How to change an engine using an excel spreadsheet

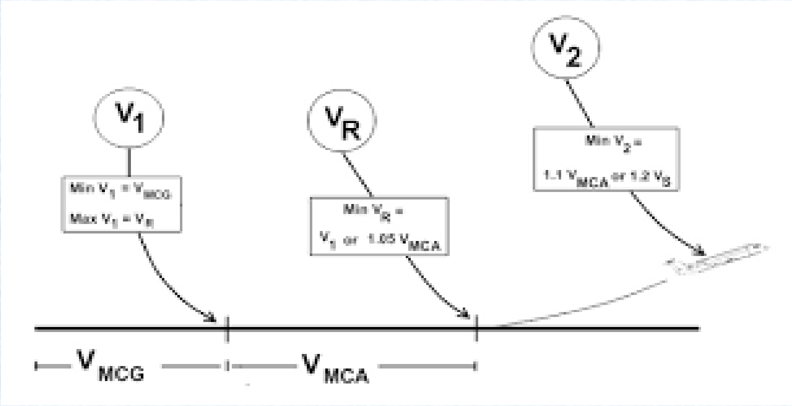
GPCAPT Steve "*Wedge*" Young

Director TED, Air Warfare Centre

FTSA Symposium, AVALON, Feb 2019

Light Tactical Airlift Capability (LTAC) Preview Testing 1998

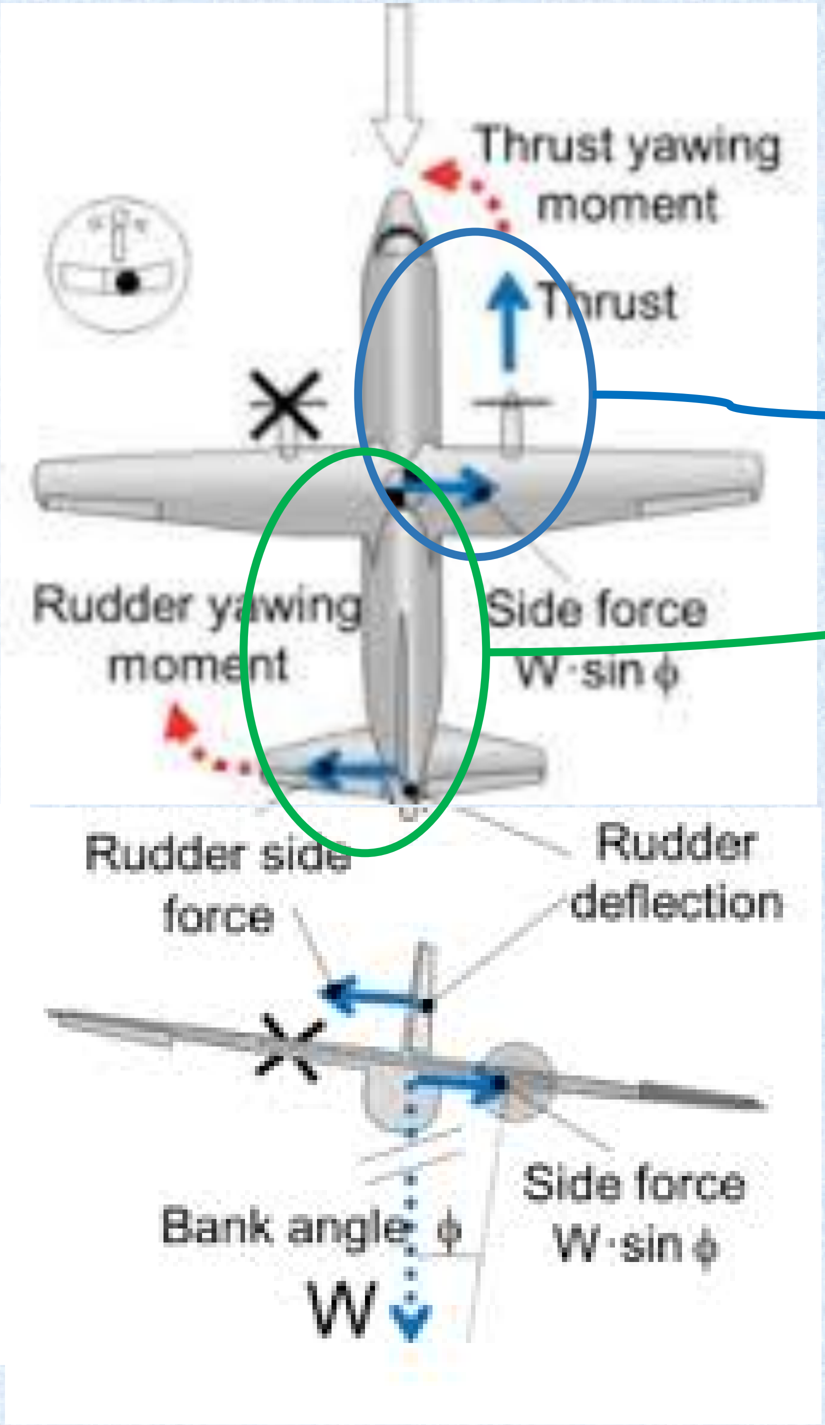
- **The problem** – how to compare STOL Take-off performance
  - C-27J prototype did not exist at that time – Test article was a G-222
  - C-27J modifications likely to significantly affect Vmca and => PGR
    - approximately 30% increase in thrust
    - Rudder deflection limit increased from 30 to 35 degrees to compensate
  - What was Vmca going to be for the C-27J ?



