# SEED COTTON TRANSPORT ANALYSES USING GIS

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## Abstract

Gin managers are under increasing pressure from state departments of transportation concerning seed cotton module transport. Module trucks are over height, width and weight restrictions for most cotton producing states. Exceptions are allowed in many cases. Still, the module truck loaded with a module exceeds tandem axle weight limits for Interstate Highway travel. No exceptions are given. An alternative to the module truck is the semi-tractor trailer (STT). Fully-loaded an STT would not exceed height, width, or even weight restrictions. STT may reduce the cost of transporting seed cotton compared to conventional module transporting with module trucks. However, modifications to the module formation system would be necessary to utilize the STT transport system economically. For a fifty mile round trip haul, an STT transport cost model predicts a $5.30 per bale cost and a corresponding module truck transport cost model predicts a $6.84 per bale cost.

Other costly elements of module transportation include the routing of trucks and the locating of modules in fields. A geographic information system (GIS) software package, ArcGIS, has the capability to route trucks along shortest distance, quickest route or alternate roads to pick up modules in the field and return to the gin. A research program for developing a transport tool using ArcGIS is in progress at Texas A&M University. Cotton production, ginning facilities, interstate highways, state highways and local roads in the state of Texas have been mapped using ArcGIS. Color near infrared (NIR) aerial photos have been uploaded as well. The transport analyst feature in ArcGIS will allow for analyses of gin service areas, regional transport ability and ultimately cost evaluations for transport.

## Introduction

Module trucking has been a concern to gin managers since the adoption of the module builder. In several states, module trucks are not in compliance with state departments of transportation (DOT) regulations concerning height, width, and weight restrictions for commercial vehicles. A typical tandem-axle module truck today can have tare weights exceeding 15,400 kg (34,000 pounds). A well built module can reach weights of 11,300 kg (25,000 pounds). It is not unusual for the combined gross weight to reach 26,700 kg (59,000 pounds).

States in the U.S. cotton production belt have weight, length, width and height restrictions on non-federal highways. The different state restrictions are exceeded in one dimension or another in all 17 states within the Cotton Belt. Many states provide exemptions from some or all of the restrictions or allow the purchase of permits exempting the truck. However, even with permits, the gin managers take a chance every season with over-weight loads being subject to stiff fines.

In addition to state and local road restrictions, the federal government limits the weight supported by the tandem-axle of a commercial truck to 15,400 kg (34,000 pounds). Since much of the module weight is positioned over the tandem-axle, transport along the Dwight D. Eisenhower System of Interstate and Defense Highways (Interstate System) fully-loaded is illegal.

Gins located close to an Interstate Highway are forced to route drivers along often longer paths in order to avoid the Interstate System. Large fuel and maintenance costs are realized due to longer return-trips along farm-to-market, county or state roads. Costs could be reduced significantly by establishing a different transportation method that would keep axle weight within requirements and allow the use of the Interstate System.

Costs will continue to rise with the following demands. Ginning facilities are continuing to decrease in number each year, approximately 17 per year in Texas since 1990. Increases in production are seen across the Cotton Belt; Texas alone has jumped from a 5 million bale average to 7.5 million bales plus in the last two years. Faster harvesting methods due to more picking/stripping heads per machine increase the time pressure on the module builder operator. Modules are stored longer in the fields as gin seasons stretch into January, February and lately even into March in Texas. The risk for rain events increases with time and modules can then become difficult to retrieve in the field.

The goal of this on-going research effort in the Department of Biological and Agricultural Engineering at Texas A&M University is to provide the cotton industry tools for:

- Minimizing module transport time and cost
- Transport on roads/Interstate Highways without violating regulations.

## Transport Costs

The current seed cotton transport system used in the U.S. is conceptualized in Figure 1. Three subsystems of cotton harvesting, transportation and scheduling, and ginning are required for the fundamental process flow. Seed cotton is formed into modules by tramping at the field where the modules are stored. For best results, modules should be formed on a high elevation turn-row instead of in low spots within the field. Module truck drivers are dispatched from the gin facility to the field to load the module and return to the gin yard or other off-site module yard. The module is unloaded and stored again. The gin usually owns a module "getter" or truck to transport the module from the yard to the module feeder lane.

