

## **US-Europe Workshop on Adaptive Aerospace Structures and Materials: Current Capabilities, Future Requirements and Developments**

*Couvent Royal, Saint-Maximin, France*

*4-7 November 2007*

### **Background:**

The European Science Foundation (ESF), in collaboration with the National Science Foundation (NSF), and the US Air Force Office of Scientific Research (AFOSR) are organising a workshop focusing on the future aerospace applications of Adaptive Structures and Materials. This initiative is the result of one of the networking and dissemination activities supported by the ESF-S3T Programme and previous US-Europe collaborative initiatives. S3T (Smart Structural Systems Technology) is currently in progress under ESF's Collaborative Research Scheme (EUROCORES) and brings together 7 consortia, consisting of over 40 principal investigators and associated partners, from diverse topics of research within the domain of Structural Systems Technologies S3T ([www.esf.org/S3T](http://www.esf.org/S3T)). The workshop is organised as a networking and collaborative effort in line with the research focus of a subset of the seven consortia within S3T, namely: MAFESMA (Tools for modelling, design and control of smart structural systems based on shape memory alloys: material algorithms, finite element methods, experiments), SCMeRe (Shape Control of Membrane Reflectors) and SMORPH (Smart Aircraft Morphing Technologies).

The main goals of this workshop are to:

- i-* Create a platform for scientific dissemination, exchange of ideas and discussions among scientists, engineers, and practitioners from Europe, the US and Canada in the areas of adaptive aerospace structures and materials.
- ii-* Create opportunities for the enhancement of existing collaborative links and for the creation of new prospects.
- iii-* Provide consolidated strategic advice for the benefit of the funding agencies, industry, research establishments and academia. This includes foresight for research planning, promotion and dissemination of knowledge, standards and best practices and applications of adaptive structures and materials for future aerospace use.
- iv-* Interaction between the three main topics of the workshop.

During this 3-day event, participants will not only discuss their current projects and future plans and ideas, but also hear from invited speakers addressing each of the main topics of the workshop illustrating the state of the art, latest advances, future research possibilities and directions. The three thematic research topics of the workshop are:

### **Theme 1: Adaptive Materials for Aerospace Applications**

- Review of latest advances and applications
- Identification of potential future applications and their requirements classified according to the contaminant constraints (temperature, load, strain, time,...)
- Characterisations with respect to inputs, outputs and control phenomena
- Materials:
  - Shape memory (alloys, polymers, composites,...)
  - Piëzo-electric materials
  - magnetostrictive materials
  - magnetic Shape Memory Alloys (SMA)
  - phase change materials
- Standardizations and best practices, e.g., for nomenclature, dimensions, performance tests and verification
- Modelling and analysis
- Processing and fabrication

### **Theme 2: Future Space Telescopes**

- Review of latest advances and future directions
- Mission requirements for astronomy and earth observation
- State of the art: From Hubble to James Webb, Earth observation telescopes,
- Distributed aperture, interferometry
- Very large reflecting surfaces: Foldable versus membrane telescopes,
- Sensing and Actuation technology,
- Control of reflecting surfaces, Metrology
- Standardizations and best practices, e.g., for nomenclature, dimensions, performance tests and verification
- Modelling and analysis

### **Theme 3: Morphing Aircraft**

- Requirements – mission adaptive structures, control surface free aircraft, greening of aircraft – drag reduction / loads reduction / noise, improved control effectiveness
- Implementation - changing planform, aerodynamic shape, wing structural properties (e.g. stiffness),
- Technologies – actuators, sensors, materials, skins, control, optimisation, design, integration with other technologies (e.g. flow control)
- Applications – civil / military aircraft, UAVs, helicopter, wind turbines

It is intended to invite a maximum of 50-60 highly recognised researchers and practitioners to the workshop. All travel and subsistence costs for the European and US invited speakers and the members of the S3T Programme will be covered by the ESF and AFOSR. Members of the industry, government agencies, academia and other existing networks and programmes are also invited to participate at their own expense. The approximate cost per person per day of the workshop is about 180€. Interested participants who have not received an invitation should contact the S3T Programme office at: [s3t@esf.org](mailto:s3t@esf.org).

