



# Sustainable Skies Conference: Contrails in Focus

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The Boeing Company

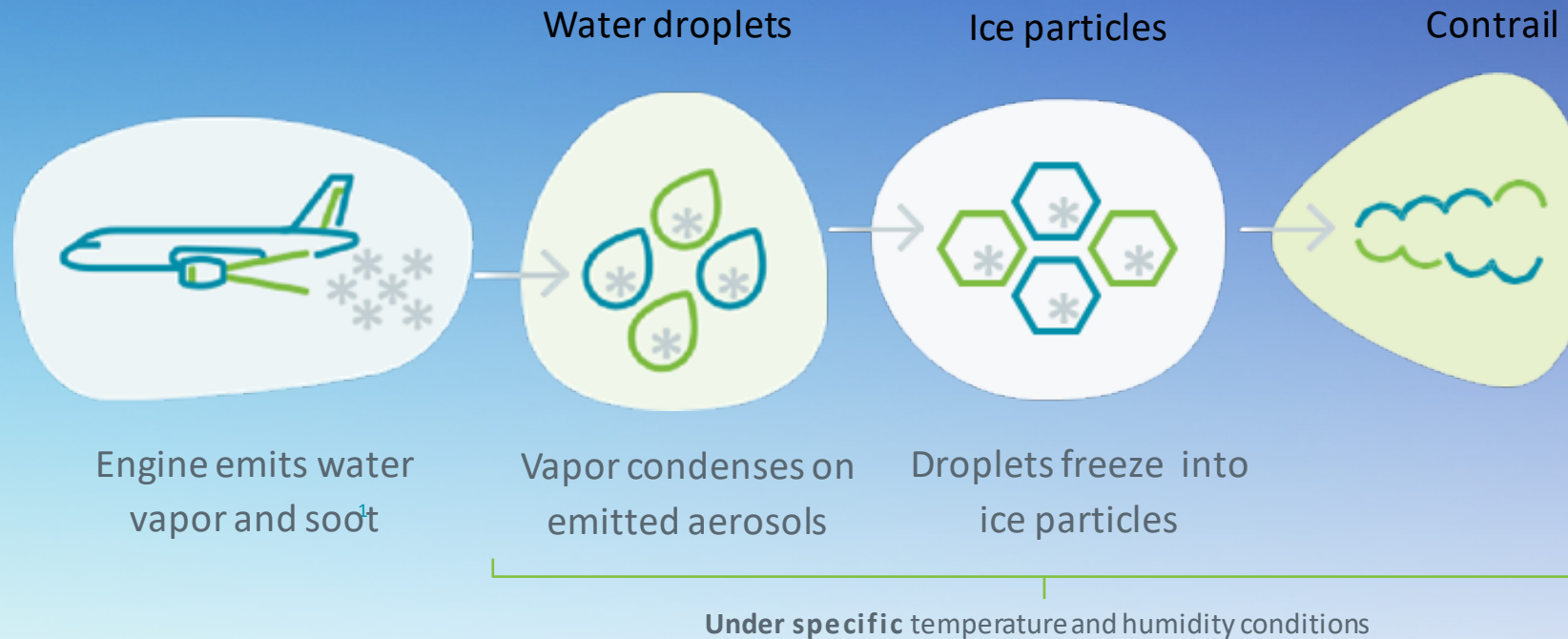
7-8 November 2023

EUROCONTROL's Brussels HQ



# Contrails

A type of cloud that forms in the wake of an aircraft at high cruise altitudes under specific temperature and humidity conditions when water vapor condenses onto emitted aerosols and then freezes to form ice particles.



