| **ESA STUDY CONTRACT REPORT**<br><br>No ESA Study Contract Report will be accepted unless this sheet is inserted at the beginning of each volume of the Report. | | | |
|---|---|---|---|
| ESA CONTRACT No<br>**AO/1-4469/03/NL/SFe** | SUBJECT<br>**BIONICS & SPACE SYSTEM DESIGN INTRODUCTION DOCUMENT** | | CONTRACTOR<br>**UNIVERSITY OF SURREY** |
| * ESA CR( )No | * STAR CODE | No of volumes 1<br>This is Volume No 1 | CONTRACTOR'S REFERENCE |
| ABSTRACT:<br><br>This is a document to introduce all deliverables to the ESA project on Bionics & Space System Design. The introduction section provides background information of the project as well as brief description of each deliverable, including Technical Note (TN) 1, 2, 3, Case Study (CS) 1 on Mars walker and 2 on biomimetic drill. The table of contents of each deliverable is also included. | | | |
| The work described in this report was done under ESA contract. Responsibility for the contents resides in the author or organisation that prepared it. | | | |
| Names of authors: Dr Alex Ellery, Mr. Gregory Scott and Dr. Yang Gao | | | |
| ** NAME OF ESA STUDY MANAGER<br>Dr Mark Ayre<br>Dr Carlo Menon<br><br>DIV: Advanced Concepts Team<br>DIRECTORATE: | | ** ESA BUDGET HEADING | |

*This page is left intentionally blank*

# BIONICS & SPACE SYSTEMS DESIGN AO/1-4469/03/NL/SFe

# Introduction Document

**Version:** 1.0

**Date:** 15 September 2005

**Prepared by:**

Dr. Alex Ellery, Mr. Gregory P. Scott and Dr. Yang Gao
Surrey Space Centre
School of Electronics and Physical Sciences
University of Surrey
Guildford
Surrey GU2 7XH, UK
Tel: +44 1483 683882
Fax: +44 1483 689503
Email: a.ellery@surrey.ac.uk

*This page is left intentionally blank*

# Table of Contents

# 1. Introduction

This project aims to provide an overview of the application of biomimicry to engineering systems in space. In particular, the study has the following goals:

- Perform a review of the current status of biomimetic engineering worldwide. In particular principle research areas and groups will be identified. A database has been constructed as part of this work package for engineers to use in accessing biomimetic solutions to engineering problems.
- Identify those areas of current, near and long-term ESA activity that are likely to benefit from biomimetic engineering.
- Review natural mechanisms and processes that could provide inspiration for biomimetic space systems.
- Perform case study investigation of a number of biomimetic space-related concepts.

The following subsections will introduce all deliverables to this project, including Technical Note (TN) 1, 2, 3, Case Study (CS) 1 on Mars walker and 2 on biomimetic drill. The table of contents of each deliverable is also included in the following sections.

## 1.1. TN1 ABSTRACT

This document is jointly authored by the University of Surrey (prime), University of Sussex, University of Bath, EADS Astrium and the British Antarctic Survey It provides a comprehensive survey of the field of biomimetics whereby engineered technology is biologically-inspired. We have emphasised its application to robotics as robotics has particular significance to space technology. This is especially the case for planetary exploration.

## 1.2. TN2 ABSTRACT

The initial motivation to include biomimetic engineering as an area of study within the Advanced Concepts Team at the European Space Agency was derived from the opinion that biomimetic engineering could have significant application to ESA programs. The future level of interest of the European Space Agency in biomimetic engineering will obviously be a function of the extent to which biomimetic engineering principles can be applied to both the near-term and long-term engineering challenges that ESA will face. At present this degree of application is unknown, and hence there is the requirement for a systematic assessment of the potential scope and impact of biomimetic engineering to ESA activities; this document is a response to that requirement.

In order to approach the problem of systematically investigating the potential application of biomimetic engineering to ESA activities, two principal information sources are required. These are:

- An existing scheme for classifying and sorting ESA activities
- An existing scheme of classification for biomimetic engineering.

The first requirement is satisfied by the core document Dossier 0, which details future ESA technological requirements and activities, and also contains the European Space Agency Technology Tree. The second

requirement is satisfied by the Advanced Concepts Team Biomimicry Technology Tree. These information sources are presented in the following sections.

## 1.3. TN3 ABSTRACT

The topic of this document is "the application of biomimetics technology to space exploration", which builds on TN 1. It was conducted by the University of Surrey with the support of the University of Sussex, University of Bath, EADS Astrium, and the Open University. It focuses on selecting specific biomimetic technologies that have nearterm application to space exploration. In particular, we focus on those aspects of space exploration related to planetary exploration. Such planetary exploration missions will become more challenging as missions focus on astrobiological investigation which represents a complex set of challenging task requirements. Many of these technologies will have wider applicability across space missions.

## 1.4. CS1 ABSTRACT

This document is jointly authored by the University of Surrey (prime), University of Sussex, University of Bath, and EADS Astrium. It provides a design of a legged robot for Mars Exploration and the investigation into the benefits and detriments of such a system. An out line of the physical design of the vehicle is provided, as well as investigations into the control system and navigation techniques.

## 1.5. CS2 ABSTRACT

This document is jointly authored by the University of Surrey (prime), University of Bath, and EADS Astrium. This case study presents a biomimetic drill based on working mechanism of wood wasp ovipositor for sampling planetary subsurface material. The ovipositor drill concept represents a novel approach of reciprocating drilling and can be used as a payload for a generic space mission. It also has technology transfer applications within the terrestrial environment. To provide a complete mission design, an asteroid micro-penetrator is considered as the mission scenario and design platform. This study outlines a micro-penetrator concept with a mass target of 5-10 kg that is suited for planetary deployment to asteroids and in-situ investigation of their chemical (astrobiologically relevant signatures) and physical properties. Such a biomimetic drill/microprobe may be deployed for the exploration of terrestrial-type planets and other small bodies of the solar system with the minimum of modifications.

# 2. TN1 Table of contents

# 3. TN2 Table of Contents

# 4. TN3 Table of Contents

# 5. CS1 Table of Contents

# 6. CS2 Table of Contents