### Workshop Co-Chairs:

**Professor Rahmat Shoureshi**  
Dean of Engineering,  
University of Denver, USA  
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**Professor Jonathan Cooper**  
Professor of Aerostructures and Aeroelasticity,  
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### Workshop Secretary:

**Ms. Donna Kolosky,**  
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**Mrs. Catherine Lobstein:**  
S3T Programme Administrator,  
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### Organising Committee:

**Dr. Les Lee, Co-Chair (US)**  
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### Programme Committee:

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**Professor Jan Van Humbeeck**  
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### Venue:

The workshop will be held at the Hotel le Couvent Royal, a 13-century basilica and convent in the heart of the French “Green Provence in the Sainte-Baume Massif”.

For further details please visit the website:

[http://www.hotelfp-saintmaximin.com/index\\_gb.htm](http://www.hotelfp-saintmaximin.com/index_gb.htm)

**Access:** 35 km from Aix en Provence, 67 km from Marseille and 71 km from Toulon

**By rail (TGV):** Aix en Provence and Marseille Saint-Charles – 3 hrs. from Paris

**By air:** From Marseille-Provence (40 min.), Toulon-Hyères (45 min.) and Nice-Côte d’Azur (60 min.)

Common transportation to the hotel will be arranged for participants arriving on Sunday afternoon at Aix en Provence TGV Station and Marseille Airport. Return trips from the hotel to the TGV Station at Aix en Provence and Marseille Airport will be arranged for Wednesday afternoon and Thursday morning. A separate accompanying document contains practical information about the venue and transportation.

## Programme Overview

<b>Sunday 04 November</b>	
12:00 – 18:00	Arrival and Registration
18:00-19:00	- Opening presentations (ESF, NSF, AFOSR) - Objectives, format & intended outcomes (Workshop and Session co-chairs)
19:00 – 20:00	Reception
20:00	Dinner
<b>Monday 05 November – 8:00 to 12:15</b>	
8:00 – 10:00	<b>Thematic Session 1:</b> Three 40-minute presentations (30-minute presentation plus 10-min Q&A) <b>Morphing Aircraft-1, Future Telescopes-1, Adaptive Materials-1</b>
	Break
10:15 – 12:15	<b>Thematic Session 2:</b> Three 40-minute presentations (30-minute presentation plus 10-min Q&A) <b>Morphing Aircraft-2, Future Telescopes-2, Adaptive Materials-2</b>
<b>Lunch</b>	
<b>Monday 05 November – 14:00 to 17:45</b>	
14:00 – 15:45	<b>Working Group Sessions</b> 3 separate working group meetings (one for each Theme)
	Break
16:15 – 17:45	<b>Working Group Sessions</b> 3 separate working group meetings (one for each Theme)
<b>Tuesday 06 November – 8:00 to 12:15</b>	
8:00 – 10:00	<b>Thematic Session 3:</b> Three 40-minute presentations (30-minute presentation plus 10-min Q&A) <b>Future Telescopes-3, Adaptive Materials-3, Morphing Aircraft-3</b>
	Break
10:15 – 12:15	<b>Thematic Session 4:</b> Three 40-minute presentations (30-minute presentation plus 10-min Q&A) <b>Future Telescopes-4, Adaptive Materials-4, Morphing Aircraft-4</b>
<b>Lunch</b>	
<b>Tuesday 06 November – 14:00 to 17:45</b>	
14:00 – 15:45	<b>Working Group Sessions</b> 3 separate working group meetings (one for each Theme)
	Break
16:15 – 17:45	<b>Working Group Sessions</b> 3 separate working group meetings (one for each Theme)
<b>Wednesday 07 November – 8:00 to 12:15</b>	
8:00 – 10:00	<b>Thematic Session 5:</b> Three 40-minute presentations (30-minute presentation plus 10-min Q&A) <b>Adaptive Materials-5, Morphing Aircraft-5, Future Telescopes-5</b>
	Break
10:15 – 12:15	<b>Thematic Session 6:</b> Three 40-minute presentations (30-minute presentation plus 10-min Q&A) <b>Adaptive Materials-6, Morphing Aircraft-6, Future Telescopes-6</b>
<b>Lunch</b>	
<b>Wednesday 07 November – 14:00 to 16:45</b>	
14:00 – 15:00	<b>Parallel Consolidating Group Meetings</b> (three breakout sessions)
	Break
15:15 – 16:15	<b>Common Consolidating Group Meeting</b> (one common group meeting)
16:15 – 16:45	<b>Final Workshop Wrap-up</b>

