Meggitt Aircraft
Braking Systems

BOMBARDIER


# Brake Wear Life Improvement

## C Series Operator's Conference

Orlando – 23 April 2018



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# Disclosure

# Outline

- Current state
- Review of aircraft operations
- MABS wear life testing program
- Carbon brake operational recommendations

# C Series brakes current state

- Based on Swiss and Air Baltic returns, C Series brake wear life is not currently meeting MABS' or BA's expectations
- CS100
  - Brake is currently averaging slightly over 1200 Landings per Overhaul (LPO)
  - Based on 62 removals at Swiss
- CS300
  - Brake is currently averaging slightly over 1350 LPO
  - Based on 14 removals at Air Baltic and Swiss
- Jump seat rides were undertaken by MABS at Swiss to help with the analysis of the operating environment

# Review of aircraft operation

## Observations / conclusions

- Brake temperatures:
  - Dispatch was typically with BTMS at 01 or 02
  - Average temperature of BTMS 04 during landing stop
  - Highest temperature during one landing stop was BTMS 07

- "BRAKE HI TEMP"
  - BRAKE HI TEMP advisory may be creating unnecessary apprehension about the thermal capability of the brakes

Swiss

CS100 Certified Max KE RTO

| Display | | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BTMS (deg C) | lower | 0 | 36 | 72 | 108 | 144 | 180 | 216 | 252 | 308 | 364 | 420 | 476 | 532 | 588 | 645 | 702 | 759 | 816 | 873 | 930 | 986 |
| | upper | 35 | 71 | 107 | 143 | 179 | 215 | 251 | 307 | 363 | 419 | 475 | 531 | 587 | 644 | 701 | 758 | 815 | 872 | 929 | 985 | 986 |
| Limitations | | No restrictions | | | | | | | Allow the brakes to cool down within the green band for takeoff. | | | | | | | | No dispatch, cool down the brakes and do a wheel inspection. | | | | | |
| Messages | | None | | | | | | | BRAKE HI TEMP | | | | | | | | BRAKE OVHT | | | | | |





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# Review of aircraft operation (cont.)
## Observations / Conclusions

- Idle thrust:
  - Aircraft accelerates rapidly under idle thrust conditions
  - Geared Turbo Fan has received considerable press regarding high idle thrust
  - Idle thrust is a significant factor contributing to high wear
    - Taxi snubs and stops can have a considerable impact on carbon brake life

- Thrust reverser usage:
  - TR absorbs some of the aircraft kinetic energy resulting in colder brakes
    - Swiss uses IDLE or MAX reverse used during all landings
    - Typically, braking is applied toward the end of the landing phase when the A/C speed has significantly reduced (60-80kts)
  - TR on C Series is especially effective
    - IDLE slows the A/C quickly – possibly reflecting the high idle thrust and efficient TR design
    - “MAX is the equivalent of applying medium braking”

# Review of Swiss aircraft operation (cont.)
## Observations / Conclusions

- Turnaround Time:
  - Turnaround time required by Swiss are not challenging to the brake (≥ 35 min)
  - Turnaround time could easily be met by hotter brakes
  - Swiss does 6-7 flights per day.
    - Normally, with this many flights per day, the brakes should be hotter than they are.

- Autobrake:
  - Autobrake is used only about 15% of the time, typically for weather.
  - When used, setting is always medium (MED).
  - If used, it would direct more aircraft KE to the brakes

