

DESIGN AND DECISION SUPPORT SOFTWARE FOR COTTON MODULE TRANSPORTATION USING A SEMI TRACTOR TRAILER

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Abstract

The number of cotton gins in the state of Texas has declined from more than 1400 in 1960, to less than 240 in 2008. Cotton production in the state of Texas has been steady with the exception of three of the last four years when production has exceeded seven million bales for the first three times in history. Gins are typically growing in size, running longer seasons, and traveling farther to retrieve seed cotton. Decision support software has been developed to aid in observing the effects of these three circumstances for both producers and ginners. The effects of rising fuel costs as well as the benefits of transportation using semi tractor trailers (STT) are considered. The design of a semi trailer capable of transporting two modules per trip was examined. Conceptually, the trailer is sixty eight feet long and uses a walking floor system to load and unload modules. For distances within 30 miles of the gin, conventional module trucks are assumed to be utilized. Distances greater than thirty miles display cost advantages with use of the STT instead of the module truck.

Introduction

The number of cotton gins in Texas has decreased from more than 1400 in the early 1960's, to less than 240 in 2008. Meanwhile, the production of cotton in the state has remained fairly consistent and actually grown from an average of five million bales to exceed seven million bales in three of the last four years. The typical gin has grown significantly in size, and the average ginning season has increased in length. Also, producers in some areas of the state no longer have a gin near their farm to process their cotton. As local gins choose to go out of business, distance to the nearest gin and the cost of transporting seed cotton from the turn-row to the gin becomes an increasingly important consideration. As the distance from field to gin increases, fuel prices become an important factor in the total transportation cost equation. Prices for diesel fuel rose to near \$4 recently. Fuel prices influence seed cotton transportation costs. As gin managers consider retrieving cotton modules at greater distances from their gins, projected costs and alternatives to current transportation practices should be considered. Additionally, producers should be able to evaluate the various factors that influence their overall seed cotton transportation and processing costs.

Most cotton produced in United States is placed in modules measuring 8 feet wide, 32 feet long, and generally 8 feet tall. Modules are built on the ground in a location that is characterized as having good drainage and usually near the edge of the field or road with easy access for module trucks. These modules are transported to the gin with module trucks capable of loading the module from the ground and placing it in a location near the gin. Module trucks are typically bobtail rigs with tandem rear axles and tilting chain-floor beds capable of backing themselves underneath modules and conveying them onto the bed of the truck. A new module truck will cost approximately \$70,000. The bed is typically between 35 to 40 feet long and will weigh approximately 16,000 pounds (McCarlos, 2007). If a module contains 15 bales of picked cotton, the module will weigh approximately 21,000 to 22,500 pounds. If it contains 11 bales of field-cleaned stripped cotton, it will weigh approximately 16,000 to 19,000 pounds. The truck loaded with a module will weigh 32,000 to 38,500 pounds. The combined axle load of a loaded module truck may exceed the allowable limit of 34,000 pounds per tandem axle. These module trucks are not allowed on the Dwight D. Eisenhower System of Interstate and Defense Highways (Interstate System) (DOT, 2007). While affected states have exceptions for these trucks, they do not apply to the Interstate System. Thus, module trucks must comply with the axel load limits or avoid interstate highways. Violators will be subject to fines.

Transportation Alternatives

A module truck is a proven and effective way to move modules over short distances from fields to a gin. It is especially designed to go to the turn-row and pick up the module directly from the ground. Because of the special

design, it is limited to transporting modules. Over longer distances, it may be more cost-effective to be able to carry more than one module.

