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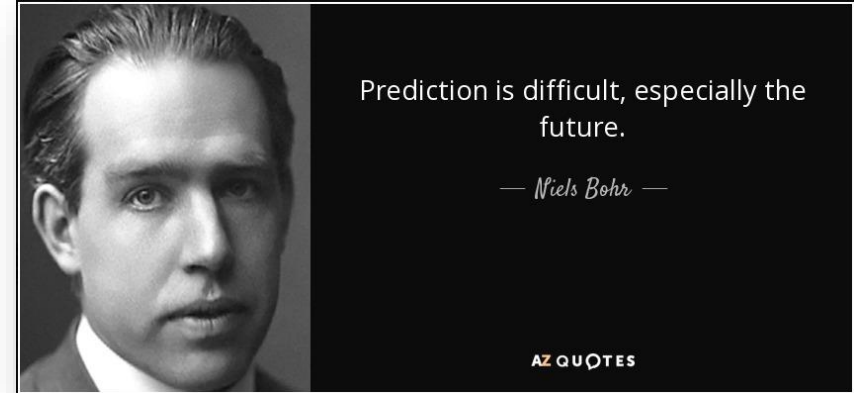
International Committee
on Aeronautical Fatigue
and Structural Integrity

Future Trends in Structural Integrity – Industry Perspective

Dr. Yuval Freed, Israel Aerospace Industries| June 30th, 2021

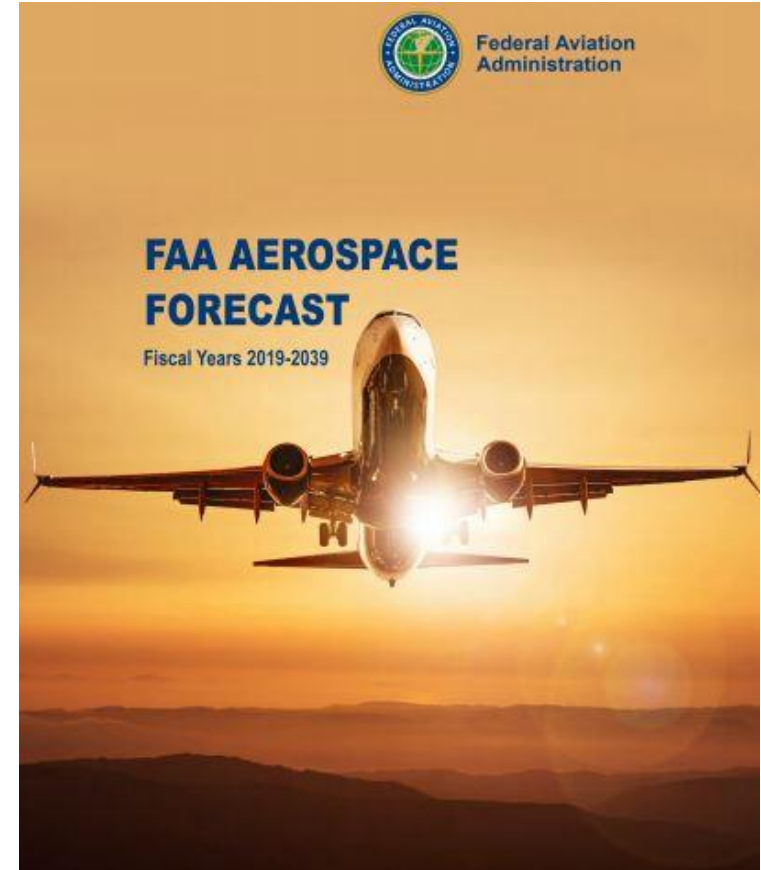
General

- This presentation outlines the major trends in the aviation industry identified as of 2021, with special focus on structural integrity topics
- More details to be provided in follow-up presentations by National Delegates
- It is acknowledged that predicting future trends is a challenging task, mainly due to the difficulty in predicting:
 - Global events (i.e., Covid-19 pandemic)
 - Disruptive technologies



