Automated Pigeon Thrower

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APT

12/03/2015

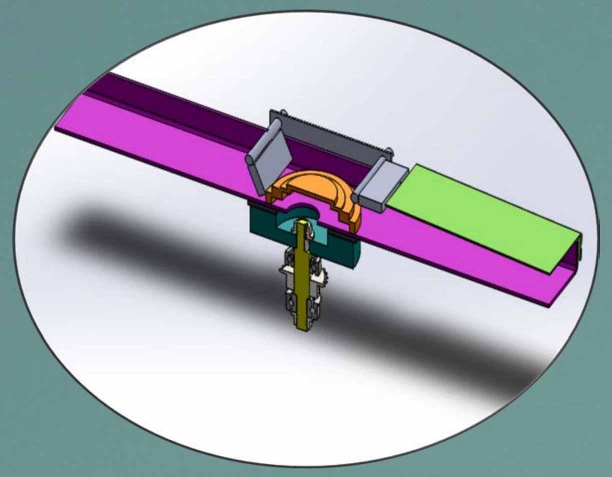
Introduction

- **Problem**

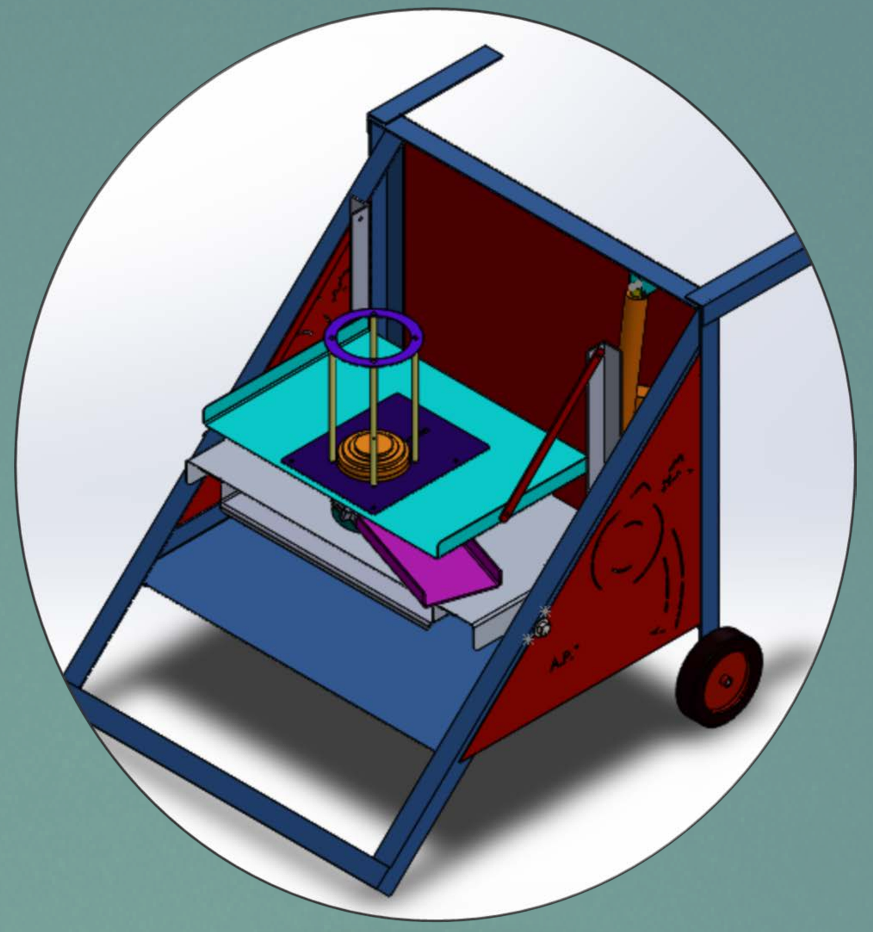
Clay pigeon throwers on the market today vary a great deal in terms of cost and functionality. Currently, a low cost, variable trajectory, automatic clay pigeon thrower doesn't exist on the market.

