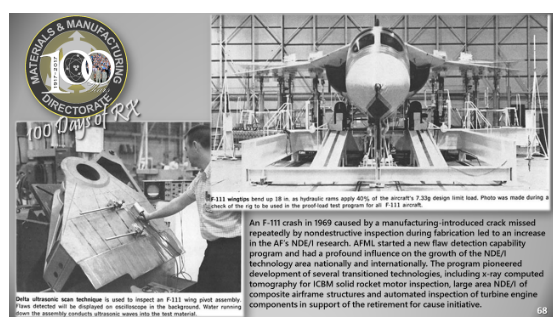
Remembrances of Don Forney

In Don Forney's excellent authoritative 'primary source' historical review of the origins and contributions of the Materials Laboratory nondestructive evaluation program teams (**ref. 1**) he notes that "the 1 October 1919 issue of the McCook Field publication 'Slipstream' cited one of the Materials Section missions as being to 'test fabricated parts and to make routine inspection tests for the Procurement Section' ". Thus the origins of this unique ML capability which continues to serve the Air Force today can be traced directly to the time when the War Department established Airplane Engineering at McCook field in 1917, an AF milestone celebrated in the 2017 centennial year.

Don notes that in the early years and extending well beyond the period after the 1927 move to Wright Field and the build-up during the WWII staff of the Materials Section was very modest, about 30 individuals total. The small NDI team within the Section focused on identifying and adopting useful new technologies for the Army Air Core aircraft. The focus was on metallic materials which, by 1930, had superseded wood as the most important structural material in aircraft design: radiography for internal visualization (1920s), ultrasonic waves for detecting defects in metals (1930s), eddy current methods (1930-40s) and fluorescent penetrant inspection (1942).

During the WW II build-up the ML staff grew from about 100 in 1941 to over 200 by 1945. The early post-war years brought advancements in materials technologies but also urgent needs for new capability. And there was growing AF-wide concern about fleet structural integrity and safety, especially as a result of B-47 and F-111 structural failures bracketing the 1958 -1969 decade. To deal with these urgent issues the Branch level NDT/NDE organization was established in early 1966 to provide the critical new technologies and expertise required by the

No. 7: '100 Days of RX'
X-rays Inspection in the early 20s



No. 68: Failure Analysis; ICBM Motor Inspection; Automation

Air Force. Don includes a graphic in his book showing the dramatic funding growth of the NDI program from the late 1960s to 1980. He was appointed chief of the Branch in July 1974 near the beginning of this tremendous growth period and successfully directed the strategy and programming required. He held this position for nearly 2 decades until his retirement in October 1990. For another 2 decades after his retirement he directed NDI contractual programs at UTC supporting the work of ML.

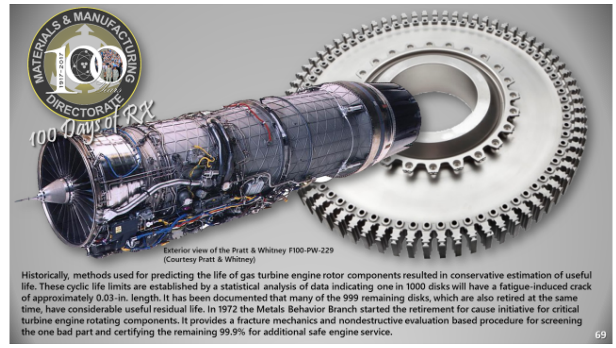
As was his style, Don created a full chapter in his book highlighting the people who worked with him over the years. Included are pictures with names of each ML and UDRI on-site NDI team member who worked with him. This team served for many years in close partnership with the Systems Support Division NDI team supported by the UTC on-site team.

