Boeing Commercial Airplanes
Technology Trends & Opportunities

Presented at FAA Research, Engineering, & Development Advisory Committee (REDAC) Subcommittee for Aviation Safety (SAS)

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7 September 2017

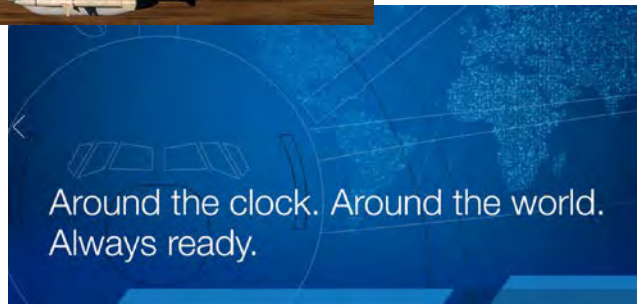
Agenda

- **Company overview**
- **Aviation safety**
- **Certification efficiency**
- **Technology trends**
  - Autonomy
  - Systems
  - Environment
  - Propulsion
  - Structures
  - Performance
  - Additional focus areas
- **Conclusions**

Overview

BCA

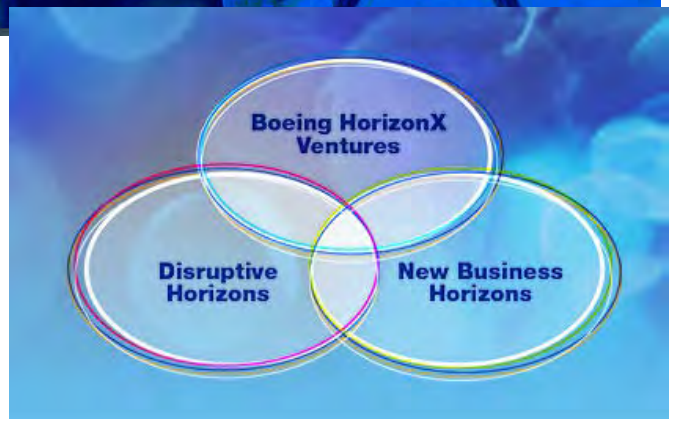
BDS



BGS

Engineering, Test & Technology

Investing to Accelerate Innovation



