HARDPODS: DESIGN FOR A DROP DEPLOYABLE INSTRUMENT PACKAGE

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ABSTRACT

The goal of this project has been the development of an inexpensive, disposable remote deployable environmental assessment instrument package. The purpose of this instrument package is to hold the sensors to obtain data and relay it to a nearby base station where it is further transmitted to people who will use the data. The package needs to survive remote deployment (hence the name, "HardPOD"), properly orient itself, and collect, process, and transmit data. The design must not only provide for a proper landing, it must survive in harsh environments, such as extreme cold or heat, an acidic or caustic environment and, of course, extreme moisture or dryness. Considerations were also given to system requirements such as power consumption and data transfer strategies. The result of this study has been the conceptual design of a two-tier instrumentation package and the identification of key parts of the hardware that make this design practical.

INTRODUCTION—EARLY DESIGN CONSIDERATIONS

The HardPOD concept that calls for a highly survivable instrument package came about after the last Mars mission. The result of that mission was an instrument package that was able to journey to another planet only to be lost in a crash. Clearly, the solution to that problem is an instrument system that can withstand crash conditions and still be functional.

The initial instrument design was based on a traditional concept of providing one unit to hold all of the needed function. These include environmental sensing and long-distance data transmission. This is what came to be called the "HardPOD." Early on in the design process it was obvious that a system could be built that would survive a crash. However, this would be large and consist of relatively expensive components and materials. This is the point where it was decided that alternative designs should be developed, particularly those which would be cost consciousness while still achieving the original objective of collecting environmental data.

The first design assumption that was challenged was the use of a single unit. This is the approach that everyone else has been using and early on, it seemed like the only approach. That is, to design a single unit that would monitor its local environment and host the data communications equipment. The stimulus for change came when it was realized that such a unit monitors only a small area and, as such, does not really give an adequate assessment of the range of conditions except in very homogeneous environments. The concept was then developed of producing many small sensing units that could be spread over a large area (called "seedpods"). These smaller units would communicate back to a larger unit. This larger unit would become more specialized than
in the original design since its primary function would be communication. This strategy allows for a much more comprehensive evaluation of the environment. The smaller sensing units, the seedpods, could then be designed with the understanding that there may be failures in some of them and that this will not put the entire system at risk.

POD DESIGN CRITERIA

Primary considerations in the design of all of the POD units have been to minimize cost and reduce construction time. The result has been the use of off-the-shelf components. These include the sensors, transceivers and computing systems. The main features sought in these components are that they are inexpensive, robust and share compatible with each other.

The design needs to recognize that the construction materials will need to withstand assault from extreme external conditions. This is not just an external coating problem. The internal components, such as the computer, transceiver, and power source, need to be shock resistant and properly insulated for survivability and operation.

Finally, there is a desire to minimize the weight (mass) of the units. This is important in their survivability since it is expected that if the units can be made extremely light, they will be able to be deployed in a relatively simple way.

HARDPOD: THE BASE UNIT DESIGN

The base unit, the HardPOD, design has several aspects including landing survivability during deployment, a capacity to properly orient to a remote platform and to collect and retransmit data. This is a relatively large unit.

The deployment design that is that this unit will be dropped inside a shell. The shell protects the components during the high-altitude descent. This detachable shell is released at a low elevation and the unit deploys a parachute to slow the descent. Further, deployment of aerodynamic leading end plates will act as an air brake system, and this further reduces the speed of the unit. It is intended that this unit crash on landing. This is a survivable crash, of course. The front or nose tip of the base unit will be hardened for ground penetration. This anchors the HardPOD unit and keeps it off the substrate so that it is more likely in a line of sight with the neighboring terrain.

The end plates that were used as air brakes will also sever as a place to locate solar panels after deployment. This will be the source of power to the unit.

The HardPod unit does not contain the environmental sensors, although it can contain instruments that perform well from a single central location. This includes a CCD imaging device. The main function of the HardPOD is to support a powerful transceiver system able to transmit gathered information to an orbiting platform and to collect data from a network of small, scattered sensing devices.

The storage of power is an important consideration for the HardPOD. It is expected that the solar panels will collect power for only part of any day, yet the unit will need to operate continuously. Since the weight (mass) of the HardPOD is not too critical, in fact if properly configured, it might help the hard point penetrate the ground, a fairly large power-storage unit can be used. This would be located in the lower central main body of the unit. This could be fuel cells or batteries. The top of the HardPOD is
reserved for the imaging device (perhaps with a pan and tilt control) and, further up, the transceiver devices for local and remote communication.

Details of the HardPOD design beyond these general considerations are awaiting the design of the small sensing units, the seedpods.