- **Solution**

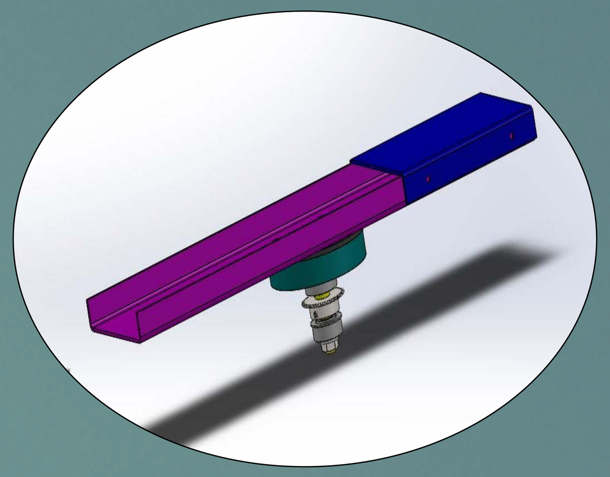
The APT can launch a clay pigeon at varying altitudes, angles, and speeds. The design will automatically load a clay pigeon into the center axis of a rotating channel. When ready, the trigger mechanism release the clay pigeon with a slight push, pushing it off center and allowing it to accelerate down the channel as the channel rotates. This allows the use of a less powerful motor and allows for more rapid firing of the clay pigeons (up to one per three second). This unique design enables the radial launch angle to vary via clay release timing with respect to the channels' angular position.



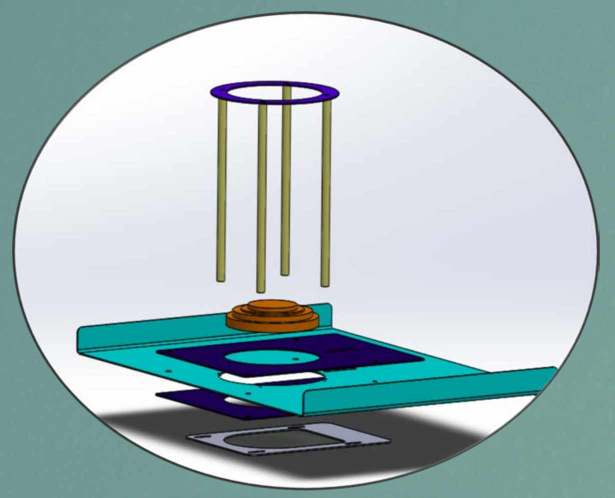
Electronic Trigger Release



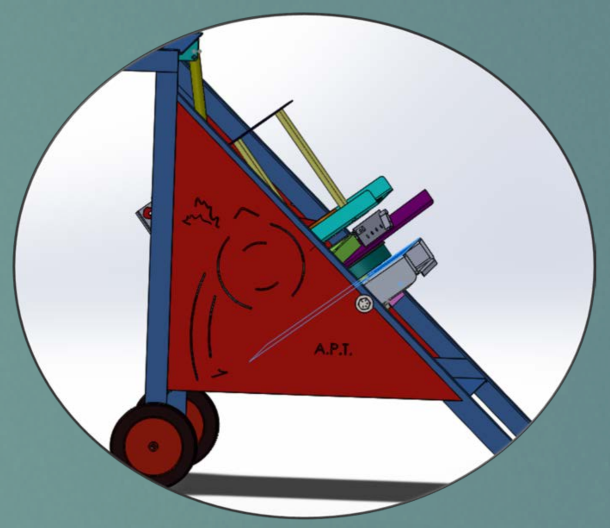
CAD Prototype



Launching Arm



Auto-Loader



Elevation Variability

The APT in the testing environment. The Loading mechanism has been detached to better show the launching arm and trigger

Design

The APT consists of four critical function prototypes:

- **Launching Arm**

This throwing arm is unique in that it energy stored in the form of a continuously spinning channel accelerate a clay pigeon to launch. A high-resolution digital encoder supplies feedback on the position of the channel, allowing us to control channel rotational speed and the angle of the channel upon launch. The channel is balanced to minimize vibration.