Global Research & Development Centers

1916|2016 100 BOEING

Boeing Capital Corporation

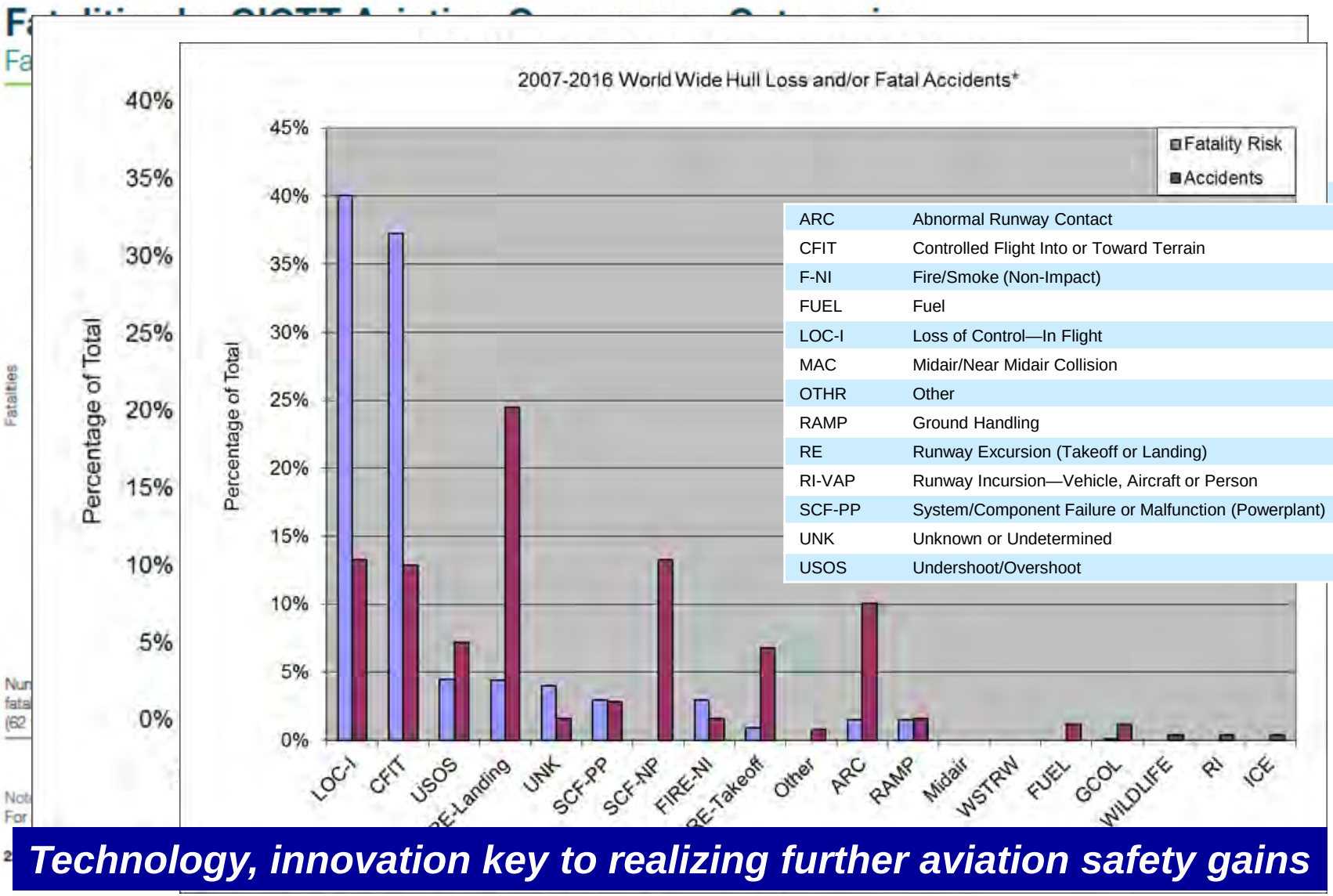
BOEING ANALYTX

JEPPESEN
A BOEING COMPANY

INSITU

CDG
a Boeing Company

Aviation Safety - Commercial Jets

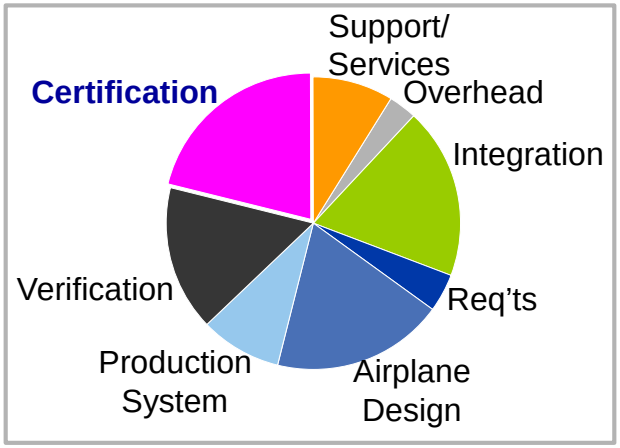


ARC	Abnormal Runway Contact
CFIT	Controlled Flight Into or Toward Terrain
F-NI	Fire/Smoke (Non-Impact)
FUEL	Fuel
LOC-I	Loss of Control—In Flight
MAC	Midair/Near Midair Collision
OTHR	Other
RAMP	Ground Handling
RE	Runway Excursion (Takeoff or Landing)
RI-VAP	Runway Incursion—Vehicle, Aircraft or Person
SCF-PP	System/Component Failure or Malfunction (Powerplant)
UNK	Unknown or Undetermined
USOS	Undershoot/Overshoot

