Manager PSG TIFAC – CORE, PSG College of Technology, Coimbatore.	**Break**	**Additive Manufacturing Technologies and its application in various industries** E.Sreedhar Kumar, Senior Manager PSG TIFAC – CORE, PSG College of Technology, Coimbatore.

	Session 1		Session 2			Session 3		Session 4
Day 3 (03.02.2021) Wednesday	**Advanced Software usage in Bio-Medical for 3D Printing**	**Break**	**Role of 3D Printing in Complex Oral and Maxillofacial Surgeries**	**Lunch**		**Slicing software application for 3D Printer**	**Break**	**Slicing software application for 3D Printer**
	Dr. Y. Ravi kumar, Associate Professor, Department of Mechanical Engineering, NIT-Warangal.		Dr. Y. Ravi kumar, Associate Professor, Department of Mechanical Engineering, NIT-Warangal.			Mr. Sriram Krishna, Rapid Prototyping & Test and Optimization Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Trichy.		Mr. Sriram Krishna, Rapid Prototyping & Test and Optimization Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Trichy..
	Session 1		**Session 2**			**Session 3**		**Session 4**
Day 4 (04.02.2021) Thursday	**Cognitive Manufacturing for I4.0**	**Break**	**Electron Beam Additive Manufacturing and its Process Parameters**	**Lunch**		**IoT Applications in 3D Printer**	**Break**	**IoT Applications in 3D Printer**
	Dr. Senthilkumaran Kumaraguru, Associate Professor, Dept. of Mechanical Engineering, IIITDM, Kancheepuram.		Dr.S.Senthil, Prof & Head, Depat of Mech.Engg, Kamaraj College of Engineering & Tech, Madurai.			Mr. Manju, IoT Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Trichy.		Mr. Manju, IoT Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Trichy.
	Session 1		**Session 2**			**Session 3**		**Session 4**
Day 5 (05.02.2021) Friday	**Application of AM for our Indian societal use**	**Break**	**Using AM for make in India - Case studies**	**Lunch**		**Design for Additive Manufacturing**	**Break**	**Design for Additive Manufacturing**
	Dr.Rajesh Ranganathan, Professor, Dept of Mechanical Engineering, Coimbatore Institute of Technology, Coimbatore.		Dr.Rajesh Ranganathan, Professor, Dept of Mechanical Engineering, Coimbatore Institute of Technology, Coimbatore.			Mr.R.Sakthivel Murugan, Asstistant Professor,, Dept of Mech.Engg, Kamaraj College of Engineering & Tech, Madurai.		Mr.R.Sakthivel Murugan, Asstistant Professor,, Dept of Mech.Engg, Kamaraj College of Engineering & Tech, Madurai.

	Session 1		Session 2			Session 3		Session 4
Day 6 (06.02.2021) Saturday	**Effect of build direction on tensile property of 3D printed Al10SiMg alloy** Dr. T Ram Prabhu Deputy Director / Scientist DRDO	**Break**	**Project Funding proposal & PhD topics in Metal Additive Manufacturing** Dr. T Ram Prabhu Deputy Director / Scientist DRDO	**Lunch**		**Metal Additive Manufacturing in Biomedical Applications** Dr. Deepak Kumar Pattanayak, Senior Scientist Electrochemical Process Engineering Division, CSIR-Central Electrochemical Research Institute, Karaikudi	**Break**	**Valedictory Ceremony**

Session Recorded Videos:

S.No	Date	Session	Recorded Video URL (Microsoft Stream & YouTube)
1.	**01.02.2021**	I	https://web.microsoftstream.com/video/1fb649b5-4e13-4e3a-80f8-e72342ee66d4
2.		II	https://web.microsoftstream.com/video/654a075f-fdb7-4b53-88c0-071843ee6e7a
3.		III & IV	https://web.microsoftstream.com/video/82bc758d-59fd-4a60-888d-61d653163178
4.	**02.02.2021**	I	https://web.microsoftstream.com/video/0e40c36d-0035-406d-8346-1670535ef188
5.		II	https://web.microsoftstream.com/video/0a3d4ed1-34b8-41cc-bb95-ee2cfa3c0e3b
6.		III & IV	https://web.microsoftstream.com/video/afbe621c-d714-47f7-b53f-c690f3b23d2e
7.	**03.02.2021**	I	https://web.microsoftstream.com/video/362231c1-d862-45d0-ab6b-33c4686412d8
8.		II	https://web.microsoftstream.com/video/6e1195df-0e70-4443-b43d-e984ee6490d1
9.		III & IV	https://web.microsoftstream.com/video/8e55adaa-ad17-431a-afec-d6d81583c0a9
10.	**04.02.2021**	I	https://web.microsoftstream.com/video/968356bc-0d25-451a-afdd-1cc965fe2141
11.		II	https://web.microsoftstream.com/video/404b3c38-bbf9-453e-9867-409ec45f1319
12.		III & IV	https://web.microsoftstream.com/video/12192dd2-32ae-49ad-96fd-7468e5de9a09
13.	**05.02.2021**	I	https://www.youtube.com/watch?v=qSEe8VjE4kA
14.		II	https://www.youtube.com/watch?v=RUHS0BzO6Qg
15.		III & IV	https://web.microsoftstream.com/video/b5b311ce-fa1d-44aa-84a5-13c5a34088e8
16.	**06.02.2021**	I	https://web.microsoftstream.com/video/dda208d3-0cf8-4475-8592-8cd977a3fc3b
17.		II	https://www.youtube.com/watch?v=1U2MTnWltgw
18.		III & IV	https://www.youtube.com/watch?v=LCUJ8auDGAI

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Department of Mechanical Engineering

Six Days

Short Term Training Programme

on

"MAKE IN INDIA: THROUGH 3D PRINTING & INDUSTRY 4.O FOR INDIAN INDUSTRIES" - Phase II

12.04.2021 to 17.04.2021

PROGRAMME SCHEDULE

Date / Day	Forenoon		Afternoon
Day 1 (12.04.2021) Monday	**10.00 am to 12.00 noon**	Lunch	**02.00 pm to 04.00 pm**
	3D Printing: A Disruptive Technology of This Era		**Slicing Software Demo**
	Dr. K. P. Karunakaran, Professor, Dept of Mechanical Engineering, IIT Mumbai.		**Mr. Sriram Krishna,** Rapid Prototyping & Test and Optimization Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Trichy.
Day 2 (13.04.2021) Tuesday	**11.00 am to 12.30 noon**	Lunch	**01.30 pm to 03.00 pm**
	FDM printing of polymer and Polymeric composites		**Recent advances in materials and structures for 3D Printing**
	Dr. M. Uthayakumar Professor, Department of Mechanical Engg, KL University.		**Dr. M. Uthayakumar** Professor, Department of Mechanical Engg, KL University.
Day 3 (14.04.2021) Wednesday	**10.00 am to 12.00 noon**	Lunch	**02.00 pm to 04.00 pm**
	Design for Additive Manufacturing		**Generative Design for Additive Manufacturing**
	Mr.R.Sakthivel Murugan, Assistant Professor,		**Dr. Ramesh Shankar** Program Manager

	Dept of Mech.Engg, Kamaraj College of Engg & Tech, Madurai.		Autodesk India Pvt. Ltd.
Day 4 (15.04.2021) Thursday	**10.00 am to 12.00 noon**		**02.00 pm to 04.00 pm**
	3D Printing and Rapid Product Development	**Lunch**	**Visual demo of Rapid Prototyping Lab**
	Dr.S.Vinodh, Assosiate Professor, Dept of Production Engineering, NIT-Tiruchirapalli.		**Mr. Sriram Krishna,** Rapid Prototyping & Test and Optimization Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Tiruchirapalli.
Day 5 (16.04.2021) Friday	**10.00 am to 12.00 noon**		**02.00 pm to 04.00 pm**
	Recent research in 3D Printer - materials	**Lunch**	**Research in Process planning for 3D printing**
	Dr. M. Uthayakumar Professor, Department of Mechanical Engg, KL University.		**Dr. Senthilkumaran Kumaraguru, Associate Professor,** Dept. of Mechanical Engineering, IIITDM, Kancheepuram.
Day 6 (17.04.2021) Saturday	**10.00 am to 12.00 noon**		**02.00 pm to 04.00 pm**
	Additive Manufacturing: A Key Technology in Industry 4.O	**Lunch**	**Project Funding proposal & PhD topics in Metal Additive Manufacturing**
	Dr. Y. Ravi kumar, Associate Professor, Department of Mechanical Engineering, NIT-Warangal.		**Dr. T Ram Prabhu** Deputy Director / Scientist DRDO Bangalore.

Session Recorded Videos:

S.No	Date	Session	Recorded Video Url (Microsoft Stream)
1.	**12.04.2021**	FN	https://drive.google.com/file/d/1fK888qkSTaq5cFmARDa40M0UZ-jo63Jw/view?usp=sharing
2.		AN	https://drive.google.com/file/d/1r1KE57baVSSqMCc2wbCUeZ1wRRQdMsIQ/view?usp=sharing
3.	**13.04.2021**	FN	https://drive.google.com/file/d/1xXTq7kGvfcEczYpgTnY8TGx5j06pTmn9/view?usp=sharing
4.		AN	https://drive.google.com/file/d/1G7ks2UWOau-eBhF7NL3OjKKzHLtfZpk-/view?usp=sharing
5.	**14.04.2021**	FN	https://drive.google.com/file/d/1G7ks2UWOau-eBhF7NL3OjKKzHLtfZpk-/view?usp=sharing
6.		AN	https://drive.google.com/file/d/1qYQXyBBKozUqoxHKYzEUBw51SQE5HA1m/view?usp=sharing
7.	**15.04.2021**	FN	https://drive.google.com/file/d/1px92i1IMYGpli5Aag2_a8yxFFa0988-_/view?usp=sharing
8.		AN	https://drive.google.com/file/d/1SBtoXb3sTM19Ku82FUdfVxB_NTMWVW03/view?usp=sharing
9.	**16.04.2021**	FN	https://drive.google.com/file/d/1AZ4xXvGaouhA237SWCtHcG6XclEn39qa/view?usp=sharing
10.		AN	https://drive.google.com/file/d/1LyrTjIs-QZuPKiIVAcZna1aQHlFEXVmS/view?usp=sharing
11.	**17.04.2021**	FN	https://drive.google.com/file/d/1yyS8gcHEk2H3Me1lqxUcb7jczkM-7b58/view?usp=sharing
12.		AN	https://drive.google.com/file/d/1yyS8gcHEk2H3Me1lqxUcb7jczkM-7b58/view?usp=sharing

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Department of Mechanical Engineering

Six Days

Short Term Training Programme

on

"MAKE IN INDIA: THROUGH 3D PRINTING & INDUSTRY 4.O FOR INDIAN INDUSTRIES" - Phase III

03.05.2021 to 08.05.2021

PROGRAMME SCHEDULE

Date / Day	Forenoon		Afternoon
Day 1 (03.05.2021) Monday	**10.00 am to 12.00 noon**		**02.00 pm to 04.00 pm**
	Project Funding proposal & PhD topics in Metal Additive Manufacturing	**Lunch**	**Slicing Software Demo**
	Dr. T Ram Prabhu Scientist DRDO Bangalore.		**Mr. Sriram Krishna,** Rapid Prototyping & Test and Optimization Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Trichy.
Day 2 (04.05.2021) Tuesday	**11.00 am to 12.30 noon**		**2.00 pm to 04.00 pm**
	3D Printing: A Disruptive Technology of This Era	**Lunch**	**Additive-Manufacturing Topology Optimization: Netfabb**
	Dr. K. P. Karunakaran, Professor, Dept of Mechanical Engineering, IIT Mumbai.		**Dr. Ramesh Shankar** Program Manager Autodesk India Pvt. Ltd.
Day 3	**10.00 am to 12.00 noon**		**02.00 pm to 04.00 pm**
	Electron Beam Additive Manufacturing and its Process	**Lunch**	**Visual demo of Rapid Prototyping Lab**

(05.05.2021) Wednesday	**Parameters** **Dr.S.Senthil** Professor & Head, Department of Mechanical Engineering, Kamaraj College of Engineering and Technology		**Mr. Sriram Krishna,** Rapid Prototyping & Test and Optimization Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Tiruchirapalli.
Day 4 (06.05.2021) Thursday	**10.00 am to 12.00 noon** **Additive and Sustainable Manufacturing** **Dr.S.Vinodh,** Associate Professor, Dept of Production Engineering, NIT-Tiruchirapalli.	**Lunch**	**02.00 pm to 04.00 pm** **National Education Policy** **Dr. D.Raja Jebasingh** Vice Principal, St Joseph College of Commerce, Bengaluru, Karnataka.
Day 5 (07.05.2021) Friday	**10.00 am to 12.00 noon** **Recent research in 3D Printer - materials** **Dr.M. Uthayakumar,** Professor, Department of Mechanical Engineering, Kalasalingam academy of research and education	**Lunch**	**02.00 pm to 04.00 pm** **Design for Additive Manufacturing** **Mr. Sakthivel Murugan** Assistant Professor Department of Mechanical Engineering, Kamaraj College of Engineering and Technology
Day 6 (08.05.2021) Saturday	**10.00 am to 12.00 noon** **Additive Manufacturing: A Key Technology in Industry 4.O** **Dr. Y. Ravi kumar,** Associate Professor, Department of Mechanical Engineering, NIT-Warangal.	**Lunch**	**02.00 pm to 04.00 pm** **Research in Process planning for 3D printing** **Dr. Senthil kumaran kumaraguru** Associate Professor IIITDM, Kancheepuram

Session Recorded Videos:

S.No	Date	Session	Recorded Video Url (Microsoft Stream)
1.	**03.05.2021**	FN	https://drive.google.com/file/d/1LZlY9ru4agVnzA5njzCIcF0JNuwvTGNf/view?usp=sharing
2.		AN	https://drive.google.com/file/d/1LZlY9ru4agVnzA5njzCIcF0JNuwvTGNf/view?usp=sharing
3.	**04.05.2021**	FN	https://drive.google.com/file/d/1MuiGUVTwkXZs72TFcCDOx3mwayjnbxl8/view?usp=sharing
4.		AN	https://drive.google.com/file/d/1LQByce7Hj60vgAoAKtD9F-ZQlc1_iBFr/view?usp=sharing
5.	**05.05.2021**	FN	https://drive.google.com/file/d/1-KDdsPiejJ-MXsK0Y5oBnGPhEstWAZzH/view?usp=sharing
6.		AN	https://drive.google.com/file/d/19ImLdyivk9aga0StCrb8wT3Ah42Lr-O0/view?usp=sharing
7.	**06.05.2021**	FN	https://drive.google.com/file/d/16e29g-5QxwGD66X7RkxBejtRtzWCGzlM/view?usp=sharing
8.		AN	https://drive.google.com/file/d/18pKFlsPGOeb12c5OBSzEXZVEGlgGk_iR/view?usp=sharing
9.	**07.05.2021**	FN	https://drive.google.com/file/d/1X88rYhB5_FDFc-jiAN6mcU5si4bSeaZz/view?usp=sharing
10.		AN	https://drive.google.com/file/d/1r5cUeGoYx7jmxX7Ai-UEQzSRnWKM7Uen/view?usp=sharing
11.	**08.05.2021**	FN	https://drive.google.com/file/d/1JpS7QP_NkYyHfDvneFvi-h_AQs7Aad_5/view?usp=sharing
12.		AN	https://drive.google.com/file/d/1eauqEAv0brbHcIqbBwfkKAB6yblKN60J/view?usp=sharing

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Department of Mechanical Engineering

AICTE- sponsored Short Term Training Programme

on

"MAKE IN INDIA: THROUGH 3D PRINTING & INDUSTRY 4.O FOR INDIAN INDUSTRIES" - Phase IV

14.06.2021 to 19.06.2021

PROGRAMME SCHEDULE

Date / Day	Forenoon		Afternoon
Day 1 (14.06.2021) Monday	**10.45 am to 1 .00 pm**		**02.30 pm to 04.30 pm**
	Fundamentals of Metal 3D Printing	Lunch	**Design for Additive Manufacturing**
	Dr. Arvind Kumar Asso. Professor, Dept of Mechanical Engineering, IIT Kanpur		**Mr.R.Sakthivel Murugan,** Assistant Professor, Dept of Mech.Engg, Kamaraj College of Engg & Tech, Madurai.
Day 2 (15.06.2021) Tuesday	**10.00 am to 12.00 noon**		**02.00 pm to 04.00 pm**
	Futuritistic Applications of 3D Printing	Lunch	**Generative Design for Additive Manufacturing**
	Dr. S. Senthil Professor and Head Kamaraj College of Engg &Tech		**Dr. Ramesh Shankar** Program Manager Autodesk India Pvt. Ltd.
Day 3 (16.06.2021) Wednesday	**10.00 am to 12.00 noon**		**02.00 pm to 04.00 pm**
	New Education Policy	Lunch	**Slicing Software Demo**
	Dr. Theenathayalan HOD-PG CERE Madura College, Madurai		**Mr. Sriram Krishna,** Rapid Prototyping Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Trichy.

Day 4 (17.06.2021) Thursday	**10.00 am to 12.00 noon**		**02.00 pm to 04.00 pm**
	Making of Medical Products through Additive Manufacturing for Indian Customer needs" - Make in India Perspective.	**Lunch**	**Visual demo of Rapid Prototyping Lab**
	Dr. Rajesh Renganathan Associate Professor, Dept of Mechanical Engineering, Coimbatore Instutite of Technology Coimbatore		**Mr. Sriram Krishna,** Rapid Prototyping & Test and Optimization Application Engineer, Siemens Center of Excellance in Manufacturing, NIT Tiruchirapalli.
Day 5 (18.06.2021) Friday	**10.00 am to 12.00 noon**		**02.30 pm to 04.30 pm**
	New Innovations in 3D printing	**Lunch**	**Laser Additive Manufacturing-Design and Innovations**
	Dr. L. Jyothish Kumar President, Additive Manufacturing Society of India Bengaluru		**Dr.C.P.Paul** Head Laser Additive Manufacturing Lab R. R. Centre for Advanced Technology Indore
Day 6 (19.06.2021) Saturday	**10.00 am to 12.00 noon**		**02.30 pm to 04.30 pm**
	Project Funding proposal & PhD topics in Metal Additive Manufacturing	**Lunch**	**3D Printing of Polymer Composites**
	Dr.T.Ramprabhu Dy. Director DRDO-Bengaluru		**Dr. Pavan Kumar Penumakala** Dept. Of Mech.Engg BITS PILANI- Hyderabad Campus

Session Recorded Videos:

S.No	Date	Session	Recorded Video Url (Microsoft Stream)
1.	**14.06.2021**	FN	https://drive.google.com/file/d/1UH5XO6p20IxedZl6cQ9oD5XG3dFVzgbH/view?usp=sharing
2.		AN	https://drive.google.com/file/d/1BtVpqRxwwDD4ZkQH1sfsebmiQ22v4oY9/view?usp=sharing
3.	**15.06.2021**	FN	https://drive.google.com/file/d/1iznbo42Ney6_y7OLhI9Y-FVk63MvfHVj/view?usp=sharing
4.		AN	https://drive.google.com/file/d/1PhWy5GlhTIAqI1RaB68hsBcupK2U877C/view?usp=sharing
5.	**16.06.2021**	FN	https://drive.google.com/file/d/1wBvnYgK7s7GS8Ey8her2iaKfYzZAztVP/view?usp=sharing
6.		AN	https://drive.google.com/file/d/1k6avavwh5TDfhthxuzldhbctp4ytR0d3/view?usp=sharing
7.	**17.06.2021**	FN	https://drive.google.com/file/d/1_u40t-478p3EqXGvIVSwhKIlVlrPdYci/view?usp=sharing
8.		AN	https://drive.google.com/file/d/1iGZLxx2J_n-8H2IBATTIVdnnTM1zAxCv/view?usp=sharing
9.	**18.06.2021**	FN	https://drive.google.com/file/d/1x1W45-0Bn1Pzwxl4PEAz7HsCvojJY8ZY/view?usp=sharing
10.		AN	https://drive.google.com/file/d/1MXH9IGRl0b59PVGfY5ievcDFHk0738ES/view?usp=sharing
11.	**19.06.2021**	FN	https://drive.google.com/file/d/1MXH9IGRl0b59PVGfY5ievcDFHk0738ES/view?usp=sharing
12.		AN	https://drive.google.com/file/d/184qLwu34EZIwaOjfFE-MiN2CDS1pl-6n/view?usp=sharing

SAMPLE PRESENTATION PPTs

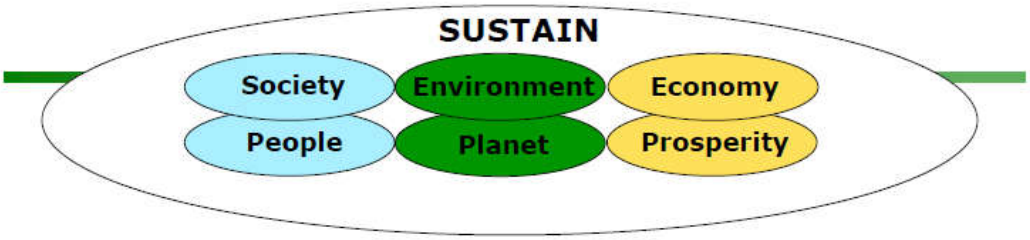
Sustainable Manufacturing

Dr. S. Vinodh,
Associate Professor,
Dept. of Production Engineering
National Institute of Technology
Tiruchirappalli – 620015
Email: vinodh@nitt.edu

Sustainability: Definitions

- There is no universally acceptable definition for the term "sustainability", but the most commonly known definition comes from the 1987 U.N.
- Brundtland Commission defined Sustainability as:
- "Meeting the needs of present without compromising the ability of future generations to meet their own needs"
- Some of the most commonly known sustainability terms are:(a) Environmental Sustainability(b) Economic Sustainability (c) Societal Sustainability

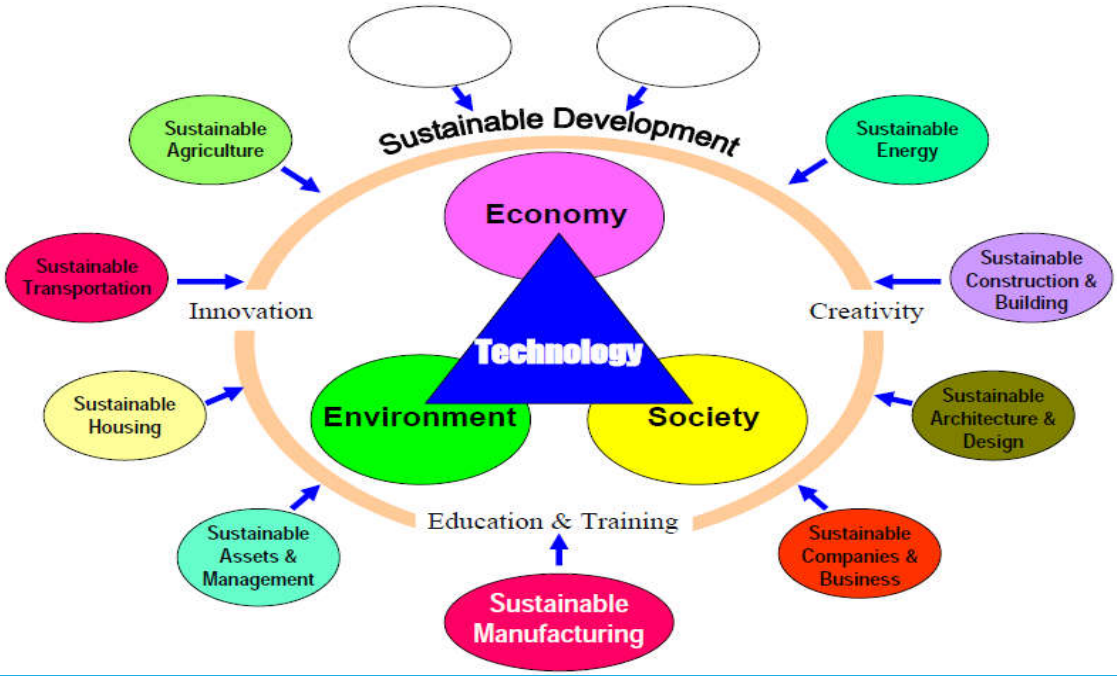
Sustainability dimensions



OBJECTIVES

Society	Environment	Economy
• Improved Health • Safety • Enhanced Quality of life • Ethics	• Cleaner Air, Water and Soil (Lower Toxicity & Pollution) • Eco-balance & Efficiency • Greater Implementation of Regulations, Codes, etc. (Improved Logistics)	• New Employment • Product and Process Innovation (Technological Advancement) • Large-Scale new business opportunities

Sustainable Development



Sustainable Manufacturing: Terms and Definitions

- Environmentally-responsible manufacturing
- Environmentally benign manufacturing
- Cleaner processes (Green manufacturing)
- Economically advantageous manufacturing (Lean manufacturing)
- Energy-efficient manufacturing
- Manufacturing using renewable source of energy

Sustainable Manufacturing: Basic Elements

Expectations:

- Reducing energy consumption
- Reducing waste
- Reducing material utilization
- Enhancing product durability
- Increasing operational safety
- Reducing health hazards/Improving health conditions
- Consistently improving manufacturing quality
- Improving recycling, reuse and remanufacturing
- Maximizing sustainable sources of renewable energy

Sustainable Manufacturing: The Paradigm “E”

- Ecology
- Environment
- Energy
- Economy
- Employment
- Empowerment
- Education
- Excellence

Tools for eco efficiently manufacturing

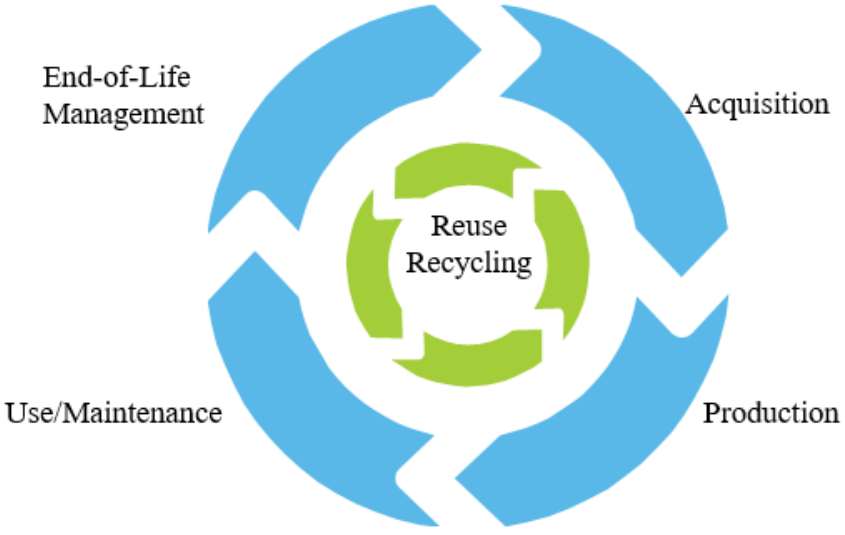
- Environmental Management Systems
- Product Design & Development
- Design for Environment
- Eco-Efficiency Analysis
- Life-Cycle Assessment
- Environmental Supply Chain Management
- Green Procurement
- Corporate Environmental Reporting
- Industrial Ecology
- Life-Cycle Costing
- Environmental Impact Assessment

Life Cycle Assessment

- Life-cycle assessment (LCA, also known as life-cycle analysis, Eco balance, and cradle-to-grave analysis) is a technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling)
- Analyses and comparisons of product, process and services according to the ISO standard covering the whole life cycle from the production of raw materials to end of life.