How to turn a G222 into a C-27J before the prototype was built…

…without just trusting the glossy brochure.

Static Vmca

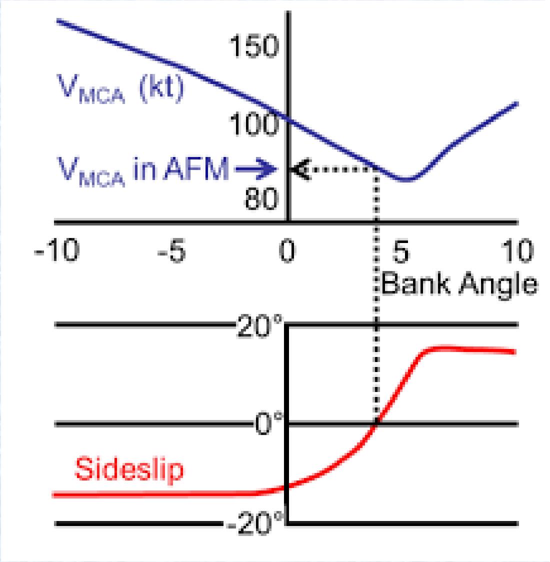


Balancing the moments

- Thrust x Engine Arm = Rudder Force x Rudder Arm

But this induces Sideslip

- Reduces rudder authority



Bank towards live

- Weight component opposes rudder sideforce
- Sideslip can be zeroed out recovering Fr
  - Vmca reduces
  - Up to 5 degrees bank permissible

A bit of maths…

Thrust x Engine Arm = Rudder Arm x Sideforce

$$F_{Thrust} = k\,F_Y$$

$$F_{Thrust} = \tau\,\Omega\,\eta_{prop} \qquad \mathrm{F_Y} = (C_{Y_{\delta r}}\delta r + C_{Y_\beta}\beta)q$$

So, $$\tau\,\Omega\,\eta_{prop} = k\,v_e^2(C_{Y_{\delta r}}\delta r + C_{Y_\beta}\beta)$$

$C_{Y_\beta}\beta \rightarrow \emptyset$

for constant Ve, $$F_{Thrust} = k\,C_{Y_{\delta r}}\,\delta r$$ or, $$C_{Y_{\delta r}} = \frac{1}{k} * \frac{\partial F_{Thrust}}{\partial \delta r}$$

