TESTIMONY OF
MICHAEL GARRETT
DIRECTOR, AIRPLANE PERFORMANCE
BOEING COMMERCIAL AIRPLANES

BEFORE THE UNITED STATES SENATE
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
SUBCOMMITTEE ON TECHNOLOGY, INNOVATION, AND COMPETITIVENESS

July 19, 2006

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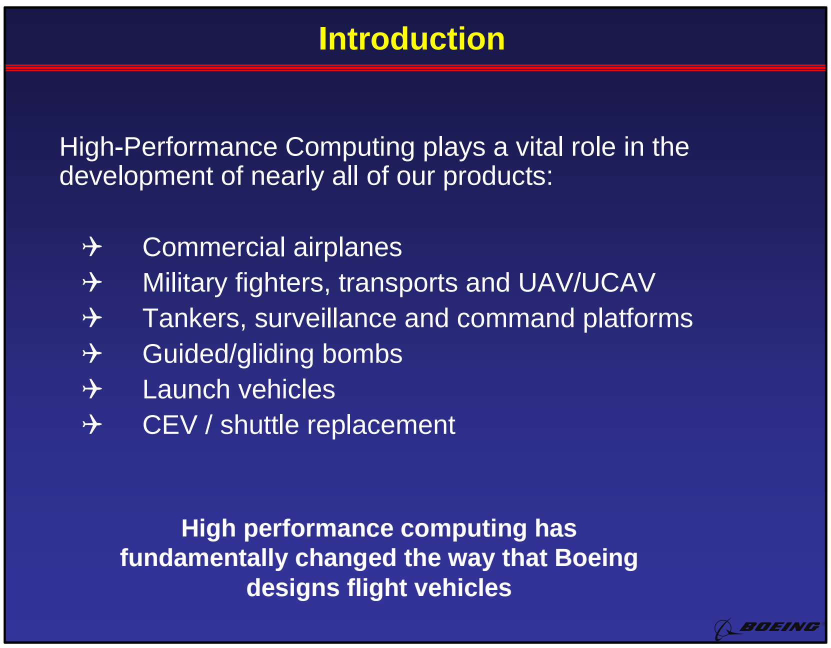
Introduction

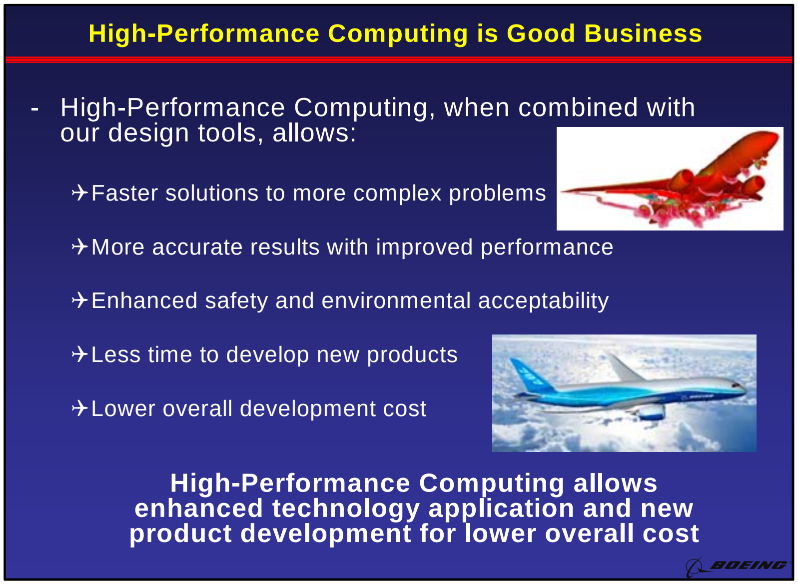
Good morning, Mr. Chairman and members of the subcommittee. I am Mike Garrett, Director Airplane Performance for the Commercial Airplane Division of the Boeing Company. I have worked at Boeing and McDonnell Douglas for 27 years with a broad range of experiences in product development, program management and marketing. In my current position, I have responsibility for the overall performance characteristics of all Boeing Commercial Airplanes, including new products, such as the 787.

At Boeing, we pride ourselves for understanding our customers' requirements and then developing, designing, building and delivering airplanes that meet or exceed those requirements.



