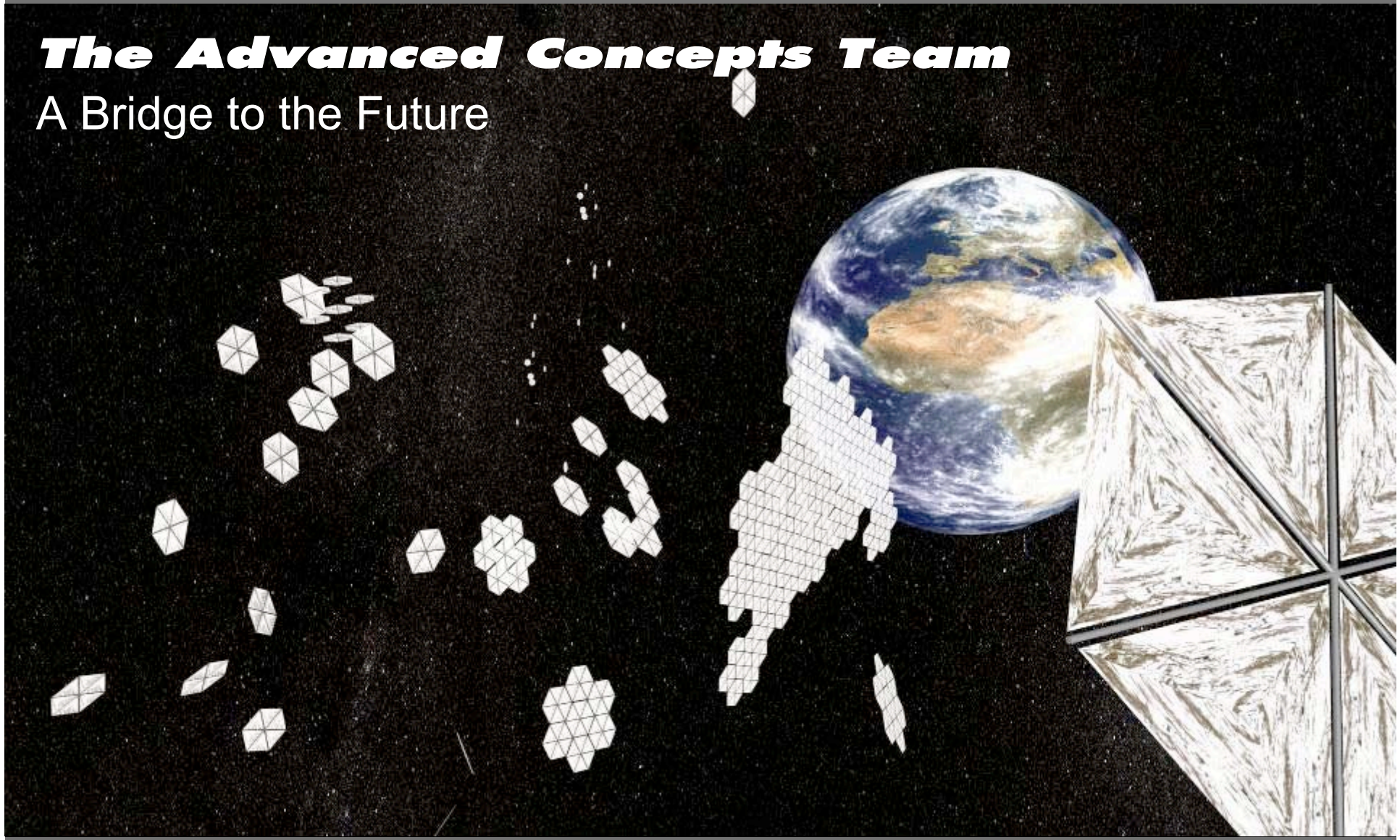


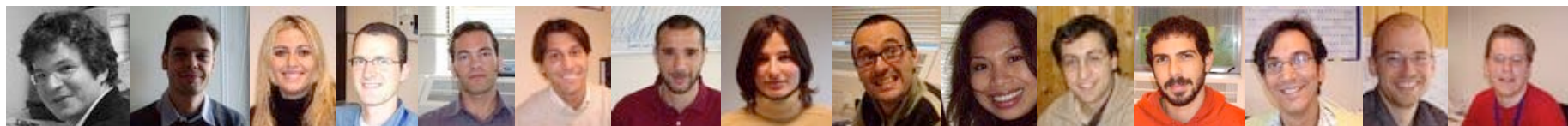
The Advanced Concepts Team

A Bridge to the Future

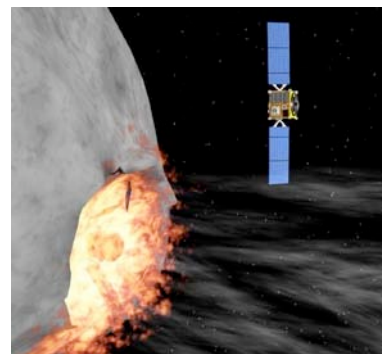




Advanced Concepts Team (ACT)



6 research fellow, 5 YGTs, 1 stagiaire, 2 staff



Objectives



*Serve as in-house think-tank**

- interdisciplinary analysis and theoretical knowledge “on-demand”
- direct interface with relevant external experts in the academic community

Entry Point for New Trends and Ideas

Assessment of Advanced Space Systems and Emerging Technologies

Privileged Bridge to and for Research Community

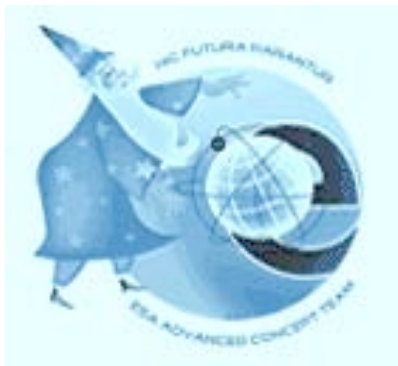
*Definitions: “A think tank is a research institute or informal group providing advice and ideas on any aspect of future planning and strategy - and are often associated with military laboratories, theorists and intellectuals who endeavor to produce analysis or policy recommendations.” (Wikipedia)

“An institute, corporation, or group organized for interdisciplinary research” (Britannica)

The Team



- Variable-geometry in-house think-tank of post-docs (research fellows) and young graduates
- Dynamic membership
 - Continuous renewal and adaptation of members and topics
 - Influx of the latest academic research skills and ideas
 - Return to academia with an improved understanding of ESA
- competence constantly adapting to new needs and opportunities
- current *main* competence areas
 - Advanced Energy Systems, Mission Analysis and System Design
 - Advanced Propulsion Systems, Biomimetics, Theoretical Physics and Nanotechnology
 - Mathematics, Artificial Intelligence