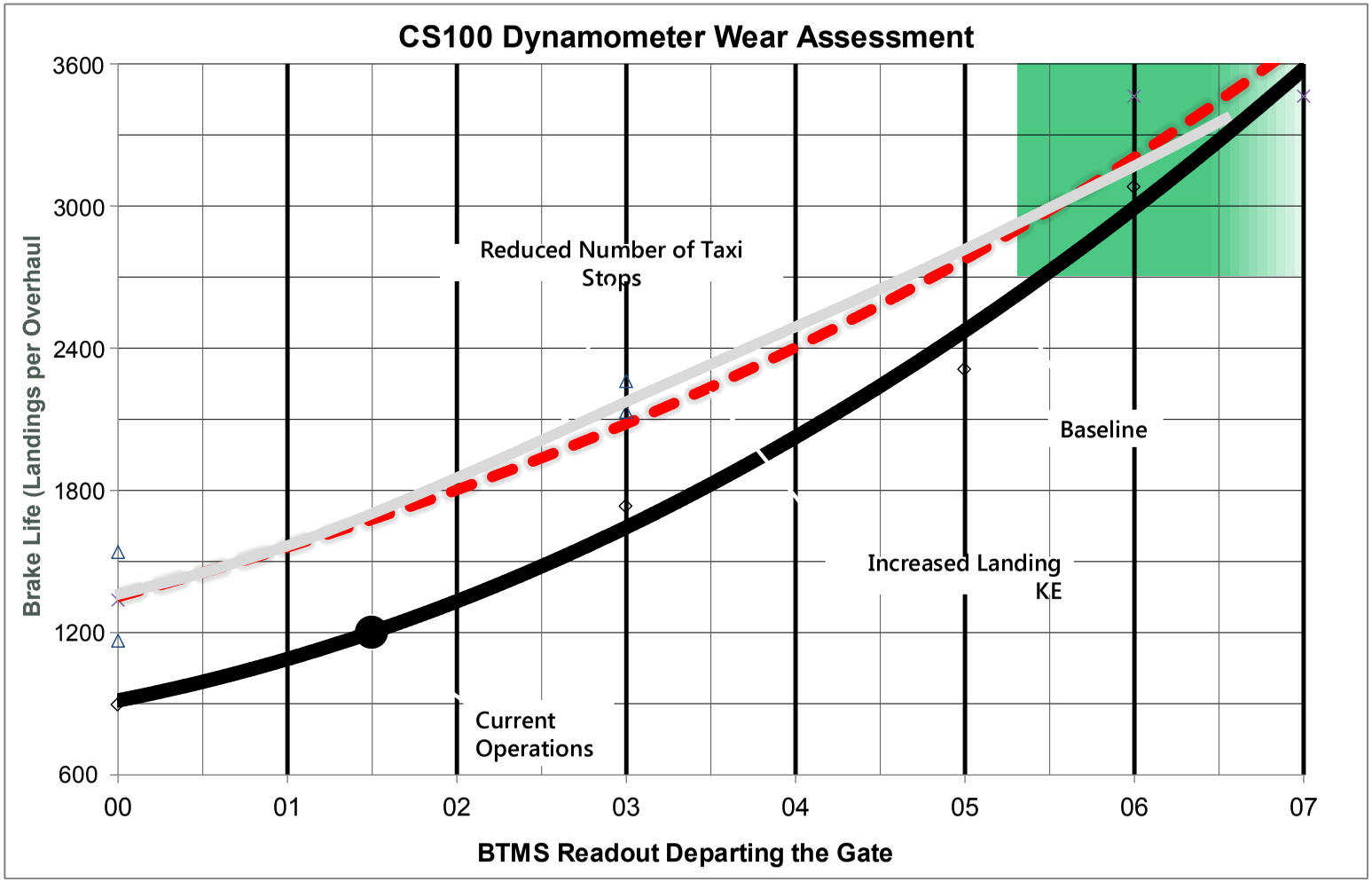
- **Aircraft operation conclusions:**
  - Current operations are unfavorable for brake life
  - The brakes have considerable thermal margin that is not being used

# C Series wear life testing

- MABS has run over 18,500 dynamometer stops on the CS100 brake alone
  - More 15,500 have been service wear testing
- Earlier this year, MABS had been performing round the clock CS100 wear testing
  - Evaluating critical factors which affect the wear rate
  - Over 7000 stops
  - Wear measurement for every braking event
- This wear testing has reaffirmed many of the well-known carbon wear influencers
- Testing has provided the precise operational insight which could be used to significantly alter an airline's brake LPO

# C Series wear life testing

## Lab testing  conclusions





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# C Series wear life testing

## Lab testing conclusions

- Increasing Landing Stop KE:
  - Increasing the main stop KE alone could provide ~40% life improvement from increased taxi-in temperature
  - However, additional benefit results from the increased gate departure temperature
- Taxi-out starting temperature:
  - Brake LPO increase of ~210%  with an increase BTMS from 01/02 to 05
- Reducing the number of Taxi snubs/stops:
  - Reducing by half increases brake LPO by ~40%
- The effects are additive

# Operational improvements
## Win-win opportunity

- MABS believes operational improvements can be a win-win for all stakeholders:
  - **Lower operating costs**
    - Longer engine/reverser life and reduced maintenance cost through lighter duty cycle
    - Improved brake life by increasing the braking energy during landing
    - Longer time on wing for the brakes
    - Potential for reduced fuel burn by avoiding MAX TR except when needed
  - **Safety**
    - Always applying brakes at high speed is a routine that helps avoid surprises
    - Improved engine reliability through lighter duty cycle
  - **Noise**
    - Lower aircraft noise levels by reduced TR use
  - **Operations**
    - Shorter gate waiting times are possible with C Series brakes
      - More flights per day are possible

# Carbon brake operational recommendations

- The guidelines for improving brake life are pretty straightforward
- Get the brakes hot during the landing stop
  - Keep heat in the brakes so that taxi out is as warm as possible
- Management of taxiing activities to minimize stops and snubs, particularly during taxi out conditions with cold brakes
- However, safety is the over-riding consideration in all cases!