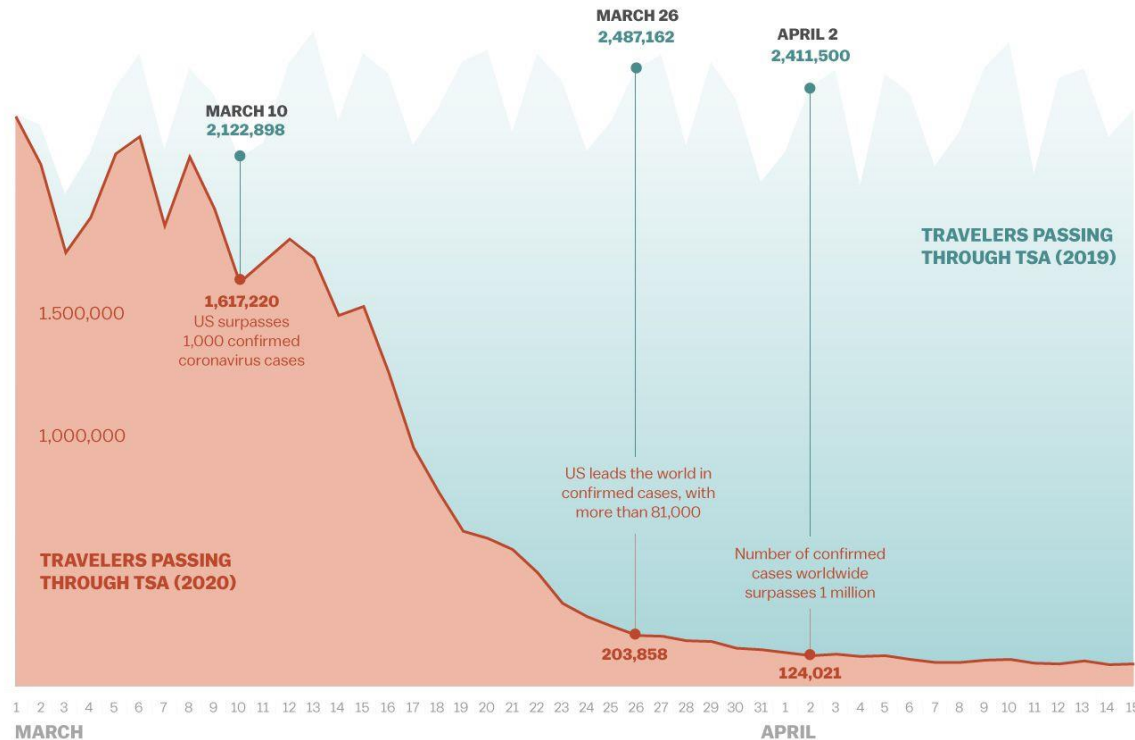
Global Events

- The 2019 FAA forecast calls for U.S. carrier domestic passenger growth over the next 20 years to average 1.9% per year (3% for international flights)



An then came COVID-19 ...

TSA reports significantly fewer travelers through US airports in 2020



Sources: TSA, Center for Systems Science and Engineering at Johns Hopkins University data

Vox

Source: How the coronavirus is disrupting US air travel, in 2 charts, vox.com, April 20th, 2020

Disruptive Technologies

- A **disruptive technology** is an innovation that significantly alters the way that consumers, industries, or businesses operate
- A disruptive technology sweeps away the systems or habits it replaces because it has attributes that are recognizably superior



