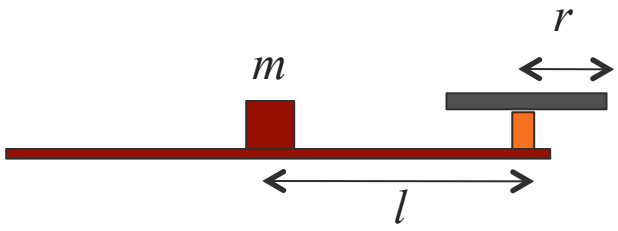
Goals

- Basic mechanics
- Control
- Design considerations
- Agility
- Component selection
- Effects of size

Agility with Scaling

- mass, inertia

$$m \sim l^3, \; I \sim l^5$$



since $r \sim l$

- thrust

$$F \sim \pi r^2 \times (\omega r)^2 \qquad \boxed{F \sim l^2 v^2}$$

rotor angular speed

$$a \sim \frac{F}{m} \sim l^3$$

- moment

$$M \sim Fl \qquad \boxed{M \sim l^3 v^2}$$

$$\alpha \sim \frac{M}{I} \sim l^5$$

maximum accelerations

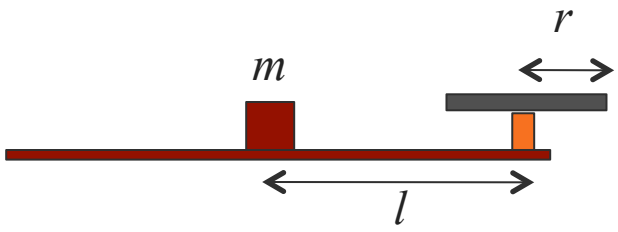
$$a \sim \frac{v^2}{l}$$

$$\alpha \sim \frac{v^2}{l^2}$$

Agility with Scaling

- mass, inertia

$$m \sim l^3, \; I \sim l^5$$



since $r \sim l$

- thrust

$$F \sim r^2 v^2$$

blade tip speed

$$\boxed{F \sim l^2 v^2}$$

$$a \sim \frac{F}{m} \sim l^3$$

- moment

$$M \sim Fl$$

$$\boxed{M \sim l^3 v^2}$$