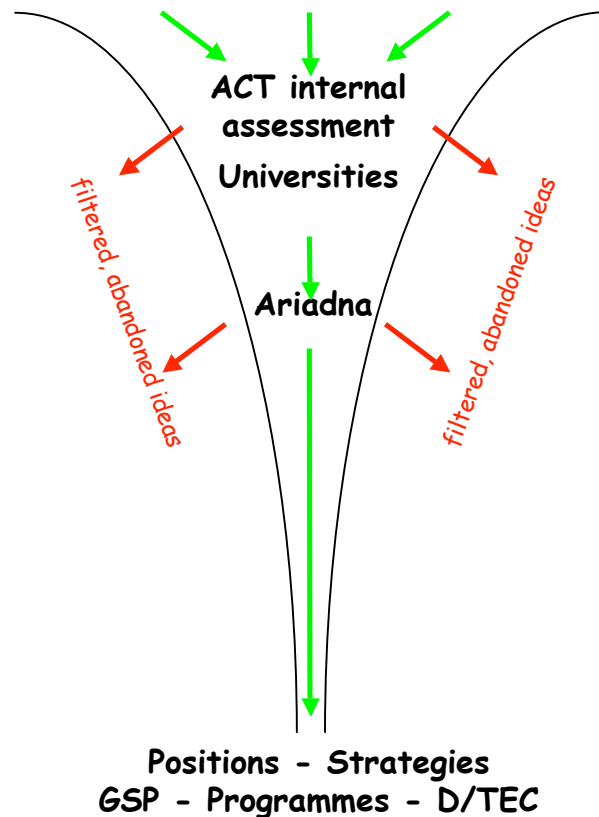
Bridge to new trends and ideas



"exotic" proposals

Scientific progress

Loose ideas linked to space



- Loose ideas linked to space
 - monitoring of academic progress (journals, conferences)
 - suggestions, emails, papers, questions, web
- first basic filtering of loose ideas linked to space
 - identification of principal 'show-stoppers'
 - identification of potential
- preliminary ACT assessments - second filter
 - state of research on subject
 - general analysis
- academic assessment
 - in group - involvement of ESA in-house expertise
 - together with universities - *Ariadna* programme
 - Intensive publication activity
- Input for ESA positions / strategy planning; transfer to ESA R&D programmes or abandon

Ariadna - A means to harness academic research



- Special requirements to effectively work with small university institutes
 - little administrative effort
 - fast and easy contractual procedures
 - recognition as cooperating *partner* instead of just *funding source*
- *Ariadna*
 - predefined mechanism for European universities
 - 2 months / 15k€ ; 4 months / 25k€ ; 6 months / 35k€
 - short and cost-efficient studies on advanced space research topics
 - enables ESA to create flexible working links with innovative research groups
 - enhances the awareness of the research community on ESA
 - adds space perspective to non-space related academic research



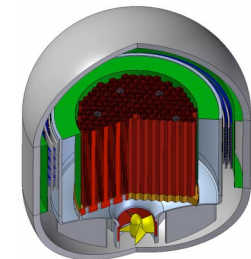
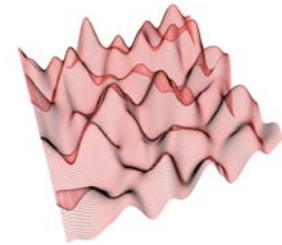
Wedding of Ariadna and Dionysus



Selected Activities



- Distributed Computing & Global Optimisation Techniques
 - potentially disruptive technology - techniques development and implementation, catalyst for academia
- Biomimetics
 - exploratory activity: cross-disciplinary emerging area of research
- Sustainable Energy Systems
 - Role of space in and for sustainable energy systems

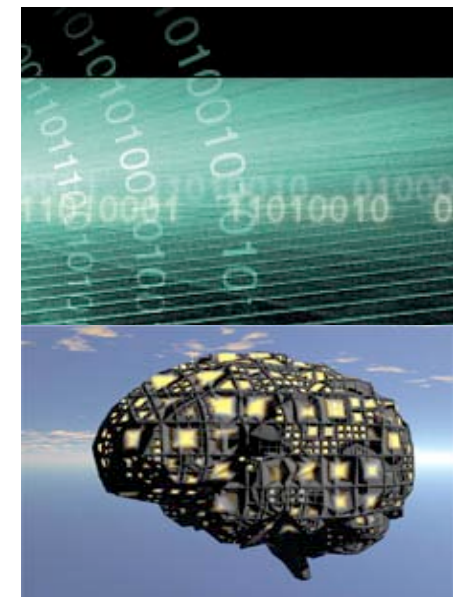
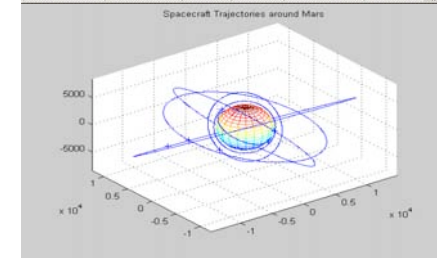