Life Cycle Assessment

An industrial environmental management approach to look holistically at products, processes, and activities.



ISO Standards for LCA

ISO provides a standardized methodology for conducting multi-media, cradle-to-grave environmental assessments

1. ISO 14040 “Life Cycle Assessment – Principles and Framework” 1997

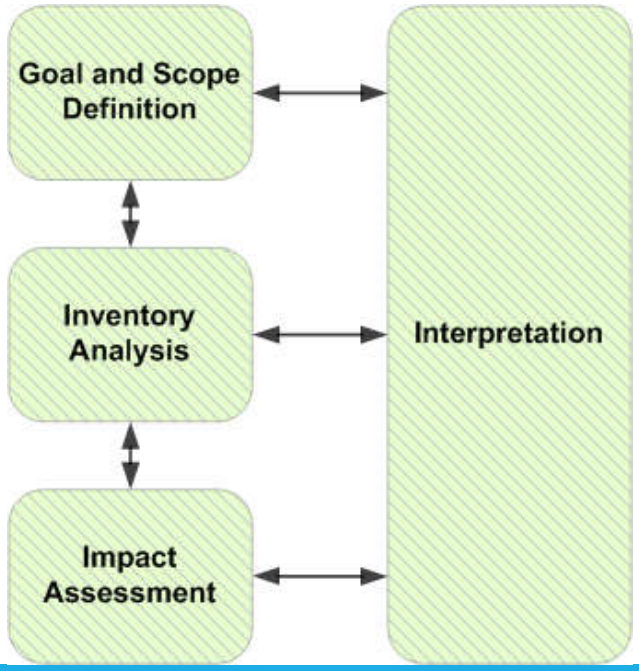
2. ISO 14044 “Life Cycle Assessment – Requirements and Guidelines” 2006

ISO* - International Standards Organization

Life Cycle Impact Assessment - Indicators of Potential Impact

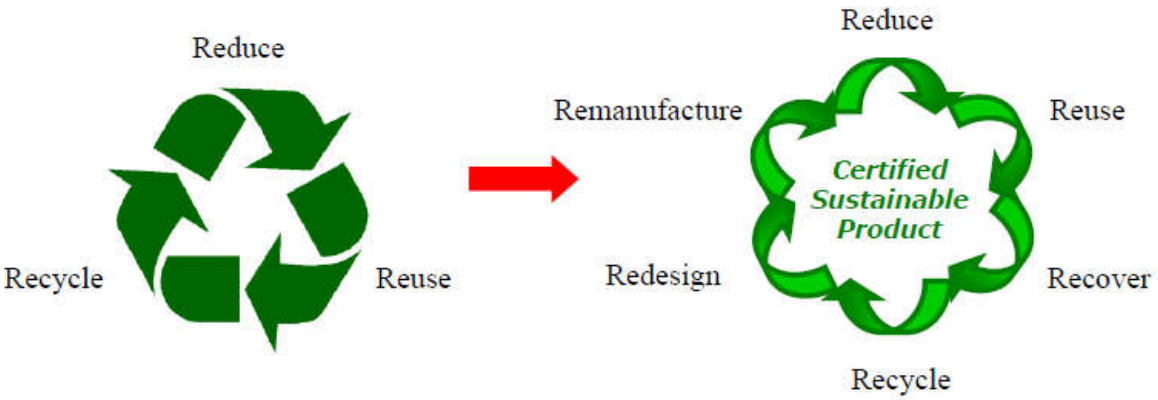
Impact Category	Indicator Measurement
• Global Warming	kg CO_2 equivalents
• Ozone Depletion	CFC-11 equivalents
• Acidification	kg SO_2 equivalents
• Eutrophication	kg PO_4^{3-} equivalents
• Smog Formation	kg Ethene equivalents
• Human Toxicity	HTx equivalents
• Eco-toxicity	ETx equivalents
• Waste	kg Waste
• Resource Use	kg Scarce Resources
• Water	m^3 Water
• Land Use	being developed

LCA phases



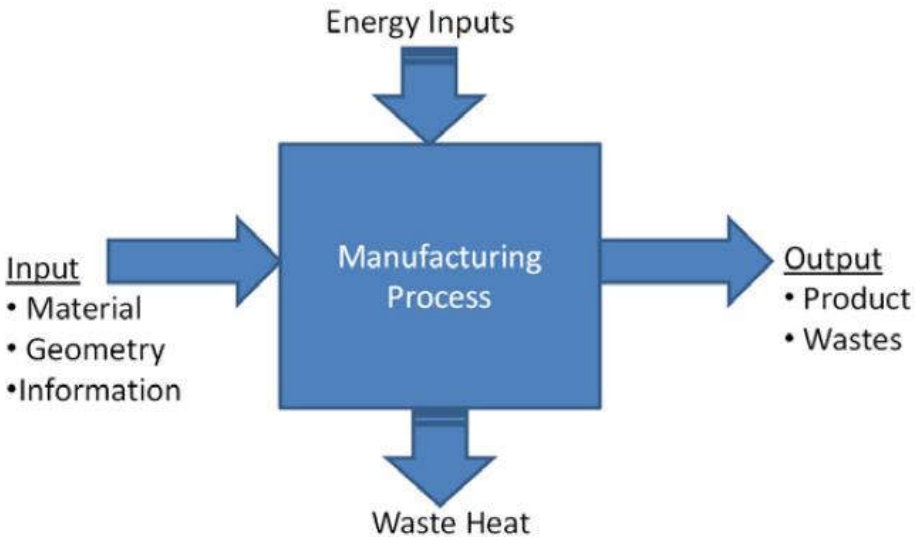
3Rs and 6Rs of Sustainable Manufacturing

3R and 6R's



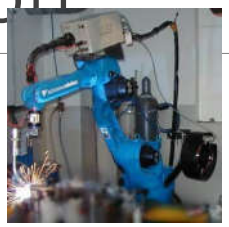
Energy Efficiency analysis of Manufacturing Processes

Process from energy point of view

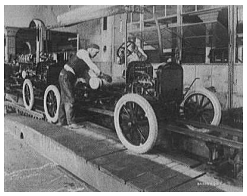


Smart Manufacturing

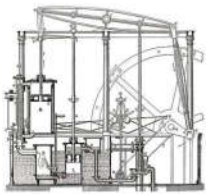
Industrial Evolution



4. Industrial revolution
Based on cyber-physical-systems



3. Industrial revolution
Through the use of electronics and IT further progression in autonomous production



1. Industrial revolution
Introducing mechanical production machines powered by water and steam

Level of complexity

Industry 1.0	Industry 2.0	Industry 3.0	Industry 4.0
End of the 18th century.	Beginning of the 20th century	Beginning of the 70th	Today

Source: DFKI/Bauer IAO

Need

To address the challenges of complexity, customization, compliance, globalization and customer expectations for near-perfect quality.

Manufacturing Digitalization

Increased reliance on modelling, optimisation and simulation.

Greater horizontal connectivity and interoperability

Material-product-process phenomenon

Applications of SM

- Aero engine fan blade manufacturing
- Air conditioning compressor manufacturing
- Automotive Assembly Industry
- Car manufacturing process
- Energy-storage system
- Fixed-position assembly systems in manufacturing
- Manufacturing industries such as automotive, aerospace, medical manufacturing,
- Oil Refining and Petrochemical Industry
- Small and medium-sized enterprise (SME)

Thank You

3D Printing Trends and Rapid Product Development

Dr.S.Vinodh

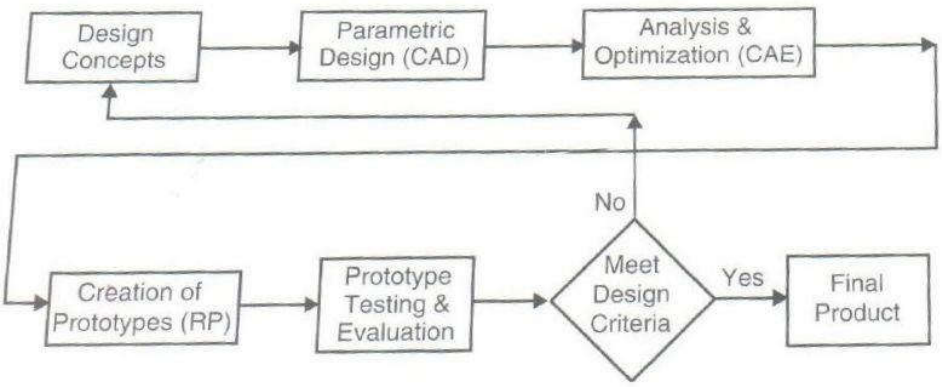
Associate Professor

Department of Production Engineering

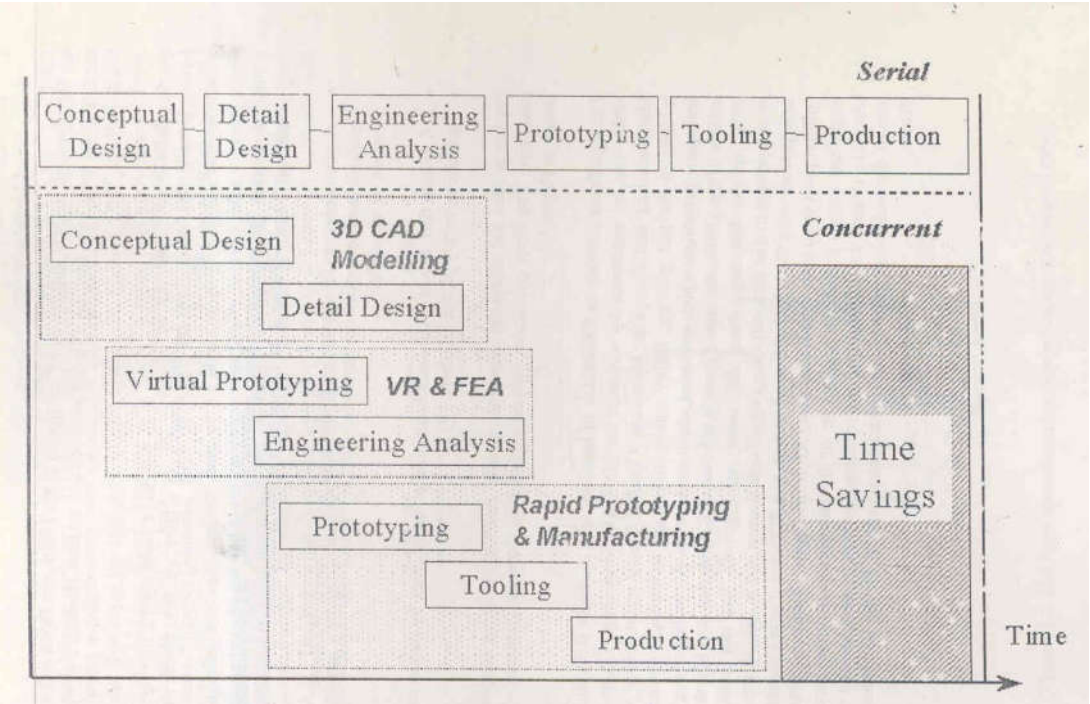
National Institute of Technology

Tiruchirappalli- 620 015, Tamil Nadu

Impact of RP on product development

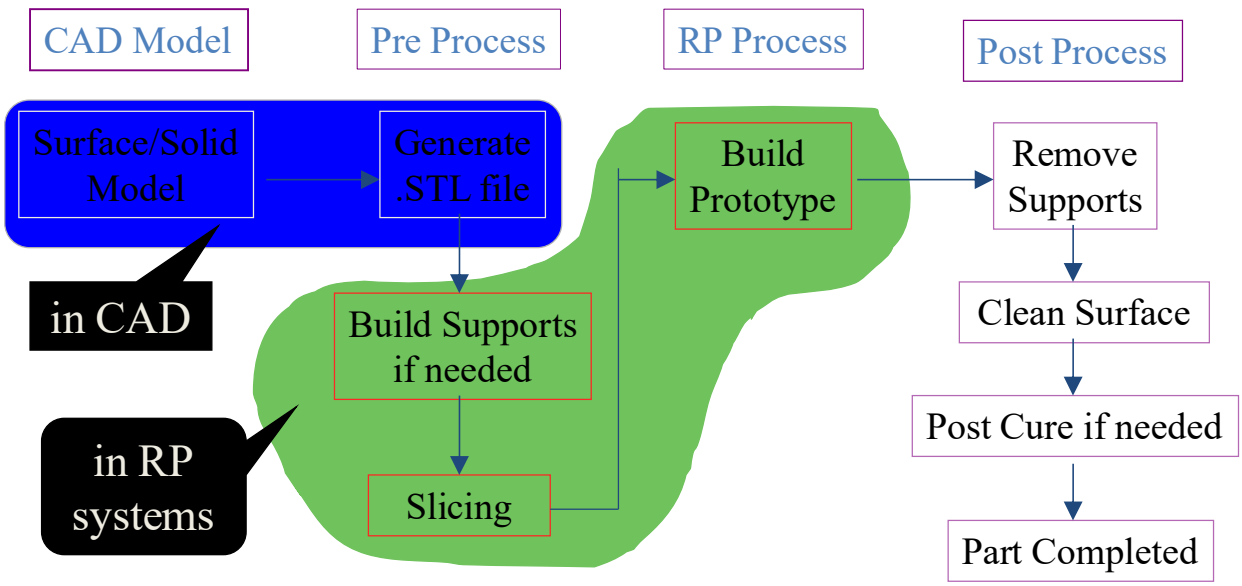


Time Compression Engineering

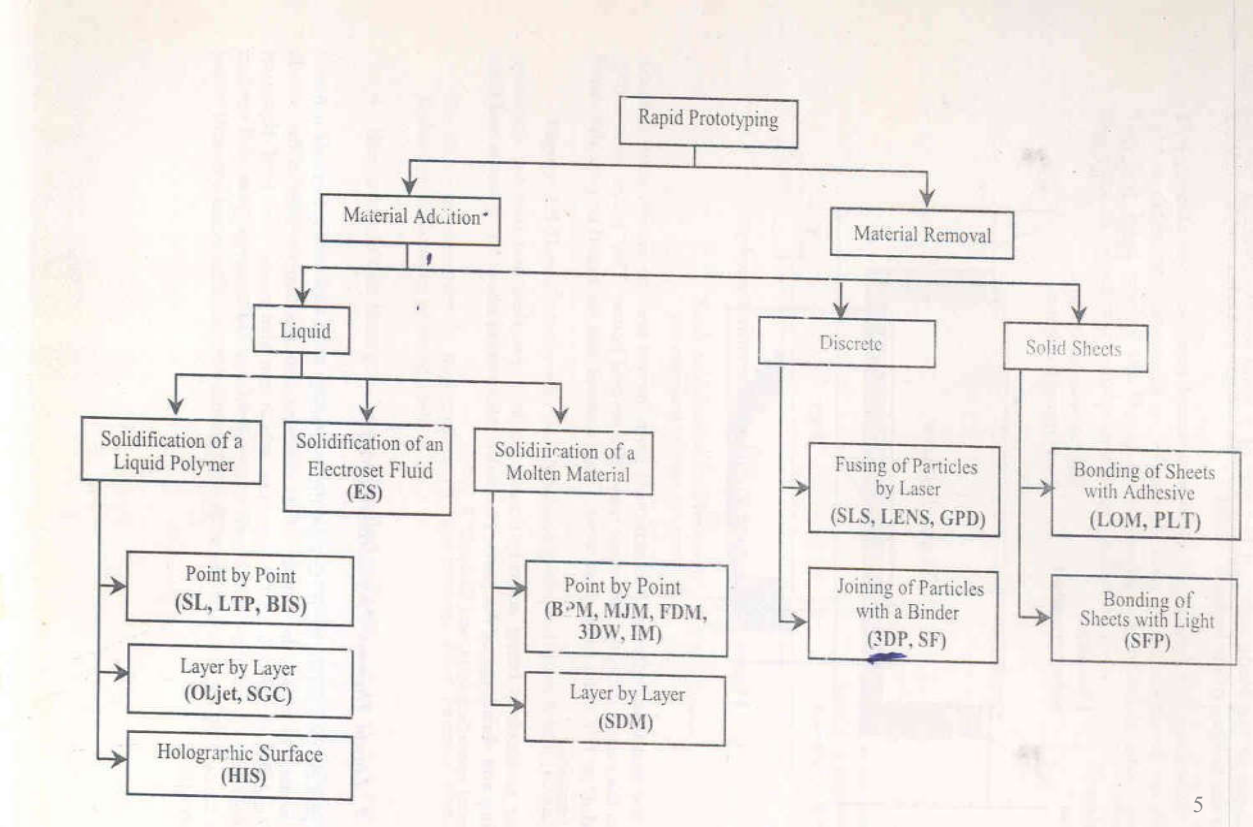


Basic process of RP

Three stages: ***pre-processing, building,*** and ***post processing***



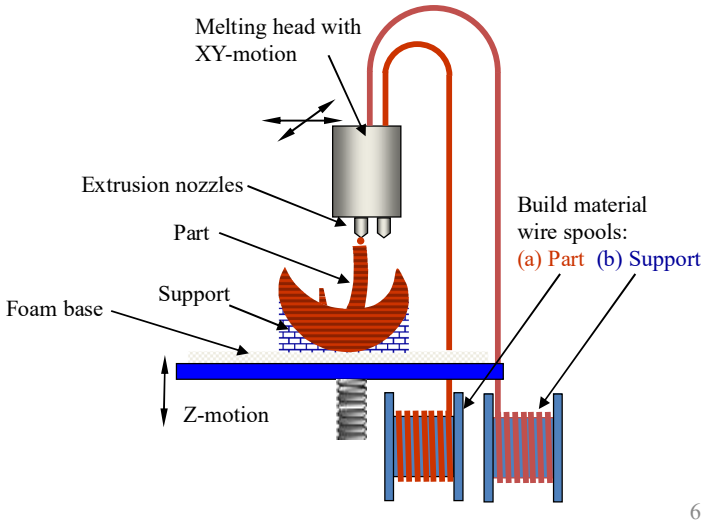
Overview on Rapid Prototyping Technologies



Fused Deposition Modeling (FDM)

→ Part constructed by deposition of melted plastic

1. A 0.05" wire of plastic pulled from a spool into head
2. Plastic is melted (1ºF over MP)
3. Molten plastic extruded through the pen nozzle to build layer



Materials:
ABS, Polycarbonate (PC), Polyphenylsulfonen (PPSF)

Advantages of FDM Process

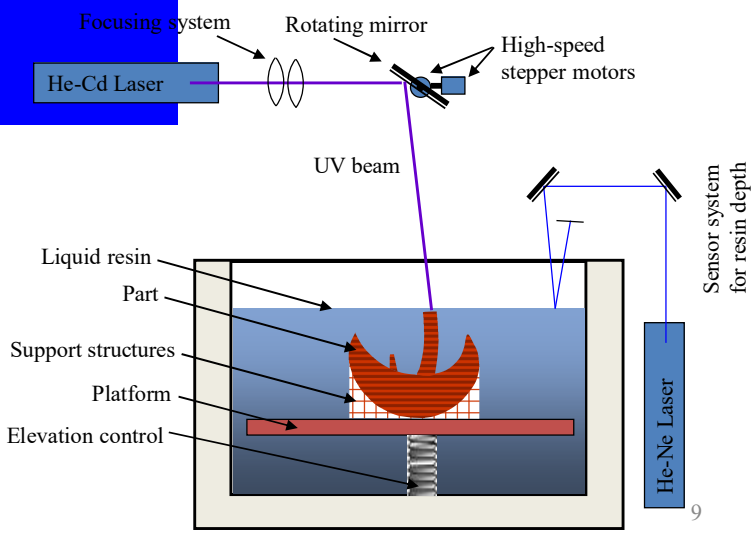
- Easy fabrication
- Minimal wastage
- Ease of removal
- Easy handling

Application of FDM process

- Designing
- Engineering analysis and planning
- Tooling and manufacturing

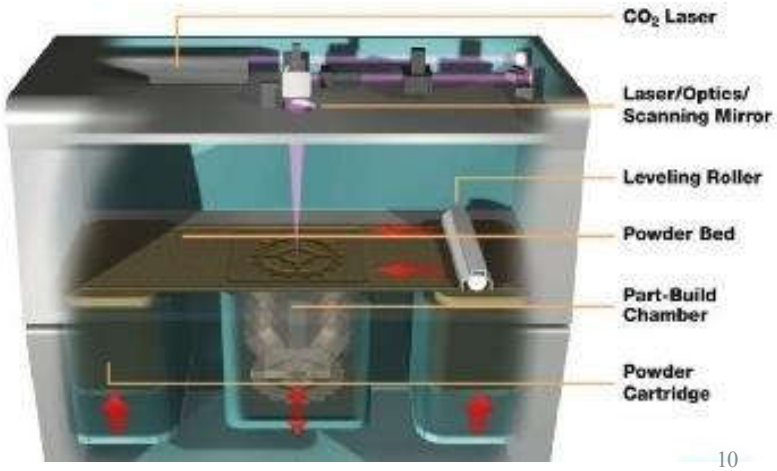
Stereolithography (SLA)

1. Raw material: viscous resin
2. Part constructed in layers of thickness *t*
3. Supporting platform → in container at depth *t*
3. UV laser solidifies part cross-section
4. Platform lowered by *t*
5. Part cross-section computed at *current height + t*
6. Repeat Steps 4, 5
7. Removed completed part,
8. Break off supporting structures
9. Cure the part in oven.



Selective Laser Sintering (SLS) and its variants

1. Deposit layer of powder on platform.
2. The CO_2 laser solidifies part cross-section
3. Lower platform by *t*
4. Deposit new layer of powder above previous layer
5. Repeat steps 2-4 to complete part
5. Shake away surrounding powder (re-used)
6. Bake model in oven to sinter (melting point – δ)*
7. Diffuse lower MP metal to fill pores**



3D printer in different Areas

- Tissue engineering
- Automotive applications
- Mechanical
- Jewellery
- Tooling
- Medical
- Building constructions
- Aerospace applications
- Scaffolding
- Toys
- Food industries
- Defense

Thank You !

Design for Additive Manufacturing (DFAM)

Presentation by

R.Sakthivel Murugan,

Assistant Professor,

Dept of Mechanical Engg, KCET.

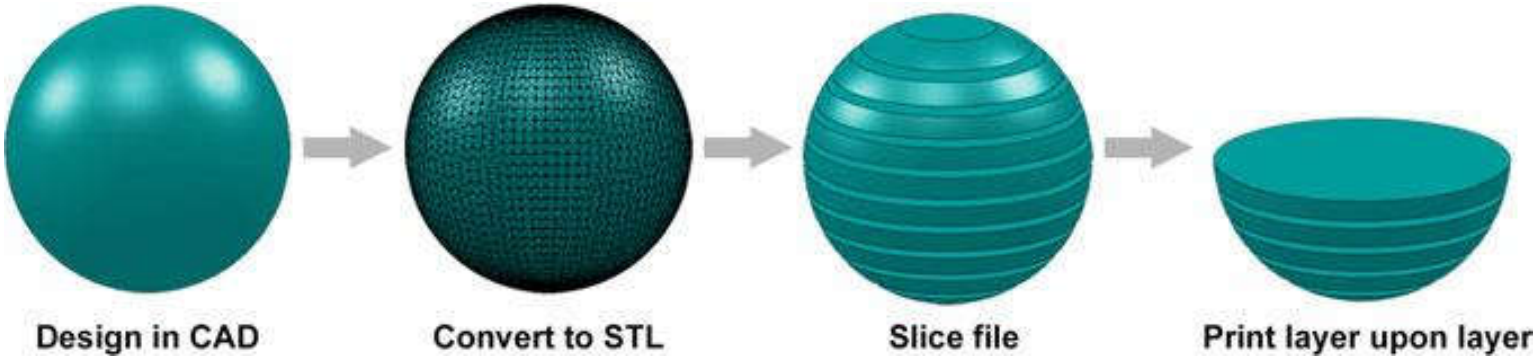
Content of Delivery

- Introduction
- Why 2D Heat Transfer Element instead of 1D Element?
- Derivations
  - Shape Functions
  - Stiffness Matrix – Both Conduction & Convection
  - Force Matrix – Due to Heat Generation, Heat Flux and Convection
- Problems on 2D Heat Transfer
  - Basic Problems
  - Application Problems

Introduction – Additive Manufacturing

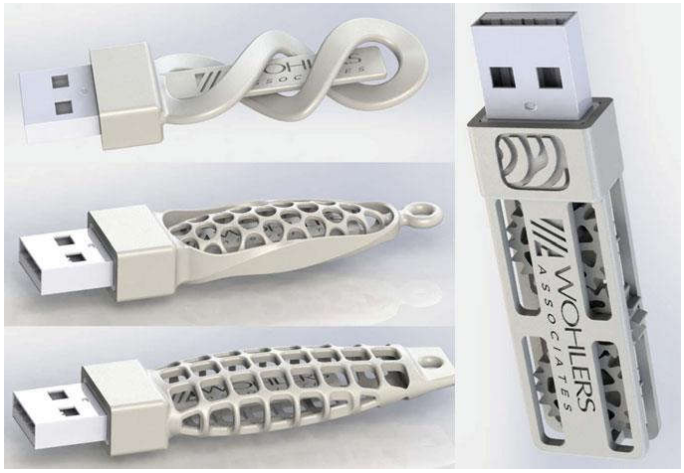
- Physical components to be made, from virtual 3D models by building the component layer-upon-layer until the part is complete.

