

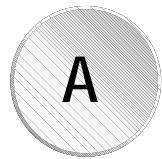


# Research Review

Dr Leo Chen  
16/08/2020  
[leo.chen.yi@gmail.com](mailto:leo.chen.yi@gmail.com)

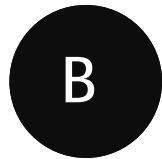
# Research

---



A

Dynamics and Control



Computational Intelligence Aided Design

and Manufacture



Go to [Exoskeleton](#)

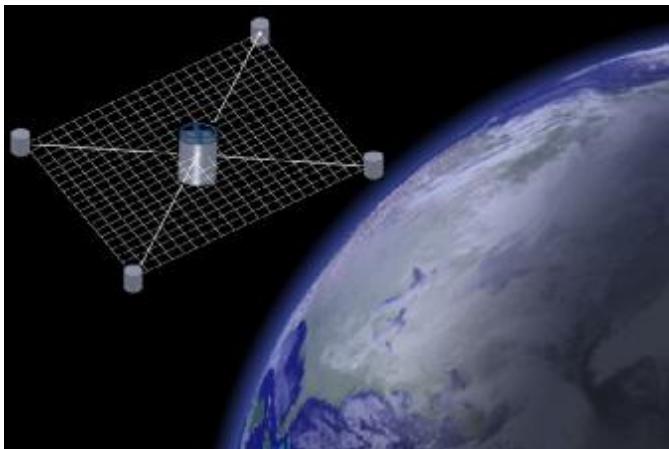
Go to [CIAD](#)

# REXUS 2009 - 2010

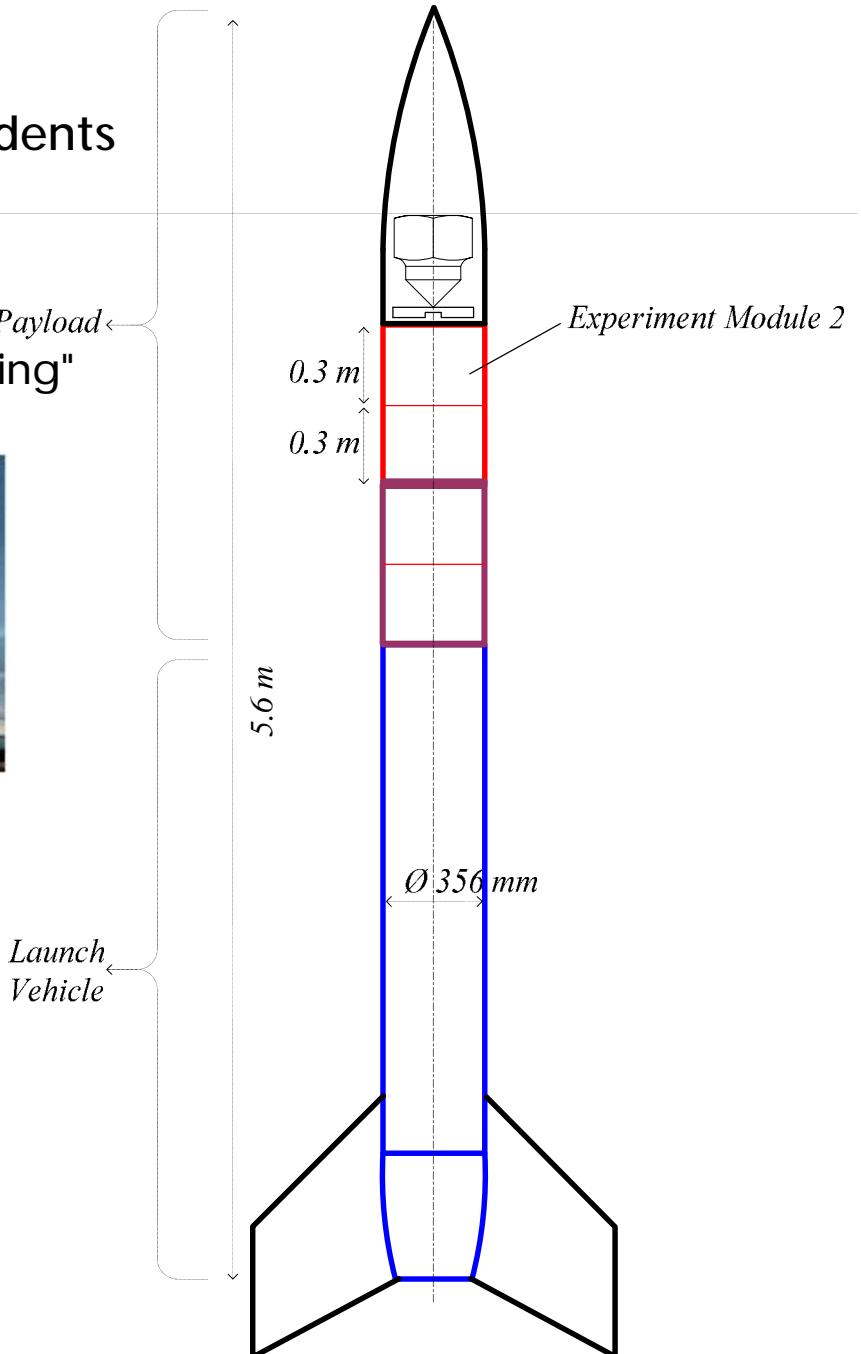
## Rocket-borne Experiments for University Students

European Space Agency

Suaineadh is a Scots Gaelic word meaning "twisting"

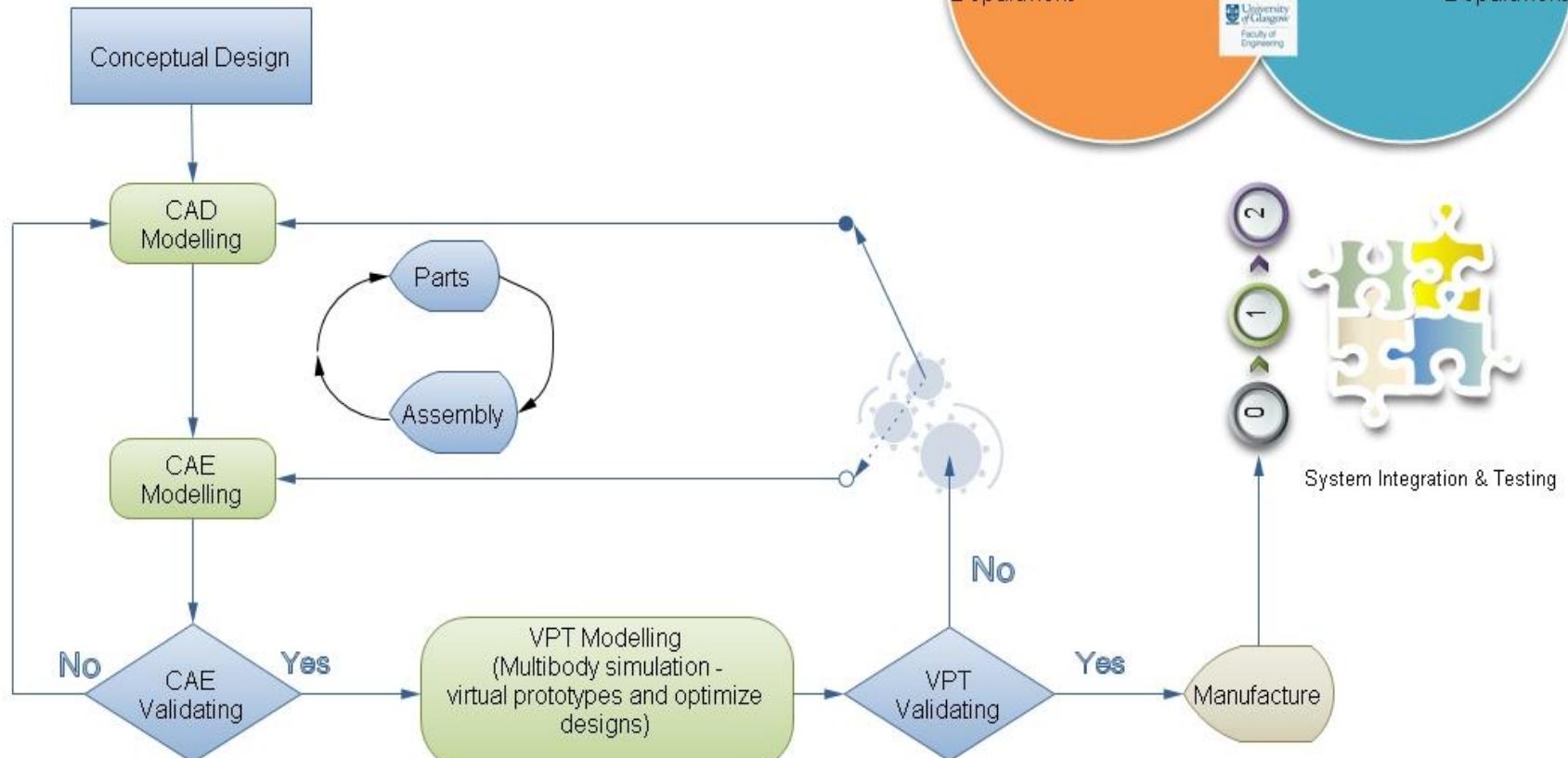
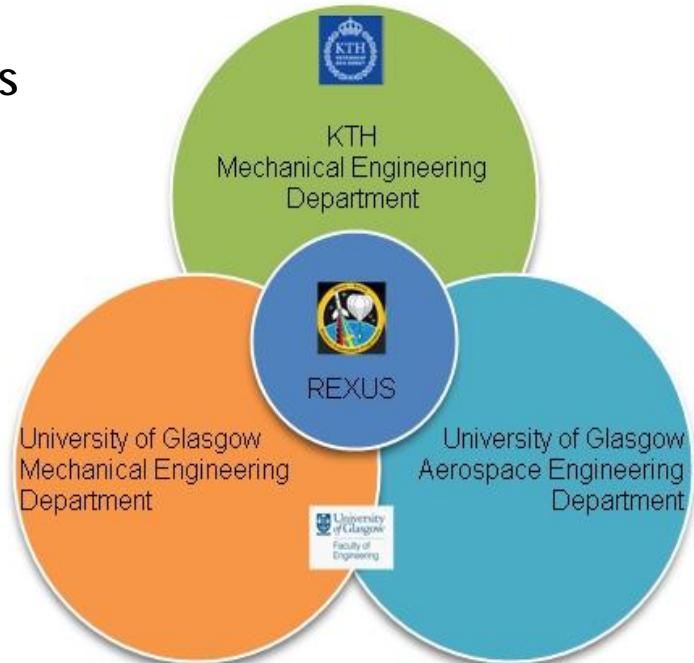
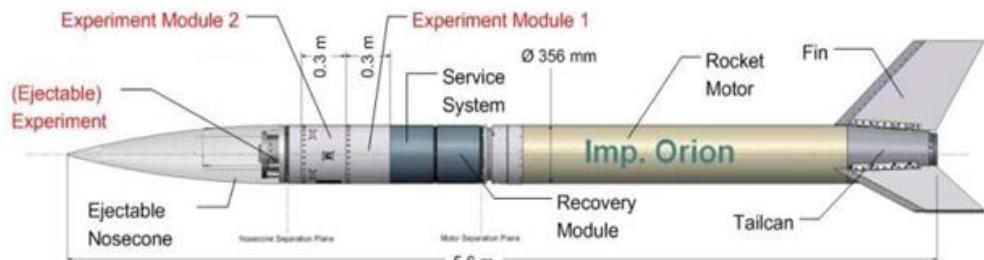


[www.rexusbexus.net](http://www.rexusbexus.net)  
[www.suaineadh.co.nr](http://www.suaineadh.co.nr)



# REXUS 2009 - 2010

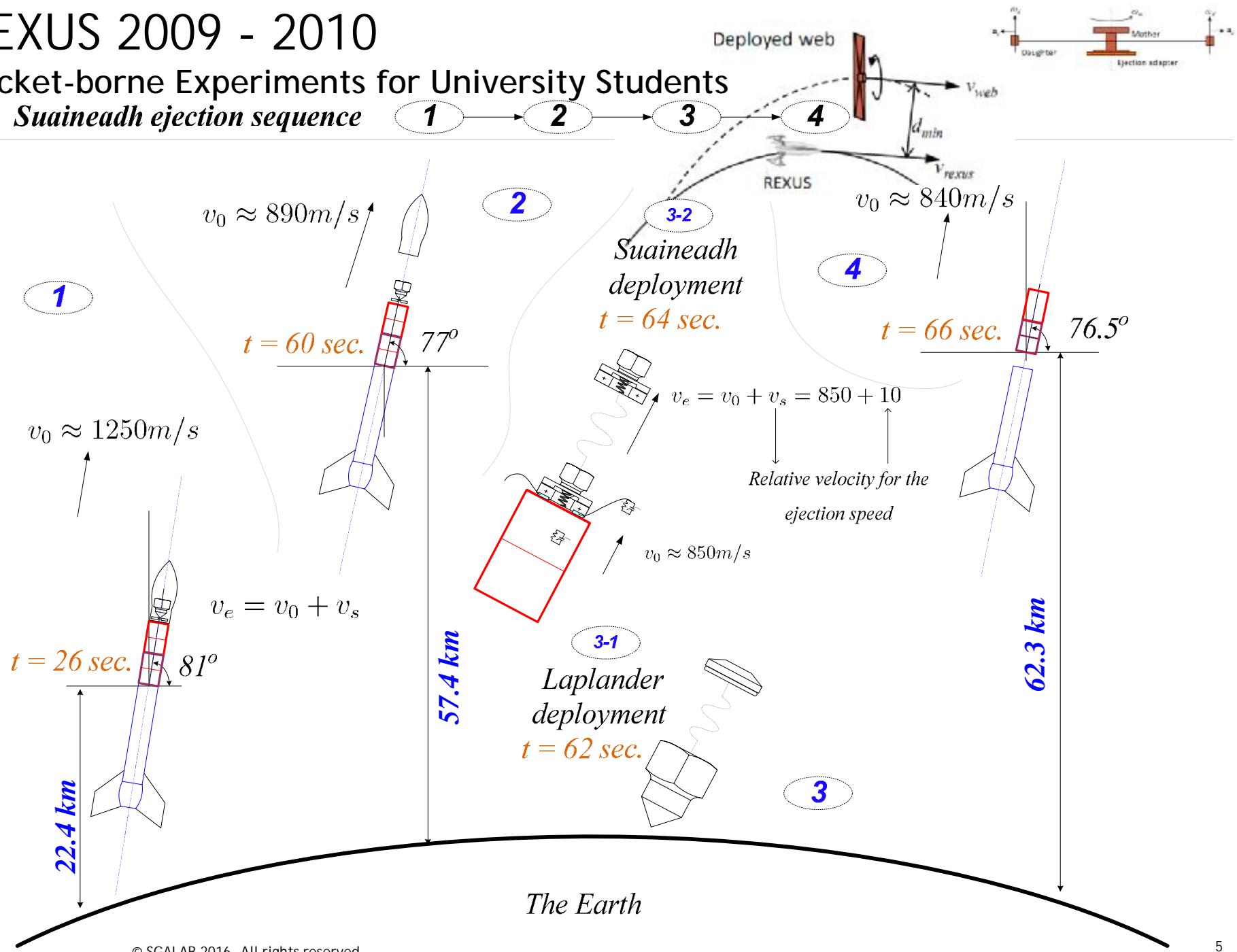
## Rocket-borne Experiments for University Students



# REXUS 2009 - 2010

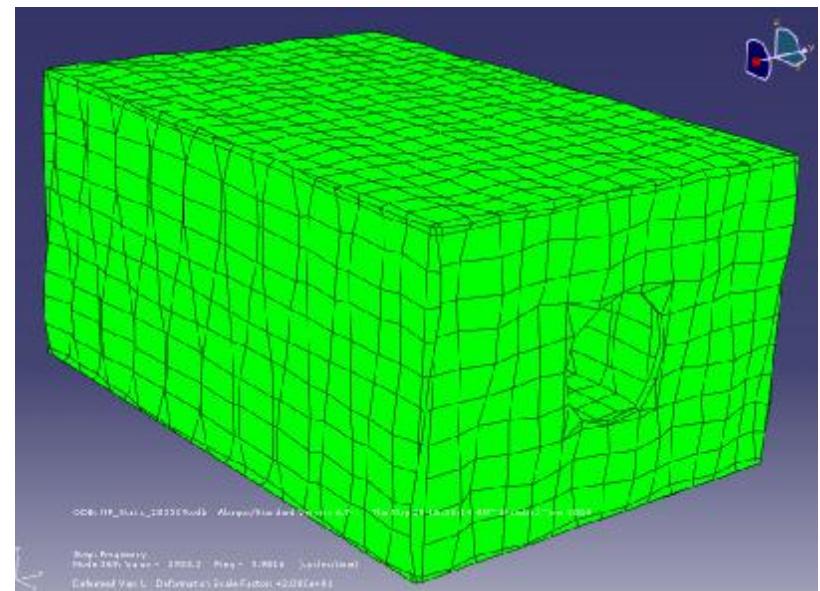
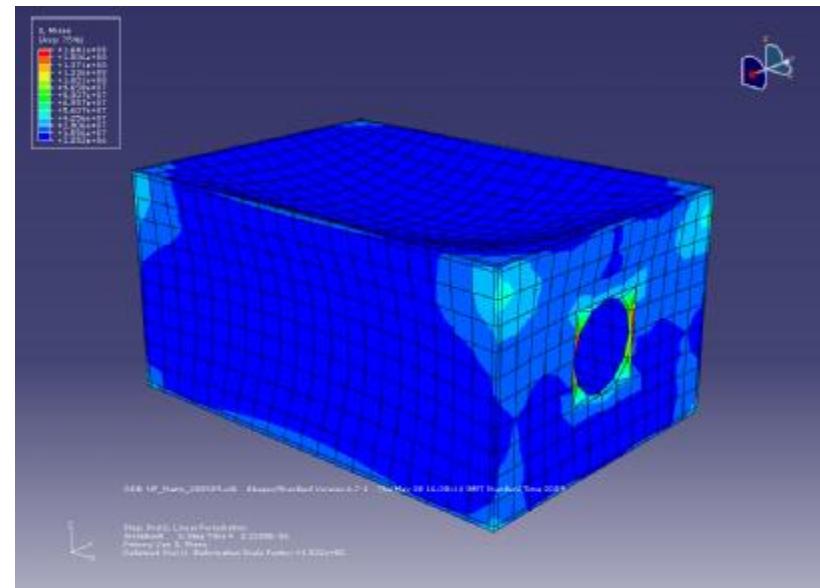
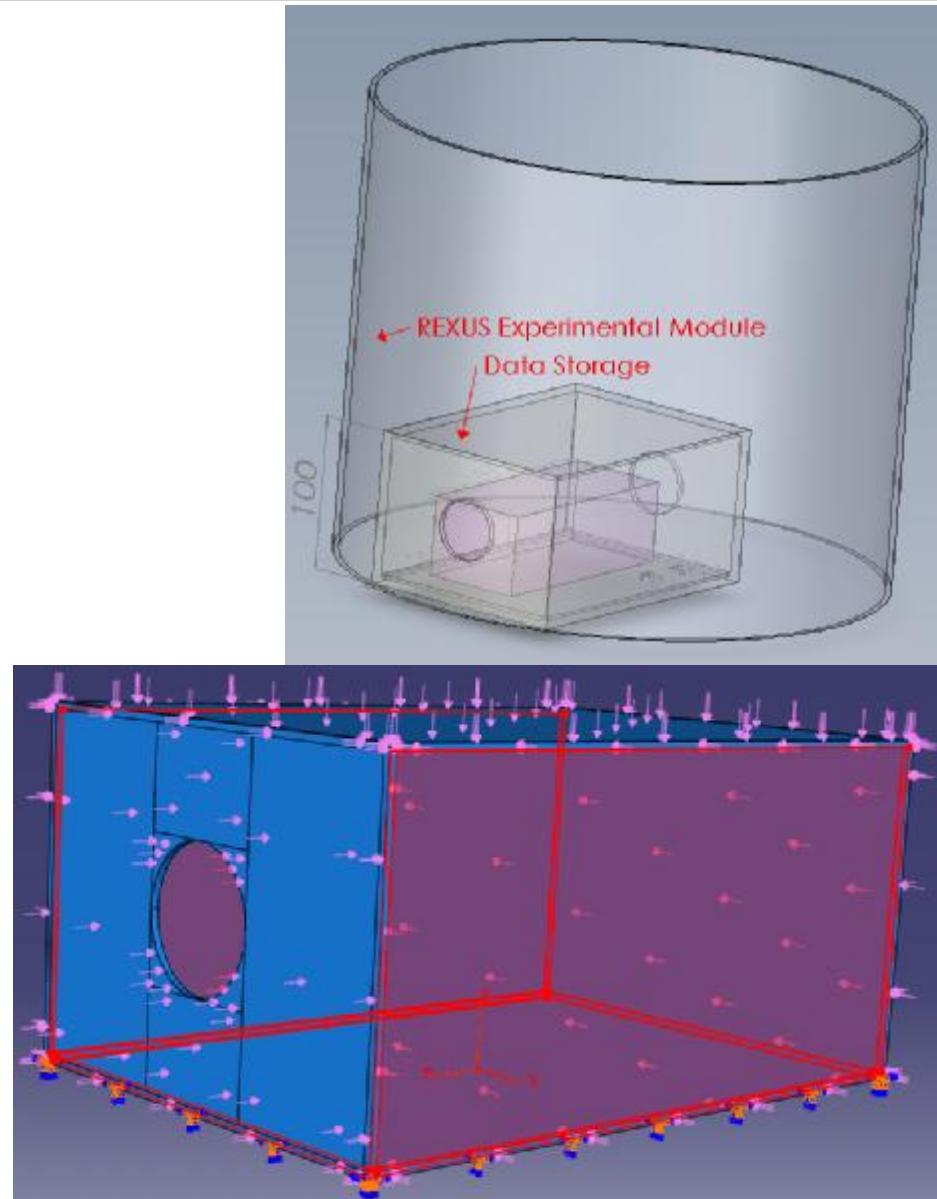
## Rocket-borne Experiments for University Students

### *Suaineadh ejection sequence*



# REXUS 2009 - 2010

## Rocket-borne Experiments for University Students

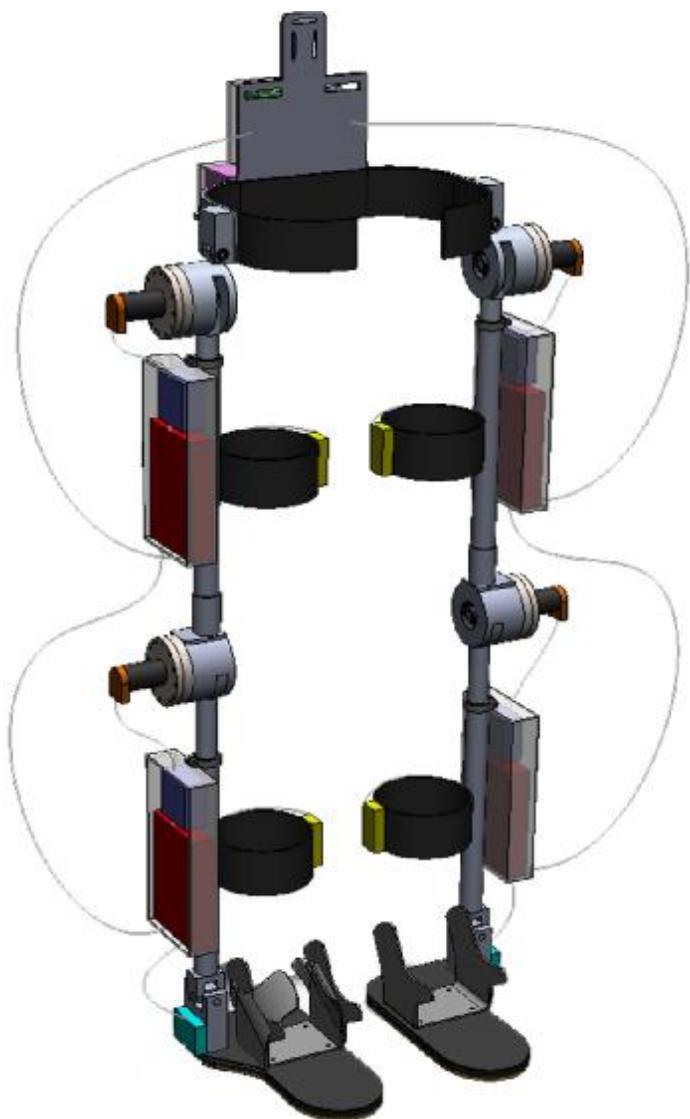


# Exoskeleton

This project is to develop an exoskeleton system for the military and healthcare services.



# Exoskeleton Virtual Prototype Model



# Exoskeleton Physical Prototype Model

---

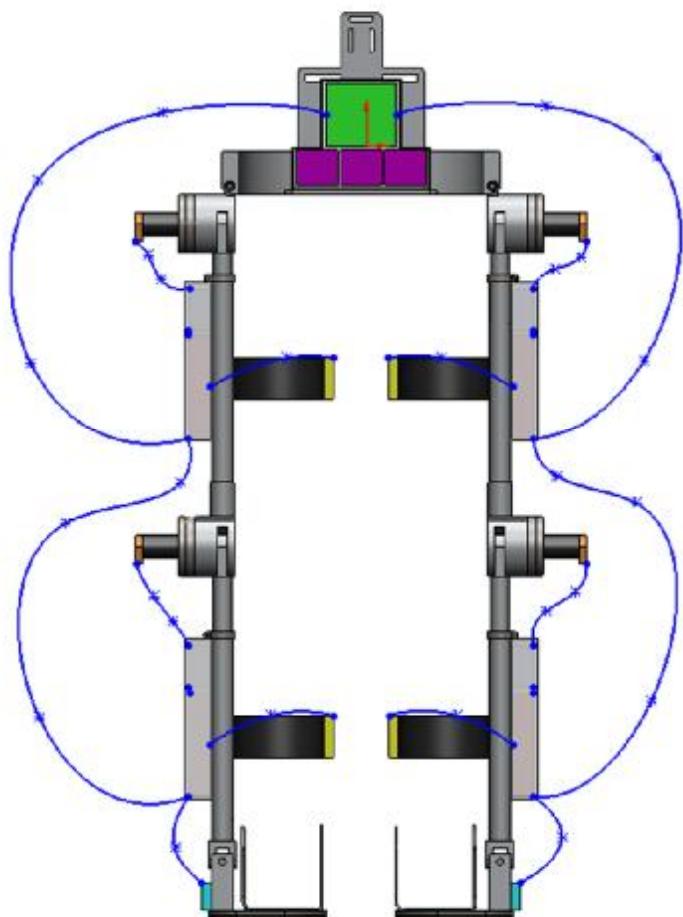
Beta1



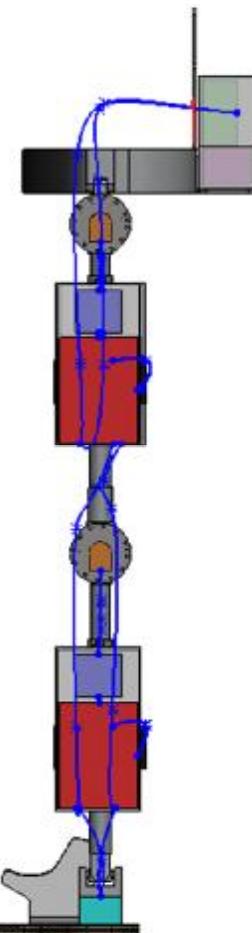
# Exoskeleton Physical Prototype Model

Beta2

Back-View



Side-View



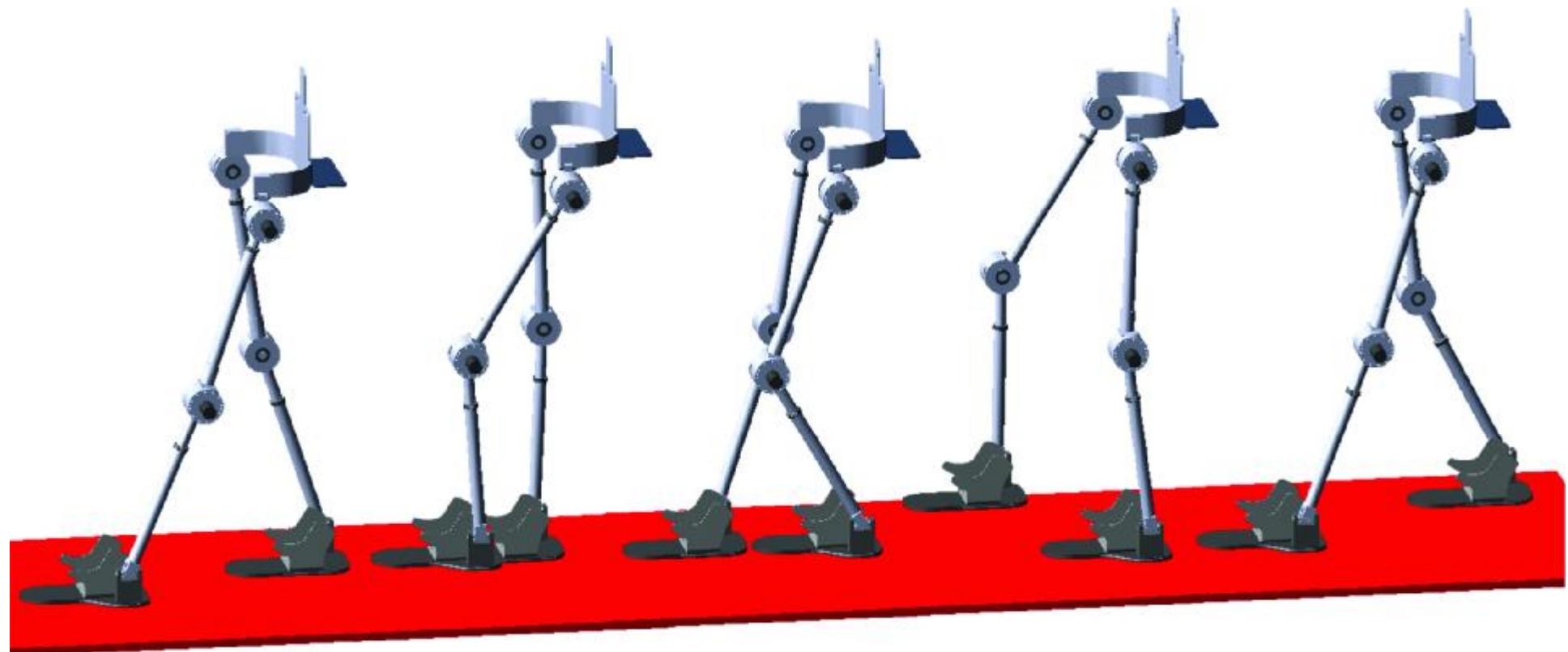
Go to [Lab Demo](#)

