Evolution of Materials in Aerospace

FAA Maintenance and Inspection Research Program
Advanced Materials Research Program

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Federal Aviation Administration

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- **PART 4: Materials in Aerospace – The Middle Ages**
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- **PART 6: Materials in Aerospace – The Future**
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- **PART 7: Current FAA Research Activity**
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PART 1: The FAA's Role in Aviation

FAA Aviation Safety Office (AVS)

- **Responsible for the certification, production approval, and continued airworthiness of aircraft; and certification of pilots, mechanics, and others in safety related positions**
- **Also responsible for**
  - Certification of all operational and maintenance enterprises in domestic civil aviation
  - Certification and safety oversight of approximately 7,300 U.S. commercial airlines and operators
  - Civil flight operations
  - Developing regulations
  - https://www.faa.gov/about/office_org/headquarters_offices/avs/

AVS Offices

- Accident Investigation and Prevention
- Aerospace Medicine
- Air Traffic Safety Oversight Service
- Aircraft Certification Service
- Flight Standards Service
- Quality, Integration & Executive Services
- Rulemaking

William J. Hughes Technical Center

- The FAA William J. Hughes Technical Center is one of the nation's premier aviation research, development, test and evaluation facilities. Its world-class laboratories and top-notch engineering place the Technical Center at the forefront of the FAA's challenge to modernize the U.S. air transportation system. The Technical Center serves as the FAA national scientific test base for research and development, test and evaluation, and verification and validation in air traffic control, communications, navigation, airports, aircraft safety, and security. The Technical Center is the primary facility supporting the nation's Next Generation Air Transportation System, called NextGen.

- Located 10 miles northwest of Atlantic City, and covering over 5,000 acres, the Technical Center consists of state-of-the art laboratories, test facilities, support facilities, the Atlantic City International Airport (ACY), and a non-commercial aircraft hangar. The Technical Center is also home to the Department of Homeland Security, Transportation Security Lab, and the United States Coast Guard Group Air Station Atlantic City, as well as the New Jersey Air National Guard 177th Fighter Wing. While the Technical Center serves to advance aviation, it is a key focal point for Homeland Security as well.

Role of FAA Research and Development

- **Aviation Safety Research Act (1988)**
  - Enacted in response to Aloha Airlines Incident
- **Allows the FAA to keep pace with the evolution of technology in the aerospace industry**
- **Used to evaluate the validity of current regulations when new technologies are introduced**
- **Also used to generate policy and guidance material for the industry (Advisory Circulars)**

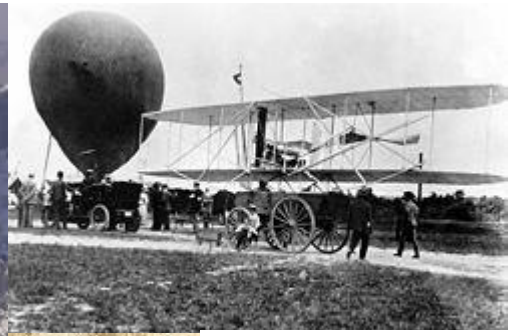
PART 2: A Brief History of Aviation

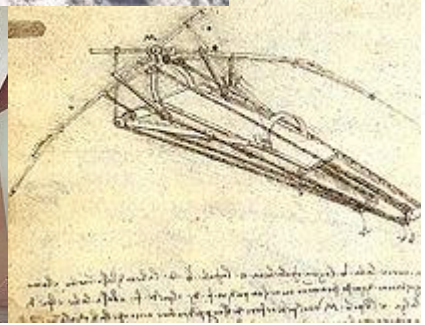
The History of Aviation

- Kite Flying in China
- Tower Jumping
- Leonardo da Vinci
- Balloons!
- Modern Aircraft

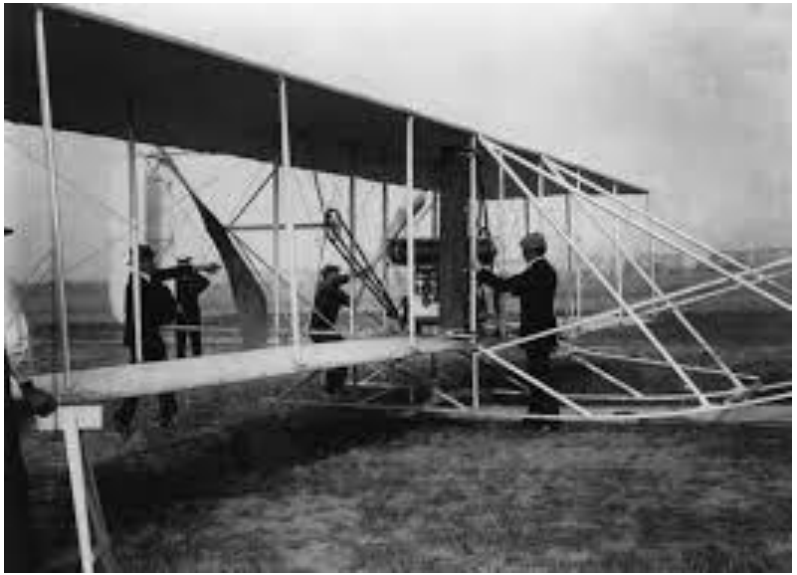
https://www.youtube.com/watch?v=3AbCLs5LbCw