# Mitigation

Possible pathways to minimize climate impact of contrails

- **Advancing engine combustion technology** to reduce particulate matter
- **Changing fuel composition** to lower fuel aromatic and sulfur content
- **Enabling aircraft route optimization** through improving upper tropospheric humidity forecasts and leveraging satellite observations

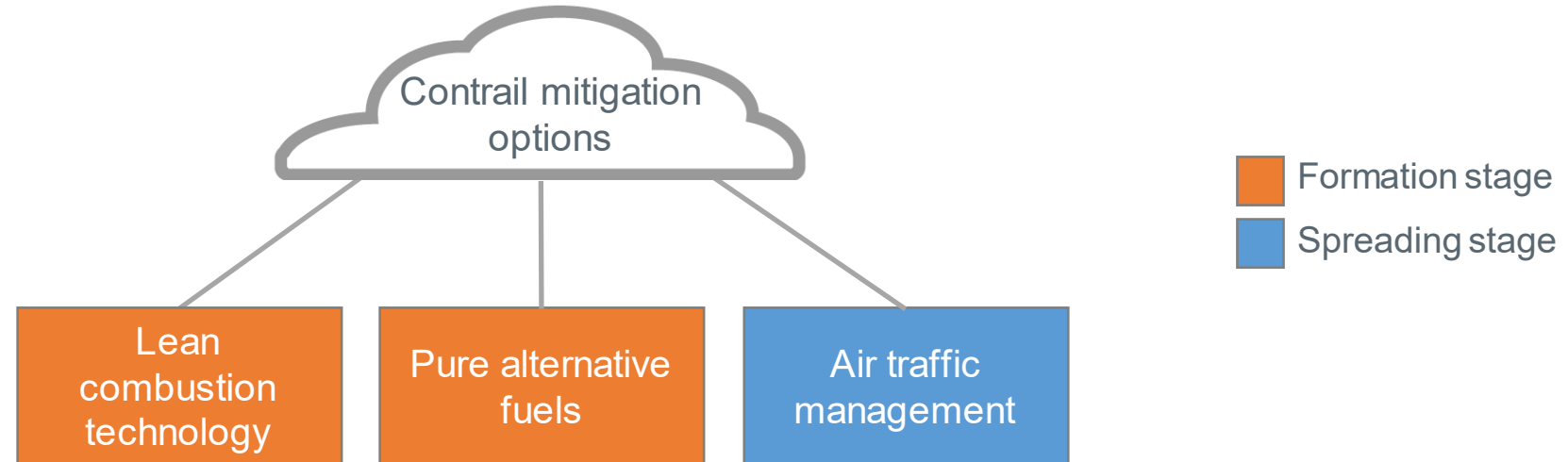
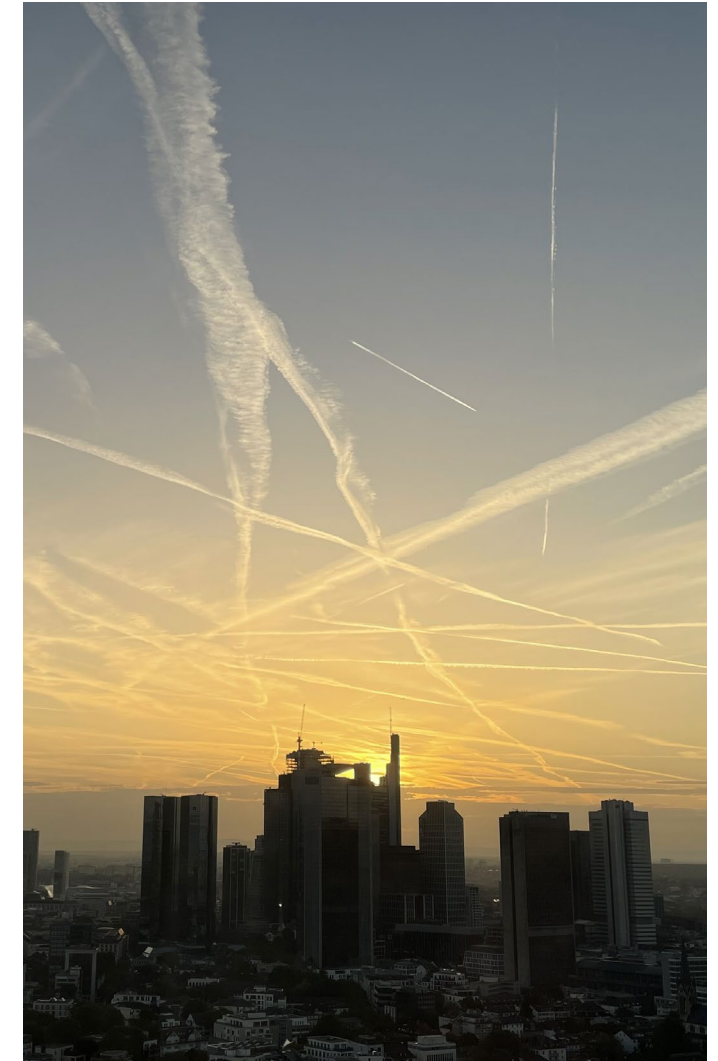