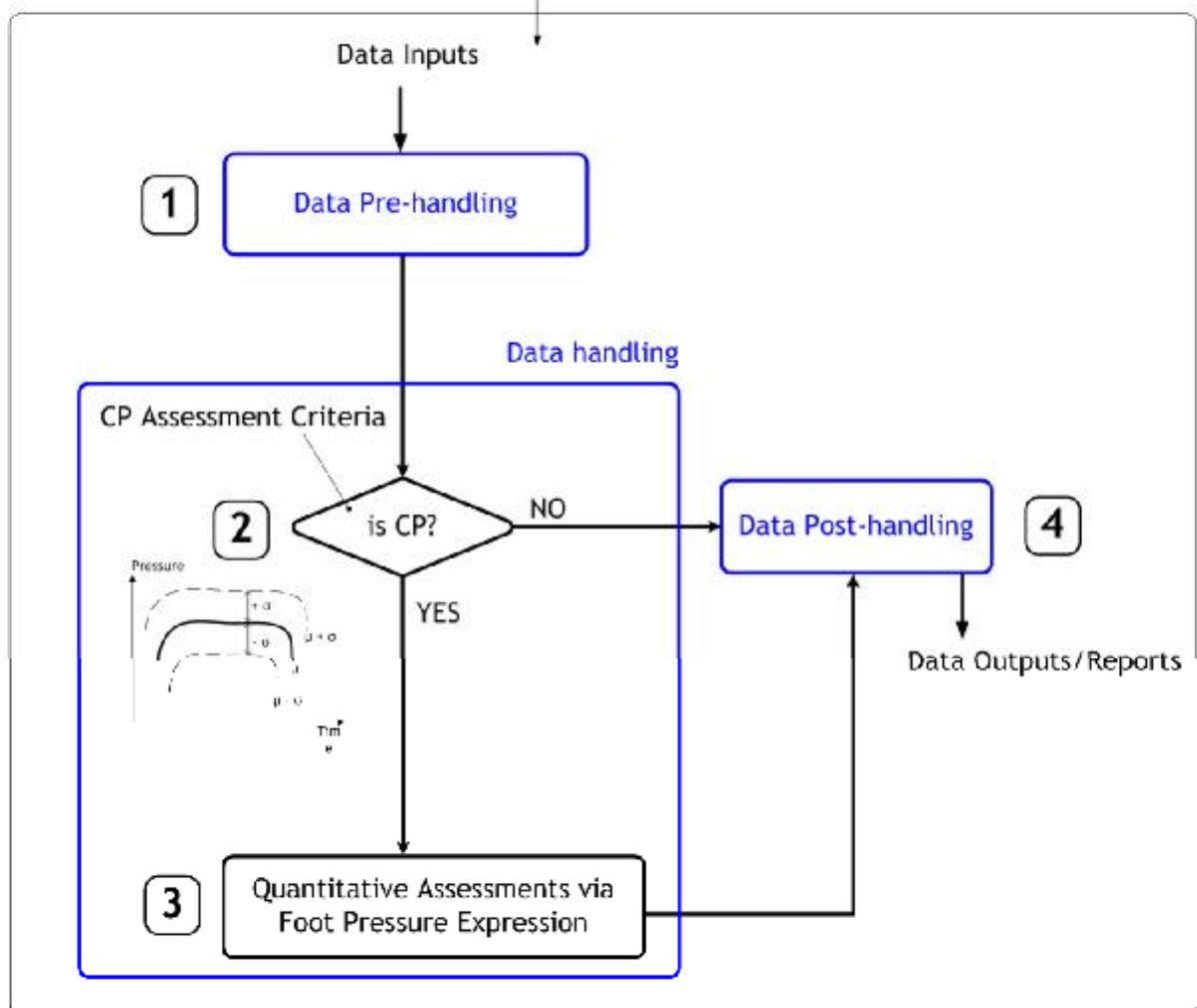
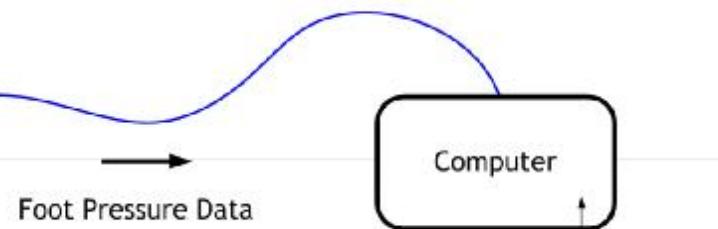
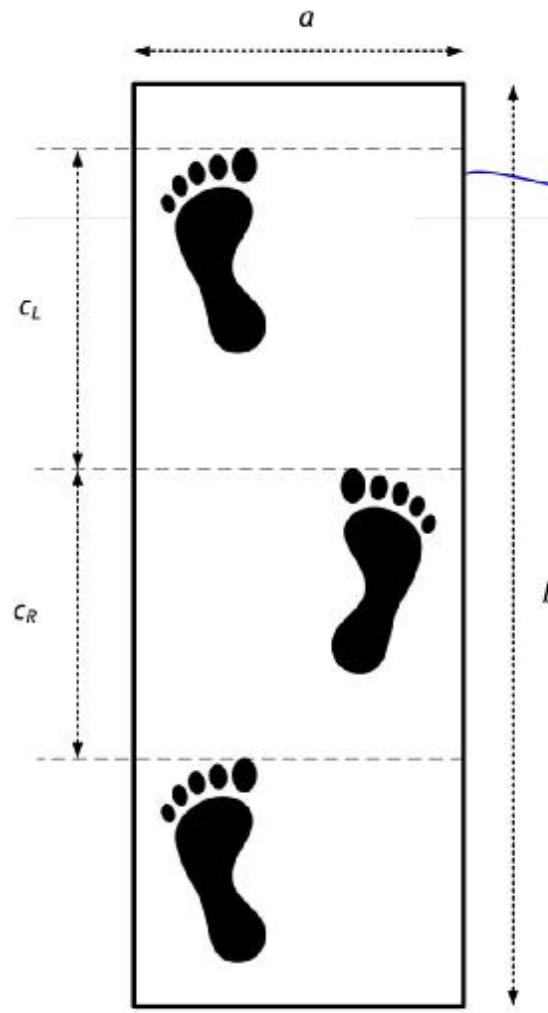
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# Exoskeleton Physical Prototype Model

Beta3

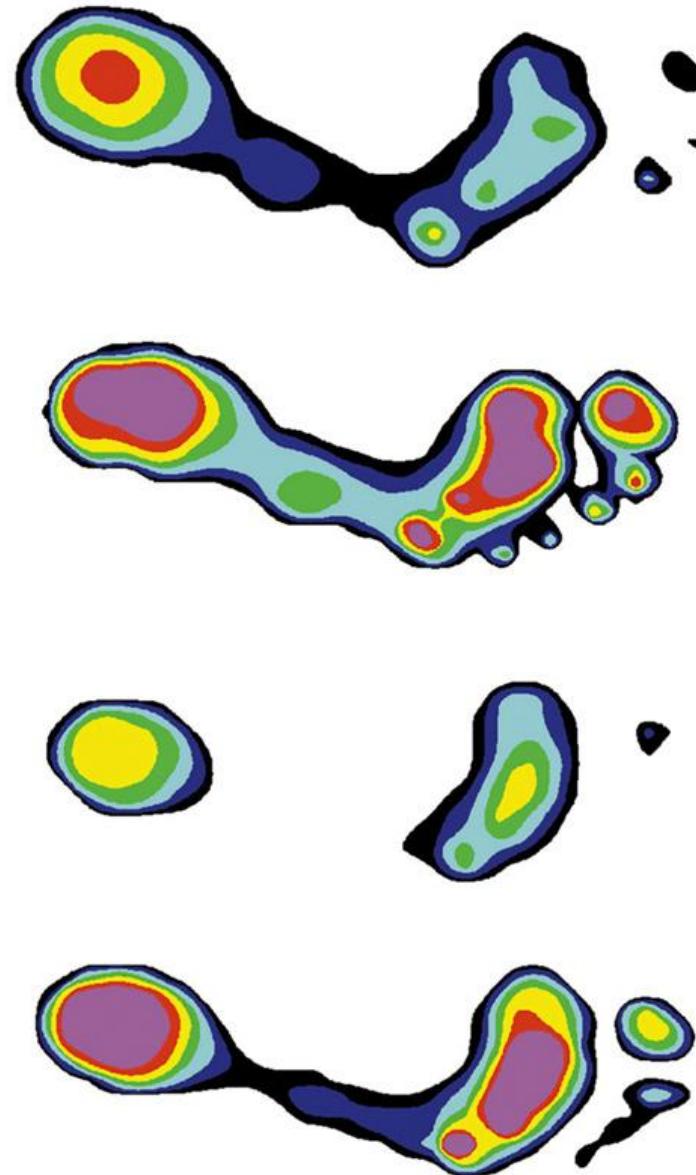
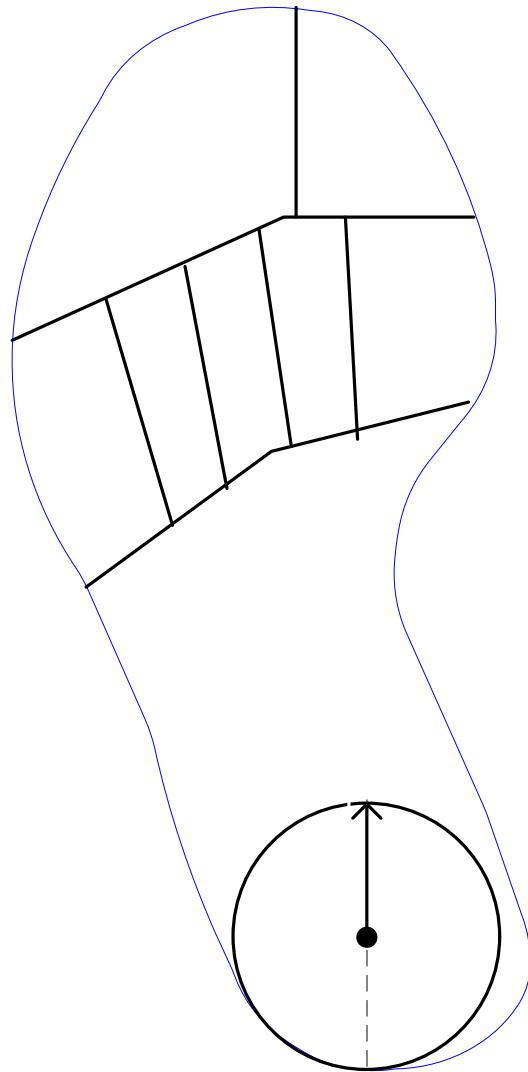




## Footscan/Vicon



# Foot Pressure Analysis

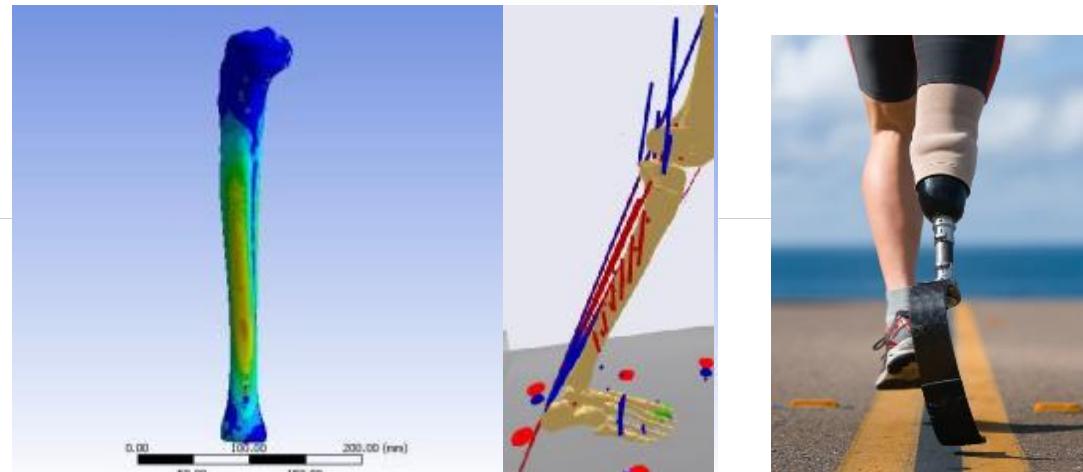


# Exoskeleton Application: Children with Cerebral Palsy(CP)

---

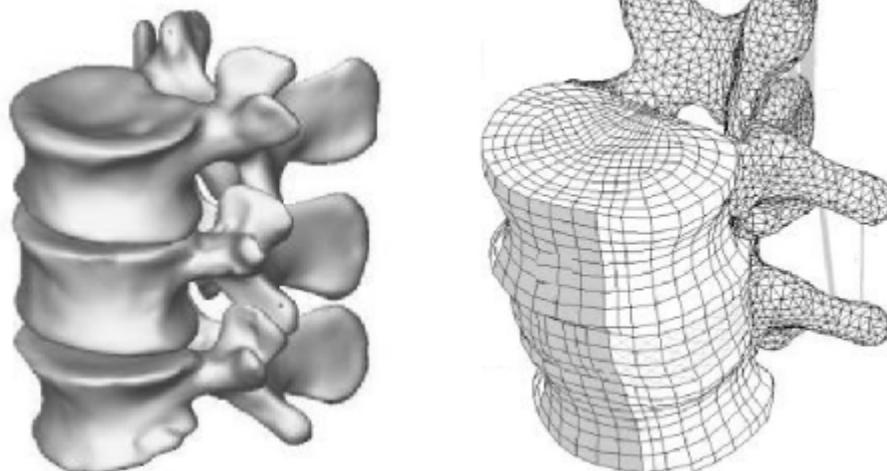
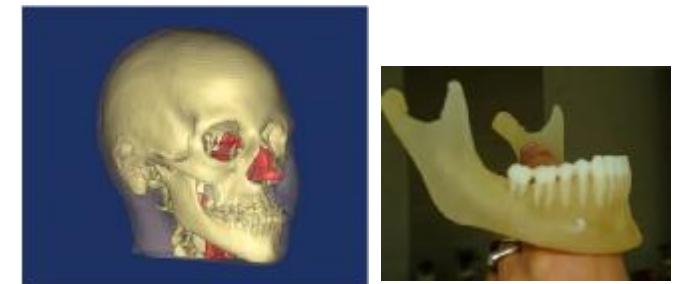
- 1) automatic gait recognition for the CP measurement;
- 2) virtual and physical prototype of the exoskeleton system for the CP rehabilitation training;
- 3) CP children gait database establishment;
- 4) rehabilitation device (exoskeleton system)  
reliability analysis;
- 5) quantitative analysis for the CP rehabilitation assessment via 3D foot pressure;

# Bioengineering



New devices are being developed that could improve the accuracy of bone surgery, including operations on the skull, teeth and limbs.

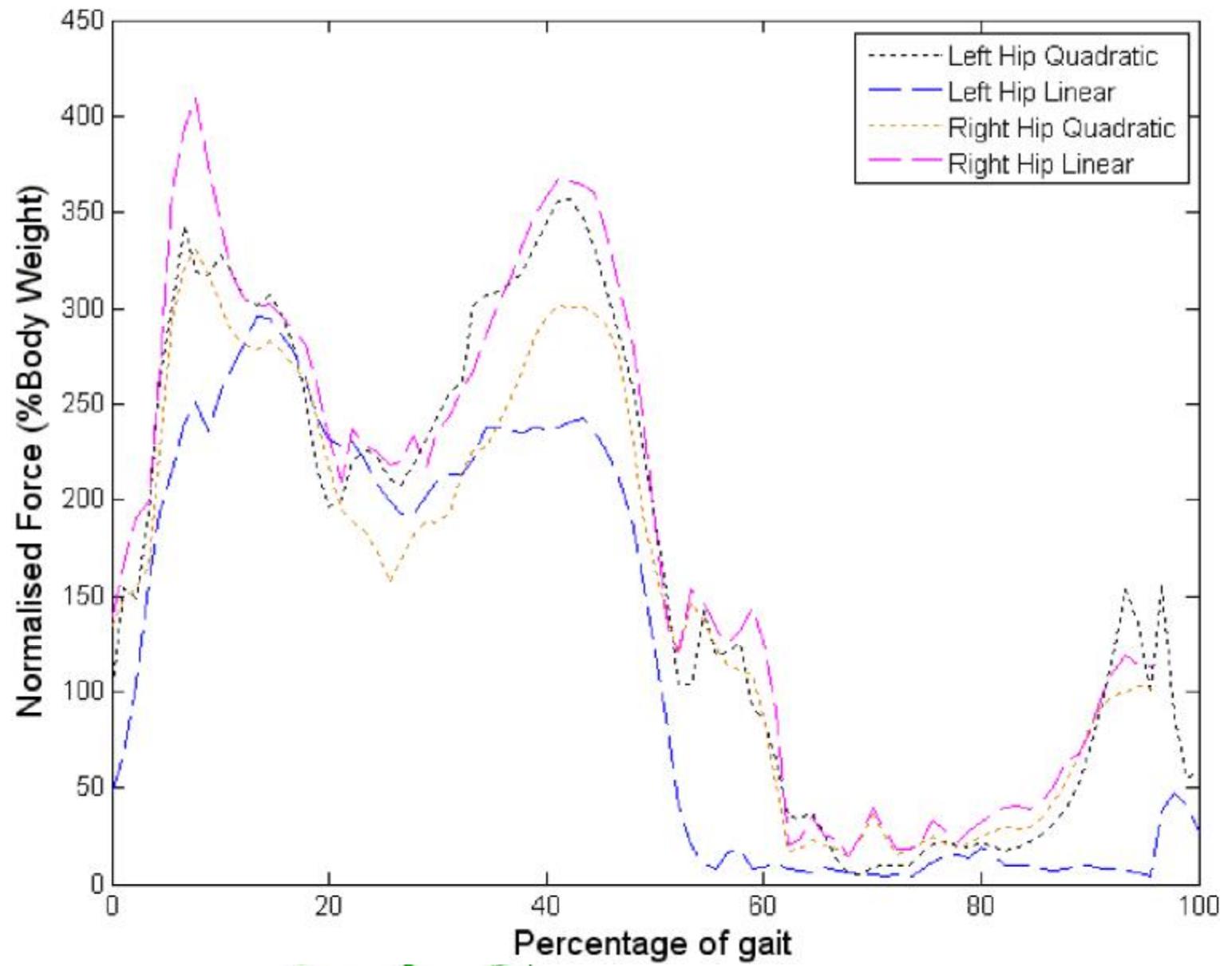
[http://www.gla.ac.uk/news/archive/2007/february/headline\\_28687\\_en.html](http://www.gla.ac.uk/news/archive/2007/february/headline_28687_en.html)



CAD/CAE Tools:  
**Anybody / SolidWorks / ABAQUS - UMAT (User-defined material)**

Numerical modeling of spinal motion segment,  
W. Kakol, T. Lodygowski, M.B. Ogurkowska, M. Wierszycki,  
2003 ABAQUS Users' Conference.

# Bioengineering





**Prognostics And Health Management System For Individual Soldier**

 Control

1. human-exoskeleton interaction
2. motion actuators
3. real-time control algorithms

 Data Management

1. system health status battery status  
armor status
2. solder health status
3. performance measurement
4. task risk analysis

 Structure by CIAD

1. Virtual prototype
2. physical prototype
3. integrated solver of computational intelligence
4. software

 Data Communication

1. data transmission
2. communication
3. firewall
4. hardware

1. 12 DOF motion sensors

2. environmental sensors thermal sensor  
magnetic sensor
3. biophysical sensor embedded in human body
4. equipment health management
5. workloads measurement
6. sensor network
7. Energy Harvesting

 Intelligent Sensors

## Physical Environment

### Open-sourced libraries

- SLAM (OpenSLAM)
- Real-time control(DROCOS)
- Path Planning (Openrave)
- Vision (OpenCV, PCL)
- 3D Simulator (Gazebo)
- 3D Visualizer (Rviz)
- Point Cloud Library (PCL)

### Development via multiple programming tools

- C++/C/C#
- Python
- Java, Lua, R, Ruby, MATLAB
- ROS Development Studio



Ubuntu



IPC

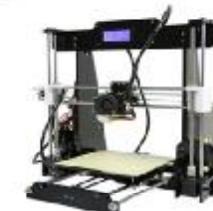
### Hardware and I/O Devices

- Single Board Computers (Raspberry Pi 3, Arduino, Robotic ARM)
- Laser Radar
- Camera (3D camera, Infrared-camera)
- Speaker
- LCD & Display
- Micro Controllers
- Motors & Actuators (Microstepping driver, DC Servo Motor )
- Power Systems (Battery and Charging System)
- Sensors
- Data Storage
- Data Communication and Human Input Devices
- Mechanical Components (Chassis, Grippers, Gears, Belts, Pulleys, Tracks, Sprockets & Chains, Gear Box Pan & Tilt)
- Electrical Components (Interface Adapters & Converters, Cables, Wires & Connectors,)
- Accessories: Sensor & Motor Mounts, Hubs & Couplers

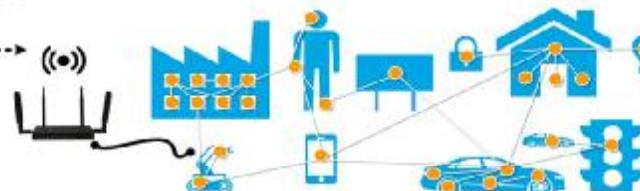


### Development via multiple programming tools

- C++/C/C#
- Python
- Java, Lua, R, Ruby, MATLAB
- ROS Development Studio



### 3D Printing and Smart Factory



### Internet of Things

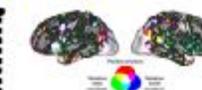


### Big Data



### Cloud Service

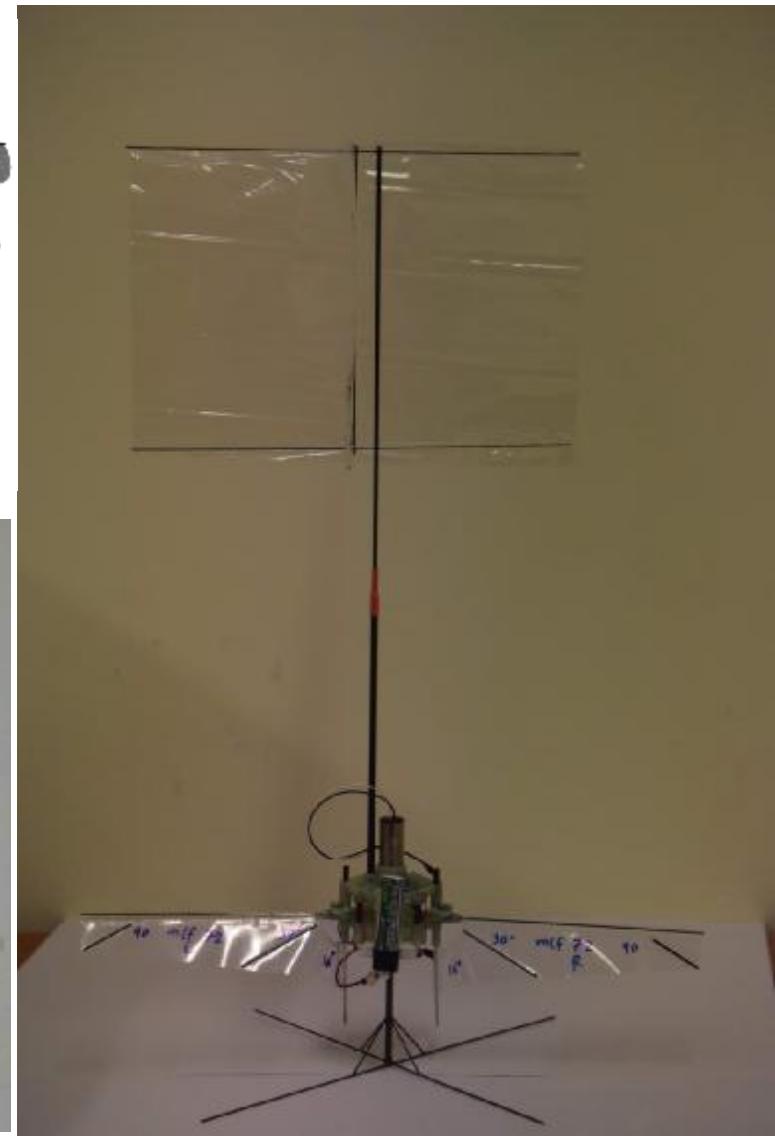
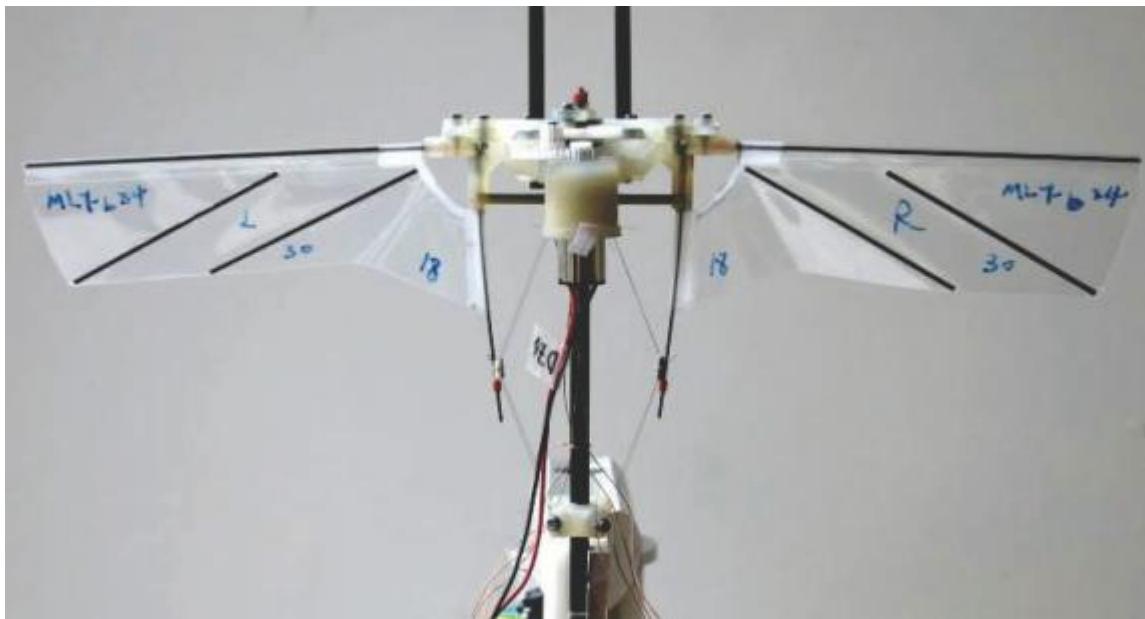
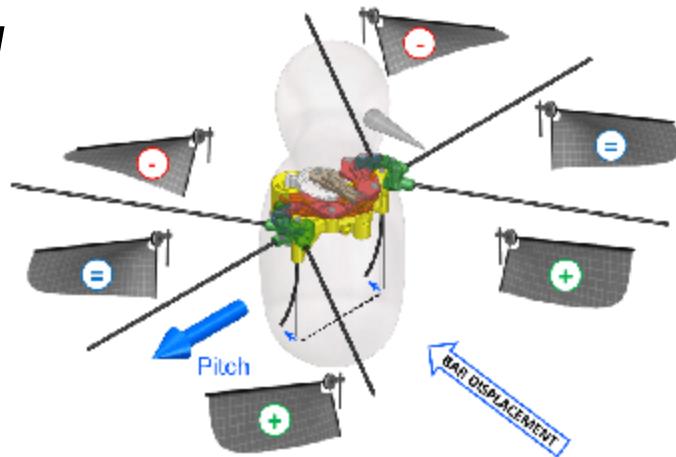
### Applications



- Artificial Intelligence
- Database & Block-chain
- High Performance Computing

# Autonomous Micro Air Robotics

*Hummingbird*



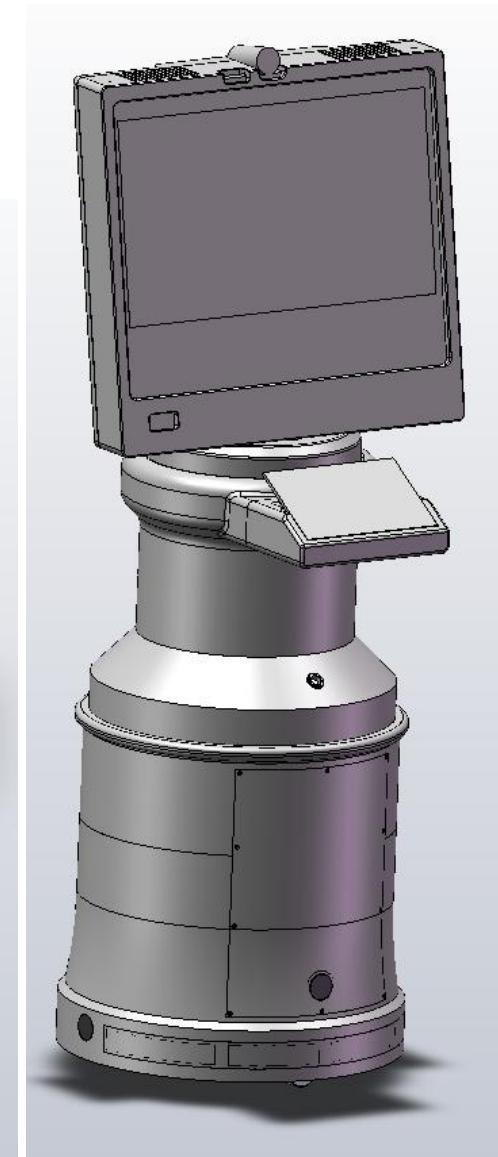
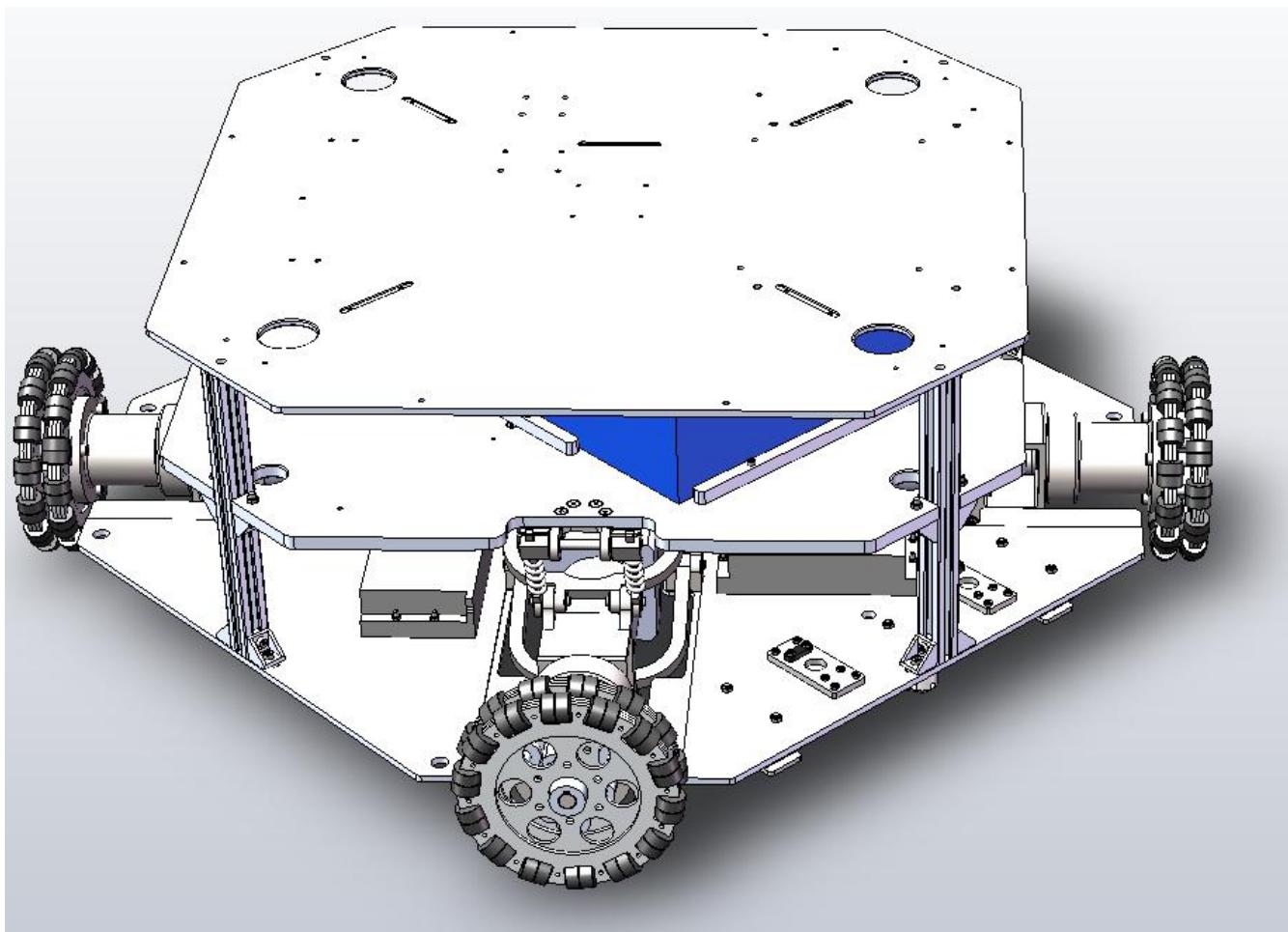
# “Big Dog” four legged robotic system