- Spacecraft



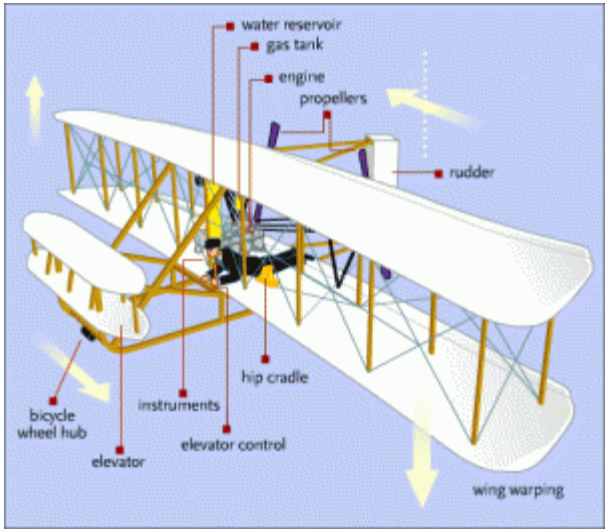


PART 3: Materials in Aerospace – The Early Years



The Wright Flyer

- **The Wright Brothers made their first controlled self-propelled flight on December 17th, 1903 at Kill Devil Hills near Kitty Hawk North Carolina**
- **Design features:**
  - Engine with lightweight aluminum engine block
  - Spruce and steel wire construction
  - Fabric Skin
- **Wood is a natural composite material that has a high strength to weight ratio**



PART 4: Materials in Aerospace – The Middle Ages

Metallic Aircraft

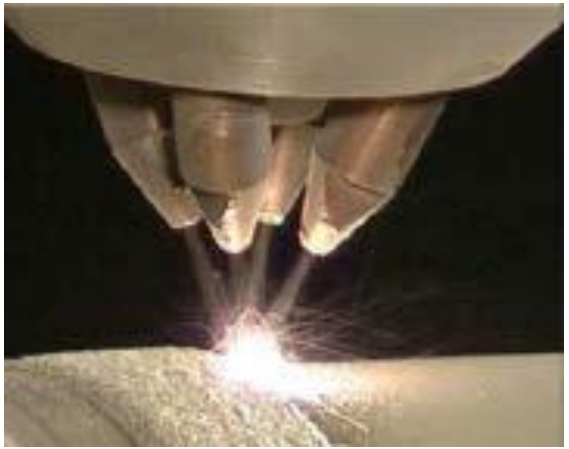
- The 1915 Hugo Junkers built the first all metal airplane using a tubular structure covered with corrugated sheet iron
- In 1925 Henry Ford purchased the Stout Metal Airplane Company - The Ford Tri-motor employed stress-skin construction (semi-monocoque)
- By the late 1930's aluminum construction techniques and semi-monocoque construction supplanted wood structures
- Aluminum alloys remain a primary aerospace material to this day

PART 5: Materials in Aerospace – Modern Times

Composite and Advanced Metallic Alloy Aircraft

- **Composite applications continue to expand**
- **Advantages of composites**
  - High strength-to-weight ratio, resistance to corrosion, resistance to fatigue
- **Development of new metallic alloys**
  - Faced with increased competition from composites, metallic material suppliers are developing alloys at unprecedented rates (e.g. Aluminum Lithium)
- **These developments present new challenges for the inspector and maintainers of modern aircraft**

PART 6: Materials in Aerospace – The Future



Additive Manufacturing

- A process of joining materials to make objects from 3D printed model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies (Ref: ASTM F2792)
- Thermoplastic AM parts have been utilized for years in multiple aircraft
- Metallic AM parts have been approved in aircraft engines (Type Certification and Design Change) and TSO (Design Change)
- Many major OEM's have announced publically that their new aviation products will include metallic AM parts
- The FAA has created the Additive Manufacturing National Team (AMNT) to promote the safe deployment of AM parts in aerospace