ACT Distributed Computing Environment



- Motivation
 - solving computationally hard problems on a network of computers
 - existing approaches (SETI@home, Distributed.net) restricted to one single purpose
- The ACT Software
 - framework for solving different type of problems based on idle time processing adapted to the entire ESA network
 - Monte Carlo simulations for constellation design
 - Ionospheric Data Processing
- Explored Applications
 - DiGMO: Distributed Global Multiobjective Optimiser
 - Cooperative use of different global optimisation techniques (simulated annealing, particle swarm optimisation, Monte Carlo, genetic algorithms, evolutionary algorithms)
 - Highly automated optimisation based on an intelligent server
 - Designed to work with a generic black-box function provided by a customer

Client computer	CPU speed (MHz)	NStart	NReceived	Best solutions found
131.176.177.117	996	2000	1268	2055, 7.14125
131.176.21.98	2893	4000	4200	2021, 6.73034
131.176.177.169	1992	3200	2924	2177, 5.60805
131.176.4.110	1992	1600	1219	2176, 5.65663
131.176.21.128	1594	200	79	1982, 8.03488
131.176.4.109	1992	400	213	2021, 6.69627
131.176.177.227	1992	1000	800	2152, 4.94058
131.176.177.116	996	200	1	895, 8.32427
131.176.179.112	996	200	9	2460, 13.6614



Biomimetics - Definition and Motivation



- Definition
 - “*practice of ‘reverse engineering’ ideas and concepts from nature and implementing them in a field of technology*”.
- Motivation
 - Biological systems represent millions of years of trial-and-error learning according to the *most stringent of metrics*: survival
 - Several problems faced by engineers are similar to those *solved* by nature
 - Not mere imitation of biological systems, but inspiration to discover promising concepts for space engineering.
 - Biomimetics as a means of finding new and realistic technologies for application in future space missions.
 - Applications in several areas as diverse as *sensors, actuation, smart materials, locomotion, autonomy...*

