FMRA
Fachgebiet Flugmechanik, Flugregelung und Aeroelastizität

Considerations for the Methodology to be used for RECAT Phase II and III

Berlin Institute of Technology

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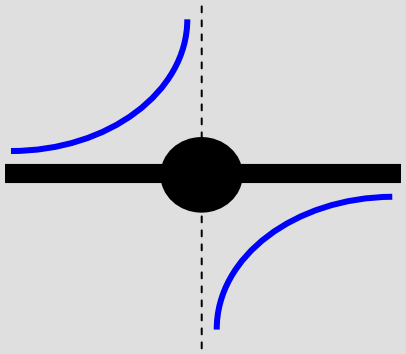
WakeNet3 - Europe Specific Workshop: RE-CATEGORIZATION

1. Motivation
2. Core Radius and Wing Span Ratio Effects
3. Simple Encounter Simulation
4. Sink Rate as a Metric?
5. Conclusion

RECAT Phase I

- Goal: Static separation requirements for aircraft categories
- Severity metric A: Γ



- Severity metric C: $\Gamma / (U_\infty \cdot b_f)$
- Supporting metric: Φ_{max} response

RECAT Phase II & III

- Goal: Static/Dynamic separation requirements for aircraft pairings

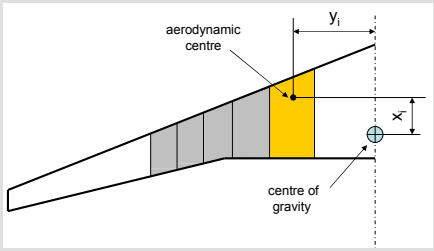
- Same severity metrics?
- Same models for metric computation?

Strip Method to calculate rolling moment coefficient

Analytical Vortex Models
e.g. Burnham & Hallock

$$u_\theta(r) = \frac{\Gamma}{2 \cdot \pi} \cdot \frac{r}{r_c^2 + r^2}$$

Strip Method



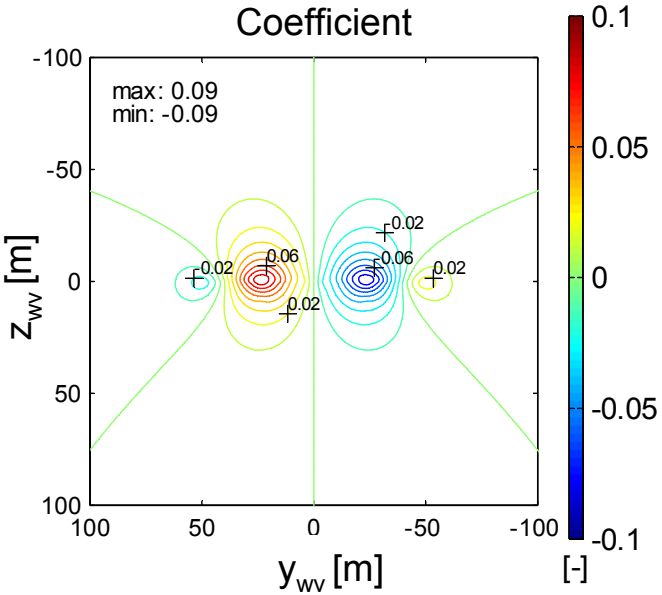
Specific A/C Data

- Wing Geometry, Aerodynamic Data
- MoI

- Computed with updated S-WAKE wake vortex simulation software
- Strip Method more sophisticated than potential vortex integral

Following results show roll acceleration
but
effects also apply to rolling moment coefficient

