PURDUE UNIVERSITY® | Agricultural and Biological Engineering

CAPSTONE/SENIOR DESIGN EXPERIENCE 2022

INC-1 Planter Row Unit Bounce Suppression

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Executive Summary

Planter row units are affected by obstacles across a field. Uniform seeding depth is crucial for uniform emergence throughout a field. A pneumatic downforce system is unable to respond quickly to these influences, resulting in uneven emergence and lower yields. The solution proposed was the addition of an automotive shock to absorb the bounce, returning the planter to being "settled" quicker. This is ideal for midsize farmers that have an existing planter not wanting to upgrade to a hydraulic downforce system. Testing was conducted by pulling a row unit over a set track with obstacles and taking data using an accelerometer. Results proved the theory and an economic analysis was conducted to provide insight into the financial background of the project.

Project Scoping/Learning and Screening

A downforce system's inability to react to abrupt changes directly affects maintaining seeding depth along with planter performance. The proposed dampening system directly focuses on reducing the bounce leading to a faster return of the system to a settled range and the potential for higher planting speeds. According to Farm Journal & R. Nielsen, even one day late on emergence can lead to a 15% reduction in yield up to leaving barren plants. Adjacent plants will not compensate for delayed emergence leading to over-competition. This solidifies the economic returns to farmers that incorporate this system to their planter. Hydraulic downforce incorporates dampening into the system, however, the high cost to upgrade may not be an economic option.

Constraints

- Under the maximum total budget
- Achieve a more uniform seeding depth
- Must build a prototype within timeline
- Lower cost than hydraulic downforce

Criteria

- Ease of installation
- Range of cost per unit
- Durability
- Manufacturability

Impact Factors

The factors considered that determined the impact of the final solution focused on the global and economic impact of higher return of yields which leads to higher profits. The deliverables of the project will provide a prototype for testing along with accurate accelerometer data for processing. The success of the project will be based off that data along with video showing a positive reduction in bounce and faster settling time. Highlights in the timeline will be shock selection, design completion, and testing.

Proposed Solutions

The proposed solutions were modeled off the automotive concept that uses shocks as the dampening system alongside their suspension. Introducing the dampening capability of a shock should reduce the bounce and return the unit back to the settled range faster. Three different shock styles were compared based on several factors. The pneumatic shock was chosen based on the matrix below (Table 1).

Table 1:	Cost	Dampening	Durability	Installation	Adjustability	Total
Score	0.25	0.25	0.2	0.15	0.15	1
Hydraulic	8	5	6	7	7	6.55
Pneumatic	8	7	6	7	7	7.05
Magnetic	1	10	8	2	10	6.15

Final Design

The final design consisted of adding two brackets to mount the shock. AutoCAD drawings (Figure 1) were created in order to create a top bracket that mounted over the John Deere airbag. The bottom bracket suspended under the bottom 4-link brackets to ensure forces are dampened.

Prototype Build

The prototype (Figure 3) required a few modifications to be equipped with a John Deere pneumatic downforce system. When designing and constructing the prototype, consideration was given to standards ASABE S506 - planter parts and ANSI B11/STD - component safety. The Monroe #34906 pneumatic shock was chosen based off calculations made for the required stroke and dampening value.

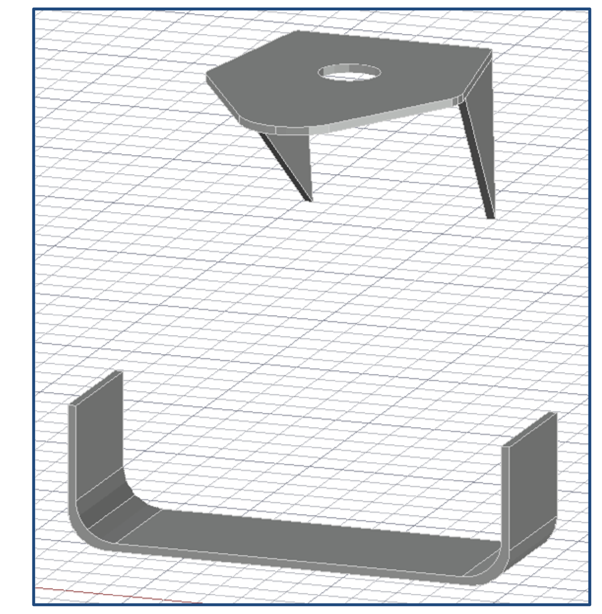


Figure 1: AutoCAD Design.

