Dear Lisa,

Today is the start of my unpaid leave from the University of Arizona. The unpaid leave is for nine weeks, and I will supplement that with three weeks of annual leave (vacation) time in December and January. This will allow me to focus entirely on the Pegasus for the next twelve weeks.

Here is the technical progress of the Pegasus as of September 30, 1995. You have seen much of this before. However, this report format directly addresses the Statement of Work in the grant.

Task 1: Field Test and Sell Prototype to Ellis Equipment, Ltd. This task includes work on both the 1993 and 1994 prototypes. To minimize confusion, I will address these machines separately.

1. Sell the 1993 Prototype to Ellis Equipment, Ltd. This is the two-row machine with the integral stalk shredder. It is the machine from which we collected the energy data submitted in the ERIP Evaluation Request. This machine proved to be a little off the mark for the US market, but appears to be ideally suited to the needs of Australian cotton farmers. The difference is that growing conditions in Australia produce larger cotton plants, hence more of a residue disposal problem at plowdown. This machine does an excellent job of shredding and incorporating plant residue into the soil, but it is better than what most US cotton farmers need or want.

In November 1994, Ellis Equipment sent Brian Sippel (their product development man) to Arizona to evaluate both the 1993 and 1994 prototypes. He gained field experience with the 1994 machine and became familiar with many of the modifications we were making to it. The Pegasus with the "stalk mulcher" (that's a shredder to us Yanks) was definitely more to his liking.

To prepare the machine for export, I completely disassembled and steam cleaned it. It was shipped in a dry cargo container, hence I had to compact the machine to fit inside. Accommodations for forklift handling and a crate for small parts had to be added. It arrived in Brisbane, Queensland on March 31, 1995.
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Mr. Sippel then went to work in it to incorporate some of the modifications being made to the 1994 prototype, most notably a more streamlined set of moldboards. The arc of the shredder blades prevented him from streamlining it as much as we did on the newer machine. He then tested it in various field conditions across Queensland and New South Wales. In extremely dry conditions, soil fractured two feet ahead of the machine and presented some problems of tearing the whole bed up before the stalks could enter the shredder. He solved that with disk coulters in front to control the soil shearing. In very wet conditions (almost mud), he experienced the same problems with soil sticking to both the insertion disks and disc bedders, and arrived at very similar solutions as we did here. Soil conditions tend to be wet at harvest time there, and the soils are mostly clay.

Overall, he reports the performance of the machine as "bloody impressive." Farmer interest is high. His boss quit the firm to work with another farm equipment manufacturer, and it appears that he took pictures of the Pegasus with him. His new boss told him to design and build another one, and Brian and I brainstorm from time to time on design ideas (I have finally gotten to where I can understand Australians and their terminology).

There were two reasons for selling this machine to the Australians. One was to recover the investment in something that I had parked for good. The second was to see what they and their competitors will do with the concept. Although I have no foreign patent rights on it, they will probably come up with something we can use in the US. It could be product development work that benefits the Pegasus Machinery Company, either in design work or in products we can import to fill market niches too small to support US production.

**Probable Outcome:** Continuing product development work in Australia will result in Ellis Equipment, Ltd. introducing a Pegasus to cotton farmers. Since at least one of their competitors knows all about the Pegasus, it is also possible that another firm will develop and introduce a similar product. We will know more in a year or two.

2. *Complete field test work on the 1994 prototype*... This is the machine labeled "preproduction prototype" and is the one without the integral stalk shredder.

**Plow Moldboards:** In December 1994 and January 1995, more streamlined moldboards were installed and field tested. They were a vast improvement, however, soil bodies sticking to them showed how the soil flow could be further improved. Soil bodies (dirt stuck to the metal, in layman's terms) are a problem because in effect they become part of the implement. The coefficient of friction of soil-to-soil is higher than that of soil-to-steel, hence soil bodies are an energy problem. We have made a small design change to the shape of the moldboard which should eliminate the soil bodies. This change is incorporated into the 1995 production prototypes now under construction, and is also being retrofitted to the 1994 prototype.