AM Process Chain



Advantages of AM

Part Complexity

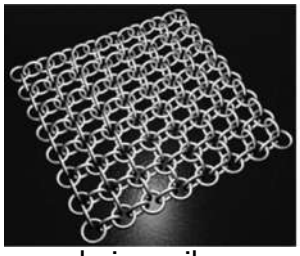


Siemens turbine burner

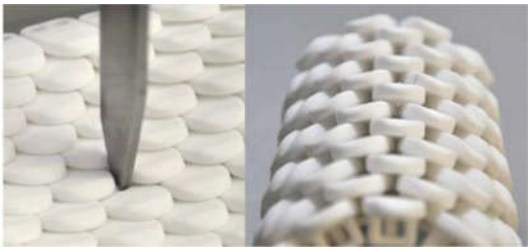
Advantages of AM

Instant Assemblies

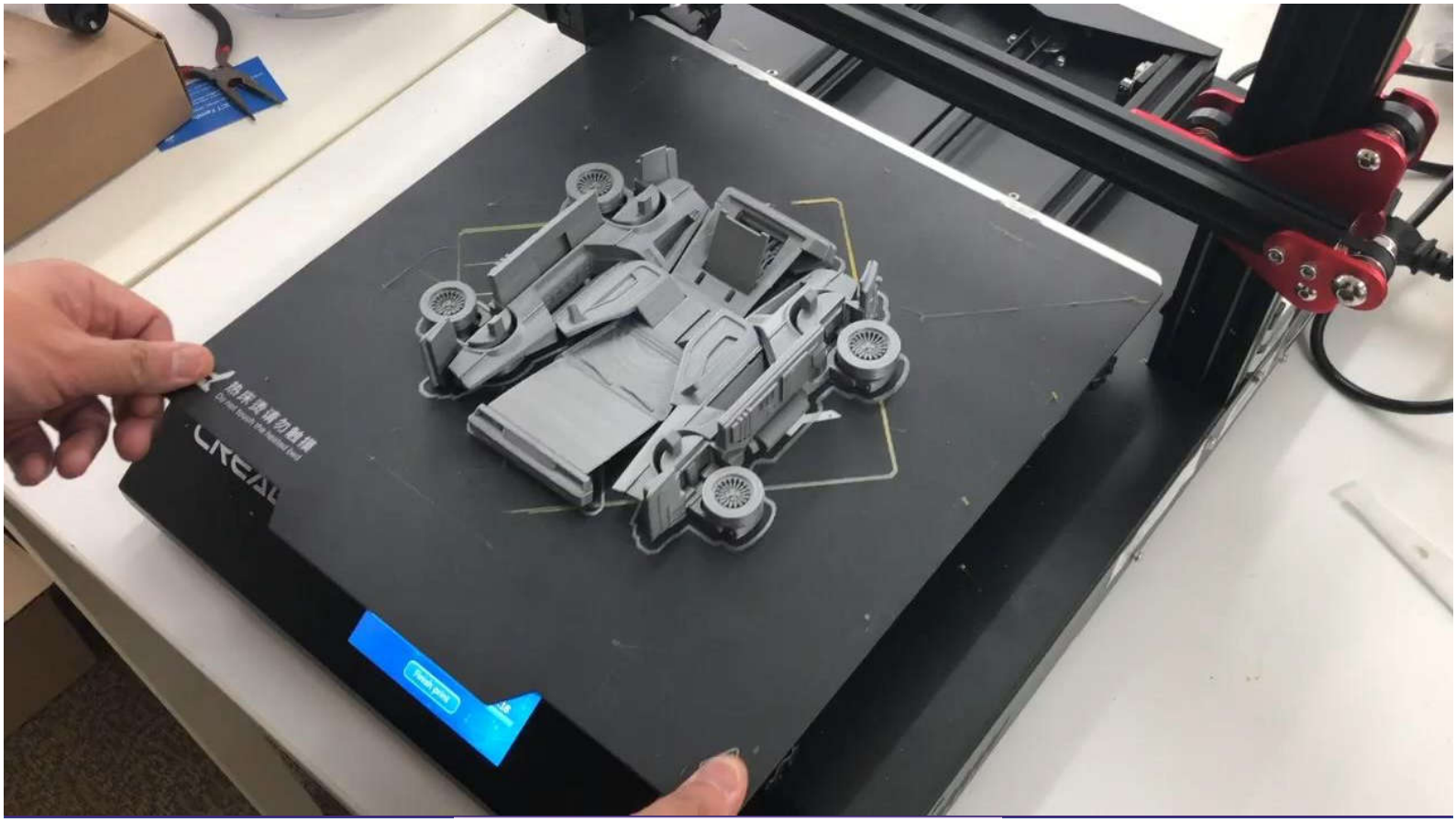
Guitar Stand



chain mail

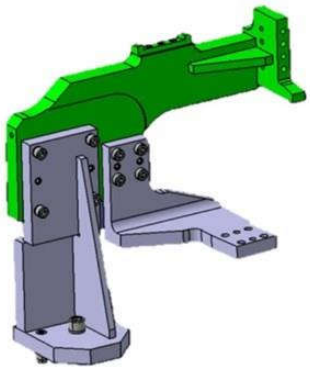


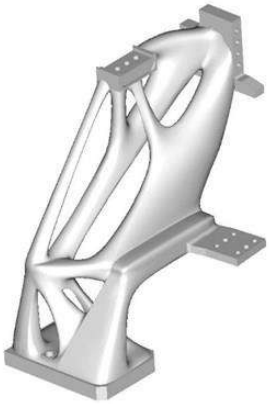
Stab-resistant armor



Advantages of AM

Part Consolidation





HP combined six parts into one

Drone with only six core components

Advantages of AM

Mass Customization

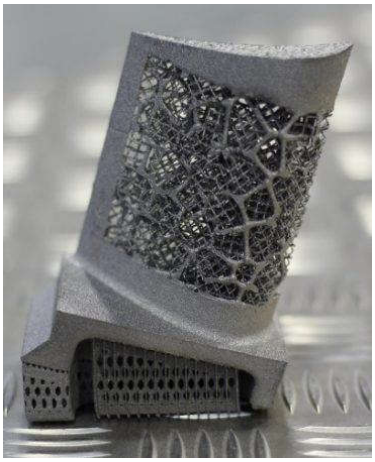
Customized prosthetic

Customized Helmet

Customized Shoe

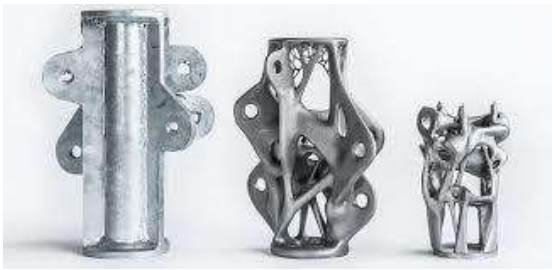
Advantages of AM

Light-Weighting



Meso structu3D printed part showing Lattice

re

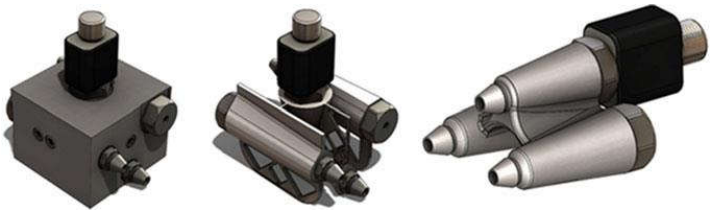


Generative Design

Topology Optimization

DFAM - Introduction

- Design for additive manufacturing (DFAM) is when designers seek to create a product design that takes advantage of the unique capabilities of AM.
- Respects the specific process constraints of the AM technology that will be used to produce the product.
- Re-designing existing parts for AM for material reduction or part consolidation.
- DFAM is definitely more of a thought process in which conscious decisions are made (often compromises) rather than just blindly following a set of design rules.



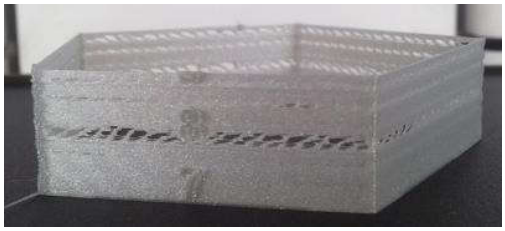
AM General Failures

Warping

layer shifting

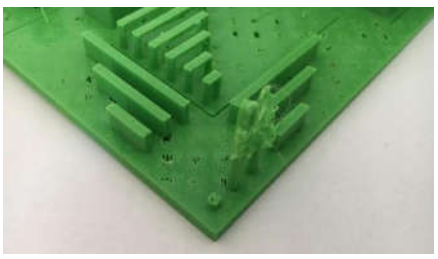
Overhanging

Under-extrusion



Layer separation

Fine details are not printed

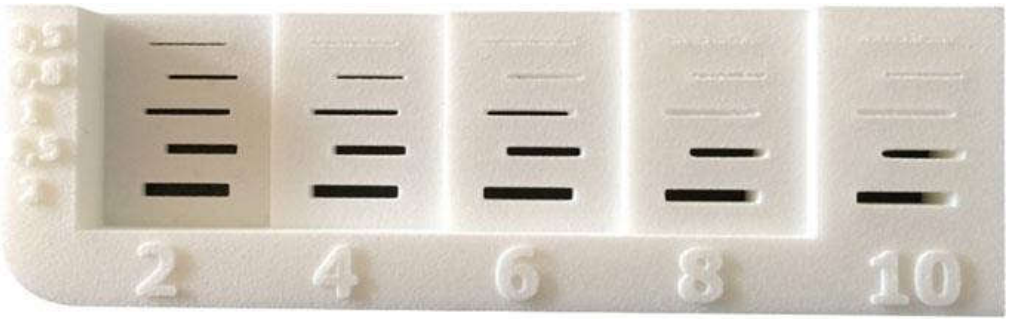


Design Analysis Needs

- To simulate the behavior and performance of a virtual design.
- To improve the design according to some given criteria.
- To simulate the physical build process to aid in finding an optimal build orientation, support structures, material properties.
- To compensate for distortions.

Design Guidelines (DFAM)

#1 Design parameters depend on other design parameters and printing conditions :

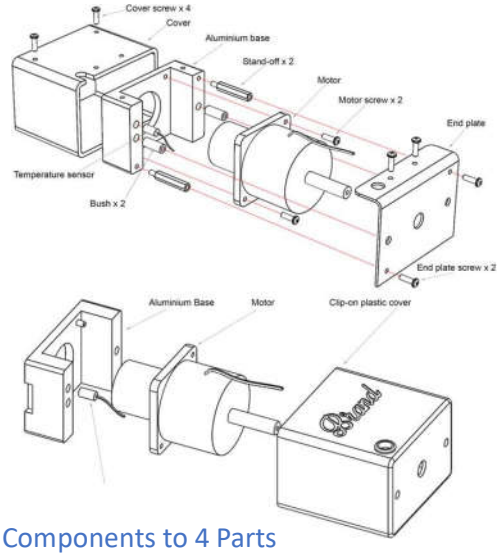


Hole size depends on material thickness

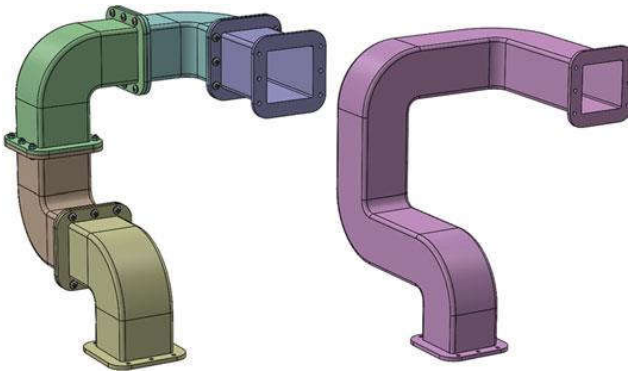
Design Guidelines (DFAM)

#2 Design for Part Consolidation.

- Design for Function
- Material Considerations
- Number of Fasteners
- Assembly Considerations



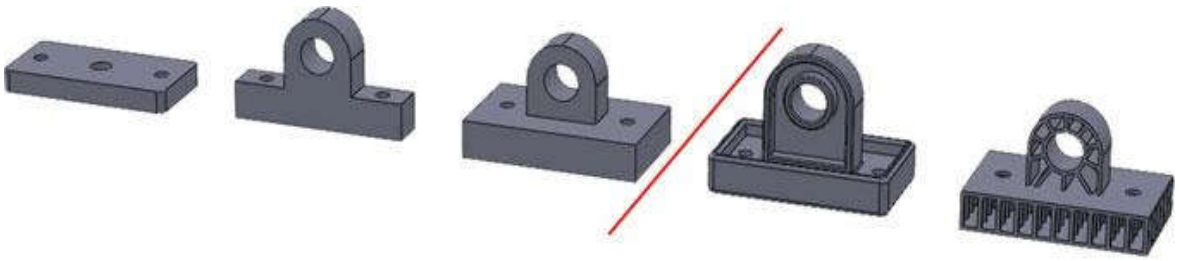
19 Components to 4 Parts



48 fasteners to 12 Fasteners

Design Guidelines (DFAM)

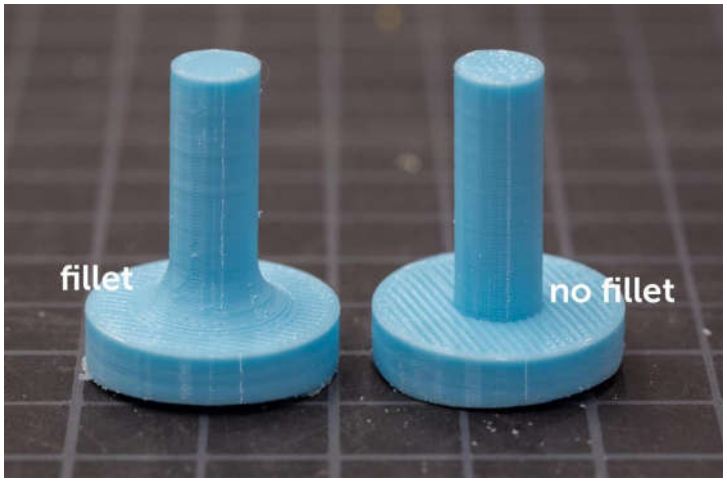
#3 Selection of AM in right place:



Complexity Selection Filter

Design Guidelines (DFAM)

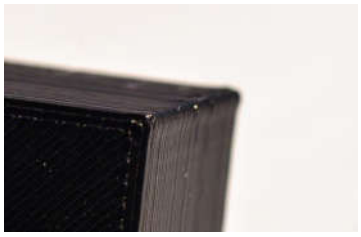
#4 Fillet all corners

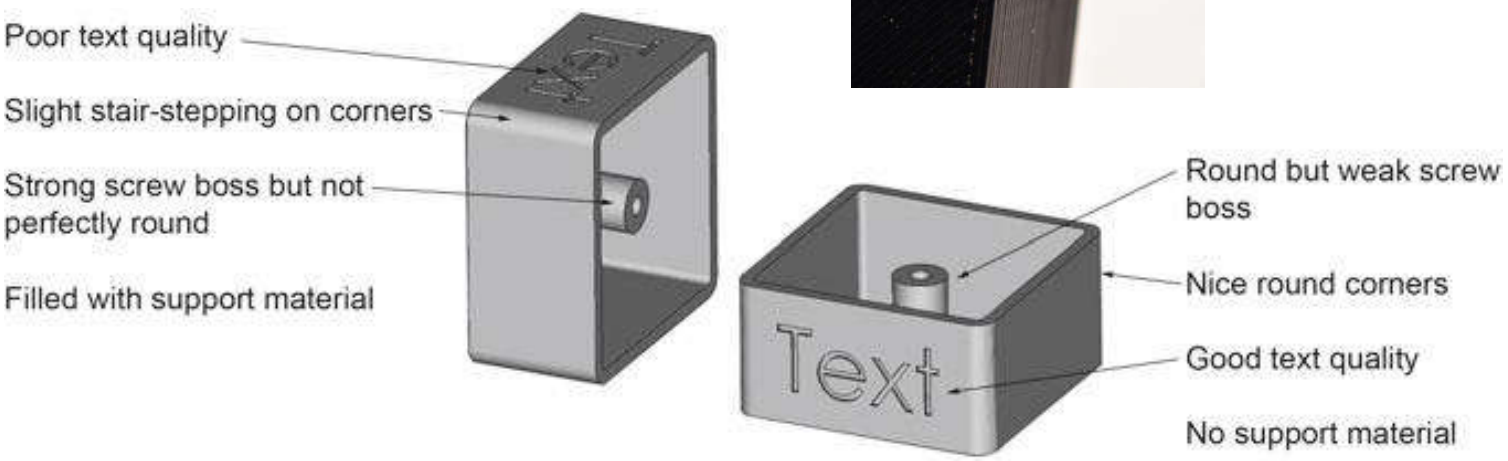


A good rule of thumb is to make the fillet ¼ of the thickness.

Design Guidelines (DFAM)

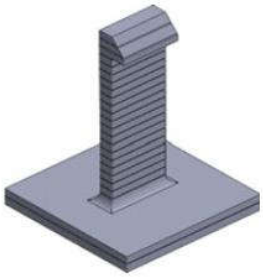
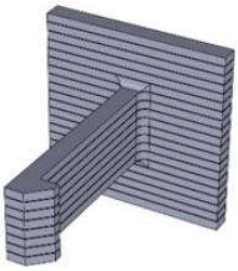
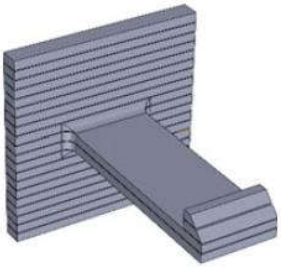
#5 Effect of Print Orientation

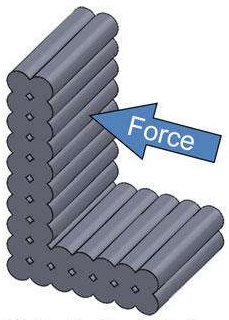




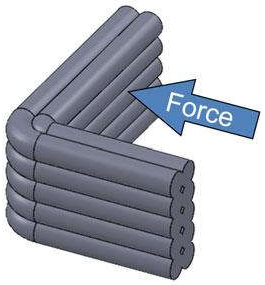
Design Guidelines (DFAM)

#5 Effect of Print Orientation

		
Clip will be weak and, almost certainly, break	Good compromise clip, with decent spring and strong hook	Clip has the best spring strength and flexibility but a weak hook



Printed in Z orientation



Printed in X-Y orientation

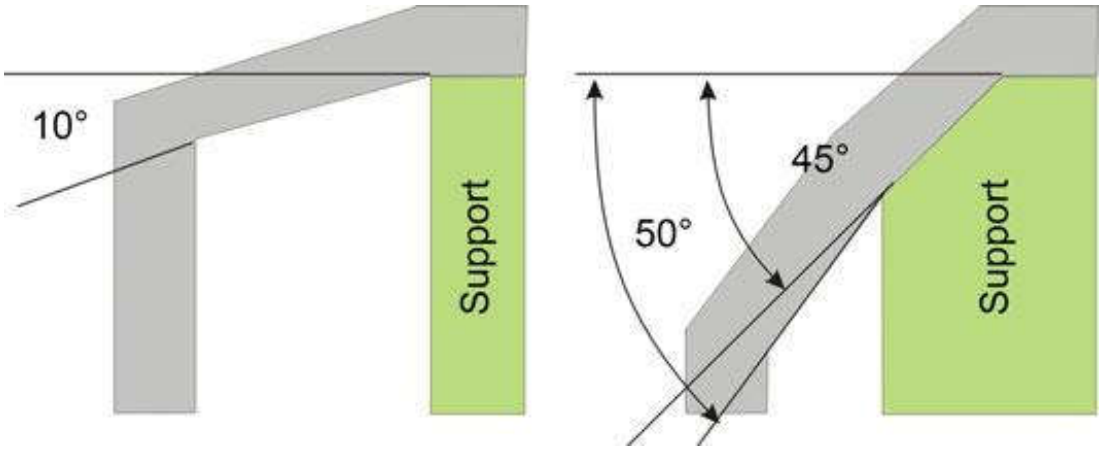
Design Guidelines (DFAM)

#6 Minimize large Masses of material

Unnecessary material that increases cost, causes more residual stress and therefore requires more support material and heat treatment.

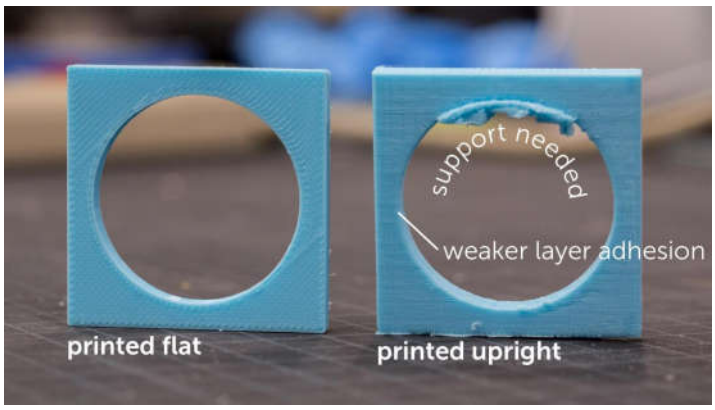
Design Guidelines (DFAM)

#7 Minimize support material



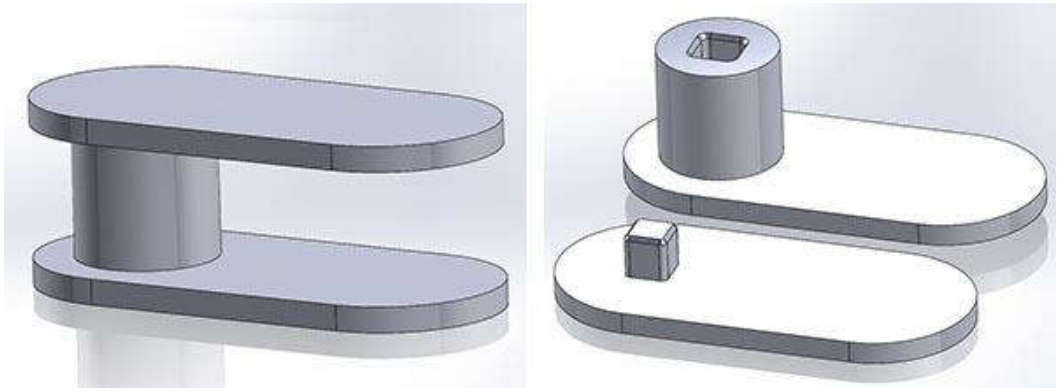
Design Guidelines (DFAM)

#7 Minimize support material



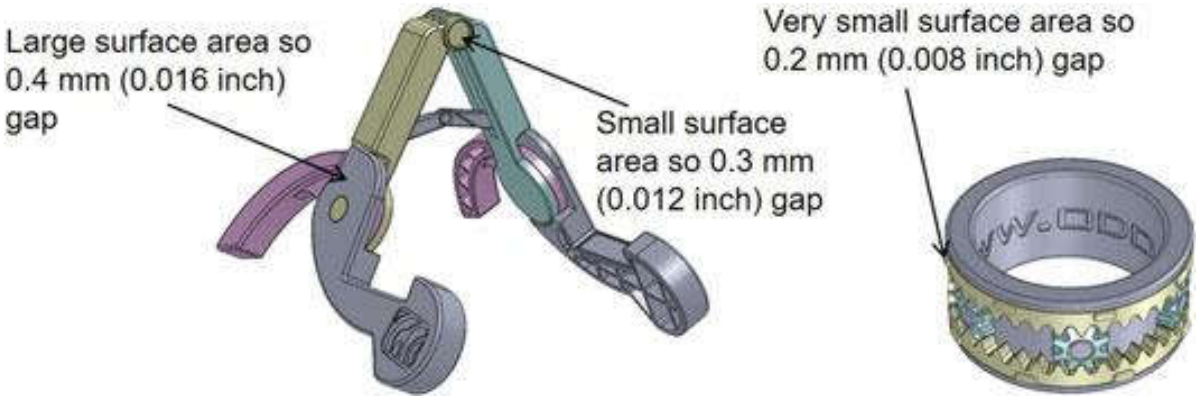
Design Guidelines (DFAM)

#8 Print all at once



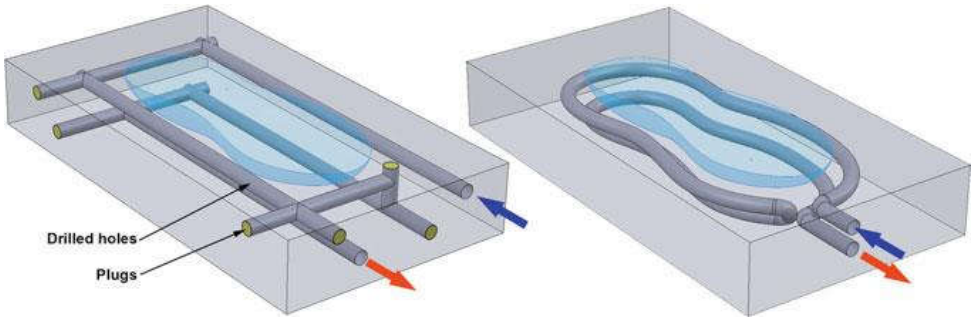
Design Guidelines (DFAM)

#9 Print Direct Assemblies



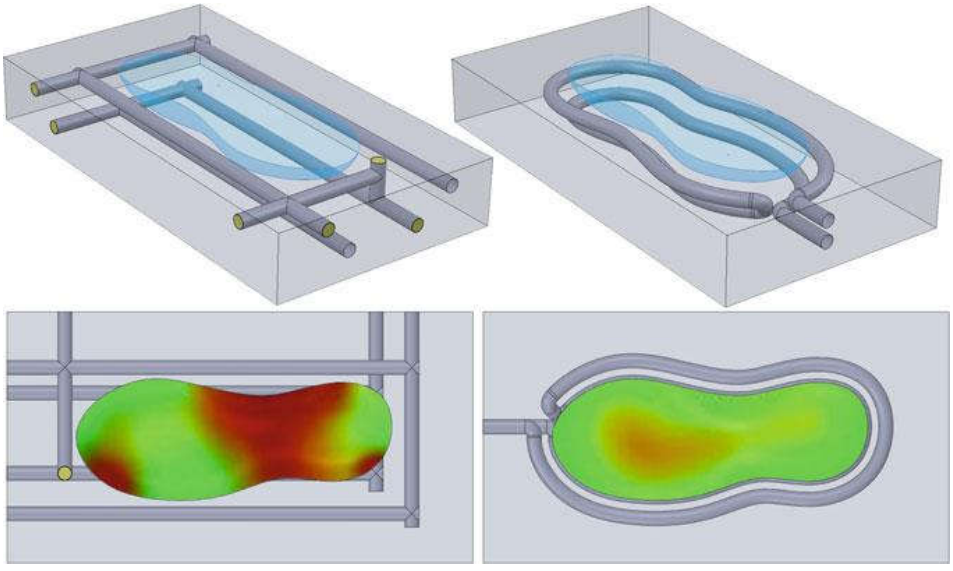
Design Guidelines (DFAM)

#10 Design on Conformal Cooling



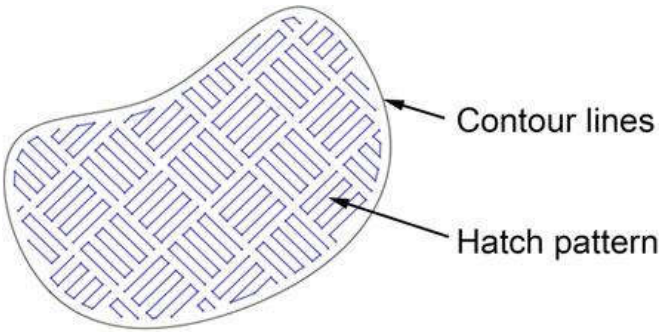
Design Guidelines (DFAM)