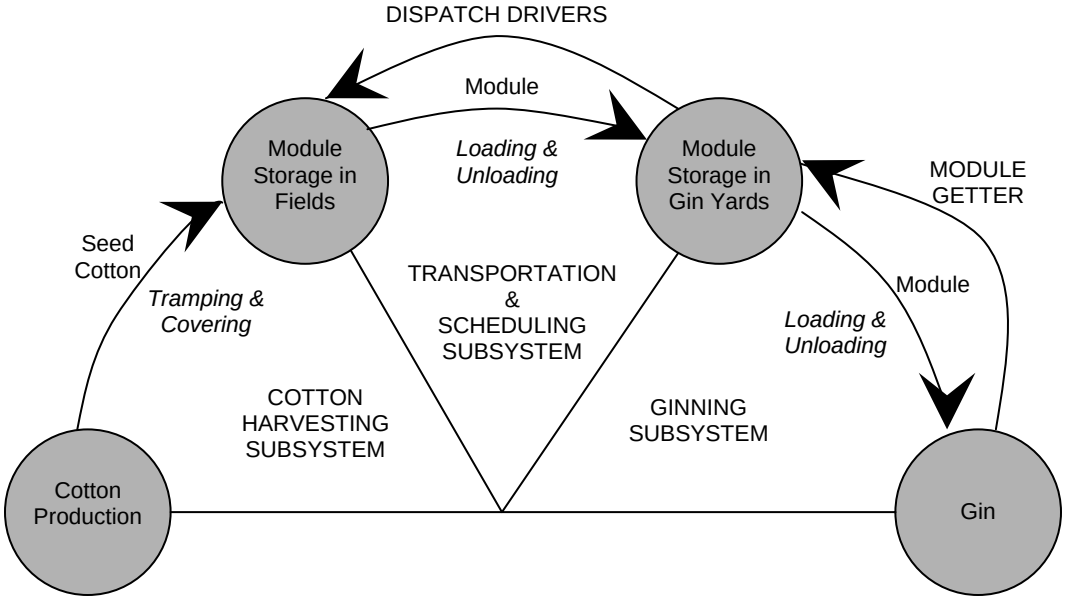


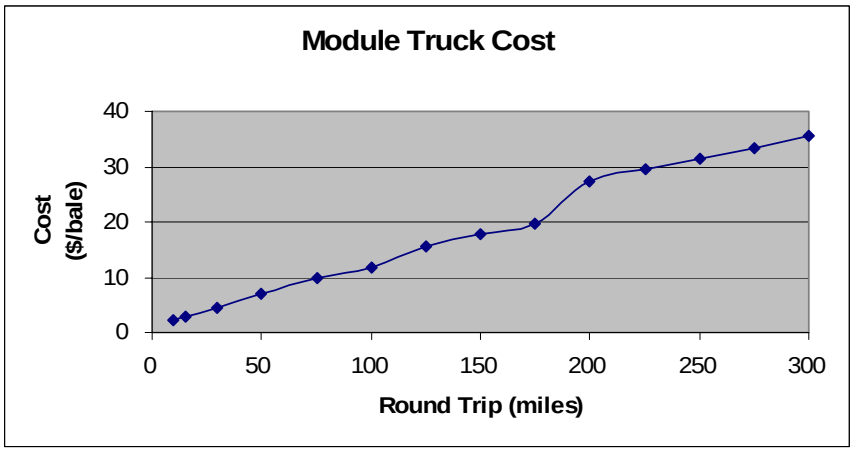

Figure 1. Conceptualized seed cotton transportation system currently in use throughout the U.S. Cotton Belt.

The subsystems for seed cotton flow will not likely differ in the future; however the details in the subsystem illustrated in Figure 1 may differ considerably. Changes may include new methods to handle smaller seed cotton packages proposed by machinery manufacturers developing new on-harvester module forming mechanisms. While this change may be in the near future, this paper will not delve into transport of the smaller packages.