The authors have been conducting research exploring the possibility of moving more than one module from the turn-row to the gin using STT (Parnell et al., 2005, Simpson et al., 2007, Hamann et al., 2008). These systems consist of a semi tractor pulling a trailer capable of hauling one and a half to two modules, therefore increasing productivity by 50 to 100 percent. A semi tractor can be used for many applications and could be less costly than a module truck. A standard size trailer capable of carrying a 1.5 module load would be easily obtained. A disadvantage to this system, along with being harder to load, is that a conventional module and half of another must be used. This requires modification of a module builder. This system would, however, work well with the new on-board module building systems from Deere and Case IH, as both make modules that can be configured to take up half of the space of a conventional module. It is also legal for semi tractors to travel on all highways, including interstate highways, and a decrease in transportation time could be expected.

A third method consists of a semi tractor pulling a trailer capable of carrying two modules. This would require a specialized trailer to be built, which would be over the legal limit for length, but a permit may be acquired to allow use on interstate highways. The trailer would be more expensive and would require additional permitting costs, but may be more cost effective than the semi tractor trailer hauling one and a half modules over long distances.

Simpson et al., (2007) developed a model for calculating transportation costs associated with module trucks. Assumptions were made for various costs including: purchase of used truck, labor, fuel, maintenance, license, insurance, fuel use, shift time, truck speed, amount of cotton per load, and loading/unloading time. The Simpson et al., (2007) model assumed a straight-line depreciation over 10 years and accounted for differences in stripper and picker cotton as well as changes in costs. Depreciation time, load and unload time, and wage information have been updated according to feedback. Fuel costs have been adjusted to reflect recent price activity and hours worked per day have been adjusted from ten to twelve. All assumptions made were as follows:

- A used module truck will cost \$50,000 @ 6% interest for a 5 year period
- Straight line depreciation of the module truck over 5 years
- Fuel mileage of 5 mpg
- Diesel cost @ \$4.50/gal
- Module truck average speed 45 mph
- Maintenance costs \$1000/yr
- Insurance costs \$1000/yr
- License cost \$500
- Driver can work a 12 hour day and is paid \$15 per hour including benefits
- Driver works 84 hours per week for an average of \$18.93 per hour including overtime
- Module weighs 22,500 pounds per load
- 15 bales per module for picker cotton
- 12 bales per module for stripper cotton
- 15 minute loading & unloading time per module

This model has been adapted to fit a semi tractor trailer hauling either one-and-a-half or two modules. First, the cost of a new semi tractor is assumed to be \$60,000. A simple tractor with tandem rear axles and a cab with no sleeper, weighing up to 16,000 pounds could be used. A trailer with a live-bottom floor and a length of 53 feet would cost approximately \$50,000. A trailer long enough to carry two modules would need to be 68 feet long and could be specially built. It is estimated that this trailer will cost \$100,000. A permit for this truck would cost no more than \$2000 in Texas and would likely bear a similar cost in other states (TXDOT, 2007). Average speed for both STT systems was assumed to increase from the 45 mph for module trucks to 55 mph and loading and unloading times were estimated to be 1.5 hours per trip.

It was assumed that a trailer 68 feet long, because of difficulty of reversing and the large weight requirements of a trailer capable of tilting to the ground while carrying 45,000 pounds would need be loaded by a separate machine. It was assumed that the STT loading would be performed by a standard module truck. Several flooring alternatives were considered for use in a trailer capable of hauling two modules. The first option was a standard flat trailer that

would require a module truck to be driven onto the trailer to accomplish the loading. This option would require ramps to be constructed at all locations where modules would be loaded on the STT system. The authors concluded that it would not be feasible to construct ramps to load modules at all possible locations. The next alternative was a chain floor. This would allow a trailer to be placed with its rear end against a module truck and the floors designed to move at a synchronized speed as the module was moved from one truck to the other. The primary disadvantage was the floor weight. It was estimated that the chain floor on the trailer would be close to double the 16,000 pounds associated with the conventional module truck bed. It was concluded that the heavy floor would be a problem and it would be expensive. The third alternative considered was a walking floor trailer. This trailer would be completely covered, and would have the same type of moving floor as is used in many gin feeding operations. As observed by Dean, et al., (2007), the floor does little damage to the module as it is moved. The floor would move slowly but, because of weight considerations, was selected for this analysis. A 68 foot walking floor trailer would need to be custom-built. The cost of the walking floor was estimated to be \$100,000 and would weigh only 17,000 pounds (Cloud, 2007). Assuming two modules weighing 22,500 pounds each, a semi tractor weighing 16,000 pounds, and a trailer weighing 17,000 pounds, the total weight of the loaded STT would be 78,000 pounds and would remain below the 80,000 pound limit for a semi tractor trailer traveling on the interstate system (DOT, 2007). Therefore, it would not require an overweight permit.