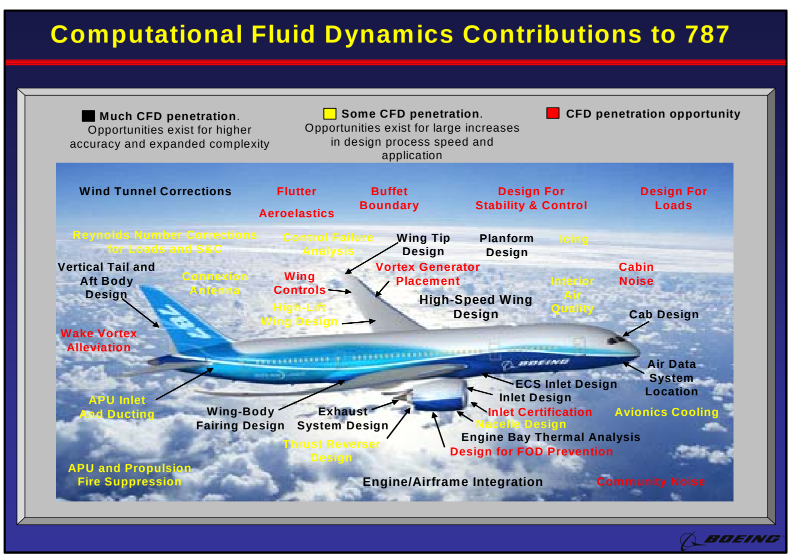
High-Performance Computing has fundamentally changed the way that Boeing designs flight vehicles, whether it be commercial transports, military fighters, unpiloted aircraft, guided bombs, launch vehicles, or crewed space exploration vehicles. Computational tools are being used to create numerical simulations to assess system performance – replacing the more costly and time consuming requirements for physical testing. For example, these new tools are being used to determine the aerodynamic performance of entire airplanes, the optimum structural layout to minimize weight, and the radar cross section of a stealthy vehicle. It is the evolution of computing hardware that has enabled more efficient simulations with reductions in overall design cycle times.

High-Performance Computing is Good Business



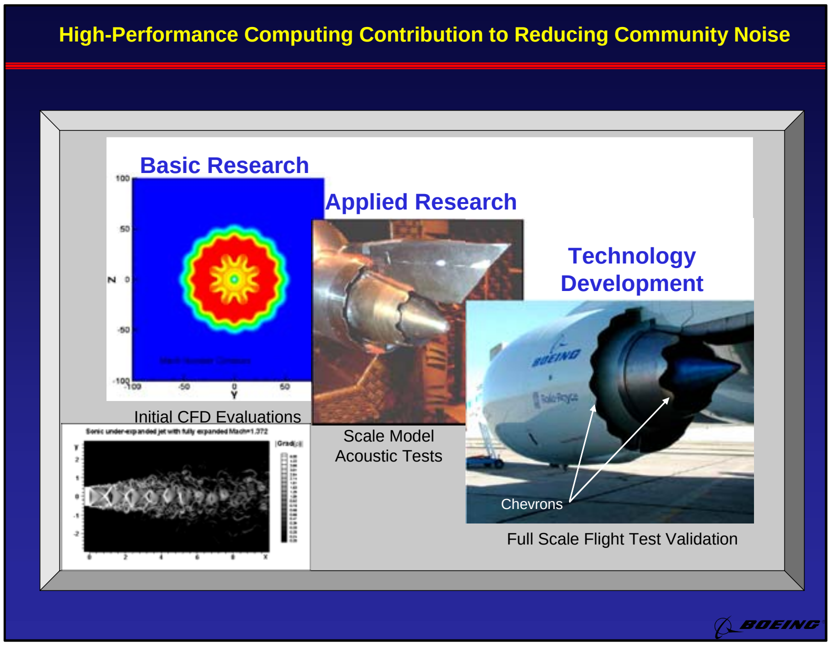
When we combine our computational design tools with the High-Performance Computing resources, we obtain incredible efficiencies in the design processes we use to develop our airplanes. Complex processes and simulations, such as computational fluid dynamics, can be run much more quickly, at lower cost, and at a level of fidelity and accuracy that is equal to that achieved in physical vehicle testing. While we will never eliminate wind tunnel and flight testing, more powerful computing tools allow us to better predict results, therefore reducing technical risk, while reducing physical testing costs.

High-Performance Computing in Computation Fluid Dynamics Applications



One of the best utilizations of High-Performance Computing is in the development of computational fluid dynamics (CFD). While CFD has been in use at Boeing for 30 years, the most extensive application has been on our newest commercial aircraft, the 787 Dreamliner. The use of CFD tools has allowed Boeing engineers to address a wide range of design challenges, including traditional wing design, the even distribution of cabin air and reduction in overall airplane noise.