The use of semi-tractor trailers (STT) to transport conventional seed cotton modules has been discussed and experimented with on a limited basis in the U.S. The Australian seed cotton transportation infrastructure uses STTs

to transport seed cotton from the field to the gin (Figure 2). Avant (2004) developed a cost model to predict the costs associated with the use of module trucks and STTs for hauling seed cotton modules. In the model, assumptions are made for various costs including: purchase of used truck/semi-tractor and trailer, labor, fuel, maintenance, license, insurance; fuel use; shift time; truck speed; amount of cotton per load; and loading/unloading time. The cost per bale is compared in Figure 3 for round trip distances in miles.

Figure 2. Australian module transport system using a semi-tractor trailer (right) and loader (Provided by © The State of Queensland Department of Natural Resources 2000).



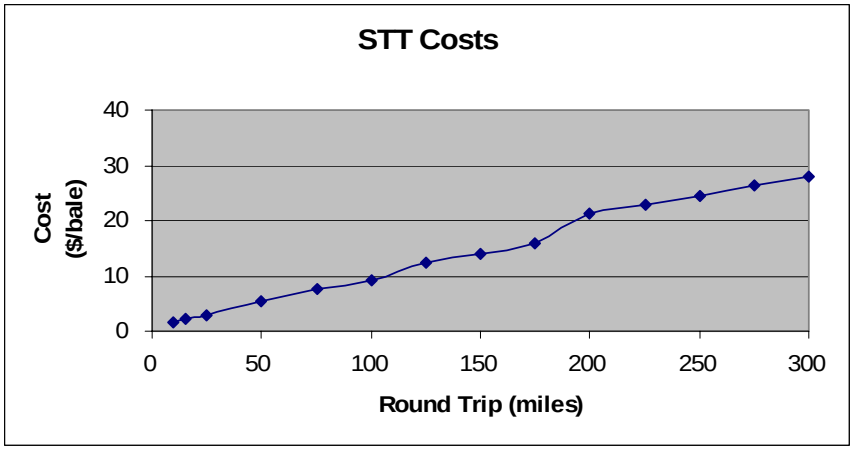



Figure 3. Cost per bale comparison for a) conventional module truck hauling and b) semi-tractor trailer hauling.

For all round trip distances, the cost for transporting modules with a module truck is higher than the STT. The longer the round trip distance becomes, the larger the difference in cost. The cost per bale at 50 miles round trip is $6.84 with a module truck and $5.30 using the SST, a $1.54 difference. At 100 miles round trip the module truck and SST costs are $11.81 and $9.34, respectively, a $2.47 difference per bale. And finally at a 200 mile round trip distance, the module truck and SST costs are $27.37 and $21.18, respectively, a $6.19 per bale difference.

Increasing production and reduced ginning facilities among other factors has forced the round trip distance upward in recent years. If one-tenth of the bales produced in the U.S. were produced 25 miles or more from a gin facility, translating to a 50 mile round trip or more transport, then savings could amount to well over $3 million.

In the model developed by Avant (2004), the STT is assumed to haul a 20 bale module or 36,000 pounds. This is considerably more seed cotton than a conventional module holds. Two ways to accomplish a 20 bale module load are to construct a larger module builder, or build a module and a half with conventional module builders. The latter has been done successfully on a trial basis. However, loading and unloading the module and a half from a module truck to a STT with a live bottom trailer was not successful. The problems encountered with chain speed and synchronization can be overcome. The cost savings certainly warrant another look at STT use.

It may be possible to modify the current module transportation system to incorporate the use of SSTs for long range transport while maintaining the use of conventional module trucks near the gin to attain the stated goals of this work.

## Using GIS as a Tool for Transport

Further reductions in cost may be attained by performing spatial analyses of the seed cotton transport areas associated with a gin, using a geographic information system (GIS). Research efforts for developing this type of transport tool have moved forward with the use of ArcGIS 9.1, commercially available from ESRI. The focus is on the Texas ginning industry and includes 268 active gins plus a few dormant gins. Color near infrared (NIR) images of all Texas counties and digitized fields in several Texas cotton producing counties were obtained from USDA-FSA Specialist Bryan Crook in College Station, Texas. Gins were located on Texas county maps (in ArcGIS) by either attaining longitude and latitude or physical addresses, or in some cases by locating the gin visibly on color NIR images and digitizing the location (Figure 4). The Interstate Highway system and local road network maps were all obtained for inclusion in the spatial analyses (Figure 5).