The use of a walking floor trailer with no tilting bed requires the use of an additional mechanism for loading and unloading. The most readily available device will be a module truck. It was originally believed that the best way to handle modules would be to have several satellite sites at distances greater than thirty miles from a gin where a module truck would gather modules awaiting transport to the gin. This module truck would also be used to load STT's as they arrived at the site. The STT would haul modules back to the gin where a yard truck would be waiting to unload the modules. This would keep the STT running constantly and would keep a module truck busy as well. However, it is anticipated that the integrity of the modules may be degraded with repeated picking up and setting down. There would be an additional need to acquire remote sites for loading and storage. It was anticipated the cost of this system would be too expensive, due to the cost of the extra module truck.

The best solution was to keep one module truck busy supporting several STTs. A just-in-time loading scenario could be applied where one module truck supports as many STTs as it can, such that the STTs only wait to be loaded and unloaded at the edge of a field and spend the rest of their time on the road. With this approach, one module truck can support four STTs at thirty miles and more as the distance to the gin increases. This allows the cost of the module truck's operation to be divided among several STTs. The number of STTs one module truck will be able to support is a function of the distance to the gin. The results of our systems analysis suggests that it becomes more cost-effective to use STTs moving two modules per trip, rather than module trucks moving one module per trip at distances over thirty three miles.

Decision Support Software for Transportation Analysis

Decision support software was developed to help producers and ginner analyze costs associated with transporting seed cotton modules from the turn-row to the gin. Figure 1 shows typical results for one scenario. These results were for module trucks carrying spindle-picked cotton modules. Variables such as fuel price, fuel economy, and modules per trip can be changed easily and the results of cost per bale observed.

Simpson et al., (2007) developed the follow models for calculating transportation costs associated with module trucks and STT:

$$TC_M = \$60 + (D-15) * \$3.35 \quad (1)$$

where: TC_M = Transportation cost per module, and

D = One-way distance from the gin site to the module.

$$TC_{STT} = 90 + 4.5(d - 15)$$

where: TC_{STT} = Transportation cost per trip (two modules), and
D = One-way distance from the gin site to the modules.

The software also incorporates different percent utilizations (%U) for cotton gins (equation 2). The concept of the %U model is that a cotton gin operating at 100%U would normally process seed cotton at 80% of its rated capacity (GR) for 1000 hours per season. Equation 1 defines the number of bales ginned (BG) per season for a gin processing cotton at 100%U with zero downtime:

$$\text{BG} = GR \times 0.8 \times 1000 \quad (1)$$

Utilizing the percent utilization model, Emsoff (2005) developed the following equation to determine ginning season length (L) in hours:

$$L = BG / (GR \times 0.8) \quad (2)$$

where: GR = Rated ginning rate in bales per hour (bph);
0.8 = assumed equipment efficiency; and
t = hours of operation without downtime (1000 hours correspond to 100%U) (Parnell et al, 2005).

$$\%U = GR * 0.8 * t \quad (3)$$

Miles/year	25,000	Fuel	\$3.00/gal
Cost of Truck	\$60,000	Fuel Economy	5 mpg
Labor (driver)	\$15 /hr	Bales/module	15
Avg Speed	45 mph	Modules/trip	1
Load/unload time	10 hr	Ibs/load	22500
Driver	12 hrs/day	-Fixed Costs	
		-Variable Costs	

How much cotton do we gin?