Figure 3: Final Design.

Figure 2: On test track.

Test Plan

A standardized test track (Figure 2) was built inside the shop to ensure repeatability and eliminate outside factors which consisted of two obstacles made from angle iron fastened to the floor (Figure 4). Data was collected on an accelerometer mounted to the row unit. Tests were performed at different PSI pressures that relates directly to lbs. downforce at 180, 250, 300 lbs., the standard choices for a row unit in sand, conventional tilled, and no-till situations respectively. Speeds of 4.14 and 5.18 mph were used to simulate the performance and effectiveness at higher planting speeds. Settled range was defined as between 4 & -4.

Table 2: 250 lbs down force at 4.14 mph
Tests 3.2 & 4.2

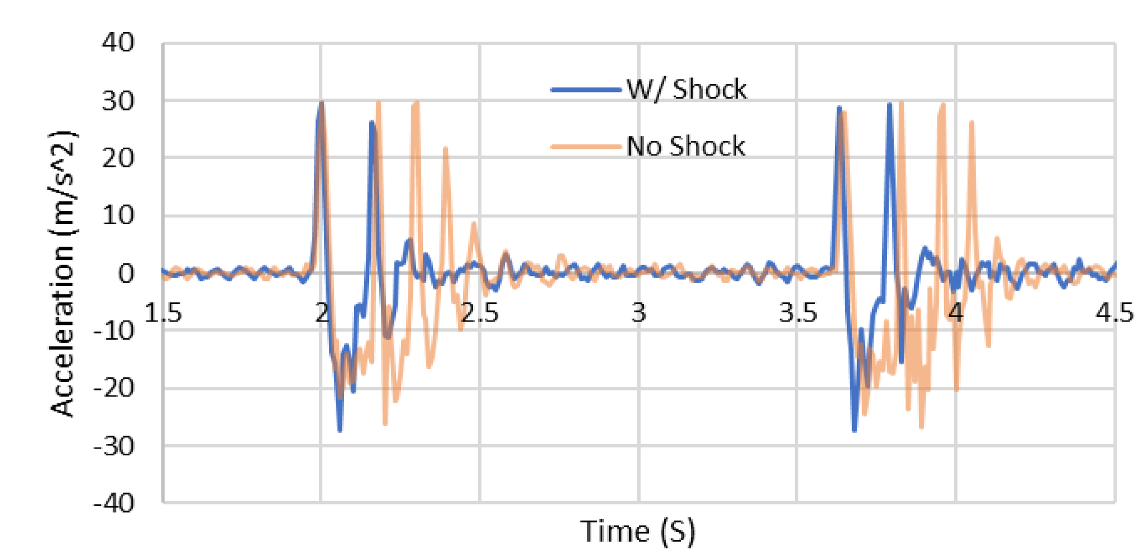


Table 3: 250 lbs down force at 5.18 mph
Tests 5.2 & 6.2

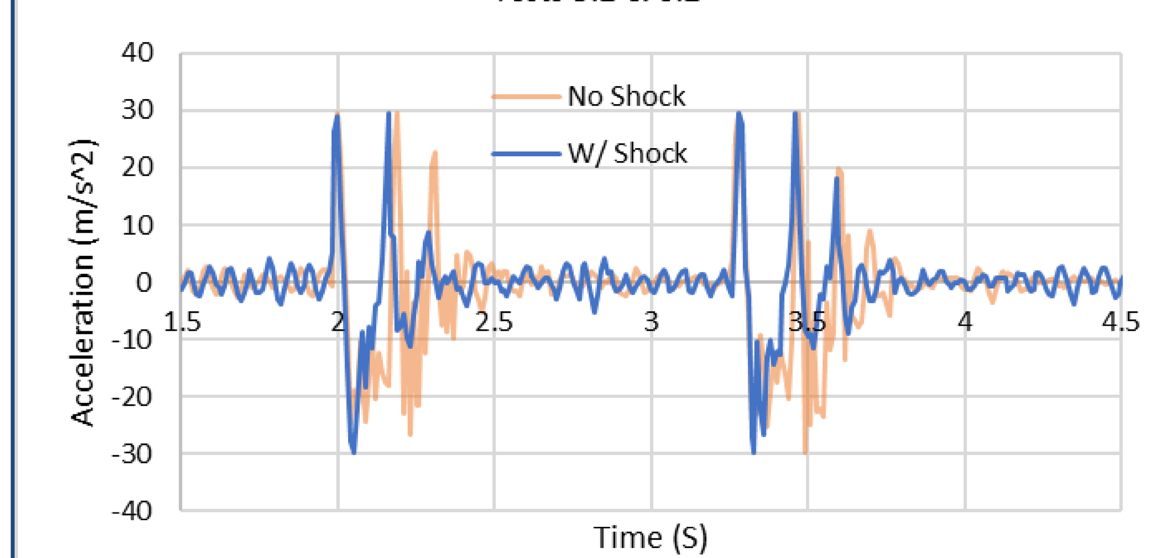
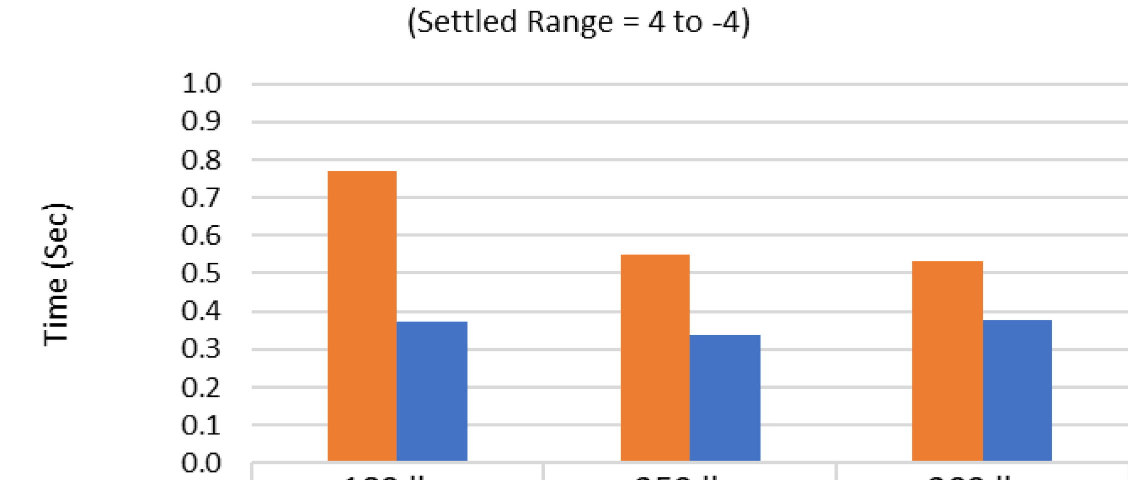
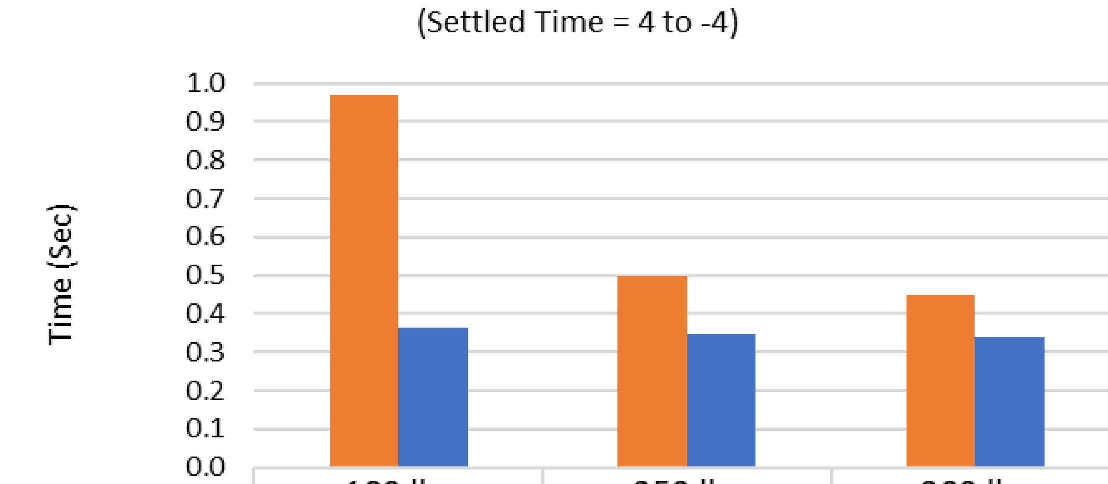


