IAA Study Group Status Report  
September 28, 2005

Responsible Commission: Commission 2. Life Sciences

Study Number and Title: 2.1 Mathematical Modeling & Physiological Simulation: The Digital Astronaut/Cosmonaut

Short Study Description: The overall goal of this IAA Study Group is to develop an Academy-endorsed, community-based publishable report on the issues, problems and benefits of an international program to develop a mathematical modeling and simulation system focused on the physiological and medical problems of space travelers.

Progress in past six months:
- Discussed the idea behind IAA Study Groups and the current Outline for the Study Group report. It was suggested that the report include a section on unsolved space problems worth solving and amenable to treatment using modeling.
- See detailed outline attached.

Website Study Information up to date? Not at this time, but updates will be made shortly. The membership is proposed to be increased slightly. The Schedule is modified slightly, but the basic study plan is unchanged.

Issues requiring resolution? None

Product Deliveries on Schedule?
Current Schedule:
- Report Outline Completed
- Individual Contributions December 2005
- First Review January 2006
- Second Review March 2006
- Final Report Submission to SAC October 2006

Study Team Member Changes? Note: Complete contact information including email, tel. and fax must be provided for all additions. Only Members with complete contact information will be listed and receive formal appointment letters from the IAA Secretariat.

Name of person providing Study Group Status (Study Group Chair or Co-Chair): R. J. White

Status Report Date: September 28, 2005
Please email the completed reports to Dr. Kasturirangan, krangan@nias.iisc.ernet.in and katkuri@isro.org, and Dick Kline, rlkline@cox.net. Then post it on your IAA Commission Website no later than September 28, 2005. Thank you!

Study Team Membership Changes

Effectivity Date: October 2005

Discontinue: None

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The Digital Astronaut/Cosmonaut:
Moving Space Biomedical Research
Into The 21st Century

OUTLINE

I. Introduction
  Comments:
  • The report will be aimed at a general reader (non-specialist) and not at
  a biologist or modeler. For two examples of space-related writing
  aimed at different levels of non-specialists, see:
  • The Introduction should be the last section written and should
  summarize the purpose of the report and the main arguments
  supporting the use of modeling and simulation in space biomedical
  research.

II. Background
  A. The Human in Space
     Comments:
     • This section should orient the reader to the environmental challenges
       that space travelers face and provide the rationale for serious study of
       the human in space as an intact organism.
     • Two draft figures relating to this section are included in the associated
       FIGURES files:
       o The Human in Space: Environmental Challenges
       o Caring for the Human in Space

  B. Modeling the Human in Space – A Brief History
     Comments:
     • This section should briefly tell the story of past modeling efforts related to
       human space flight. It is not intended that this section include a thorough
       review of previous work (see Srinivasan, R. S., Leonard, J. I. and White, R.
       J. Mathematical Modeling of Physiological States. *Space Biology and
       Medicine, Vol. III, Book 2* (ed. by Leach-Hunton, C. S., Antipov, V. V. and
       review). Rather, it should provide succinct highlights and a few success
       stories.
     • The following draft figures relating to this section (probably more than we
       would use) are included in the associated FIGURES files:
       o Biomedical Modeling & Space Flight
       o The Whole-Body Algorithm: The Digital Astronaut of the 1970s
C. The Digital Human and Related Projects

Comments:

- This section should provide an overview of current activities in the community related to the Digital Astronaut.
- A draft figure relating to this section and to Section III.D is included in the associated FIGURES files:
  - The Digital Human & Related Systems (courtesy of J. Coolahan)

III. The Digital Astronaut

A. Definition

Comments:

- One definition that I have used in the past is: *The Digital Astronaut is an integrated, modular modeling and database system that enables the construction and utilization of important predictive simulations of the whole human body.* Of course, the definition should continue and describe the types of space-related and ground-analogue conditions that should be the focus of the system.
- The important points about this definition are:
  - that the Digital Astronaut is an integrated SYSTEM, not a single model,
  - that it includes, as an integral part, an associated biomedical database related to space flight and to important ground experimental analogues, and
  - that the system itself is modular.

B. Goal

Comments:

- This needs to be developed carefully, taking into account the international community of scientists that might be interested in participating in this activity and of the difficulties of carrying out a project of this type with such a distributed group.
C. **Approach**

Comments:
- The approach needs to be developed in conjunction with the goal defined above. It may be that we will need to have an international workshop to converge on the goal and approach (and on ways to handle the difficulties below). That might be feasible.

D. **Difficulties**

- Foundational (unified ontology, modeling methods, computational methods, community training, …)
- Structural Integration (whole body, organs, tissues, …)
- Functional Integration (coupled physiological subsystems)
- Data Integration (representation, archiving, utilization, standardization, …)

Comments:
- It is important to recognize these (and other) difficulties and to have a strategy to deal with them.

E. **Benefits**

- Space Research Community – Strengthens hypothesis development & testing and enables multidisciplinary team research to be more effective
- Engineers & Managers – Mission biomedical risk reduction through improved understanding of human systems and improved planning
- Physicians – Improved medical care through rapid access to all available data & additional capability of realistically testing therapies prior to use in space
- General Health Care Benefits (training, remote care, …)
- Unsolved Problems in Space Physiology

Comments:
- The benefits are very important to describe clearly. Otherwise, this kind of difficult project will not find the support it needs to actually be initiated.
- A draft figure relating to this section is included in the associated FIGURES files:
  - The Digital Astronaut System: A Few Benefits

IV. **International Cooperation**

Comments:
- The important role of international cooperation in a project such as this one should be presented so that it is clear to the reader why such cooperation is valuable (essential).

V. **Summary and Conclusion**

VI. **Bibliography**
Comments:

- Some references that I have found useful are included on the next few pages. The list is both personal and by no means complete.

Draft Bibliography & Assorted Useful References


Murray, J. D. *Mathematical Biology II. Spatial Models and Biomedical Applications (3rd Ed)* (Springer-Verlag, New York, 2003).


