CONTINUOUS CLIMB OPERATIONS WITH MINIMUM FUEL BURN

Judith Rosenow, Stanley Förster and Hartmut Fricke
Delft, 2016-11-2016
Continuous Climb Operations

Conventional climb profile
Continuous Climb Operations

Continuous climb profile:

- min. level-offs
- min. thrust changes
Continuous Climb Operations

Continuous climb profile:

min. level-offs
min. thrust changes

Climb gradient 3%...16%

Aircraft?
Weather?

Definition complete?
Continuous Climb Operations

Conjectures:
Min. fuel CCO depend on

Aircraft weight

Enigne power

Aircraft aerodynamics

Atmosphere
Methodology

• CCO simulation
• A320, B738, MD11F, B777F
• Real weather

Flight performance model COALA
Air traffic simulation tool TOMATO
Methodology

COALA: COmpromized Aircraft performance model with Limited Accuracy:

- Unsteady flows
- (not) empirical
- BADA: $c_W$ ($c_A$), MMO, MCL, $m_f$
- $\sin \gamma_{TAS} \rightarrow \max$
Methodology

Min. fuel CCO depend on:
Cruising pressure and cruising TAS

Climb angle and TAS

\[ \text{TAS}_{\text{new}} = \alpha \text{TAS} \]
Methodology

Min. fuel CCO depend on:
- Cruising pressure and cruising TAS
- Climb angle and TAS

\[ \text{TAS}_{\text{new}} = \alpha \times \text{TAS} \]

Are these parameters constant for each aircraft type?
CCO Results

Optimized CCO:

A320: $\alpha =1.01$  
B738: $\alpha =1.01$  
MD11F: $\alpha =0.98$  
B777F: $\alpha =1.00$

A320: $p=210$ hPa  
B738: $p=200$ hPa  
MD11F: $p=190$ hPa  
B777F: $p=220$ hPa
Outlook

Continuous climb cruise A320

\[ \alpha = 1.01 \quad p = 220 \ldots 180 \text{ hPa} \]

\[ \alpha = 1.01 \quad p = 210 \text{ hPa} \]

\[ \frac{TAS}{m_f} \rightarrow \text{max} \]
Outlook

Application

Today:
1. Wind optimal lateral path at preferred flight level
2. Climb: TAS for max. climb rate
   \[ \sin \gamma \cdot TAS \]
3. Cruise: TAS for max. spec. Range
   \[ \frac{TAS}{m_f} \]

Tomorrow:
4. Cruise: Altitude adjustment to max. spec. Range and wind optimal lateral path
Thank you for your attention

Continuous Climb Operations with Minimum Fuel Burn

TU Dresden
Dr.-Ing. Judith Rosenow
Judith.Rosenow@tu-dresden.de

Financed in the framework of MEFUL by