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GAS-611
FIREFLY IN ZERO GRAVITY
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ABSTRACT:

A study of Insects in a Micro-Gravity environment has not been investigated to date. There have been some short duration experiments on animals and plants. Long duration ZERO-G exposure was made possible through the NASA-Space Transportation system utilizing the Space Shuttle Orbiter. The effects of micro-gravity on living organism can only be tested over a long duration. Then, reliable data can be obtained and applied where needed, possibly assisting in the attempt to safely colonize Space. Many material,man-made and natural,exhibit different characteristics when introduced to weightlessness. Mechanical properties that are associated with some materials become obsolete. The effects of "gravitational pull" is found throughout the Universe at many different levels. With the exploration of deep Space at our door step, understanding microgravity is a new challenge to 'Today's Engineer'. NASA made available the largest microgravity laboratory known to man and now challenges him to explore it's secrets. The study of processing materials in space can start with experiments that are biological in nature. GAS-611 Project will carry a small, self-contained, biological experiment into a microgravity environment for a period of 120 hours. The payload will be a colony of "Lampyridae", commonly known as the Firefly or 'lighting bugs'. The ability of this beetle to produce light, with an efficiency of 98%, will be evaluated in a micro-G environment. The chemical process that occurs could be assisted by Mother Earth's Gravitational pull and the very complex tracheae system found within this species of Beetle. The ability to place "Natures Light" next to a Star could only happen in dreams, until NOW!

Funding for this project is assisted by the sale of GENERIC CADD drafting software.

Objectives: The Firefly in Micro-Gravity

-What is the effect microgravity has on the ability of the Firefly to produce light? Can this effect be quantitatively measured?
-Does microgravity effect the insects ability to function?
-Is the larva of the Firefly effected by microgravity?
-With the absence of thermal convection, is the Firefly affected in an way? Can this condition be determined?
-What are the effects of the extreme G-forces introduced during the launch, on the firefly?
-Does the Firefly respond to vibration in space the same way it responds on earth?
-Is the Mating ritual the same in space as on earth?
-Was mating successful? Are there any side effects after the space exposure?

MICROGRAVITY: {17}The Lewis Research center in Cleveland Ohio, has a fully equipped laboratory to conduct research in a microgravity environment. Working in close proximity with NASA, this facility can provide from 1 second to 20 minutes of microgravity. The space shuttle program made available the extended duration of microgravity that is needed to study biological as well as materials and processing techniques. The advantages to studying the effects of microgravity on earth related materials is complicated by the required Space Application Engineering needed to construct the Environment that houses the experiment. The engineering techniques, used on earth may not apply when subjected to a Zero "G" environment. The effects of 'Shuttle Launch' can vibrate the entire Payload apart. Electronics will self destruct if not properly designed for temperature compensation. These are only a few of the design parameters that surround a Space exposure experiment.

The children of today are the engineers of tomorrow and the future Space Application Engineers must be nurtured and motivated,because they will be provided with the challenge to become a 'Modern-Day Pioneer' in the 1990's. The responsibility to future exploration can only be guaranteed if today's youth is motivated and challenged.

BIRTH OF THE GET-AWAY SPECIAL PROGRAM: In 1972,NASA was given the assignment to develop a reusable space vehicle that could carry large,heavy scientific experiments,and manufacturing facilities into low earth orbit. The space shuttle that was selected by NASA for the Space Transportation System is built around a reusable space vehicle called the Orbiter with expendable external tanks and two reusable solid rocket boosters. The Orbiter, which is approximately the size of a DC-9 aircraft, contains a crew compartment, that can accommodate up to 7 crew members,and a 60 foot long by 15 foot diameter cargo bay, designed to carry 65,000 pounds. The cargo bay doors will open in orbit to permit a variety of experiments, investigations, and space applications. {14} In accordance with national policy, NASA must be reimbursed for providing launch services to non-NASA

customers. The pricing policy which NASA implemented is designed to recover the Space Shuttle operations cost over the defined 12 year operational lifetime of each Orbiter. The load factor per flight,based on either the length or weight of the payload, averages between 60% and 80%. This was the basis for establishing the pricing formula for major payloads.{10}The Shuttle reimbursement policy principle, recovers the projected average cost per flight whenever the cargo bay is 75% utilized ($1300 per lb). Since the remaining space was not required to produce revenue, the idea evolved that it could be used to provide opportunities to fly payloads of a small size, at a very low cost per pound {10} ($50.00 per lb); provided limited Orbiter services and resources such as power,crew support and deployment would not be required. {14}The objective for providing this opportunity, was to encourage the use of space research by educational institutions,small companies,organizations,and individuals that could not possibly afford the investment required to fly a major payload. These Payloads could Generate new Activities unique to Space,(GAS) thus providing the stepping stones to deployment of larger scientific or commercial payloads on future shuttle flights. To accomplish this objective NASA established the criteria that payloads of this class must be for scientific research and development purposes. NASA will not attempt to judge the scientific merit of a proposed experiment. All users will be required to furnish NASA evidence of scientific research and development intent and sufficient information for verification by NASA that the payload is for peaceful purposes and complies with applicable law and policy.