Figure adapted from Kärcher et al., *Nature Comm.*, 2018, DOI: 10.1038/s41467-018-04068-0

# Boeing's approach

- **Boeing, NASA, FAA partnership** - multi-year emissions testing research on the Boeing ecoDemonstrator program for fuels and engine technology
- **The U.S. Department of Energy ARPA-E PRE-TRAILS program** - Mature technologies for near-term mitigation of persistent contrails that may contribute to aviation's climate impact
- **Enabling operational changes through industry collaborations** – CICONIA, RMI Contrails Task Force, Chief Technology Officers Non-CO<sub>2</sub> Working Group, industry standards (WMO, RTCA/EUROCAE), etc.



# Boeing ecoDemonstrator emissions testing

SUSTAINABLE  
AEROSPACE  
TOGETHER

ecoDemonstrator  
PROGRAM



2021



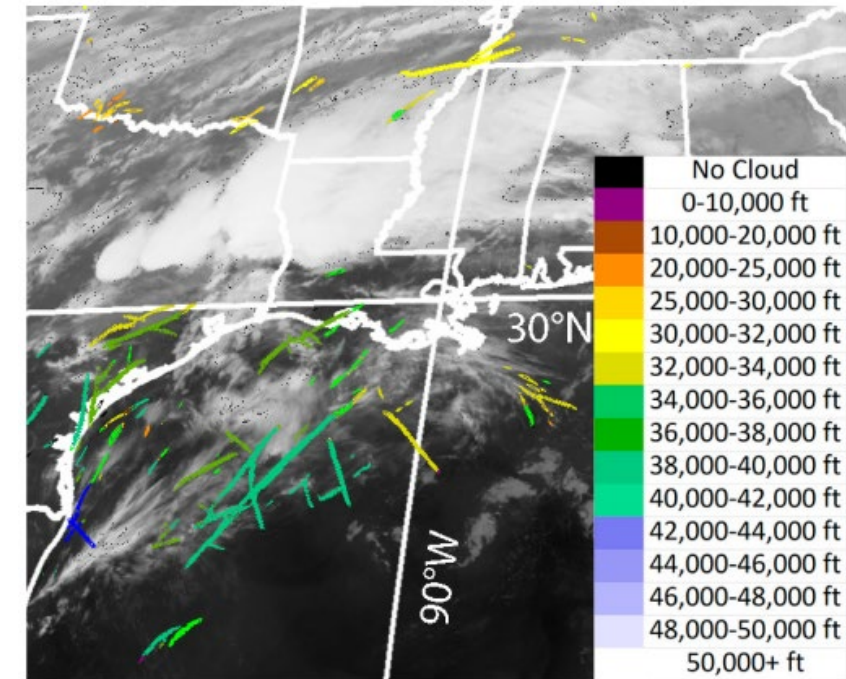
2022



2023

## Contrail **IN**formation for **C**ollaborative **O**perations

- **Objective:** Mature technologies for near-term mitigation of persistent contrails that may contribute to aviation's climate impact
- **Team:** Avionics sensor suppliers, satellite meteorologists, Boeing engineers
- **Approach**
  - Development of a water vapor sensor is a key tenet of this effort - humidity in the upper troposphere is not well understood
  - Blend satellite-based observations, deep learning and emerging observations from improved water vapor sensors
  - Use of a higher resolution numerical weather prediction model
  - Develop a comprehensive approach for operational mitigation of strongly warming persistent contrail



Hoffman et al., *Remote Sensing*, 2023, 15, 2854.

# Collaboration to enable operational mitigation

SUSTAINABLE  
AEROSPACE  
TOGETHER

- **Joint initiatives**
- **University research**
- **Airline partnerships**
- **Industry collaboration**
- **Government agencies**

