FAA William J. Hughes Technical Center

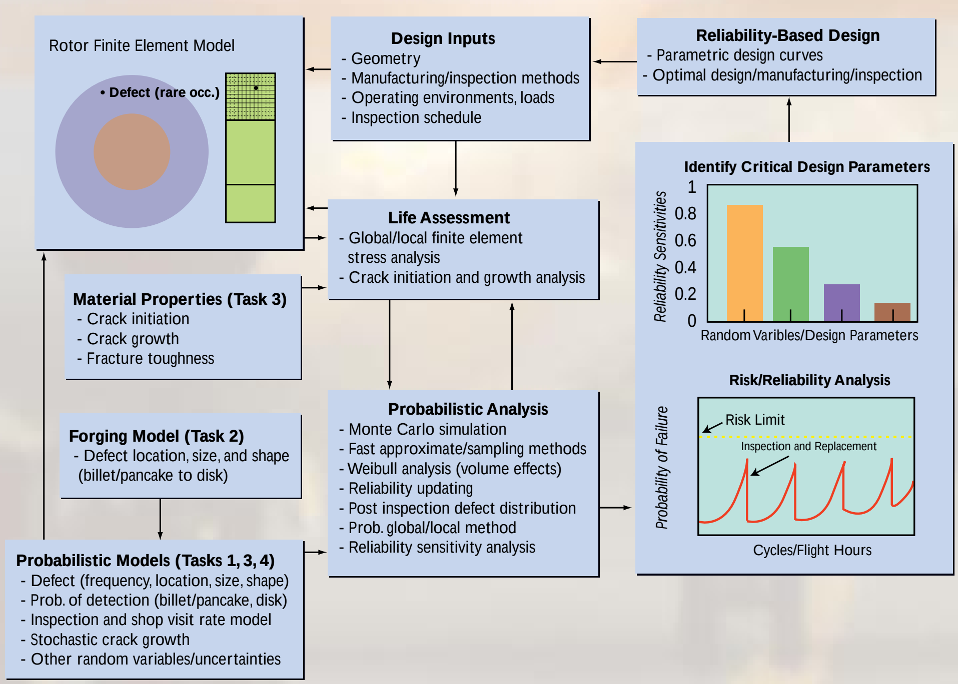
Turbine Engine Research

Safety

FAA Service Difficulty Reports (SDR) show that there are an average of 15 uncontained rotor failures per year in the US involving turbine powered aircraft.

Approximately 40 percent of the uncontained failures are caused by design and life prediction or quality control problems. Analysis of specific accidents and incidents has shown that the primary inherent failure modes result from the presence of material and manufacturing anomalies that can degrade the structural integrity of high-energy turbine rotors. The primary failure mode of the Sioux City DC-10 accident in 1989 was a fatigue crack that originated from an undetected titanium alloy melt-related defect. In response to this accident, both the NTSB and the FAA independently made recommendations related to the improvement of titanium metallurgical quality, nondestructive inspection, and rotor structural design and lifing standards.

As a result of the Sioux City accident and the subsequent findings and recommendations, the FAA and industry initiated a collaborative effort to identify and implement cost-effective safety improvements. The industry is participating through a number of consortia and working committees including the Aerospace Industries Association (AIA), Materials and Structures Committee, the AIA Rotor Integrity Subcommittee, the FAA Engine Titanium Consortium, the Jet Engine Titanium Quality Committee, the Aviation Rulemaking Advisory Committee (ARAC), and the Power Plant Installation and Harmonization Working Group. Working in concert with the FAA, these groups have identified potential improvements in the areas of manufacturing process control, manufacturing inspection, in-service inspection, design and life management, and rotor failure hazards mitigation. Some of these improvements related to material tracking and manufacturing inspection have been developed and implemented. Others related to in-service inspection, advanced manufacturing process control, design



processes, and guidance on uncontained fragment hazard mitigation require additional technical development prior to full implementation.

The Turbine Engine Research Program is developing the means to evaluate and enhance the safety and reduce the risk associated with failures of engine systems. Benefits will accrue in the form of reduced risk of engine failures and fewer accidents, which in turn will lead to fewer injuries and fatalities. This research is developing criteria, guidelines, and data to support improvements in turbine engine certification compliance requirements. The primary focus in the Turbine Engine Research Program is currently on developing a probabilistic rotor design life methodology. Turbine rotor components are currently assigned a design operating life that does not exceed the safe operating life of the component. Thus, components are removed and scrapped (retired) at prescribed intervals. If a flaw or crack is detected before the scheduled retirement of the component or if the component is diagnosed as having a problem, the component is removed from service on an as-required basis rather than an interval basis. Generally, formal design procedures do not account for the adverse affect of metallurgical defects on the safe life of rotor disks. These life methods are based on the assumption of nominal material and manufacturing conditions that may not include the presence of a wide range of possible material and manufacturing anomalies.

An industry-FAA working group proposed an approach to enhance the conventional safe-life methodology by explicitly addressing these anomalous conditions. The Turbine Rotor Material Design (TRMD) research program is developing a probabilistically based damage tolerance design code to augment the current safe-life management philosophy used on commercial aircraft turbine engine rotor disks. This design code is intended to be a supplemental tool and will not replace the existing engine company design methods.

This TRMD program is being conducted by a team of industry members led by Southwest Research Institute with General Electric, Pratt & Whitney, AlliedSignal, and Allison engine manufacturers. The program is divided into four integrated tasks as depicted in the figure on the front. The technology will be transferred to the engine manufacturers as software codes and data in the form of technical reports, manuals, and a training workshop. The FAA Engine Titanium Consortium program is providing nondestructive inspection technology and contaminated titanium billet test trail samples as valuable support to this program.

The research will lead to enhanced rotor material design and durability, a crack initiation and growth model for selected alloys, and a probabilistic-based rotor design code. This generic, public-domain, enhanced design life and risk assessment tool will be the basis for a revised certification advisory material of engine rotor integrity. Technical guidance material for a proposed update to Advisory Circular 33.14 that includes specialized tools in the form of analytical software codes and standardized database(s) will be developed.

To find out more about the Turbine Engine Research Program, contact:

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