---



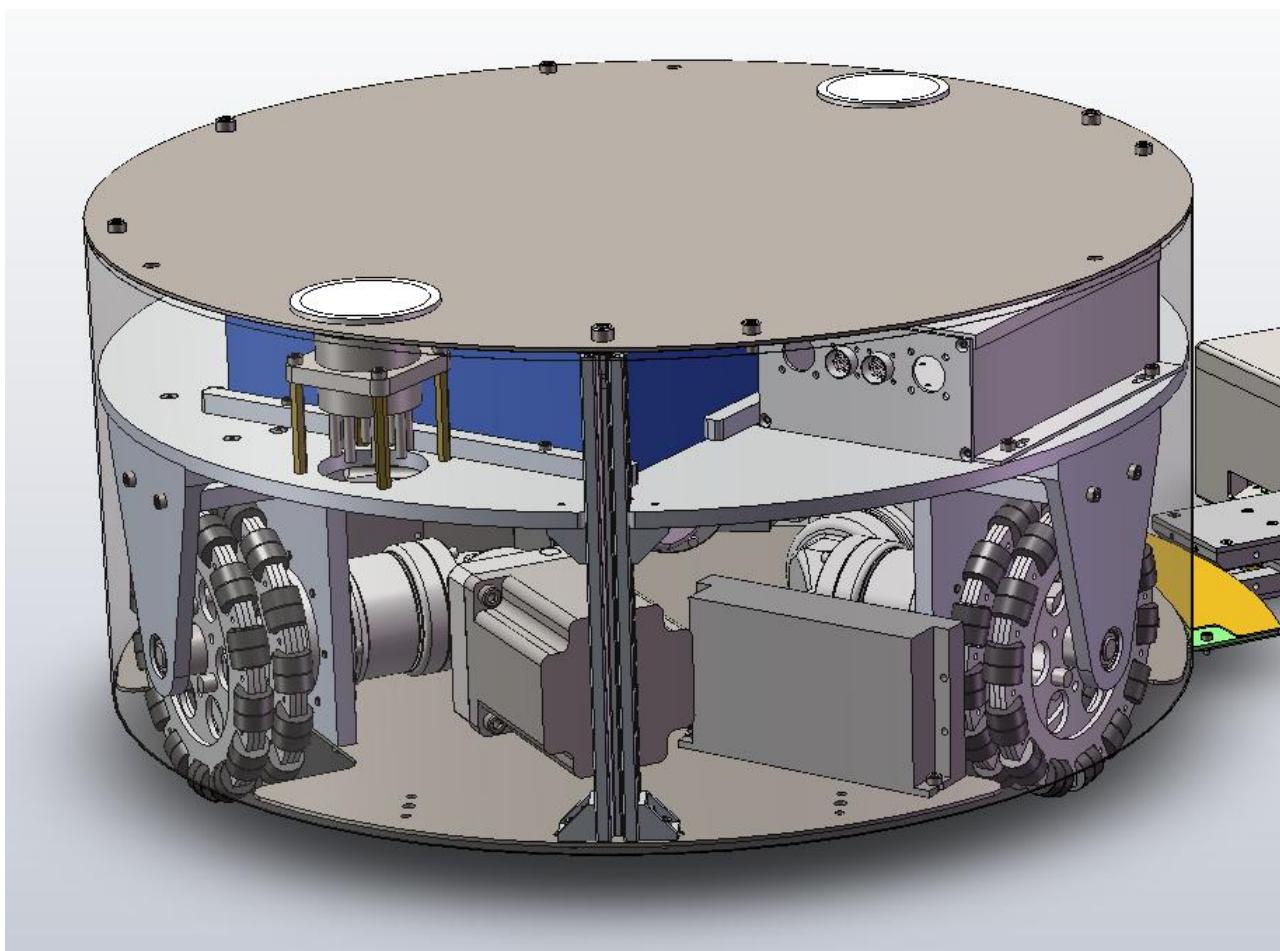
# “4 Wheel Autonomous Rover” for social service

---

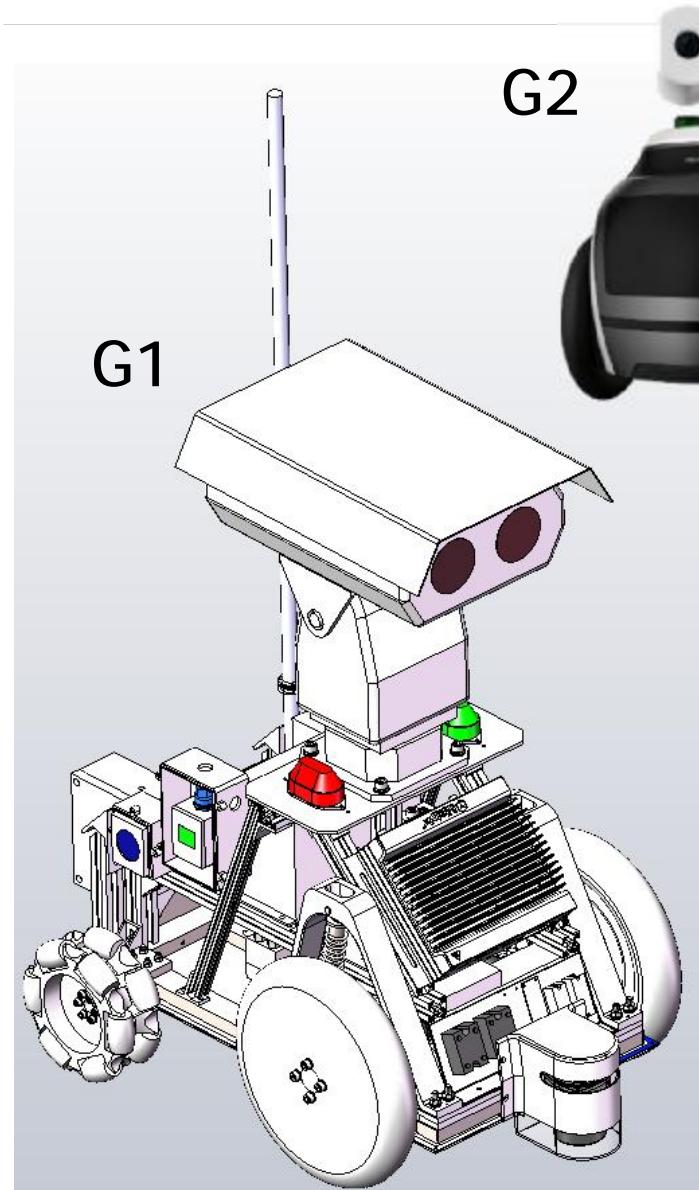


# “3 Wheel Autonomous Rover” for social service

---



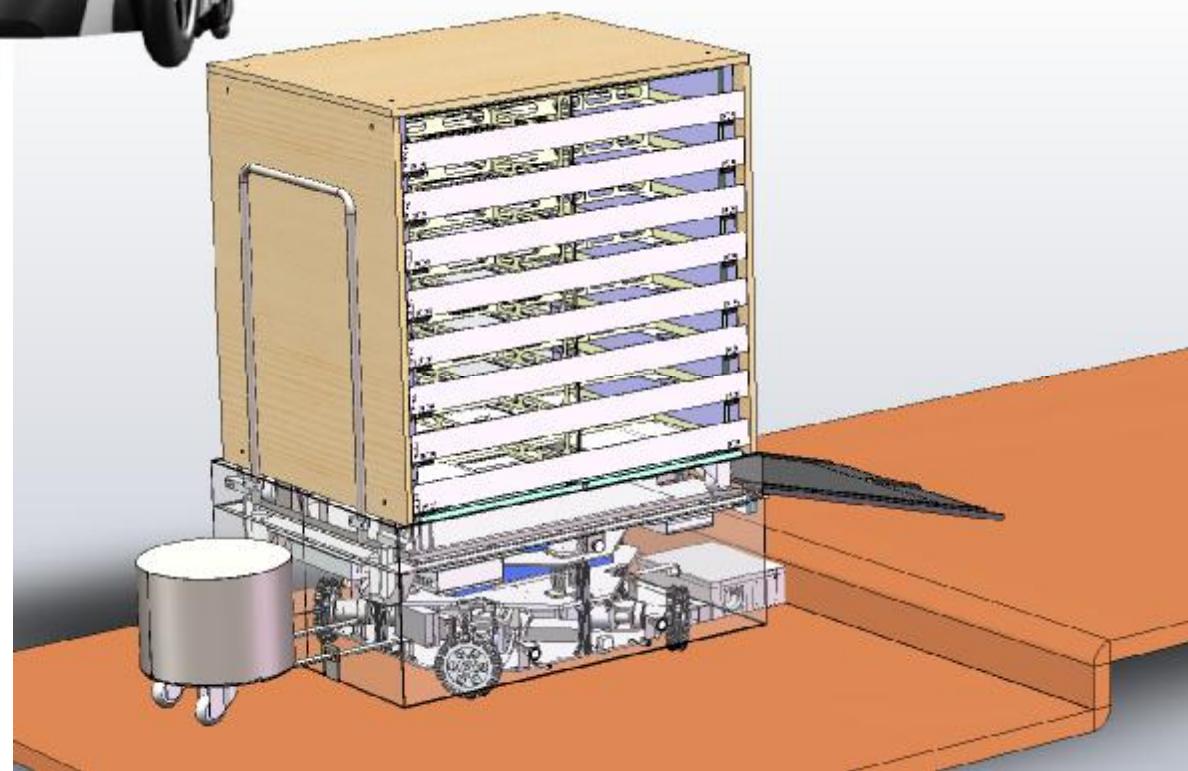
# Power-station inspection



G2



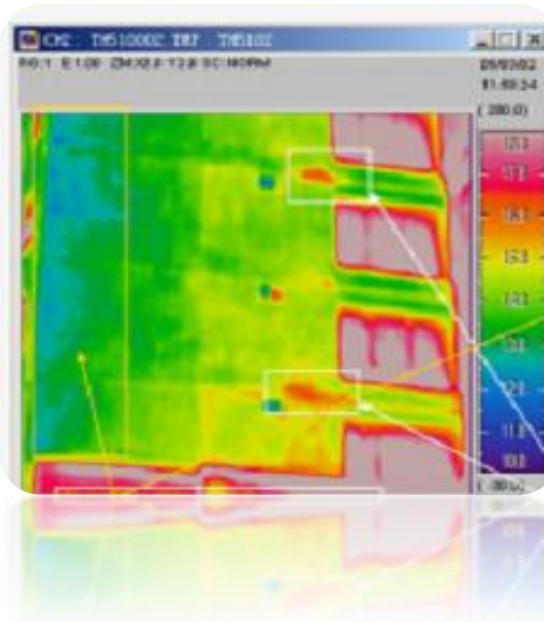
# catering service



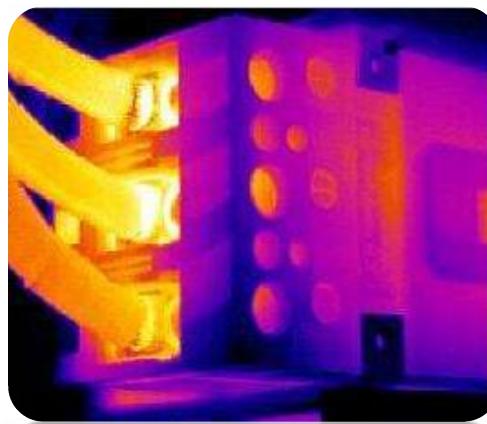


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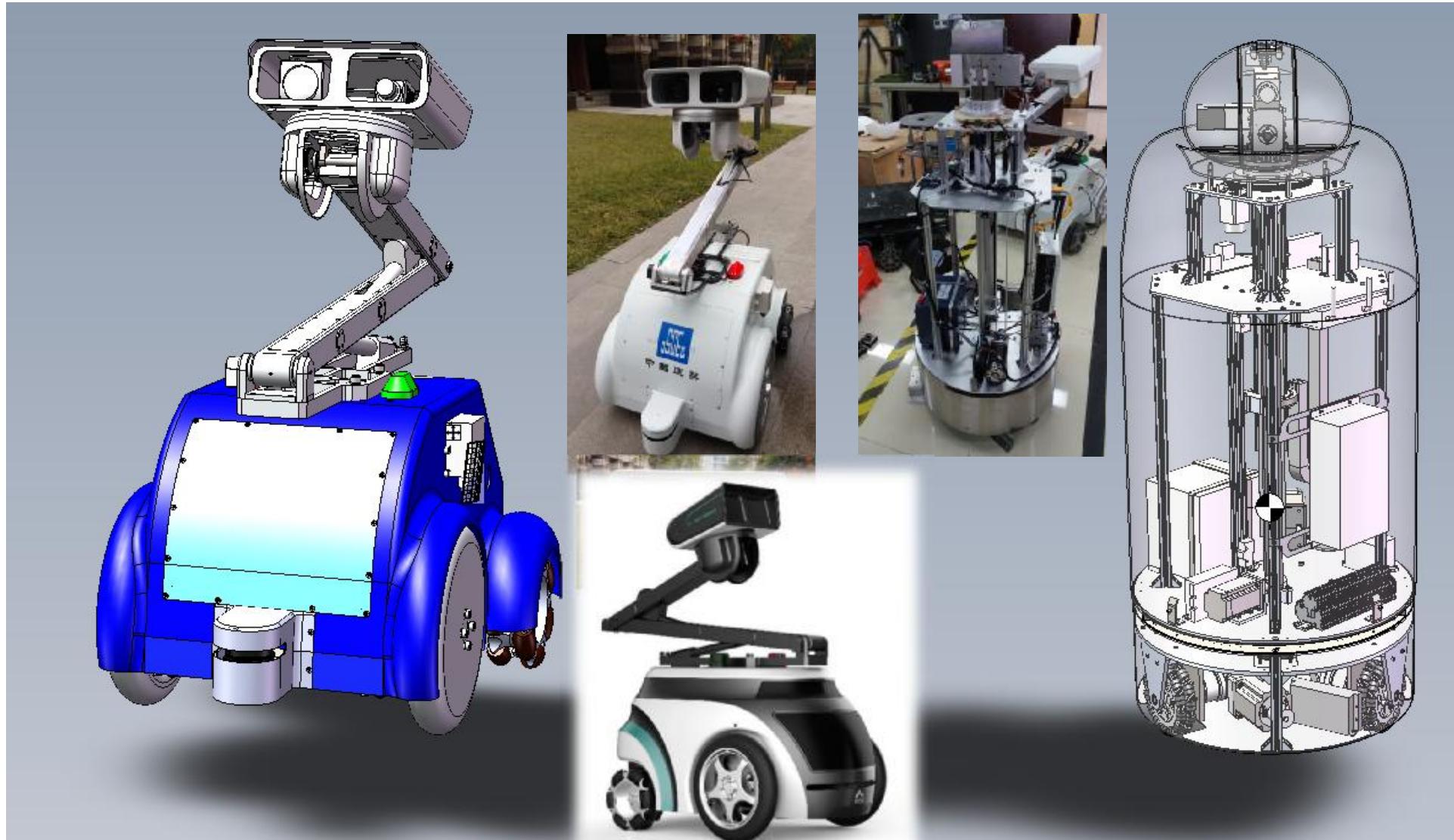
## G2-I



## G2-II

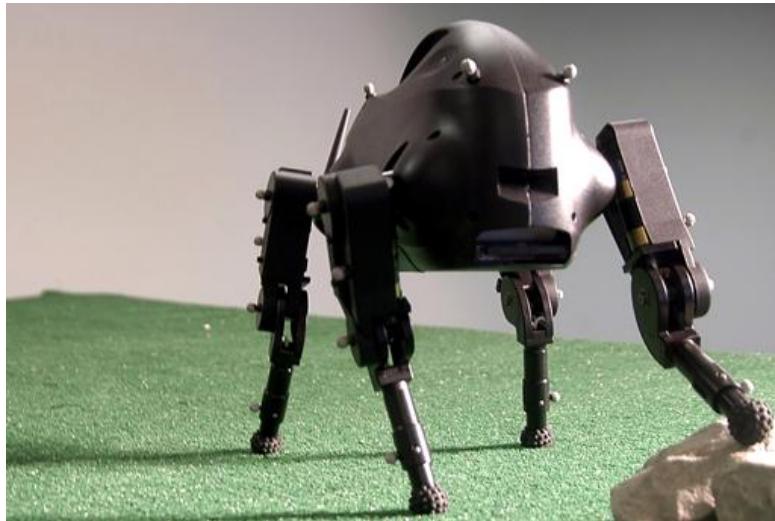


- § Left: Underground pipe Inspection Robot [CAD1](#)
  - § Right: Social Service [CAD2](#)
- 



# Doggy

---



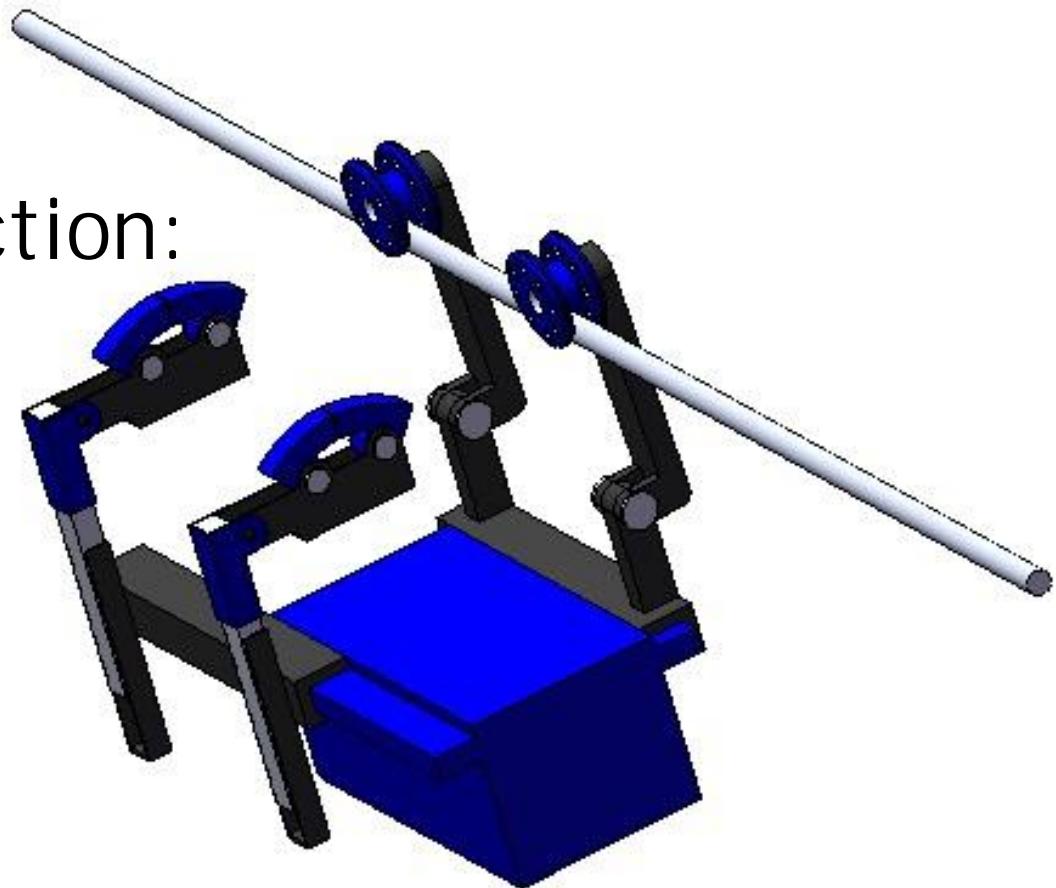
# Inspection Robot

for High-voltage Transmission Lines

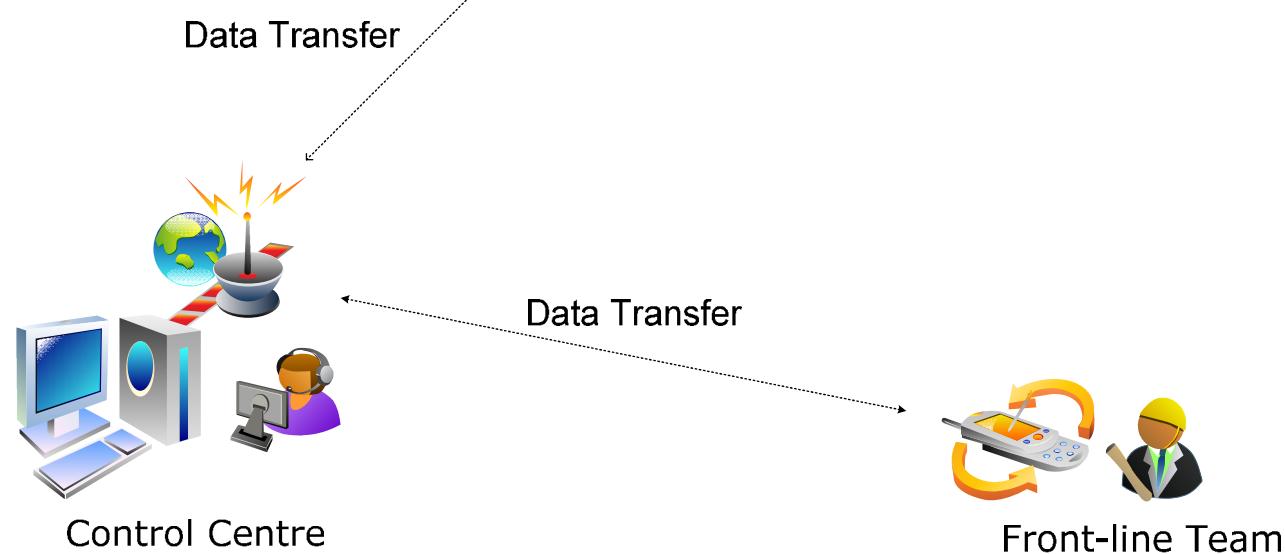
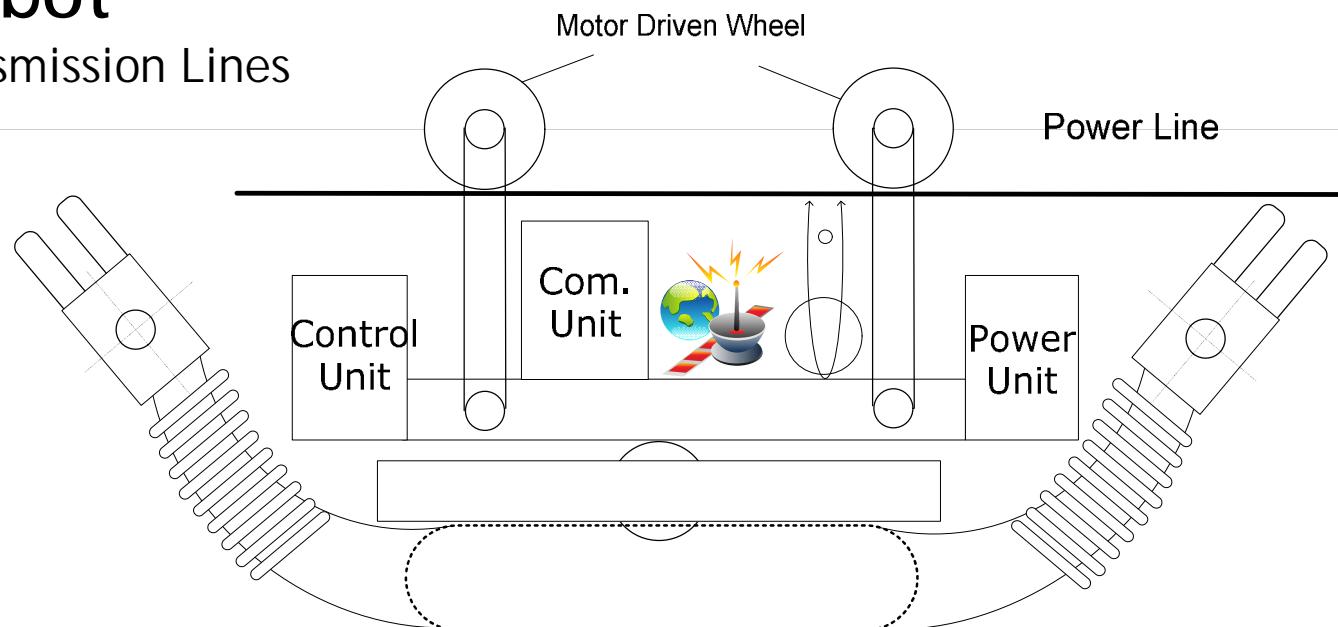
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High-voltage Inspection:

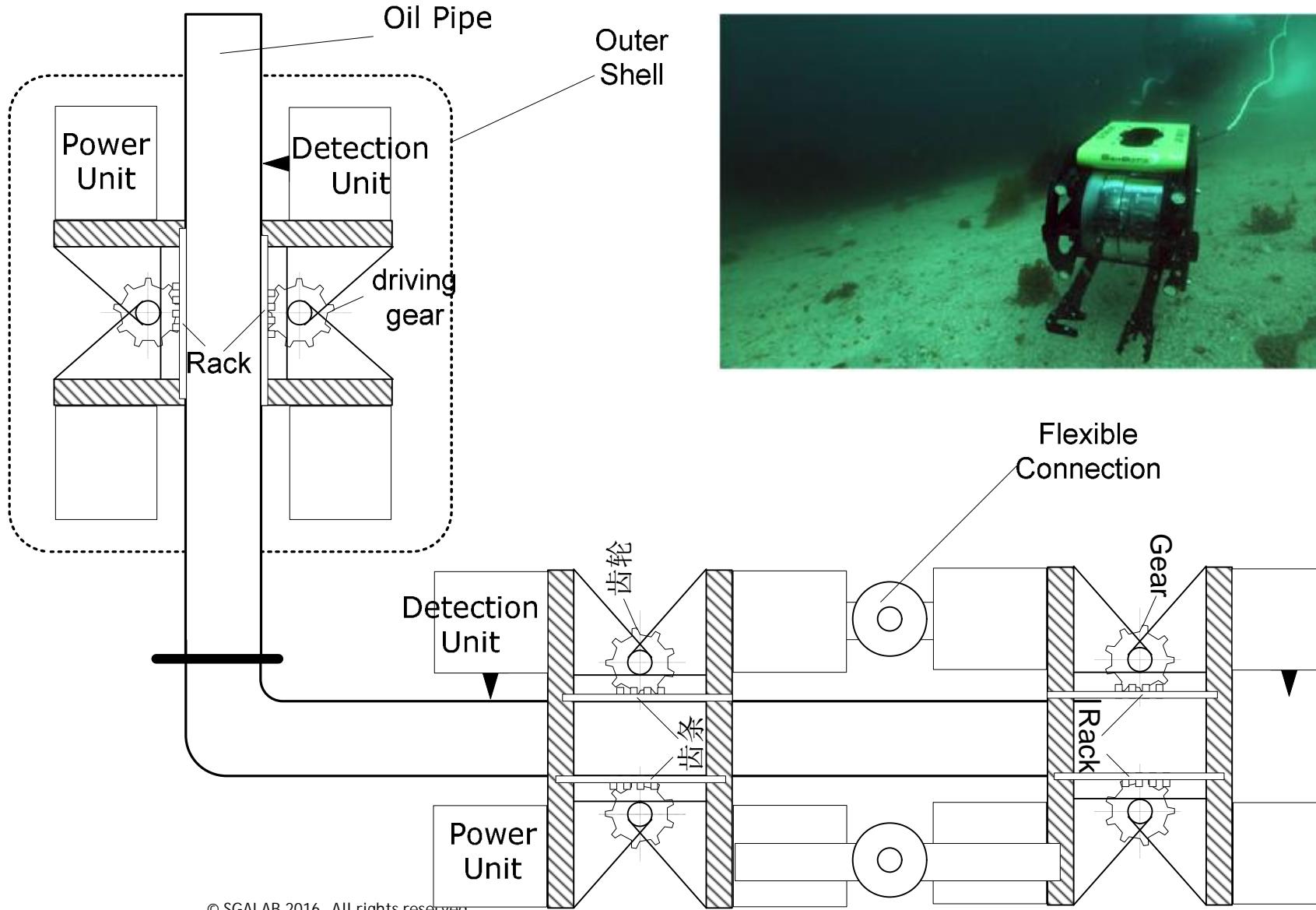
1. human
2. robotics



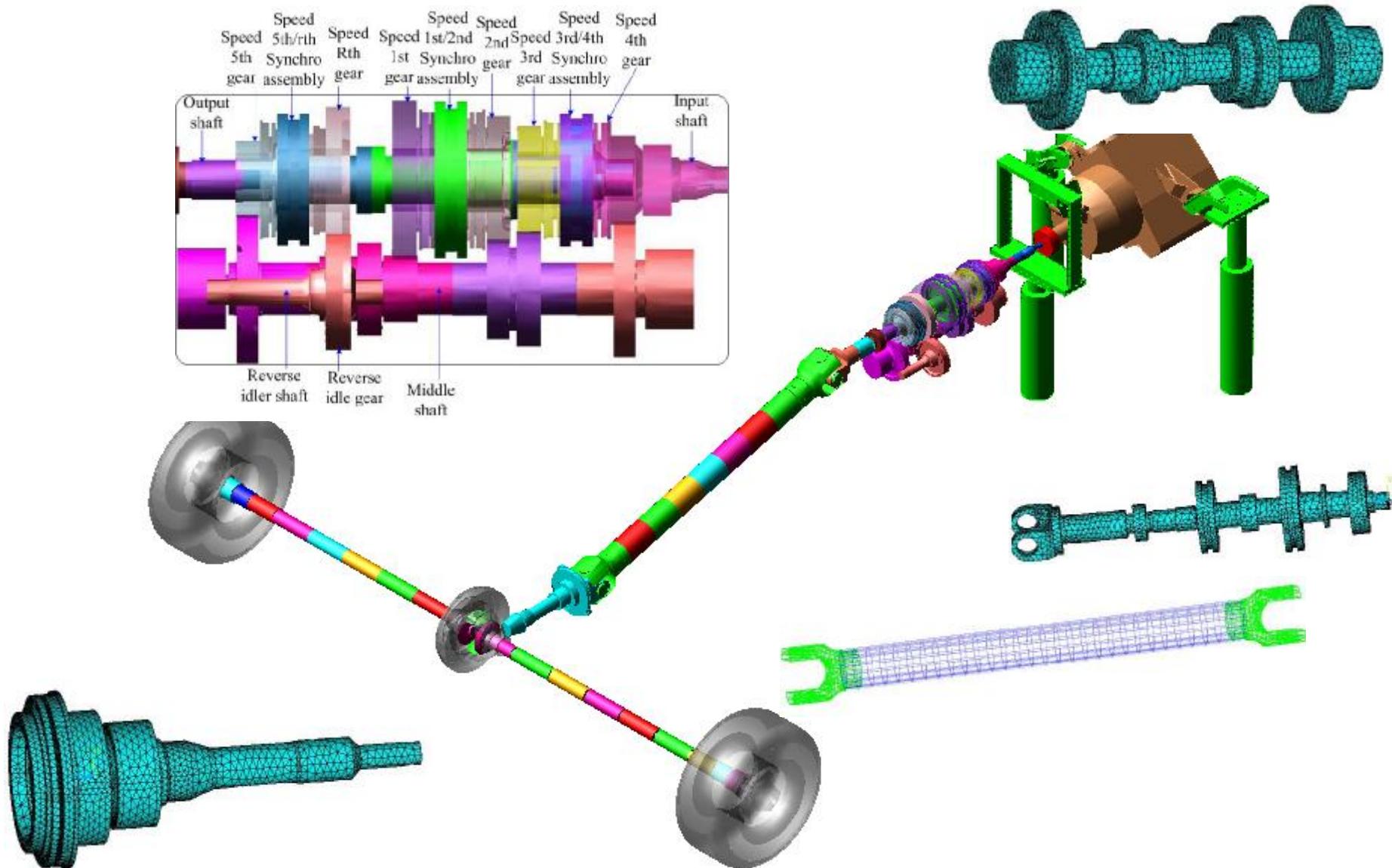
# Inspection Robot for High-voltage Transmission Lines