Figure 4. Gin buildings located spatially on NIR picture.

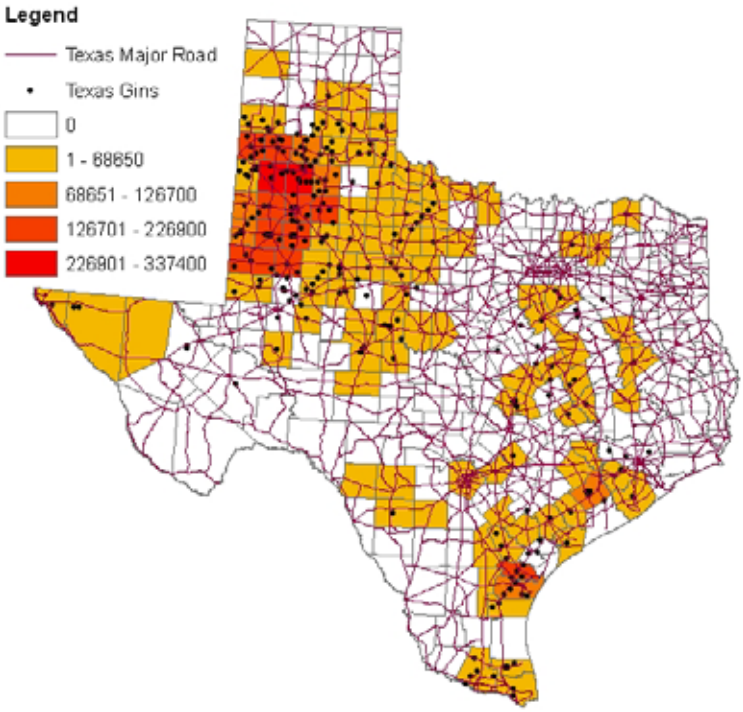



Figure 5. Texas cotton production areas, gin plant locations (randomly placed before located with latitude and longitude) and major highway network.

The transport tool may be applied in the field in several ways to reduce time and money. Once modules are built, the producer could call in or email to the gin, the field location of each module. Each module is associated with one particular field in the database (Figure 6). The gin manager would then develop a transport route using the transport analyst. The route from a gin to a field in the Southern High Plains and returning to the local gin is shown in Figure 7.

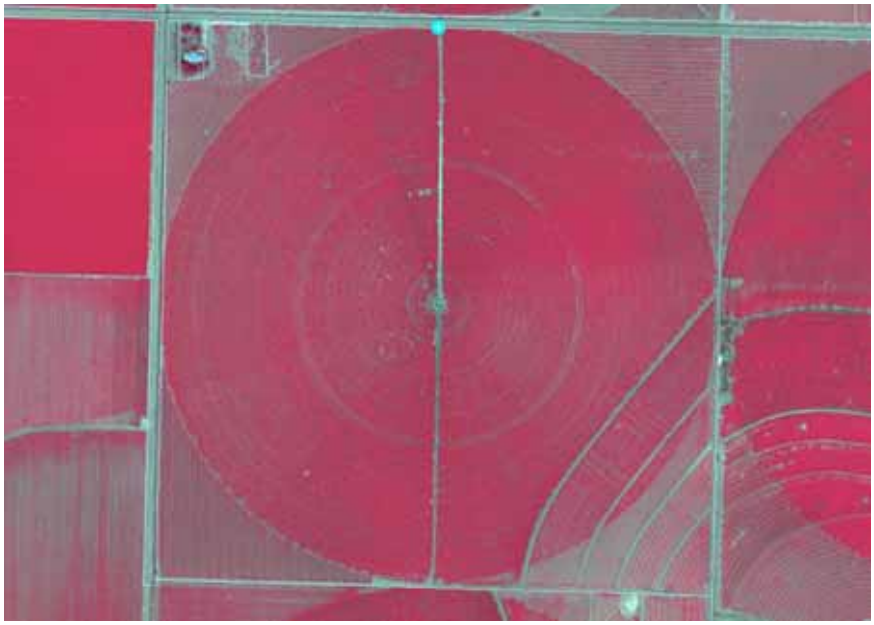


Figure 6. Near infrared (NIR) picture of a field spatially defined in ArcGIS software.