The Small-Self Contained Payload (SSCP) or Getaway Special program opened the Mysteries of the Universe to anyone who dared to challenge her.

EVOLUTION OF A PROJECT: {9} Working with the experimenters handbook a rough estimate of the thermal requirements can be obtained. {see Fig-A} 2.5 cubic foot container,with an insulated end cap,requires 15 Watts/hr. to maintain 26 degrees centigrade. Since the heating requirements will only be needed during the actual mission and a conservative estimate of 120 hours is established. A 1.8KWH battery pack will be needed for heating. The housekeeping requirements of the avionics,needed to control this payload will increase the battery pack to 2.0 KWH capacity.(Based on 5vdc@ 333ma continuous 120 hours). With this information the weight and volume of the batteries can be found in Graph B. Prior GAS payloads have used, NASA approved, Silver-Zinc (Ag-Zn) with much success. The weight of the battery pack is approximately 30 Pounds. The volume of these batteries will be 0.4 cubic feet,without containers and mounting hardware.
Structure weight estimate:Aluminum 6061-T6 (NASA approved)
Density= 0.098 lbs/in3 (44.49 gm/in3) {11}
V=3.1415*R2*L A=3.1415*D2/4 M=L*roh*3.1415*R2
The Shelves:Diameter= 19.0 inches Thickness= 0.125 inches
{these dimensions contingent on Stress Analysis}
L=0.125in pi=3.1415 roh=0.098 lbs/in3 radius=9.5 in.

Mass s= 0.125*0.098*3.1415*90.25
Mass s=3.34 pounds for each shelf(using 4 shelves=13.89 lbs)
Side Brackets: Using a Symmetrical 'T' shaped bracket
(also contingent on stress analysis.)
Length=0.75 in. Thickness=0.25 in. Height= 14.00 in.
Mass b= (2*(0.250*0.75)*14.0)*0.098
Mass b= 0.5145 pounds each (using 6 brackets= 3.087 lbs
Total Structure weight: Mass t= 13.89+3.087
= 16.977 pounds (occupying 0.1 cubic feet)
The experiment recording system will be a 35mm camera with a close-up lens,autowinder and a special 250 film pack. The film is used to record numerical data via LCD display in the field of view of the camera. This method is a simple and permanent form of data storage. This system may be replaced by a video camera / recorder if the weight limit is still maintained.

The avionics and recording weight is estimated to be 3.0 pounds. Actual weight of the electronics package is not calculated for this presentation. The weight of the recording system was determined by the shipping weight of a complete AE1-Program camera outfit from a mail order house.

Weight of the Enviro-Chamber: Structure= 4 Shelf ===> 13.890 Pounds 6 Brackets=> 3.087 "

Total ===>	16.977	"		
Batteries=	30.0	"	Weight Limit	60.0 lbs
Recorder & Avionics	3.0	"	- total	50.0 "
Total SBR	50.00	"	Enviro-Chamber	10.0 "

The Get-Away Special program has a size and weight parameters that are within the guidelines of the space transportation system. The model presented is the first pass attempt to establish the direction needed to obtain the required design for reliable payload results. The smallest payload parameter, offered by NASA, was selected as the starting point for this project. (9) Payload Envelope Parameters:Container Size 19.75" x 14.13" Weight limit 60 lbs---- 2.5 cu ft. The payload will be completely self-supporting,with 3 electrical controls to be operated by the Astronauts. (9) The NASA supplied container,that houses the payload, is made of aluminum with an insulation on the exterior. The mounting plate is 19.75" x 0.625" thick aluminum with purging ports and can not be altered by the experimenter. The inside of this container will maintain 1 atmosphere of dry air throughout the entire mission. This experiment requires an environment that can sustain the life of insects for 15 weeks. The total time in a microgravity state will be 4 to 7 days. This will occur approximately 75% into the 15 week mission. Temperature of the enviro-chamber will be 26 degrees centigrade for the entire 15 weeks. Strip type heaters will be activated by a high/low thermostat to maintain this temperature. In the event the temperature rises too high, then a small fan will be activated, by the thermostat, inside the avionics bay.