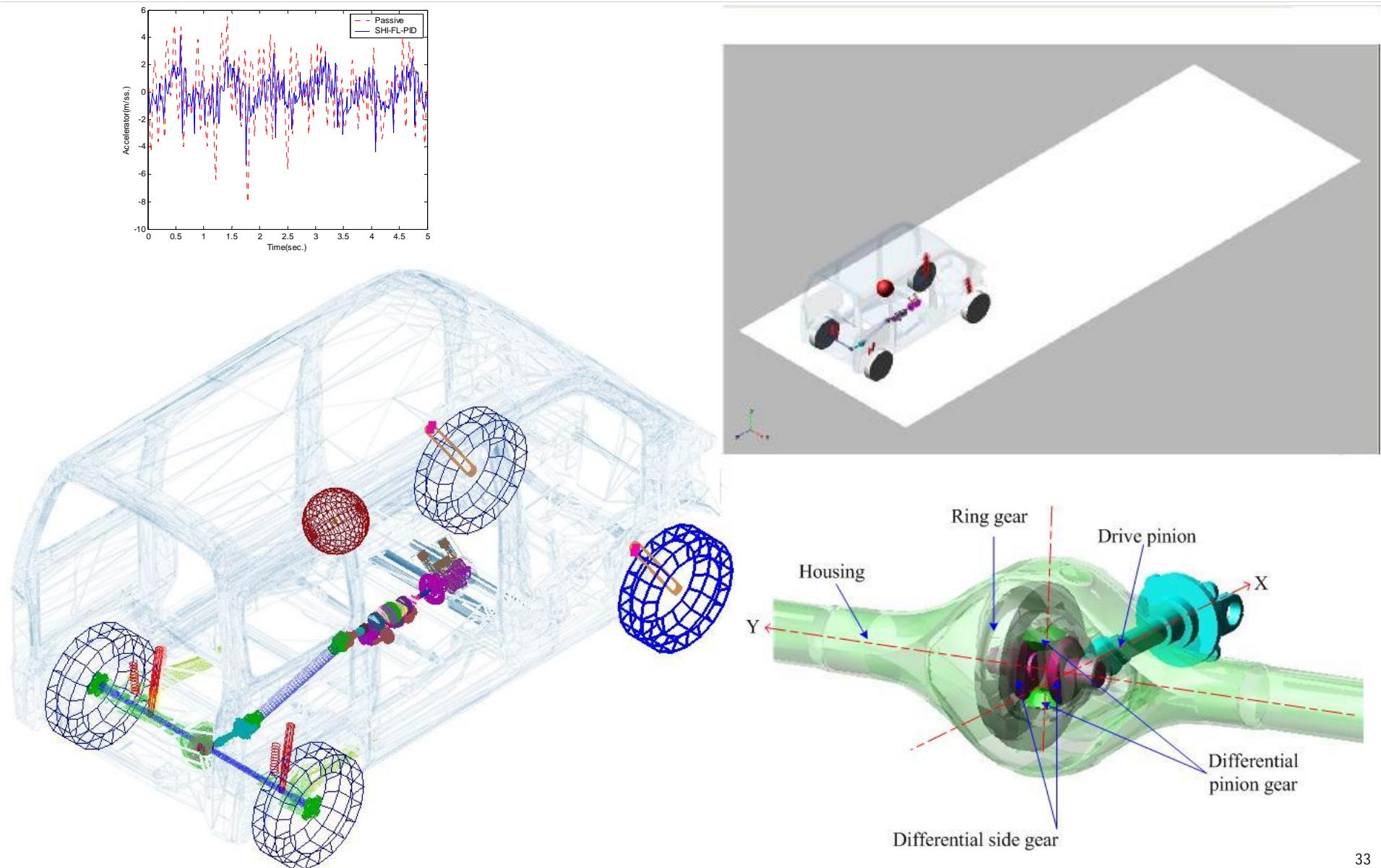
# Autonomous Underwater Vehicle (AUV)



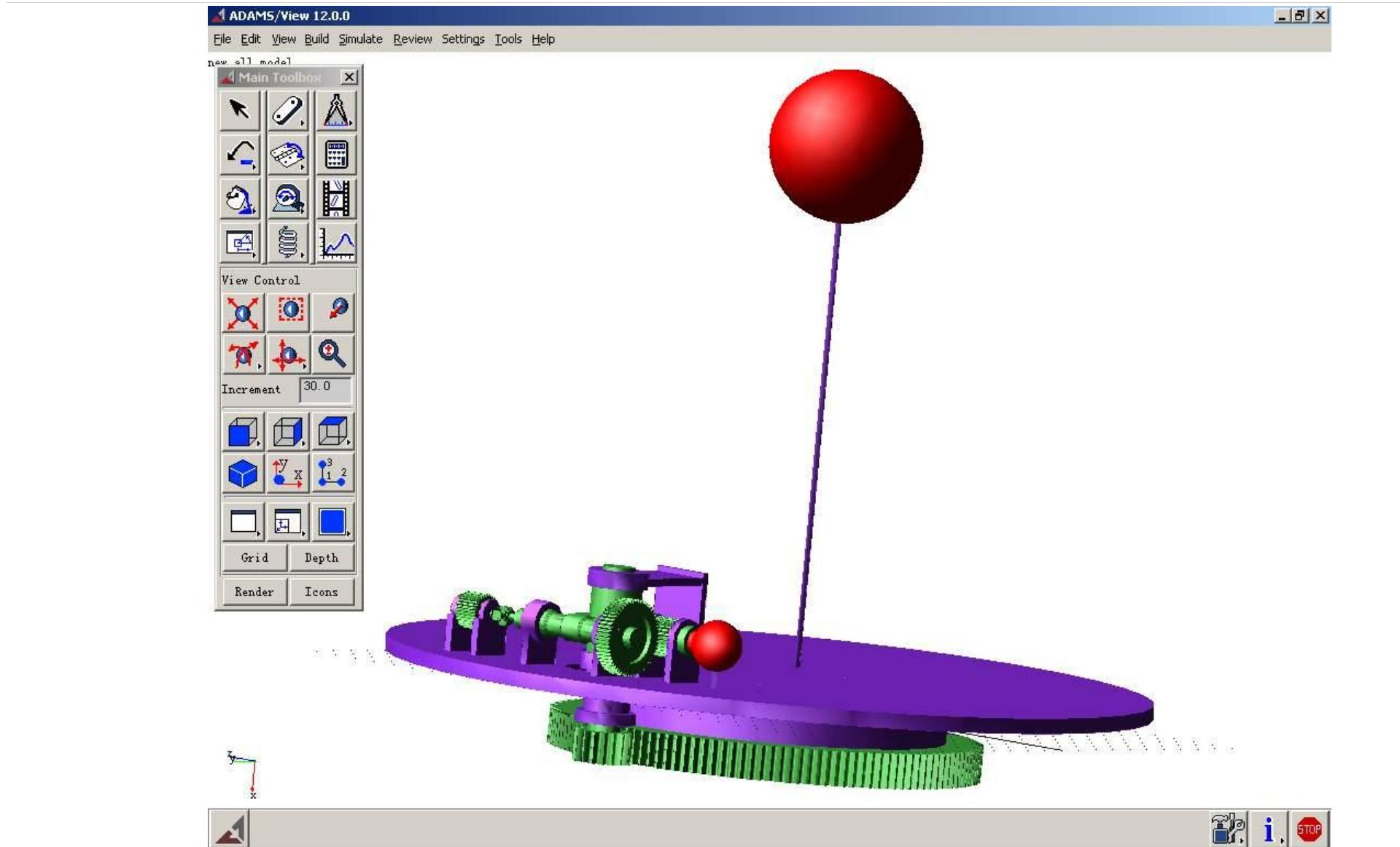
# Driveline Modelling and Simulations



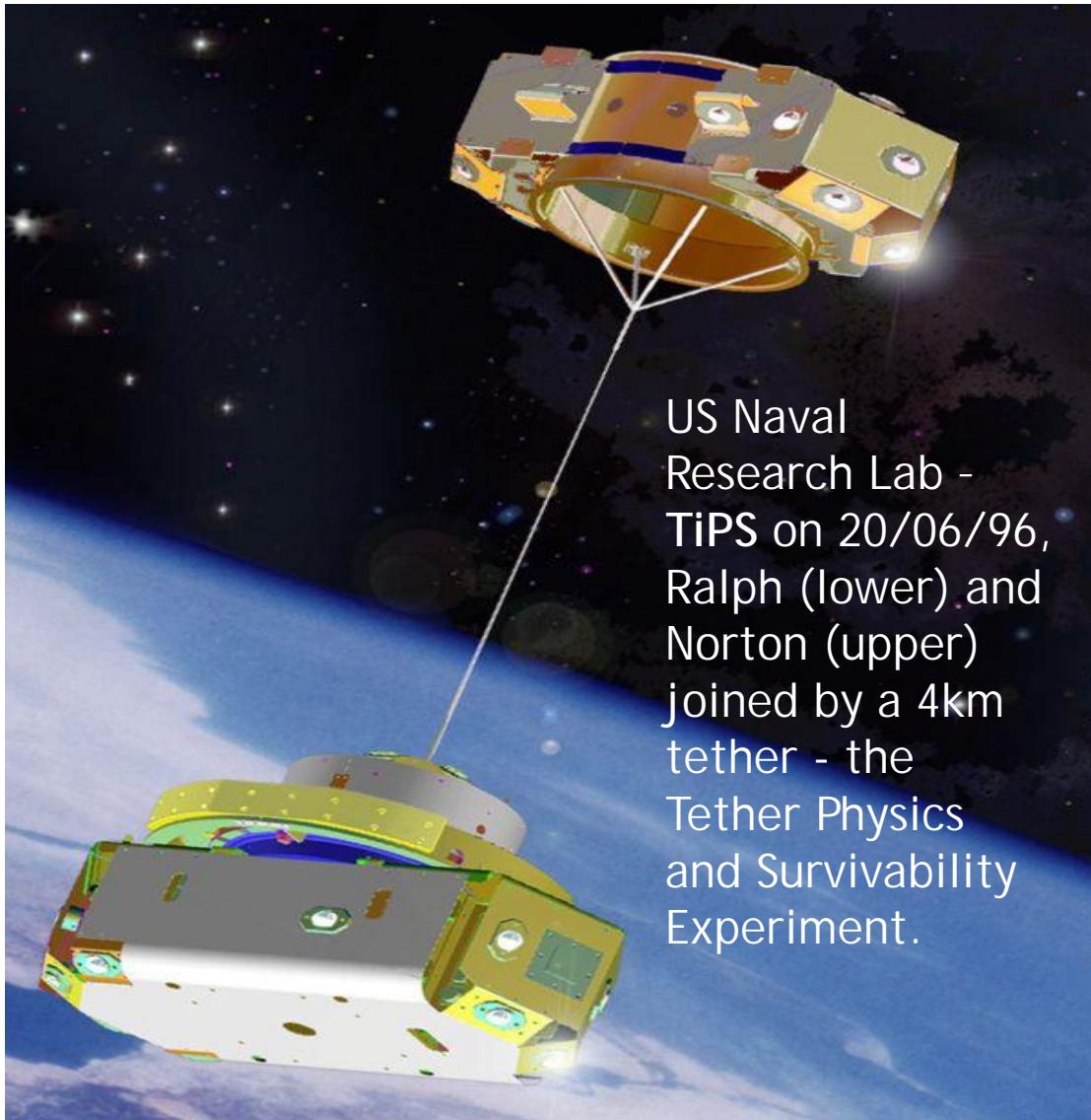
# Driveline Modelling and Simulations



# Rotating System



# Momentum Exchange Space Tethers



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- | Tsiolkovsky (1895) - proposed exploitation of gravity gradient force for an elevator, and rotating structures for artificial gravity
- | Tsander (1910) - suggested the use of a tapering cable to connect the Earth and the Moon
- | Artsutanov, Isaaks, and Pearson (1960s) - re-invented the space elevator
- | Gemini 11 & 12 - 1966
- | Oedipus A - 1989
- | TSS1 - 1992
- | SEDS1 - 1993
- | PmG - 1993
- | SEDS2 - 1994
- | Oedipus C - 1995
- | TSS1R - 1996
- | TiPS - 1996
- | ATEx - 1998

„ The concept of [the motorised momentum exchange tether \(MMET\)](#) was first proposed by [Cartmell](#) in 1998, and its modelling and conceptual design were developed further, in particular modelling of the MMET as a rigid body by [Ziegler and Cartmell](#), and modelling of the MMET with axial elasticity by [Chen and Cartmell](#).

*The system is composed of the following parts:*

>> a pair of braided **propulsion tether** tube sub-spans, #1 and #2 upper

>> a corresponding pair of braided **outrigger tether** tube sub-spans, #1 and #2 lower

>> the launcher **motor** mass within the rotor and the launcher motor mass within stator

>> the **outrigger payload masses**

>> the two **payload masses**

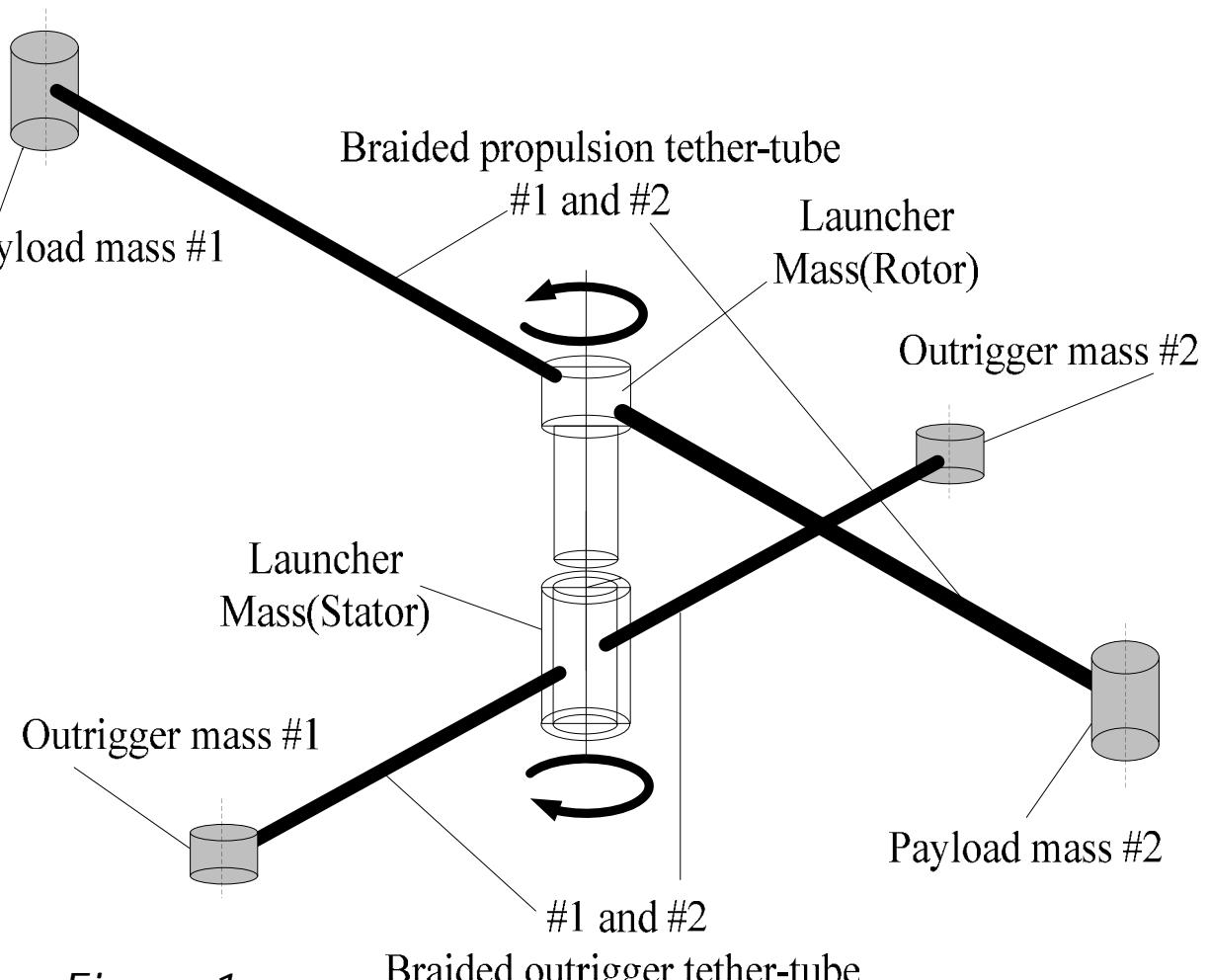
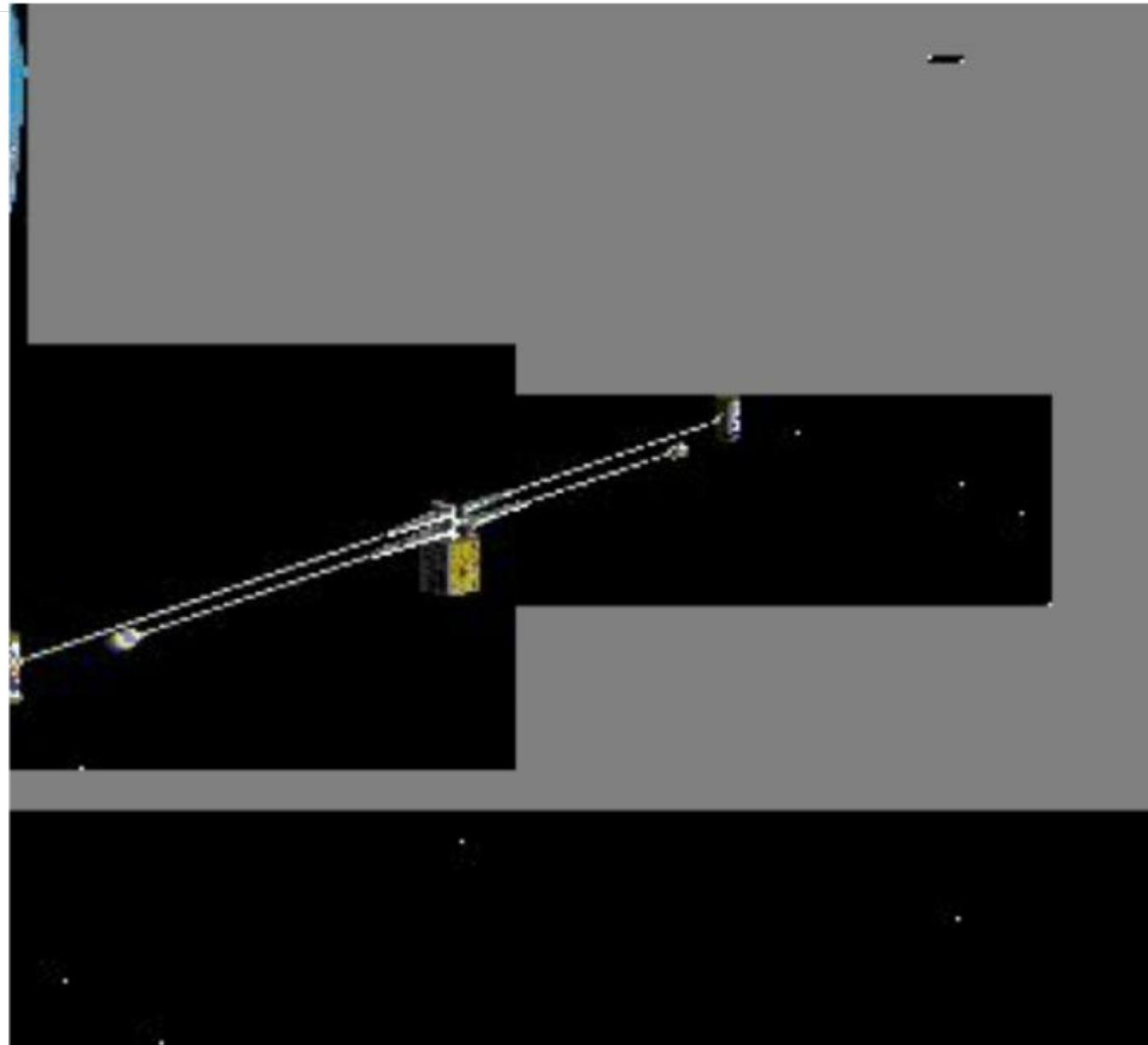
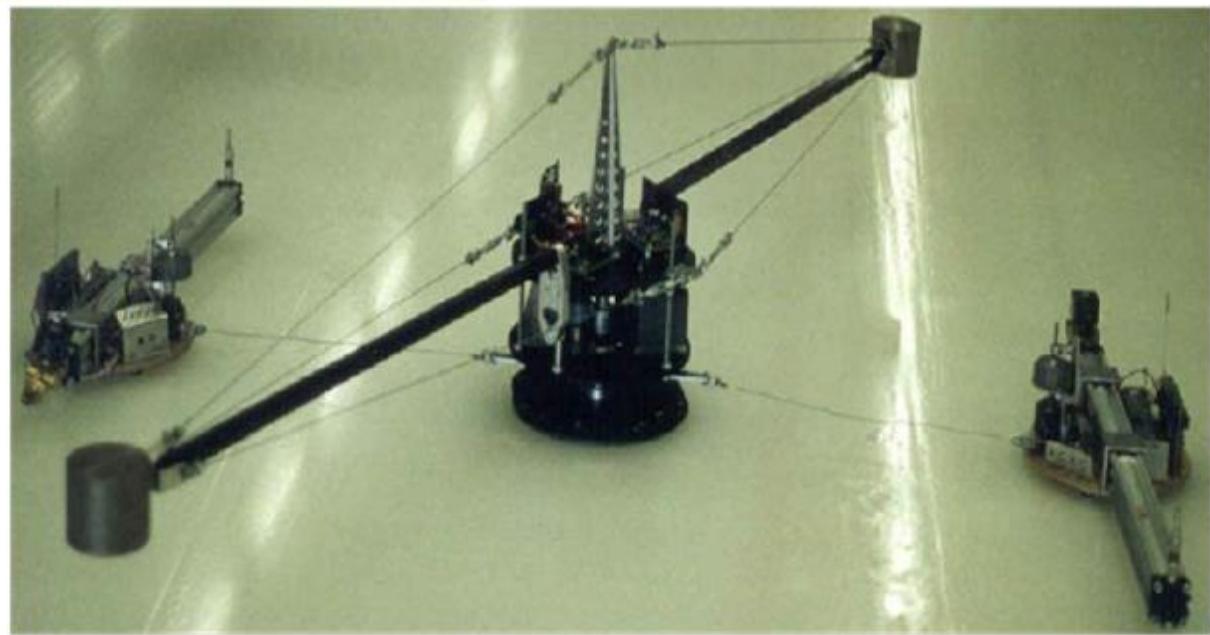
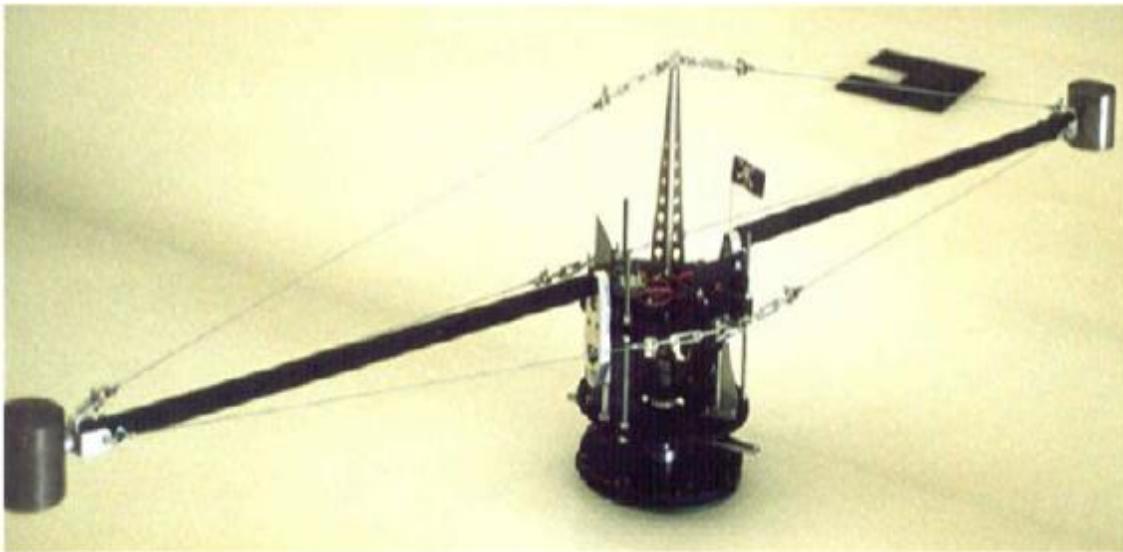


Figure 1.

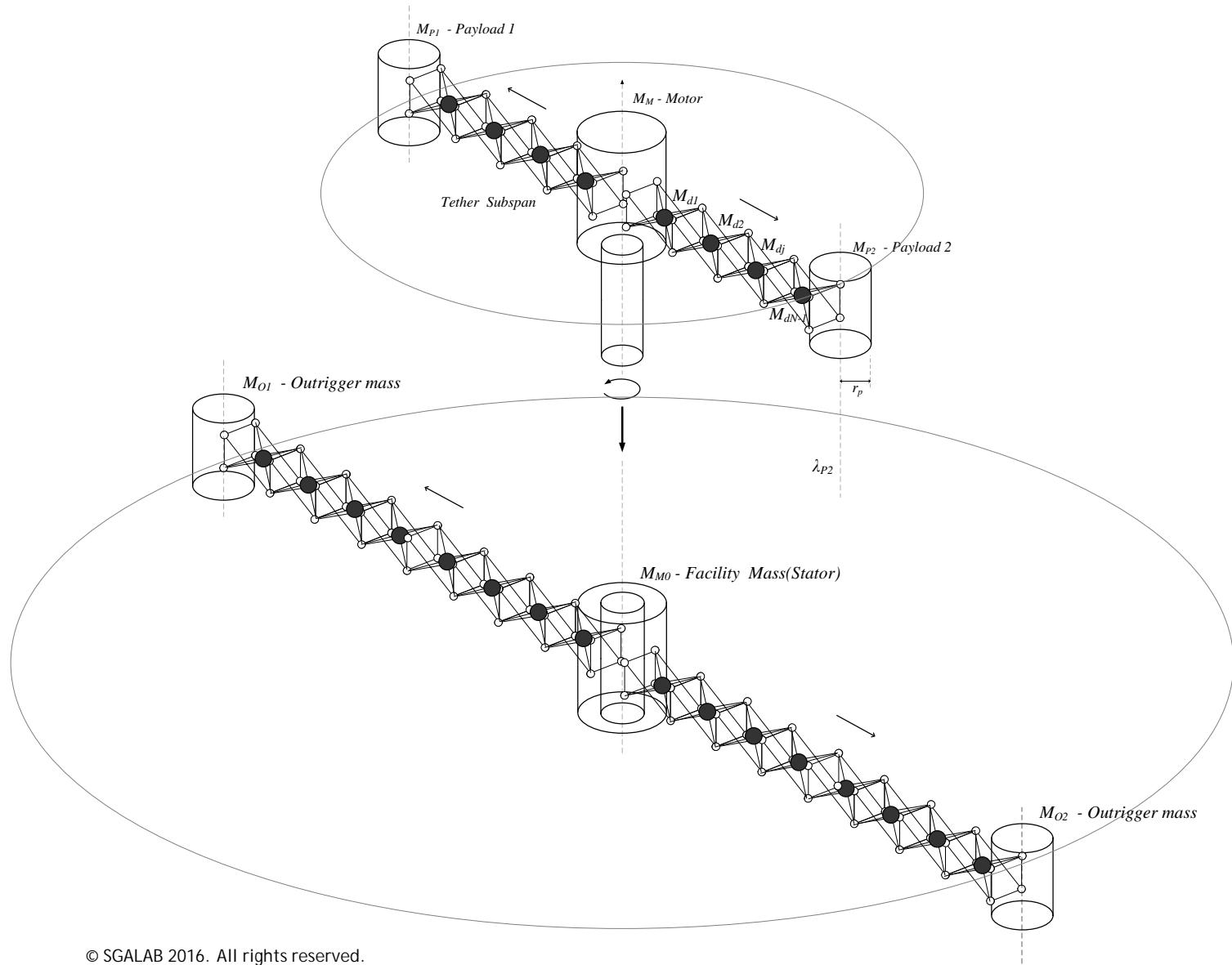
## Tether 3D - The MMET Demonstration



# Scale MMET Modelling Experiments

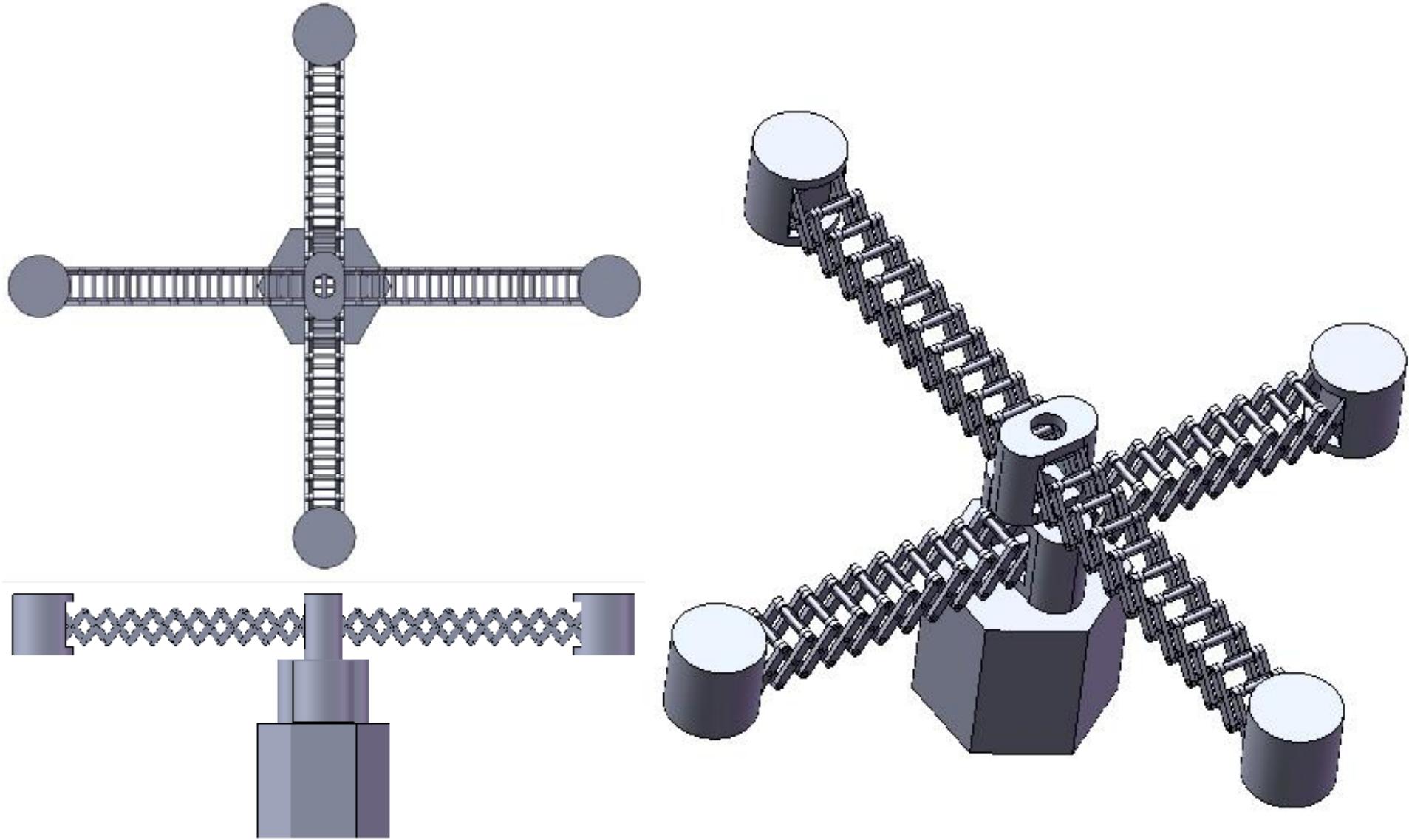


# Robotic MMET



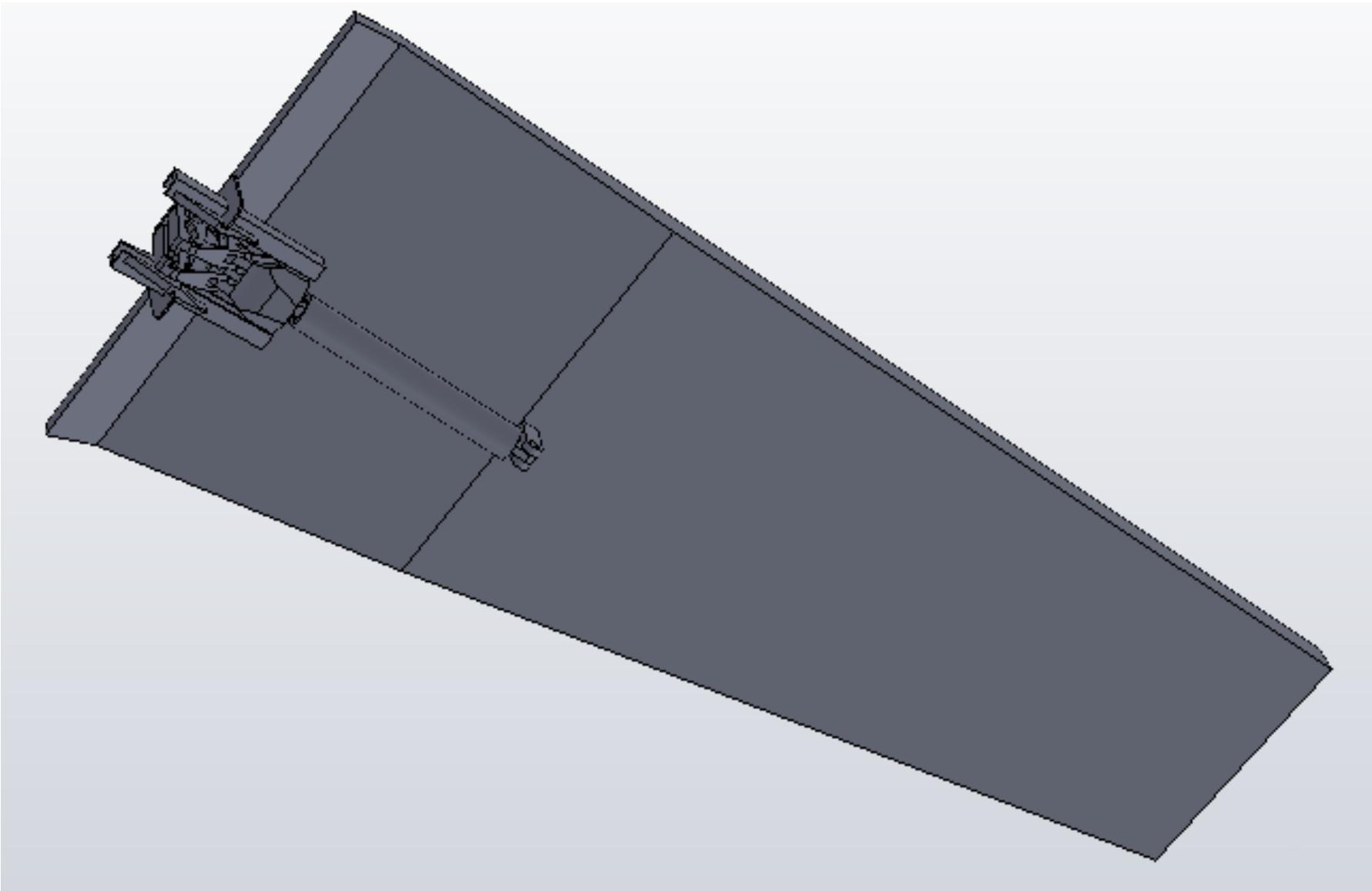
# Robotic MMET(1-ORMMET-2)