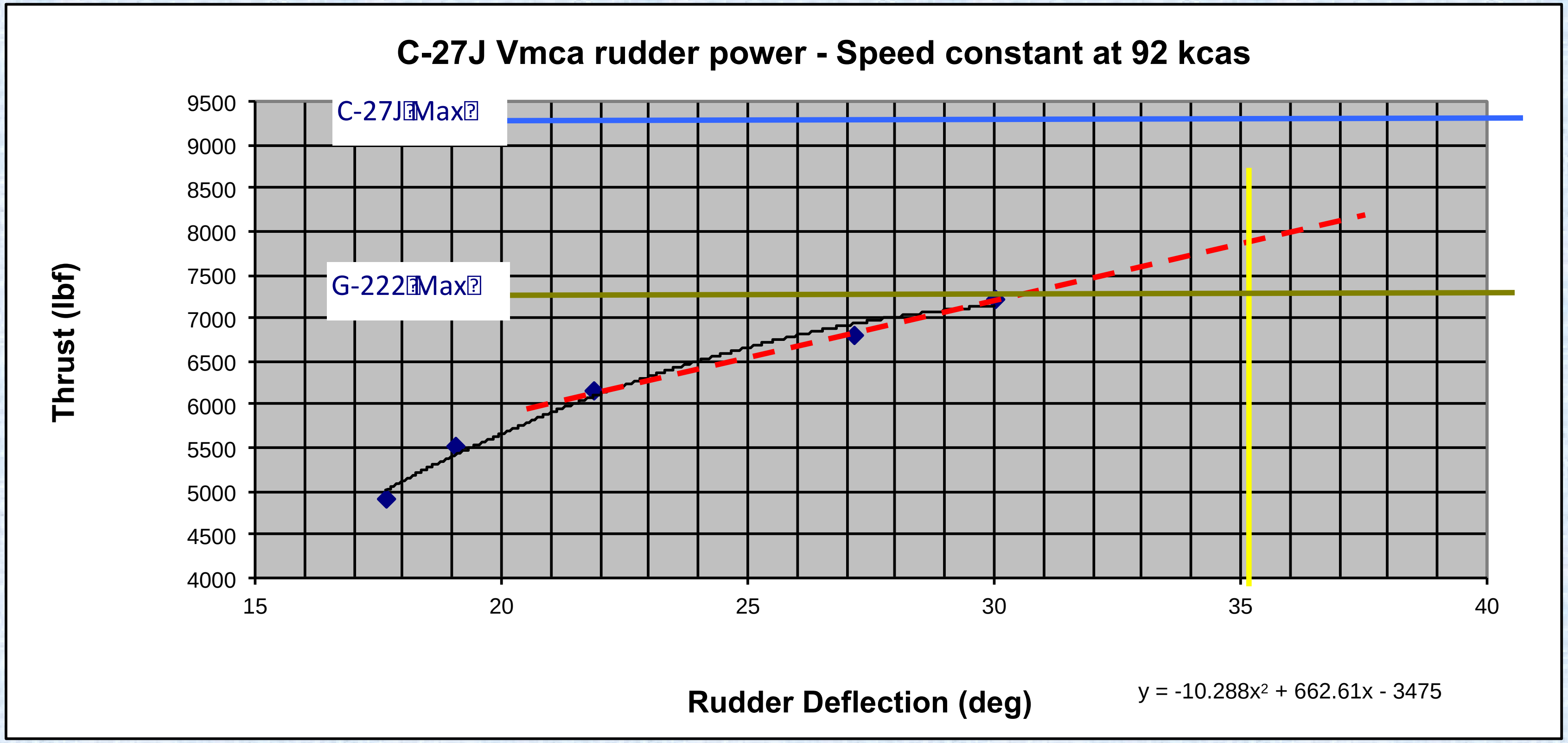
and then, $$\boldsymbol{v_{mca}} = \sqrt{\frac{\boldsymbol{\tau\,\Omega\,\eta_{prop}}}{\boldsymbol{k\,C_{Y_{\delta r}}\delta r}}}$$

Test Method

Measure the rudder defection required to maintain a stable Vmca condition across a range of power settings at a constant speed (92 KIAS)

- *Trim point – Nominally 1.3 Vs , PLF, AEO, 1000ft below test altitude.*
- *Shut down the critical engine*
- *Decelerate to target speed (92 KIAS)*
- *Increase operative engine to target thrust setting*
- *Maintaining zero sideslip by banking towards the live engine (<5AOB)*
- *Measure the rudder deflection (δr) required to hold constant heading*
- *Recover and repeat at next power setting.*

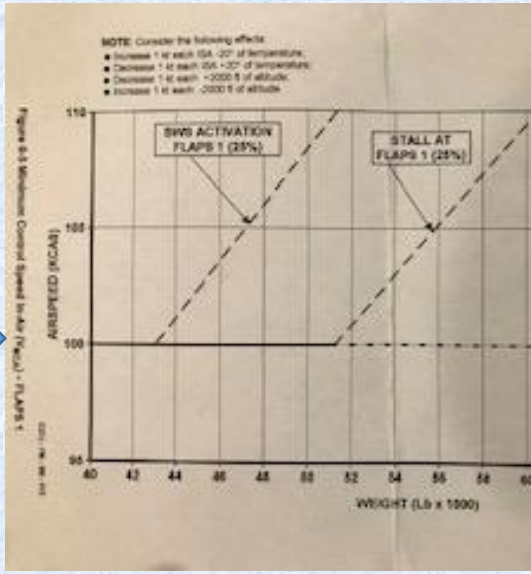
Results



Maximum thrust for	**92**	**kcas Vmca at ____;**	35	
Linear extrapolation of last 3 points gives			7880	lbf
2nd order excel fit gives			7114	lbf

Vmca	C-27J max thrust	9369	
Estimate	Best Case	100.3	kcas
	Likely Case	105.6	kcas

100




A34-001
001
001
AUSTRALIAN AIR FORCE

Questions…