

# Harvest Assist

- Hard to replace humans at picking
- Can make humans more efficient
  - Less fatigue
  - Eliminate non-picking harvest tasks
  - Prime mover, fruit transport and bin filling will also be needed with full automation
- May expand labor pool



# DBR Vacuum Harvester



## Firmness and maturity of apple cultivars included in Pennsylvania augmented harvest system evaluations.

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Cultivar	Firmness (lbs)	Starch index <sup>z</sup>
Golden Delicious	18.7	4.8
York	22.0	2.5
Cameo	15.7	4.3

<sup>z</sup> Blanpied and Silsby generic starch-iodine index

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# Efficiency in apple orchard plots harvested with vacuum assist system and platform compared to hand harvest and ladders.

<i>PA Trials, 2012</i>		Harvest time/bin	Harvest time/acre	
Cultivar	Harvest System	(min/1 person) <sup>z</sup>	(hrs/4 workers)	(% change)
Golden Delicious	Vacuum assist	45.6 c <sup>y</sup>	8.3	33
	Hand	68.0 a	13.6	--
York	Vacuum assist	45.5 c	5.8	33
	Hand	68.0 a	13.6	--
Cameo	Vacuum assist	58.0 b	11.6	15
	Hand	68.0 a	13.6	--



<sup>z</sup> 23 bushel plastic bin.

<sup>y</sup> Completely randomized design with 4 replicates. Mean separation by Fisher's protected least significant difference at  $P \leq 0.05$ .

## Quality of apples harvested with vacuum assist system and platform compared to hand harvest and ladders.

Cultivar	Harvest System	Extra Fancy <sup>z</sup>	Fancy	Downgraded
		(%)	(%)	(%)
<b>Golden Delicious</b>	Vacuum assist	85.0 a <sup>y</sup>	7.1 a	7.9 a
	Hand	85.4 a	7.5 a	7.1 a
<b>York</b>	Vacuum assist	85.0 b	7.1 a	7.9 a
	Hand	96.1 a	2.1 a	1.8 b
<b>Cameo</b>	Vacuum assist	93.7 b	3.8 a	2.5 a
	Hand	99.2 a	0.8 b	0.0 b

<sup>z</sup> Bruise evaluations conducted on 60 fruit per treatment from each of four replicates. Percentage of fruit in each market grade based on bruise allowances in USDA fresh market grade table.

<sup>y</sup> Mean separation within columns and cultivars by Fisher's protected least significant difference at  $P \leq 0.05$ .