Structural Integrity/Damage Tolerance. Don summarizes the critical Air Force, national and international need for new NDI/E technologies and expertise driven by catastrophic structural failures in high performance military aircraft and in commercial aircraft as well. As noted above, a series of disastrous B-47 crashes in 1958 (four of 5 were caused by fatigue cracking) and the F-111 crash in 1969 (caused by manufacturing defect) provided the first urgent signals of the critical need to understand and deal with the effects of cracks and crack propagation in highly stressed structural components. An AFRL history of breakthrough technologies (**ref. 2**) elaborates on the F-111 issues and the enhanced ML NDI/E capabilities ordered by the secretary of the AF as a result. Fortunately, in the early 60s the development of powerful new structural analysis tools had begun enabling the understanding of failures in flight performance aircraft. These developments lead by the Aeronautical Systems Division at Wright Patterson and by Boeing yielded a powerful new damage tolerance toolset - the Aircraft Structural Integrity Program – 'ASIP'. To apply these tools it became clear immediately that detailed NDI/E information and ML developed structural design data were essential. Using the ML data these powerful tools not only enabled effective monitoring but were also used to quantitatively predict performance over time for effective 'fleet management'. Don highlights the ML partnership team formed with the system engineering/SPO teams at ASD lead by Jack Lincoln and Chuck Tiffney at Boeing. Jack came to WP in 1971 shortly before Don assumed leadership of the NDI Branch. The structural integrity systems engineering teams lead by Jack and the many contributing ML members formed a unique and powerful partnership invaluable to the Air Force. This team remains in place today.

Turbine Engines. Aircraft losses due to turbine engine failure began to occur as well in the same time period as loses due to structural issues. The initial response especially for very high stress/high performance military turbine engines was ultra-conservative: immediately replace suspect turbine engine components and retire all similar apparently sound components based on usage time: e.g. when 1 of 1000 parts could potentially develop a crack all 1000 would be retired to eliminate the possibility of catastrophic failure in flight. Don describes how the Engine Structural Integrity Program (ENSIP) came into being in 1978 to tackle this safety/reliability/cost problem building on the successful ASIP structural integrity/damage tolerance framework for structures. He notes that the first ENSIP analyses were performed on GE and P&W engines in

1979/80. Not only did this engine damage tolerance framework ensure safety of flight and timely repair, it eliminated the ultraconservative extremely costly usage-time retirement of completely sound components – some costing over $100K each.

The Materials Laboratory turbine engine teams - NDI/E, ‘system support’ and the high temperature materials development team lead by Wally Reiman, Ted Nicholas, Jack Henderson and others built strong, productive and enduring relationships with the AF turbine engine customers at the Air Force Logistics Centers and in industry. The ‘Retirement for Cause’ strategy which emerged from this collaboration is considered one of the most significant technology-driven successes in the history of the Air Force: safe operation, long component lifetime, minimum life cycle cost.



No. 69: Turbine Engine Retirement for Cause

<u>Space & Missile Systems.</u> In the aerospace century space and missile emerged relatively late. Don introduces this much different NDI/E applications arena observing that in 1978 the search began for more effective means of inspecting and nondestructively evaluating carbon-carbon (C/C) composites – a new family of unique thermal protection composites invented in ML. Conventional inspection methods were inadequate for these and other new composites. NDE Branch scientists Drs. Robert Crane and Thomas Moran investigated X-ray Computed Tomography (CT) methodology just emerging for medical care. As is well known by all, ‘CAT scan’ technology became a powerful medical evaluation tool and, of course, remains in use today. These ML scientists used the CT instruments at the WP Medical Center to demonstrate the unique capability for quality control and detection of anomalies in C/C and other rocket component manufacturing. This new capability was also used immediately for inspection of the thermal protection tiles in the NASA Space Shuttle. The results of these visionary experiments were so striking that a major program was launched by ML for development of an industrial –class X-ray CT system capable of inspecting hardware ranging from small engines and missile components to very large Peacekeeper ICBM motors. ML NDI/E engineers developed and managed ManTech programs beginning in 1980 to develop the prototype of the first operation aerospace industry x-ray CT system. The capability to inspect 30-inch diameter sections became operational in 1982. These units were the forerunners of the many systems in use today capable of inspecting 96 inch Peacekeeper solid motors at the Air Force Logistics Centers and elsewhere.