In this redesign, we also managed to eliminate the landside of the plow. This is a vertical plate which rubs against the soil on the opposite side of the moldboard. On most plows, landsides are necessary to counteract the side draft of the moldboards. Since the Pegasus has equal numbers of right-plows and left-plows, there is no net side draft. Eliminating the landsides reduces the manufacturing costs. It also eliminates an area of friction between the implement and the soil, hence should improve the energy performance.

**Trash Coulter and Clearing Disk Arrangements:** Last winter's field testing showed that concave clearing disks are superior to flat trash coulters. The concave disks cut and throw debris, where the flat coulters just cut. The soil is thrown in the same direction that the plow moldboards move soil, so the soil movement is consistent. Using a disk blade to move some of the soil ahead of the plow should slightly improve the energy performance, because a disk will generally move soil with less energy than a fixed moldboard.
Recent efforts have focused on cleaning up the mounting hardware of the clearing disk. We are doing this with the idea of the USDA-ARS research work on plowing under whole cotton stalks. This will require a very clean entrance of the stalks into the machine. The new design is now being built into the 1995 prototypes and is being retrofitted to the 1994 prototype.

Disc Bedder Attachments: This was one of the biggest headaches of the test work in 1994. To save yet another pass over the fields, most prospective customers want disc bedders on the rear of the machine. So equipped, the Pegasus not only plows the cotton under, but also puts up new beds. The problem was that as the soil flows out from between two Pegasus row units, it is a large volume of soil which will clog almost any kind of furrowing device or disc bedder. No fixed furrowing device would work, and the energy performance of fixed soil-engaging elements is generally inferior to rolling elements (discs). We finally devised a disc bedder that worked. In Texas, a brainstorming session with a manufacturer showed how this disc bedder could be further simplified and can utilize mostly off-the-shelf components. The new design disc bedders are now being built for the 1995 prototypes and are being retrofitted to the 1994 prototype.

Alternative Configurations for Engaging Teeth on Insertion Disks: This was resolved last winter's field testing. We removed some material from the teeth to reduce soil build-up in wet conditions. Performance in dry conditions is not affected by this change.

Design Scraper for Insertion Disk: In wet soil conditions, a scraper is required to keep soil from building up on the insertion disk. We jury-rigged one that worked. Designing the scraper itself is easy, the problem is designing a scraper mount which is user-friendly and does not get in the way of stalks entering the machine. Scraper mounts have been designed and built, as described in the next section. Further field testing of this is addressed in Task 2.

Outcome to Date: All of the functionality issues of the Pegasus have been addressed. However these design changes remain to be proven on the 1995 production prototypes and on the retrofits to the 1994 prototype.

3. Review design with a safety engineer and insurance company... Design and print warning stickers... Safety engineer Jim Morris has reviewed the machine in the field and identified one non-obvious safety concern. Because the Pegasus is so unique, some farmers and plowdown inspectors will ride on the rear bar of the toolframe to watch it work. Because the machine does not make much noise or dust, it does not appear to present any hazards other than the obvious ones of falling off and getting run over. The non-obvious hazard is that the engaging teeth of the insertion disk could grab a pant leg or shoe and pull a person under the machine. We are designing a warning label to point out this hazard and to re-reinforce the widely accepted caveat of not riding on farm implements.

Product liability insurance will be with Sentry Insurance, under their Farm Equipment Manufacturer's Association group plan. This is by far the most economical alternative, and Sentry has developed an expertise in this area. This program is managed by Ted Cayford, who has seen slides of the Pegasus and agrees with Jim Morris' safety assessment. Mr. Cayford points out that most accidents result from power take-off (PTO) driven parts and from hydraulic-actuated folding toolbars and row markers. The Pegasus does not have any PTO or hydraulics.

When Sentry initiates a product liability policy they always perform a safety review. I had planned to start a policy this fall, however Mr. Cayford points out that the product liability policy will not cover the prototypes. Prototypes are not entered into the stream of commerce as
products. Therefore we would only get the benefit of a safety review for the $3,000 policy premium and no actual insurance coverage. Since I had already made a commitment with Jim Morris to do the safety review, we will delay the initiation of the product liability policy until we enter products into the stream of commerce. Until then, we will buy general liability coverage to cover the prototypes and other issues.