ENVIRO-CHAMBER DESIGN:Based on a 10 pound limit and a remaining volume of:{Fig-C}

Structure	= 0.1 cubic feet	
Battery	= .5 " "	{19"dia.x 3"high}
Recorder/Avionics	= .82 " "	{19"dia.x 5"high}
total SBR	= 1.42 cubic feet	
Volume limit	= 2.50 cubic feet	
minus total SBR	= 1.42 " "	
Enviro-chamber	= 1.08 cubic feet	

The chamber construction will be made of wood for this model. It's dimensions are 12" x 12" x 5" Square.
White Pine Density = 0.0156 lbs/in3 {11}

Sides:	5"* 12"* 1"= 60 in3* 2 = 120 in3*0.0156=	1.872 lbs
	5"* 10"* 1"= 50 in3*2 = 100 in3*0.0156=	1.560 lbs
Top & Bottom :	10"* 10"* 1"= 100 in3 * 0.0156 * 2=	3.120 lbs
	Total	= 6.552 lbs

The inside of the chamber will be lined with moist earth. The soil will be retained in a 'mesh' envelope and will have the necessary Nutrients to sustain the insect's diet. For this model the density of Moist Earth=0.0451 lbs/in3 {11}.

Plates:	3"* 10"* 0.25"=7.5 in3 *4 = 30 in3* 0.0451 =	1.353 lbs
	10"*10"* 0.25"=25 in3 * 1 = 25 in3* 0.0451 =	1.128 lbs
(bottom only)	Total	= 2.481 lbs

Weight of the Wood structure and the lining plates = 9.03 lbs

The inside of the walls will have 3 slots milled 0.5"wide x 10.0" long x 0.5" deep to provide a natural 'Crevice'{1}habitat the insect is familiar with. The weight of the enviro-chamber is reduced by the slots and the opening of the Camera system by 0.935lbs. These 'roads' will also be linked vertically and will be constructed such that when traveled the insect will be directed to the open chamber where the recording system can document their activity. The bottom plate will have a water seeding system, consisting of a simple 'Wick' laced within the plate. This will provided needed moisture for some humidity. {18} It must be noted that the dry air used by NASA has a Dew point of -76 degrees Fahrenheit. This condition is not desirable inside the Enviro-Chamber as it could cause dehydration.

In the center of the open chamber is a four sided pyramid, coated with mirrors to provide the 'window' to observe the inside of the entire chamber. The water seeding bag will be housed by this structure. The water seeding bag requires a special valve that prevents it from emptying at launching because of the large 'G' force imposed on it. A heater will be mounted on the bottom side of the top cover and will be controlled by a thermostat near the center of the chamber. Additional heaters will maintain the outside temperature of the enviro-chamber. This method of maintaining the payload temperature will reduce the thermal gradient of the internal payload structure and transfer the

additional stress to the NASA supplied canister. A composite material will be used to further insulate the remaining volume of the Enviro-Chamber Bay. Weight is the determining factor.
COSTS:Design,and Construct or Lease the Equipment? The success of an individual is determined by that individual's ability to find a need and fill it. With the introduction of the GAS program,the emergence of unique support groups have evolved. The GAS Program is a small part of a very large unit called NASA. The program is structured to accommodate the experimenter and allow a simple idea to expand to a full project without the red tape associated with a typical Military space experiment. The redundancy has been left out. There still are many requirements for a GAS project. The safety manual is 200 pages not counting the continuous flow of mail that is termed 'associated' with the GAS program. The money charged,by NASA ($3000.00 for this Project) for it's role in a project,can be considered to be the best-deal-in-town, because the support provided by NASA is far greater than the actual charges. To the new user this may not be evident when first introduced to the program. Many times NASA officials will verify a particular part or material to assure it is safe to use in the environment of space. The key too pushing a project through the portholes of NASA Safety program is to use materials and methods already approved. Re-inventing the 'so-called wheel' methodology is not a cost effective thing to do when designing a Space exposure project. The cost start to escalate when one tries to shrink a full size 'earth environment' into 2.5 cubic feet with a maximum weight of 60 lbs. {9} The cost of Silver-Zinc batteries for this project,based on 2.0 KWH will be about $1800.00 (1979-dollars).
A typical, commercially available, Data recorder ranges from $1500.00 to $55,000.00 and not only carries a hefty price tag but weighs a TON. The INDIVIDUAL-OUT-OF-POCKET raw cost to complete this project is $25,000.00. With the support of 'sponsors' this projection could be on the high side.

There is an alternative, three companies will provide their expertise and lease an experimenter a complete payload integration service,tailored to the user's requirements. The paper work with NASA is also handled so the user can concentrate on the Experiment.

Who's Who: Vendor		Cost for services
Instrumentation Technology Associates(ITA-Exton,Pa)	------>	Start at $55,000.00
Getaway Special Services Bellevue,Washington	------>	$35,000.00 to $50,000.00
MBB-Erno Germany	----->	Start at $100,000.00
Quartic Systems Salt Lake City	Has an Electronic computer/recorder that draws 15 milliwatts. (NICE)	

The dollar value may be considered high when first reviewed but for a ONE TIME experiment these services could save much time as well money. The experimenter that establishes the requirement of multiple flights would reuse his original Payload canister.