Induced Rolling Moment Coefficient



Effect of Core Radius r_c

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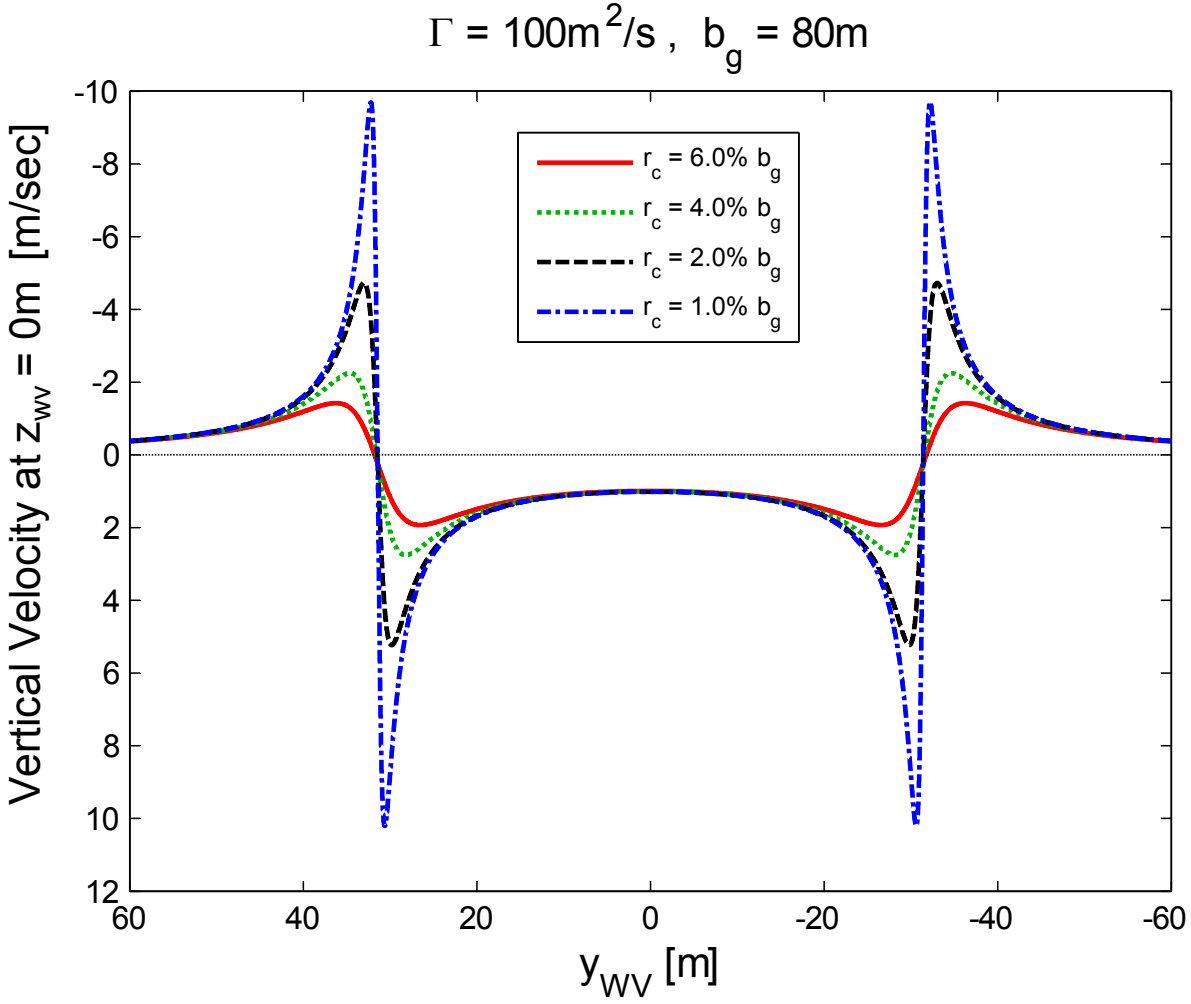
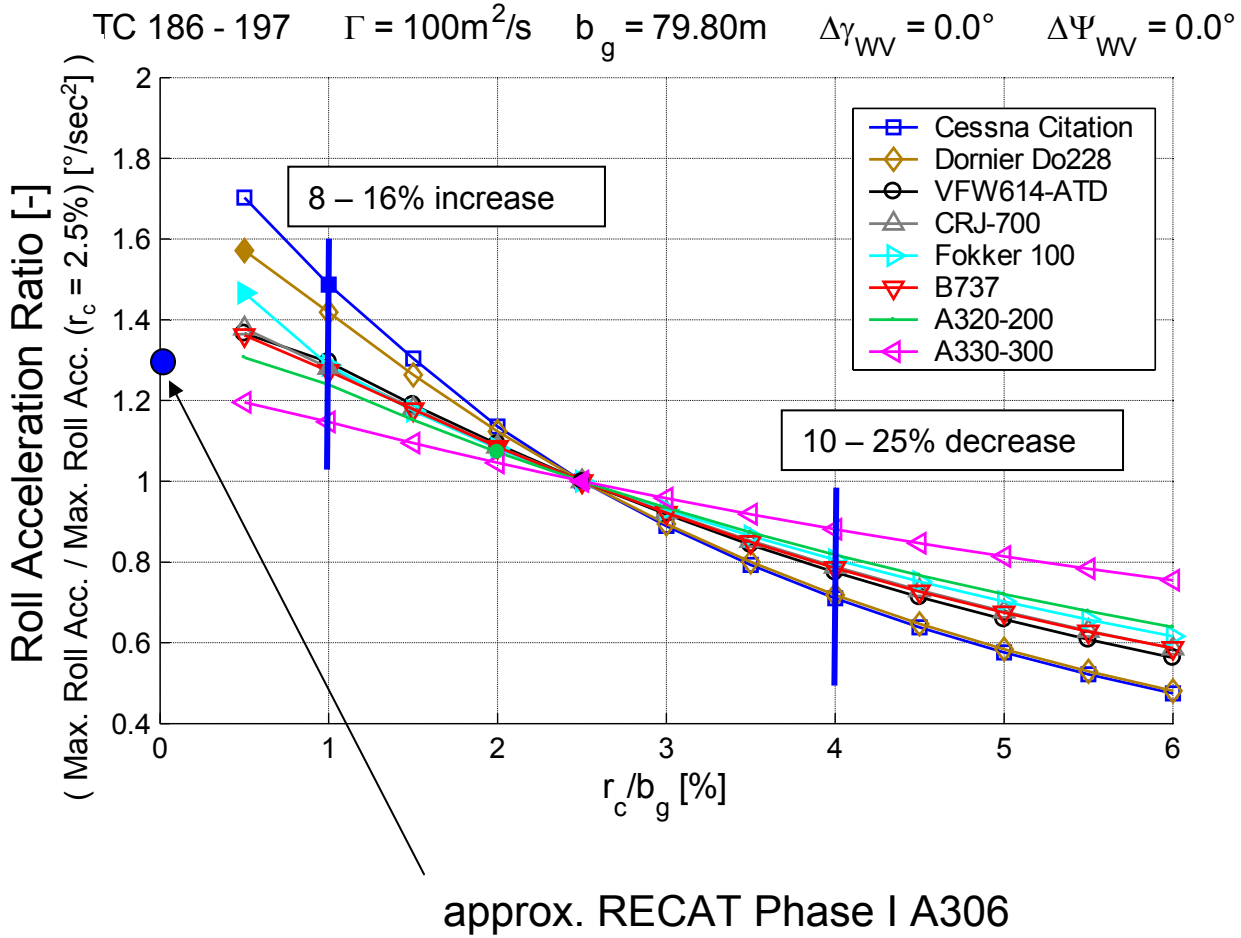