---

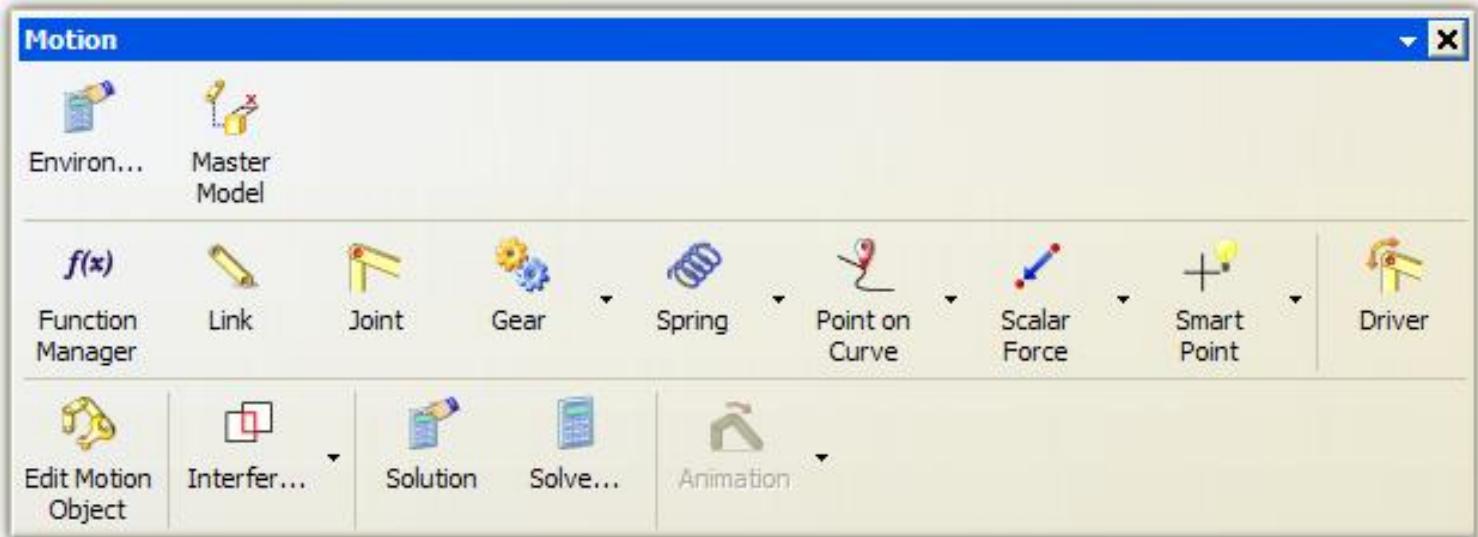


# Multidisciplinary Design, Analysis and Optimisation (MDO) for *Aircraft with Folding Wing*

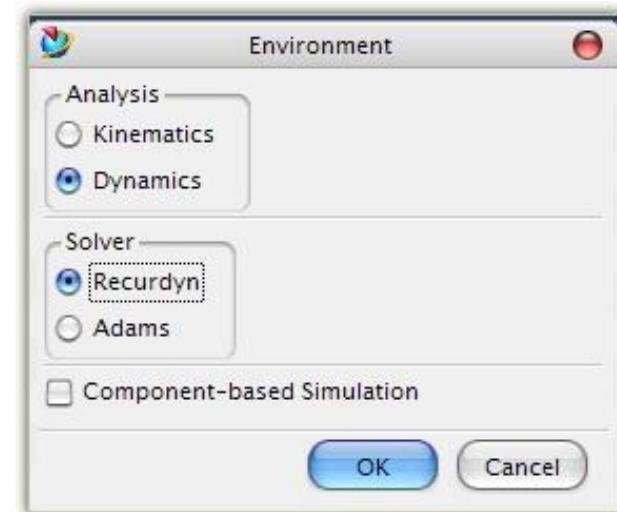
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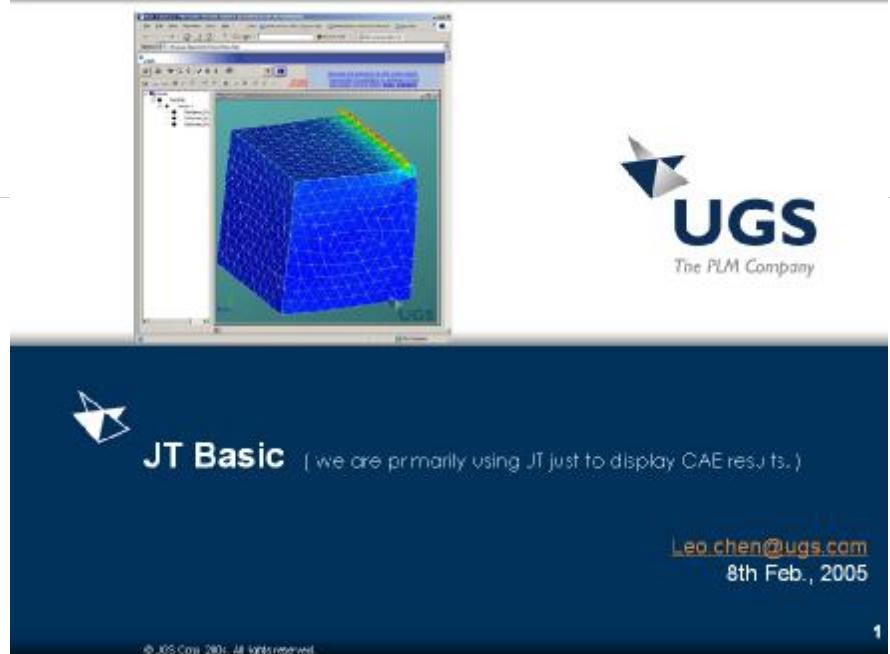
# Siemens PLM Software's NX Digital Lifecycle Simulation



[http://www.plm.automation.siemens.com/en\\_gb/products/nx/simulation/mechanical\\_simulation/index.shtml](http://www.plm.automation.siemens.com/en_gb/products/nx/simulation/mechanical_simulation/index.shtml)



# Siemens PLM Software's NX Digital Lifecycle Simulation

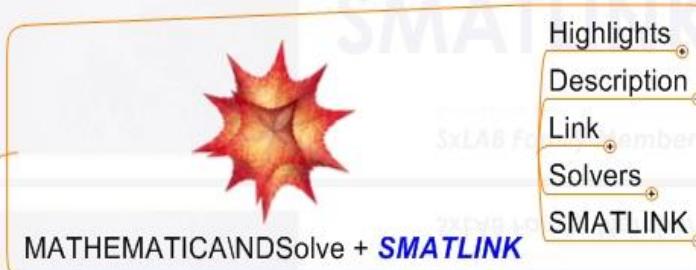


# Multi-body **Dynamics** and **Control** Numerical Co-Simulation

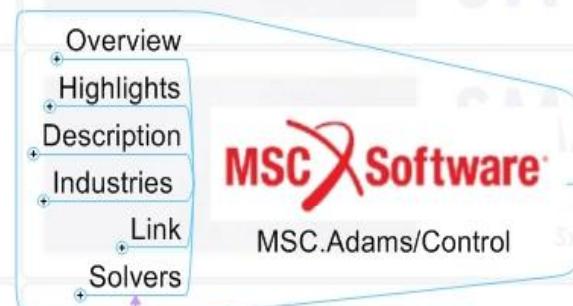
Yi Chen  
15-Oct-2008  
leo.chen.yi@gmail.com



SxLAB Family Member



SxLAB Family Member



SxLAB Family Member



MATLAB/SIMULINK



LMS Virtual.Lab Motion -  
Controls & Hydraulics Interfaces

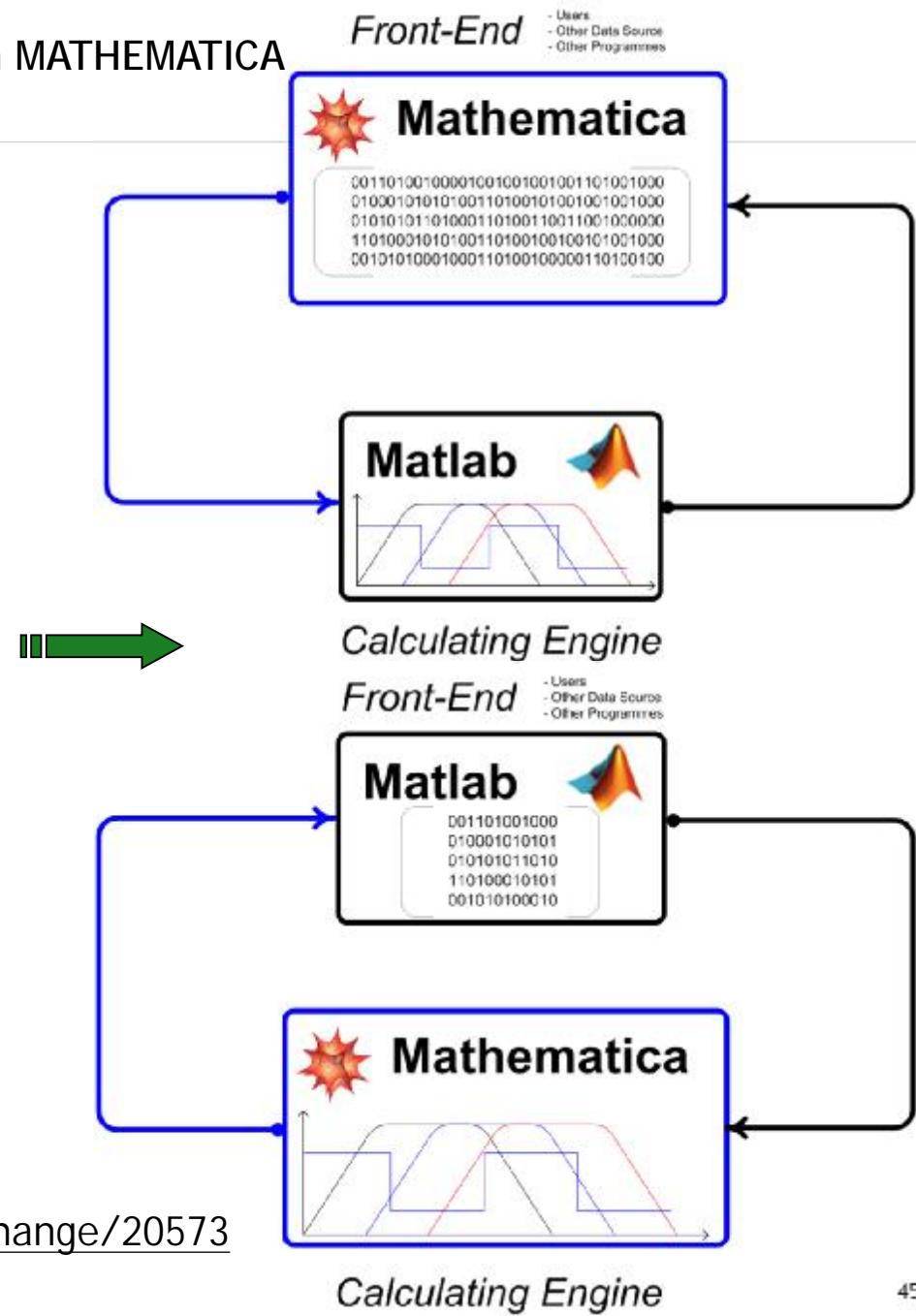
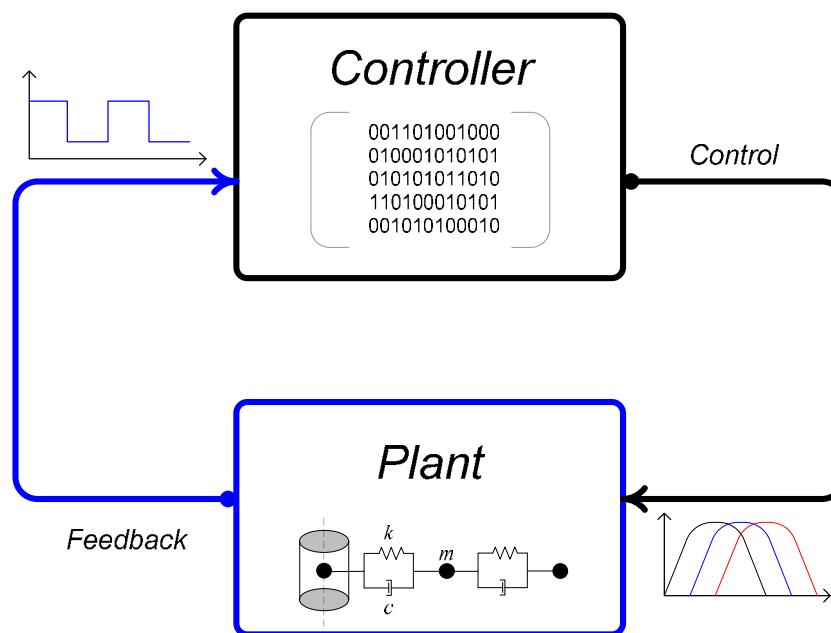
Highlights  
Description  
Link  
Solvers



MSC.Adams  
FunctionBay's RecurDyn  
LMS Virtual Lab Motion

SIEMENS  
Siemens PLM  
NX for Mechanical Simulation -  
CAE Motion Solvers

# SMATLINK - Let MATLAB dance with MATHEMATICA



[www.mathworks.com/matlabcentral/fileexchange/20573](http://www.mathworks.com/matlabcentral/fileexchange/20573)

# Research

---

A

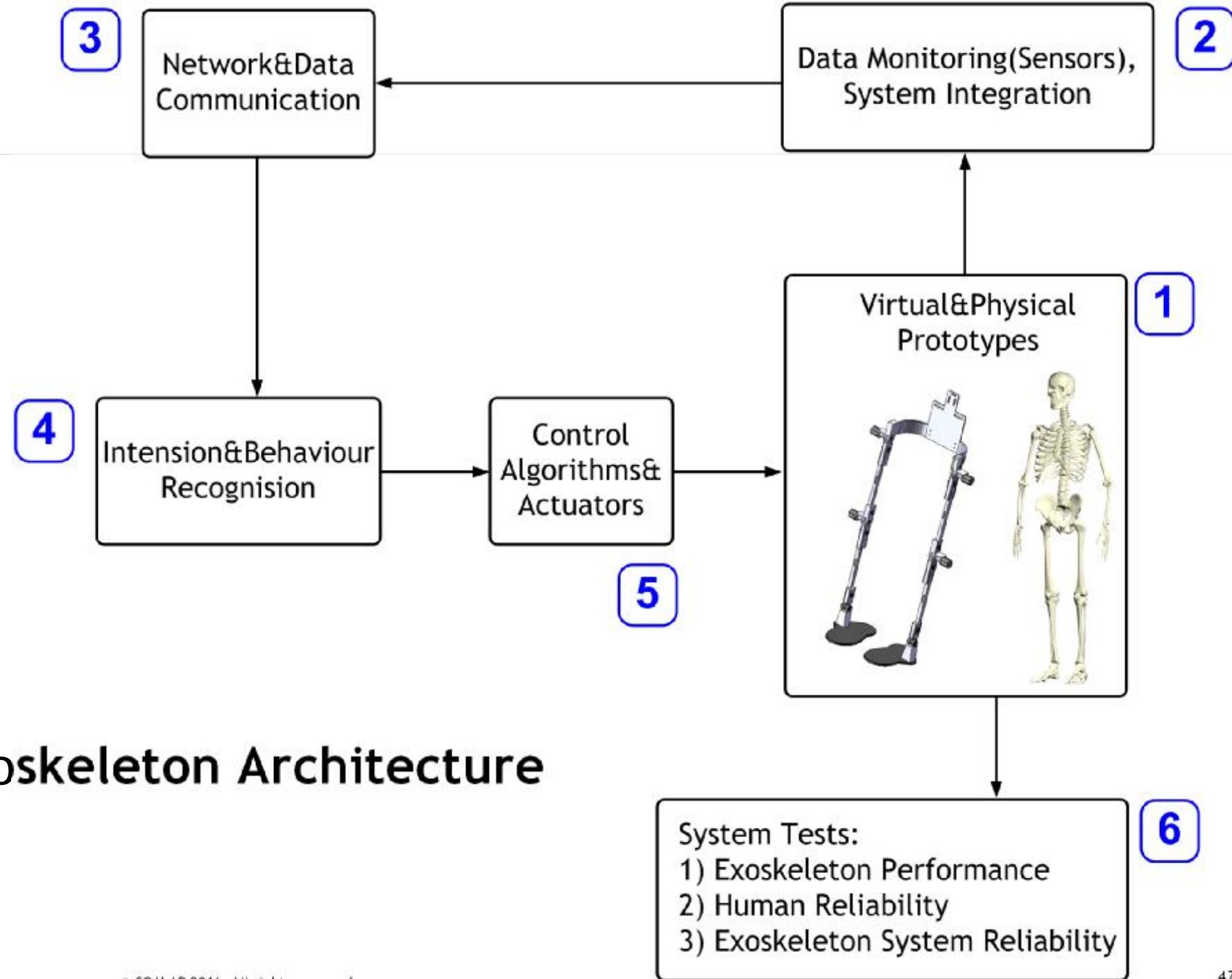
Dynamics and Control

2

Computational Intelligence & Applications

System and Control

- *Robotic Systems*
- *Vehicle Subsystems*
- *Space Tethers*



## Exoskeleton Architecture

# Intension Recognition and Real-time Control

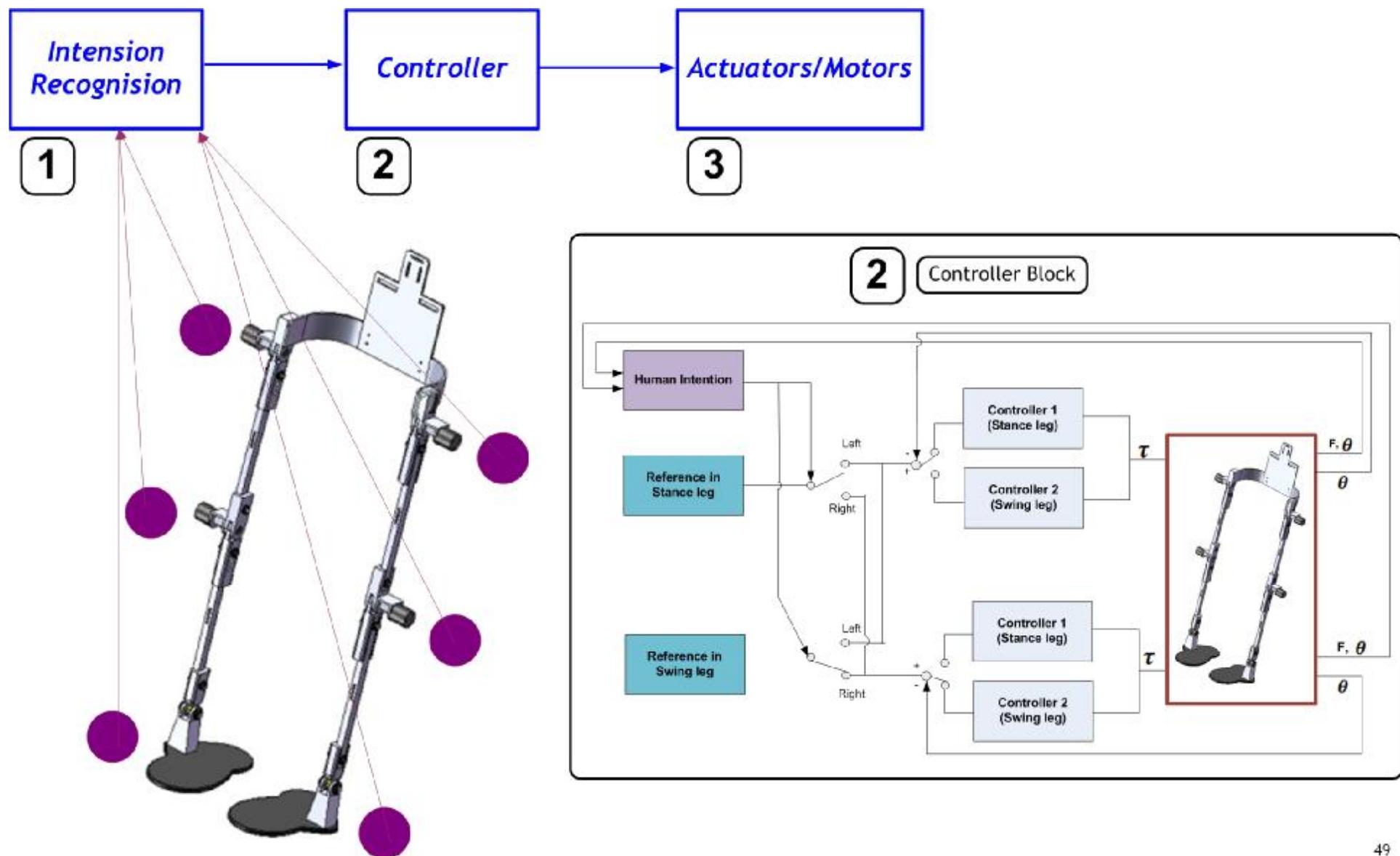
- for Exoskeleton



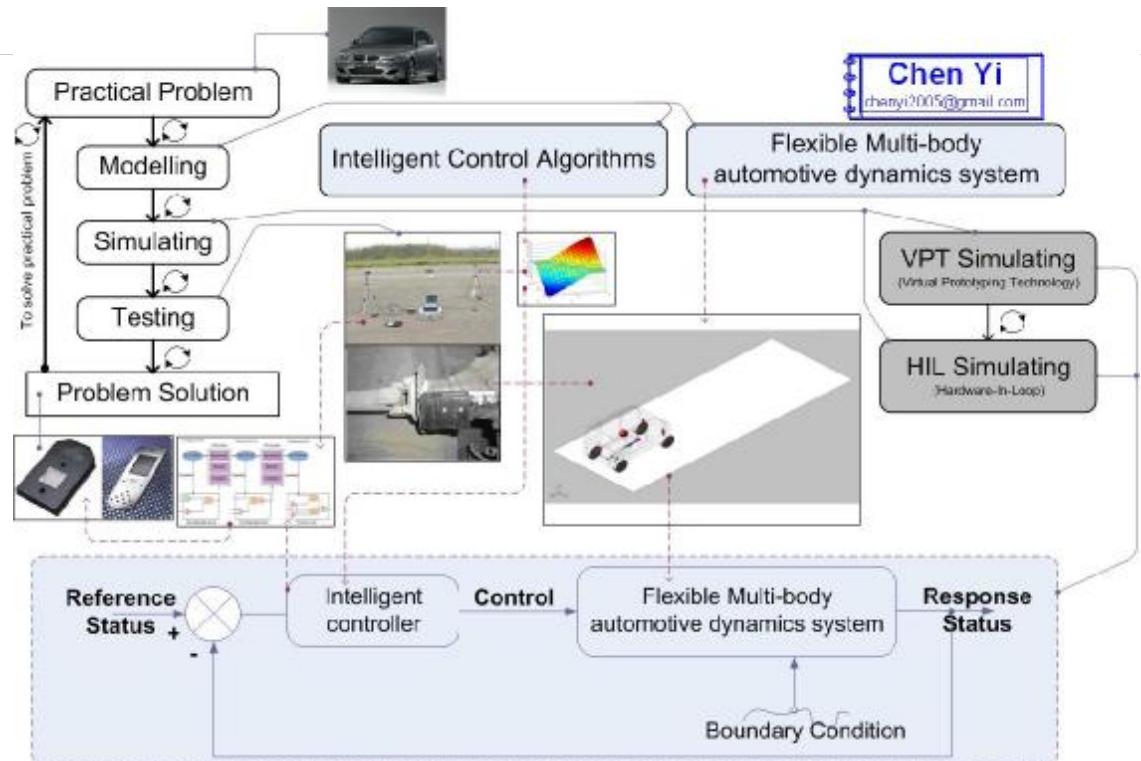
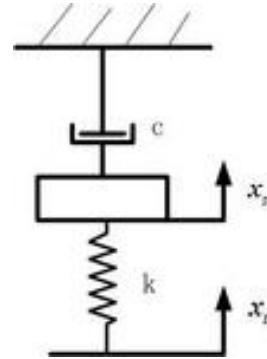
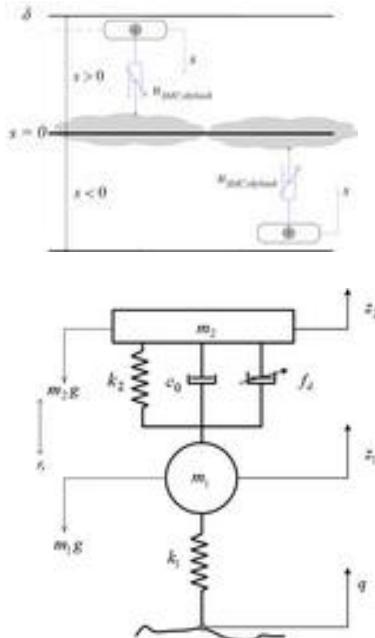
Go to [VPT](#)

# Intension Recognition and Real-time Control

- for Exoskeleton



# Suspension Modelling and Control



Semi-active Control of Skyhook for 1/4 Suspension System

<http://www.mathworks.co.uk/matlabcentral/fileexchange/11118>

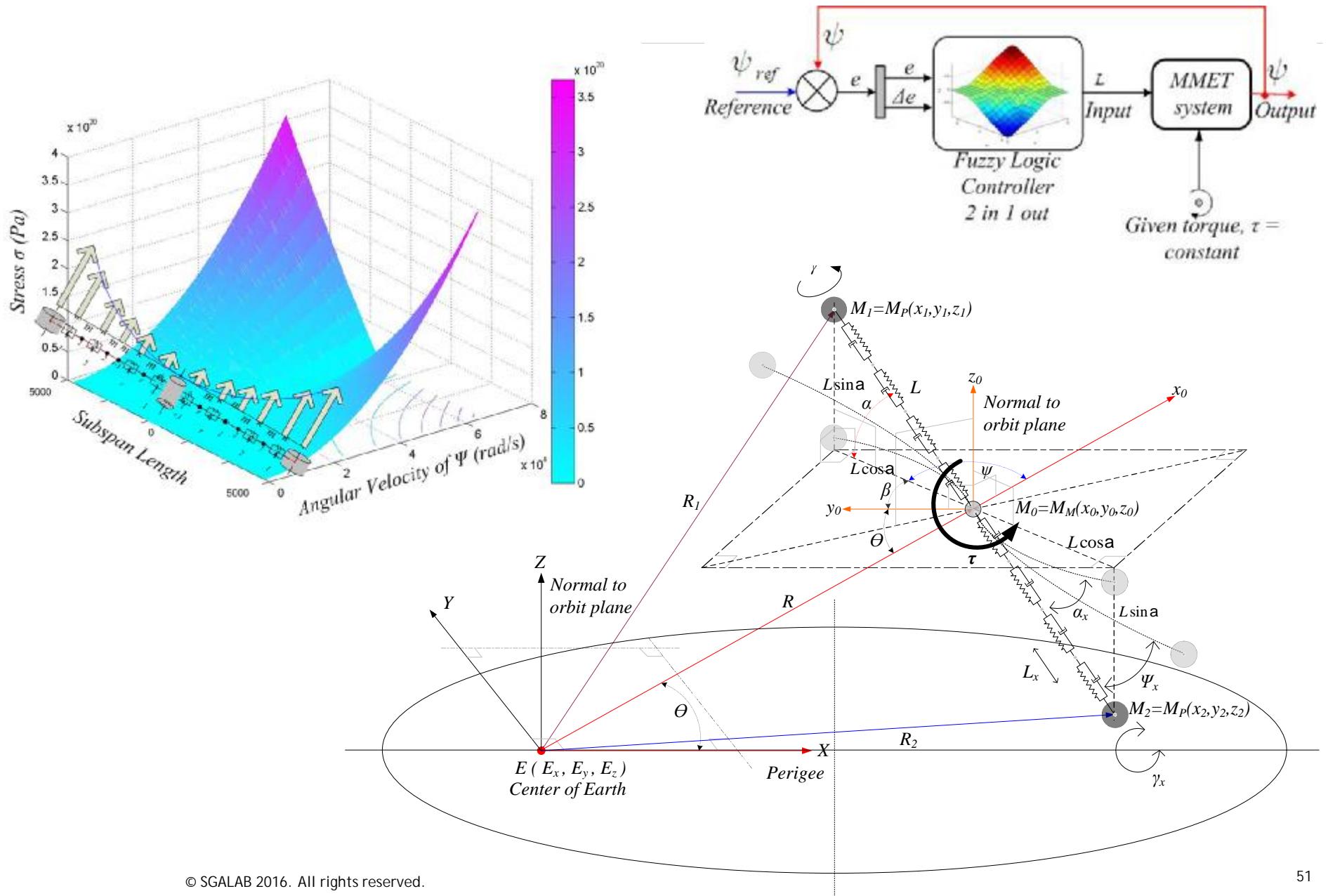
Fuzzy Controller of Semi-active control for 1/4 Suspension System