	1	2	3	4
Machine:	Utilization	Utilization	Utilization	Utilization
Sales/season	48,000	72,000	96,000	120,000
Maintenance	\$1,000	\$1,000	\$1,000	\$1,000
License/Permit Fee	\$500	\$500	\$500	\$500
Insurance	\$1,000	\$1,000	\$1,000	\$1,000
Payment/truck	\$11,870	\$11,870	\$11,870	\$11,870
Depreciation	\$4,500	\$4,500	\$4,500	\$4,500
Total FC	\$16,870	\$16,870	\$16,870	\$16,870
FC/mile	\$0.75	\$0.75	\$0.75	\$0.75
FC/trip (module) - 15 miles outer distance	\$23	\$23	\$23	\$23
Labor - 15 miles	\$25	\$25	\$25	\$25
Fuel - 15 Miles one way	\$18	\$18	\$18	\$18
Fuel/mile	\$0.60	\$0.60	\$0.60	\$0.60
Total VC - 15 miles one way	\$43	\$43	\$43	\$43
VC/mile (one way distance)	\$2.87	\$2.87	\$2.87	\$2.87
Total Cost/trip - 15 miles one way	\$66	\$66	\$66	\$66

	100%	150%	200%	250%
0-15	90%	33%	25%	34%
15-30	90%	33%	25%	20%
30-45	0%	33%	25%	20%
45-60	0%	0%	25%	20%
60-100	0%	0%	0%	6%

	100%	150%	200%	250%
0-15	24000	24000	24000	40800
15-30	24000	24000	24000	\$139,430
30-45	0	24000	24000	\$0
45-60	0	0	24000	\$0
60-100	0	0	0	7200

	100%	150%	200%	250%
Cost/bale	\$4.62	\$5.97	\$7.36	\$7.38

Figure 1. Example of decision support model analyses for module trucks transporting picker modules.

Figure 2 is a sample print out for the decision support software. This result is for a 60 bale per hour (bph) gin operating at 100 to 250%U. As %U increases, the number of bales processed at the gin increases and the number of days needed to acquire the additional seed cotton increases. As the location of the seed cotton supply changes, the number of days of operation for one STT (2 modules per trip) is listed. If the number of days per season for seed cotton transport exceeds the number of days per season for the gin operation, more than one truck will be required.

60 both	1	2	3	4
	100% Utilization	150% Utilization	200% Utilization	250% Utilization
Machine:				
Bales/season	48,000	72,000	96,000	120,000
Maintenance	\$1,000	\$1,000	\$1,000	\$1,000
License/Permit Fee	\$2,500	\$2,500	\$2,500	\$2,500
Insurance	\$1,000	\$1,000	\$1,000	\$1,000
Payment/yr STT	\$37,983	\$37,983	\$37,983	\$37,983
Depreciation	\$28,000	\$28,000	\$28,000	\$28,000
Total FC	\$71,283	\$71,283	\$71,283	\$71,283
FC/mile	\$2.05	\$2.05	\$2.05	\$2.05
FC/trip (module) - 15 miles outer distance	\$86	\$86	\$86	\$86
Labor - 15 miles	\$39	\$39	\$39	\$39
Fuel - 15 Miles one way	\$27	\$27	\$27	\$27
Fuel/mile	\$0.90	\$0.90	\$0.90	\$0.90
Total VC - 15 miles one way	\$86	\$86	\$86	\$86
VC/mile (one way distance)	\$4.38	\$4.38	\$4.38	\$4.38
Total Cost/trip - 15 miles one way	\$151	\$151	\$151	\$151
30				
Trips/day	4	4	4	4
Bales/day	120	120	120	120
Days/season for transport	20	150	160	200
Cost/bale	\$8.01	\$8.01	\$8.01	\$8.01
Total Cost/season	\$19,221	\$144,156	\$153,766	\$192,208
35				
Trips/day	4	4	4	4
Bales/day	120	120	120	120
Days/season for transport	20	150	160	200
Cost/bale	\$8.69	\$8.69	\$8.69	\$8.69
Total Cost/season	\$20,851	\$156,383	\$166,809	\$208,511
40				
Trips/day	4	4	4	4
Bales/day	120	120	120	120
Days/season for transport	20	150	160	200
Cost/bale	\$9.37	\$9.37	\$9.37	\$9.37
Total Cost/season	\$22,496	\$168,724	\$179,972	\$224,965

