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Final Report: P.O. H-22785-D; Life Sciences Centrifuge Facility Review
DCN 1-4-EA-00896

Enclosed please find the final report for my participation as a consultant on the subject review, along with the Report Documentation Page (SF-298).

This concludes my work under the subject contract. Please note that I did not develop any specifications or statements of work to be incorporated into a solicitation. I appreciated the opportunity to work with NASA on this important activity.

Sincerely,

cc: EA01/Hopson (2)
CN22D
LA01
CC01/Intellectual Property Counsel
NASA Center for AeroSpace Information (1+repro)

Life Sciences Centrifuge Facility Review

Final Report

Laurence R. Young

Sept. 13, 1994

Introduction:

The reviewer participated in the Code U ISSA Life and Microgravity Science Research Facility Assessment for the Centrifuge Facility Project. The review began with a careful inspection of a briefing book supplied prior to the site visit, and a supplementary report to the author, supplied by Ames, describing the centrifuge ground studies relating to size and to the frequency of interruption of centrifugation. The site visit at NASA Ames during the week of Aug. 30, 1994, included both detailed briefings and a series of three valuable tours of the facilities and demonstrations of related equipment. A sufficient library of background material covering the science requirements and previous reviews by the Science Working Group and the 1994 Ad Hoc Review Panel (Cleave panel) was made available to the reviewers at the briefings to supplement the oral presentations and charts.

On the basis of this material, the reviewer confirms the assessment of the Independent Review Team that the Centrifuge Facility Project is on schedule and sufficiently in control of all risks, so that proceeding toward the Phase C/D program at this time is warranted.

Assessment of Science Requirements (Maturity & Planning)

The Science Requirements are clearly and completely described in the Level II SRD, and the Project has responded satisfactorily to each of the requirements. The summary statements of the Science Working Group fully justify all major aspects of the facility, including the centrifuge, glove box, habitats and laboratory support equipment. The scientific importance of the research that will be conducted with this equipment is paramount -- indeed it represents the future for gravitational biology. All the major reviews of space life sciences over the past two decades have stressed the need for long duration exposure of humans, animals and plants, and for the provision of a variable gravity on-board centrifuge to study levels of gravity below

one-g, and to isolate microgravity exposure from other aspects of space flight. The CFP promises to fulfill these needs.

The centrifuge science requirements have been simplified somewhat from earlier versions in two respects -- the willingness to stop the centrifuge periodically to remove habitats, and the limitation to rodent mammals for the initial experiments. Ground studies using centrifuges of different radii were used to justify the 2.5m radius of the flight centrifuge as well as the acceptability of periodic brief stopping of the rotation. Although the current habitats do not accommodate squirrel monkeys, the design specifically avoids anything that would preclude future use of primates.

Assessment of Performance Requirements

a) Definition Phase Studies

Thanks to the many years that have passed since the original Phase A studies, and which included an extended Phase B, with two contractors submitting proposals and with extensive in-house studies, the performance requirements are mature and well understood. For example, the adequacy of LED illumination for normal plant growth has been proven, the requirement for CO_2 regulation beyond that of the cabin air has been refined, the adequacy of habitat air and water systems has been demonstrated with real animals for extended duration, and the vibration levels tolerable for normal plant growth have been shown. No further major definition phase studies are needed before proceeding with equipment design.

b) Interface Documentation Maturity

The internal interface documentation is adequate to go on, and covers such key aspects of the facility as the manner of placing habitats in the habitat rack, the centrifuge and the glove box. The external interface is not well defined at this point because of the continued absence of a commitment from ISSA as to the location of the centrifuge and associated racks (module, half module, node or Spacehab) or the launch accommodations. Until these important details are clarified the Project will remain uncertain concerning such important aspects as whether the centrifuge is to be launched substantially assembled or if it is to be assembled on-orbit.

Indications from the ISSA briefing were that these arrangements would be made on time.

Assessment of Facility Cost and Schedules

All the schedules appeared to be reasonable, and consistent with the scientific needs of the community to have access to plant and animal experimentation on the Space Station as early as possible. The most significant impact on the overall schedule would be further delay, or changes in the definition of the location for the centrifuge or the centrifuge launch date.

This reviewer does not have the background to assess the cost estimates, and has made no contribution to the overall review in that area.

Assessment of Programmatic Risk

Five categories of risk were identified: biological, technical, program/schedule, resource and intangible.

Biological risks:

1. There exists a risk that the **habitats** will not adequately support the normal development of the specimens (e.g. CO_2 levels, cage size, waste removal, water delivery, food delivery and adequacy, plant unit lighting, temperature control and biocompatibility of the implanted biotelemetry.)

These risks can be minimized by proceeding with ground testing of adequacy of implanted biotelemetry for 90 day periods, maturing rats

2. There is some risk that the **centrifuge,** while operating according to the specifications, and working to satisfaction in the primary role of a variable g device, does not fully allow comparisons of 1-g in flight to 1-g on the ground.

(E.g., Coriolis forces and motion sickness, or the g-gradient, might lead to abnormal growth or behavior; periodic stopping of the

centrifuge for habitat removal might interfere with the flight 1-g status of the specimens.)

This risk can be approached with early verification flights to determine the difference between 1-g on orbit and 1-g on ground It may also be feasible to provide sufficient health monitoring on the centrifuge (biotelemetry, video, possible strain gauge scale) to assure animal health without stopping the centrifuge.

Technical Risks:

The project, though complex, requires no new technology development, and is of relatively low risk.

Centrifuge dynamic balancing might not prove adequate for meeting the ISSA micro-g requirements, during animal movement on the centrifuge.
(The rreviewer understands that there was an adequate demonstration of this technique made by a contractor. Therefore, this concern is withdrawn)

III Program/Schedule Risks
As mentioned earlier, any delay or change in ISSA accommodation of the centrifuge would impact the schedule, cost, and scientific utility of the centrifuge equipment (e.g. change from lab module to Spacehab home for the centrifuge after initiation of Phase C/D contract, or physical separation of the Glovebox from the centrifuge or the hab racks).

This schedule and cost risk could be avoided by fixing a date in the schedule for certain determination of ISSA accommodation and interface.

Resource risks

Power usage, already quite high for CFP, might not permit centrifuge or hab full usage except during rare 90 day increments dedicated solely to CFP experiments.

Logistics requirements are also high (e.g., 8 racks plus centrifuge) and may only be met fully during rare increments dedicated to CFP expts, unless ISSA provides adequate payload stowage.

The resource allocation risks can be reduced by development of the current straw man of mission usage and resource allocation models to assure that adequate numbers of increments can be used by the CFP.

Intangible risks

There might be a real or perceived objection from the anti-vivisection community which could limit the performance of key animal experiments

This risk is best met by providing adequate health status monitoring to satisfy all the needs of accepted levels of animal care.

Other Issues:

No other issues threatening the project were identified. The CFP team is highly experienced and very capable, and should be able to produce a device of great importance to all space life scientists.

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The Centrifuge Facility Project at NASA's Ames Research Center was reviewed by a code U team to determine appropriateness adequacy for the ISSA. This report represents the findings of one consultant to this team (Dr. Laurence Young) and concentrates on scientific and technical risks. The report supports continuation of the project to the next phase of development

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