Burnham/Hallock Model

r_c = 0% describes potential vortex case

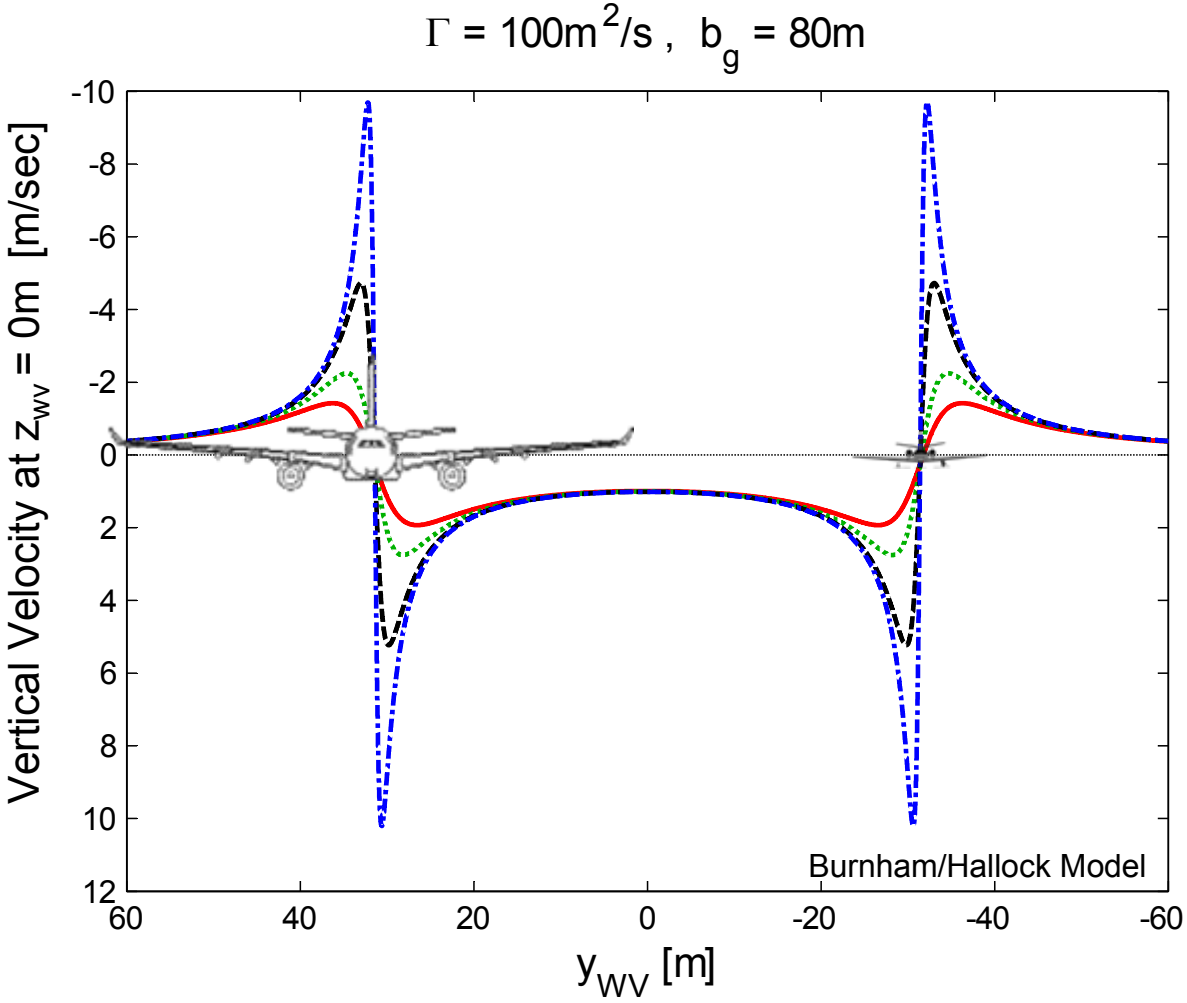
Effect of Core Radius r_c



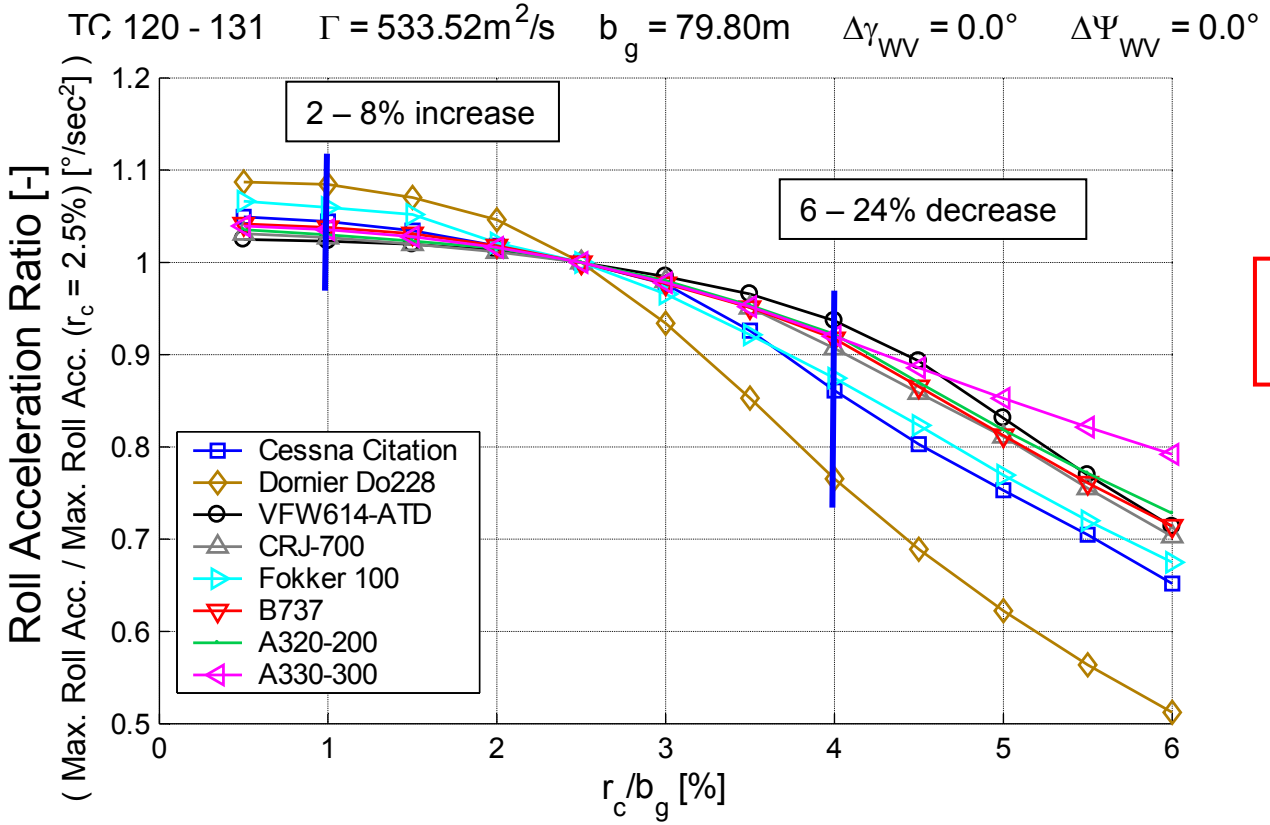
- Core radius effect depends on follower size
- Significant influence of core size for small aircraft
- Smaller influence on larger aircraft