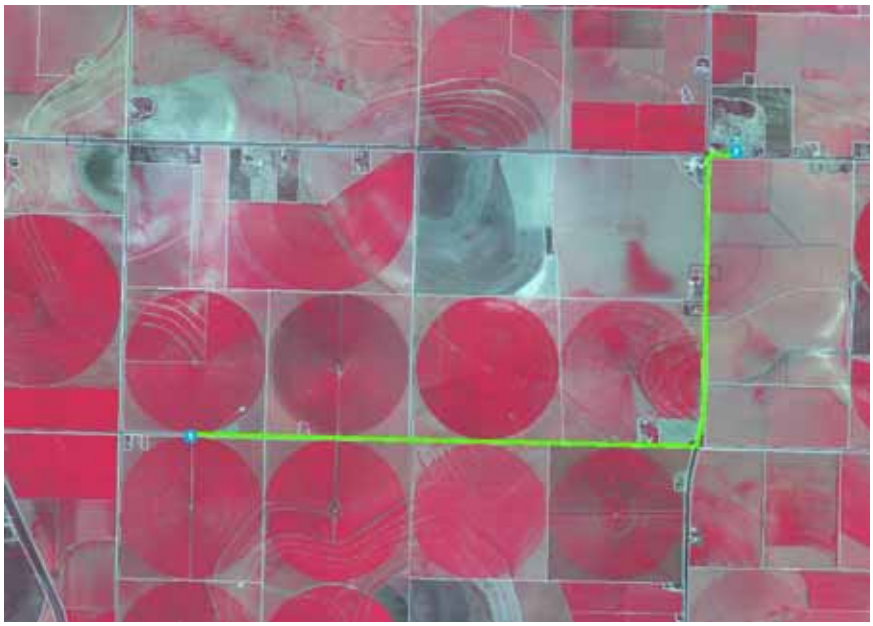


Figure 7. Transport route from field to gin defined by the green highlighted roads.

One application of the transport tool uses the global positioning system (GPS) to help guide drivers to a specified location. The module truck can be equipped with a GPS receiver that would direct the driver from the gin to the module in the field. In many locations, module transporting is contracted out to drivers that are not familiar with the area roadways, especially small country roads. This feature may help to minimize the time it takes to transport modules from the field to the gin.

Alternate routes may be easily determined using the transport analyst. Figure 8 shows a route along Interstate 27, highlighted in yellow, from the gin to the field without a module load. Once the truck picks up the module, the Interstate System must be avoided (due to weight restrictions), so an alternate route back to the gin must be determined (the alternate return route is highlighted in green). Many alternate routes may be selected; however, the quickest travel time was selected for the route pictured.