Application to Space Engineering

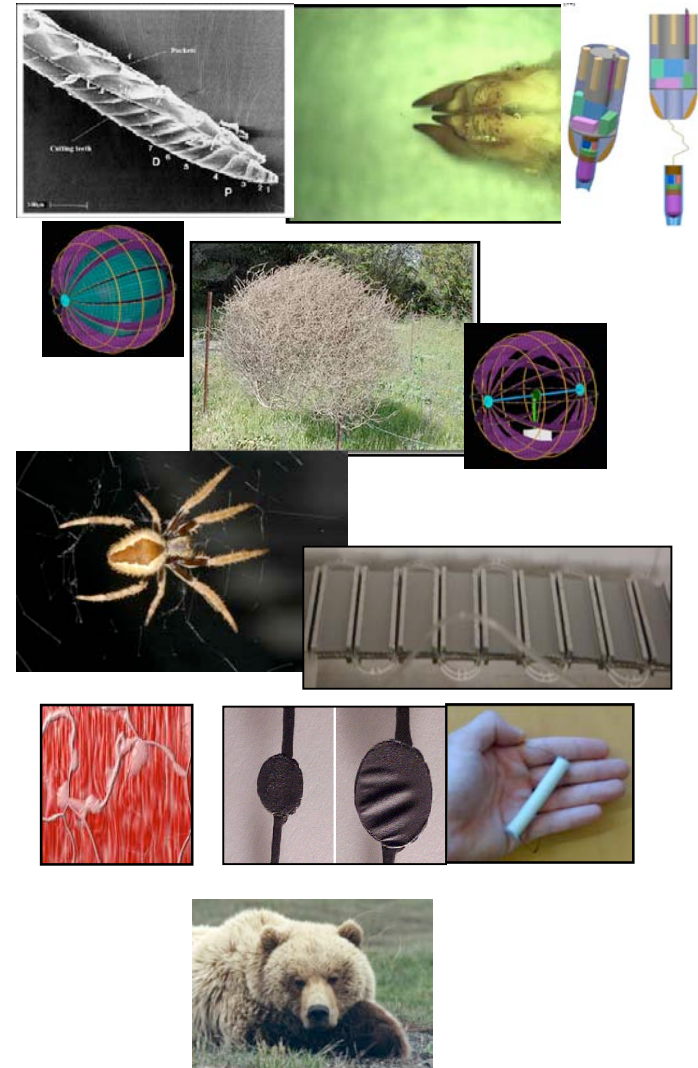


- Adaptability
 - Environments to be explored are typically unknown
 - Natural organisms excel on adaptability to the environment
- Autonomy
 - Real-time control is precluded beyond Earth orbit
 - For Earth orbiting platforms, ground station control is dominant in operational costs
 - Biological organisms exhibit autonomy par excellence
- Miniaturization
 - prospect of greater miniaturisation, integration and packaging efficiency
- System design
 - Natural systems: holistic design
 - Functional unit designed in a concurrent and multidisciplinary way
- Satisfying robust solutions
 - Satisfying solutions represent the approach in biology
 - Engineers often seek optimal solutions
 - The process could benefit if “satisfying” solutions are already known

Preliminary Results



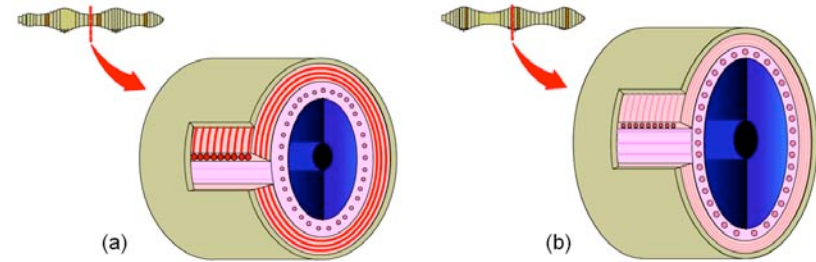
- Digging mechanisms
 - Ovipositor 'valves' of the locust; Wood wasp
 - Space environment – micro penetrator
- Biologically inspired solutions for mobility
 - Few examples: Dandelion seeds, maple seeds, hoppers, Russian thistle
 - ballast-drive mechanism used to steer
- Spider-inspired embedded actuators
 - Novel, scalable (mini, micro) actuator system inspired by spider legs
 - Embedded in the structure
- Artificial muscles
 - Potential of EAPs for space systems - dielectric EAPs
 - High voltage requirement
- Hypo-metabolic state
 - For long proposed for manned space exploration
 - At least six mammalian orders exhibit torpor
 - Review research and state of the art in medical / biological field
 - To be re-assessed in 5 years timeframe
- Bio-inspired joints
 - Bio-mechanical analysis of animal articulations
 - Synthesized a new mechanical joint
 - Kinematic and stiffness analysis of biologically inspired joints
 - Geometric *optimisation*