Effect applies to rolling moment coefficient as well

Effect of Core Radius r_c



Effect of Core Radius r_c



Influence of core radius limited by stall effects

Effect of Wing Span Ratio b_g/b_f

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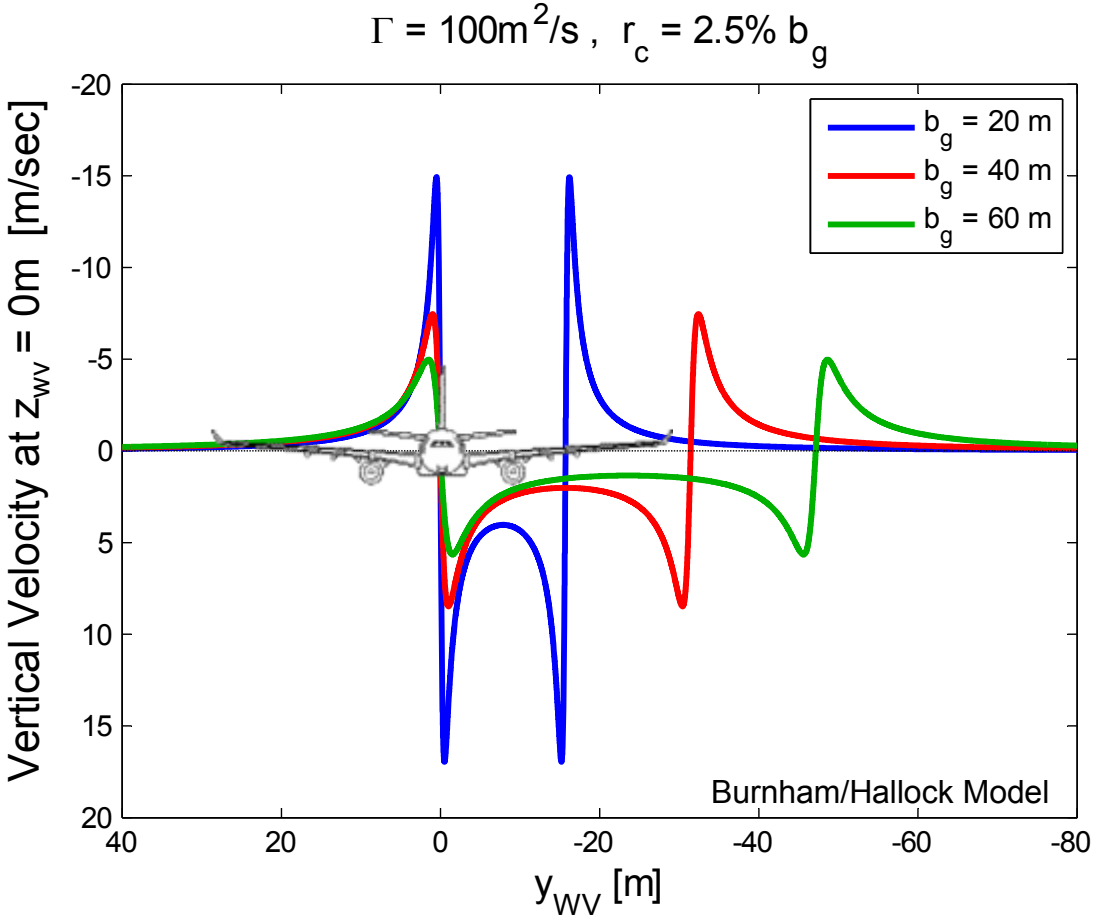
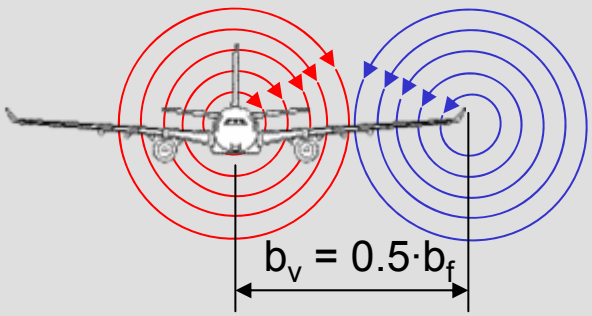