Figure 2. Semi-tractor trailer (STT) transportation costs for modules of picker cotton for 100 to 250%U. Distance from the gin to the module pickup point increased with higher %U. Each STT transported two 15 bale modules per trip. Distances from the gin to the module storage site for each %U are listed in Figure 1.

Figures 3 and 4 illustrate average costs per bale versus %U for both a picker module truck (1 module per trip) and a picker STT (2 modules per trip). As the %U increases, more modules of seed cotton are located farther from the gin. The number of bales gathered from each region changes as defined by the length of the gin season corresponding to the number of hours the gin operates. The total cost per bale for transporting cotton at different %U is shown for module trucks and STT. The transportation costs per bale for cotton inside of thirty miles are the same because it was assumed that a module truck would gather all of these modules. The STT is more cost effective as the distance from the gin increases. The costs per bale for both module truck and STT for this example are similar, \$5.25 to \$8.20. These numbers will change proportionally with distance from the gin. These results incorporate the assumption that the STT was loaded by a module truck, whose operation is funded by the producer.

	100%	150%	200%	250%				
0-15	50%	40%	30%	34%				
15-30	45%	35%	25%	20%				
30-45	5%	25%	20%	20%				
45-60	0%	0%	25%	20%				
60-100	0%	0%	0%	6%				
	100%	150%	200%	250%	100%	150%	200%	250%
0-15	24000	28800	28800	40800	\$92,178	\$110,614	\$110,614	\$156,703
15-30	21600	25200	24000	24000	\$136,182	\$158,879	\$151,313	\$151,313
30-45	2400	18000	19200	24000	\$23,410	\$175,576	\$187,281	\$234,102
45-60	0	0	24000	24000	\$0	\$0	\$305,064	\$305,064
60-100	0	0	0	7200	\$0	\$0	\$0	\$134,096
			Cost/bale		\$5.25	\$6.18	\$7.86	\$8.18

Figure 3. Average cost per bale - module truck.

	100%	150%	200%	250%				
0-15	50%	40%	30%	34%				
15-30	45%	35%	25%	20%				
30-45	5%	25%	20%	20%				
45-60	0%	0%	25%	20%				
60-100	0%	0%	0%	6%				
	100%	150%	200%	250%	100%	150%	200%	250%
0-15	24000	28800	28800	40800	\$92,178	\$110,614	\$110,614	\$156,703
15-30	21600	25200	24000	24000	\$136,182	\$158,879	\$151,313	\$151,313
30-45	2400	18000	19200	24000	\$22,496	\$168,724	\$179,972	\$224,965
45-60	0	0	24000	24000	\$0	\$0	\$274,993	\$274,993
60-100	0	0	0	7200	\$0	\$0	\$0	\$113,059
			Cost/bale		\$5.23	\$6.09	\$7.47	\$7.68

Figure 4. Average cost per bale - STT.