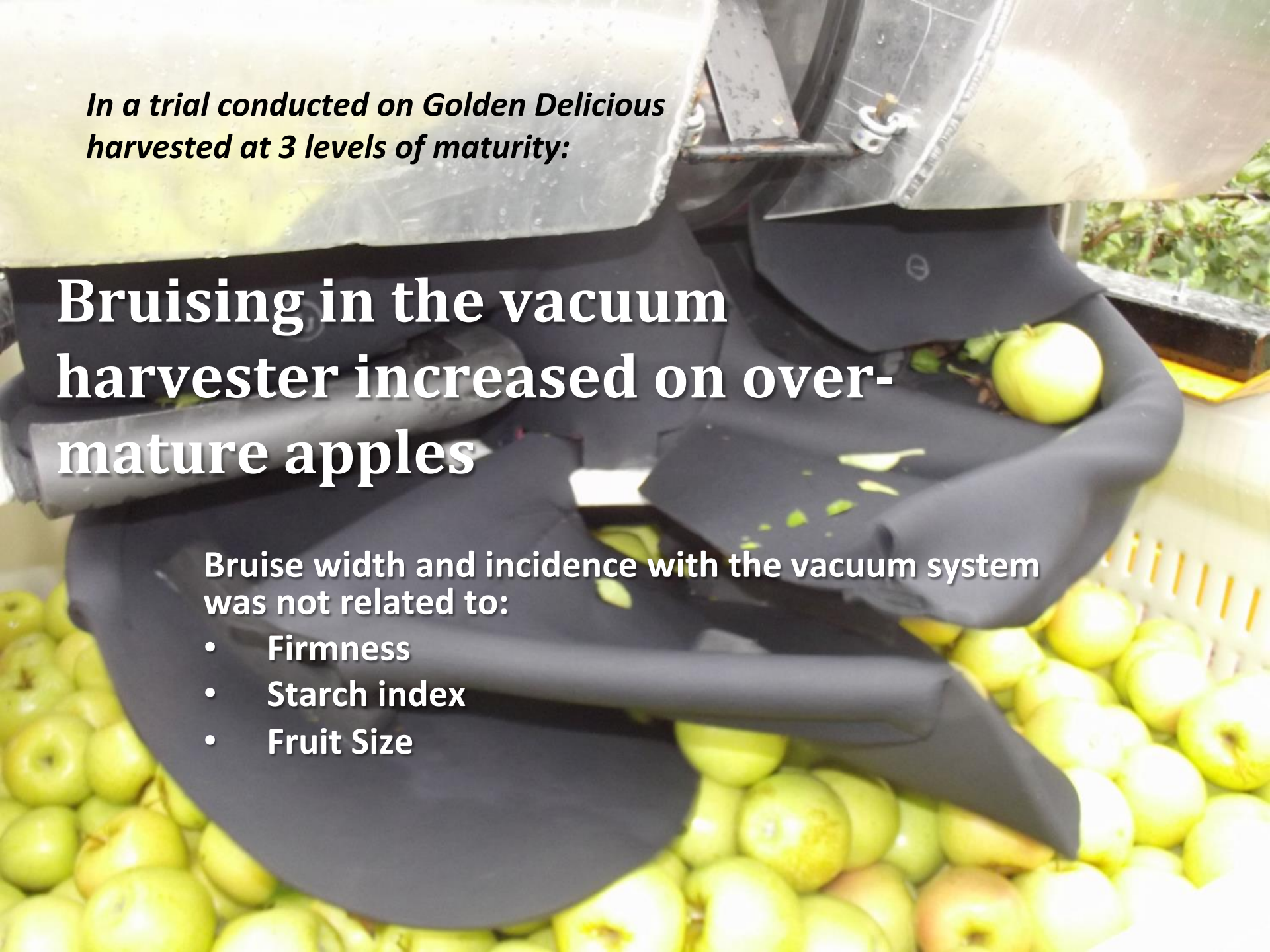
## Classifications of bruise damage based on USDA Fresh Market Grades.

Class	USDA Fresh Market Standard	Bruise specifications
1	"Extra Fancy"	No bruising
2	"Extra Fancy"	Bruise diameter $\leq$ 3.2 mm (1/8 in.)
3	"Extra Fancy"	Bruise diameter 3.2 to 6.4 mm (1/8 to 1/4 in.)
4	"Extra Fancy"	Bruise diameter 6.4mm (1/4 in.) to 12.7 mm (1/2 in.) or area of several bruises $\leq$ 127 mm <sup>2</sup>
5	"Fancy"	Bruise diameter 12.7 to 19 mm (1/2 to 3/4 in.)
6	Downgraded	Bruises larger than the tolerances in "Fancy"
7	Downgraded	Cuts or punctures of any size

**Detailed breakdown of Extra Fancy apples following augmented harvest system handling.**

<b>Cultivar</b>	<b>Class 2 (%)</b>	<b>Class 3 (%)</b>	<b>Class 4 single bruise (%)</b>	<b>Class 4 multiple bruises (%)</b>
<b>Golden Delicious</b>	0.0	12.1	8.3	6.3
<b>York</b>	0.0	5.0	3.3	0.8
<b>Cameo</b>	0.4	6.3	5.4	0.4

Grade classes described in USDA fresh market grade table.