Mr. Cayford advises that most claims on this type of implement arise from automobile collisions while the farmer is driving the tractor on public roadways. Warning lights will be standard equipment on the Pegasus. A red reflective tape is also applied across the rear bar of the tool frame.

The first draft of the warning sticker is enclosed. I did this on a University computer, and really shouldn't have because of conflict-of-interest rules. This company's present computer equipment and software is not up to the job, hence an upgrading will be required to finish the work. In this grant we had budgeted $3,000 for desktop publishing equipment for the purpose of developing the operator's manual and parts book. I would like to acquire the equipment sooner so we may also be able to use it to finish the warning labels. Since I had over-budgeted for the building of the production prototypes, we should be in good shape according to the budget period rules in Part 7 of this grant. I will consult you before proceeding.

Progress to Date: The major safety and liability issues have been identified. More work remains to be done, including completion of the warning labels.

Task 2: Redesign, Build, and Field Test Two Prototypes.

1. Design and build a mount for the hub and spindle assembly of the insertion disk. Earlier prototypes had insertion disk mounts which were adjustable in all directions and angles. With this, we determined the optimal location and angle of this disk. The only adjustment needed now is a height adjustment. I have accomplished this with a one-piece welded assembly. It attaches to the plow unit with one pivot bolt in the front and two slotted adjusting bolts in the rear. This represents a big savings in weight and manufacturing cost. The assembly also incorporates the mount for the insertion disk scraper (the scraper itself remains to be designed, but this part is simple).

We did identify some minor manufacture-ability problems with this piece. Minor design changes will solve the problems. Bonita Steel Builders has an idea for reducing the cost of the insertion disk and we will evaluate that in test work this year.

Redesign the plow units. I did this with a plywood mock-up. This is the only way I know how to do it without the benefit of 3D Computer Aided Design (we have 2D CAD). This new design should solve the problem of soil bodies building up on the moldboards mentioned in Task 1. It eliminates the landside plate, which reduces weight, cost, and complexity. This should also improve energy performance. The soil-engaging parts are easier to replace because the bolts are now more accessible. Bonita Steel Builders made CNC plasma-cutting programming right off this mock-up. The pieces fit together beautifully in prototype construction.

Another change is that we reduced the thickness of one large plate of steel to save weight, while changing it from mild steel to abrasion-resistant (AR) plate to increase wear life. This thinner AR plate is about the same strength as the thicker mild steel.

Improve mounting hardware for the clearing disks. This was mostly a matter of cleaning up the design to allow freer flow of stalks into the plow units. We had experimented with setups
where disk hubs were sticking out into the flow of stalks, and it was not satisfactory. We moved the disk hub to the opposite side of the disk and away from the stalks. We made the disk hub detachably mounted on a standard for two reasons. One reason is that when we weld the disk hub assembly, the bearing sleeve shrinks and then needs to be re-bored on a lathe to the correct diameter to accept the disk bearings. The detachable hub lends itself to being whirled around in a lathe. Another reason is that a detachable hub makes it easier for the farmer to replace the bearings.

*Simplify disc bedder attachment.* This involves making the most of off-the-shelf components. Instead of mounting two disc blades on one tool shank, we will have two assemblies of one blade on one shank. While overall weight is about the same, having two assemblies of half the weight is easier to adjust in the field. Because we have been back ordered on the parts we have been held up on this work. Those parts are now in captivity. The remaining part of this task is to design and build the disc hub assemblies consisting of a bearing sleeve and a mounting flange. These will be left and right hubs. Most of the rest of the disc bedders will consist of off-the-shelf clamps, shanks, and other components. We will also redesign stone shields and scrapers for these, but this is not complicated.