Fuel Costs

The effect of fuel price on the cost of transporting seed cotton modules to the gin was addressed with this decision support software. This past year (2008), fuel prices varied from \$1.50 to over \$4 per gallon of diesel. Results shown in Figures 5, 6 and 7 illustrate how fuel costs impact the transportation costs per bale for distances from 10 to near 100 miles from the gin. It was assumed that both module trucks and STT achieved the same fuel economy. Figure 5 shows the costs per bale for module trucks transporting one module per trip compared to STT transporting two modules per trip for \$2.50 per gallon and Figure 6 illustrates the comparison for \$4.50 per gallon. These results suggest that it is less expensive to use module trucks to transport modules within 60 miles to the gin, when the fuel price is \$2.50/gallon (Figure 5). When the fuel price increases to \$4.50/gallon, the results in Figure 6 suggest that it would be less expensive to use STT, when the modules were located 33 or more miles away from the gin. If the fuel price were \$6/gallon, it would be less expensive to use STT, when the modules were located 27 or more miles away from the gin (Figure 7).

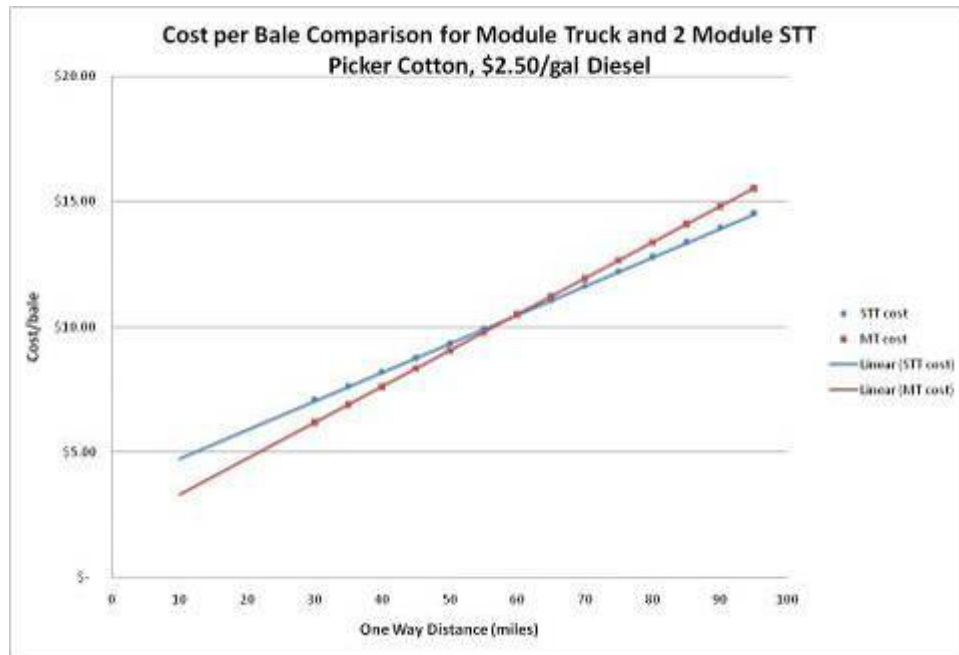


Figure 5. Costs per bale for a module truck and STT at \$2.50/gal.