ORIGINAL PAGE IS
OF POOR QUALITY

GET AWAY SPECIAL
SMALL SELF-CONTAINED PAYLOADS
2 1/2 FT³ CONTAINER WITH INSULATED END CAP

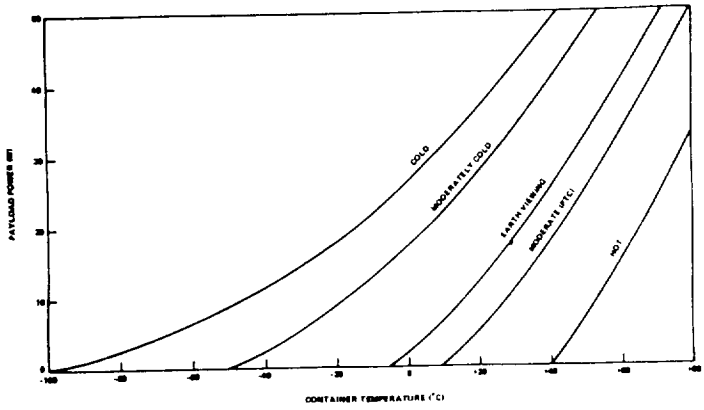

FIGURE A

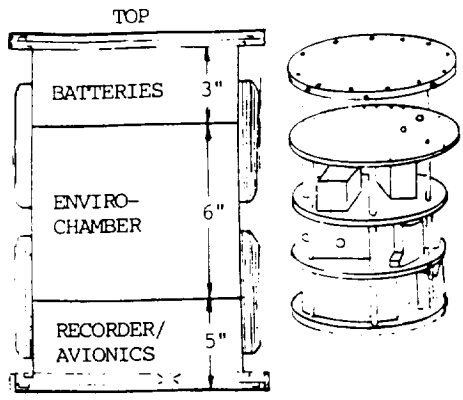

FIGURE C

GET AWAY SPECIAL
SMALL SELF-CONTAINED PAYLOADS
BATTERY DATA

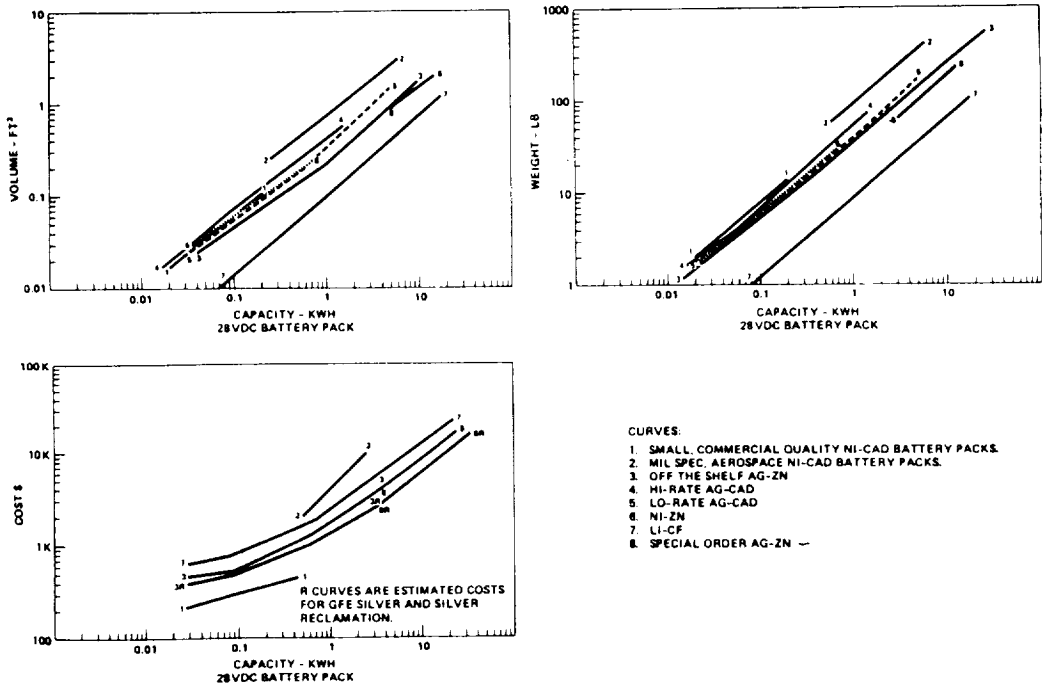

FIGURE B

GAS-611 Project FIREFLY References:

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Microgravity Materials Science Laboratory
NASA-Lewis Research Center
17 Cleveland, Ohio 44135
September 1985
Services available to Study Microgravity

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