## Detailed Programme

<b>Sunday 04 November</b>	
<b>12:00 – 18:00</b>	<b>Arrival and Registration</b>
<b>18:00 – 18:30</b>	<b>Opening presentations:</b> <ul style="list-style-type: none"> <li>▪ Dr. Patrick Bressler, Head of Unit, Physical and Engineering Sciences, ESF</li> <li>▪ Dr. Shi-Chi Liu, Program Director, Sensor Innovation &amp; Systems, NSF</li> <li>▪ Dr. B. L. (“Les”) Lee, Program Manager for Mechanics of Multifunctional Materials &amp; Microsystems, AFOSR</li> </ul>
<b>18:30 – 19:00</b>	<b>Objectives, format &amp; intended outcomes (Programme Committee)</b> <ul style="list-style-type: none"> <li>▪ Prof. Rahmat Shoureshi, Workshop co-chair, Dean of Engineering and Computer Science, University of Denver</li> <li>▪ Prof. Jonathan Cooper, Workshop co-chair, Department of Engineering, University of Liverpool</li> </ul>
<b>19:00 – 20:00</b>	<b>Reception</b>
<b>20:00</b>	<b>Dinner</b>
<b>Monday 05 November – 8:00 to 12:15</b>	
<b>8:00 – 10:00</b>	<b>Thematic Session I:</b> (30-minute presentations plus 10-min Q&A) Chair: Prof. Jonathan Cooper (University of Liverpool)
8:00 – 8:40	<b>Morphing Aircraft (MA-1):</b> <ul style="list-style-type: none"> <li>▪ Dr. Jay Kudva, (<i>Next Generation Aeronautics</i>), "<i>Morphing Aircraft - What's It All About</i>"</li> </ul>
8:40 – 9:20	<b>Future Telescopes (FT-1):</b> <ul style="list-style-type: none"> <li>▪ Prof. Luc Damé (CNRS &amp; Paris Observatory), "<i>Space-based versus earth-based astronomical telescopes - The Solar case.</i>"</li> </ul>
9:20 – 10:00	<b>Adaptive Materials (AM-1):</b> <ul style="list-style-type: none"> <li>▪ Prof. Greg Carman (UCLA): "<i>Commentary on Active Materials: Past, Present, and Possible Future</i>"</li> </ul>
<b>Break</b>	
<b>10:15 – 12:15</b>	<b>Thematic Session II:</b> (30-minute presentations plus 10-min Q&A) Chair: Dr. Brian Sanders (Air Force Research Laboratory)
10:15 – 10:55	<b>Morphing Aircraft (MA-2):</b> <ul style="list-style-type: none"> <li>▪ Prof. Sharon Swartz (Brown University), "<i>Data-Mining 500 Million Years of Evolutionary Experiments: How Biology Can Inspire Aircraft Design</i>"</li> </ul>
10:55 – 11:35	<b>Future Telescopes (FT-2):</b> <ul style="list-style-type: none"> <li>▪ Prof. Don Leo (Virginia Tech), "<i>Active Materials for Adaptive Optics &amp; Space Mirror Applications</i>"</li> </ul>