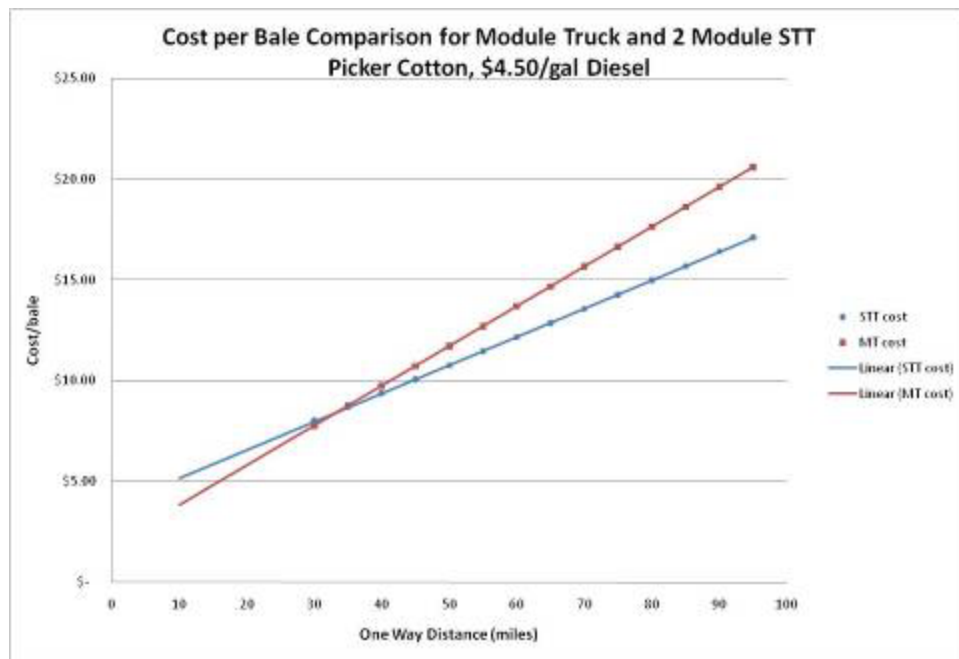


Figure 6. Costs per bale for a module truck and STT at \$4.50/gal.

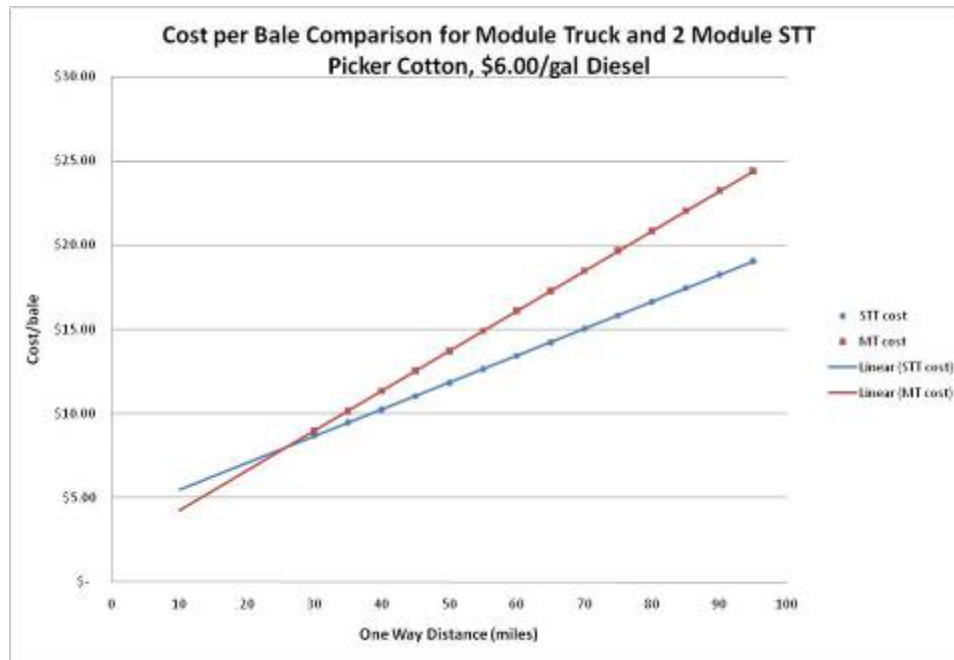


Figure 7. Costs per bale for a module truck and STT at \$6.00/gal.