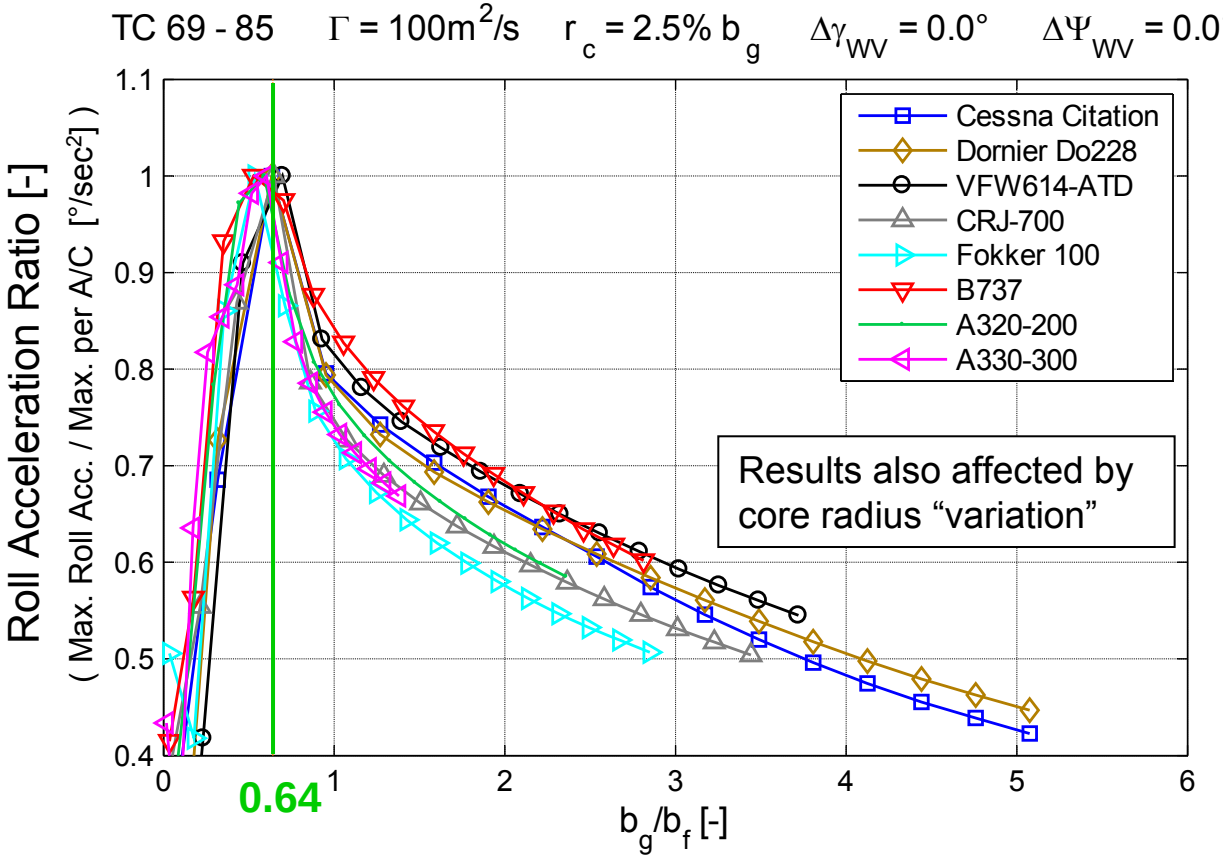
Effect of Wing Span Ratio b_g/b_f

Theoretical Worst Case for Roll Acceleration



$$0.5 \cdot b_f = b_v = \pi/4 \cdot b_g$$

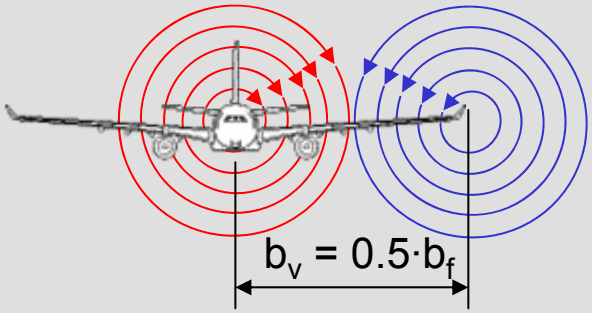
$$b_g/b_f \approx 0.64$$



Effect applies to rolling moment coefficient as well

Effect of Wing Span Ratio b_g/b_f

Theoretical Worst Case for Roll Acceleration



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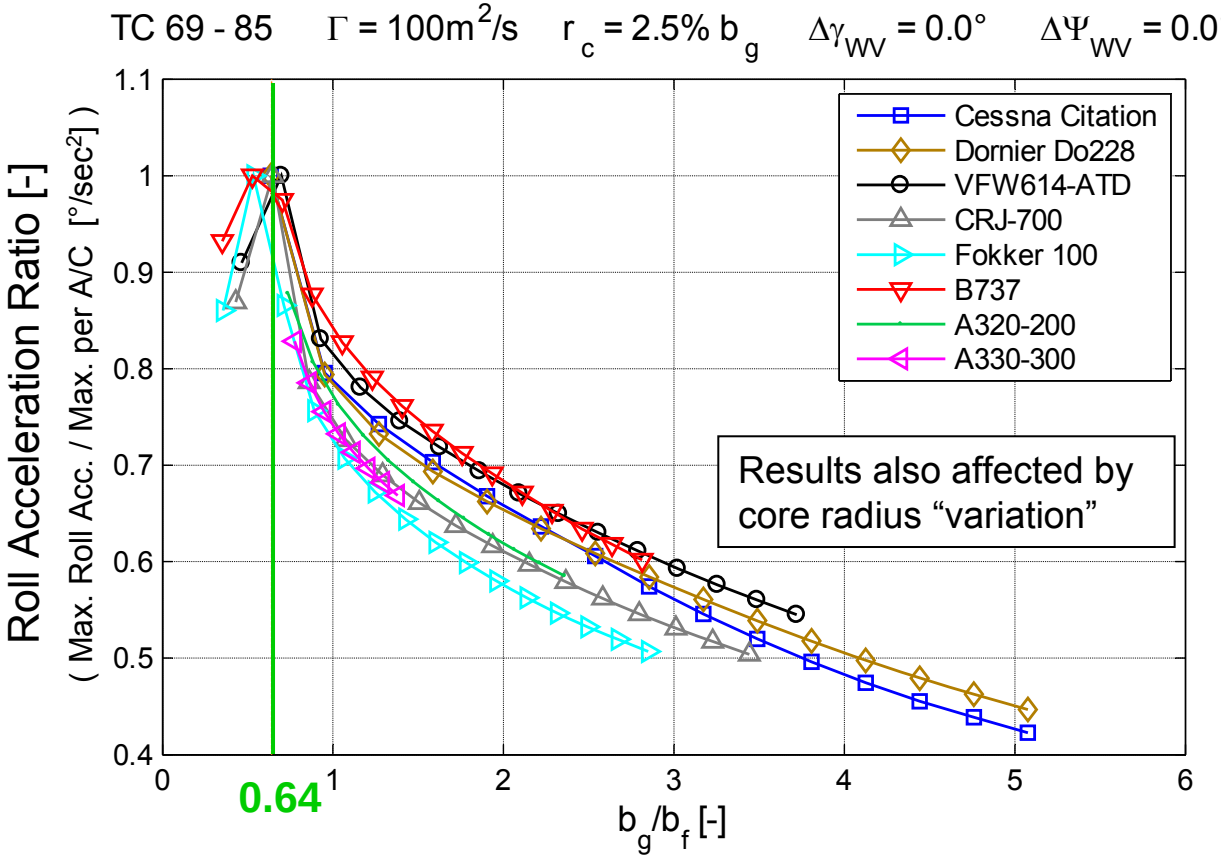