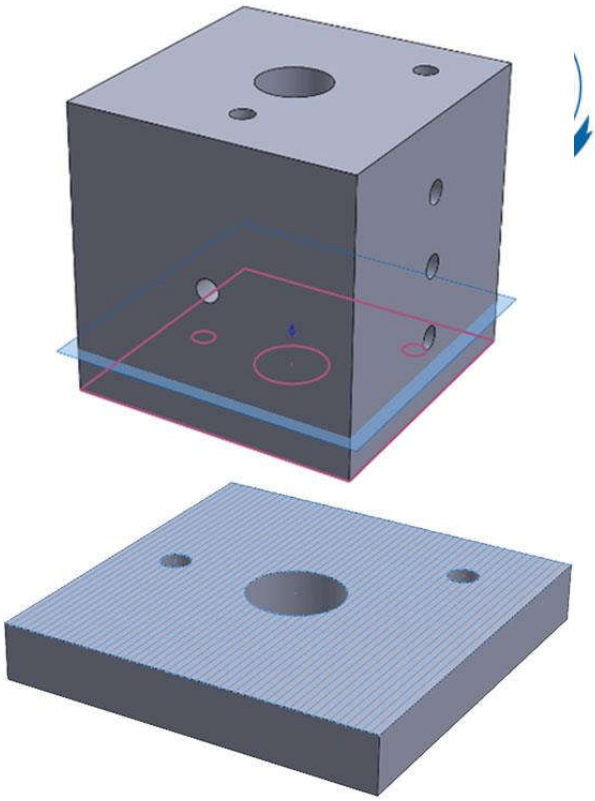
#10 Design on Conformal Cooling



Design Guidelines (DFAM)

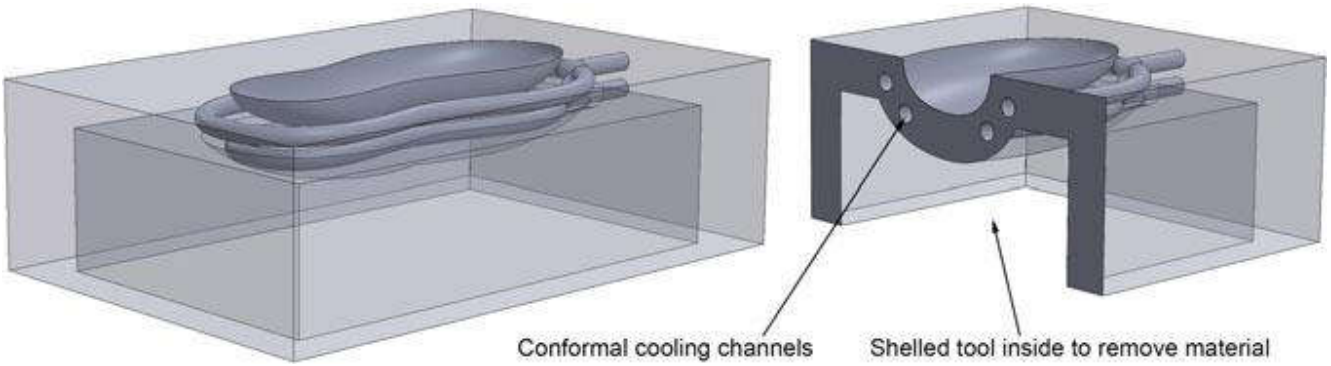
#11 Design to Minimize Print Time





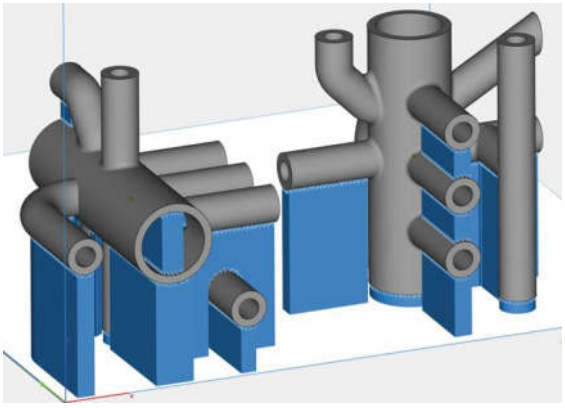
Design Guidelines (DFAM)

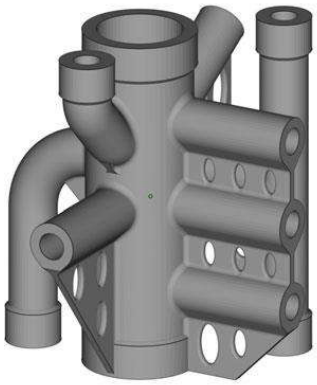
#11 Design to Minimize Print Time

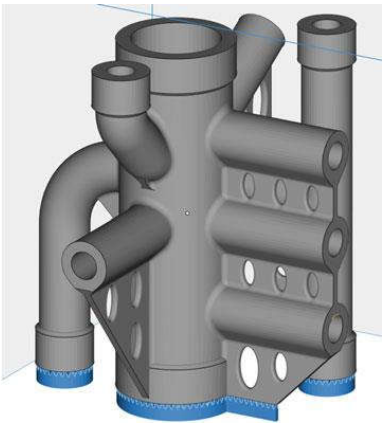


Design Guidelines (DFAM)

#12 Design to Minimize Post-processing



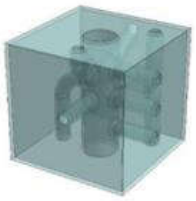




The idea is that the added wall becomes the support material, and becomes a permanent feature of the part.

Design Guidelines (DFAM)

#12 Design to Minimize Post-processing

	 Solid block manifold	 Shelled block manifold	 Optimised DfAM manifold
Scan time for hatch pattern	191 h 1 min 33 s	36 h 31 min 21 s	19 h 40 min 39 s
Machine cost in metal@$65/h	$12,415.00	$2379.00	$1261.00
Material weight	7.411 kg	1.232 kg	0.558 kg
Material cost @ $70/kg + 10% waste	$570.64	$94.86	$42.96
Bureau quotes for part in 316L stainless	$15,293.82	$3735.12	$1986.25

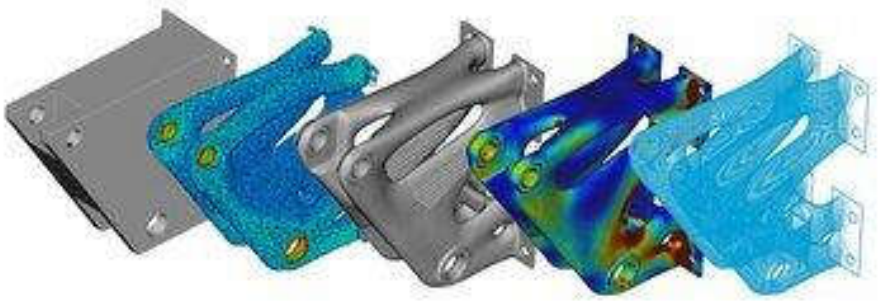
Design Guidelines (DFAM)

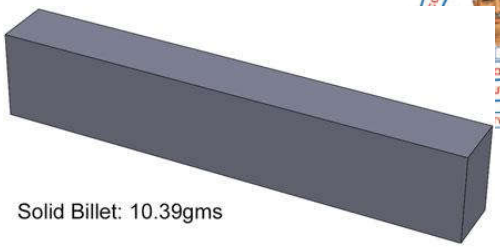
#12 Design to Minimize Post-processing

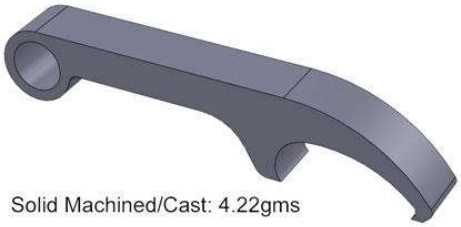
Aluminium distillery manufactured with AM

Design Guidelines (DFAM)

#13 Design of light weight structures (Topology Optimization)







Design Guidelines (DFAM)

#14 Design of light weight structures (Lattice Structures)

Design Guidelines (DFAM)

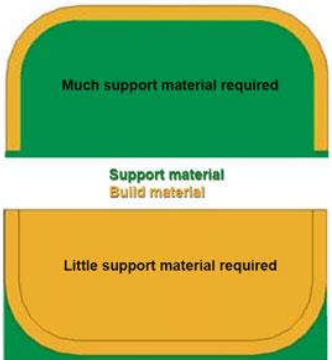
#15 Design of light weight structures (Generative Design)

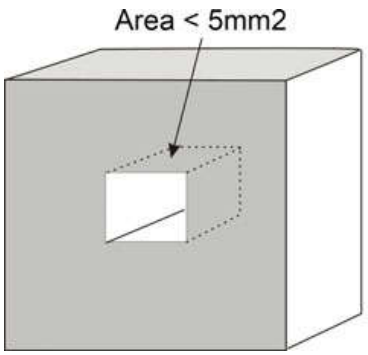
Design Guidelines (DFAM)

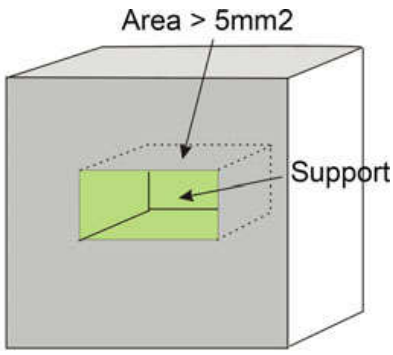
#15 Design of light weight structures (Generative Design)

Design Guidelines (DFAM)

#16 Design for Holes

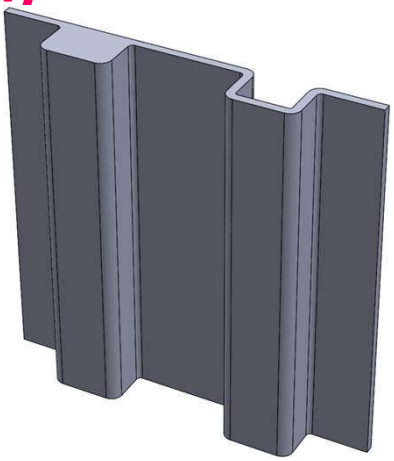






Design Guidelines (DFAM)

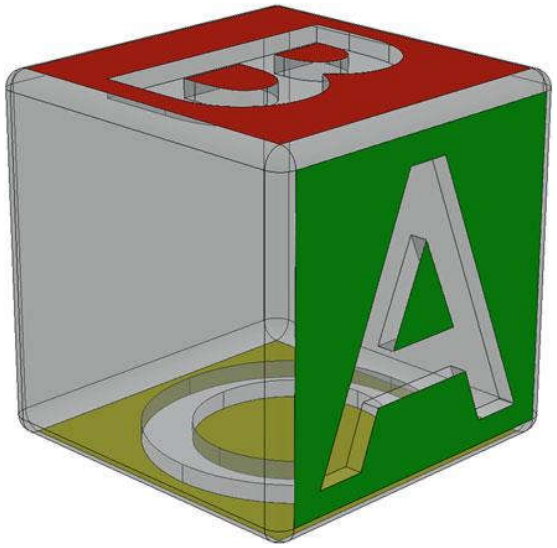
#17 Design of Ribs



Coring out thick ribs

Design Guidelines (DFAM)

#18 Design for Texts & Decals



A font size that usually works on all surfaces is 14pt, and at least 0.4 mm (0.016 in.) in depth.

On vertical surfaces one can go down to about an 8pt font

Computer Software Tools for DFAM Supports

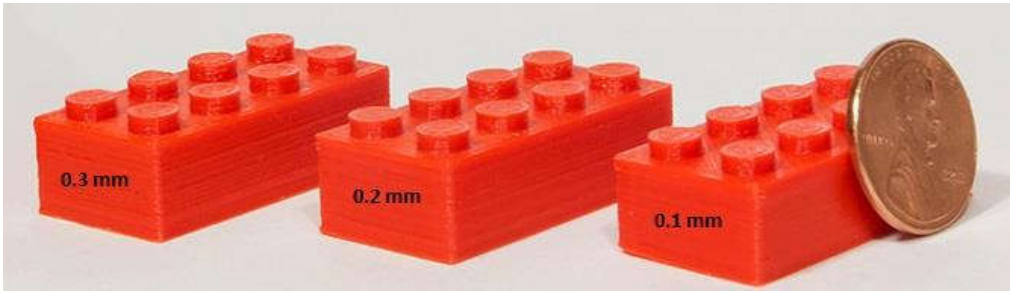
- Abaqus (Dassault Systems)
- Ansys (Ansys Inc)
- Netfabb (Autodesk)
- Siemens NX (Siemens AG)
- Materialise Magics (Materlise NV)
- Simplify3D (Simplify3D)
- 3D systems (3D Systems)
- GrabCAD Print (GrabCAD)
- Makerbot Print (Makerbot Industries)
- Cura (Ultimaker)
- Preform (Formlabs)
- 3Dsim (3Dsim)
- Simufact Additive (MSC Software)

Design Rules/Constraints/ Considerations

- Layer Thickness
- Accuracy and Tolerances
- Support Structure Style
- In Fill Style
- Vertical Wall Thickness
- Horizontal Walls
- Support Material Overhang Angles
- Clearances Between Moving Parts
- Built-in Screw Threads
- Square Profile Through Holes
- Hole Proximity to Wall Edge
- Vertical Circular Holes
- Circular Pins

Design Rules/Constraints/ Considerations

Layer Thickness



- 0.1 mm layer thickness will take three times longer to print than a 0.3 mm layer thickness.
-

Design Rules/Constraints/ Considerations

Accuracy and Tolerances

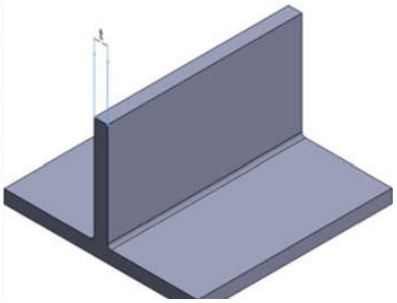
- Accuracy is how close the part is to the CAD model data.
- Tolerance is the acceptable degree of variation.

The standard accuracy we offer for ABS is 0.15% with a lower limit on ±0.2 mm.

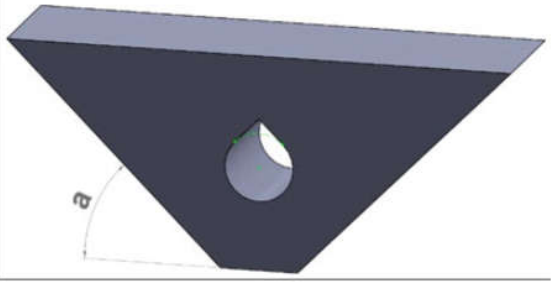
Reality rule of thumb for Material Extrusion: typically 0.25 mm (0.01 in.)

Design Rules/Constraints/ Considerations

Process variable	Wall thickness (t)	
Layer thickness	Minimum	Recommended minimum
0.18 mm (0.0071 in.)	0.36 mm (0.014 in.)	0.72 mm (0.028 in.)
0.25 mm (0.0098 in.)	**0.50 mm (0.02 in.)**	**1.00 mm (0.039 in.)**
0.33 mm (0.013 in.)	0.66 mm (0.026 in.)	1.32 mm (0.052 in.)

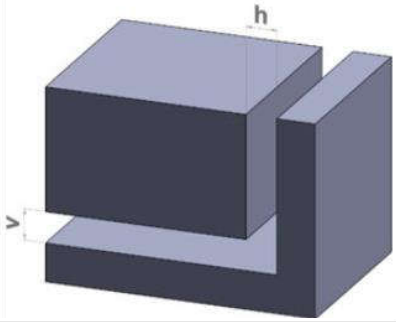


Maximum overhang angle (a)
45° This is a safe default number. But the angle can vary greatly from printer brand to printer brand, and depends on the desired surface quality

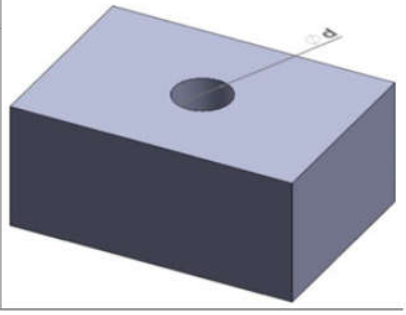


Design Rules/Constraints/ Considerations

Process variable	Minimum clearance	
Layer thickness	Horizontal (h)	Vertical (v)
0.18 mm (0.0071 in.)	0.36 mm (0.014 in.)	0.18 mm (0.0071 in.)
0.25 mm (0.0098 in.)	**0.50 mm (0.02 in.)**	**0.25 mm (0.0098 in.)**
0.33 mm (0.013 in.)	0.66 mm (0.026 in.)	0.33 mm (0.013 in.)

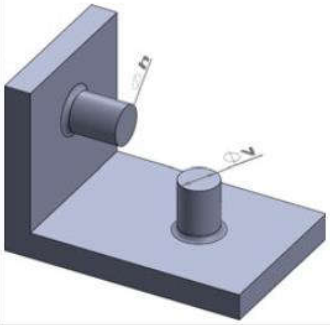


Required diameter (d)	CAD model diameter
5.0 mm (0.197 in.) 10.0 mm (0.394 in.) 15.0 mm (0.591 in.) 20.0 mm (0.787 in.)	5.2 mm (0.205 in.) 10.2 mm (0.402 in.) 15.2 mm (0.598 in.) 20.2 mm (0.795 in.)

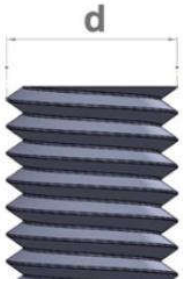


Design Rules/Constraints/ Considerations

Minimum diameter for vertical pins (v)	Minimum diameter for horizontal pins (h)
2.0 mm (0.079 in.)	2.0 mm (0.079 in.)

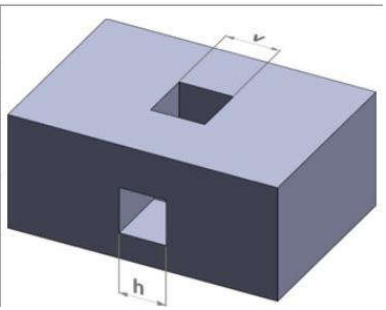


Minimum thread diameter (d)	Minimum "dog-point" lead in (l)
5.0 mm (0.197 in.)	1.0 mm (0.039 in.)

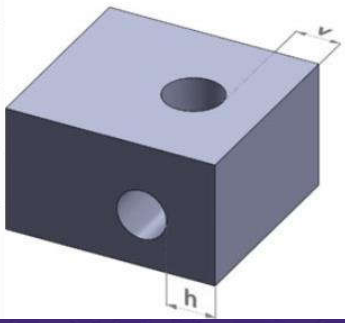


Design Rules/Constraints/ Considerations

Process variable	Minimum diameter	
Wall thickness	Vertical hole (v)	Horizontal hole (h)
1 mm (0.039 in.)	0.5 mm (0.019 in.)	0.8 mm (0.031 in.)
4 mm (0.157 in.)	0.8 mm (0.031 in.)	1.2 mm (0.047 in.)
8 mm (0.314 in.)	1.5 mm (0.059 in.)	1.3 mm (0.051 in.)



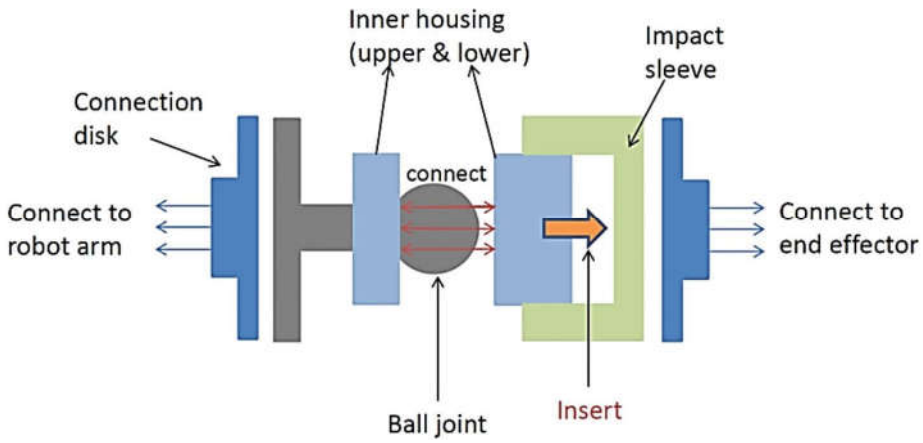
Design variable	Minimum distance to edge	
Hole diameter	Vertical hole (v)	Horizontal hole (h)
2.5 mm (0.098 in.)	0.8 mm (0.031 in.)	0.8 mm (0.031 in.)
5.0 mm (0.197 in.)	0.9 mm (0.035 in.)	0.95 mm (0.037 in.)
10.0 mm (0.394 in.)	1.05 mm (0.041 in.)	1.0 mm (0.039 in.)



Case Studies

Case Studies

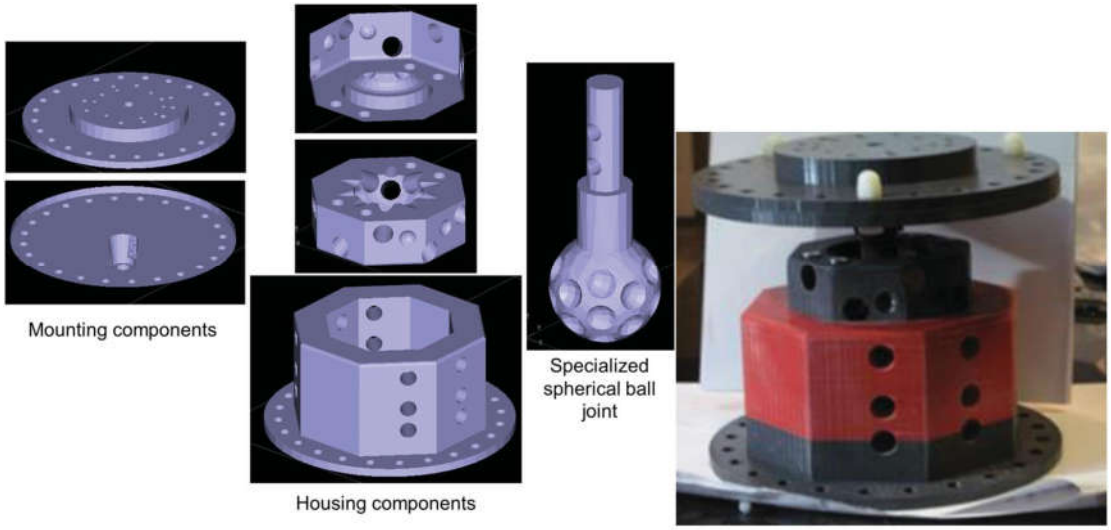
#1. Flexible robot end effector coupling



R. J. Urbanic & R. Hedrick (2016) Fused Deposition Modeling Design Rules for Building Large, Complex Components, Computer-Aided Design and Applications, 13:3, 348-368.

Case Studies

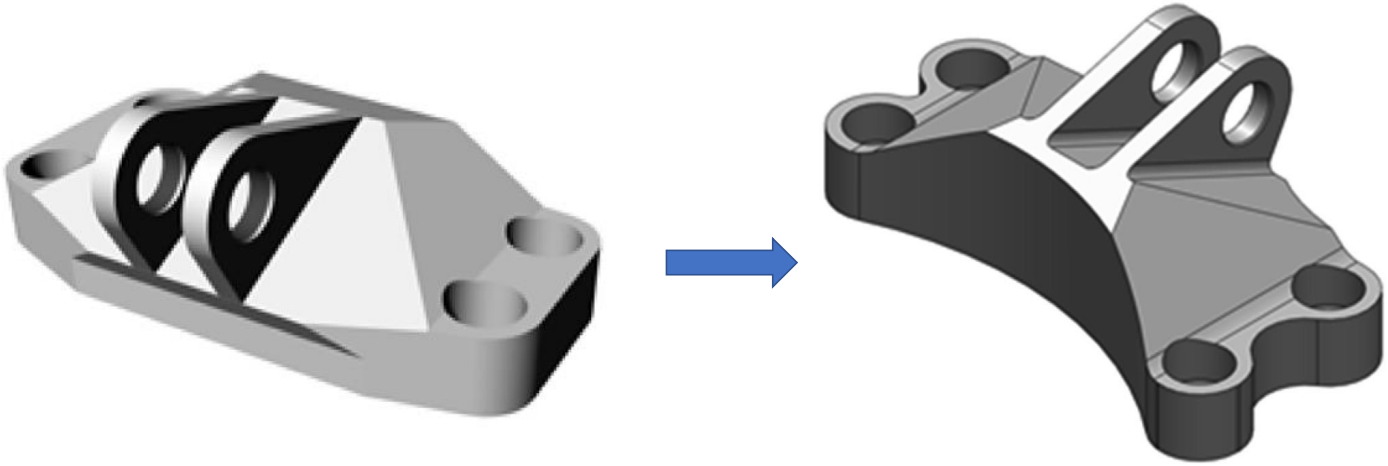
#1. Flexible robot end effector coupling



R. J. Urbanic & R. Hedrick (2016) Fused Deposition Modeling Design Rules for Building Large, Complex Components, Computer-Aided Design and Applications, 13:3, 348-368.

Case Studies

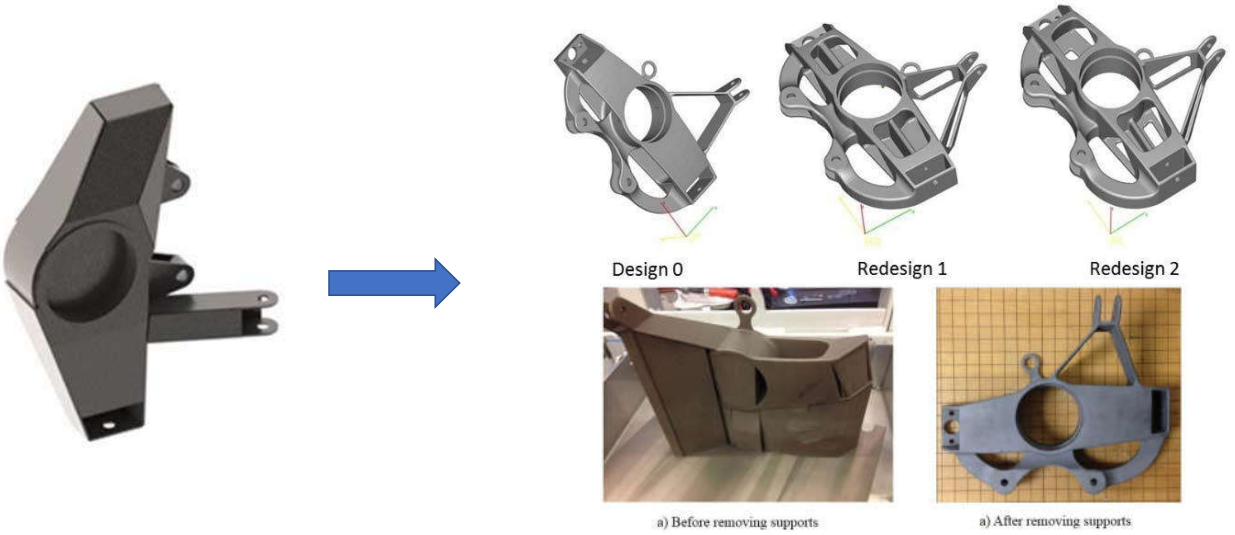
#2. Engine Bracket



Yunlong Tang, Kieran Mak, Yaoyao Fiona Zhao (2016) A framework to reduce product environmental impact through design optimization for additive manufacturing, Journal of Cleaner Production , Volume 137, 20 November 2016, Pages 1560-1572.