Technology, innovation key to realizing further aviation safety gains

Certification Efficiency

- **Challenges**
  - Certification cost is significant
  - Globalization
    - role of NAAs increasing
  - Regulatory standards for new technology
    - tendency towards prescriptive
    - often developed in reactive environment



Distribution of Airplane Development Costs

- **Opportunities**
  - Productive engagement early in technology development process
  - Airworthiness standards aligned to mitigate safety risks
  - Simplify certification processes
  - Expanded use of analytical simulations

FAA Certified

Safe, Efficient, Effective, Flexible, Agile, Adaptable, Robust, Timely

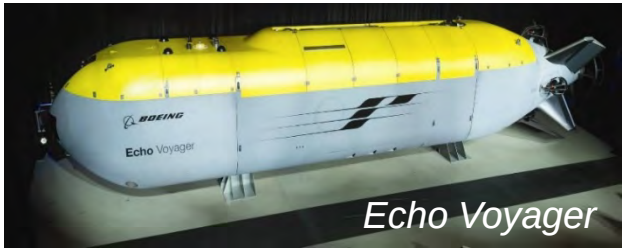
Technology Trends - Autonomy

- **Increased presence of autonomy**

Insitu ScanEagle

Phantom Eye

QF-16 Unmanned Moving Target



Echo Voyager

Phantom Express

Technology Trends - Autonomy

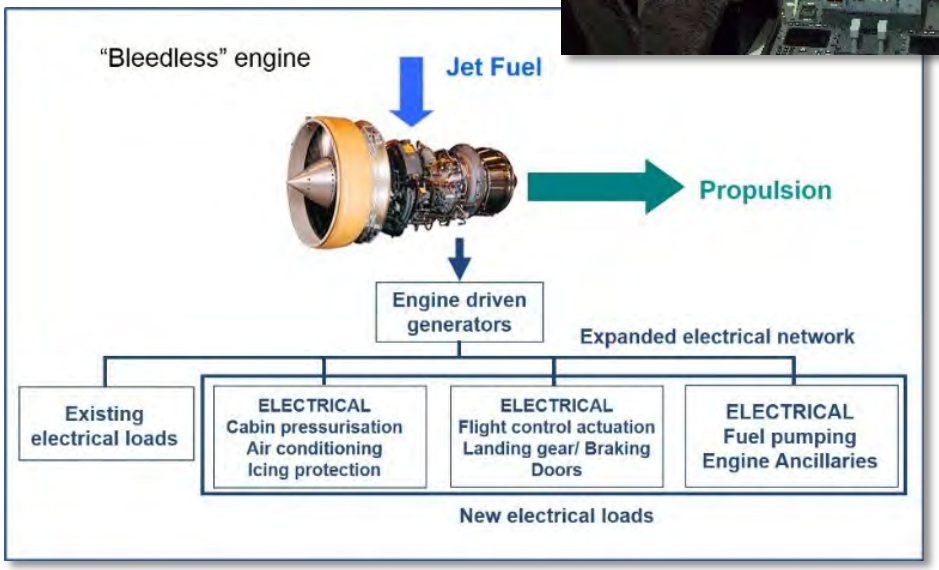
- **Current Capabilities:**
  - Auto flight
  - Auto land
  - Thrust management
  - Navigation
  - Systems management
  - Airplane health monitoring & reporting

- **Current development focus**
  - Autonomous taxi
  - Machine learning
  - High integrity systems

- **Technology challenges**
  - Ground Operations
    - Push back and engine start
    - Taxi
    - Take off roll
  - Flight Operations
    - Sense and avoid
    - Flight path optimization
    - Contingency planning
  - Infrastructure & Environment
    - Integration into airspace
    - Cooperative trajectory management
    - Conflict management
    - Airplane health management