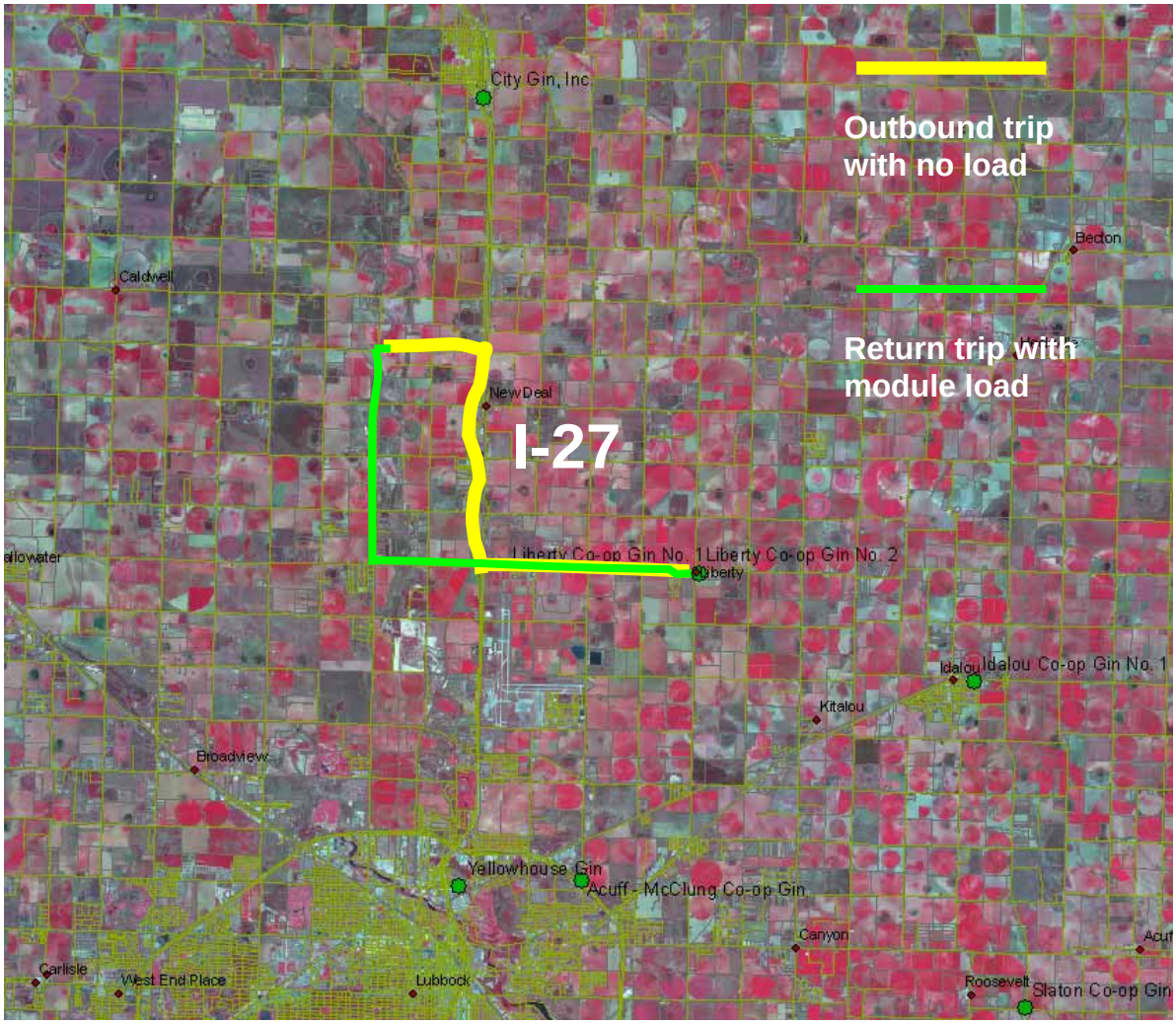



Figure 8. Alternate routing to avoid restricted road when over weight limits.

Another application of the transport tool could allow ginners and producers to determine what size of service area or how far away from the gin field could still provide the producer a profit growing cotton. Seen in Figure 9 are six gin points in a single county of Texas. The dark green area around each gin represents a 5 mile radius around the respective gin on the roadways. Expanding the service area to a 15 mile radius allows each gin to cover all areas of the county indicated by the beige colored area. The service area could be expanded past county borders as well. The transport tool can quickly determine the shortest distance and quickest route from the field, outlined in black, to the nearest gin helping producers and ginners to optimize transportation resources.

As production increases, neighboring gins have begun to "farm-out" portions of their annual ginning volume in order to decrease the wear and tear on the gin, gin the cotton in a timely manner, and reduce overall ginning costs. Recall the four gins in Figure 9 that are in close proximity to each other. In any year one gin's service area could experience a bumper crop while a neighboring gin's service area could have crop failure due to weather or insect pressures. A relationship could develop so that the four gins rely on each other for "farming-out" cotton. A local and centralized module yard would be preferable for seed cotton storage and still be accessible by all four gins. A transport tool would aid in determining where to best locate the yard.