- **Electronic Trigger**

The trigger constrains the clay pigeon in the center of the channel to prevent it from accelerating. Upon launch, the trigger releases the clay pigeon with a slight push, putting the clay pigeon off-center in the rotating channel and allowing the channel to fling it into the air.

- **Loading Mechanism**

The loading mechanism was designed to automatically load the clay pigeon in the channel. Its main function is to reliably and quickly reload the thrower with clay pigeons. The interval time between the exiting clay is adjusted by the speed of loading.

- **Tilting Variability**

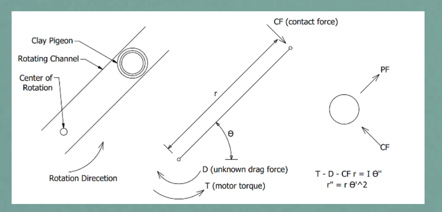
The tilting mechanism was designed to change the elevation of the exiting clay between zero and fifty degrees to the horizon. Combined with the release timing of the trigger this allows us to launch with a variable horizontal and vertical angle.

Testing

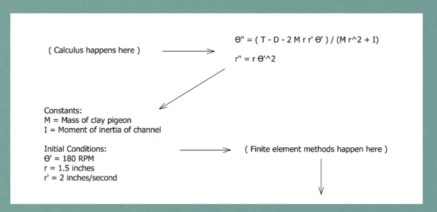
Logical Analytics

Theory & Calculation

- *Theoretical and Free body diagrams*
- *Application of Calculus & Finite Element Methods*



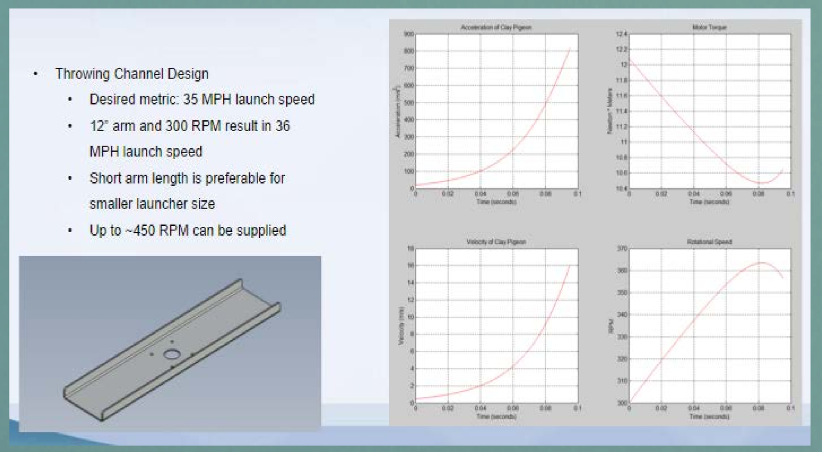
Free Body diagram

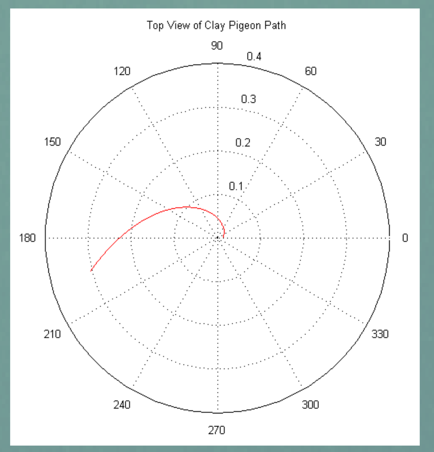


Derivation of position, velocity and acceleration Equations

Channel and clay speed Simulation

- *Assumption: no drag force, no friction force between the clay and the aluminum plate*
- *Existing clay speed goes to 36MPH while rotating a 12in channel length at 300RPM*
- *Acceleration of the clay increases while the motor torque decreases*
- *Kicking the clay off-center of the channel about 0.5in, the clay exits between a range of 180 and 210°*





Logical Analytics of the rotating channel, motor and clay pigeon.