*In a trial conducted on Golden Delicious harvested at 3 levels of maturity:*

## **Bruising in the vacuum harvester increased on over-mature apples**

**Bruise width and incidence with the vacuum system was not related to:**

- Firmness
- Starch index
- Fruit Size



# Growers' Perspectives on Adopting New Technologies

Shannon Caplan, Brian Tilt, Clark Seavert, OSU; Tara Baugher, PSU, Karen Lewis, WSU

- Case study interviews with fruit producers to assess factors that influence the adoption of new technologies or practices, drawing upon a field called “diffusion of innovations.”
- 18 producers total, 6 each from small, medium or large operations
- Technologies – assisted harvest, automated insect traps, automated tree caliper

# Benefits of Assisted Harvest Adoption Identified by PA and WA Growers

- Reduced human error and fatigue during harvest
- Lower labor costs
- Eliminating some risk associated with current labor pool
- Possible increase in fruit quality and harvest management efficiency

# **Barriers to Assisted Harvest Adoption Identified by PA and WA Growers**

- Possible large financial burden
- Geographic concerns – hilly terrain; multiple small parcels to move harvester to
- Potential for equipment breakdowns
- Managing harvest employees

## **Some additional work:**

Detailed engineering assessment of the apple decelerator and distributor of the vacuum harvest assist system

# What has been studied

- Effect of gravity on apple travel speed and distance
- Observation of apple motion on the machine with a transparent tube
- Multiple-apple behavior during transport inside the vacuum tube
- Effect of presence of one vacuum tube on the other
- Effect of apple size, aspect ratio, and tube diameter and length on apple travel speed and distance

# Gravity Test

- Performed with small, medium, and large apples.
- Using rigid clear tube
- Tube lengths: 2 ft, 4 ft, 6ft
- Padded and Non-padded



# Velocity Observation



# Gravity Test

- Performed with small, medium, and large apples with different aspect ratios.
- Using flexible clear tube
- Tube lengths: 15-ft
- Tube inside diameters: 5-in, 6-in
- Non-padded