Realistic wing span ratios
e.g. $b_g \geq 10$m

Core radius and wing span ratio affect induced roll acceleration / rolling moment coefficient !

Is it necessary to consider r_c and b_f/b_g in the severity assessment for RECAT II & III ?

If so, how ?

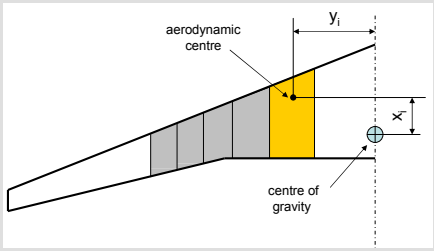
Simple Vortex Encounter Simulation

Strip Method to calculate bank angle response

Analytical Vortex Models
e.g. Burnham & Hallock

$$u_\theta(r) = \frac{\Gamma}{2 \cdot \pi} \cdot \frac{r}{r_c^2 + r^2}$$

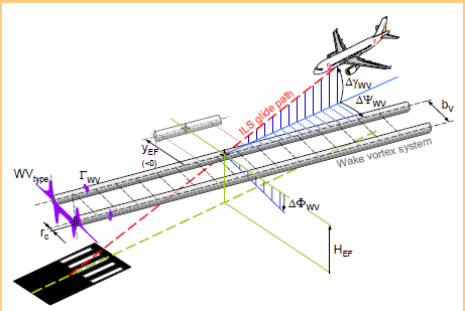
Strip Method



Specific A/C Data