Analytics of the Launch Velocity and Angle at 200 RPM and 400 RPM

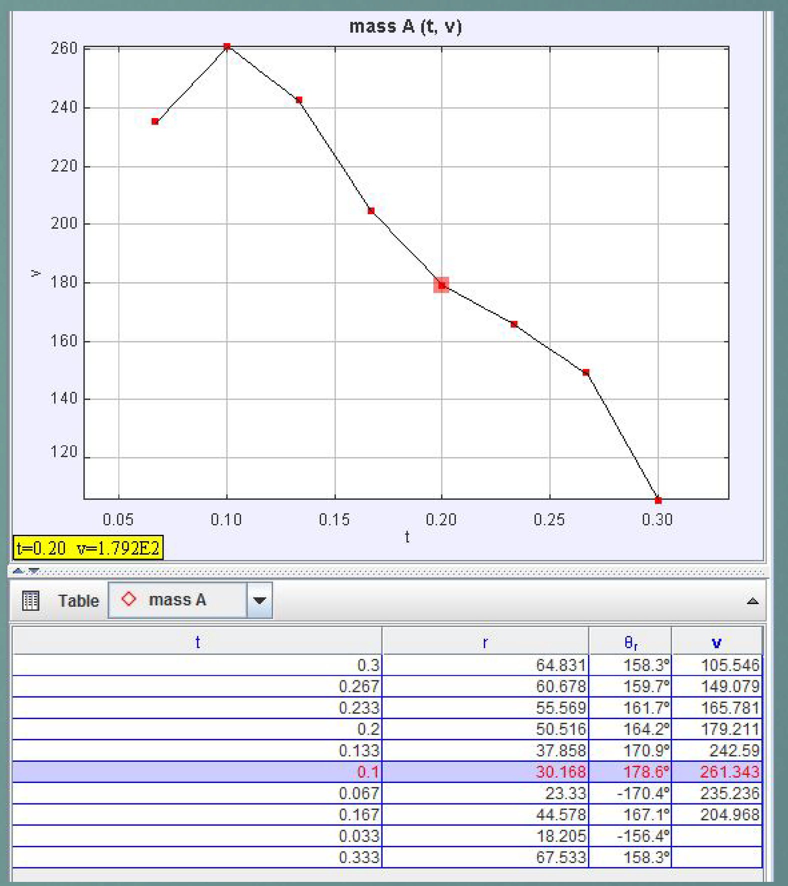
- *Assumption: no drag force, no friction force between the clay and the aluminum plate*
- *Expected launching velocity error to be < 5MPH*
- *Expected launching angle degree error to be < 10 degree error*

- Trigger mechanism will have variance
  - Clay pigeon release velocity is not constant
  - Up to 20% error is expected
- Channel RPM will have variance
  - Up to 10% error is expected
- Goals
  - less than 5 MPH error
  - less than 10 degree error