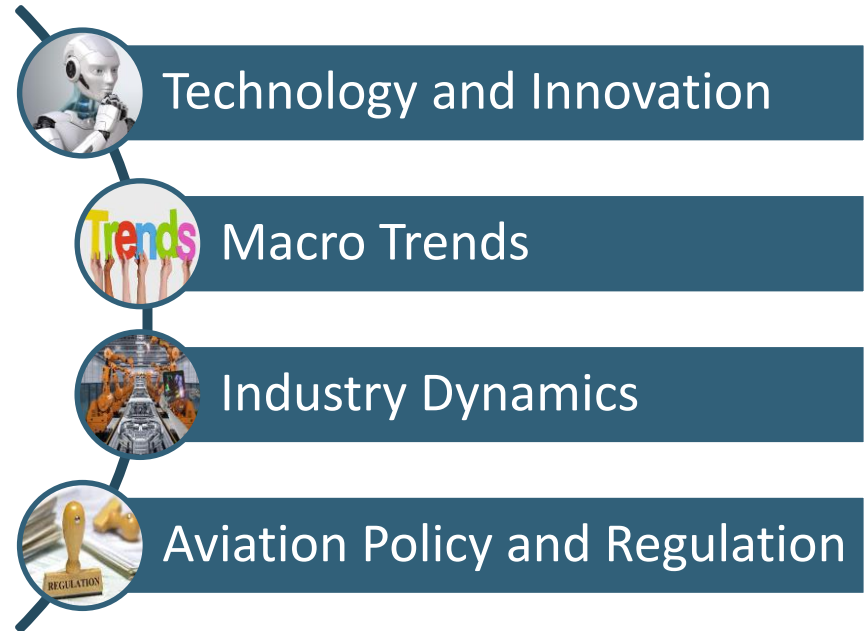
Hogwarts main hall floating candles

Electric light did not come from the continuous improvement of candles



Future Trends in the Aviation Industry

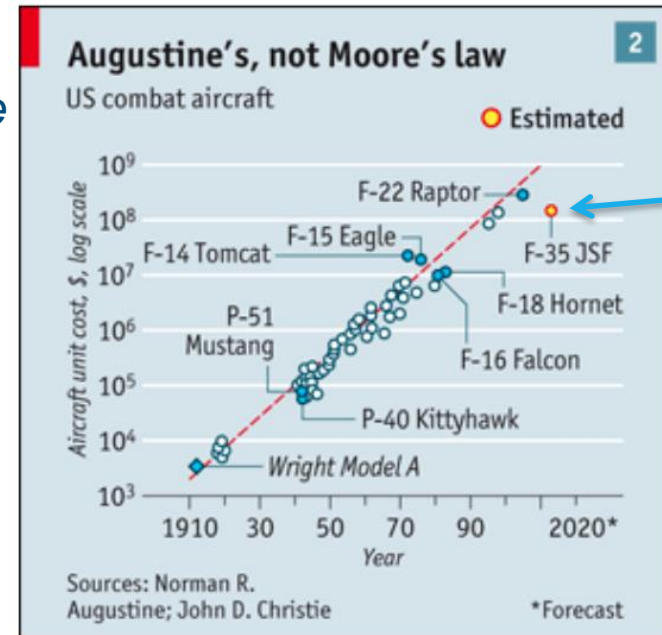
- The following aspects are considered when future trends are predicted
- From industry perspective, it is essential that these trends will lead to ***significant reduction in development costs and duration***, leading to shorter entry to market period
- Aviation policy perspective to be presented by Dr. Michael Gorelik



Augustine's Law #16

- Norman Augustine is an aeronautical engineer who started working at Douglas Aircraft in 1958. In 1984 he published a set of laws related to the aviation business, which many of them are still valid today

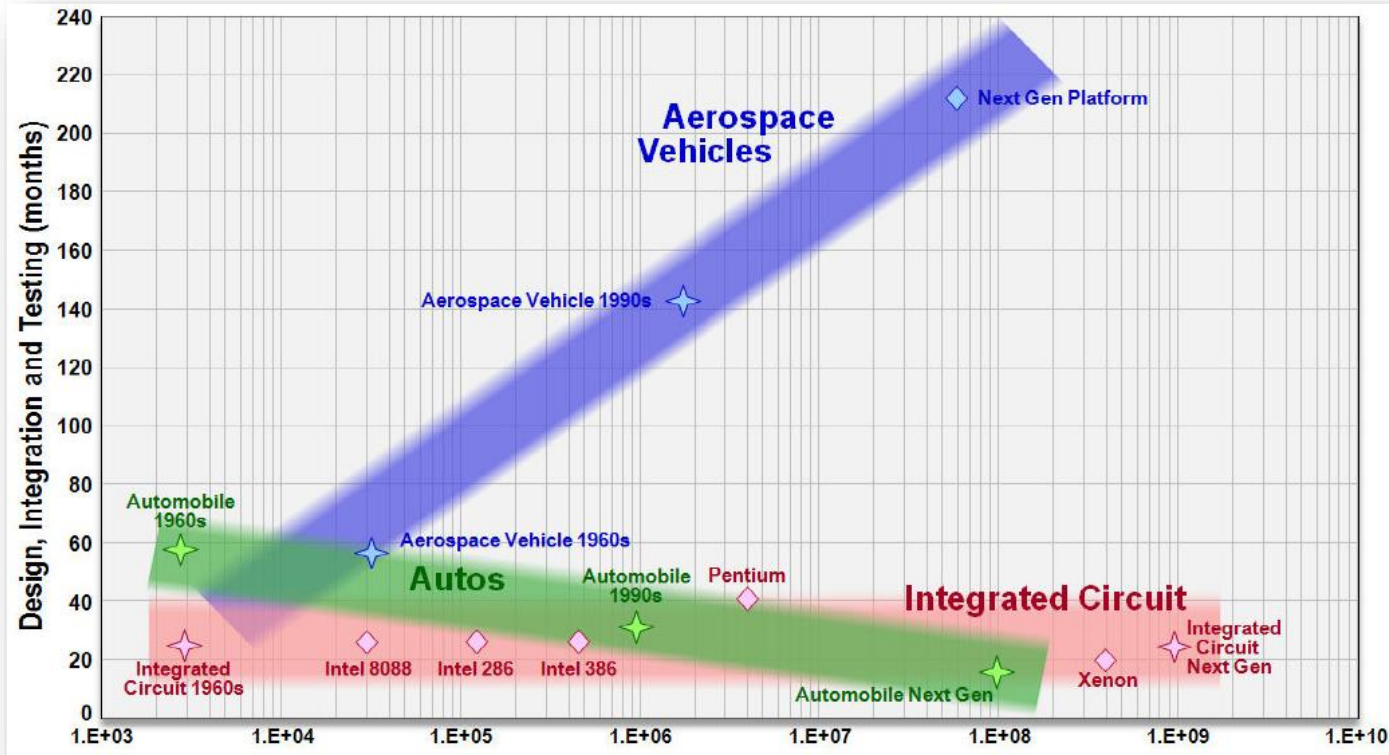
- Law #16: *"In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3.5 days each per week except for leap year, when it will be made available to the Marines for the extra day"*