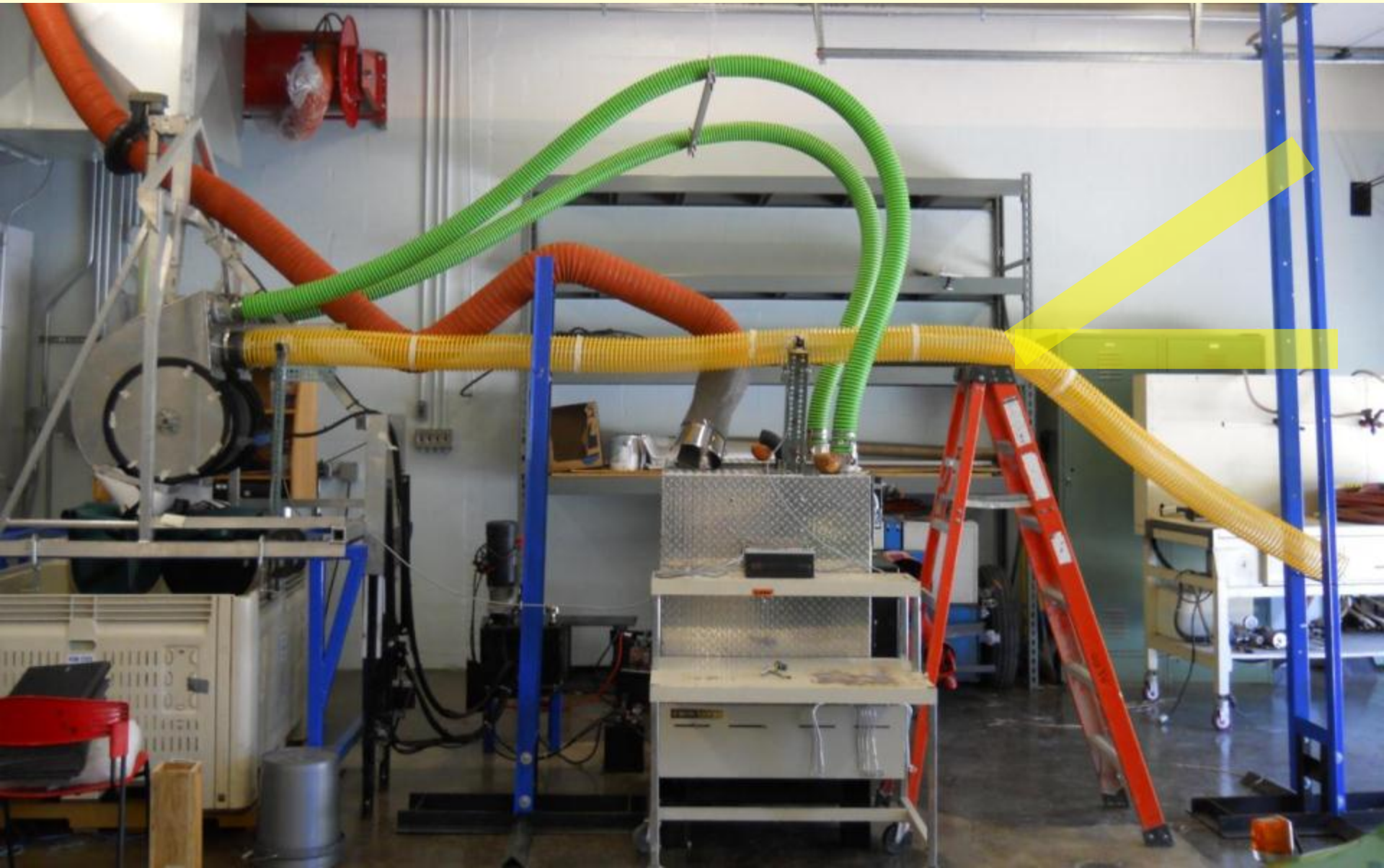


# Vacuum System Testing

- High Throttle, Low Throttle, Medium Throttle

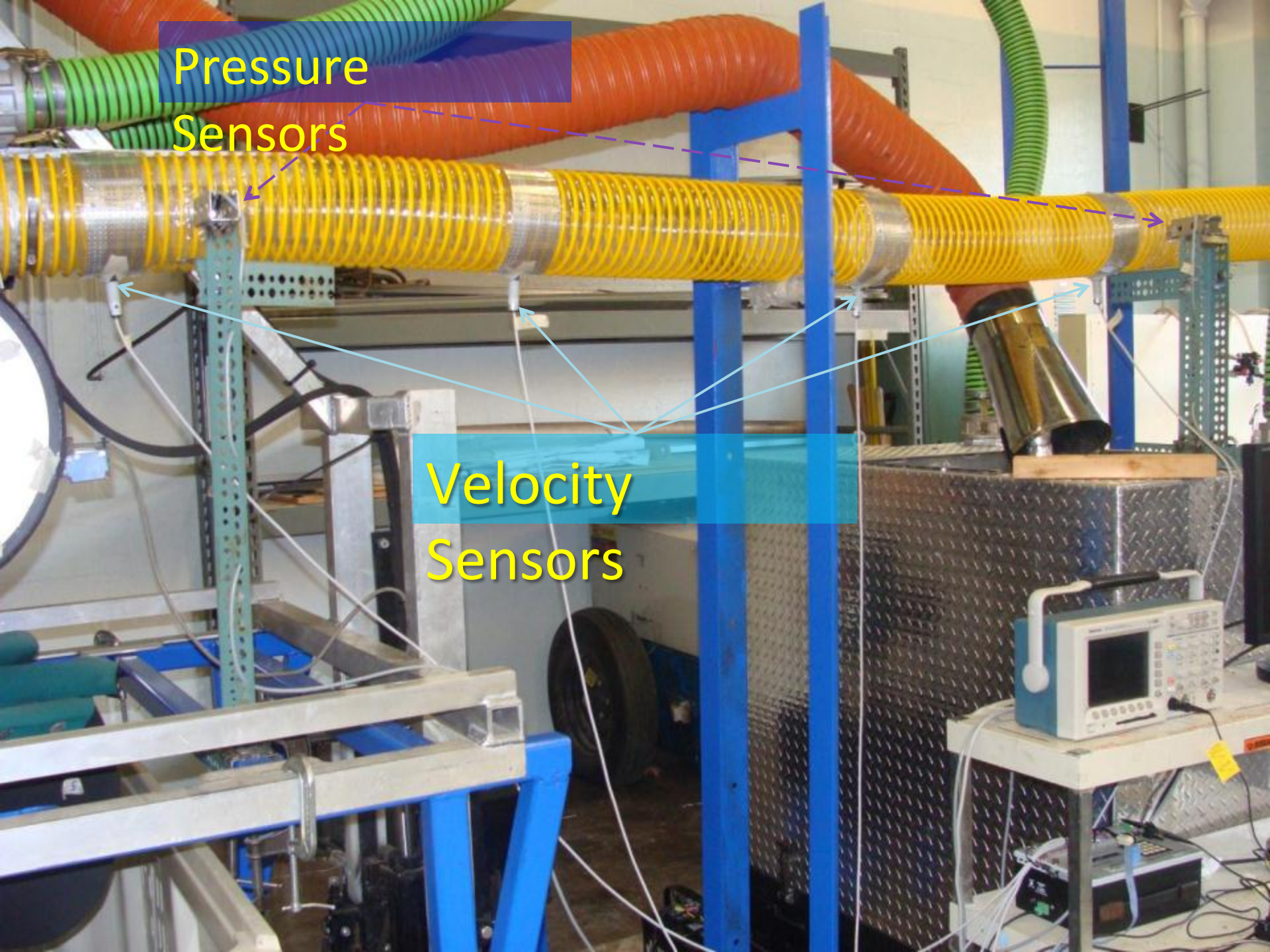