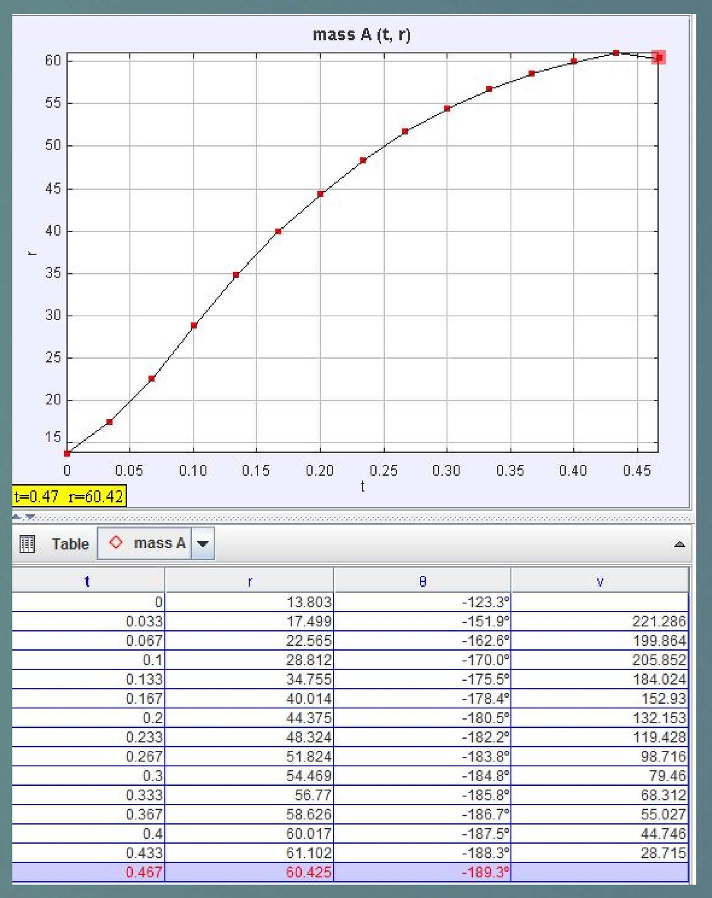
Desired Conditions	Condition Error	Calculated Launch Velocity (mph)	Error (mph)	Calculated Launch Angle (deg)	Error (deg)
200 RPM, 12 in/sec release velocity	+10% RPM	17.523	~1.5	36.323	~2.5
	-10% RPM	14.452	~1.5	30.419	~3
	+20% release velocity	15.982	~0	27.735	~5.5
	-20% release velocity	15.994	~0	40.075	~6.5
400 RPM, 12 in/sec release velocity	+10% RPM	34.595	~3	52.797	~2
	-10% RPM	28.372	~3	48.662	~2
	+20% release velocity	31.484	~0	46.861	~4
	-20% release velocity	31.479	~0	55.236	~4

Logical Analytics of the launch velocity and launch angle with their launch errors.

Experimental Analytics



An example of raw data from motion tracking software. The x axis is time in seconds. The y Axis is velocity in inches per second.



Raw data from motion tracking software. The x axis is time in seconds. The y Axis is the velocity in inches per second. This instance showed a launch velocity of ~15 MPH.

Empirical Testing

- *Thirty separate launches performed*
- *Recorded launches with Go-pro camera*
- *Motion tracking software use to analyze raw video*
- *Velocity, launch angle*

Results

- *Launch velocity was within 5 MPH of desired value on 85% of launches*
- *Launch angle was within 10 degrees on 70% of launches*
- *Launch failure rate was below 10%*
- *Maximum launch velocity was 28 MPH*
- *Loading mechanism was reliable*
- *Vibration was significantly less than expected*

Conclusions

- *Basic concept was successfully demonstrated*
- *Theoretical calculations were accurate and predicted experimental data*
- *Robotic control was accurate and effective*
- *Design effectively launched pigeons without using powerful motor or transmission*
- *Costs were more than anticipated*
- *Launch velocity was less than anticipated*
- *Construction took more time than anticipated*
- *Redesign of non-core components required before mass production*

Going Forward

- *Core concept is possible but refinement is needed before marketing*
- *Longer launch channel will increase launch velocity*
- *Simplified safety features will reduce weight and cost*
- *Better sourced components and materials will reduce cost*

Acknowledgements: *We would like to thank Dr. Kam Leang, Tom Slowik, Paul Hamric and Michael Knutson for theirs time dedicated in our project.*