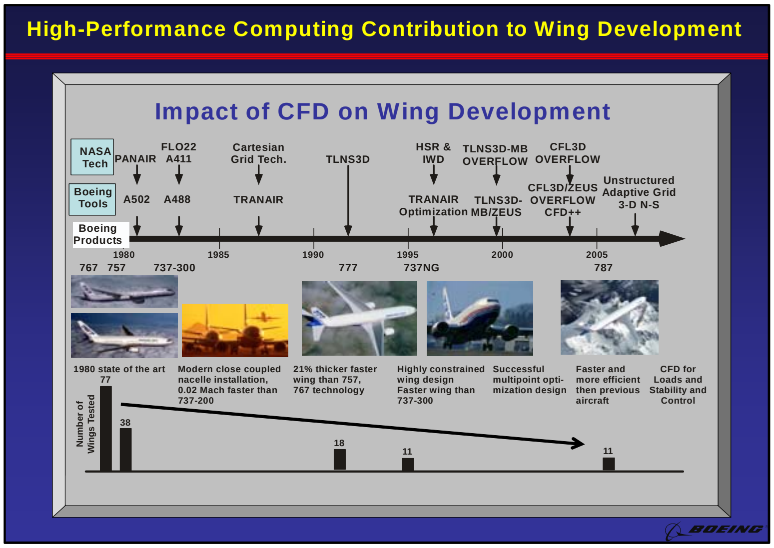
High-Performance Computing in Aircraft Noise Reduction



High-Performance Computing, together with our CFD tools, has also played a significant role in reducing airplane noise. The example above shows how an engine noise-reduction feature called "chevrons" was developed for application to our commercial airplanes. The 787 will be the first Boeing airplane with this technology. We were able to simulate the noise reduction characteristics of numerous chevron configurations and determine the best configuration for noise reduction before ever testing in the acoustic tunnel or in actual flight test. This means the 787 will be a quieter aircraft, making it more environmentally friendly for those who live and work near airports.

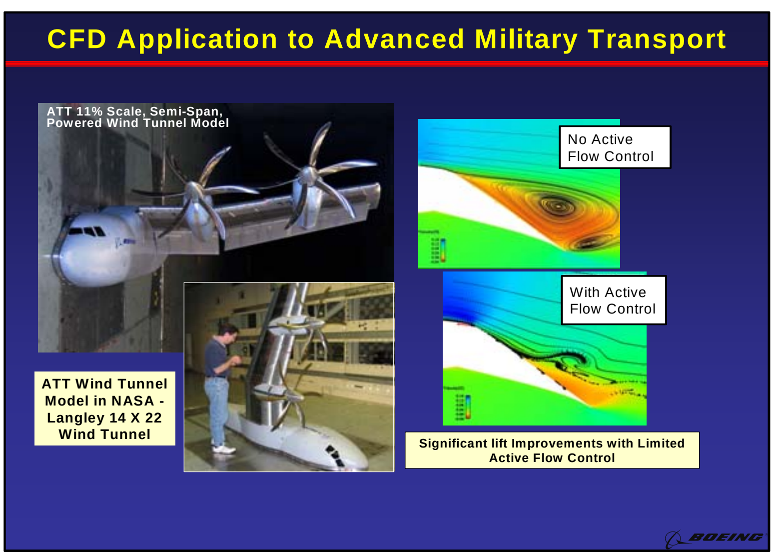
It is the knowledge gained from the this process that reduces the product development life cycle allowing our customers to get our products faster while meeting our commitment to improve the environmental performance of our airplanes.

<u>**High-Performance Computing in Wing Design**</u>



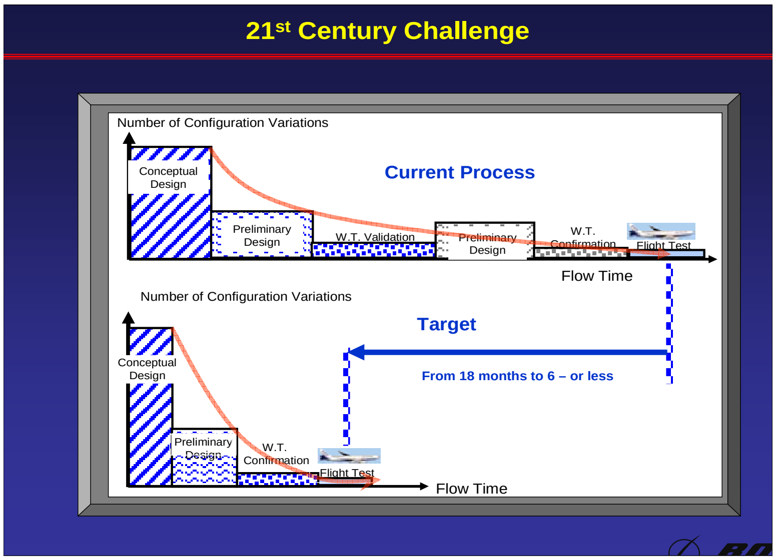
Another example of the benefit of High-Performance Computing and improved computational capability has been in our wing development over the last 25 years. In 1980, Boeing tested 77 wings in wind tunnels to arrive at the final configuration of the 767. Just 25 years later, we built and tested 11 wings for the 787 -- a reduction of over 80%. Those 11 wings took less people to design, less time to design, and the wind tunnel results matched the CFD predictions.