Case Studies

#3. Box Welded UPRIGHT used in SAE Formula 1 Race Car



Nithin Reddy (2016) APPLICATION OF TOPOLOGY OPTIMIZATION AND DESIGN FOR ADDITIVE MANUFACTURING GUIDELINES ON AN AUTOMOTIVE COMPONENT, Proceedings of the ASME 2016 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference.

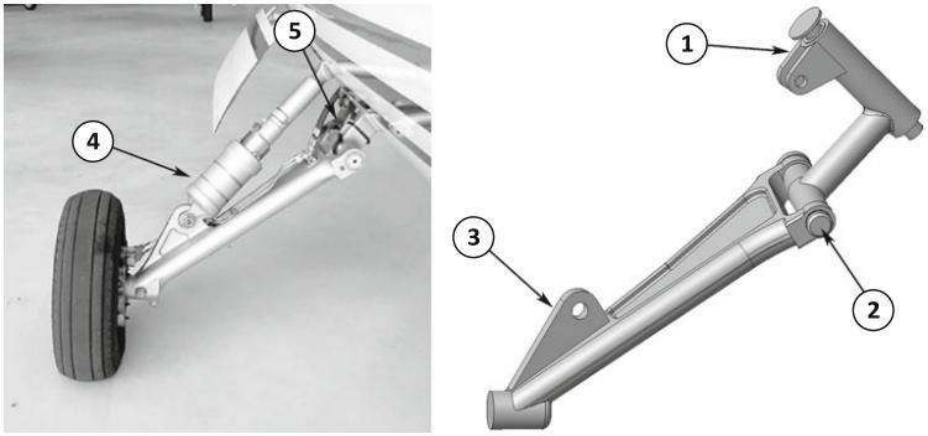
Case Studies

#3 Airbus A320 nacelle hinge brackets & Airbus A380 bracket

Rozvany GIN (2009) A Critical Review of Established Methods of Structural Topology Optimization. Struct Multidiscip Optim 37(3):217–237.

Case Studies

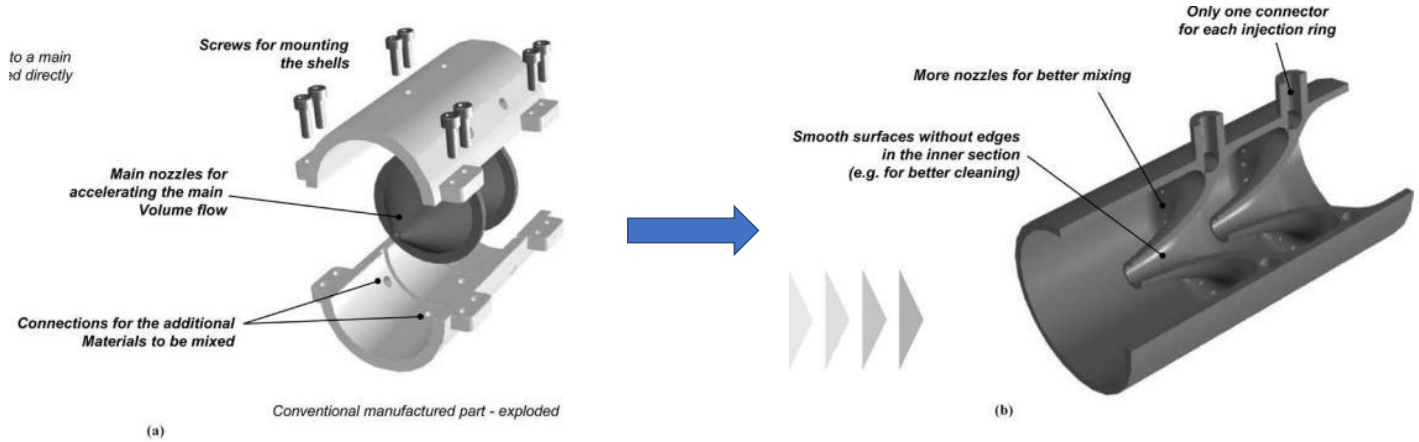
#4 Landing Gears in Italian aircraft P180 Avant II by Piaggio Aero Industries



E. Atzeni and A. Salmi, "Economics of additive manufacturing for end-usable metal parts," International Journal of Advanced Manufacturing Technology, 2012..

Case Studies

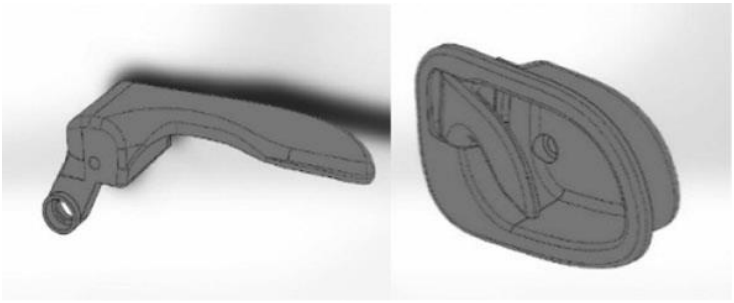
#5 Nozzle used in GE Aviation for LEAP engines



J. Corney, R. Becker, A. Grzesiak and A. Henning, Rethink assembly design, 2005.

Case Studies

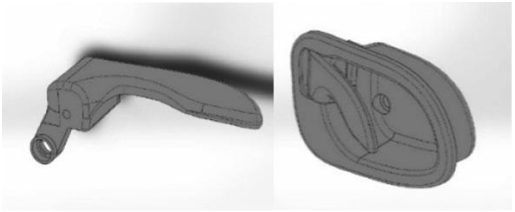
#6 Car Interior Door Handle

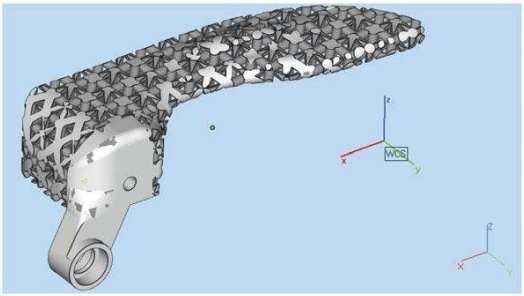


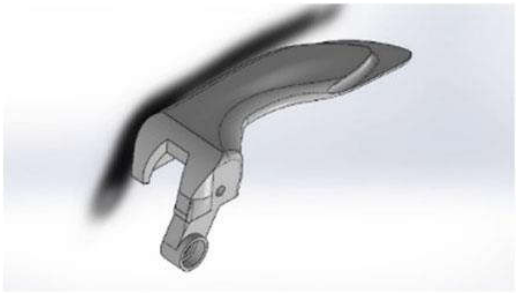
R. Sakthivel MuruganS. Vinodh, Application of Design for Additive Manufacturing to an Automotive Component, Industry 4.0 and Advanced Manufacturing pp 169-183 .

Case Studies

#6 Car Interior Door Handle







R. Sakthivel MuruganS. Vinodh, Application of Design for Additive Manufacturing to an Automotive Component, Industry 4.0 and Advanced Manufacturing pp 169-183 .

Case Studies

#6 Car Interior Door Handle

By implementing the guidelines sequentially,

(1) Topology optimization
(2) Direct printing of assemblies
(3) Design by build orientation
(4) Support structure reduction
(5) Design by lattice structure.

the final redesigned automotive component can be optimized around

11.20% in printing time,
80.32% in material usage and
19.89% in support material usage.

R. Sakthivel MuruganS. Vinodh, Application of Design for Additive Manufacturing to an Automotive Component, Industry 4.0 and Advanced Manufacturing pp 169-183 .

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1. Mary Kathryn Thompson et al (2016), '*Design for Additive Manufacturing: Trends, opportunities, considerations, and constraints*', CIRP Annals - Manufacturing Technology 65 (2016) 737–760.
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Thank You

Role of 3D Printing in Complex Oral and Maxillofacial Surgeries

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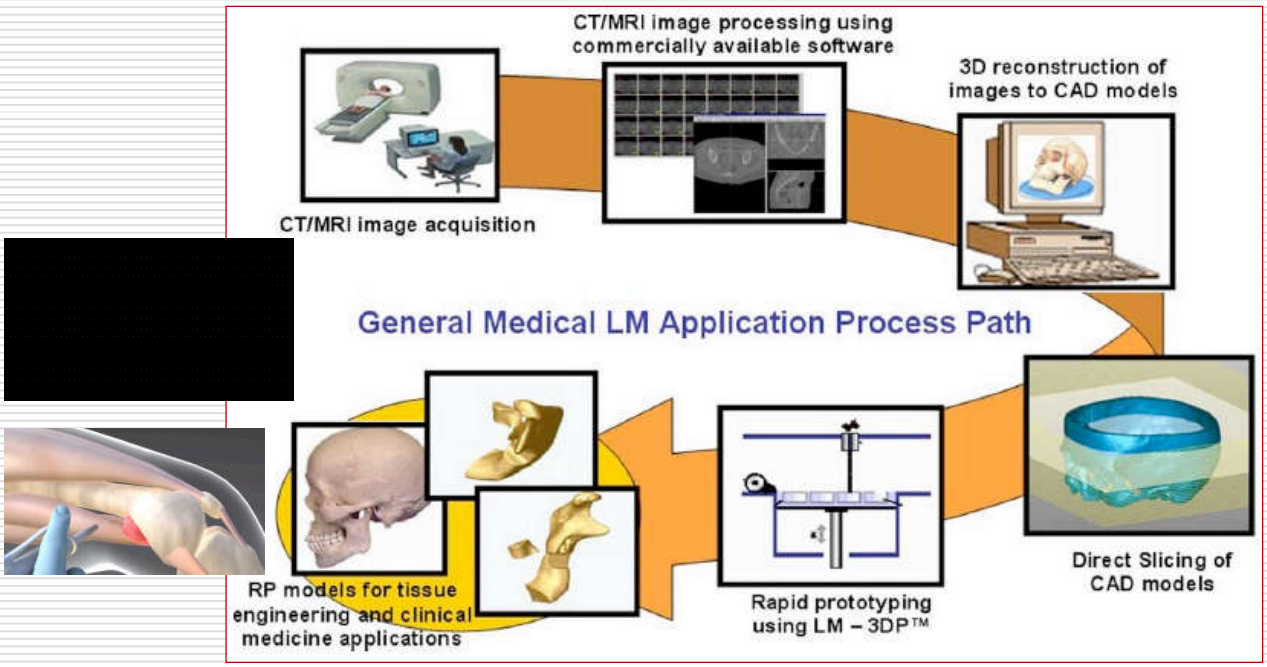
Presentation Outline

- Introduction to Medical-3D Printing
- Case I: Cranioplasty: Modelling and Analysis of Cranial Implant
- Case II: Dental: Implant Placement
- Case III: Mandibular Distraction Osteogenesis
- Case IV: Cancerous Bone Reconstruction
- Case V: Tempero Mandibular Joint Ankylosis
- Case VI: Basal Osseointegrated Implant
- Future: Organ Printing

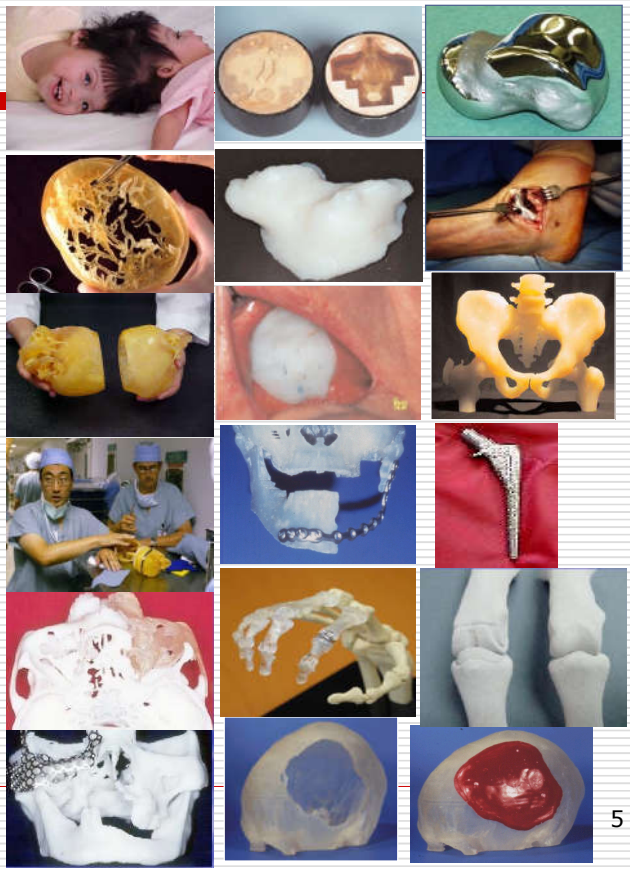
Introduction to Medical 3D Printing

General Procedure of Medical 3DP



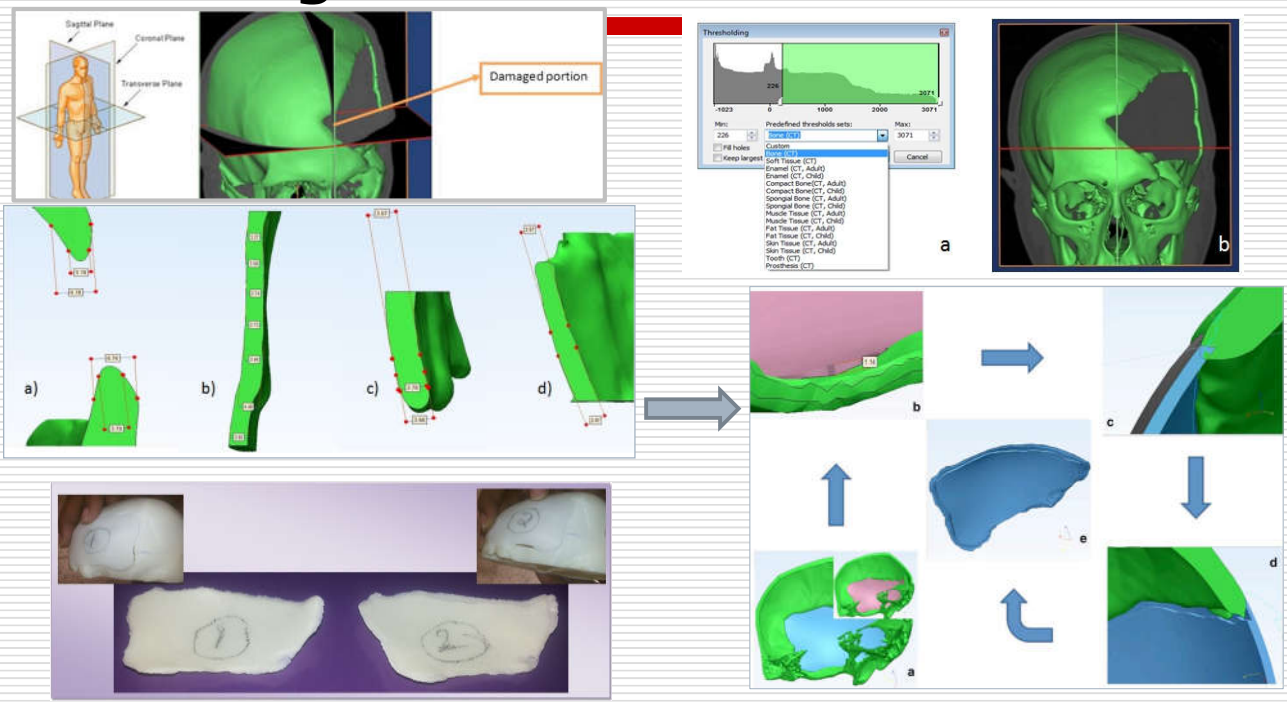
Application of 3DP in Medicine

- Orthopaedic surgeries: Total hip replacement
- *Dental Implants*
- *Cranioplasty*
- *Maxillofacial surgery*
- Biomedical Devices
- Biosensors
- BioMEMS Devices
- Microfluidic devices for Bioprocess & Bioseparation
- Augment Tangible Molecular Models for Research & Education



Case I: Cranioplasty: Modelling and Analysis of Cranial Implant

Case I: Cranial Surgery: 3D Printed Customized Implant for Surgical Planning



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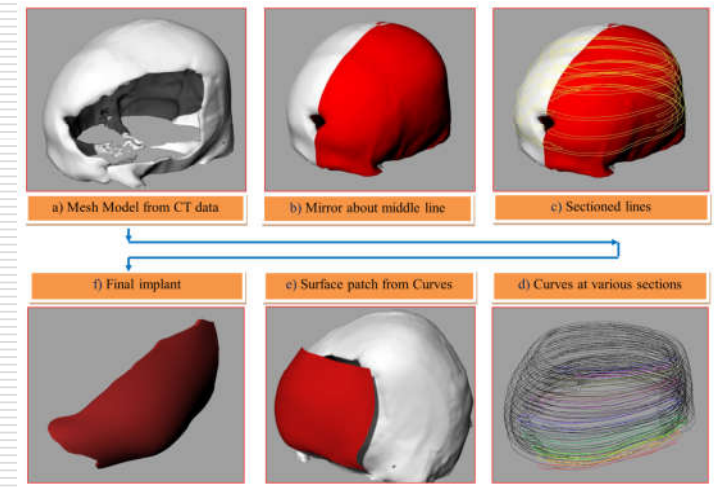
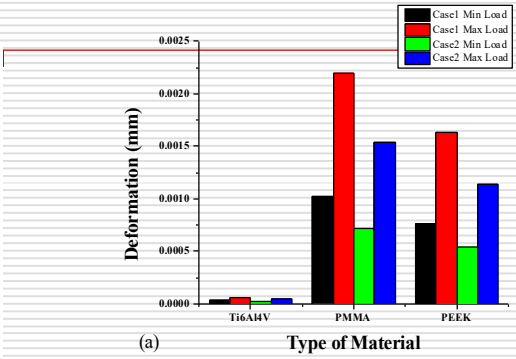
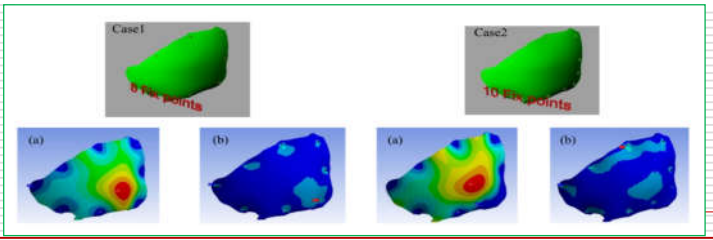
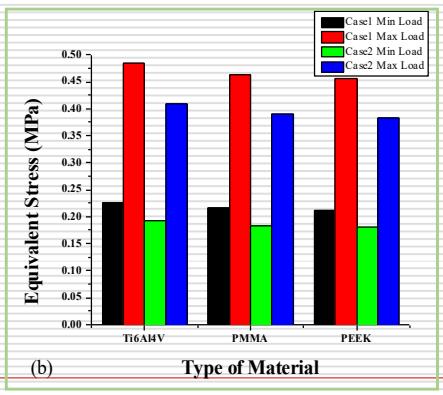
Case I: Cranial Surgery: Modelling and Analysis of cranial Implant beyond mid-line Deformation



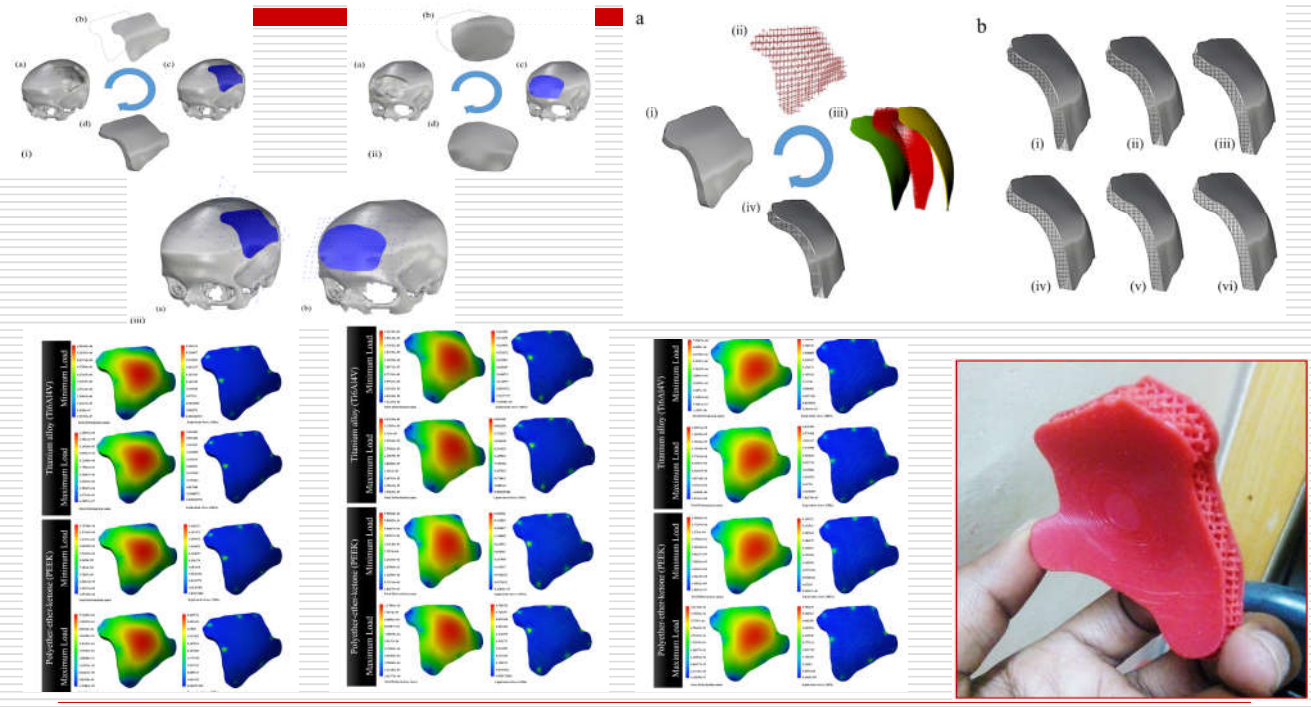






V Phanindra Bogu, **Y. Ravi Kumar**, K. Asit Kumar, "Modelling and structural analysis of skull/cranial implant: beyond mid-line deformities", **Acta of Bioengineering & Biomechanics, Vol. 19 Issue 1, p125-131, 2017.**

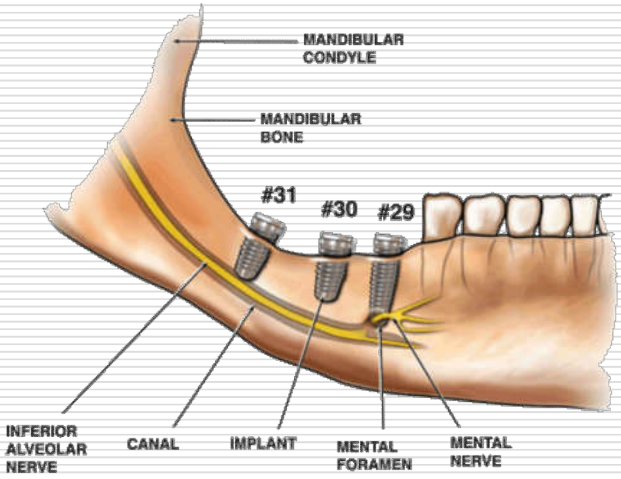
Case I: Cranial Surgery: Modelling and Analysis of Cranial Implant: Meshless Approach

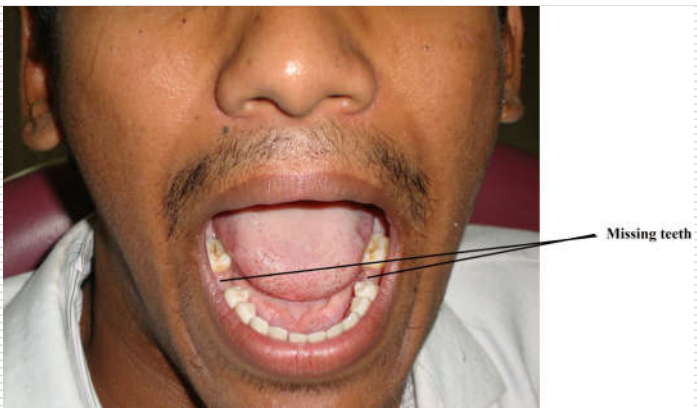


V Phanindra Bogu, **Y. Ravi Kumar,** K. Asit Kumar, "Homogenous scaffold based cranial/skull implant modelling and structural analysis – Unit cell Algorithm – Meshless approach", **Medical & Biological Engineering & Computing, pp 1–13, 2017.**

Case II: Dental: Implant Placement

Case II: Dental: 3DP Models in Dental Implant Placement:19 Year Old Boy





Patient with missing teeth

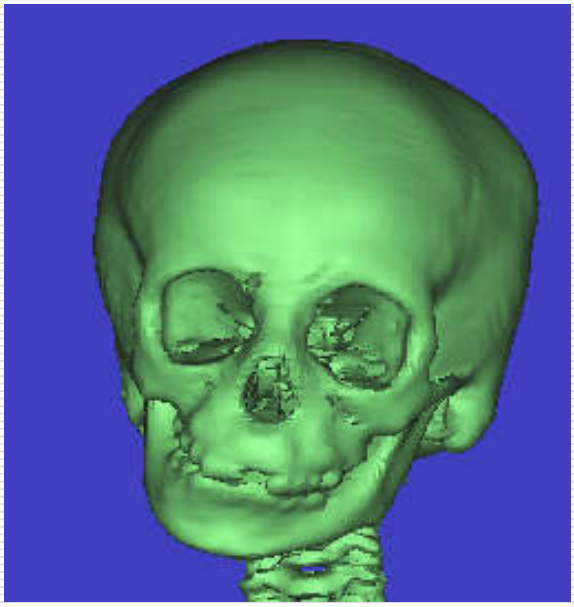
Case II: Dental: 3DP Models in Dental Implant Placement: Mock-Surgery

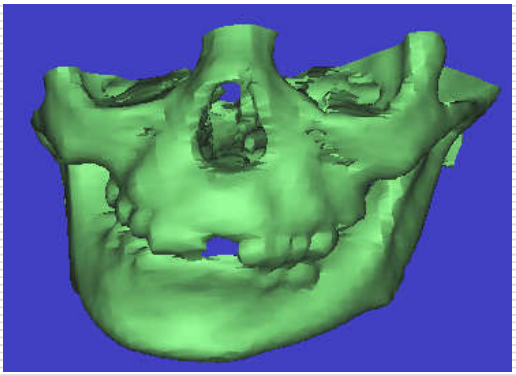
Case II: Dental: 3DP Models in Dental Implant Placement: Surgery

Ravi Kumar, Y., Ghosh, S., "Dental Surgical Planning using CT Scan and Rapid Prototyping", **International Journal of Biomedical Engineering and Technology, 9 (4), 2012, pp. 351-368.**