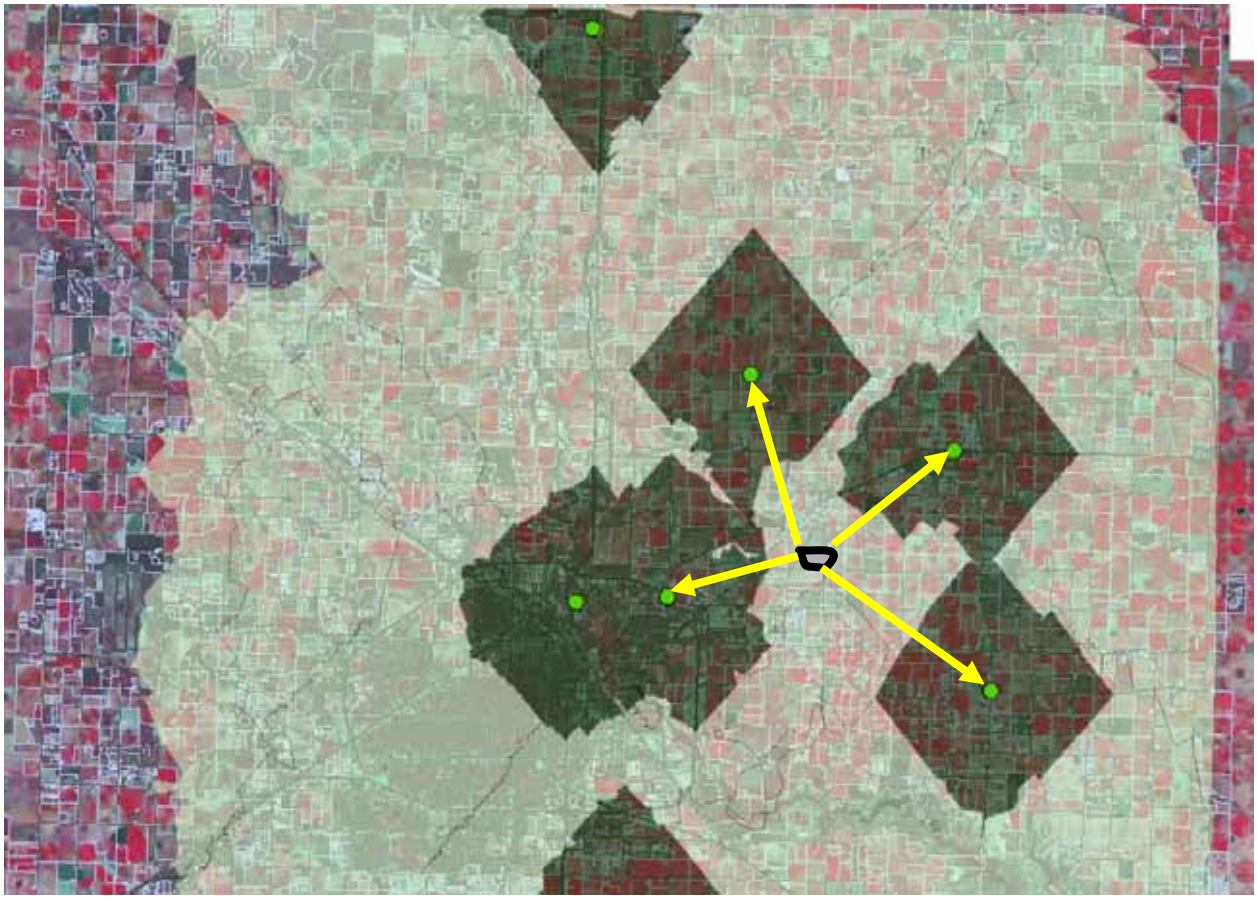


Figure 9. Service areas for six gins in one Texas county.

## Conclusion

The gin manager and cotton producer both can benefit from a semi-tractor trailer (STT) based module transport system as well as a computer based transport tool which automates the logistics of hauling seed cotton modules. Costs can be reduced, time saved, and efficiencies in transport and ginning gained. The main advantages of using a computer based logistics tool are:

- Optimizing truck routes to minimize travel time and distance traveled,
- Scheduling trips to and from fields,
- Providing directions to truck drivers,
- Using GPS in truck to guide drivers directly to fields/modules, and
- Locating modules in fields.

Development of the transport tool is on-going in the Department of Biological and Agricultural Engineering at Texas A&M University.

## Acknowledgements

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## References

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