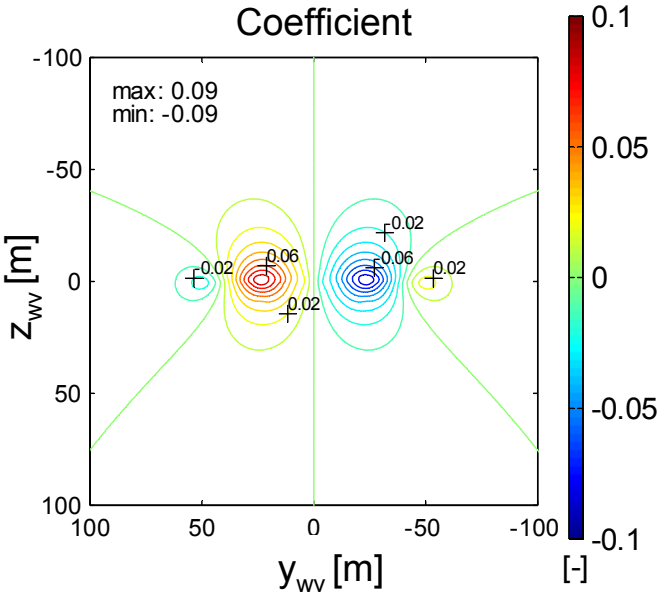
- Wing Geometry, Aerodynamic Data
- MoI

Encounter Geometry



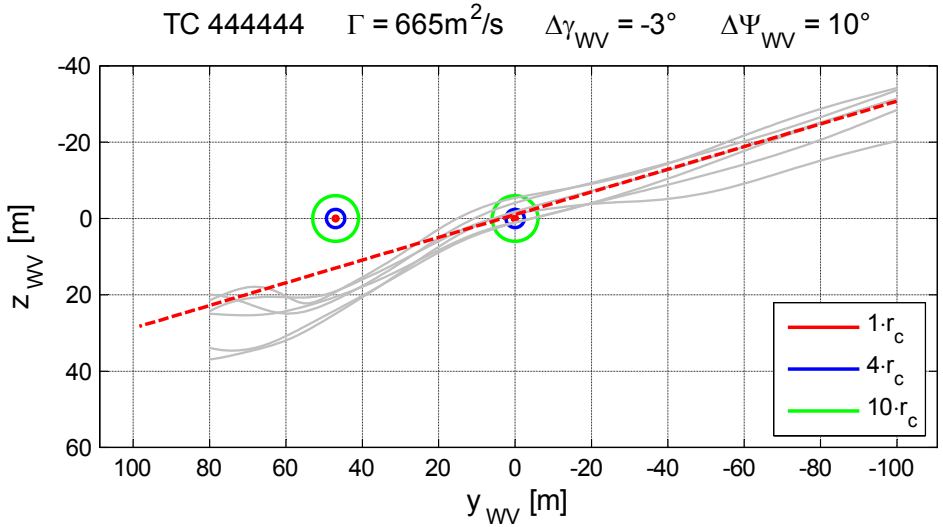
Worst Case Scenario

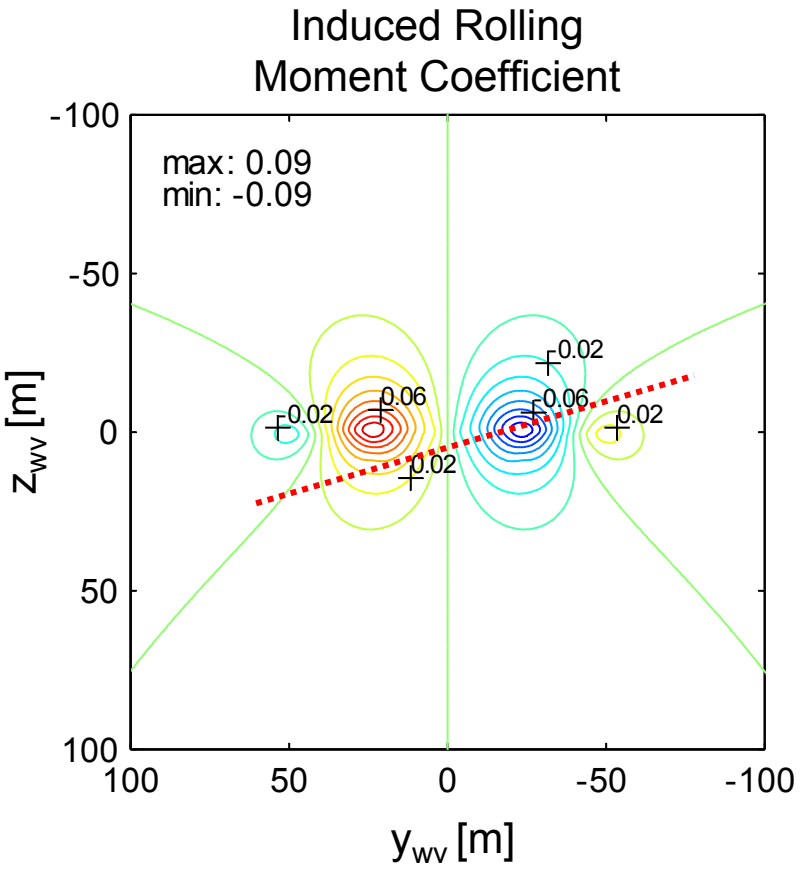
Induced Rolling Moment Coefficient



Flight Path Assumption

- Worst case scenarios: $\Delta\Psi_{WV}$ = 10 – 15°
- Flight path almost straight



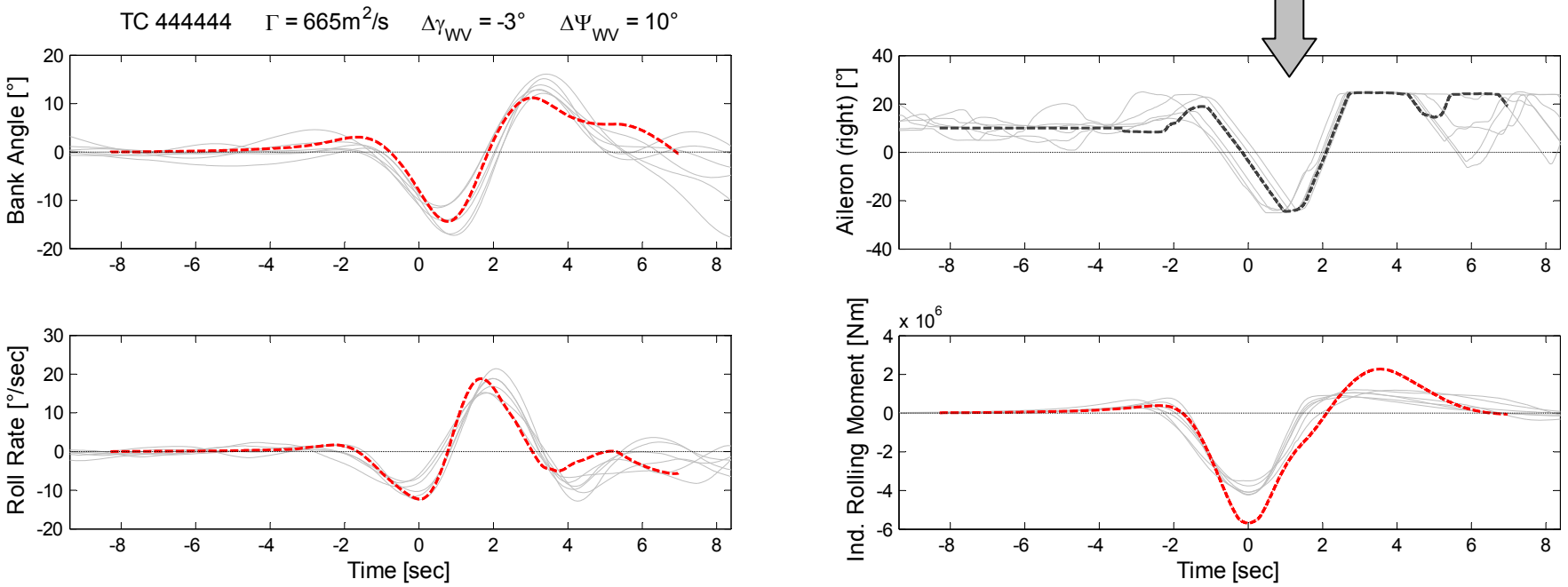


Recorded data from A330 FFS

Simplified flight path (straight)

Simple Vortex Encounter Simulation

- Dynamic vortex disturbance
- Linear 1DoF model for aircraft roll motion
- Recorded control surface deflections