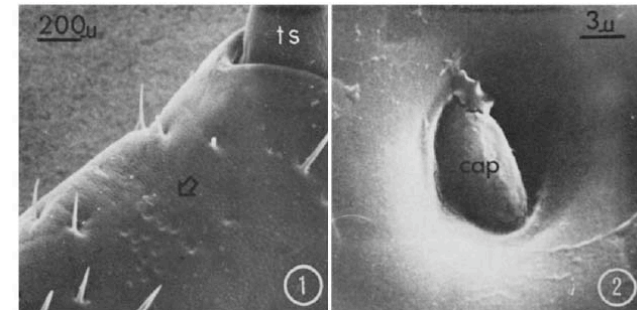
Ongoing Research



- Bio-inspired distributed system for particles transport



- Embedded strain sensors inspired by campaniform sensilla



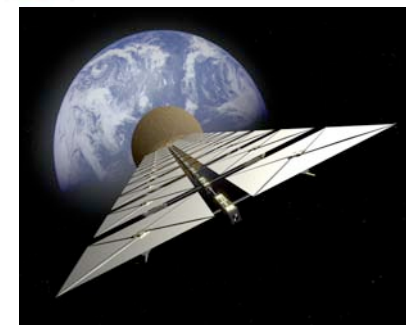
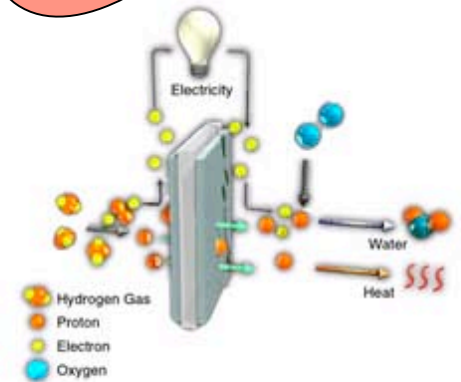
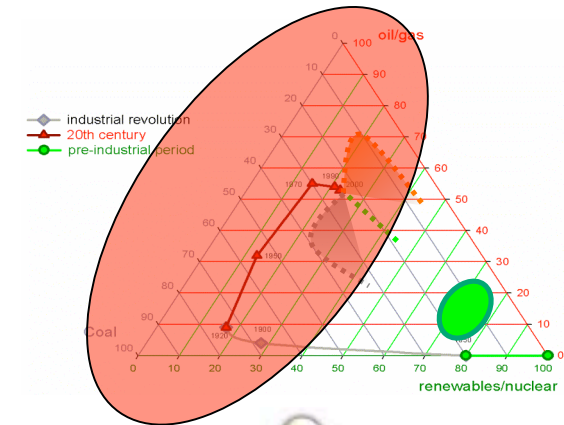
- Non invasive brain-machine interfaces (BMI) - controlling space system by “thinking”



Sustainable Energy Systems



- Space and Energy
 - Two sectors with traditionally only loose links
 - Long time scales and largely publicly funded/controlled
 - Of strategic importance
- Energy as central element for a sustainable economy
- Role and potential contributions from space?
 - *Inherent* sustainability of space energy systems
 - Space technologies and hydrogen economy
 - Combination and connection of existing space assets for renewable energy grids
 - Long-term vision of solar power from space



Wide Spectrum of Activities



- Advanced Energy Systems
 - Nuclear power systems for space
 - Solar Power from Space
 - Advanced Energy storage systems, Biomass based fuel cells
 - Wireless power transmission; non-mechanical laser beam steering
 - *Furoshiki* antenna deployment
- Informatics and Mathematics
 - Natural language processing techniques
- Near Earth Objects
 - NEO mission research
 - deflection strategies
- Mission Analysis
 - Interval arithmetic and verified integration techniques applied to space mission analysis
 - Diffused satellites - probabilistic interpretation of satellite motions
- Artificial Intelligence
 - Swarm intelligence for distributed and autonomous control and navigation
 - Uncertainties modelling for decision support in concurrent space system design
- Theoretical Physics
 - “lossless” telecommunication via gravitational waves
 - Interaction with magnetic and gravitational fields \leftrightarrow propellant-less propulsion
 - Pioneer anomaly
 - Pulsar navigation
- Space tourism - emergence of second space age?

Conclusions



- In-house think-tank aiming at providing critical multi-disciplinary assessments of new trends, potentially disruptive innovations, technologies and research results



Thank you for your attention!

"Take hold of the future or the future will take hold of you." -- [Patrick Dixon](#)