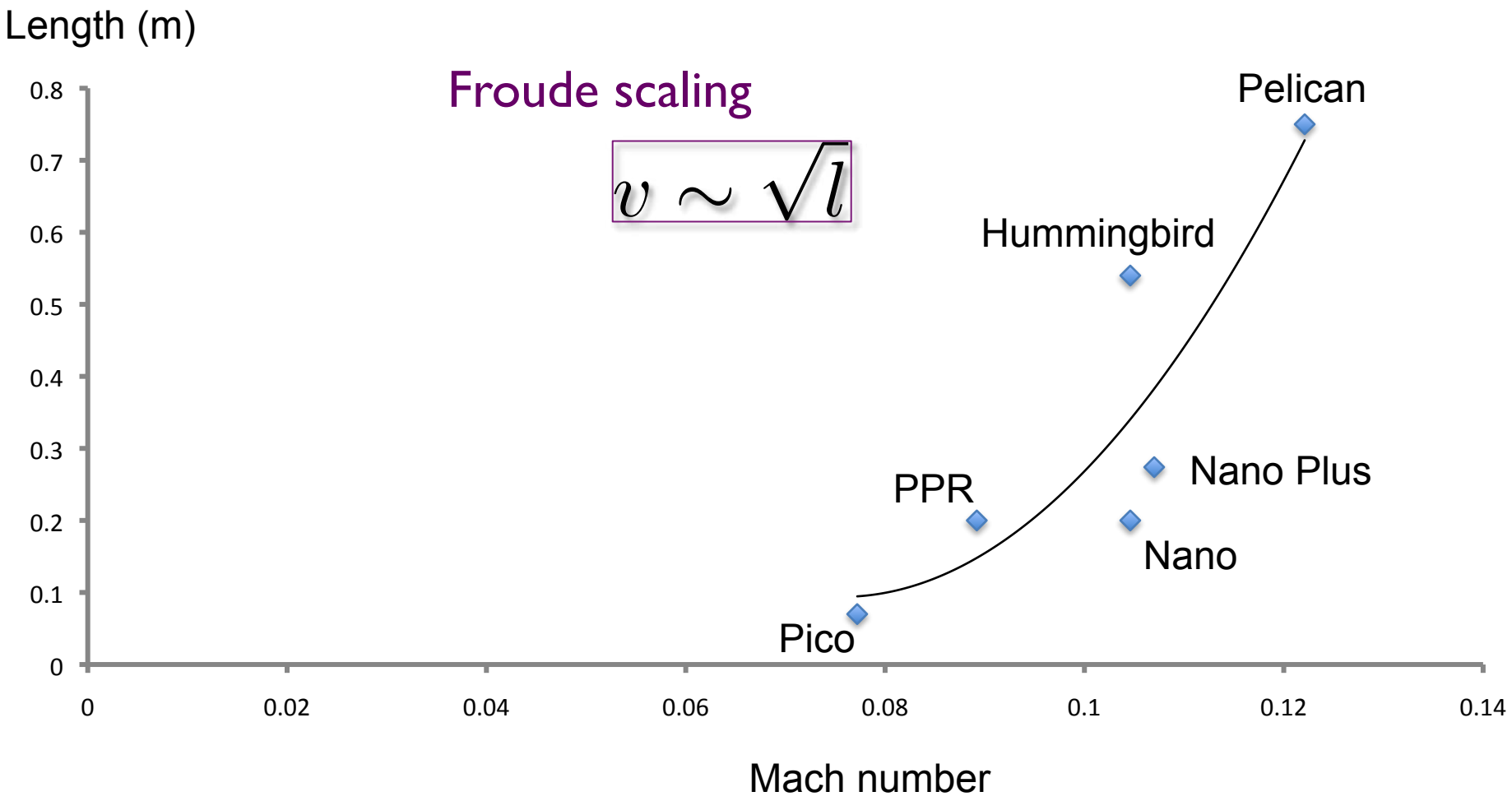
$$\alpha \sim \frac{M}{I} \sim l^5$$

maximum accelerations

$$a \sim \frac{v^2}{l}$$

$$\alpha \sim \frac{v^2}{l^2}$$

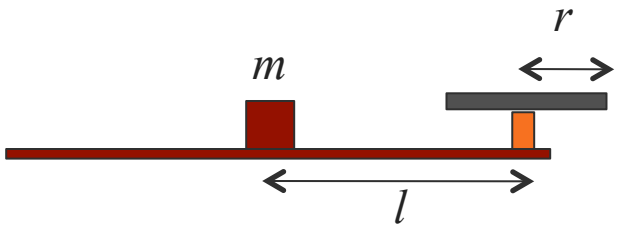
Scaling Experiments



Yash Mulgaonkar, Michael Whitzer, Brian Morgan, Christopher M. Kroninger, Aaron M. Harrington, Vijay Kumar, Power and weight considerations in small, agile quadrotors, in Micro- and Nanotechnology Sensors, Systems, and Applications VI, Thomas George, M. Saif Islam; Achyut K. Dutta, Editors, Proceedings of SPIE Vol. 9083, May 2014.

Agility with Scaling

- Froude scaling



$$v \sim \sqrt{l}$$

$$F \sim l^3$$

$$a \sim 1,\ \alpha \sim \frac{1}{l}$$

- Mach scaling

$$v \sim 1$$

$$F \sim l^2$$

$$a \sim \frac{1}{l},\ \alpha \sim \frac{1}{l^2}$$

The maximum angular acceleration tends to be higher from smaller vehicles