<http://www.mathworks.co.uk/matlabcentral/fileexchange/11119>

2,4,7 DOFs Suspension Model for Simulink

<http://www.mathworks.co.uk/matlabcentral/fileexchange/11199>

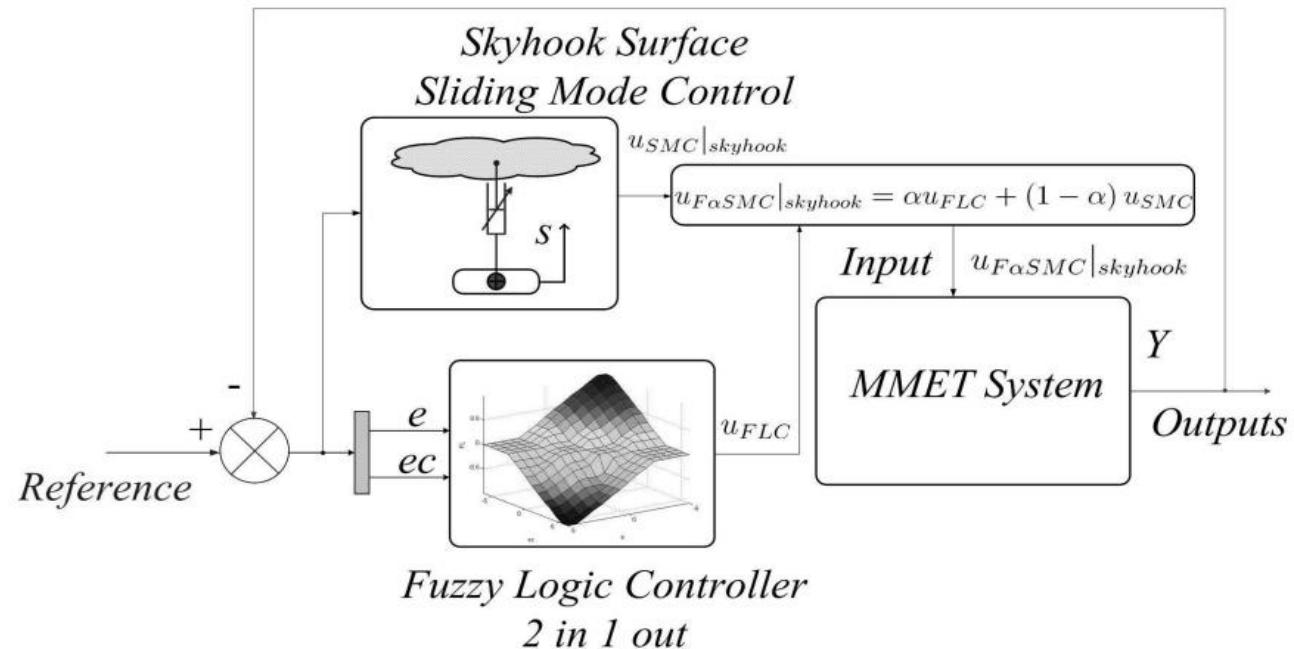
# Space Tether Modelling and Control



# Hybrid Control Strategy

## Fuzzy Skyhook Surface Sliding Mode Control for Semi-active Suspension system

<http://www.mathworks.co.uk/matlabcentral/fileexchange/25456>



# Research

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## Dynamics and Control

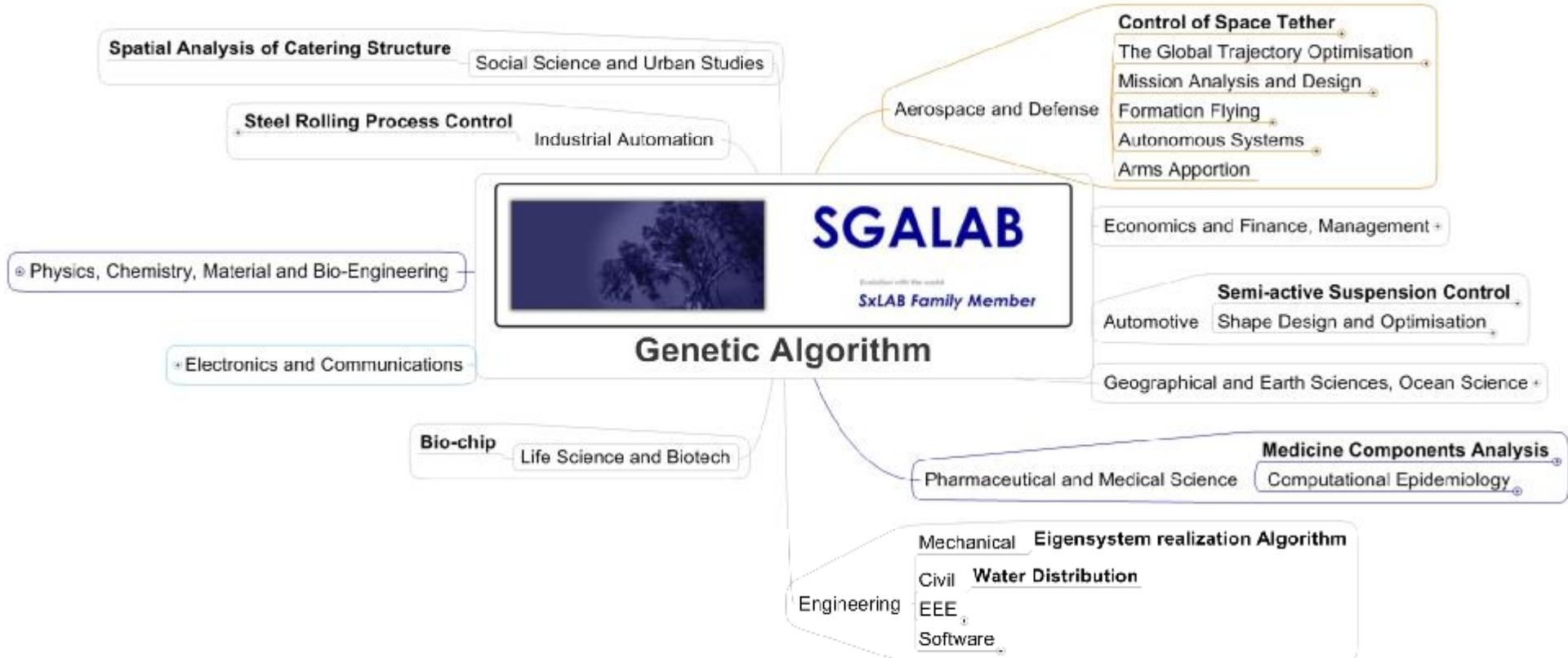
B

### Computational Intelligence Aided Design and Manufacture

#### *CI Algorithms*

- *Genetic Algorithms*
- *Swarm Algorithms*

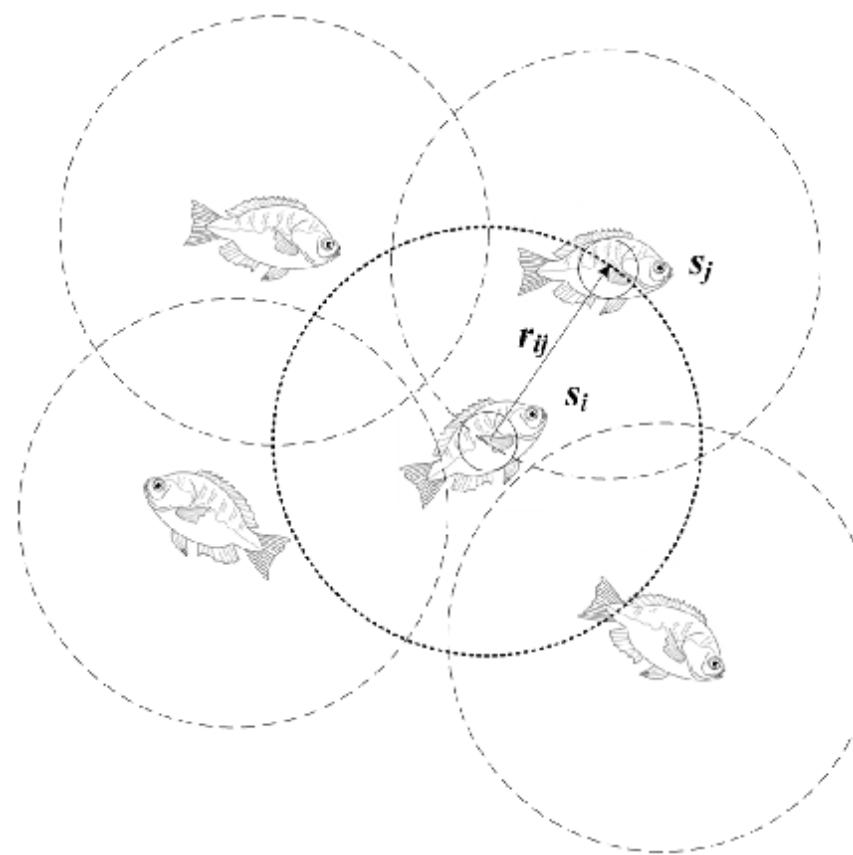
# Genetic Algorithms & Applications



<http://www.mathworks.com/matlabcentral/fileexchange/5882>

# SwarmFish - The Artificial Fish Swarm Algorithm

the AFSA includes five steps of operations: (1) behaviour selection, (2) searching behaviour, (3) swarming behaviour, (4) following behaviour and (5) bulletin. A 'max-generation' is the trial number of an AF school searching for food under given initial conditions, which is one of the widely used criteria for the simulation termination.



<http://www.mathworks.com/matlabcentral/fileexchange/32022>

Cost	1SA	2NY	3BR	4MA	5LO	6ST	7JO	8MO	9ND	10CQ	11SH	12TO	13CA
1SA	106.05	106.05	104.45	845	845	845	845	845	807	656.89	525	1019	735.34
2NY	106.05	916	575	297	381	989	635	604	775.69	644	359	933.34	
3BR	1109	999	784	919	1068	1279	1059	1643	2145	1971	1266	1954.68	
4MA	582.95	273.71	862.89	44.18	79.75	352.26	239.34	1042.07	942.65	365.76	670.23	2145.71	
5LO	544.38	496.88	632.54	47.49	18.26	465.82	155.27	405.54	884.89	548.03	652.16	1296.52	
6ST	1374.72	260.9	877.05	54.18	18.06	702.44	124.43	434.84	936.59	634.87	400.09	2864.24	
7JO	948.65	516.11	2054.74	610.59	580.81	647.82	610.39	707.39	1496.76	896.33	767.01	2656.52	
8MO	809	315	810	291	170	145	433	307	774	525	700	1286.8	
9ND	597.20	560.52	1519.70	304.98	372.12	305.9	551.29	305.9	546.69	470.09	490.06	1004.95	
10CQ	703.19	836.1	2510.72	927.92	927.92	1496.76	1074.72	712.86	180.02	918.26	1767.14		
11SH	555.79	459.13	1555	490.29	394.71	473.63	146.31	451.08	567.87	180.02	459.13	1753.75	
12TO	1547.04	2229.47	3952.24	2352.91	2352.91	3303.96	3006.5	2711.45	2117.62	1266.09	427.26	2582.71	
13CA	1319.61	1756.67	2873.73	911.69	911.69	1132.6	1114.1	911.69	794.37	2343.69	1025.93	2320.63	

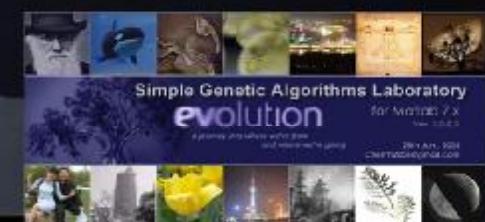
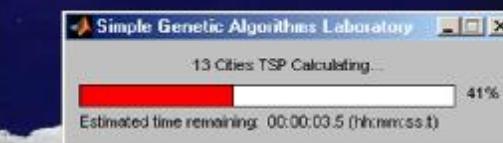
# 13 Cities Traveling Salesman Problem

Simple Genetic Algorithms Laboratory (SGALAB) 1.0.0.3 for Matlab 7.x

31st Nov., 2005

Chen Yi

chenyi2005@gmail.com



**Best TSP Path :**  
10 → 13 → 9 → 1 → 2 → 6 → 5 → 3 → 4 → 7 → 8 → 12 → 11 → 10

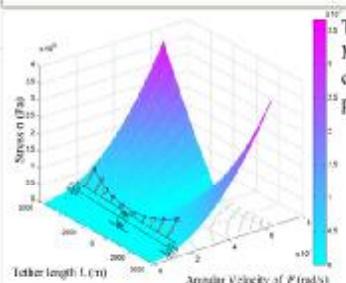
Lowest Flight Cost : 7.3505e+003

# Multi-objective Optimisation of the Motorised Momentum Exchange Tether for Payload Orbital Transfer

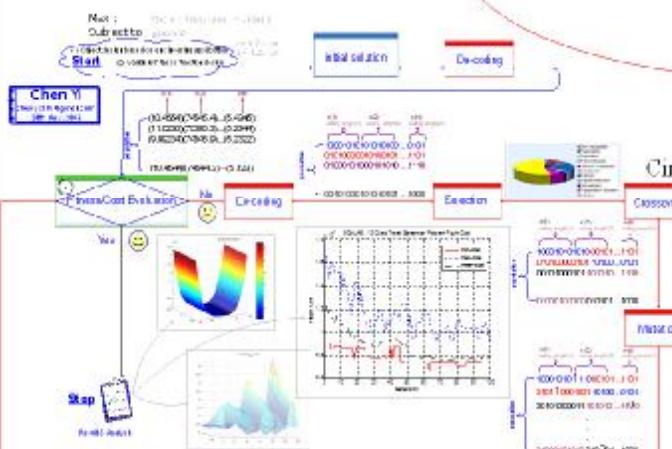
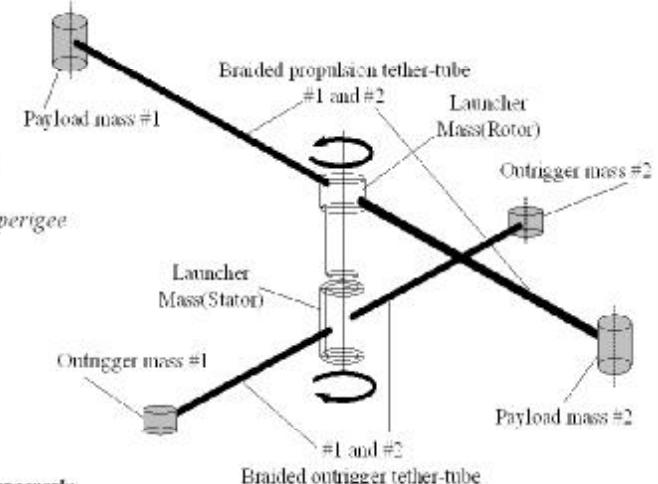
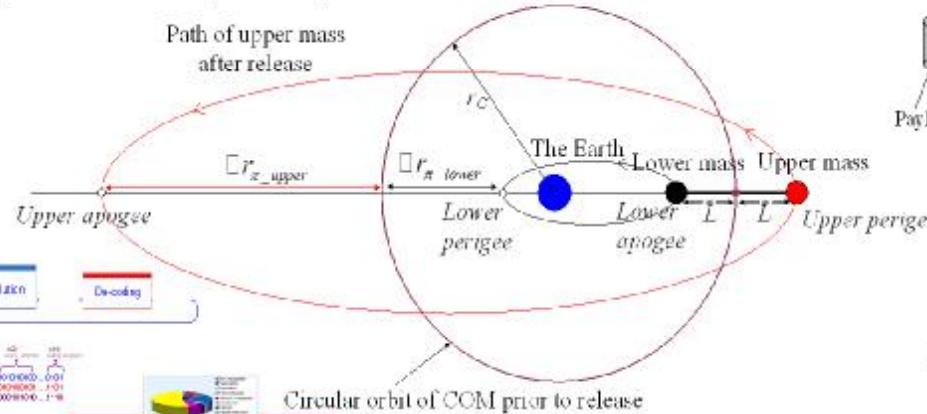
Yi Chen  
[yichen@mech.gla.ac.uk](mailto:yichen@mech.gla.ac.uk)

Matthew Cartmell  
[m.cartmell@mech.gla.ac.uk](mailto:m.cartmell@mech.gla.ac.uk)

Department of Mechanical Engineering  
University of Glasgow  
<http://www.gla.ac.uk>



The motorized momentum exchange tether (MMET) was first proposed by Cartmell, then discussed further by Ziegler and Cartmell, and a more developed idealized MMET of spinning system with point masses was proposed by Ziegler, which motorized by a motor driver and took physical angular coordinates for the generalised coordinates representing spin and then tilt, together with an angular coordinate for circular orbital motion and a further angular co-ordinate defining backspin of the propulsion motor's stator components. This poster shows the last researches on MMET with axial elastic effects.



## Conclusions:

- The 4 multi-objective methods of MOGA, NPGA, NSGA and NSGAII showed **flexible optimisation ability for the MMET practical objectives**, and the Pareto dataset suggests a series of solutions for the MMET, designing for the strength criterion and payload transfer performance.
- The GAs simulation helps to **validate** the current MMET payload transfer design.

## Tether Payload Transfer Problems:

A. *Tether strength*  
Min :  $y_1 = \sigma_0$

$$\rightarrow f_1(\dot{\psi}, L, A) = \sigma_{LIM} - \sigma_0$$

B. *Upper payload transfer*  
Max :  $y_2 = \frac{\Delta r_{\pi,upper}}{L}$

$$\rightarrow f_2(\dot{\psi}, L) = \frac{\Delta r_{\pi,upper}}{L}$$

C. *Lower payload transfer*  
Min :  $y_3 = \frac{\Delta r_{\pi,lower}}{L}$

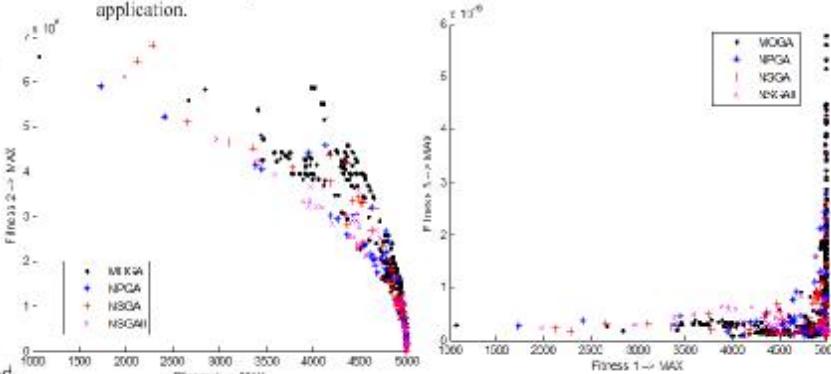
$$\rightarrow f_3(\dot{\psi}, L) = \frac{1}{\Delta r_{\pi,lower} + \varepsilon}$$

where,  $\varepsilon$  is a small value parameter, which helps to avoid  $f_3 \rightarrow \infty$ , and  $\varepsilon \rightarrow 0$ .

Subject to:  $\sigma_0 \leq \sigma_{LIM}$

## Max Fitness Functions:

- more specific or **practical conditions** for each MMET application.



The authors would like to acknowledge the funding support of the Doctoral Research Awards Scheme and the Faculty of Engineering, School of Engineering, University of Glasgow.

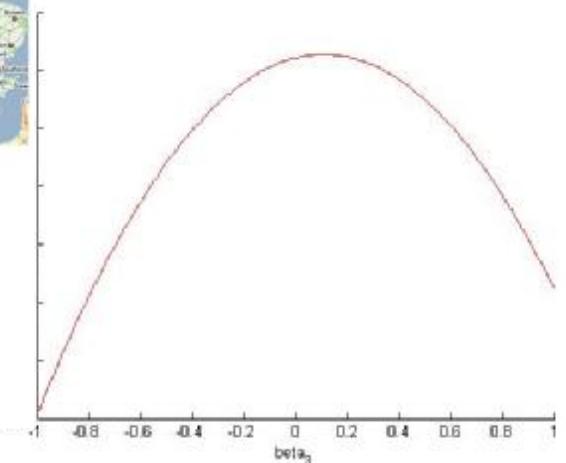
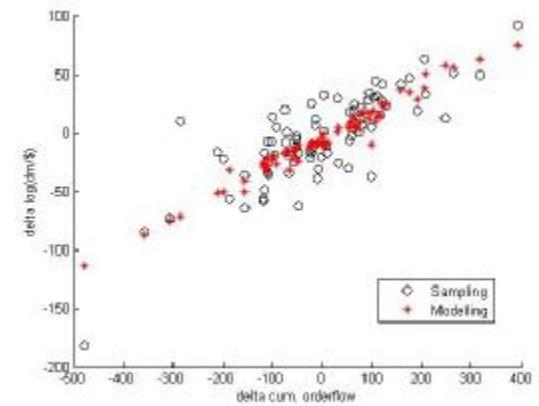
# Genetic Algorithm with Mendel's Principle: Exchange Rates Determination



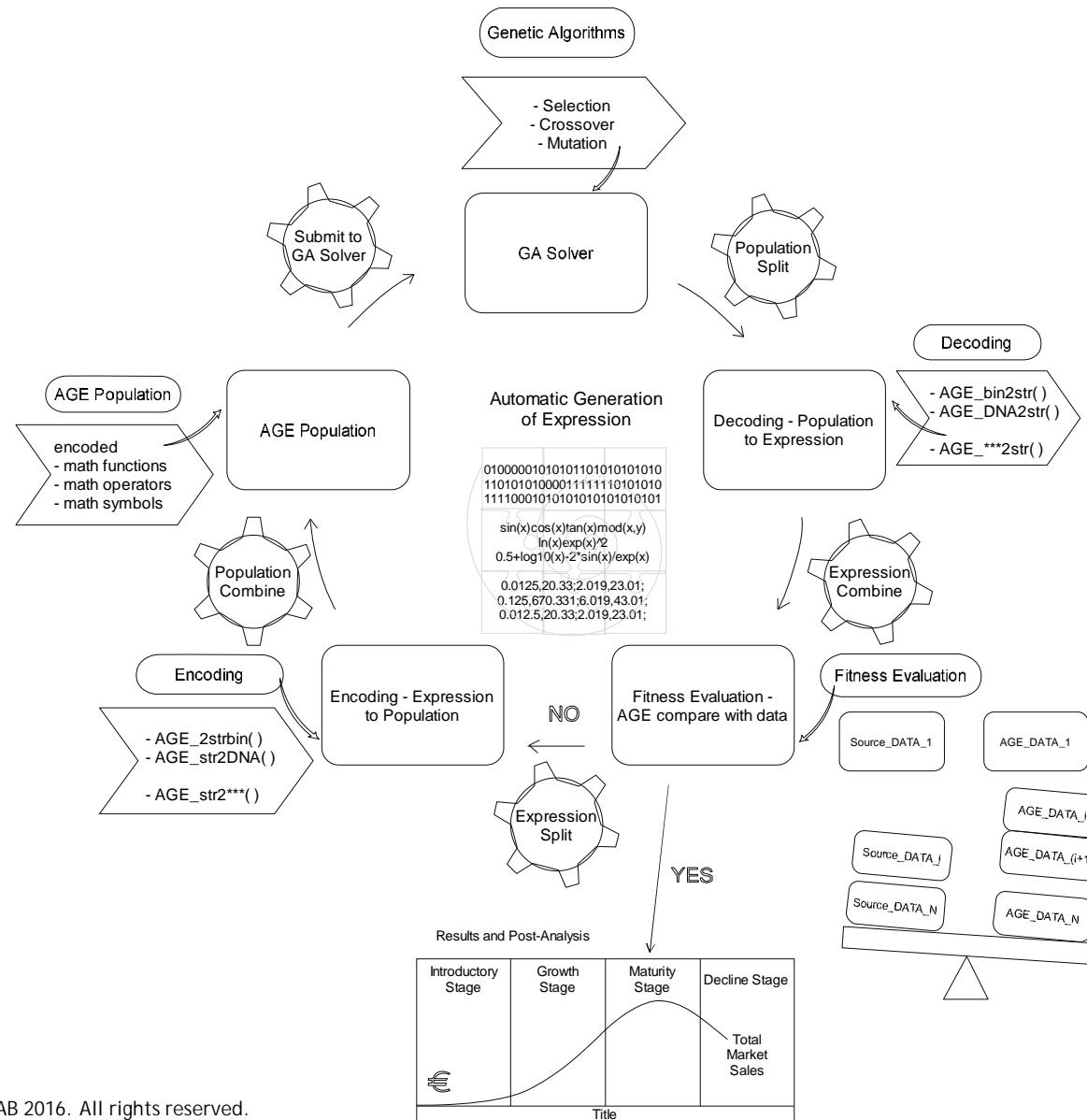
*Gregor Mendel (1822-1884)*



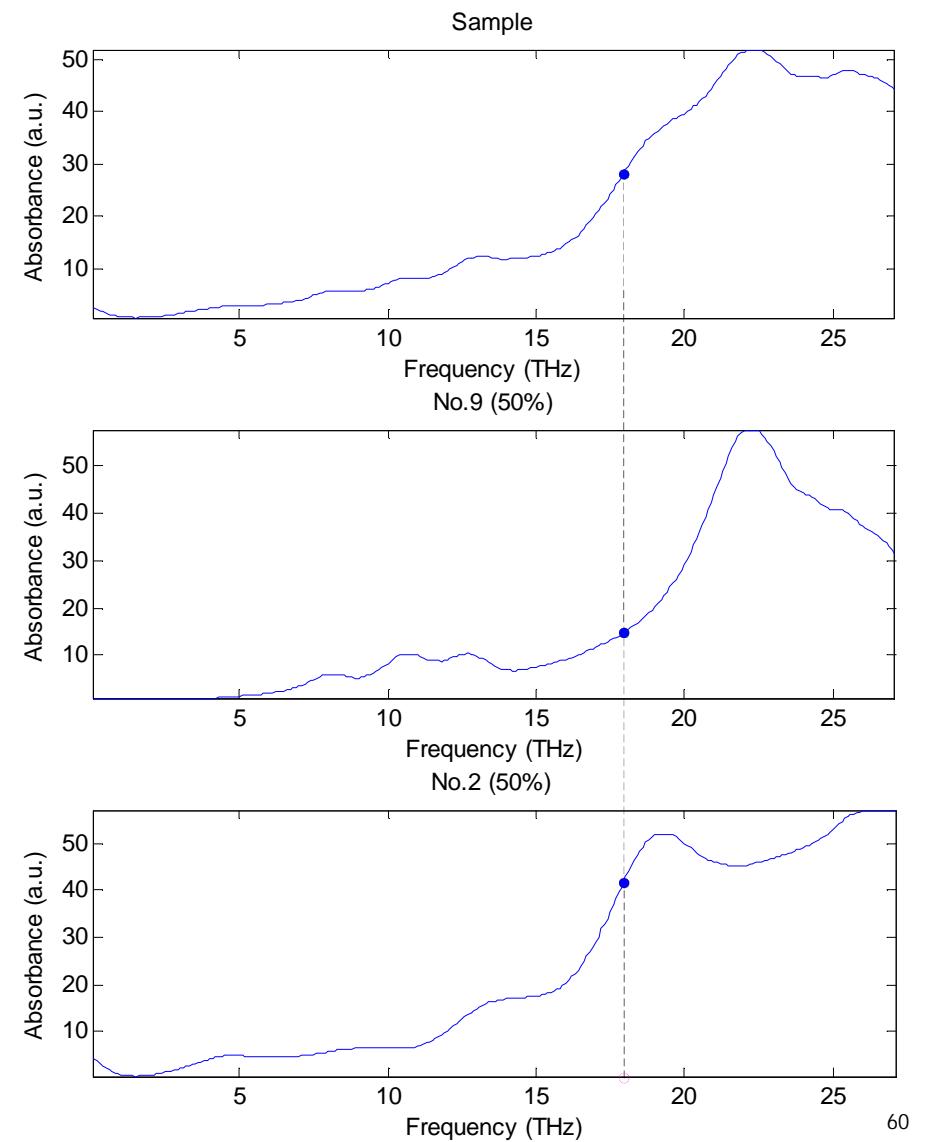
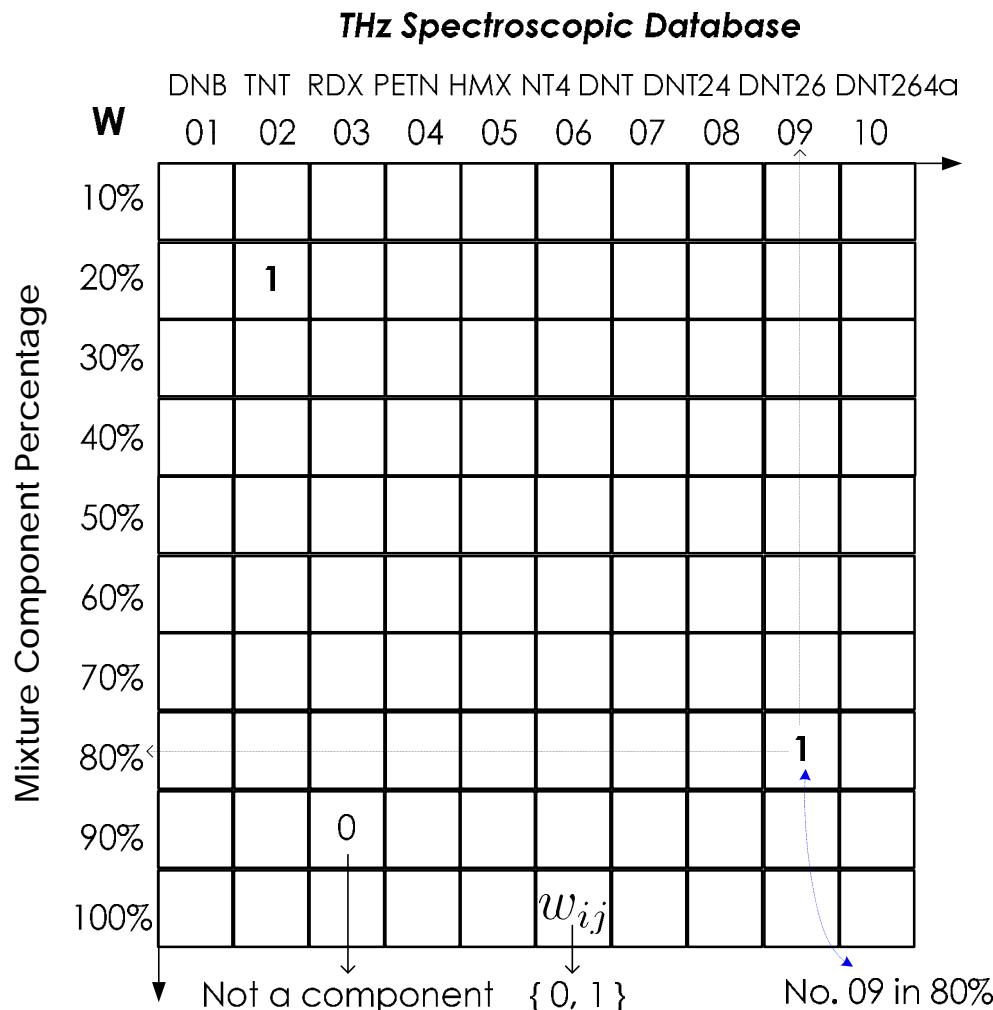
pea plants