Case III: Mandibular Distraction Osteogenesis

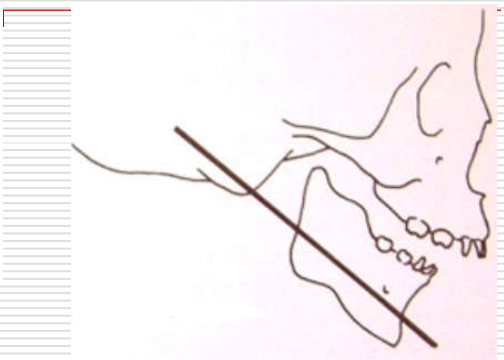
Case III: Reconstruction Surgery: 3DP Models in Oral and Maxillofacial Surgery: MIMICS Software: 3D Model





Case III: Reconstruction Surgery: 3DP Models in Oral and Maxillofacial Surgery: Mandibular Distraction Osteogenesis

Internal mandibular distraction



Distraction along the mandibular

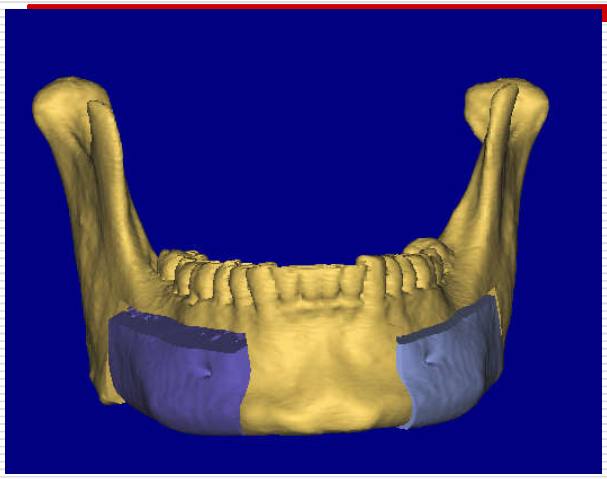
Unidirectional intraoral distractors were fixed in place

Case III: Reconstruction Surgery: 3DP Models in Oral and Maxillofacial Surgery: Bio-Model

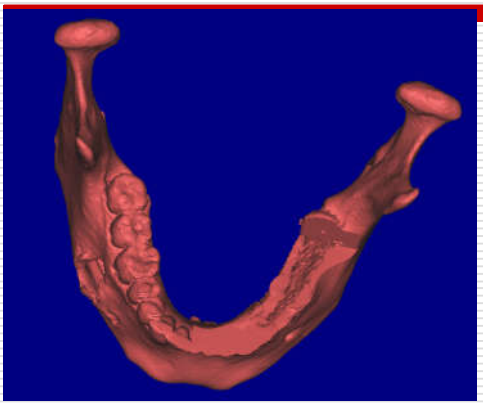
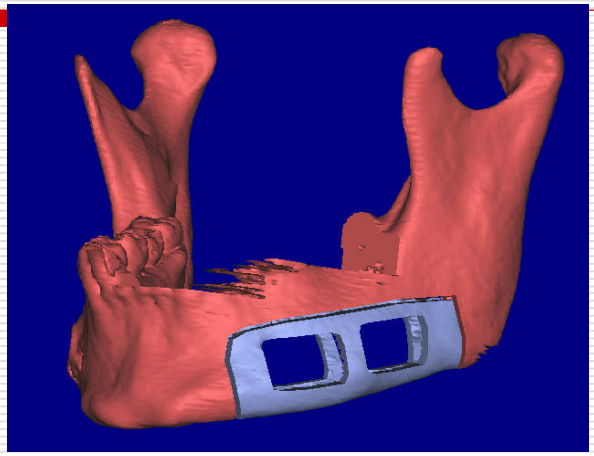
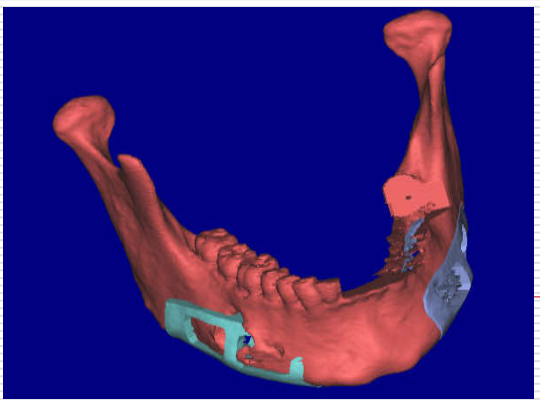
Manmadhachary, A., **Ravi Kumar, Y.,** and Krishnanand, L., "Effect of CT Acquisition Parameters of Spiral CT on Image Quality and Radiation Dose", **Measurement, 103, 2017, pp. 18-26.**

Case IV: Ameloblastic Fibroma of Mandible/Cancerous Bone Reconstruction

Case IV: Cancerous Tumor Removal Surgery: 3DP Models in Oral and Maxillofacial Surgery: Planning the Tumor Removal




Case IV: Cancerous Tumor Removal Surgery: 3DP Models in Oral and Maxillofacial Surgery: Weight Optimization


Case IV: Cancerous Tumor Removal Surgery: 3DP Models in Oral and Maxillofacial Surgery: Fabrication of Customized Metal Implant

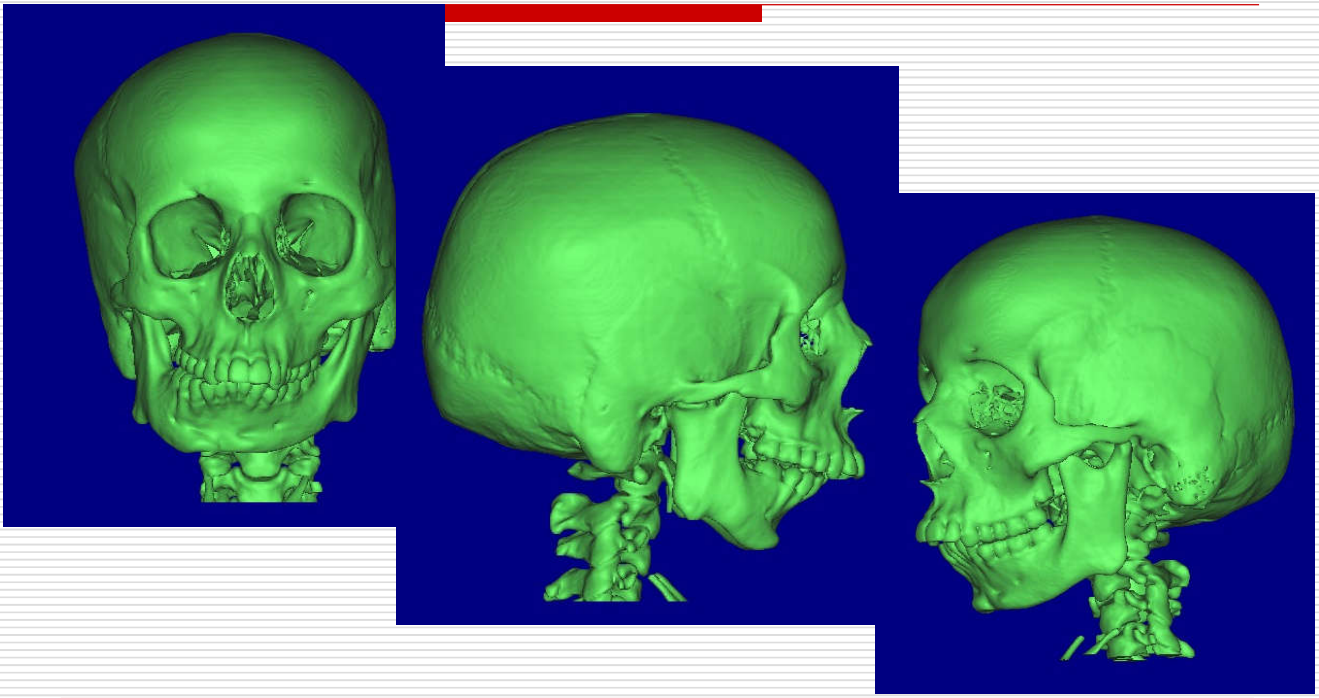
Manmadhachary, A., **Ravi Kumar, Y.,** and Krishnanand, L., "Finding of Correction Factor and Dimensional Error in Bio-AM Model by FDM Technique", **Journal of The Institution of Engineers (India): Series C, 2016, pp. 1-8.**

Case IV: Cancerous Tumor Removal Surgery: 3DP Models in Oral and Maxillofacial Surgery: Planning the Metal Implant

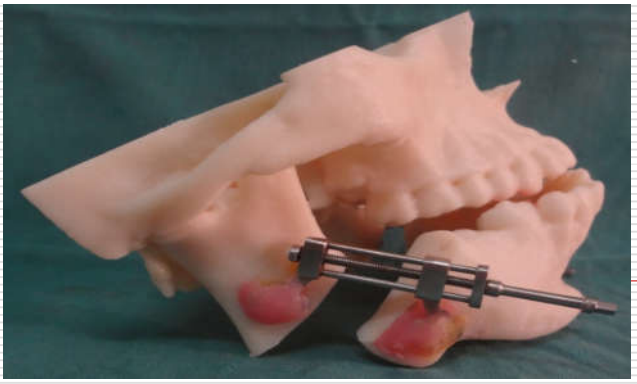
Case IV: Cancerous Tumor Removal Surgery: 3DP Models in Oral and Maxillofacial Surgery: Post-operative

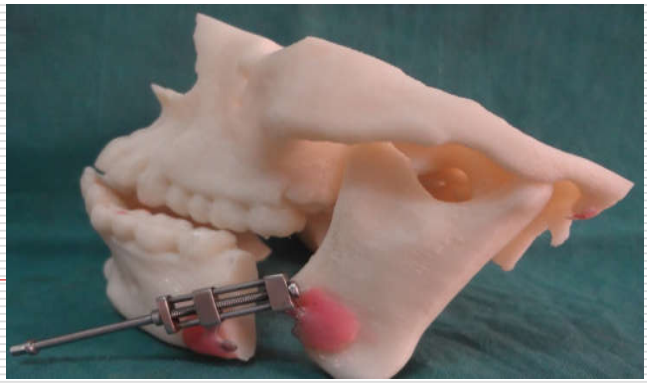
Case V: Tempero Mandibular Joint Ankylosis

Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: 3D CAD Model



Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: Planning for Distraction Osteogenesis



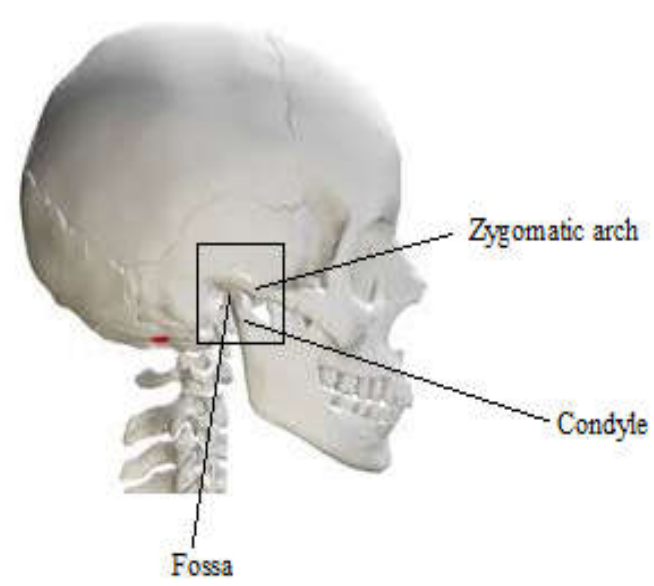


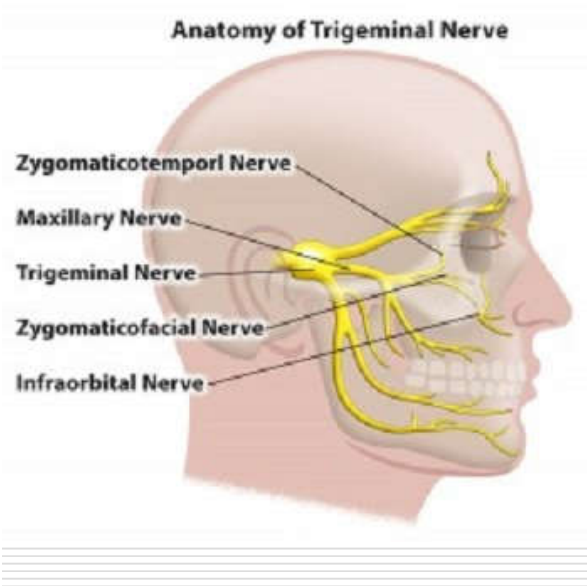
Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: Intra-operative

Manmadhachary, A., **Ravi Kumar, Y.,** and Krishnanand, L., "Improve the accuracy, surface smoothing and material adaption in STL file for RP medical models" **Journal of Manufacturing Processes, 21, 2016, pp. 46-55.**

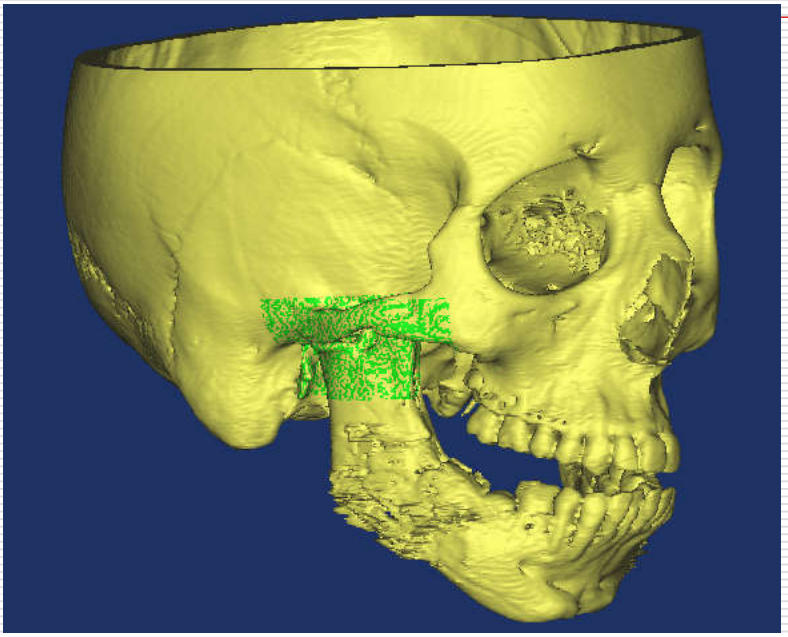
Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: Pre and Post-Operative Conditions

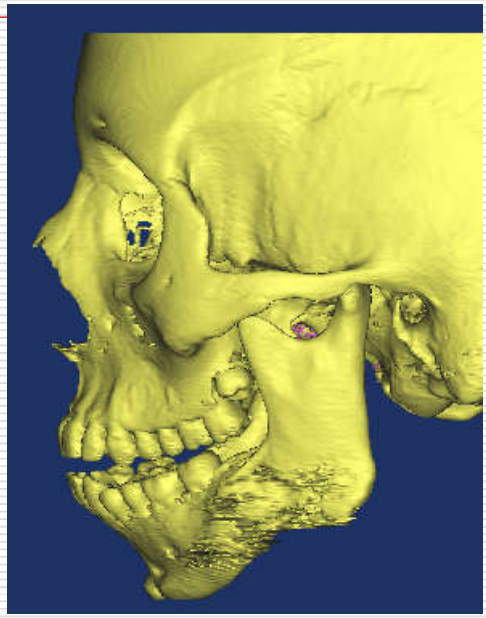
Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: TMJ Joint Anatomy and Nerve System



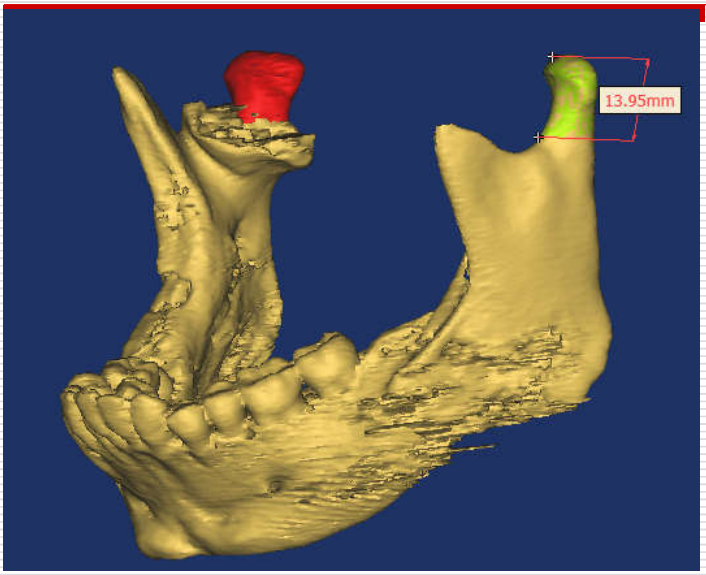


Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: Replacement of TMJ Joint (Patent Pending)



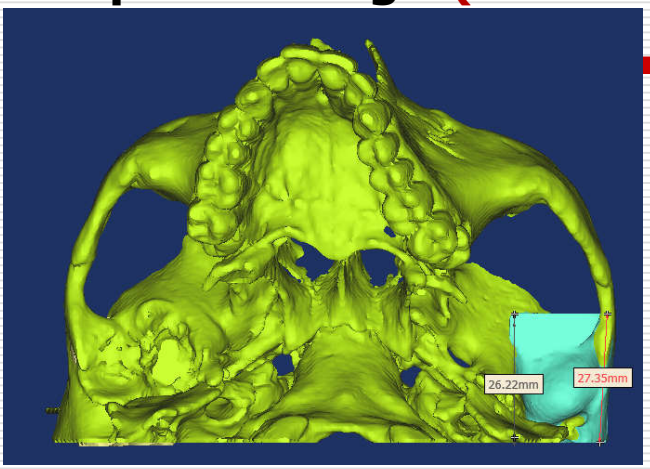


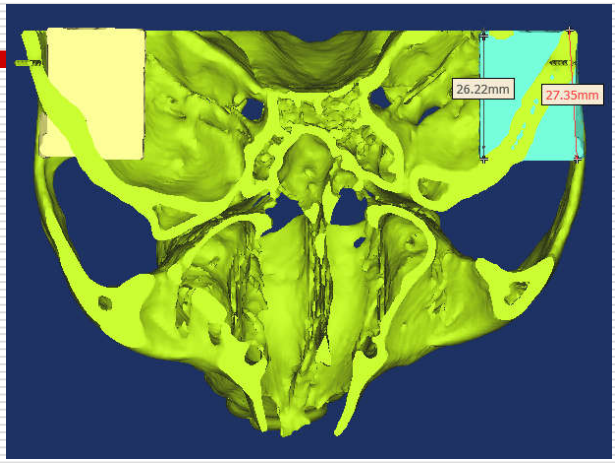
Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: Condyle Implant Design (Patent Pending)



A. Manmadhachary, Aditya Mohan Alwala, V. Giridhar Kumar, **Y. Ravi Kumar,** "Implantable Device for Tempero Mandibular Joint and Method of Production thereof", **Indian Patent No. 201741023907**, 07.07.2017.

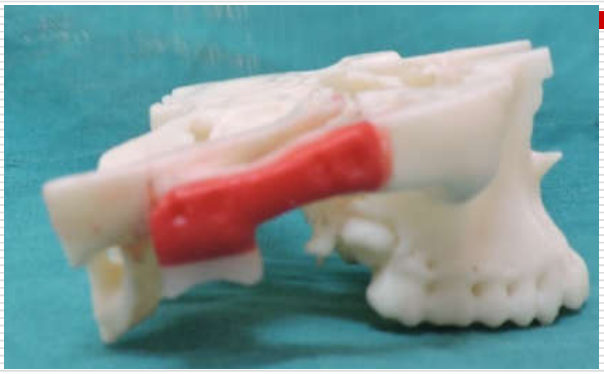
Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: Fossa Implant Design (Patent Pending)

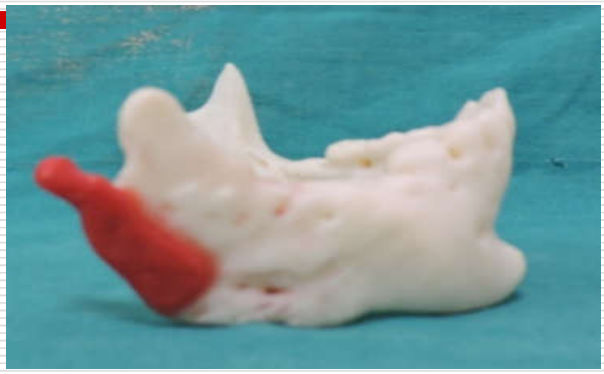


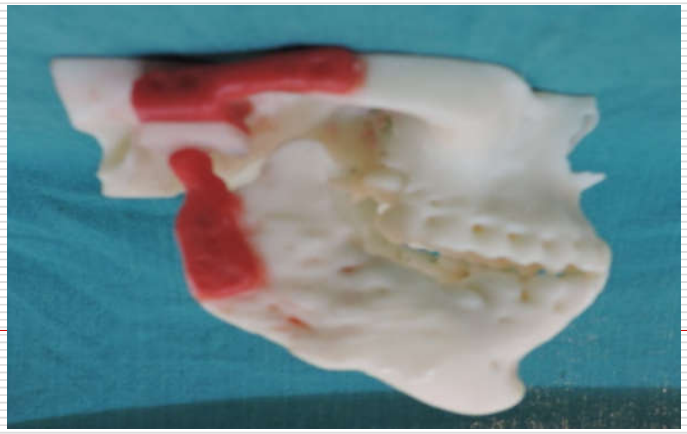


Polycarbonate (PC) material with biocompatible certification (ISO 10993 USP Class VI)

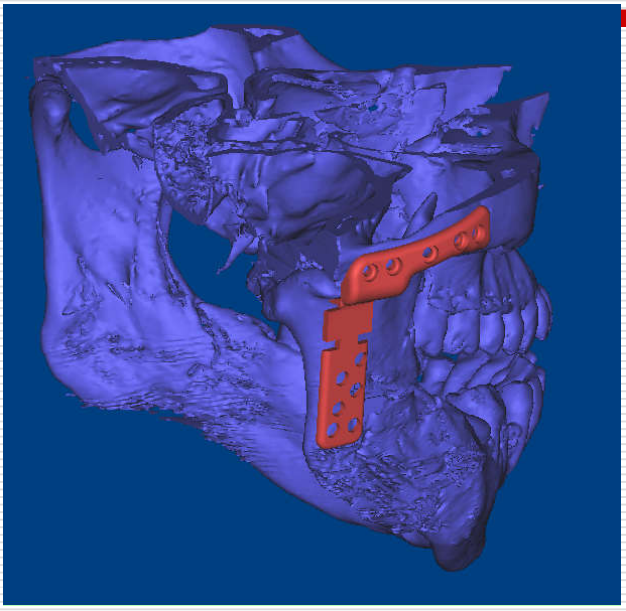
Case V: Tempero Mandibular Joint (TMJ): 3DP Models in Oral and Maxillofacial Surgery: Pre-surgical Planning for Resection of Ankylotic Mass and Alloplastic TMJ Reconstruction (Patent Pending)

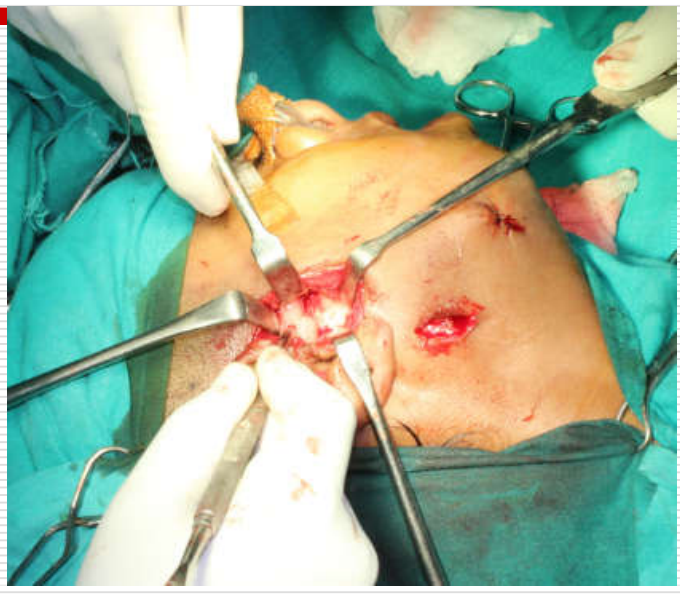






Case V: Tempero Mandibular Joint (TMJ): 3DP Design & Fabrication of Patient Specific Guide: TMJ Joint Reconstruction (Patent Pending)



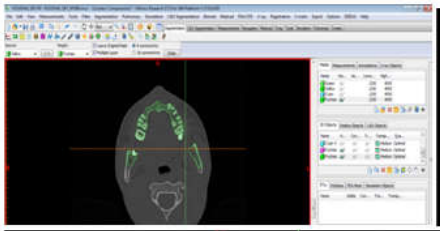


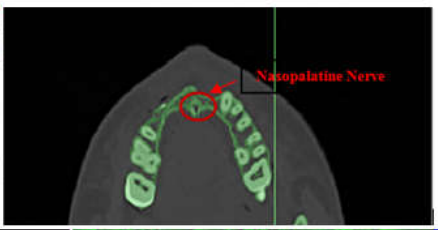
A. Manmadhachary, Aditya Mohan Alwala, V. Giridhar Kumar, **Y. Ravi Kumar,** "Implantable Device for Tempero Mandibular Joint and Method of Production thereof", **USA Patent No: 16/628663**, 04-01-2020.

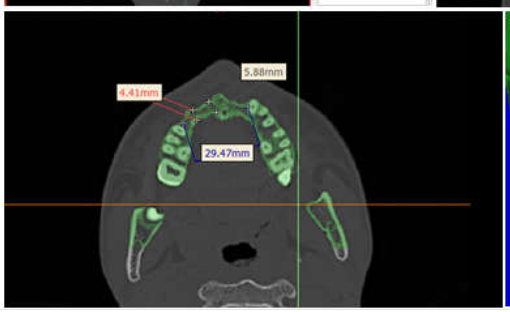
Case VI: Basal Osseointegrated Implant

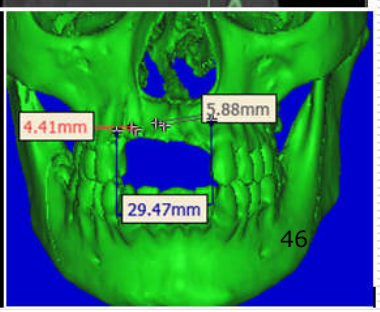
Case VI: Basal Osseointegrated Implant (BOI): Description of the Case

- Due to one major accident patient lost 5 teeth and partial bone damage.
- Cannot fix 5 teeth through convention way
- Nerve Reliving Option.
- Density of the bone is not uniform.
- Angle of the teeth placement.