Table 4: Average Settling Time at 4.14 mph
(Settled Range = 4 to -4)



	180 lbs	250 lbs	300 lbs
No Shock	0.770	0.550	0.531
W/ Shock	0.372	0.338	0.375

Table 5: Average Settling Times at 5.18 mph
(Settled Time = 4 to -4)



	180 lbs	250 lbs	300 lbs
No Shock	0.970	0.499	0.447
W/ Shock	0.365	0.348	0.339

Results

On average, the planter settled 0.256 sec. faster with shock at 4.14 mph and 0.288 sec. faster with shock at 5.18 mph. This resulted in up to a 52% reduction in settling time at 4.14 mph and up to 62% reduction at 5.18 mph. Charts 2 and 3 visualise this settling while charts 4 and 5 detail the change the shock made. These results prove the goal of the project in reducing bounce in the row unit. The shock was most effective at lower psi tests, but still provided consistent settling times across the different downforce pressures.

Economic Analysis

- Economic response is determined by the increase in the uniformity of planting depth. A reduced bounce should allow for a more even seeding depth even when planting at higher speeds.
- When compared to upgrading to hydraulic downforce this system is significantly cheaper as it would cost $2250 a row and require a tractor with more capacities while our system will cost around $252 (after adding estimated production costs associated with commercialization) given a pneumatic system is already installed.
  - Over 1000 acres our system costs $4.04/acre while hydraulic downforce costs $36/acre on a 16 row planter.
  - A yield increase of .58 bu/acre over 1000 acres on a 16 row planter is needed to break even with $7.00/bu corn. 5.14 bu/acre if hydraulic downforce was used.

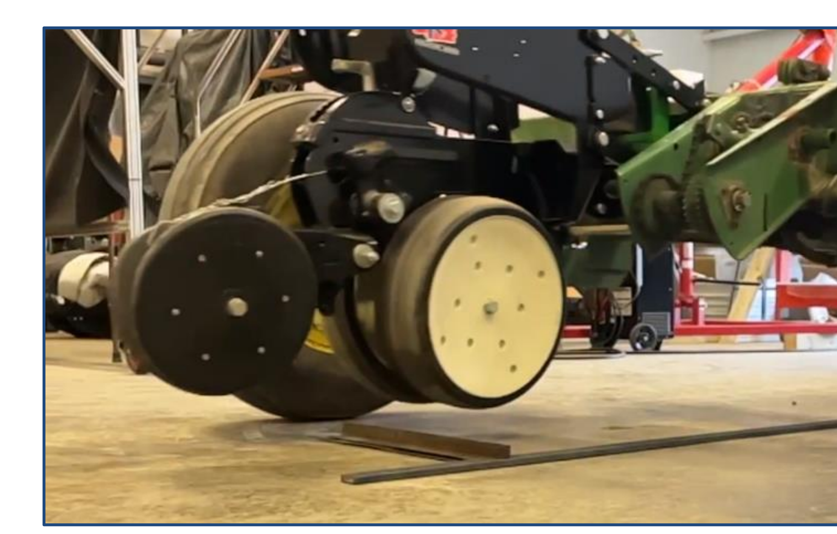


Figure 4: Unit mid-bounce.

Conclusion

Utilizing a shock absorber with a pneumatic downforce systems shows promise to provide an agronomic response. The settling time was consistently shortened with the shock in use when an obstacle was introduced. The data has shown that it is feasible but more testing should be performed to prove an agronomic difference and leaves the potential to test a variety of shocks.

References:
Farm Journal - February 2022
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Successful Farming - Laurie Bedford

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