*General Serviceability:* This machine will not have a single grease zerk on it. The problem with "regreasable" bearings is that if a hired hand applies one shot of grease too much, the grease seal blows out and the bearing is essentially ruined. Sooner or later it happens. The gauge wheels and insertion disks run on tapered roller bearings which should be repacked annually. All other bearings are triple-sealed for their service life. Not spending a half-hour greasing every morning amounts to that much more acreage plowed per day.

**Outcome to Date:** We have made good progress on the redesign. Delays in parts shipments have caused some schedule slippage. This will be complete by the end of October 1995.

2. **Select a farm machinery manufacturer.** As you know, I thought this had been taken care of. Because the president of Bigham Brothers Inc. refused to sign the certifications required to be a sub-contractor on this grant, I had to go to Lubbock, Texas and gather the whole thing up. I am now working with Bonita Steel Builders, Inc. in Tucson. They are not a farm equipment manufacturer at all, in fact 70% of their business is with the copper mines around Tucson. They are very capable, and I now understand enough about the farm equipment business to make this work at Bonita or elsewhere. We are discussing volume production, including an idea for line flow production year-round. This would give the lowest per unit cost but would involve significant inventory financing costs. We will keep working on this, and it must be resolved before I can set prices. Bonita wants to complete the prototypes before giving me firm volume production prices.

There are some benefits to working with Bonita. One is that it is five miles from my house, not 650 miles. Another is that I will be more intimately involved in the parts buying and production, hence should be able to keep costs in control. Yet another is that the farm equipment business has two big selling seasons, which are spring and fall. This causes seasonal capacity crunches, and the Pegasus is right in the middle of one of them. That is not a factor at Bonita.

I have price quotes from Bigham Brothers and could go with that. But I'm a little afraid to go back there. What if I get orders for 100 machines and he decides that he doesn't want to mess with it?

Whether Bonita or Bigham Brothers builds the machines, they will be pricey. The problem is that there is a lot of fabrication work in the plow units; much more so than with other implements. The six-row will have to sell for about $32,000 retail and the four-row will have
to go for around $22,000. Farmers howl, but when I show them how much money the
Pegasus will save the complaining usually stops. That is my marketing challenge, to
demonstrate the benefits and economic returns. I always knew that this would have to be a
premium priced implement.

While I fully realize that I could find someone to build the machines for about 30% less that
Bonita or Bigham Brothers, the quality would be awful. Sundance sold low quality
implements, and it is one reason they are no longer in the farm implement business. Every
farmer who owns a Sundance system complains about how it falls apart. I just won't go the
low quality route.

Make a Business Plan. The business plan I developed in the UofA MBA Entrepreneurship
Program (won the UA Business Plan Competition in '92, was a finalist in a national
competition in '93) is now out of date. The big change is that in '93 I didn't have a clue about
product development, DOE and my suppliers have taught me a lot about that since then. The
start-up timeline and investment costs have changed considerably. The marketing issues have
not changed much, except for some changes in competitors' positions.

I had developed some updates to the business plan and submitted them as part of my ERIP
Evaluation Request last year. Now even those are out of date.

In the absence of an up-to-date, formal business plan, I now have a statement of work,
financing, budget and cash flow projection that will suffice for now. During this fall and
winter I need to focus on test work and beta testing with customers. I will update the business
plan as soon as those tasks are completed. One reason for doing this is that we will need to
secure inventory financing (this will probably be with Transamerica Commercial Credit as part
of their Farm Equipment Manufacturers' Association group plan).

Develop CNC programming and welding jigs. Bonita Steel Builders developed the CNC
plasma-cutting programming for the prototype construction. The cost for this is small and is
included in that construction. We have delayed building any welding jigs because we will be
making some design changes before starting volume production.

Acquire a truck and trailer to transport the prototypes. The truck is a new Chevrolet K-2500
heavy-duty (I'm a Ford man, but Chevy was the lowest bidder). I have set it up with trailer
towing equipment, cellular phone, and other equipment to do the job. This vehicle is a mobile
office and workshop.