# Different Tube Configurations



Pressure  
Sensors

Velocity  
Sensors



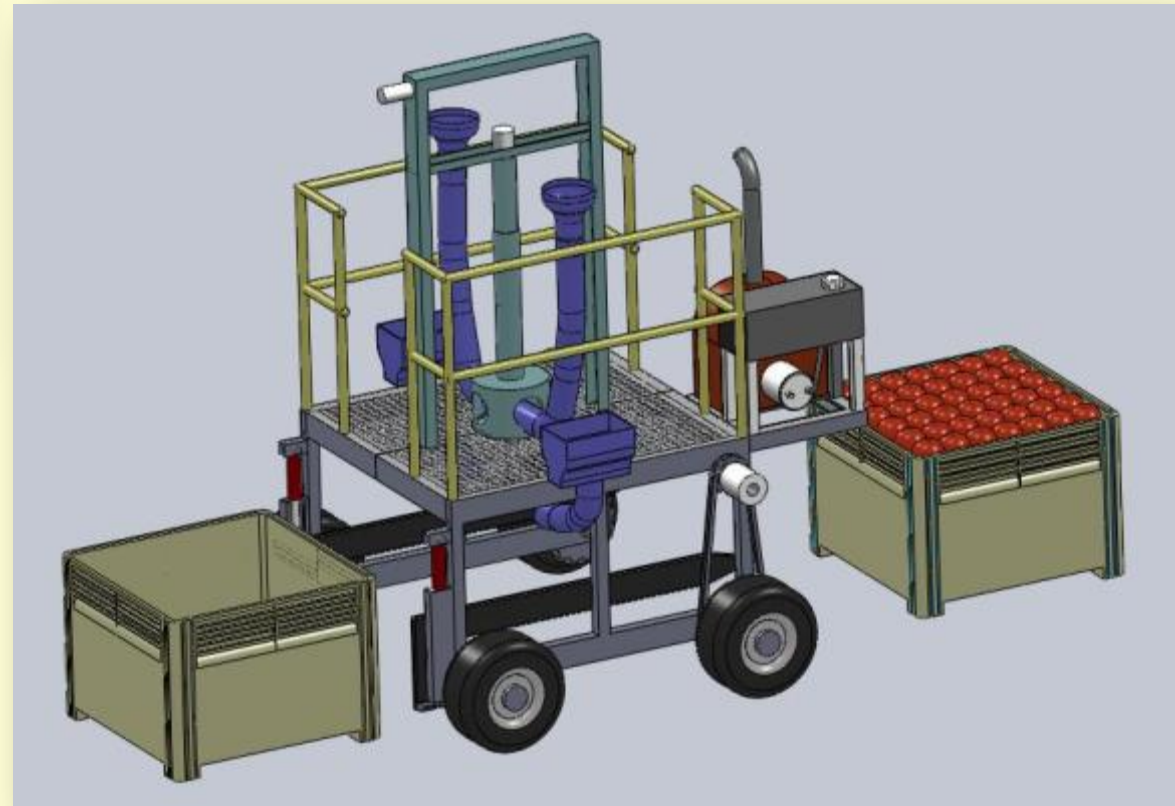
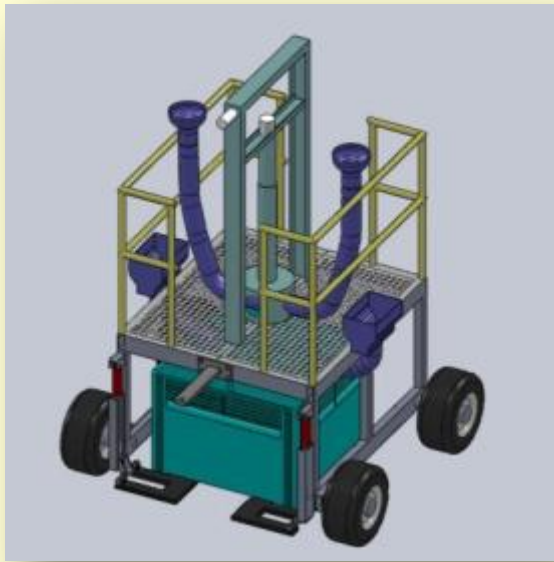
# Findings

