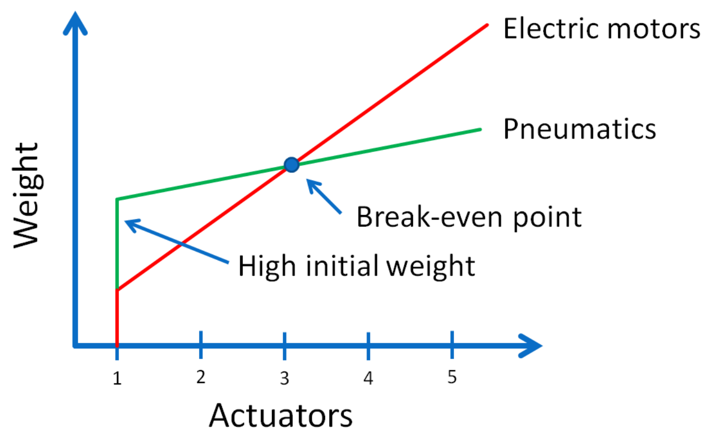
FRC Pneumatics
"Marginal weight" analysis

N. Laverdure, Mentor, FRC Team 122
5 Nov 2013

Background

The associated presentation makes the claim, illustrated by this "cartoon" graph, that the standard FRC pneumatic options offer a lower "marginal weight" than the standard options for motors. This is used to justify the claim that in order to minimize weight, systems that require a large number of actuators should be designed with pneumatics, and systems that require a small number of actuators should be driven by motors.



This claim is inherently unfair. It does not take into account that motors typically provide rotary motion, while pneumatics typically provide linear motion, and that both types of motion cannot be integrated into all designs. It disregards the fact that motors can be run constantly over the course of a standard 2-minute match, but that pneumatic actuators can easily exhaust their air supply before the match ends.

However, this claim can be supported by actual data by comparing the weights of typical FRC systems. Here, the lightest-possible motor choices are compared against a typical choice for a pneumatic actuator. Some auxiliary items are explicitly included in the analysis, such as the require control devices (motor controller and pneumatic solenoid valve). Many lightweight items are not included, such as wiring, pneumatic tubing, and pneumatic fittings.

Contributors to initial weight

Motors

None. All "overhead" components required for operating a motor are assumed to be already included in the basic robot for both the motor-actuated and pneumatic-actuated designs.

Pneumatics

A fully "on-board compression" design is chosen such that stored air will constantly regenerated as it is consumed by the pneumatic actuator(s). Since we're comparing this design to a continuously-operating motor-driven system, this choice is justified.

Item	*Weight [lbf]*
Compressor	2.39
Air tank	0.56
Primary regulator and bracket	0.41
2X Pressure gauge	0.24
Pressure switch	0.16
Pressure release valve	0.19

<u>Contributors to marginal weight</u>

Motors

The lightest possible choices for a motor, gearbox, and speed controller are the following:

Item	*Weight [lbf]*
BAG motor	0.71
3:1 VersaPlanetary gearbox	0.59
Talon SR speed controller	0.20

Pneumatics

Typical weights for a pneumatic actuator and control valve are given here:

Item	*Weight [lbf]*
Pneumatic cylinder	0.24
Pneumatic solenoid valve	0.09

<u>Conclusions</u>

A system that uses exactly one actuator will have a total weight that equals the sum of the initial weight and the marginal weight. For each additional actuator (of the same type) added to the system, one more instance of the marginal weight is added to this sum. Therefore, the total weight of a system that uses a given number of actuators (greater than zero) is represented by:

$$Total\ weight = Initial\ weight + (Number\ of\ actuators)(Marginal\ weight)$$

For the data presented in the above tables, these systems will have the total weight that is presented in the following table:

No. of Actuators	*Total weight [lbf]*	
	Motors	*Pneumatics*
0	0	0
1	1.50	4.39
2	3.00	4.73
3	4.50	5.06
4	6.00	5.40
5	7.50	5.73
6	9.00	6.06
7	10.50	6.40
8	12.00	6.73
9	13.50	7.07

Using this data, the cartoon graph given in the associated presentation can be rebuilt. It is clear that the break-even point, where a pneumatically-actuated design will weigh approximately the same a motor-actuator design, occurs when between 3 and 4 actuators are required.