The trailer is a Donahue implement carrier, which is unique in that the bed rolls forward and
down from the undercarriage. This places the implement on the ground, where it can be
hitched directly to a tractor. This solves most of the logistical headaches of moving implements
from farm to farm. It does require a 4X4 truck to push the bed back up onto the undercarriage.
The problem is that it is sold as a farm implement without the fenders, lights, and etc. required
on public roads. I spent quite a few weekends modifying it to street legal condition. It is now
complete and licensed.

No federal funds were used for the truck or trailer.

Outcome to Date: Many manufacturing and financing issues remain to be resolved, and must be
firmed up in the next few weeks.

3. Build two full-scale preproduction four-row and six-row prototypes. Bonita Steel Builders has
completed most of the fabrication work and most of the components are painted. The major
assembly work is complete. The only problem was that we had some delays in acquiring the
disc bedder parts. While waiting for parts to arrive, Bonita had to set the project aside and run some other work through the shop. The parts are now in captivity, and work will resume this week. The machines will be complete on about October 30-31.

**Outcome to Date:** We did experience one month's schedule slippage, mainly due to the fiasco at Bigham Brothers in Texas and parts shortages. However the Central Arizona cotton crop is running about three weeks late, so we have not missed too many testing opportunities. However, it is too late to test in the Yuma area.

4. *Field test the prototypes...* Here is the plan:

**Test work with Dr. Lyle Carter, USDA-ARS:** This will involve the 1994 two-row prototype in work at the USDA Shafter Experiment Station in Shafter, CA. The experiment will focus on plowing under whole cotton stalks without shredding them. The hypothesis is that if we can bury whole stalks, they will decompose more slowly than shredded stalks; hence organic matter will be conserved in the soil for a longer period of time. Dr. Carter now has a test under way where they have buried whole cotton stalks by hand, and they periodically dig up samples to measure organic matter decomposition and soil microflora. Early data are very encouraging. Not having to shred stalks would be an additional energy savings.

USDA is paying Bonita to update the 1994 prototype with all of our latest modifications. I will begin field testing it in near Tucson around the end of this week.

USDA is also purchasing the earliest prototype we developed at the UofA. This machine is the all-disk one depicted in the patent. It was disassembled in Dr. Coates' bone yard. The machine is now being re-assembled in Dr. Coates' shop.

For 1995, we will do all of this tillage work at the Shafter Station during the week of November 13th. I will bring both prototypes with me on the Donahue trailer. While California and Arizona regulations require that cotton stalks be shredded, Dr. Carter has an experimental exemption from the California Department of Food and Agriculture for this one experiment at the Shafter Station.

In 1996 and 1997, we plan on doing this at other sites, probably the Imperial Valley of California and Yuma, Arizona. To do this we will have to get additional experimental exemptions to the plowdown regulations.

Our test protocol will involve taking energy data from both Pegasus prototypes. The conventional tillage treatment in this study is the Interstate Shredder-Bedder followed by a Johnson rotovator (that is not unusual in the San Joaquin Valley). We will take energy data from those implements for comparison purposes.

This work is formalized in a Cooperative Research and Development Agreement (CRADA) between USDA-ARS and the Pegasus Machinery Company (you have a copy of the CRADA). This is going to upset a lot of old notions about cotton tillage and stalk management. I will be proud to be a part of it.

**Test work with the production prototypes:** The schedule slippage precludes us from testing in the Yuma area, where the crop always runs much earlier and tillage is now mostly complete. I wanted to do some testing there to evaluate performance in dry soil (it hardly ever rains in Yuma).

For testing in Central Arizona, we are still in good shape. The crop is running late due to awful spring weather. I will be able to find dry soil to test in if we don't get any rain in the
next week or two (none is forecast). By late November we can count on wetter soil conditions.

I am now lining up test sites with farmers. I am also lining up some other equipment to make this work go more smoothly.

About the only problem you can have with a Pegasus is that if you get the machine badly misaligned with the rows, stalks start going around the wrong side of the plow and it will plug up. Machine guidance systems can prevent this from happening. I have arranged with Sunco Marketing to demonstrate two of their Acura Trak guidance systems along with the Pegasus prototypes. The Sunco people will be here November 1st to deliver the Acura Traks and get me set up. They will get some good exposure and I will solve an operational problem. I have been researching and demonstrating machine guidance at the UofA as part of an EPA funded project on mechanical weed control.