Summary

Decision support software (Hamann et al., 2008; Emsoff et al., 2007; Parnell et al., 2005a and 2005b; Simpson et al., 2006 and 2007) was used to illustrate the comparison of transportation costs per bale using module trucks and Semi Tractor Trailer (STT) systems. The interactions of transportation and ginning costs including the concept of percent utilization (%U) were included to illustrate the utility of this software. This paper illustrated how this particular software could be used to test the hypothesis that the STT system could be used to transport modules of cotton more economically than module trucks. In the simulations, the STT system was used to transport two seed cotton modules per trip compared to one module per trip, for module trucks. The results suggest that the transportation costs per bale were dependent upon fuel costs per gallon. If the module locations were less than 27, 33, and 60 miles from the gin, it would be less expensive to use module trucks rather than STT for fuel costs of \$2.50, \$4.50 and \$6.00 per gallon, respectively.

An effort was made to develop a method to load two modules on STT. It was concluded that a walking floor trailer with no tilting bed would be the best approach. A module truck would be used to load the walking floor trailer.

An example of a 60 bale per hour (bph) was used to illustrate the interaction of the time required to process seed cotton at the gin operating at 100 to 250 %U and time required to transport seed cotton at different distances from the gin using module trucks and STT. A sample distribution of modules for different distances from the gin was used. The results suggest that STT was more economical for cotton located further from the gin, but the difference was not a large. The costs per bale ranged from \$5.25 to \$8.20.

Both round cotton modules and square modules created by the new on-board module builder designs offered by Deere and Case IH may be used to transport seed cotton to the gin by module trucks or STT systems. The round bales offer the advantage of not needing the walking floor for the STT. The half module offers the advantage of not needing the 68 foot special trailer. One and one half modules can be loaded on a standard 53 foot trailer and the live bottom floor of this trailer would be approximately 50% of the special trailer live bottom floor.

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References

Cloud, S.; 2007. Personal Communication. Keith Mfg. Co., Madras, Oregon.

Dean, D. R., M.T. Hamann, S. Steffen. 2007. Design of a Round Cotton Module Handling System. BAEN 479 Project Report. Texas A&M BAEN Dept. College Station, TX.

DOT. 2007. Code of Federal Regulations: Federal Highway Administration, Department of Transportation. 23CFR658.17. Office of the Federal Register, National Archives and Records Administration. Available at: www.gpoaccess.gov/cfr/index.html. Accessed December 2007.

McCarlos, J. 2007. Personal Communication. Module Truck Systems, Inc. Lubbock, Texas.

Emsoff, S., C.B. Parnell, Jr., S.L. Simpson, M. Hamann, B.W. Shaw, and S. Capareda. 2007. Systems engineering of seed cotton handling and ginning in Texas. Proceedings of the 2007 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN

Hamann, M., C. Hammock, S.A. Emsoff, C.B. Parnell, and S.L. Simpson. 2008. Seed cotton ginning and transport modeling. Proceedings of the 2008 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Parnell, C.B., Jr., B.W. Shaw, S.L. Simpson, S.C. Capareda, J.W. Wanjura, and S.A. Emsoff. 2005a. Systems Engineering of cotton Production and Ginning in Texas. Paper presented at the 2005 ASAE/CSAE Annual International Meeting held July 17-20, 2005; Tampa, Florida. Paper No. 051097. ASAE, St. Joseph, Michigan.

Parnell, C.B., Jr., S.L. Simpson, S.C. Capareda and B.W. Shaw. 2005b. Engineering Systems for Seed Cotton Handling, Storage and Ginning. In: Proceedings of the 2005 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Parnell, C.B., S. Emsoff, J.D. Wanjura, S.L. Simpson, B.W. Shaw, and S.C. Capareda. 2006. Systems Engineering of Seed Cotton Handling and Ginning in Texas. Proceedings of the 2006 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Simpson, S.L., C.B. Parnell, J.D. Wanjura, S.C. Capareda, and B.W. Shaw. 2006. Systems Analysis of Seed Cotton Storage and Transport. Proceedings of the 2006 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.

Simpson, S.L., M. Hamann, C.B. Parnell, Jr., S. Emsoff, S. Capareda, and B.W. Shaw. 2007. Engineering of Seed Cotton Transport Alternatives. Proceedings of the 2007 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.