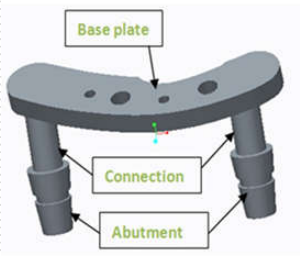


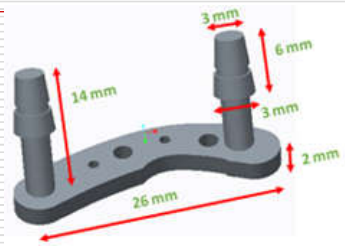


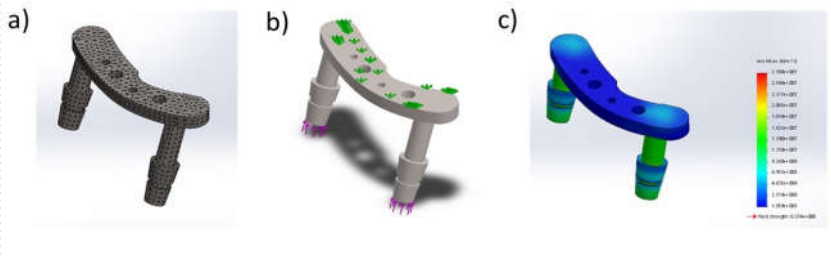


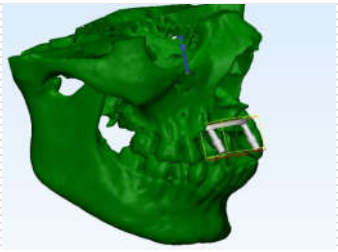


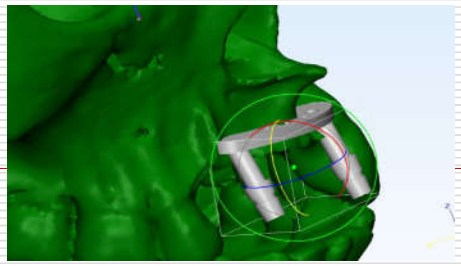
Case VI: Basal Osseointegrated Implant (BOI): Patient Specific BOI Implant

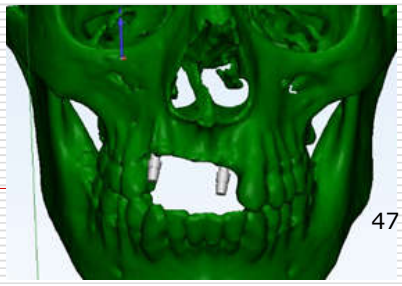




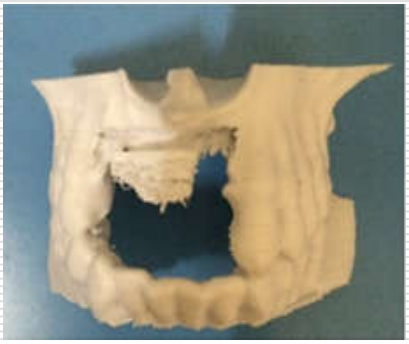




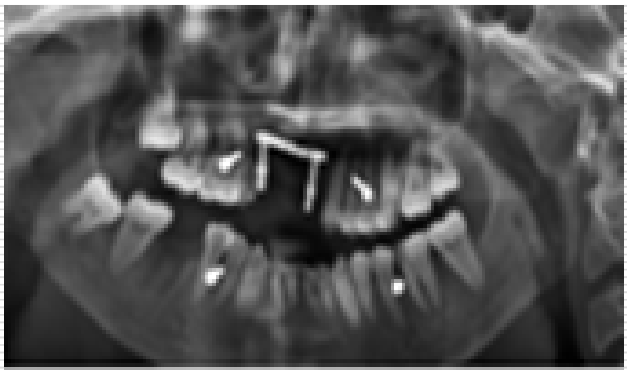




Case VI: Basal Osseointegrated Implant (BOI): Mock Surgery on Patient Specific Medical Model



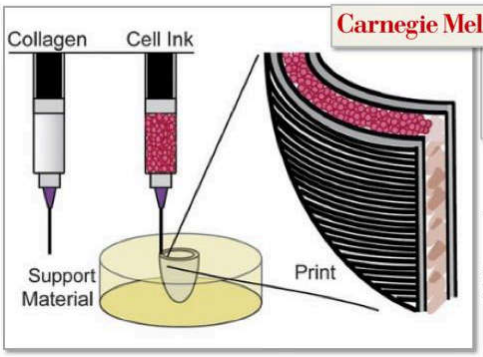
Case VI: Basal Osseointegrated Implant (BOI): Post Surgery of the Patient



Future: Organ Printing

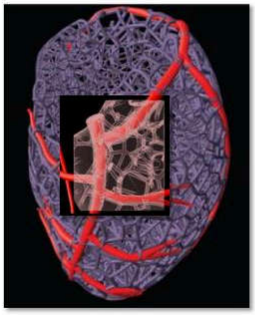
3D Printed Organs and Tissues

Freeform Reversible Embedding of Suspended Hydrogels (FRESH) bioprinting

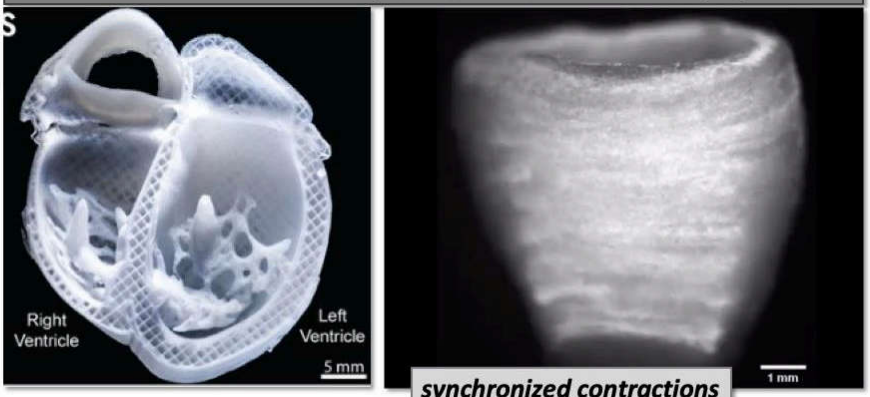


Carnegie Mellon University

MRI data of a human heart → 3D bioprint collagen & human heart cells



Cardiac ventricles printed with human cardiomyocytes

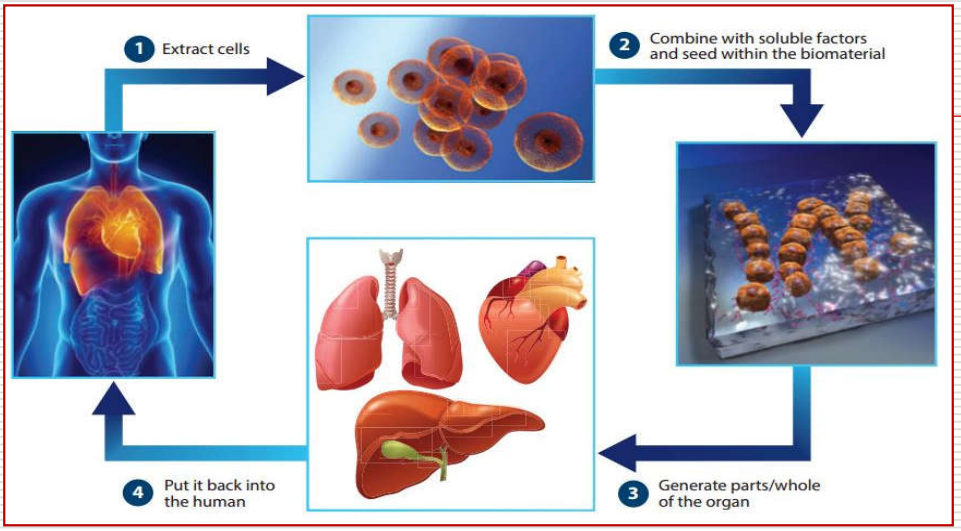


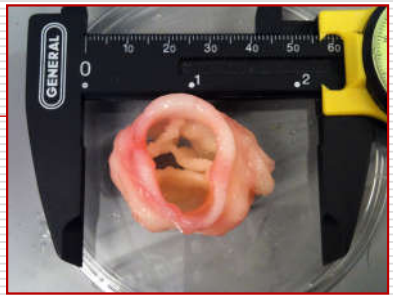
synchronized contractions after 7 days

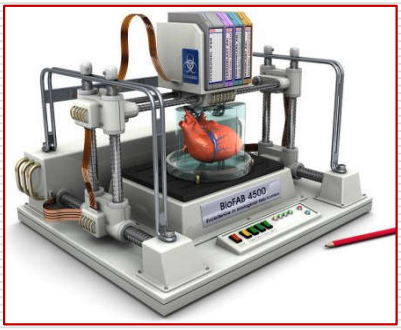
Source: science.sciencemag.org/content/365/6452/482

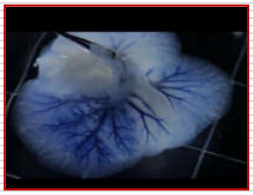
Prof. Adam Feinberg - *CMU Bioengineered Organs Initiative*

Organ Printing









Summary

- General Medical-3D Printing Procedure
- Virtual Models
- Diagnostic Models
- Pre-planning Surgical Models
- Customized Implants & Prosthetics
- Medical Devices
  - IMPLANTABLE
  - NON-IMPLANTABLE, TOOLS, GUIDES, TEMPLATES etc.,
  - SUPPORT DEVICES (ARM BRACES, KNEE BRACES, etc.,)
- Tissue Engineering & Organ Printing

Acknowledgements

- **Dr. N.V.S. Sekhar Reddy & Dr. Aditya Mohan,** Oral & Maxillofacial Surgeon, Panineeya Mahavidyalaya Institute of Dental Sciences and Research Centre, Hyderabad
- **Dr. P. Mahesh,** Prosthodontics & Implantology, Narayana Dental College & Hospitals, Nellore, India
- **Department of Science and Technology (DST), New Delhi, India** for the financial support under SR/FTP/ETA-35/08, under fast track scheme for young scientists
- **Science & Engineering Research Board (SERB), New Delhi, India** for the financial support under SB/S3/MMER/0037/2013, under extra mural research (EMR) scheme
- **UG, PG Students and Ph.D Schalors**

YouTube Channel: **AM LAB NIT Warangal**

AM Facility at NIT Warangal

❑ 3D Printer/3D Scanner

1. DMP Flex Metal 3D Printer
2. Dimension FDM Machine
3. Mojo 3D Printer
4. Ultimaker 2+
5. EinScan-S
6. Sense 3D Scanner
7. Muffle Furnace
8. Shot Peening Machine

❑ 3D Printing Software

1. MIMICS
2. Magics
3. 3-matic
4. Catalyst
5. 3DXpert

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Advanced Software usage in Bio-Medical for 3D Printing

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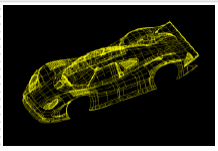
Presentation Outline

- Introduction to 3D Printing
- Medical Image Data Processing Tools
- Importance of Physical Models in Medical
- Reverse Engineering Tools
- Medical Application Development
- 3D Printing Data Formats
- Topology Optimization and Bionic Design
- 3D Printing Simulation Tools
- Fabrication Challenges of 3DP

Introduction to 3D Printing




- **Rapid Prototyping (RP)** is a technology that produces models and prototype parts from 3D CAD model data, CT and MRI scan data, and model data created from 3D object digitizing systems.

- Terry Wohlers

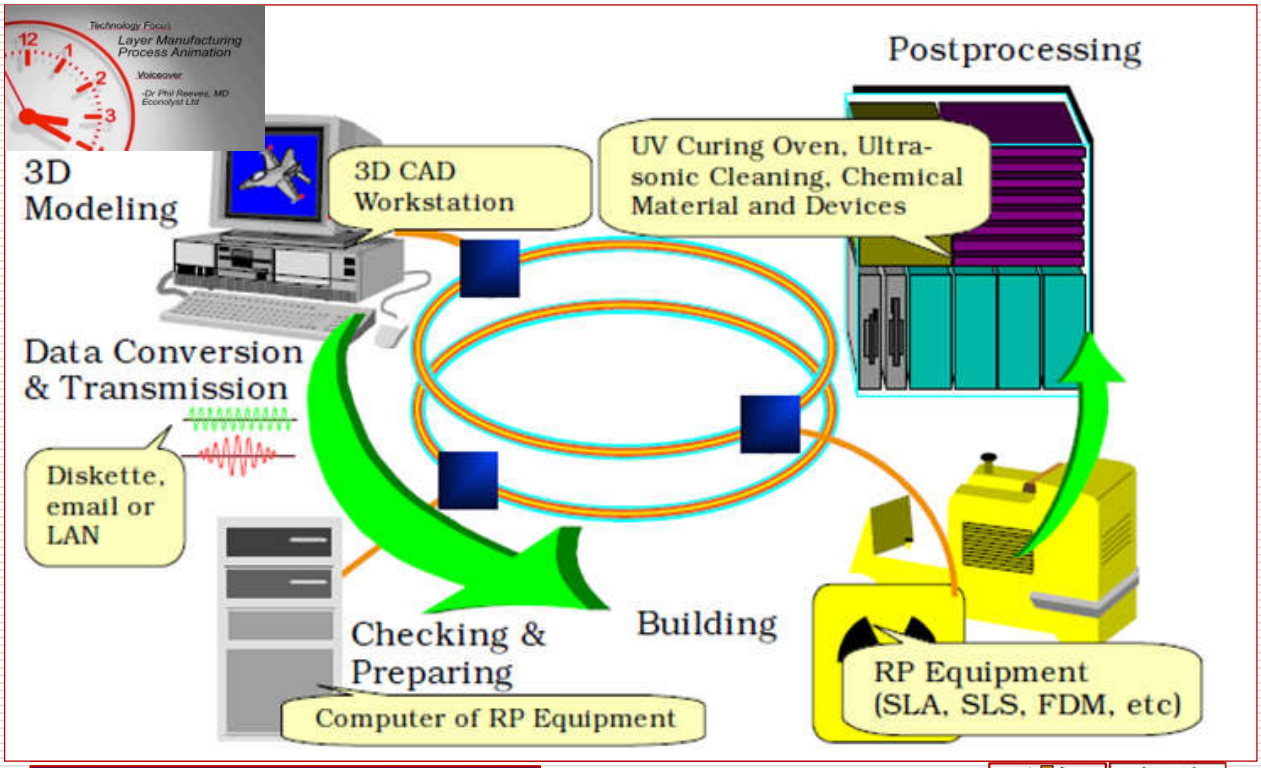
- **Additive Manufacturing (AM)** is new process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies.

- ASTM Definition F2792-10

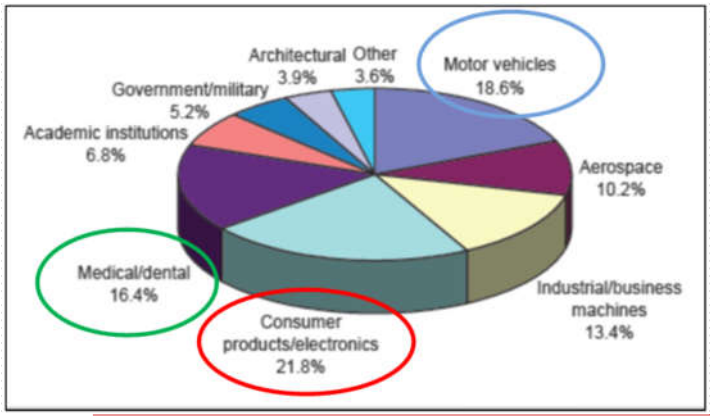
- **3D Printing:** The fabrication of objects through the deposition of a material using a print head, nozzle, or other printer technology.

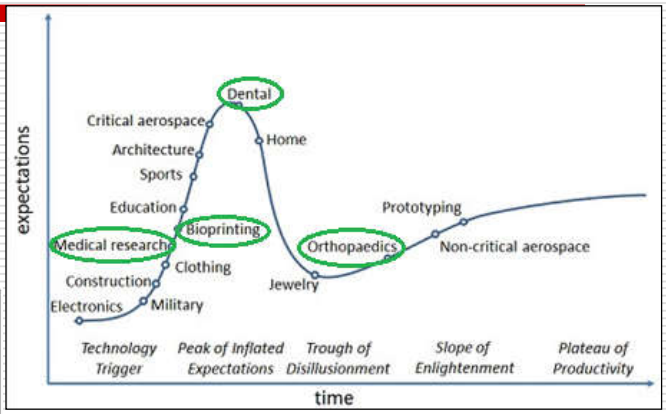
- Terry Wohlers

3DP Process Chain



Applications of 3D Printing



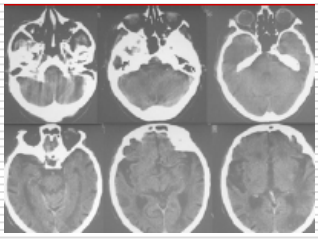


Source: Wohlers Associates, Inc.

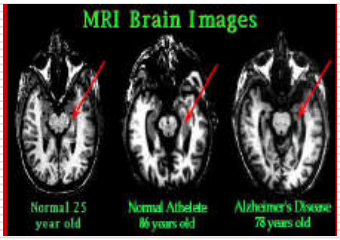
Medical Image Data Processing

Medical Image Processing

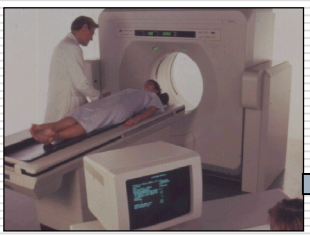
X-ray



CT



MRI



CT/MRI Scan

2-D Cross Sections

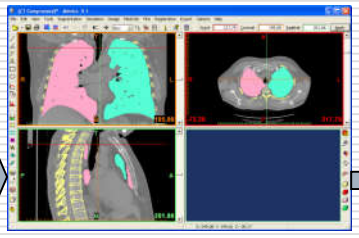
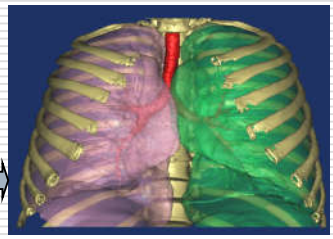


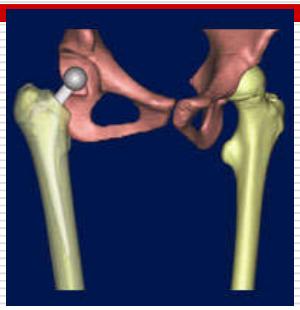
Image processing



Virtual Model

Data Processing in Software

CAD



Simulation

3D Computer Model

FEA

Physical 3D Model

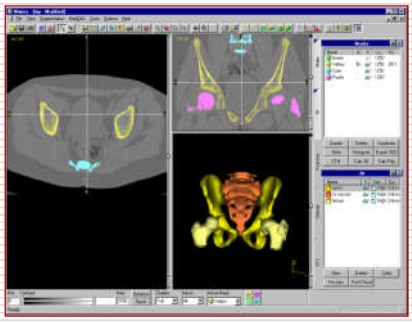
Design Validation

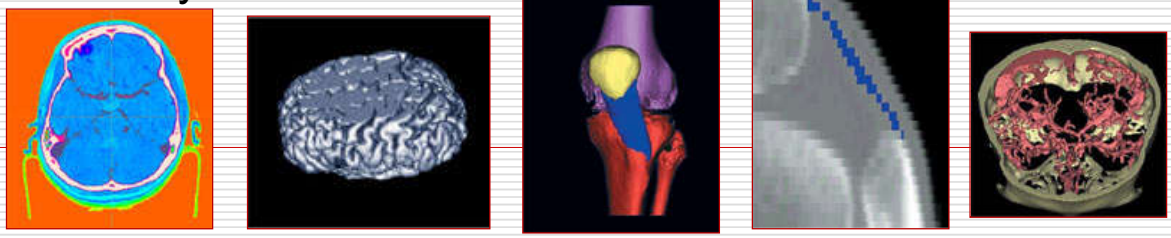
Scanner Image Import

- Mimics imports CT/MRI data from a wide variety of scanner formats in DICOM (Digital Imaging and Communications in Medicine) standard
  - Toshiba, Siemens, Philips, Hitachi, GE, Elscint, Asahi Roentgen, Picker, Shimadzu, Yokogawa

Segmentation Tools

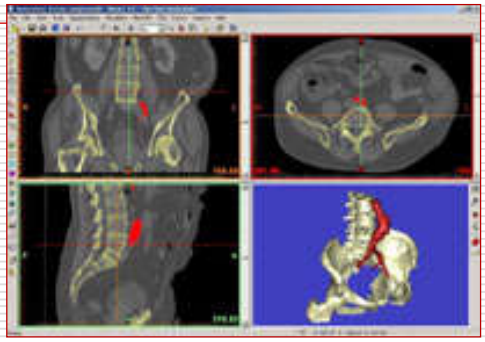
- Segmentation masks are used to highlight regions of interest
  - Thresholding
  - Region Growing
  - Editing (Draw, Erase, Local Threshold)
  - Dynamic Region Growing
  - Morphology Operations
  - Boolean Operations
  - Cavity Fill

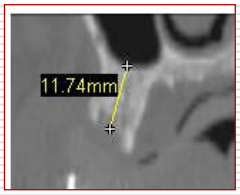


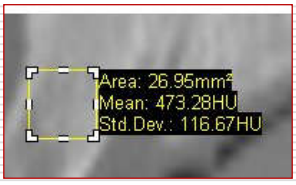


Visualisation and Measurement Tools

- Visualisation
  - 3D Rendering and 3D information
  - Reslicing
- Measurement
  - Point to point
  - Profile line and gray value measurement
  - Density measurements
  - Labels
  - Reporting

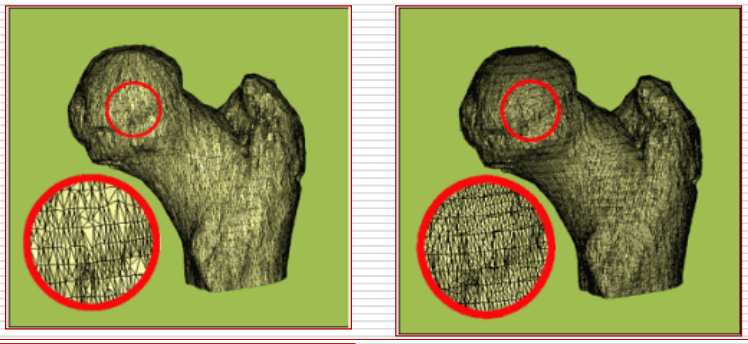






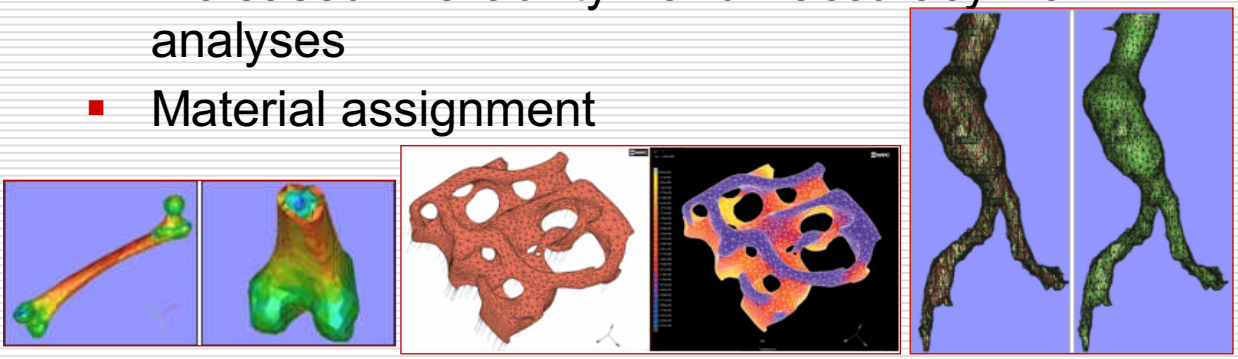
STL+ Module

- It interfaces from Mimics to any kind of 3D Printing system via triangulated files
  - ASCII STL, Binary STL, DXF, VRML 2.0 and Point Cloud



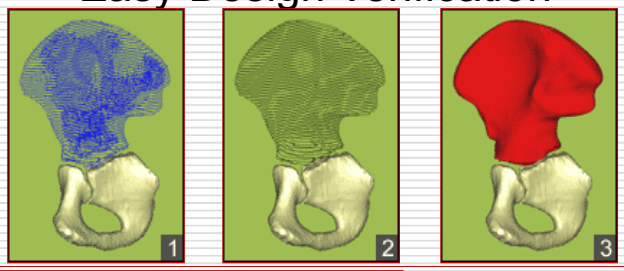
FEA Module

- It provides an interfacing to FEA and CFD
  - Patran Neutral, Abaqus, Ansys, Fluent, Nastran
  - Remesher
  - Increased reliability and accuracy of FE analyses
  - Material assignment



MedCAD Module

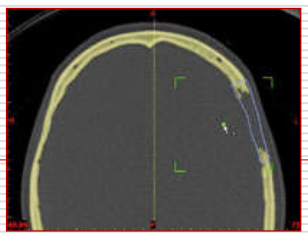
- It provides a bridge between medical imaging (CT/MRI) and CAD design
- The MedCAD Module creates a two-way interface from the imaging system to the CAD system and vice versa
  - Transfers scanner images to CAD objects
  - Easy Design Verification

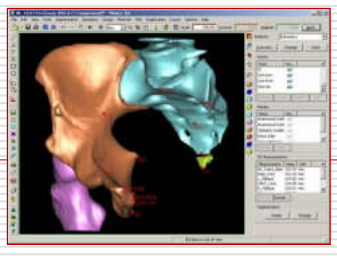


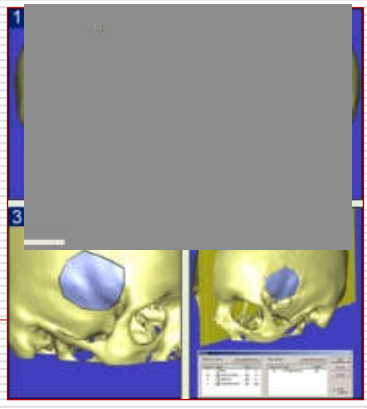
Simulation Module

- It enables to perform a detailed analysis of data using the anthropometric analysis templates, alter 3D objects with the cutting or reposition operations or simulate and explain surgical procedures for implant design
  - Anthropometric Analysis, Landmarks list, Planes list, Measurements list
  - Surgical procedure simulation

    (Cut, Split, Merge, Mirror, Reposition)

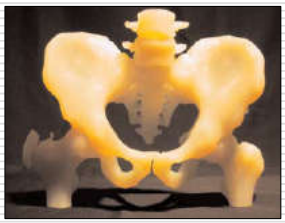






RP Slice Module

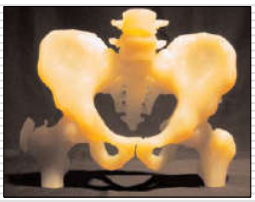
- It interfaces from Mimics to any kind of Rapid Prototyping system via sliced formats
- It automatically calculates the support structures necessary to produce the RP model

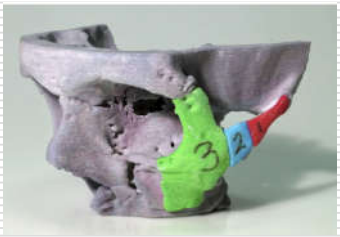
Medical Image Processing Software for 3D Printing

- Mimics
- iNtuition
- F.A.S.T
- Dolphin 3D Surgery
- D2P
- Amira
- OsiriX MD
- Vitrea
- 3D-Doctor
- Simpleware
- AnatomicsRx
- Analyze
- NemoFAB
- Seg3D/Biomesh3D
- Ossa3D
- 3D Slicer
- MeVisLab
- Itk-SNAP
- 4DICOM
- Velocity 2

Role of Physical Models in Medical



Why Physical Models?