To minimize the headaches of switching tractors, I have arranged with the John Deere dealer in Tucson to demonstrate some of the new 8000 series tractors. Farmers will pay for the hours they use the tractor, and we can drive the whole rig from farm to farm with a minimum of hassle and downtime. I will make similar arrangements in Pinal and Maricopa Counties.

The challenge here is more than getting farmers to accept the idea of a different kind of plow. This different kind of plow means making other changes to the farming system, including using a guidance system, different deep tillage techniques, and some changes in seedbed preparation. Many farmers are so frustrated with conventional tillage that they will readily make the changes. But I must be able to serve as a reliable consultant on these issues, and to Tom Sawyer other manufacturers and dealers into helping out. My youth as a cotton farmer and Extension Agent was not completely wasted.

One good factor this year is that wheat prices are extraordinarily high and many farmers will plant wheat behind their 1995 cotton crops. Using the Pegasus for this is a no-brainer. We just shred the stalks, spread preplant fertilizer in the stubble, and run the Pegasus. This makes an ideal wheat seedbed.

**Outcome to Date:** People, places, and equipment are lined up. I'm anxious to get going.

This about summarizes the progress to date. No federal funds were received during the quarter, but I have asked Michele Miskinis for a copy of SF-272 anyway and will submit it later. The advance check for the two production prototypes arrived last week, and I have deposited it into a separate checking account titled "Pegasus Machinery Company - DOE Project."

I will call you in a few days to consult about reimbursements and advances on this grant.

Sincerely,

Gary W. Thacker

Enclosure: Draft of Warning Label

Copies: Michele Miskinis @ Office of Placement and Administration, HR-561.21 US-DOE, Office of Scientific and Technical Information
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THE PEGASUS PROTOTYPE

This prototype was designed to plow under shredded cotton stubble. When equipped with disk bedders, it also rebuilds the beds. We used an earlier prototype to plow under whole cotton stalks without shredding them, however Arizona plowdown regulations specify that cotton must be "shredded". In regions where shredding is not required, plowing under the whole stalks is a possibility for the Pegasus. This will provide very quick field turnarounds for more timely planting of rotational and cover crops.

The Pegasus is a very simple machine. All moving parts turn with the soil as the tractor pulls it. At the front of the prototype shown here, trash coulters cut through debris. Next is the unique plow which opens a deep slot in the soil next to the plant row. A horizontal ripper knife at the bottom of the plow undercuts the cotton tap roots. Then the large disk at the rear inserts the cotton stubs and tap roots into the deep slot, using engaging teeth which are bolted to the opposite side of the disk in this photo. As the machine continues moving forward, soil falls back into the temporary slot, covering the tap roots and stubs. This invention is protected under US Patent Number 5,285,854.

Production models will be four-row and six-row. This two-row prototype was built for field testing to refine the concept and to test reliability. One of the features of this prototype is that virtually everything is adjustable. This facilitates fine-tuning to determine design features for the production models. Production models will be greatly simplified, since we have determined the optimum locations of components and have determined which parts need to remain adjustable (very few). Several other refinements will be made before this invention reaches the market, including easier replacement of soil-engaging parts and a thorough review by a safety engineer.

Disk bedders will be optional. They will be similar to the center double disk bedder on this prototype. As with the rest of the Pegasus, the disk bedders on production models will be simplified from the highly adjustable prototype shown here. The single disk bedders will be used in outside furrows only.

Power requirements are not high. An earlier prototype required 45.6 drawbar horsepower at 4.1 MPH. We have not tested this prototype for power requirements as of this writing, however it is much more streamlined than its predecessor and should require less power.

The first production models will reach the market in 1996. Although this prototype works well, we will continue to test and refine it during 1995 to ensure that the production models will be as safe, reliable, and trouble free as possible.

We are looking forward to solving your tillage problems. In the not too distant future, we would like to show you how the Pegasus can save you time, money, and fuel.