Technology Trends - Systems

- **Flight deck displays**
- **Improved GPS**
- **Electric architectures**
- **Improved sensing**



Technology Trends - Environment

- **Hazardous material replacements**
  - cadmium, chrome plating, chromium, borate, halon, . . .
- **Sustainable material solutions**
- **Reduced emissions**
  - aerodynamic improvements
  - operational efficiency
  - biofuels
  - noise

ecoDemonstrator

- **Accelerate innovation**
  - Learn by doing
  - Speed implementation
  - 18 - 24 month cadence
- **Collaborate with government, suppliers & industry**
- **Inspire action & innovation**

ecoDemonstrator

- **ecoDemonstrator 2018**
  - propulsion advancements
  - advanced materials
  - efficient flight operations

ecoDemonstrator

- **ecoDemonstrator 2019**
  - smart cabin
  - autonomy

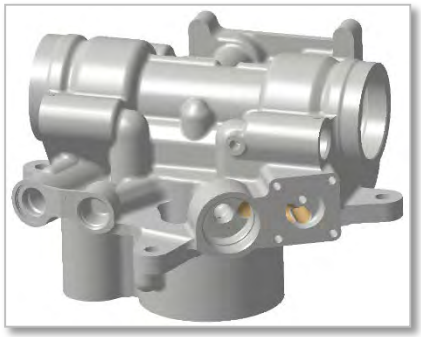
Technology Trends - Propulsion

- **Open rotors**
- **Hybrid, electric propulsion**
- **Fuel cells**
- **Hypersonics/ Space transportation**

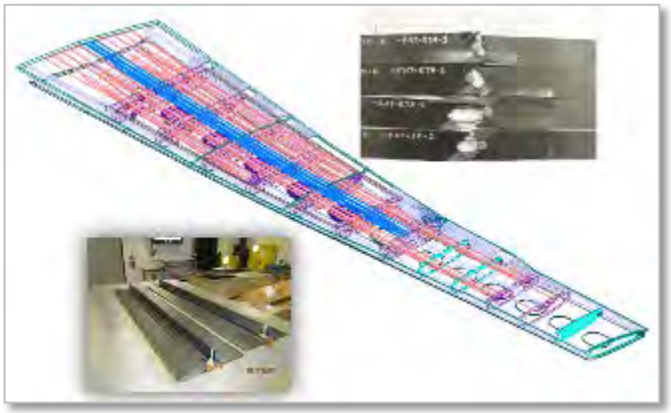
Technology Trends - Structures

- **Advanced materials**
- **Additive manufacturing**

1st FAA-approved Titanium Structural Production Part - 787 Passenger Floor Support (shown in as-deposited condition)



Hydraulic Manifold



CLEEN II – Structurally Efficient Wing

Optimized Ftg

Expanding Thermoplastics Applications

Technology Trends - Performance

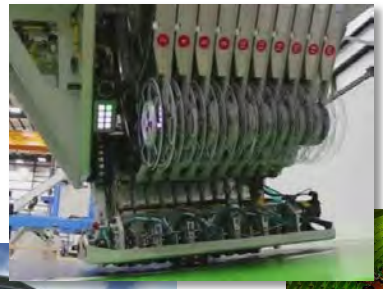
- **Advanced aerodynamics**

- **New configurations**

Technology Trends - Add'l Focus Areas

- **Big Data**
  - data analytics
  - aircraft & engine health monitoring systems

- **Advanced Manufacturing**



Advanced Automated Fiber Placement

- **Air Traffic Management**

Automated Assembly

- **Simulation**
  - systems, manufacturing, training, testing

Dynamic Simulation

Conclusions

- **Boeing is advancing technology & innovation for improved transportation solutions**
  - Connect people – efficiently
  - Improve safety
  - Reduce environmental footprint
- **Pace of technological advancement is increasing**
- **Regulatory framework must facilitate application of new technologies - safely & efficiently**