The F-35 beats Augustine's law, with ~100M\$ per unit. A purchase of a single aircraft is now expected at 2074

Development Duration

- Aviation vs. other industries:



Source: S. Eric Cregger, Composite Durability Workshop, 2013

Trends



Autonomous Air Vehicles

- Having autonomous air vehicles for civil product is a great challenge, from both engineering and regulatory point of view
 - Especially in urban environment
- However, the economic logic for this is clear
 - Also much safer flights are expected
- Structural integrity aspects:
 - Light weight reliable structures
 - “Sense and avoid” and discrete source damage scenarios



Remember Colonel Petrov

- In Sept., 26th, 1983, the Soviet military monitored its early warning satellites over the US when alarms went on and the computers warned that five intercontinental ballistic missiles had been launched from an American base
- A 44 years old lieutenant colonel Petrov was in command that day



After five nerve-racking minutes Colonel Petrov decided that the launch reports were probably a false alarm

“it was a gut decision, at best a 50-50 guess”

Digitization

- Modern digitization is expected to significantly reduce development costs and development durations by means of
 - Modern digital design and substantiation tools
 - Better integration between different groups (cloud-based environment and unified tools... remember NASA spacecraft lost due to a metric conversion mistake)
 - Replacing large scale tests by virtual tests
 - Digital twins leading to tailor-made condition based maintenance
 - Harvesting tools and big data
- Requires a mindset change... simulations over tests !
- More on this topic to be presented by Min Liao

Replacing Tests by Simulations?

- Why not? We are living in an exciting era and make an amazing progress
 - Self driving cars
 - Computers that interact with us
 - Data analysis
- The amount of data generated in **two days in 2021** is as much as all data generated in **human history before 2003**



New Materials and Processes

- Composite materials are not going anywhere
 - Improvement is sought for in bonding procedure, leading to efficient, cheap and light weight assembly (Lockheed Martin's ACCA demonstrator)
- Additive Layer Manufacturing – going from coupon level to full scale product
- Major structural integrity issues to be resolved:
 - Reduction factors from all worlds - composites/ welding/metals
 - Quality assurance and NDT – how to make it cost effective?
 - Surface treatment – major issue for fatigue
- To be discussed in detail by Elke Hombergsmeier



IAI Fully 3D-Printed UAV
(SkyPrinter)

Going More Electric

- Electric propulsion systems and other electric systems are essential for the aviation industry to
 - Reduce life cycles costs related to fuel consumption
 - Reduce complexity, weight and maintenance life cycle costs involved with hydraulic systems
 - Reduce environmental footprint
- Structural integrity challenges:
 - New mindset from design and certification point of view
 - Morphing wing?



Hyundai-Uber Electric Flying Car

Reduce Environmental Footprint

- The EU has recently published call for expressions of interest for technologies development aiming at mid-2030s
 - New generation large aircraft platforms are aimed toward sustainable climate neutral flight
- Structural integrity challenges:
 - Lighter materials and assembly processes
 - Environmental friendly manufacturing process and coating
 - “Green” regulations (REACH)



ZERO-EMISSION AIRCRAFT

ZEROe: H₂ concept aircraft

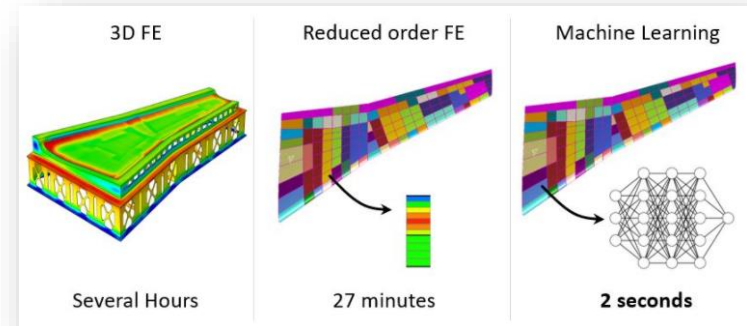
- Turbofan:**
 - <200 passengers
 - 2X hybrid-hydrogen turbofan engines
 - +2,000 NM (range)
 - liquid hydrogen storage & distribution
- Turboprop:**
 - <100 passengers
 - 2X hybrid-hydrogen turboprop engines
 - +1,000 NM (range)
 - liquid hydrogen storage & distribution
- Blended-Wing Body:**
 - same as turbofan