11:35 – 12:15	<p><b>Adaptive Materials (AM-2):</b></p> <ul style="list-style-type: none"> <li>▪ Prof. Christian Boller (University of Sheffield), “<i>Rapid Prototyping and Feasibility Demonstration of Adaptive Aerospace Structures Using Micro Aerial Vehicles</i>”</li> </ul>
<b>Lunch</b>	
<b>Monday 05 November – 14:00 to 17:45</b>	
14:00 – 15:45	<p><b>Working Group Sessions:</b> (3 parallel breakout sessions – one per Theme)</p> <p><b>Morphing Aircraft (MA-WG 1):</b> “<i>Overview of current status of Morphing Aircraft - what has been demonstrated, to what level, what have been the proven benefits, where are the gaps / problems?</i>”</p> <ul style="list-style-type: none"> <li>▪ Moderator: Prof. Sergio Ricci (Politecnico di Milano),</li> <li>▪ Recorder: Prof. Fernando Lau (Instituto Superior Tecnico, Lisboa)</li> </ul> <p><b>Future Telescopes (FT-WG 1):</b> “<i>Space Telescope Architectures</i>”</p> <ul style="list-style-type: none"> <li>▪ Moderators: Dr. Anna McGowan (NASA, Langley), and Dr. Ben Braam (TNO, the Netherlands)</li> <li>▪ Recorder: Dr. Matthew Santer (University of Cambridge)</li> </ul> <p><b>Adaptive Materials (AM-WG 1):</b> “<i>Overview of "all" adaptive materials, classification depending on experience, economical aspects, availability, environmental aspects, needs for implementation</i>”</p> <ul style="list-style-type: none"> <li>▪ Moderator: Prof. Jan Van Humbeeck, (KUL Leuven),</li> <li>▪ Recorder: Prof. Nahkiah Gouldbourne, (Virginia Tech)</li> </ul>
<b>Break</b>	
16:15 – 17:45	<p><b>Working Group Sessions:</b> (3 parallel breakout sessions – one per Theme)</p> <p><b>Morphing Aircraft (MA-WG 2):</b> “<i>What are the challenges in the basic technology sets? What disciplines should we try to draw together to get to the next level of adaptive structures concepts?</i>”</p> <ul style="list-style-type: none"> <li>▪ Moderator: Prof. Jonathan Cooper (University of Liverpool)</li> <li>▪ Recorder: <b>TBA</b></li> </ul> <p><b>Future Telescopes (FT-WG 2):</b> “<i>Reflecting and active materials for controllable reflecting surfaces</i>”</p> <ul style="list-style-type: none"> <li>▪ Moderators: Dr. Anna McGowan (NASA, Langley), and Dr. Ben Braam (TNO, the Netherlands)</li> <li>▪ Recorder: Dr. Matthew Santer (University of Cambridge)</li> </ul> <p><b>Adaptive Materials (AM-WG 2):</b> “<i>Adaptive materials in Transport and Aerospace</i>”</p> <ul style="list-style-type: none"> <li>▪ Moderator: Dr. Richard Vaia, (AFRL),</li> <li>▪ Recorder: Prof. Nahkiah Gouldbourne, (Virginia Tech)</li> </ul>