SEEDPOD DESIGN

![Construction Details]

Modification: hooked ends

COMPONENTS OF SEEDPOD

- Solar Cell
- Basic Stamp Computer
- Light Sensors
- Transmitter and Receiver
- Capacitor

The smaller units, the Seedpods, will be deployed when the main transport shell is removed (at the time the HardPOD is opened). This is for low altitude air dispersal and, if the Seedpods can be sufficiently light, they should float to the surface and suffer no damage on impact. This dispersal strategy is used so that they will cover a large area and monitor enough different places that the environmental diversity can be determined.
The SeedPODS have a relatively radical design. This is driven, in large part, by three design criteria. They must be light so that they survive the landing impact. They must orient properly no matter how they land. Finally, they should land (and stay) in places that enhance the probability of getting as wide a range of environmental conditions as possible.

**Minimizing Weight.** The SeedPODS have a variety of environmental sensors (such as temperature, light), a computer to process the sensor information and schedule data transmission, a power source, a power storage unit, and a transceiver. All of these components, except for the power storage, have become very light as the result of recent technology developments. Solar panels that are emerging from R and D labs are very lightweight, for example. The majority of the weight appears to come from the need for batteries to store energy during periods when the solar panels will not operate. Design alternative uncovered the possibility of using an electrical capacitor (for example, a 1 farad) as an alternative. This is practical if a very small computer is used and is scheduled to operate for very short intervals. Given the goal of getting a general set of environmental measurements, such constraints fit in the general design for this project. Such a capacitor-based storage system is also very inexpensive.

**Landing Orientation.** The design question is how can you get a air dispersal unit to properly orient without increasing its size and weight? The current solution to is the use of a structure with a regular tetrahedron shape. By configuring all of the faces identically (each has sensors and solar panels), this unit will land with a face down and an apex pointing up. This means that it will always properly orient itself with having a need for a sensing system or re-orienting machinery. Each face of tetrahedron contains a temperature sensor, a moisture detector, and a solar panel. Light sensor is located in each apex so that on landing, one of these points up. Since of the tetrahedron faces is on the bottom, it shades one of the temperature sensors, is an advantage since one is usually interested in a temperature that is not influenced by direct radiation. This design presupposes that the seedpod face that is on the bottom lifted off the substrate. This will be discussed later.

**Multiple Environments.** The environments to be surveyed might be little more than dry soil on other planets, but in the design used here, it is thought desirable to make Earth-like environments be used as the standard. This means that the seedPODS should be able to land in, and sample, flat soil, water bodies (such as lakes) and vegetation on the case of the vegetation, the challenge is to get them to stay in vegetation such as a canopy. This requirement has been met by using support struts that extend beyond the length of the tetrahedral faces. The ends of the struts have a hook. In vegetation, this shown to work well in holding the SeedPODS to the leaves and twigs.

The interior configuration of each of the SeedPODS consists of a transceiver, a very small computer, a capacitor for power storage and an antenna for communication. The exterior of the units has to be constructed of materials that cannot only withstand extreme environments, including being moisture proof. The integrity of the interior must remain uncompromised by any type of moisture (neutral, acidic or caustic). Effectively this will mean a sealed interior environment that is then insulated from raw temperature changes with the outer surface.
The result of all of the design constraints was an extremely lightweight unit that met the goals of proper orientation on landing and being able to withstand a range of harsh environmental conditions.

CONCLUSIONS

Complex design tasks are often best solved by approaching the problem from a radically different direction. That was the case in this study. By abandoning the single-unit design, the resulting system is easier to construct, likely to be much more reliable and should result in more useful information. Some of the components looked at in the design process were one-wire technology due to the decrease in the harness size and complexity. The reduction in complexity ultimately means a reduction in cost. That has always been the basic philosophy, which has driven the endeavor. Technology is expanding at such phenomenal rates that it is difficult to be aware of what is available today. My purpose was to see if one could develop a system "by thinking outside the box" that would actually meet all the standards that were outlined in my proposal.

The most difficult part that I encountered in the project was the software program writing; assistance from students and professors in other departments helped reduce the complexities of this problem. The basic concept is for all the SeedPODS to be able to collect and transmit data to each other thereby forming a working chain of units. This will allow for an extended area to be analyzed in a single deployment. It will also be designed to operate if there are disruptions in any single units (more or less a leap-frogging-effect). This will allow for a continuous flow of data to the main HardPOD unit for further long distance transmission.

At this time I am working on developing materials for the exterior. To date the most successfully tested is a lightweight, acid and caustic resistant material, that tolerates extreme cold (remains flexible after being frozen in liquid nitrogen). The testing so far has shown that this material can be moved directly from extreme cold to high heat without showing any signs of degradation. Further experimentation is required to see if this material will actually prove useful.

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