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AIRBUS

Artificial Intelligence and Machine Learning

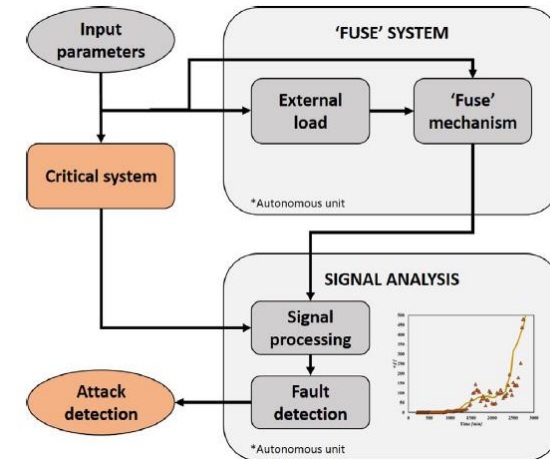
- From structural integrity point of view, how can we exploit machine learning technologies for analyzing big data?
 - Structural Health Monitoring (SHM) and Condition Based Maintenance (CBM)
 - Data harvesting during full scale testing
 - Fleet monitoring
- Example: Theory guided machine learning which aims to integrate the thermal management during processing of advance composites into machine learning algorithms for more accurate predictions



Zobeiry N. and Humfeld K.D.,
Engineering Applications of Artificial
Intelligence, 2021

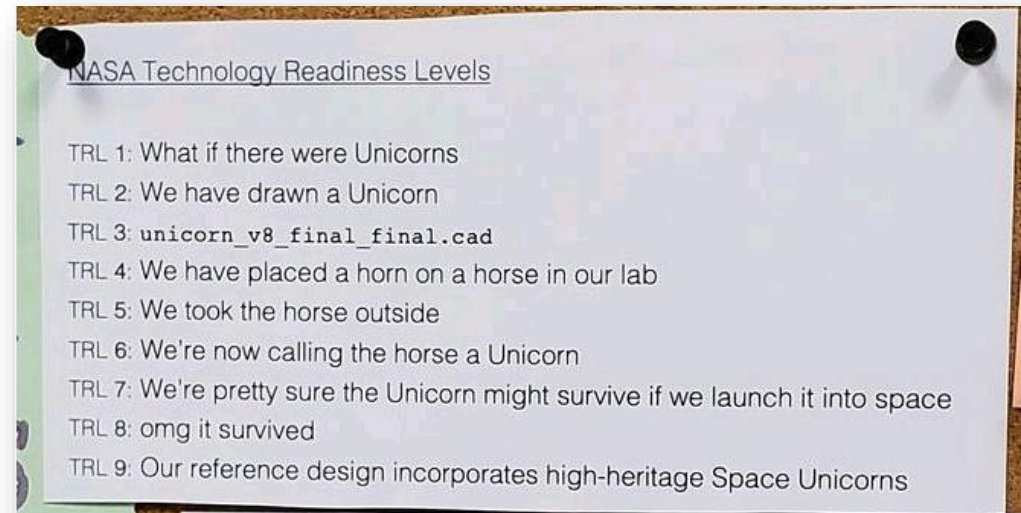
Smart Technologies for MRO

- SHM and machine learning capabilities alongside with development of digital twins concepts provide opportunities for development of smart and efficient maintenance programs, significantly reducing the product life cycle cost
- Such technologies can be even used for homeland and cyber security proposes, as was proposed by Gazizulin et al, Int. J. of Critical Infrastructure Protection, 2019:
 - Usage of SHM technologies for early detection of a “fuse” failure in protection due to hacker attacks (via “overloading” the system) of critical rotating infrastructures



Final Words

- Development costs and durations rise up rapidly
- We need to find ways to drive down costs and development durations
- Several future trends were highlighted
- Many new and exciting technologies are available, but we need to remember that we are terrible at making predictions, especially about the future



“One machine can
do the work of fifty
ordinary men. No
machine can do the
work of one
extraordinary man”
Elbert Hubbard