No. 83: Rocket Motors & Space Systems

<u>Growth of Program Influence and Importance: AF Systems Support/ManTech & Industry/ Commercial Aviation/ International/Electronics Failure Analysis/</u>. First and foremost the technology challenge is creating effective partnerships with the customers. The ML collaboration initiatives for both the ASIP and ENSIP arenas - 'Have cracks will travel' - is one of the clearest examples of productive NDI/E teams doing this. The 1978 AF Logistics Command survey across all the Air Logistics Center and a large number of operational bases revealed significant and serious NDI/E shortfalls. Don's branch and the companion NDI/E teams in the Systems Support Division launched the joint advocacy roadshow to describe the situation and, more importantly, show how, by working together, the challenges could be met. This effective partnership remains in place today.

In the 60s, ML was chosen to manage the entire AF ManTech program. The NDI/E teams were very effective in guiding MT programs for manufacturing quality control and building the NDI/E industrial base capability in industry and at the air logistics centers. Early on, the 1969 F-111 crash was the clearest example of the need for stringent manufacturing quality control in high performance components. And prototype shop floor capability demos provided essential risk reduction so that industry and the logistics centers could build major capital facilities.

Internationally, military and commercial aerospace industry faced the same challenges as the Air Force and the United States. Don devotes a full chapter describing the interagency, national and international partnerships his team engaged to leverage expertise and resources worldwide solving common problems. With the NATO countries the NDI/E teams in collaboration with systems engineering teams in ASD lead by Jack Lincoln conducted very productive joint programs over many decades. Especially strong and enduring partnerships were also built with Australia and other English speaking countries in the TTCP program.

Internal to ML the NDI/E team approach and their tool sets became the foundation used to establish failure analysis/systems support capabilities in entirely new areas most notably for the electronics arena during Frank Kelly's tenure in the late 70's. This team received national recognition for its work with NASA on the Space Shuttle and in the investigations of the TWA 800 tragedy. And ML staff mobility actions helped broaden and strengthen the overall Laboratory capability. Tobey Cordell who became NDI branch chief after Don's retirement brought important advanced composites/MT perspectives and Tom Cooper who was also NDI branch chief became director of the Systems Support Division. Dedication and persistence adopting new technologies characterizes the teams today. Classical ultrasonic NDI has been made easy to use on the flight line and in the depots with lightweight, portable and user friendly hardware. The mobile automated ultrasonic scanner (MAUS) first prototyped in 1985 is still being improved today. New development in digitization of NDI maintenance/performance information and powerful

No 80: New Capabilities: for Composites; MAUS Enhancements

software analysis tools are revolutionizing capabilities for ICBM inspection, whole aircraft maintenance and turbine engine life extension.

Legacy and Heritage. One view of the research, technology and systems engineering contributions of the of ML over more than a century of service to the Air Force pictures these accomplishments resting on 3 pillars: 1) direct partnering with warfighters/sustainers in the field; 2) partnering directly with industry along many paths lead by the leadership of AF ManTech program; 3) applying the high performance teaming techniques first envisioned and implemented in the early 60s by Dr. Alan Lovelace which were fully embraced throughout ML and subsequently by other AFRL and AF organizations.

Don's authoritative history clearly demonstrates how this legacy and heritage were fulfilled by him, his NDI/E team and the others with whom he worked and whom he influenced.

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*After his retirement from ML, encouraged by his colleagues at UTC especially Jim Mattice and Warren Johnson, Don prepared a memoir of his December 1941 experiences at Pearl Harbor (**ref.3**). Along with the memoir and with the help of Pam Kearney at UTC he prepared a slide presentation.*

Many friends and ML colleagues had the good fortune to hear this presentation. He gave this presentation at local schools and civic gatherings as well. Jim also arranged for Don to present this exciting story at the Engineers Club of Dayton.

References

1) "*In Search of Quality - A Historical Review*", AFRL – ML-WP-TR-2006-4145, Donald Forney, (May 2006).
https://apps.dtic.mil/dtic/tr/fulltext/u2/a460631.pdf

2) "*Nondestructive Inspection and Evaluation*"**,** Breakthrough Technologies Developed by AFRL and Its Predecessors, p 221-226**,** (21 December, 2005).
http://www.dtic.mil/dtic/tr/fulltext/u2/a528970.pdf.

3) "*Eyewitness to History at Hickam Field/Pearl Harbor, December 7, 1941*", Donald M. Forney, Jr., (May 1999).
https://www.afmmaa.org/memoirs