- Apple speed is sensitive to apple size and vacuum tube size.
- Larger apples can catch up with small apples.
- Decelerator and elephant ear rotating speeds should be individually-adjustable. The relationship between these two speeds needs to be investigated.
- Two vacuum pumps should be able to “engage” or “disengage” separately.
- Gravitational force can be utilized to “assist” transporting apples from the upper part of the tree to the bin.
- Tube diameter has an important impact on apple motion under gravity driven and when applying vacuum air flow.

# Other designs

- Low-cost gravity based
- Vacuum assist
- Vacuum driven

# Low-cost devices for small operations



Transport of fruit primarily by gravity or vacuum-assist

# Other proposed activities

- Ergonomics
- Socio-economic



# Thank You!

Funds provided by:

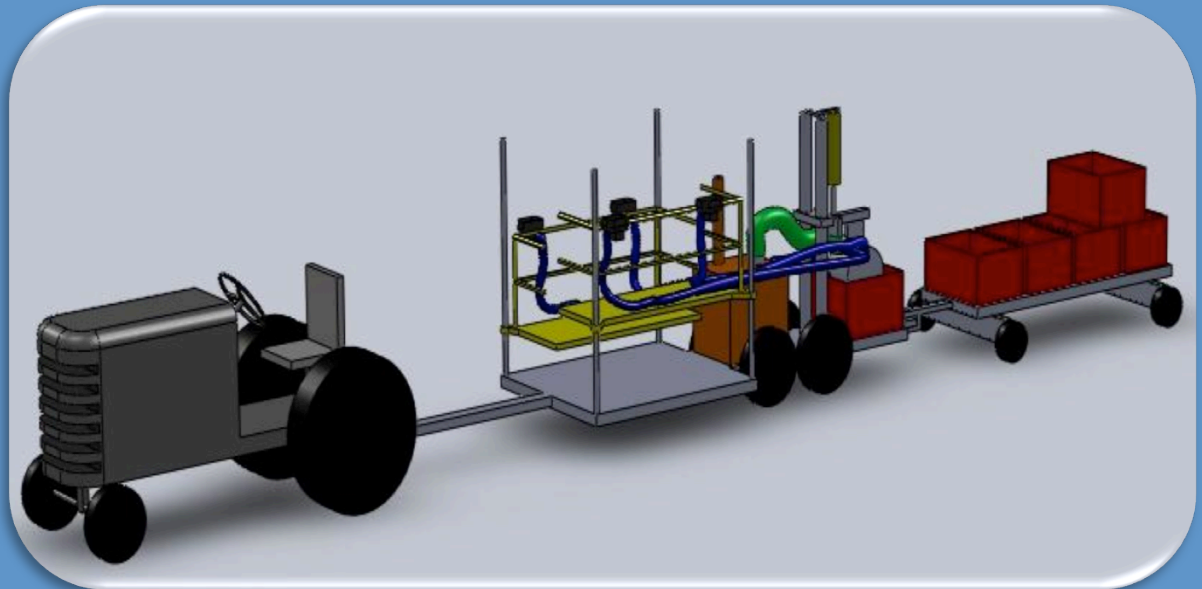
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