Recorded data from A330 FFS

Simple simulation model

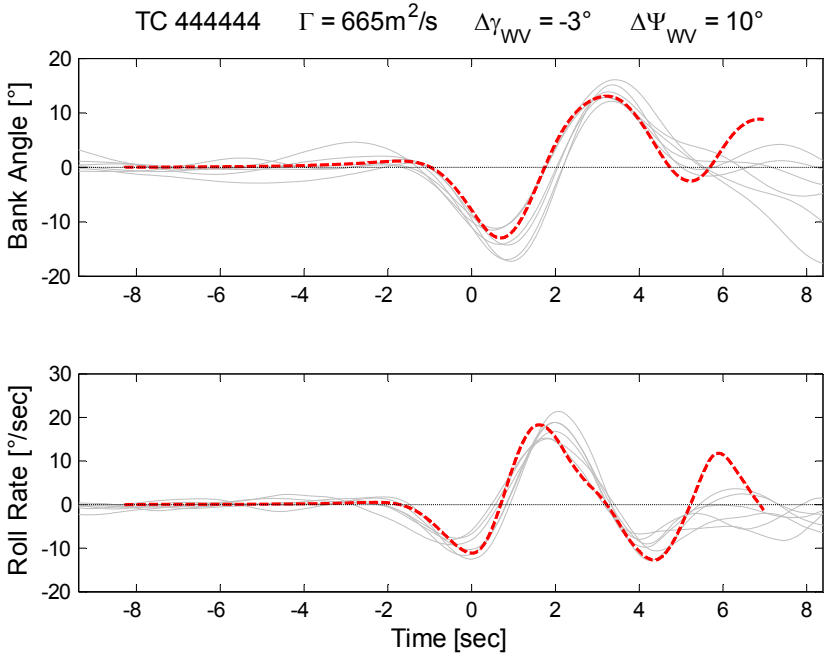
Simplified Vortex Encounter Simulation

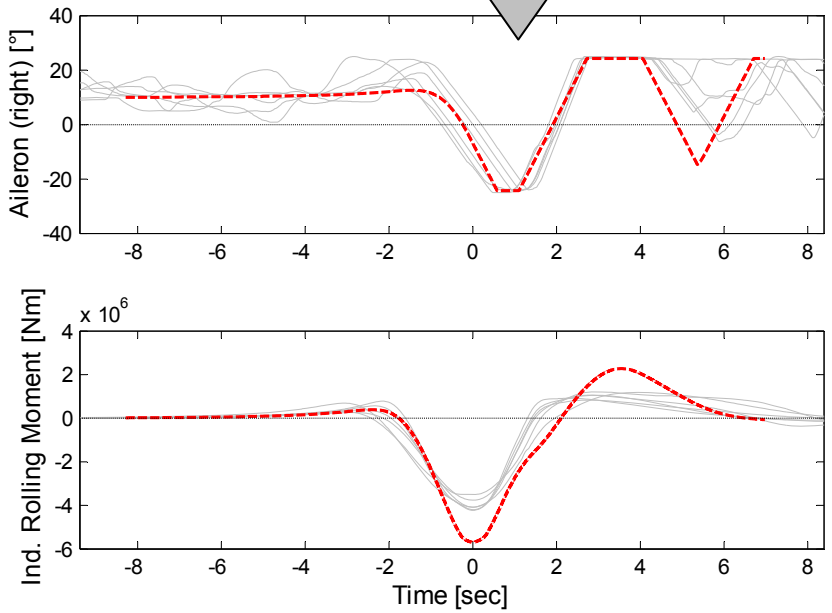
- Dynamic vortex disturbance
- Linear 1DoF model for aircraft roll motion
- Generic control surface deflections

Simple Pilot model

+

Simple FCS model





Recorded data from A330 FFS

Simple simulation model

All elements modeled!
Conservative model?
→ Research need!

Simple dynamic models for roll rate and bank angle computation are feasible.

Is it necessary to consider roll rate and bank angle in the severity assessment for RECAT II & III ?

If so, there is development need for such models.

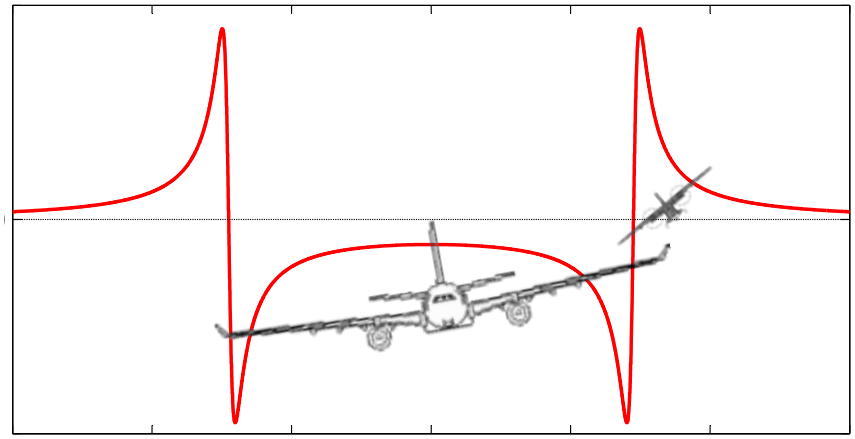
Sink Rate as a Metric?

Do228 (Light)

A330 (Heavy)

Evaluation of pilot ratings documented in SWAKE-TN-320-1-v1

1) Bank Angle
2) Roll Rate
3) Pitch Angle
4) ILS Deviation
5) Sink Rate
6) Yaw Angle
7) Air Speed



1) Sink Rate
2) Bank Angle
3) Pitch Angle
4) ILS Deviation
5) Roll Rate
6) Air Speed
7) Yaw Angle

Sink rate during WVE is important for large aircraft.

Is it necessary to consider sink rate in the severity assessment for RECAT II & III ?

If so, there is research need for simple models.

Thank you for your attention!

Questions?