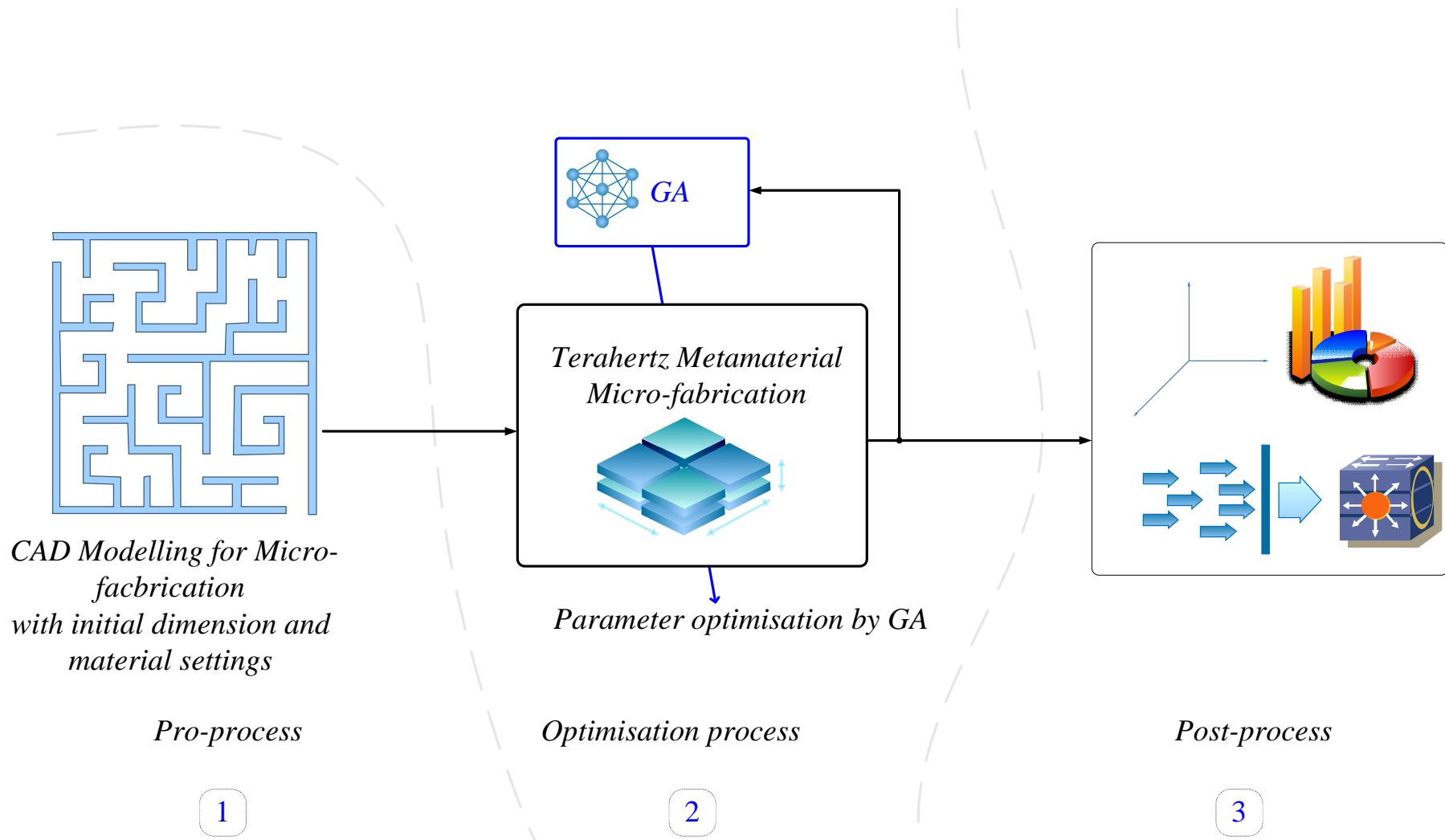
# Automatic Generation of Expression - Data Mining



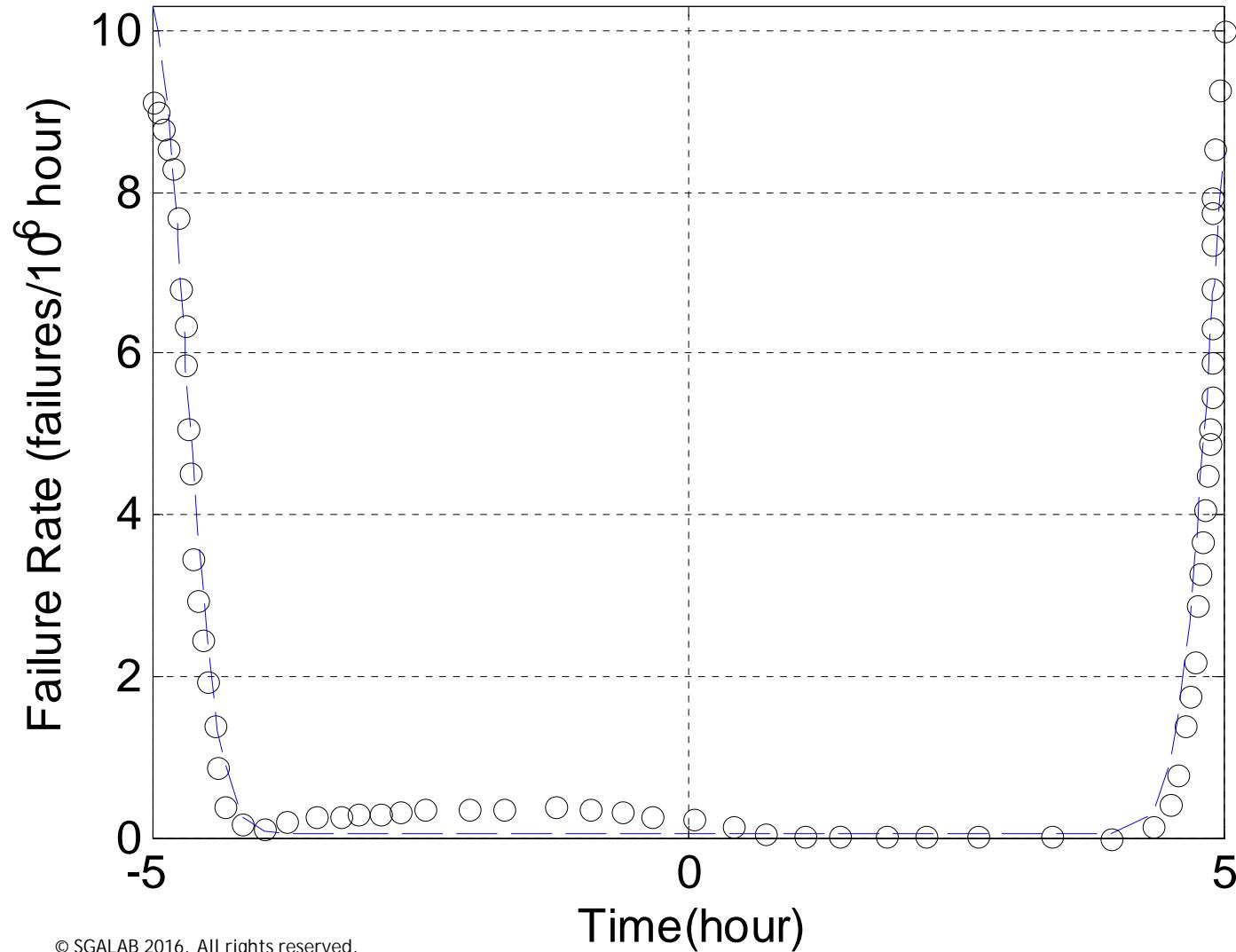
# Explosive Mixture Determination via Terahertz Spectroscopic Statistical Analysis



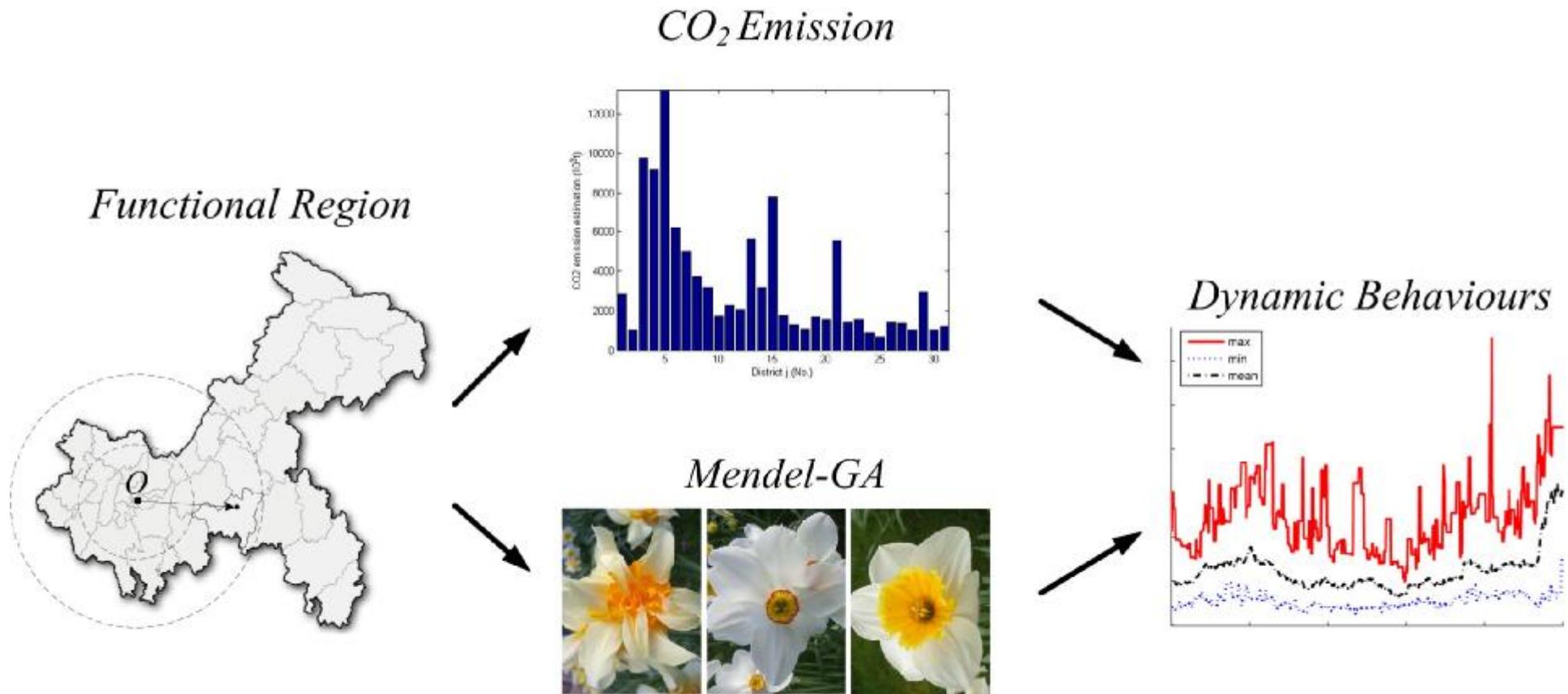
# Optimisations for Terahertz Meta-material



# Parameters Determination for Adaptive Bathtub-shaped Curve Using Artificial Fish Swarm Algorithm



# Multi-State Weighted Behaviours of Rural Area with Carbon Dioxide Emission Estimation



# Research

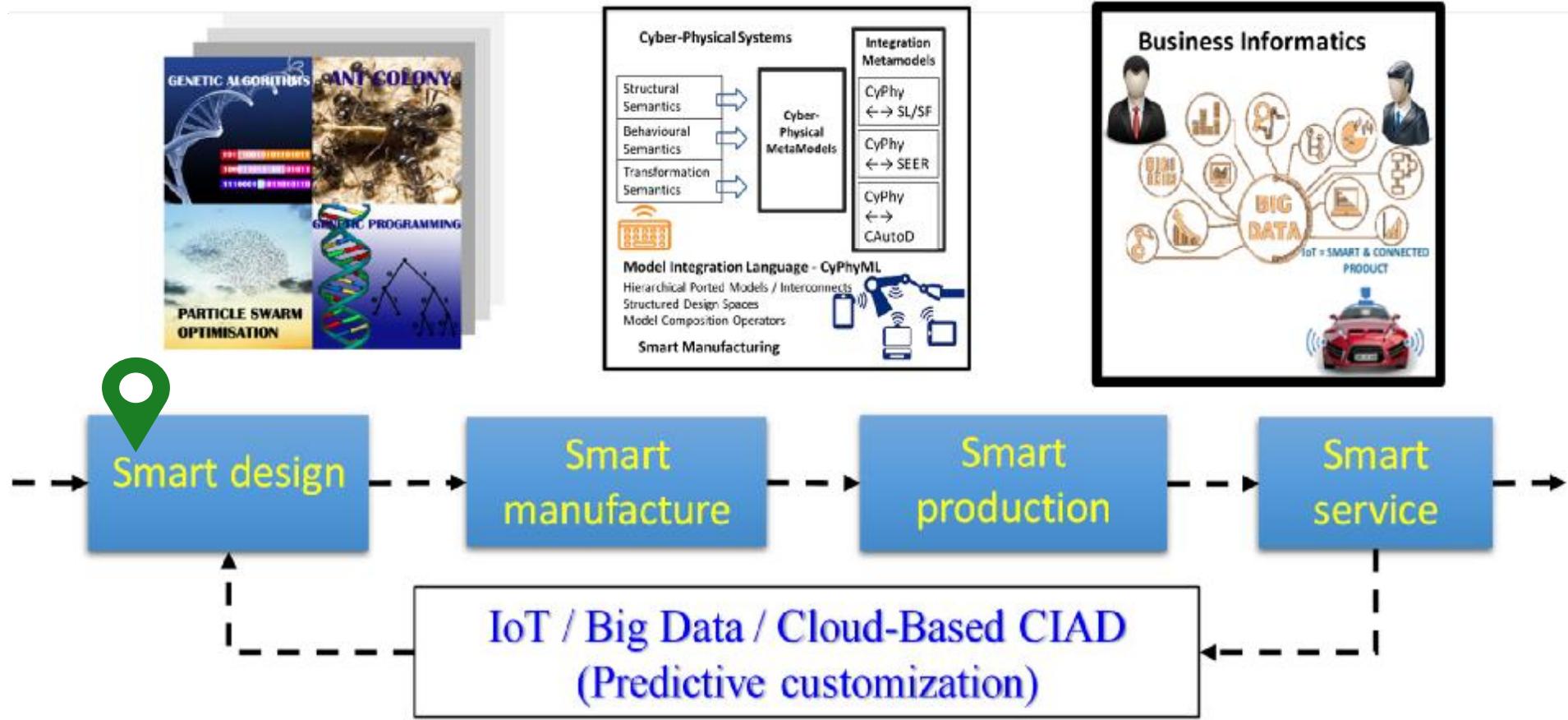
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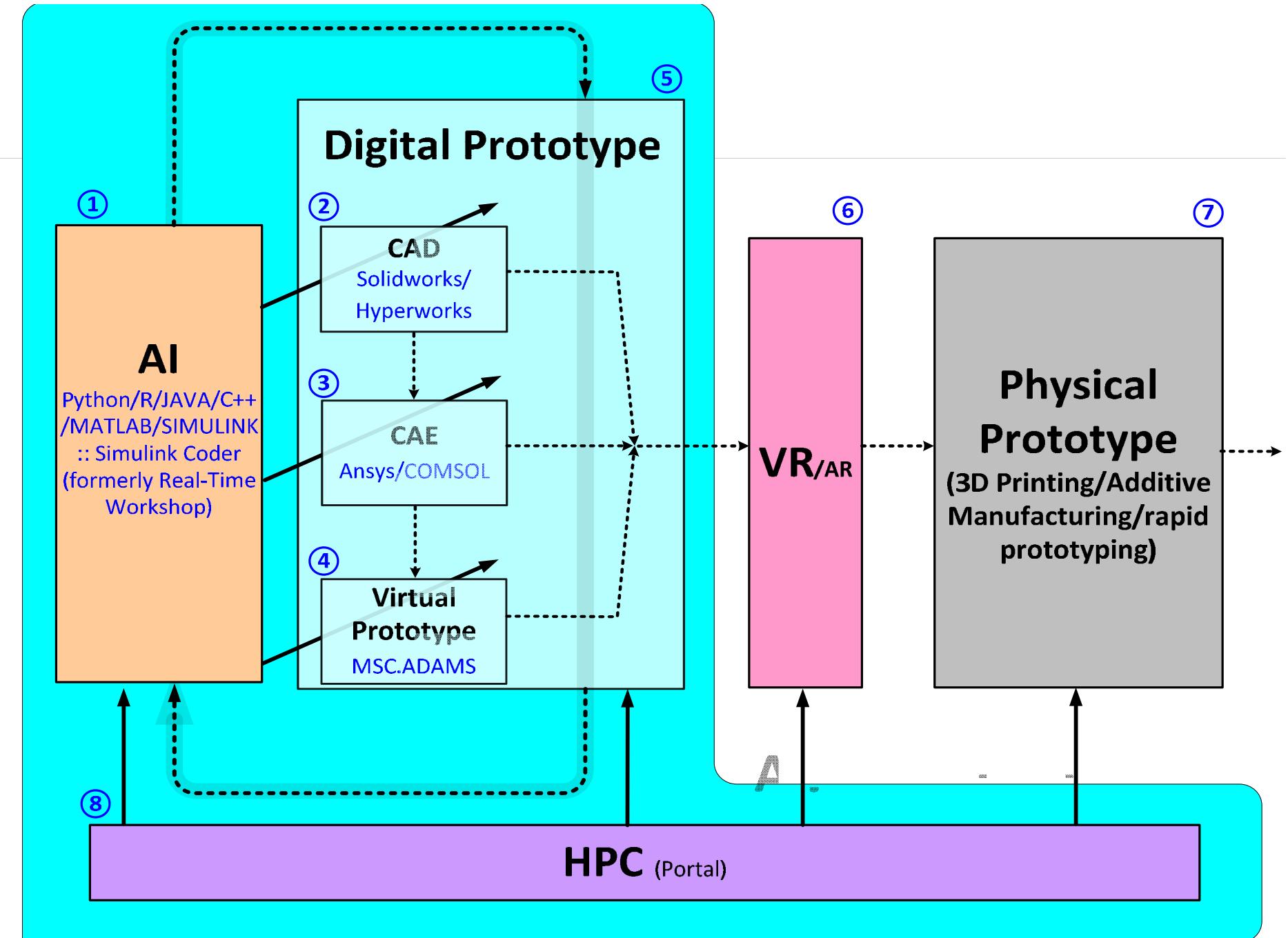
Dynamics and Control

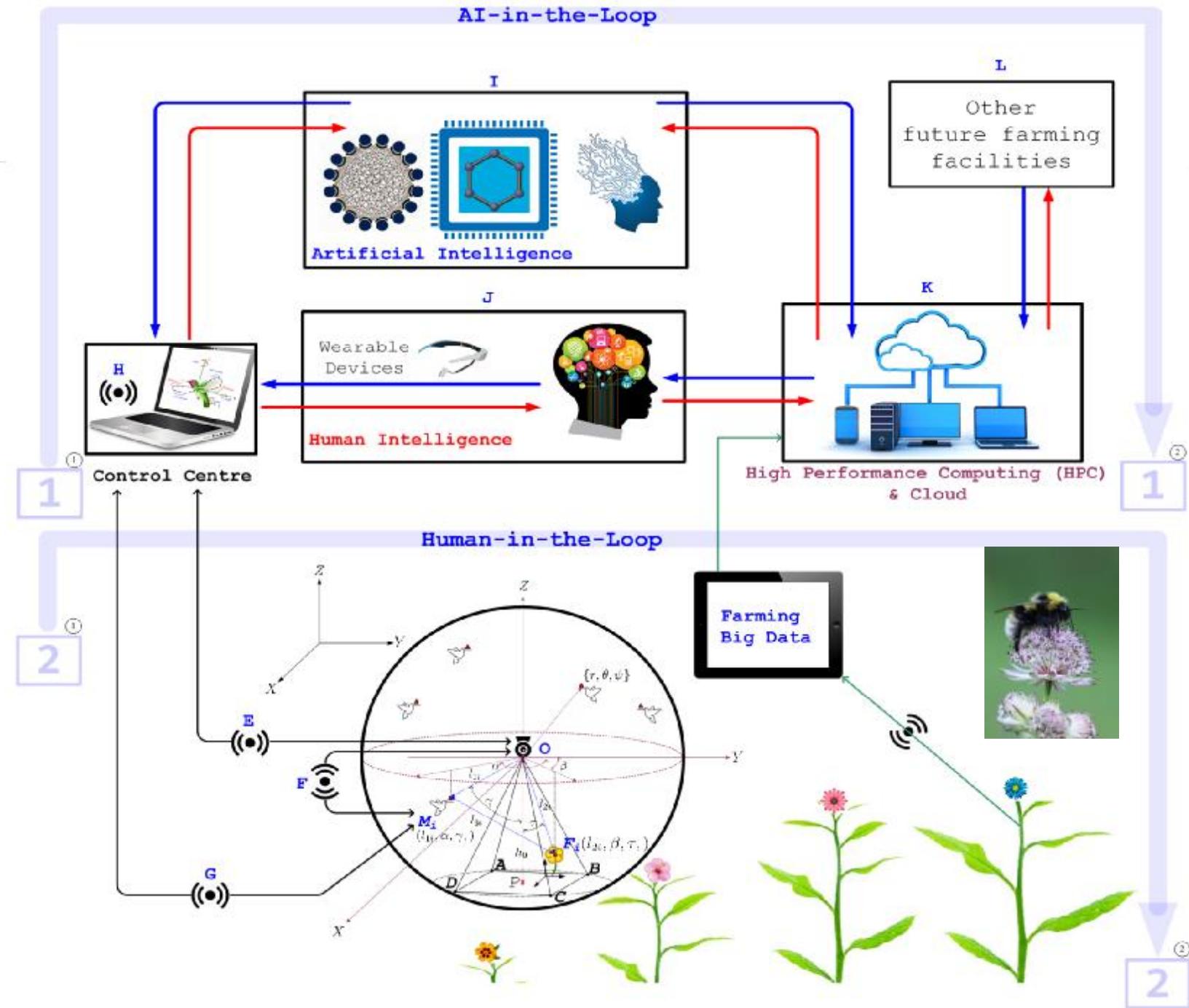
B

Computational Intelligence Aided Design and Manufacture

*Smart Design for Industry 4.0*

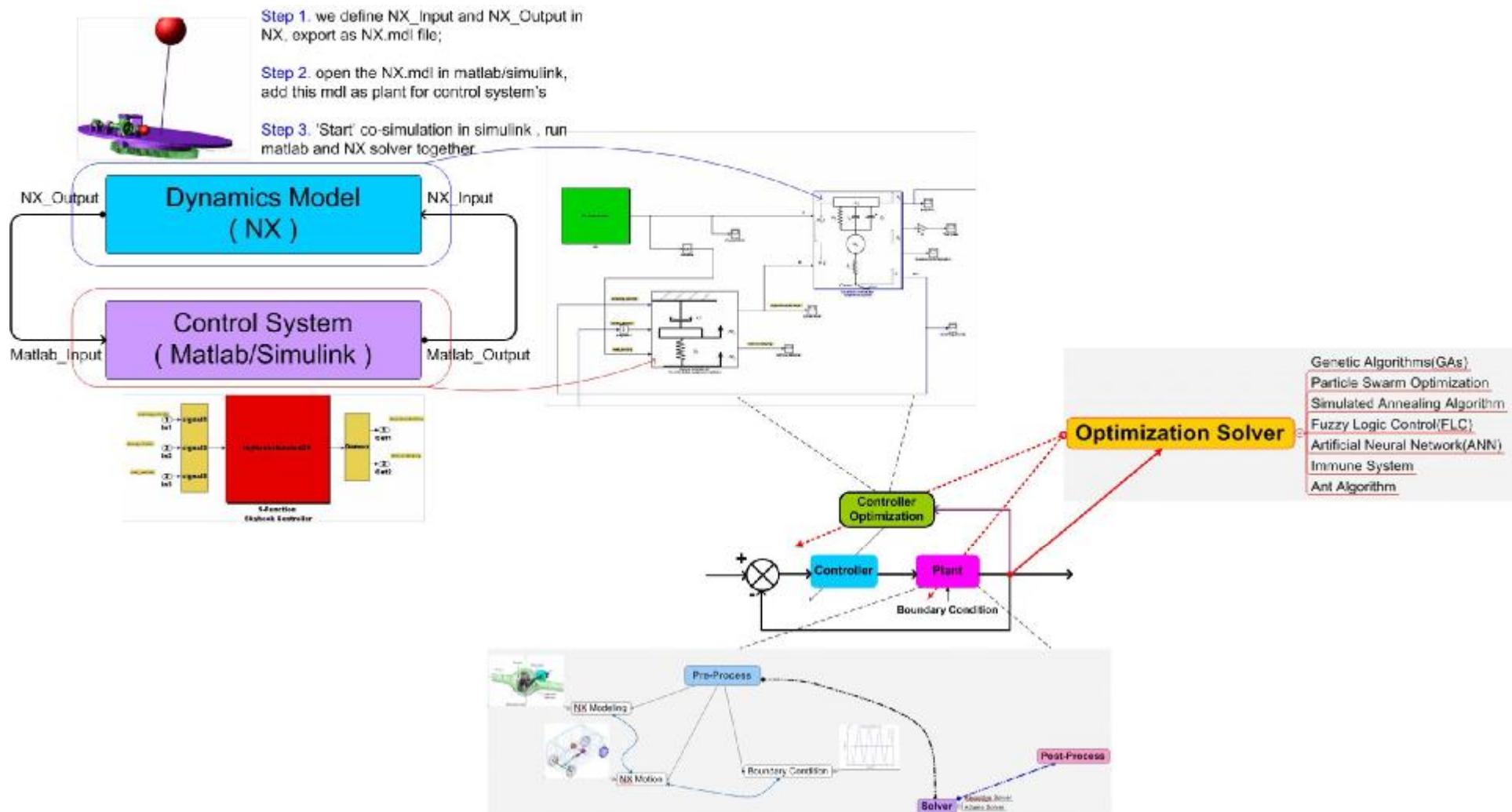




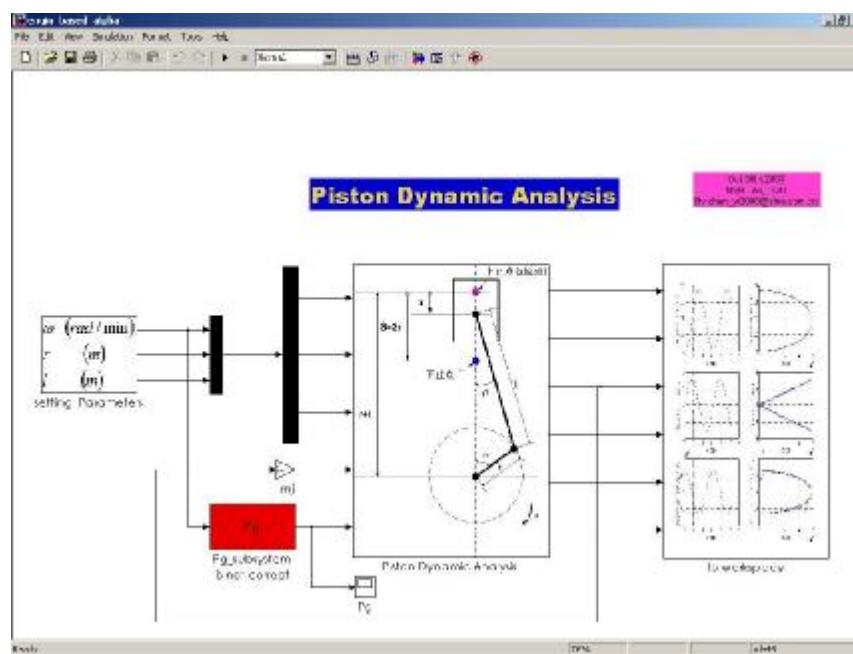
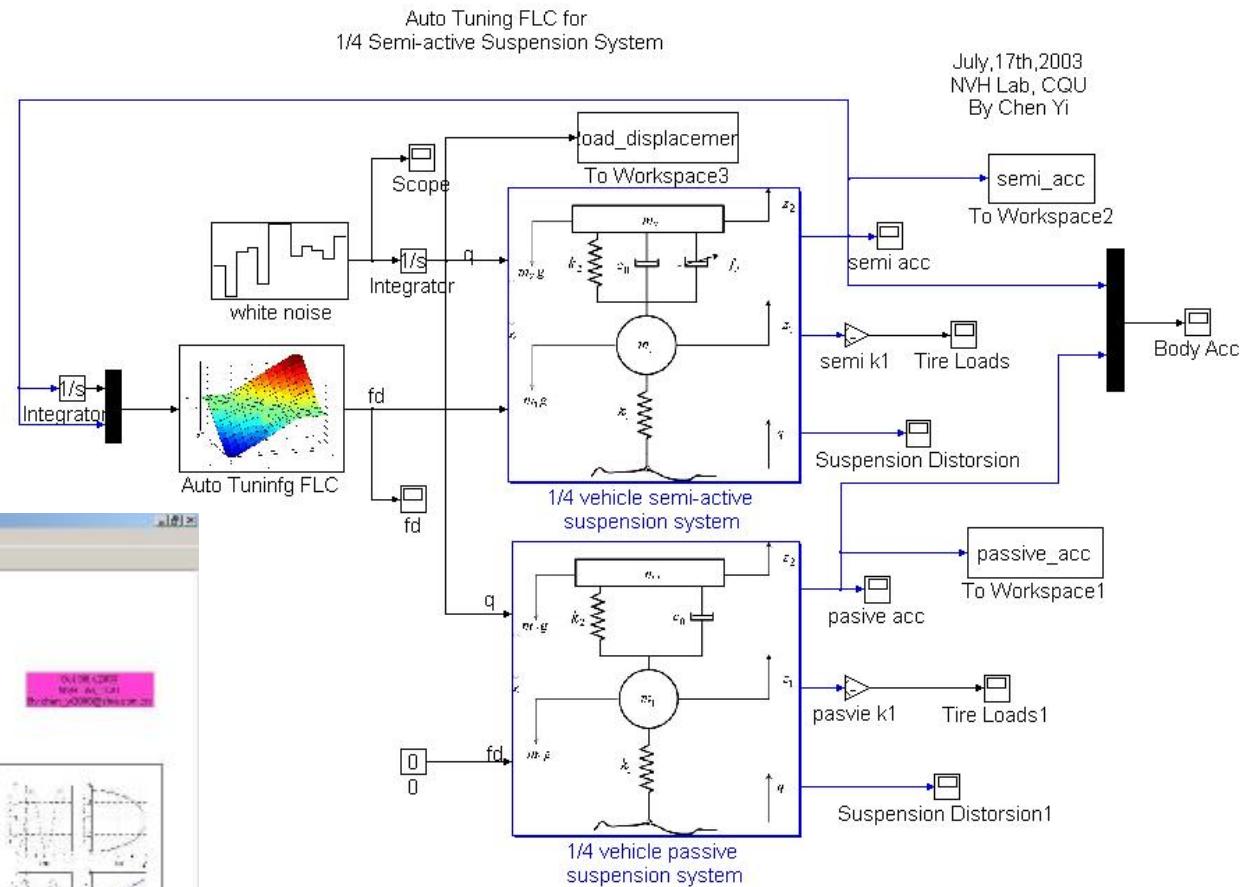
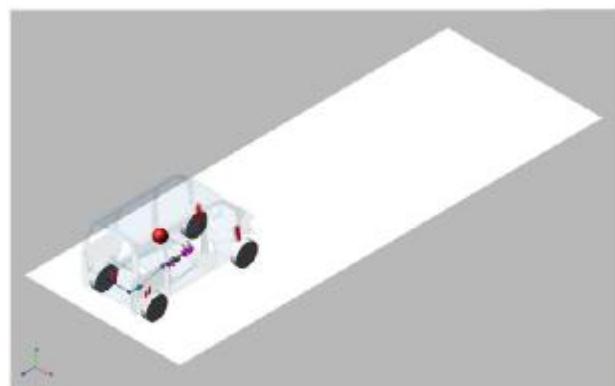


# Co-simulation: CAD/CAE

<http://www.mathworks.co.uk/matlabcentral/fileexchange/authors/15500>



# Co-simulation: CAD/CAE



# Simulation Cases

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- Fuzzy Skyhook Surface Sliding Mode Control for Semi-active Suspension system

<http://www.mathworks.co.uk/matlabcentral/fileexchange/25456-fuzzy-skyhook-surface-sliding-mode-control-for-semi-active-suspension-system>