- Visualization problems
- No physical feel of the area of interest
- **Physical Models**
  - for surgical team communication and to educate patient
  - to assist surgeons with diagnosis and surgical planning
  - for the rehearsal and simulation of surgery
  - for the creation of customized prosthetics
  - for the accurate placement of implants

Fabrication of Physical Models

- **Subtractive (NC Milling)**
- **Additive (3D Printing)**

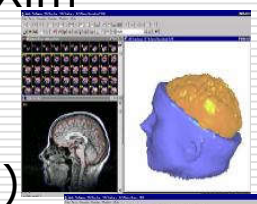
- It start with a 3D CAD model of the anatomy which is derived from CT/MRI data
- The shape of the model is milled from a block of polyurethane or foam
- **Limitations:** Complex geometries (undercuts, voids, internal geometries like neurovascular canals) are difficult to program, materials are brittle, soft, and non-sterilizable.

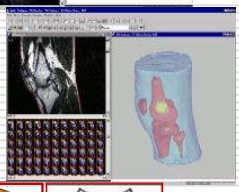
Steps in Medical-3DP

1. Data Acquisition
1. Non-contact (CT/MRI)
2. Contact

2. Data Processing
1. MIMICS
2. Velocity^2 Pro
3. 3D-Doctor
4. VoXim

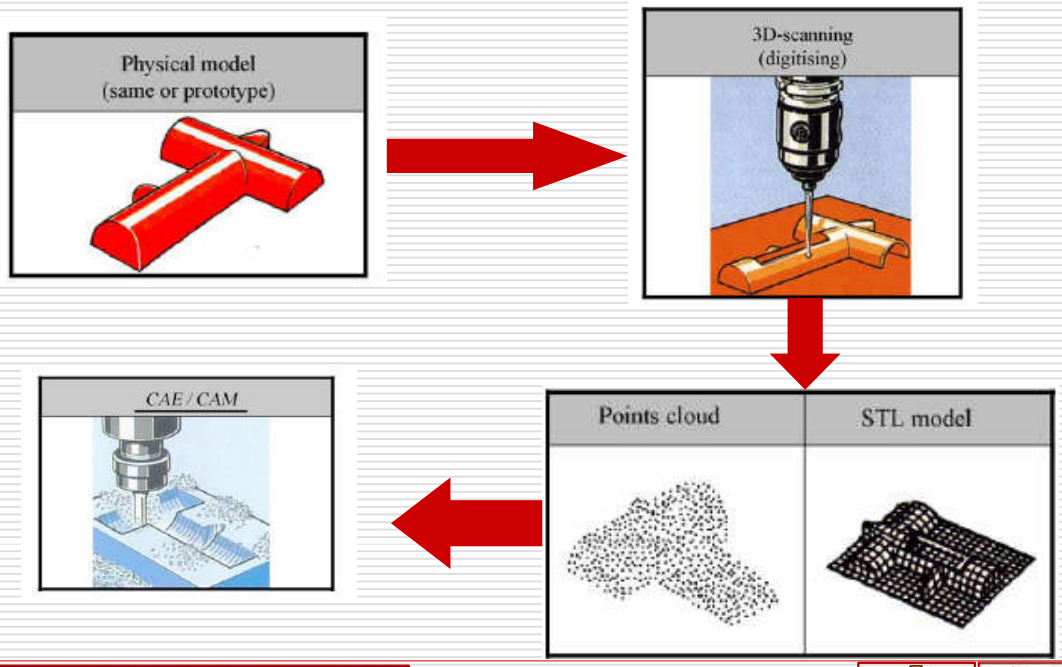
3. Model Fabrication
1. Stereolithography (SLA)
2. Fused Deposition Modeling (FDM)
3. Selective Laser Sintering (SLS)
4. Laminated Object manufacturing (LOM)
5. Three Dimensional Printing (3DP)
6. Laser Engineered Net Shaping (LENS)



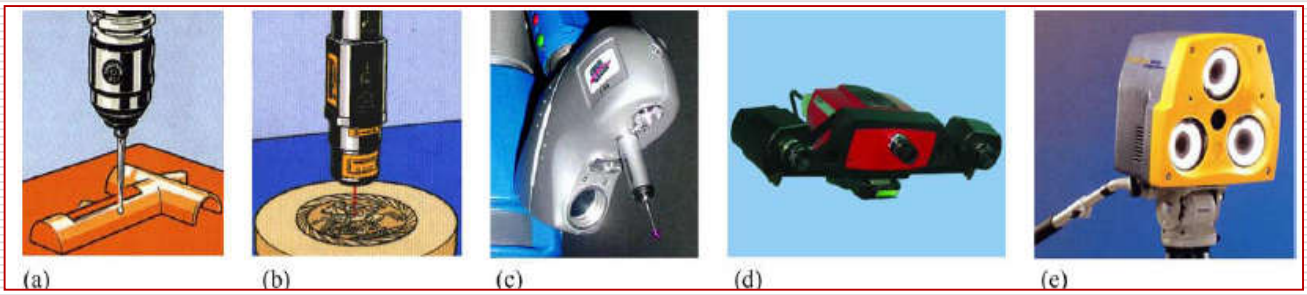


Introduction to Reverse Engineering

Steps in Reverse Engineering



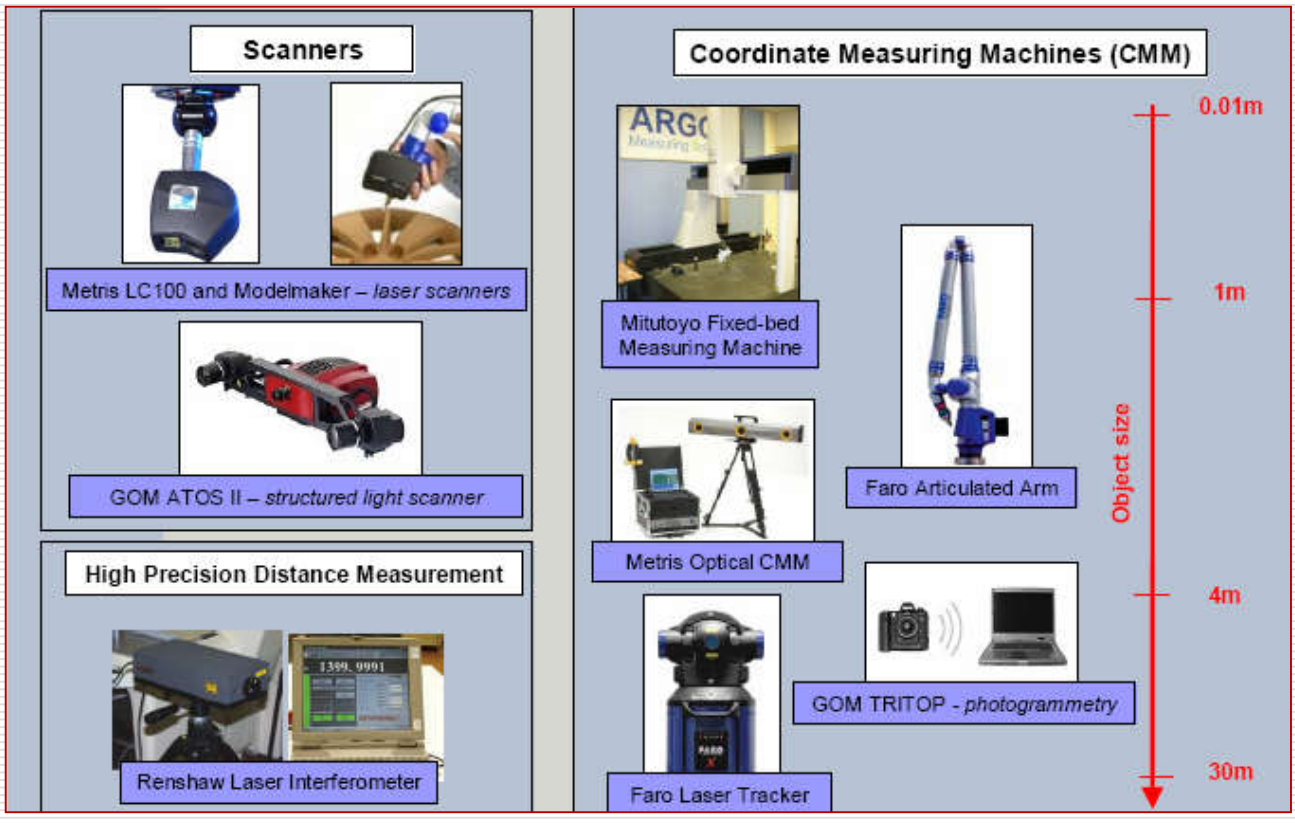
Types of Scanning Devices



(a) Physical touching probe
(b) Laser beam probe
(c–e) Optical (CCD cameras)
(f) CT Scanner

(f)

RE Scanners



3D Scanning Tools

- Geomagic
- KinectFusion
- ReCap
- Metashape
- ContectCapture
- Scandy Pro 3D
- Scann3D
- Trnio
- Qlone
- PolyWorks
- Pix4D
- Photomodeler
- Artec Studio
- Skanect
- Meshroom
- MicMac
- OpenMVG
- 3DF Zephyr
- FlexScan3D
- DroneDeploy

3D Printing Data Formats

3D Printing Design Process and Tools

3D Model capture	CAD Design	Mesh repair	Slicer Software
Kinect Fusion Autodesk Recap …	Blender AD Fusion 360 Meshmaker Rhino …	Netfabb AD Meshmixer Meshlab …	Cura, Repetier Simplify 3D Slicer for Fusion …

Ansys SpaceClaim, Autodesk Inventor, Siemens NX, SolidWorks …

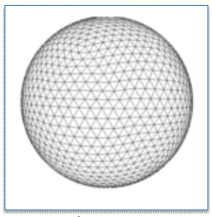
Design libraries of existing 3D models, e.g.: Thingiverse

For added Color and Texture:
e.g. *Blender* or proprietary software such as *Stratasys GrabCAD*

3DP File Formats

3D design files may contain data about geometry, color, texture, and materials

.STL
- old and simple format: describes anl object as a series of linked triangles (Tesselation)
- no info regarding color, texture, material, file security



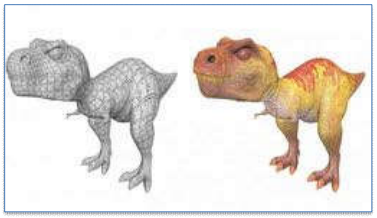
Tesselation: .STL

.OBJ
- best for color and high precision printing; tessellation or free form curves/surfaces
- color and texture stored in a paired .MTL file

Free form curves: .OBJ

.AMF
- potential new format (ASTM)

.3MF
- potential new format (Microsoft)

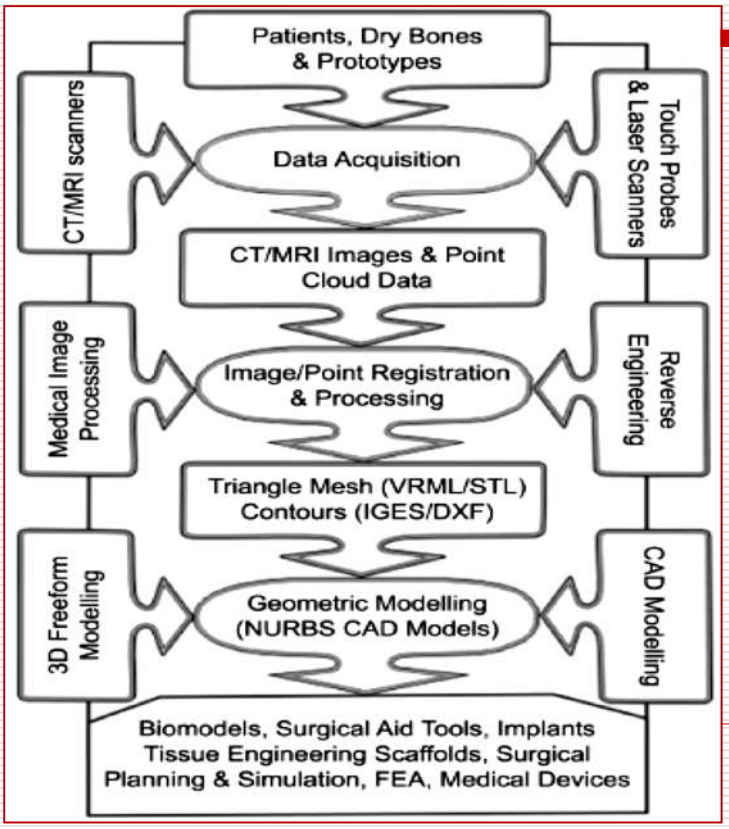


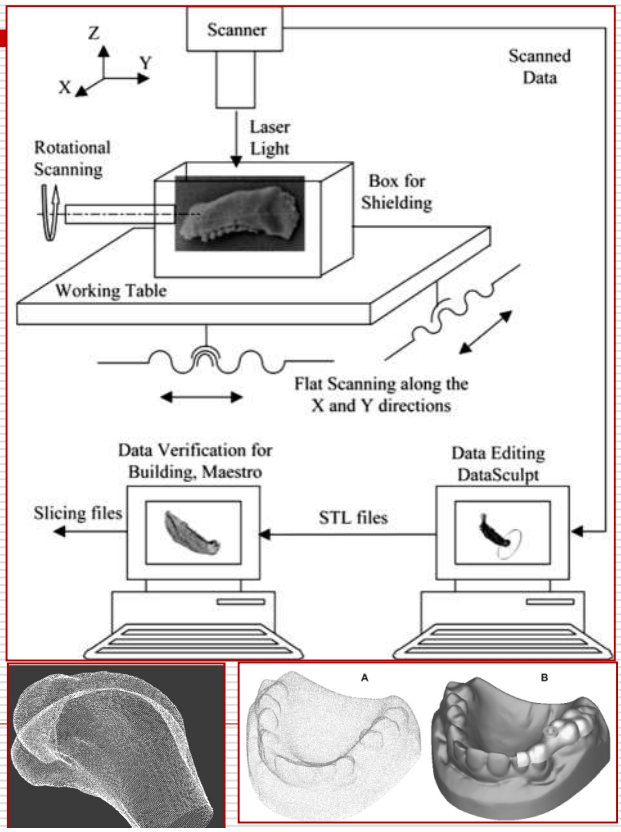
Encoded colors and textures: .MTL

Source: all3dp.com

Medical Application Development

Medical Application Development from CT/MRI and RE Data





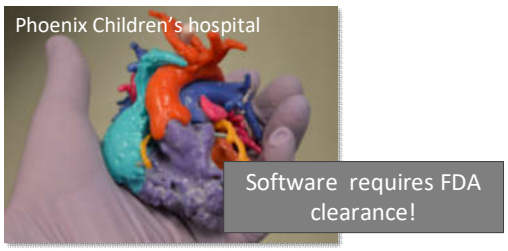
3DP in Medical

Implants

Ti chest implant

Spinal wedge implants

Surgical Planning



Patient-specific pediatric heart model

Orthopedic Casts

Light-weight patient-specific 3D-printed cast

Personalized Medicine

Printlets™ technology

Source: www.anatomics.com; www.zimmerbiomet.com ; www.rapidreadytech.com; www.materialise.com

Topology Optimization and Bionic Design in 3DP

Topology Optimization & Bionic Design

Parametric and generative design, topology optimization, lattice structures and biomimicry (bionic design)

Examples:

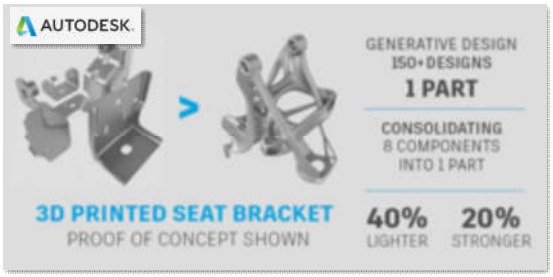
AUTODESK. — **Fusion 360 Ultimate** generative design

CogniCAD™: Cognitive Computer Aided Design Platform For Ultimate Lightweighting

FRUSTUM — **Generate (TM)** topology optimization

nTopology — **Element** design optimization software

Altair solidThinking — **Altair Inspire™** topology optimization / generative design



Also: Compensation for shrinkage & warping (e.g. part orientation) and adding support structures

35

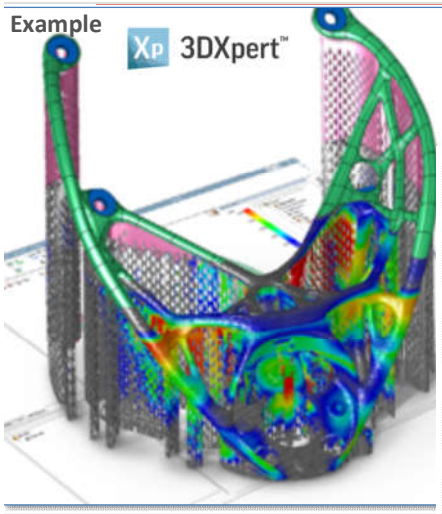
Topological Optimization Tools

- ☐ Altair OptiStruct
- ☐ Vanderplaats Genesis
- ☐ Simulia Tosca
- ☐ Abaqus ATOM
- ☐ MSC Nastran
- ☐ SolidThinking Inspire
- ☐ Within Enhance
- ☐ PERMAS-TOPO
- ☐ FEMtools Optimization
- ☐ OPTISHAPE-TS
- ☐ BESO3D
- ☐ ParetoWorks
- ☐ CATOPTO
- ☐ Topostruct
- ☐ ProTOp
- ☐ SmartDO
- ☐ META4ABQ
- ☐ ToPy
- ☐ TRINITAS
- ☐ TopOpt

3D Printing Simulation Tools

Build Simulation Software:
Multi Physics Multiscale Modelling of 3D Printing Processes

Example



Source: 3DSystems

- Model distortions & residual stresses for processes
- Suggest distortion compensation
- Model optimal support structures
- Minimize risk of printer damage (e.g. re-coater damage)
- Minimize number of build tryouts
- Predict impact of postprocessing (e.g. heat treatment, HIP, support removal)

Optimize build-up orientation, support configuration
Verify influence of operating conditions on distortions, plastic strains and residual stresses

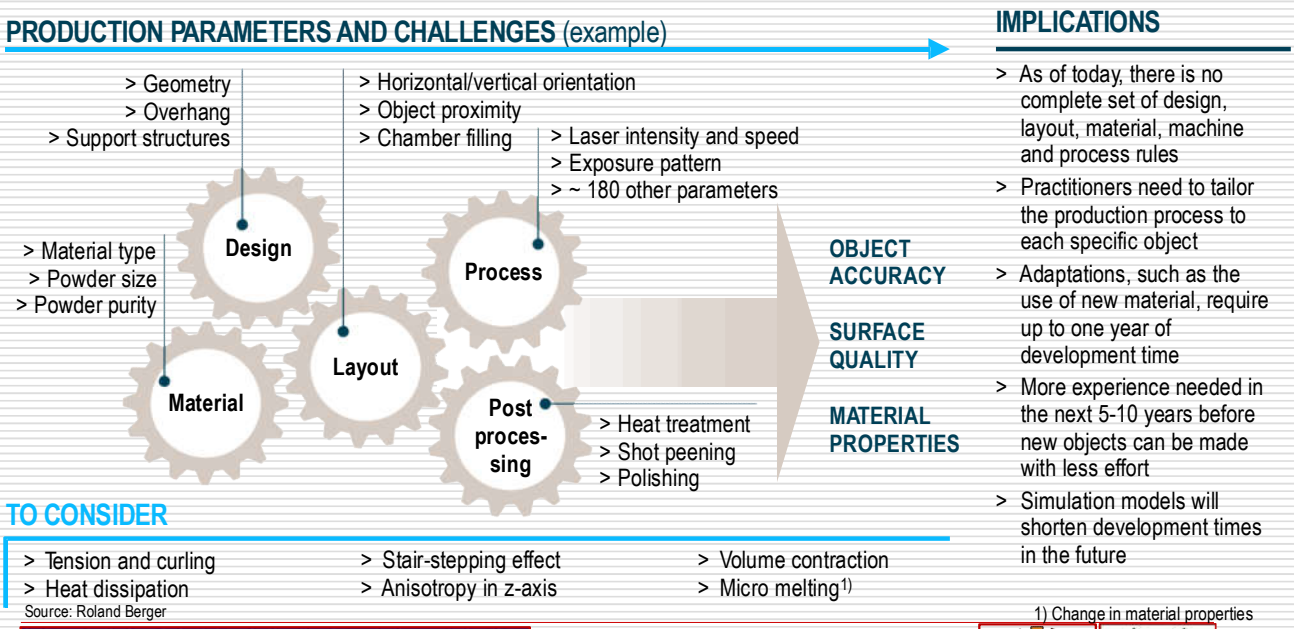
3DP Simulation Tools

- ANSYS Additive Print
- 3DSystems 3DXpert
- Geonxs Virfac
- ESI Additive Manufacturing
- AlphaSTAR Corporation's GENOA 3DP
- e-Xstream's Digimat-AM
- Additive Works' Amphyon
- Hexagon's Simufact Additive
- Autodesk's Netfabb
- Siemens NX Simcenter

Fabrication Challenges of 3D Printing

Fabrication Challenges in 3DP

Complexity of AM production process



Fabrication Challenges in 3DP

Standardization of processes (machine-to-machine and run-to-run variability)

- Consistency of source material
- Process control and error correction

Post processing requirement

- Impact on cost, time and quality

Certification of parts

- How to distinguish a good part from a faulty one

New potential health hazards to operators

- e.g. particulates, VOCs

Integrity of digital data

- E.g. employ blockchain technology to secure data ('Cubichain Technologies')

Protection of Intellectual Property

Summary

- Introduction to 3D Printing
- Medical Image Data Processing Tools
- Importance of Physical Models in Medical
- Reverse Engineering Tools
- Medical Application Development
- 3D Printing Data Formats
- Topology Optimization and Bionic Design
- 3D Printing Simulation Tools
- Fabrication Challenges of 3DP

YouTube Channel: **AM LAB NIT Warangal**

AM Facility at NIT Warangal

- **3D Printer/3D Scanner**
  1. DMP Flex Metal 3D Printer
  2. Dimension FDM Machine
  3. Mojo 3D Printer
  4. Ultimaker 2+
  5. EinScan-S
  6. Sense 3D Scanner
  7. Muffle Furnace
  8. Shot Peening Machine
- **3D Printing Software**
  1. MIMICS
  2. Magics
  3. 3-matic
  4. Catalyst
  5. 3DXpert

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STTP QUESTION SET

PART A **25X1=25marks**

1.	Which one is NOT related to 3D Printing definition? a) Layer-by-layer b) Physical model c) From 3D CAD data **d) Production line**
2.	Which of the following processes is mostly automated in additive manufacturing? **a) Part Building** b) Machine setup c) File Manipulation d) Design
3.	The technique used to quickly prepare a scaled model of a physical part can be best termed as: a) Rapid Manufacturing b) Rapid Production **c) Rapid Prototyping** d) Quick Design
4.	Which Manufacturing process is suited to large volume production with simple part design a) Smart Manufacturing b) Rapid Manufacturing c) Hybrid Manufacturing **d) Subtractive Manufacturing**
5.	In AM, STL Stands for **a) Standard Tessellation Language** b) Standardized Tooling Library c) Standard Training Language d) Standardized Tessellation Library
6.	Which of the following approaches does the additive manufacturing use primary **a) Layer based approach** b) Layer less approach c) CNC approach d) Topography
7.	Design for Manufacturing helps in preventing designs that **a) are simple and inexpensive but are difficult or expensive to service and support** b) simplify assembly operations c) simplify component manufacture d) are complex to manufacture

8.	**Design for Additive Manufacturing deals with** a) simplifying component design for reducing cost of additive manufacturing **b) opportunity to rethink design possibilities with additive manufacturing** c) part build parameters like build orientation and support structure design d) Innovation
9.	In the medical arena, leading to direct manufacture of medical replacement part a) Reverse Engineering **b) Tissue Engineering** c) Cell Structure d) Rapid Engineering
10.	In Rapid Prototyping system, holes should be oriented in such a way that their axes are: a) At an angle to the building platform b) Parallel to the building platform **c) Perpendicular to the building platform** d) coplanar
11.	Which of the following is not an example of additive manufacturing? a) Fused-deposition-modeling b) Beam Deposition process c) SLS d) **Injection molding**
12.	Directly printing from a CAD file reduces the number of in-house remakes by a) 20 % b) 45 % c) 90 % **d) 100 %**
13.	Which of the process, the input material is in powder form? a) Laminated object manufacturing (LOM) **b) Selective laser sintering (SLS)** c) Fused deposition modeling (FDM) d) Multi-jet Modeling (MJM)
14.	The process which uses a fine powder which is heated with a Carbon Dioxide laser so that the surface tension of the particles is overcome and they fuse together. a) Gas Phase Deposition b) Laser Engineering Net Shaping **c) Selective Laser Sintering** d) AMSI

15.	Which of the following is an Additive Manufacturing process? **a) Stereolithography** b) Room temperature vulcanization c) Vacuum Casting d) Silicon Rubber Molding
16.	Which of the following processes joins the powder grains by using either a laser or a separate binding material? **a) Selective Laser Sintering** b) 3D Printing c) Wireless manufacturing d) Bioextrusion
17.	Which of the process is using extrusion concept? a) Stereolithography apparatus (SLA) **b) Fused deposition modeling (FDM)** c) Selective laser sintering (SLS) d) Laminated Object Manufacturing
18.	The processes where all of the part material is dispensed from a print head are called as: a) Indirect Printing **b) Direct Printing** c) Smooth Printing d) Laser Printing
19.	What is Rapid prototyping in the context of equipment a) More machines to do prototypes **b) Quick fabrication of enclosures** c) To give aesthetic slots d) Use of plastic in place of metal
20.	Which of the following is a type of material removal Rapid Prototyping? **a) Laminated Object Manufacturing** b) Solidification of an electroset fluid c) Fused Deposition Modelling d) SLS
21.	In the formulation of liquid material, the substances which is added to the liquid to attain acceptable characteristics is called as **a) surfactants** b) pellets c) granules d) molecules

22.	The Post processing operation in Fused Deposition Modeling as comparison to Stereolithography is: **a) Lower** b) Higher c) Equivalent d) Similar
23.	Which is generally only one layer and on the outside and in contact with the print in 3D Printing to allow for better adhesion a) Raft **b) Brim** c) Skirt d) Outrise
24.	Which of the following is the process that involves solid sheets? a) Selective Laser Receptive Sintering b) Selective Area Laser Deposition **c) Laminated Object Manufacturing** d) Stereolithography
25.	Which of the following methods can be used to create scaffolds? **a) Using hydrogels** b) Using concrete c) Using wood d) Using Fibre

PART B **1X15=15 marks**

Demonstrate the various application of 3D Printing from the context of Indian Industries (15 marks)