<b>Tuesday 06 November – 8:00 to 12:15</b>	
<b>8:00 – 10:00</b>	<b>Thematic Session III:</b> (30-minute presentations plus 10-min Q&A) Chair: Prof. André Preumont (Université Libre de Bruxelles)
8:00 – 8:40	<b>Future Telescopes (FT-3):</b> <ul style="list-style-type: none"> <li>▪ Prof. Scott Olivier (Lawrence Livermore Lab), “<b>Title TBA</b>”</li> </ul>
8:40 – 9:20	<b>Future Telescopes (FT-4):</b> <ul style="list-style-type: none"> <li>▪ Mr. Dominic Doyle (ESTECT, ESA), “<i>Telescopes for ESA's missions: i-Review of Missions in implementation,</i>” and, Mr. Joao Pereira Do Carmo (ESTECT, ESA), “<i>Telescopes for ESA's missions: ii- R&amp;D activities for Future Missions</i>”</li> </ul>
9:20 – 10:00	<b>Adaptive Materials (AM-3):</b> <ul style="list-style-type: none"> <li>▪ Prof. Thomas Wallmersperger, (University of Stuttgart), “<i>Electroactive Materials: Basics, Modelling, and Application</i>”</li> </ul>
<b>Break</b>	
<b>10:15 – 12:15</b>	<b>Thematic Session IV:</b> (30-minute presentations plus 10-min Q&A) Chair: Dr. Brett DeBlonk (Air Force Research Laboratory)
10:15 – 10:55	<b>Adaptive Materials (AM-4):</b> <ul style="list-style-type: none"> <li>▪ Dr. Richard Vaia (AFRL), “<i>Adaptive and Responsive Polymer NanoComposites,</i>” and, Prof. Ounaies Zoubeida (Texas A&amp;M University), “<i>Towards Enhanced Sensing and Actuation Performance</i>”</li> </ul>
10:55 – 11:35	<b>Morphing Aircraft (MA-3):</b> <ul style="list-style-type: none"> <li>▪ Dr. Ian Bond (University of Bristol), “<i>Morphing Aircraft Systems Utilising Multistable systems</i>”</li> </ul>
11:35 – 12:15	<b>Morphing Aircraft (MA-4):</b> <ul style="list-style-type: none"> <li>▪ Dr. Jeff Baur (AFRL), “<i>Multi-functional Adaptive Materials Systems including Active Composites</i>”</li> </ul>
<b>Lunch</b>	
<b>Tuesday 06 November – 14:00 to 17:45</b>	
<b>14:00 – 15:45</b>	<b>Working Group Sessions:</b> (3 parallel breakout sessions – one per Theme)
	<b>Future Telescopes (FT-WG 3):</b> “ <i>Issues in reflector metrology. End to end metrology of deployable and segmented reflectors. Cophasing segmented mirrors</i> ” <ul style="list-style-type: none"> <li>▪ Moderators: Dr. Anna McGowan (NASA, Langley), and Dr. Ben Braam (TNO, the Netherlands)</li> <li>▪ Recorder: Mr. Gonçalo Rodrigues (ULB Brussels)</li> </ul>



	<p><b>Adaptive Materials (AM-WG 3):</b> <i>“Discussion on modelling and experiment”</i></p> <ul style="list-style-type: none"> <li>▪ Moderator: Dr. Petr Sittner (Czech Republic Academy of Science),</li> <li>▪ Recorder: Dr. Merja Sippola (VTT)</li> </ul> <p><b>Morphing Aircraft (MA-WG 3):</b> <i>“What other adaptive structure concepts can be envisaged?”</i></p> <ul style="list-style-type: none"> <li>▪ Moderator: Prof. Afzal Suleman (Instituto Superior Tecnico, Lisboa)</li> <li>▪ Recorder: Prof. Fernando Lau (Instituto Superior Tecnico, Lisboa)</li> </ul>
	<b>Break</b>
<b>16:15 – 17:45</b>	<p><b>Working Group Sessions:</b> (3 parallel breakout sessions – one per Theme)</p> <p><b>Future Telescopes (FT-WG 4):</b> <i>“Issues in shape control of deployable/segmented reflectors; Passive control of wrinkles in membrane reflectors”</i></p> <ul style="list-style-type: none"> <li>▪ Moderators: Dr. Anna McGowan (NASA, Langley), and Dr. Ben Braam (TNO, the Netherlands)</li> <li>▪ Recorder: Mr. Gonçalo Rodrigues (ULB Brussels)</li> </ul> <p><b>Adaptive Materials (AM-WG 4):</b> <i>“The way forward in adaptive materials”</i></p> <ul style="list-style-type: none"> <li>▪ Moderator: Prof. Nahkiah Gouldbourne (Virginia Tech)</li> <li>▪ Recorder: Prof. Thomas Wallmersperger (University of Stuttgart)</li> </ul> <p><b>Morphing Aircraft (MA-WG 4):</b> <i>“What is the range of understanding we should be understanding? What is the nature of the technology transition that is required?”</i></p> <ul style="list-style-type: none"> <li>▪ Moderators: Dr. Brian Sanders (AFRL)</li> <li>▪ Recorder: <b>TBA</b></li> </ul>
<b>Wednesday 07 November – 8:00 to 12:15</b>	
<b>8:00 – 10:00</b>	<p><b>Thematic Session V:</b> (30-minute presentations plus 10-min Q&amp;A) Chair: Prof. Daniel J. Inman (Virginia Tech)</p>
8:00 – 8:40	<p><b>Adaptive Materials (AM-5):</b></p> <ul style="list-style-type: none"> <li>▪ Prof. Minoru Taya (University of Washington), <i>“Design of adaptable materials and structures based on bioinspirations and bioinspired design of active materials and composites”</i></li> </ul>
8:40 – 9:20	<p><b>Adaptive Materials (AM-6):</b></p> <ul style="list-style-type: none"> <li>▪ Prof. Daniel Guyomar (University of Lyon), <i>“Energy harvesting and self-powered wireless applications based on switched electroactive materials”</i></li> </ul>
9:20 – 10:00	<p><b>Morphing Aircraft (MA-5):</b></p> <ul style="list-style-type: none"> <li>▪ Dr. Boris Grohmann (EADS), <i>“Actuators for Morphing”</i></li> </ul>
	<b>Break</b>

