# Wind in Cities: Challenges and Opportunities for MAVs

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#### **Projects at RMIT**

- 1. Talking; interacting with air traffic control
- 2. Sheepdog; rounding up cattle and/or sheep
- 3. Eagle; scaring pigeons from sporting venues
- 4. Brain; using human brain waves for control
- 5. Sampling; monitoring sewage from board of works
- 6. Security; waterproof for communicating with boat refugees
- 7. Quiet; minimising noise from rotors
- 8. Sniffing; gas detection for MFB
- 9. Mining; close up viewing of large open cut mines
- 10.Flight in cities under windy conditions

#### **Use of MAVs in Cities**



#### **Global Trend: Vertical Urbanisation**



Can we extend flight time by using the wind (updrafts, DS)?



How can we keep MAVs as steady as possible?

#### How can we keep MAVs as steady as possible?





X

**TOP-VIEW** (Lower Working Section)

**NOT TO SCALE** 





# **Turbulence Quantities**



- Intensities lu, lv, lw
- Power Spectral Densities
- Integral Length Scales
- Pitch angle as a function of lateral spacing



### Types of Craft Tested



#### Fixed wing







Morphing



Flapping

# Main Conclusions from Flight Trials

- Reducing span gives greater potential roll rates since roll inputs do not reduce as much as polar MOI
- Need better control systems than IMU-based to hold steady flight





# **Avian Sensing**

- Inertial Sensing
- Optical Flow
- Load Sensing (Muscles)
- Local Flow Sensing (Feathers)



Not

explored

## **Biologically inspired pressure sensing**



## Several studies using pressure sensing



Good correlation between upstream turbulence, leading edge pressures and roll but:

 Time between leading edge pressure change and generation of rolling moment is very short (but longer than roll acceleration from accelerometer)

• Our control systems still cannot react sufficiently rapidly

 Need more time-forward information (phase-advanced) thus LATENCY is a big issue





## **Extending Sensing Upstream**







## **Turbulence Modelling**

Studying wind to assist building design and energy harvests in cities



**RMIT University** 





#### Conclusions

- Sensing upstream of aircraft very useful; full patent lodged
- Effect of small scale turbulence negated by technique
- Autonomous updraft soaring possible in cities but challenge is the large scales of turbulence – lift comes and goes







# All in the name of research!!

#### "If we could just get above the trees we wouldn't have to deal with all this bumpiness" Orville to Wilbur circa 1903

Suma

## **PSD** Replication in Tunnel