Inspection Challenges With AM Parts

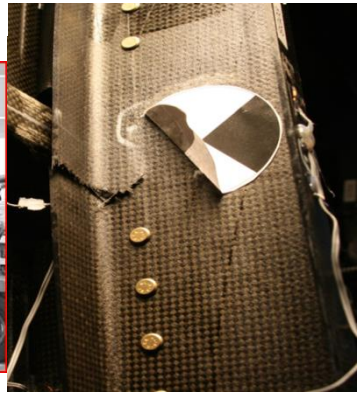
- Critical Defects
  - Lack of complete understanding
- Complex Geometry
  - Present a challenge for conventional NDE methods like UT, ET, and RT
- Physical Reference Standards
  - Basic requirement for any NDE process
- Inspection Procedures
- In-Process Monitoring
  - Recognized as a game changer in 1) improving the consistency, repeatability, and uniformity across machines and 2) qualification and verification of parts
- Qualification and Certification
  - Once the effects of critical defects are understood, physical reference standards have been fabricated, and suitable NDE inspection procedures have been developed, qualification and certification of parts made by AM becomes achievable and practical

Illustrative NDE Data for AM

- **Computed Tomography**
  - Demonstrated ability of CT to detect simulated internal flaws and inaccessible internal features
  - Demonstrated ability to confirm closure of porosity by HIP post -processing and to detect high-density inclusions in EBM as-manufactured titanium specimens
  - This demonstrated the value of CT to 1) detect deep or embedded defects; 2) interrogate inaccessible features; 3) confirm the effectiveness of post-process treatments; and 4) to characterize and qualify as-manufactured parts made by AM
  - One limitation is the ability to reliably detect cracks, since cracks orientated perpendicular to the x-ray beam may not be detected
- **Penetrant Testing**
  - Porous or rough parts limit the effectiveness of PT
- **Eddy Current Testing**
  - ET of accessible regions of AM components should prove to be very similar to that of conventionally formed metals
- **Structured Light**
  - Can be used to verify part accuracy
- **Ultrasonic Testing**
  - Used to interrogate embedded voids
- **Near Infrared Camera Measurement for In Situ Process Monitoring**
  - Used to improve quality of EBF processing
  - Can detect defects in parts during fabrication

PART 7: Current FAA Research Activity

Composite Impact Damage and Characterization



High Energy Wide Area Blunt Impact (HEWABI) Damage

Can Result in Substructure Damage with No Visible External Damage

Conventional NDI Methods May Not Be Able to Detect Hidden Damage

Investigating Using Lamb Waves to Detect Damage

Inspection and Teardown of Aged In-Service Bonded Repairs

DELTA

NIAR Wichita State University National Institute for Aviation Research

Sandia National Laboratories

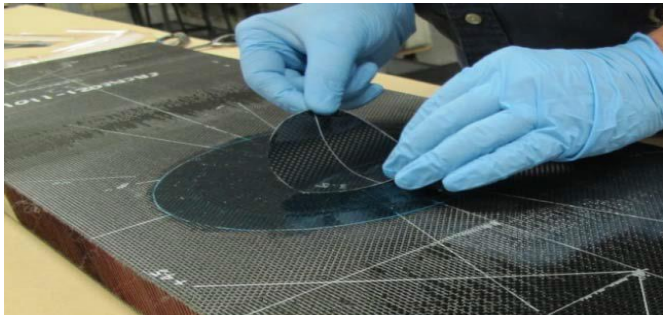
- The Objective of this Research is to Evaluate the Durability of Aged In-Service Bonded Repairs
- Document Lessons Learned and Best-Practices

14 CFR Part 147 Composite Technician Training

Wichita State University
National Institute for Aviation Research

- CFR Part 147 Regulates curriculum for Aviation Maintenance Technician School
- Requires Basic Composite Awareness
- This Research Will Provide the Necessary Teaching Points for Both Levels of Training
    - Level I Training: Composite Awareness, Advantages/Disadvantages, Regulatory Aspects
    - Level II Technician Skills: Composite Awareness, Regulatory Aspects, Tools an Equipment, Skill Building Exercises

Commercial Aircraft Composite Repair Committee (CACRC) Structural Repair Manual (SRM) Repair Round Robin



- Composite Materials Applications Increasing: B787, A350
- Bonded repair being performed
- Evaluate the Existing
  - CACRC Repair Standards and
  - Approved Materials Used for Repair of Composite Structures
- Asses Repair Process Variability Between Depots
- Investigate Variability Associated with Technician Training
- Compare Strength of Different Repair Materials
- Evaluate Environmental Effects

FAA Update on Current Priorities

- **Integration of UAS into the NAS**
  - Part 107 Rule (Under 55lbs)
  - Regulation Gap Analysis (Over 55 lbs)
- **Part 23 Rewrite**
  - Less prescriptive, more performance based
- **Cyber Security, Big Data**
- **Additive Manufacturing**

Thank You for All of Your Hard Work and Dedication!!!

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