<b>10:15 – 12:15</b>	<b>Thematic Session VI:</b> (30-minute presentations plus 10-min Q&A) Chair: Prof. Jan Van Humbeeck (Catholic University of Leuven)
10:15 – 10:55	<b>Morphing Aircraft (MA-6):</b> <ul style="list-style-type: none"> <li>Dr. Zhong You (Oxford University), “<i>Mechanisms for Morphing</i>”</li> </ul>
10:55 – 11:35	<b>Future Telescopes (FT-5):</b> <ul style="list-style-type: none"> <li>Mr. Christophe Devilliers (Thales-Alenia-Space), “<i>Future large space telescopes: a new challenge for passive/active opto-mechanical technologies,</i>” and, Mr. Laurent Blanchard (Thales-Alenia-Space), “<i>A tape-spring hexapod for deployable telescopes: from concept to deployment modelling</i>”</li> </ul>
11:35 – 12:15	<b>Future Telescopes (FT-6):</b> <ul style="list-style-type: none"> <li>Dr. Vit Babuska (Sandia Nat'l Lab), “<i>Title TBC</i>”</li> </ul>
<b>Lunch</b>	
<b>Wednesday 07 November – 14:00 to 16:45</b>	
<b>14:00 – 15:00</b>	<b>Parallel Consolidating Group Meetings</b> (Three parallel breakout sessions – each covering all three Themes)
	<b>Consolidating Session 1 (All-CS 1):</b> <ul style="list-style-type: none"> <li>Moderators: Dr. Anna McGowan (NASA, Langley), and Prof. Jan Van Humbeeck, (KUL Leuven)</li> <li>Recorder: Dr. Stéphane Roose (CSL, University of Liège)</li> </ul>
	<b>Consolidating Session 2 (All-CS 2):</b> <ul style="list-style-type: none"> <li>Moderators: Dr. Ben Braam (TNO the Netherlands), and Prof. Nahkiah Gouldbourne, (Virginia Tech)</li> <li>Recorder: Mr. Gonçalo Rodrigues (ULB Brussels)</li> </ul>
	<b>Consolidating Session 3 (All-CS 3):</b> <ul style="list-style-type: none"> <li>Moderators: Dr. Richard Vaia, (AFRL), and Dr. Matthew Santer (University of Cambridge)</li> <li>Recorder: Prof. George A. Lesieutre (Pennsylvania State University)</li> </ul>
<b>Break</b>	
<b>15:15 – 16:15</b>	<b>Common Consolidating Group Meeting</b> (one common session covering all three Themes) <ul style="list-style-type: none"> <li>Moderators: Dr. Ben Braam (TNO the Netherlands), and Dr. Anna McGowan (NASA, Langley)</li> <li>Recorder: Dr. Matthew Santer (University Of Cambridge)</li> </ul>
<b>16:15 – 16:45</b>	<b>Final Workshop Wrap-up</b> <ul style="list-style-type: none"> <li>Programme co-chairs - Programme Committee</li> </ul>