- Semi-active Control of Skyhook for 1/4 Suspension System

<http://www.mathworks.co.uk/matlabcentral/fileexchange/11118-semi-active-control-of-skyhook-for-14-suspension-system>

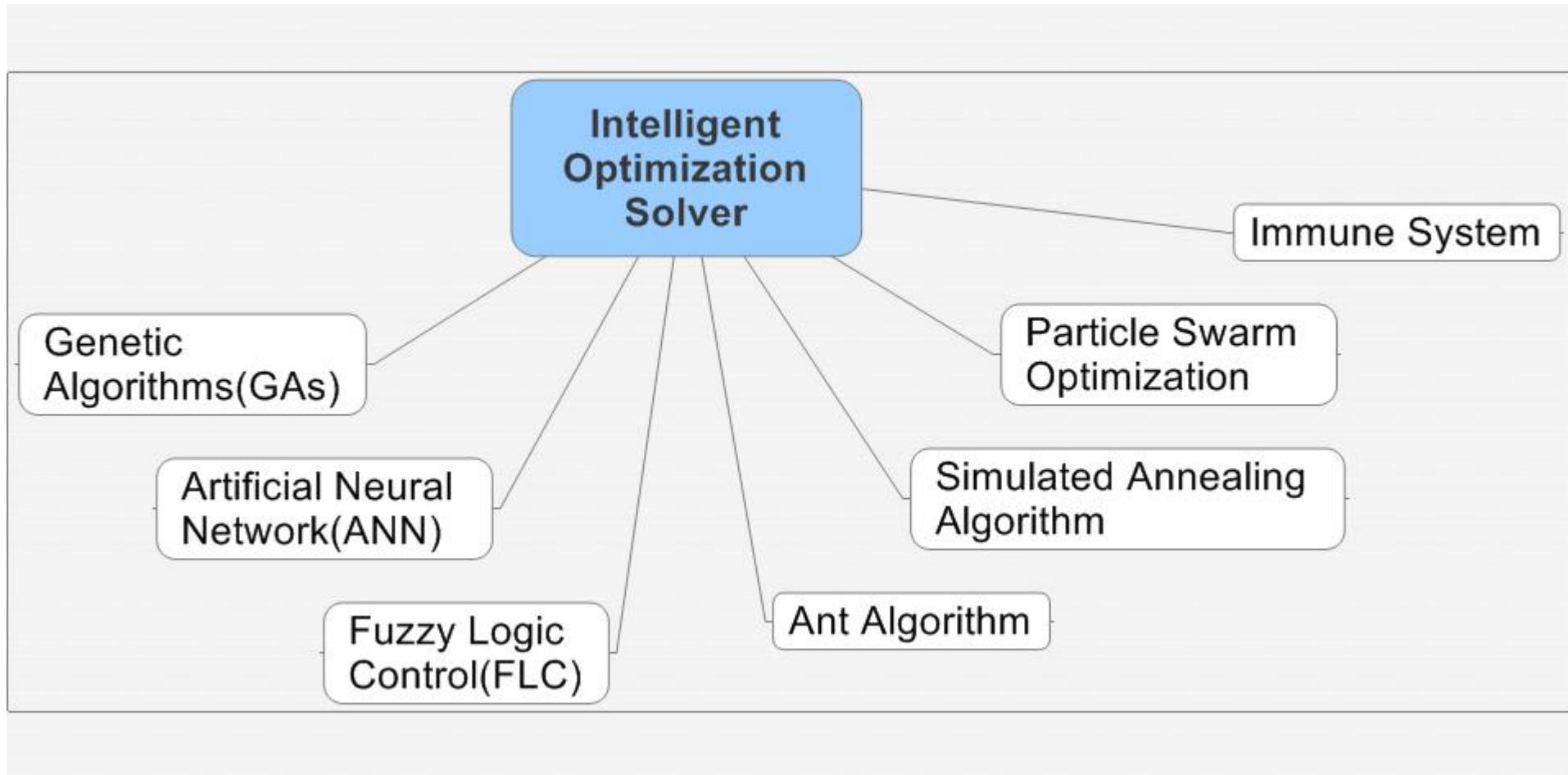
- Fuzzy Controller of Semi-active control for 1/4 Suspension System

<http://www.mathworks.co.uk/matlabcentral/fileexchange/11119-fuzzy-controller-of-semi-active-control-for-14-suspension-system>

- 2,4,7 DOFs Suspension Model for SIMULINK

<http://www.mathworks.co.uk/matlabcentral/fileexchange/11199-247-dofs-suspension-model-for-simulink>,

# Computational Intelligence Solvers



# Selected Publications - CIAD

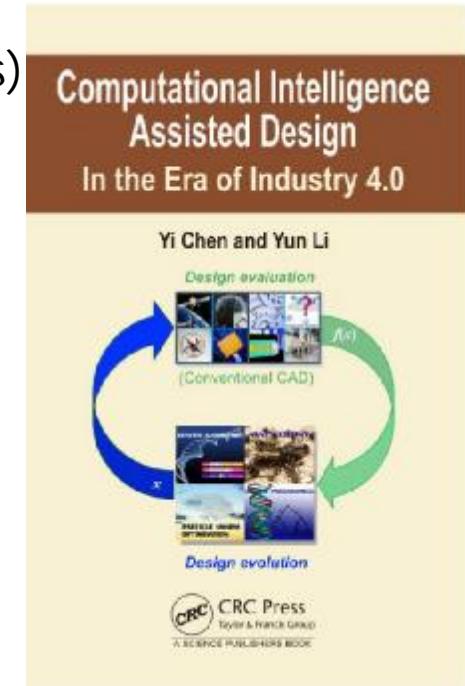
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- Yi Chen, et al., (2018), Spatio-Temporal Evolutionary Analysis of the Township Enterprises of Beijing Suburbs using Computational Intelligence Assisted Design Framework, **Palgrave Communications** ([www.nature.com/palcomms](http://www.nature.com/palcomms)) (**CIAD for Social Science**).
- Guangfeng Zhang, Yi Chen\*, et al.,(2017), Intelligent Swarm Firefly Algorithm for the Prediction of China's National Electricity Consumption, **International Journal of Bio-Inspired Computation** (**CIAD for Energy**).
- Yi Chen, et al.,(2016), Multi-objective optimization on multi-layer configuration of cathode electrode for polymer electrolyte fuel cells via computational-intelligence-aided design and engineering framework, **Applied Soft Computing**, Volume 43, Pages 357-371. (**CIAD for Thermal Design**)
- Yi Chen, et al., (2014), Quantitative modelling of electricity consumption using computational intelligence aided design, **Journal of Cleaner Production**, Volume 69, Pages 143-152. (**Proposed CIAD**)

# Research Achievements

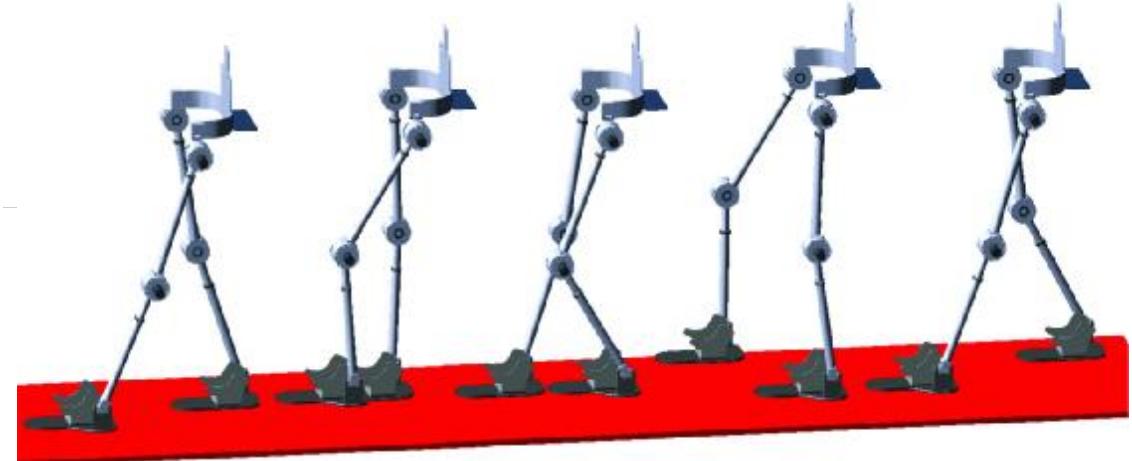
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- 5 first-authored papers for [REF2021](#) (100+ papers)
- 2 books , 10+ patents (+ 5 PCTs )
- Research Grants (10+, >800K GBP as PI)
- 5 special issues as guest editor
- 3 special sessions as organiser/co-organiser
- 1 JCR Q2 journal editorial board member
- Regular reviewer for over 30 academic journals
- 10 more invited talks (national and international)
- **Volunteer:** [IET Mentor](#)(2017), [Professional Review Interviewer](#) (2018),  
[Member of The COVID-19 Outbreak Expert Database](#), [UK Parliament](#) and [Cabinet Office](#)





Glasgow Caledonian  
University



# Dynamics: Theory and Applications

Course Sample

M1234567

Dr Leo Chen

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School of Engineering & Built Environment

# Contents

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History and Modern Applications

Basic Concepts

Solving Problems in Dynamics

Dynamical Modelling

Reference

Course Sample



University  
of Glasgow



# Engineering Vibration



Course Sample

# Contents

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Introduction

Mathematical Modelling

Generalized Coordinates

Dimensional Analysis

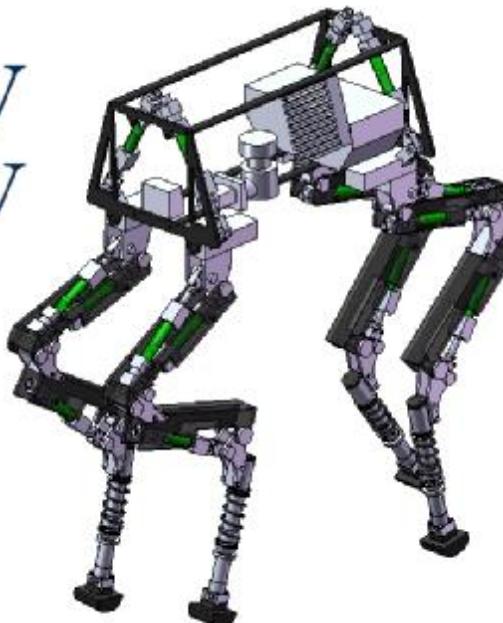
Simple Harmonic Motion

Case Studies

Course Sample



University  
of Glasgow

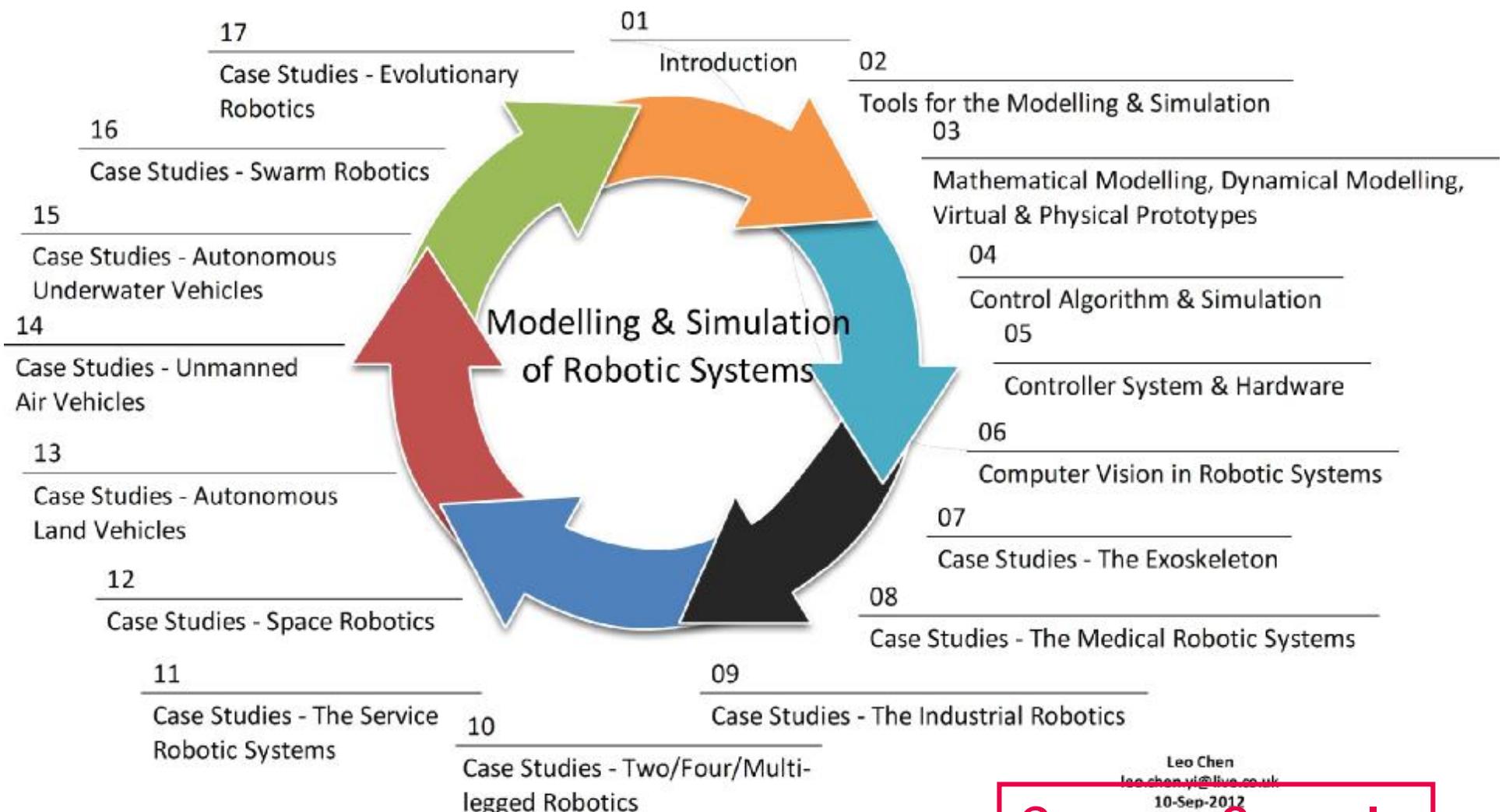


# Modelling and Simulation of Robotic Systems



Course Sample

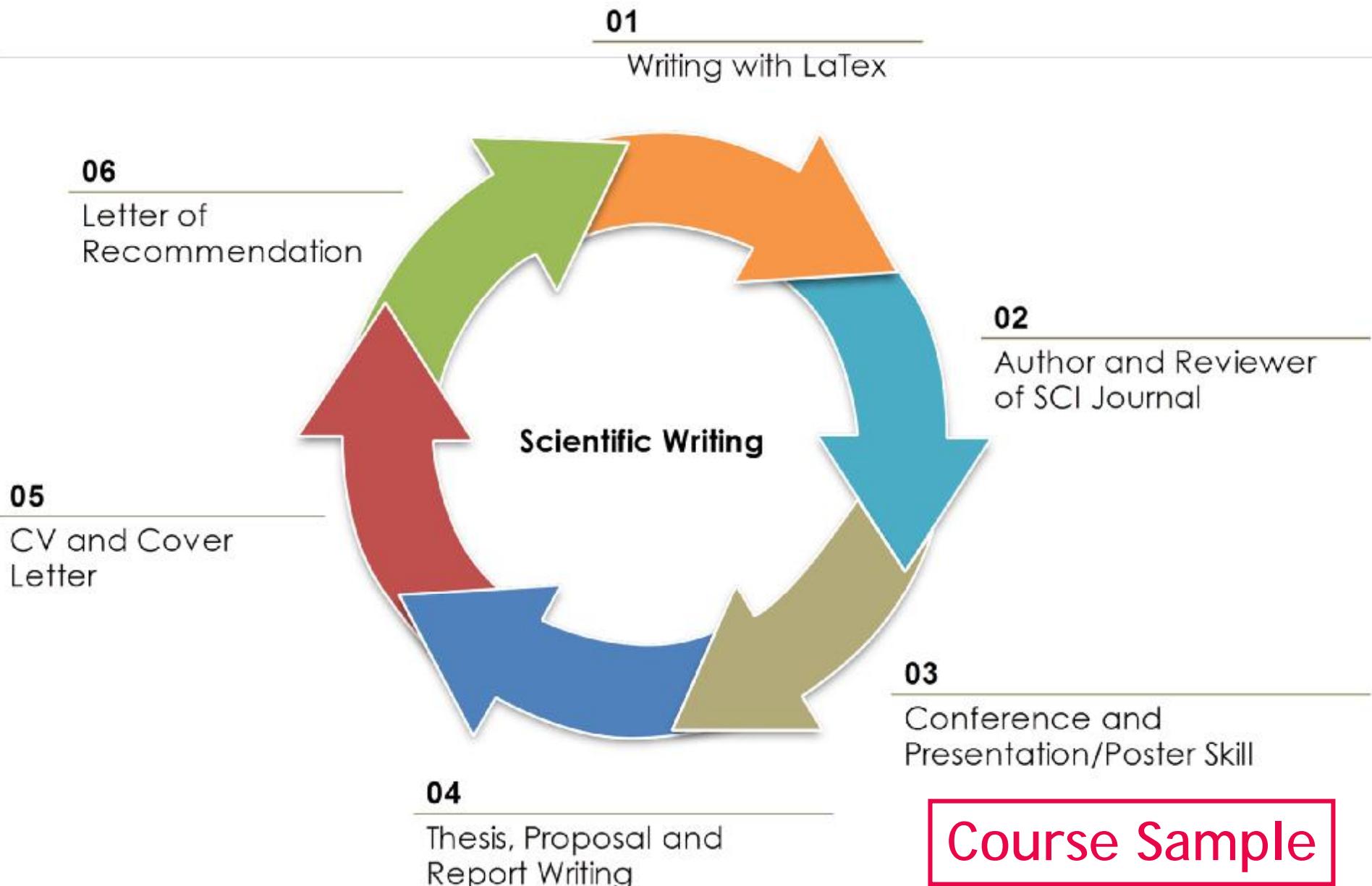
# Series Contents



Leo Chen  
leo.chen.wi@lblue.co.uk

10-Sep-2012

Course Sample





## C Programming Practice (32H)



Yi Chen  
leo.chen.yi@live.co.uk



**No1** - Introduction (2H)



**No2** - Types, Operators  
And Expressions (2H)



**No3** - Control Flow (6H)

Statements  
and  
Blocks

Conditional  
Statements

If-Else  
Switch

Loop

While  
For



**No4** - Functions And Program Structure (6H)



**No5** - Pointers And Arrays (4H)



**No6** - Case Studies And Practices (12H)

## Course Sample



Glasgow Caledonian  
University



# Risk Analysis and Management

Course Sample

MMH113155

Dr Leo Chen

[leo.chen@gcu.ac.uk](mailto:leo.chen@gcu.ac.uk)

2015-07-12 School of Engineering & Built Environment

# Contents

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Introduction

Terminology

Reliability Programmes

Quantified Risk Assessment

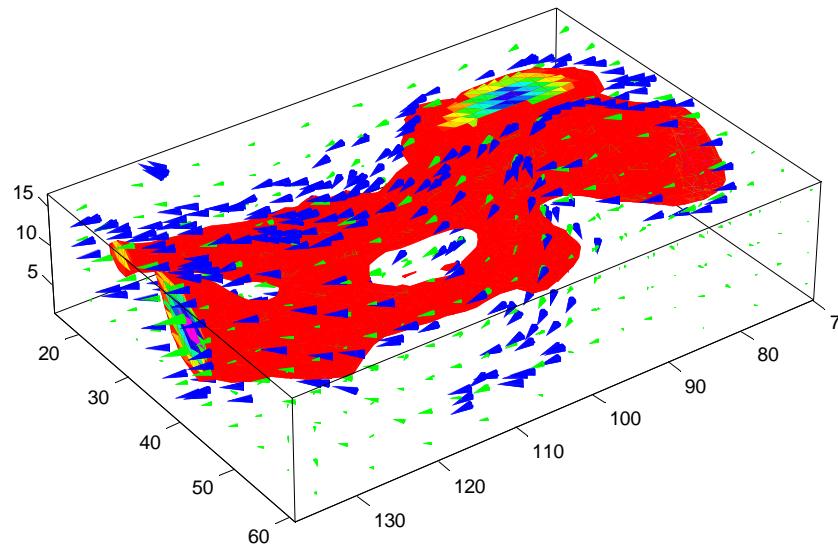
Risk Assessment Studies

Reliability In Risk Assessment

Risk Ranking



Course Sample



# A First MATLAB Course for University Students

## 00 Pre-session

Course Sample



University  
of Glasgow



# Project Management for University Students

- A Case of the Exoskeleton

**Course Sample**

# Contents

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What is Project Management

Project Management Framework

Teamwork

Time Management

Project Management Tools

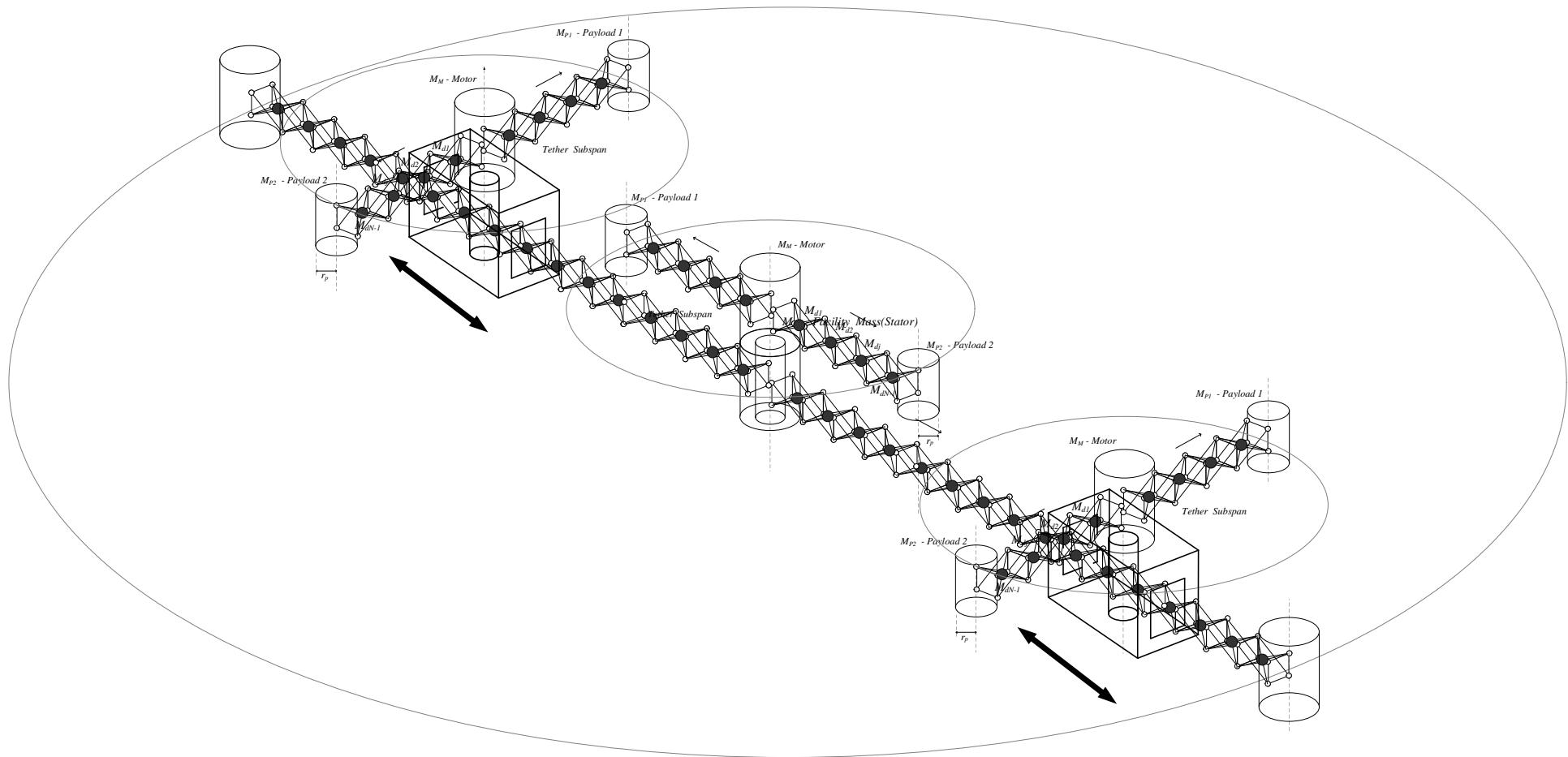
Software tools

Data Management

A Case - the Exoskeleton Project

**Course Sample**

# New Conceptual Design



Dr Leo Chen Email: leo.chen.yi@live.co.uk

### 1. Introduction

*What is the Robotic Motorised Momentum Exchange Tether(RMMET)?*

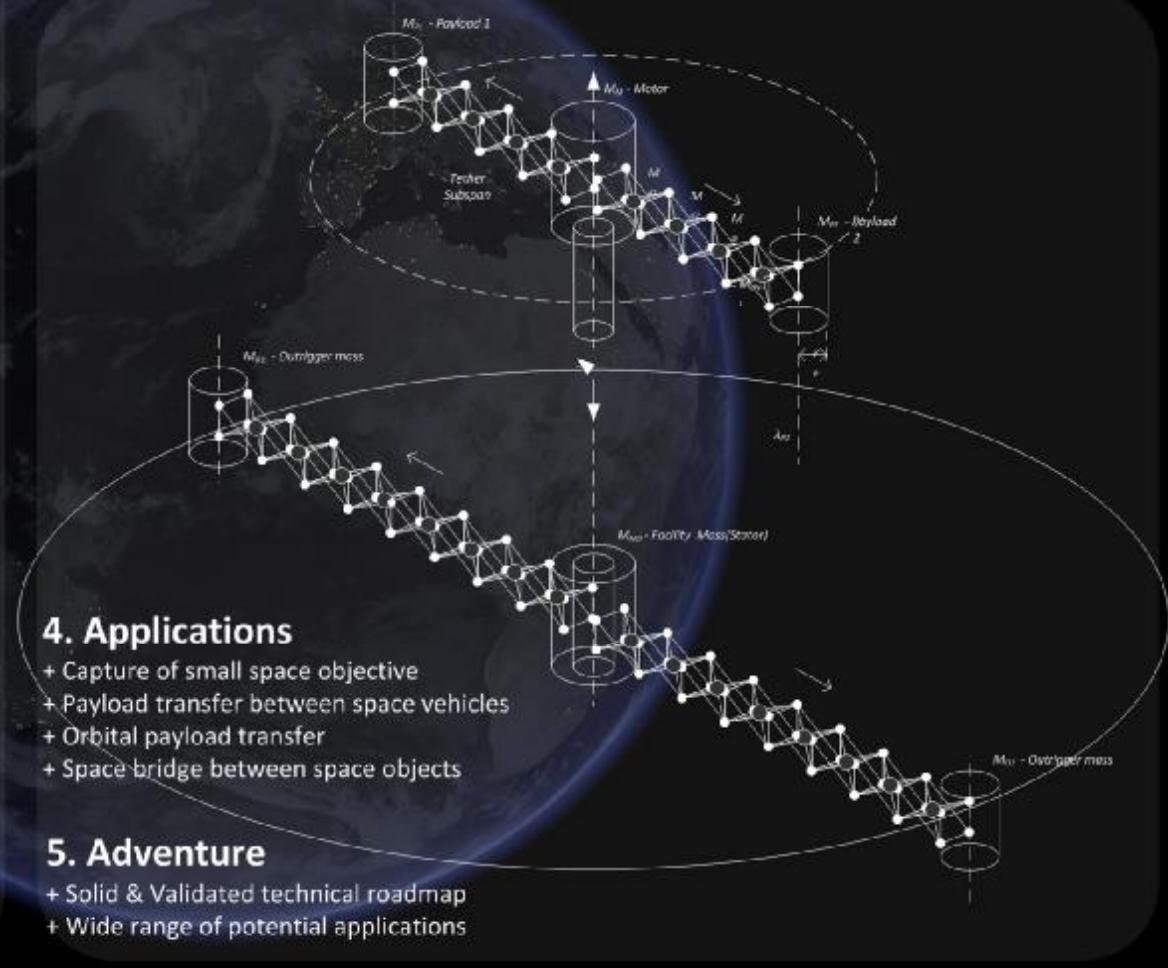
- + A New Robotic System and Mobile Space Platform :  
Robotic Motorised Momentum Exchange Tether(RMMET)

### 2. Objectives

- + Concept Design of A New Mobile Space Platform: the RMMET System
- + Virtual Prototype of the RMMET
- + A Novel Solution of Capture of Space Deribs using RMMET System:
  - Space Web Deployment Using RMMET
  - Dynamical Modelling of Space Deribs Capture
  - RMMET for the Payload Transfer and Trajectory Optimisation
  - RMMET Space Mobility and Optimisation

### 3.Methodology

- + Dynamical modelling method
- + Virtual prototype technology
- + Reliability modelling methods
- + Computational intelligence methods

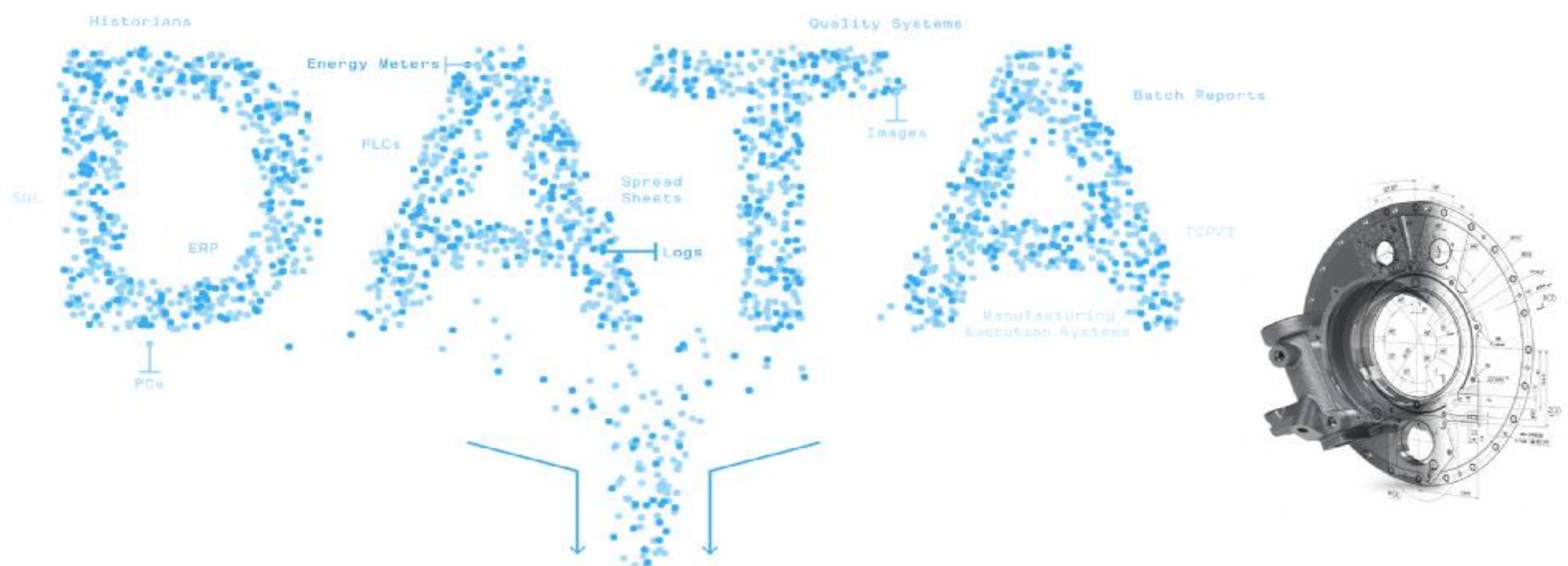


### 4. Applications

- + Capture of small space objective
- + Payload transfer between space vehicles
- + Orbital payload transfer
- + Space bridge between space objects

### 5. Adventure

- + Solid & Validated technical roadmap
- + Wide range of potential applications



Thanks & Questions

## Research Review



Dr Leo Chen  
16/08/2020

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