While our CFD tools today are very good, there are still some flight conditions that cannot be simulated very well. These conditions will continue to require significant wind tunnel testing. As more advanced computer hardware is developed, the computational tools and processes should improve and we will one day be able to calculate the airplane's characteristics everywhere in the flight regime with high fidelity.

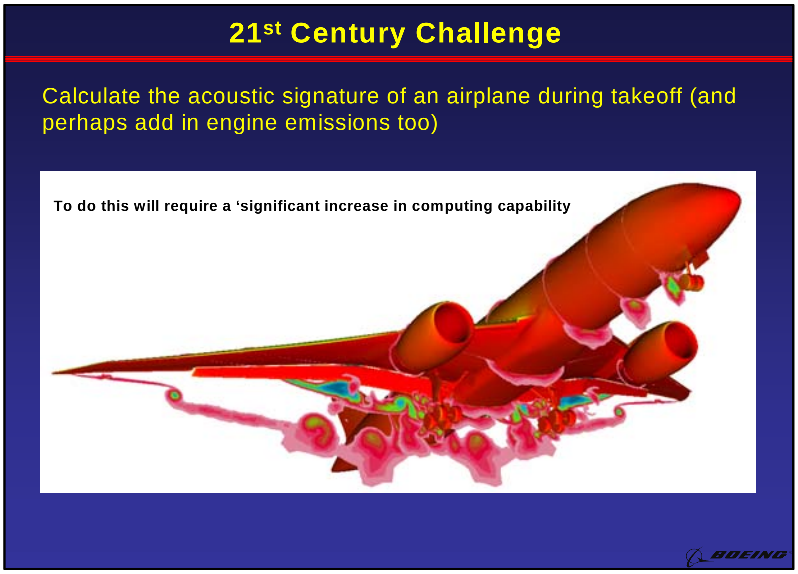


The chart above shows another wing design application which resulted in a configuration that could not have been designed without CFD design tools and High Performance Computing. The Air Force has a requirement for a battlefield delivery transport. It must operate out of unimproved, very short runways -- runways shorter than C-17s can use today. Meeting these challenging specifications requires a new and innovative wing with performance never previously demonstrated. A new active flow control technology was evaluated to achieve that performance using CFD. This computation, shown in the pictures above, demonstrated that when air remains attached to the wing, as in the picture in the lower right hand corner, lift is increased. This additional lift enables the aircraft to take off and land in shorter distances. After computer simulation, this concept was then successfully demonstrated on the Advanced Tactical Transport model at the NASA Langley wind tunnel.

Future of High-Performance Computing



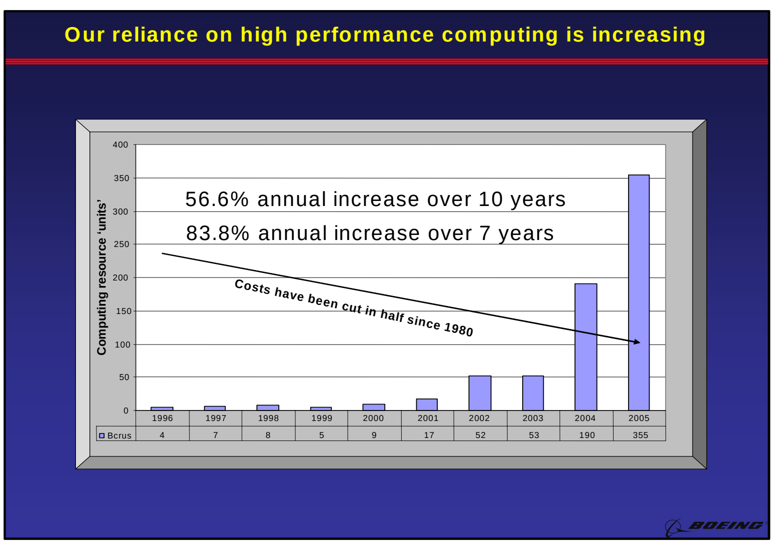
As previously stated, we have reduced the amount of wind tunnel testing required for new product development. Our vision for a future design environment would be that all simulation work would be done computationally, enabled through more powerful High-Performance Computing tools. This would allow us to test only two or three wings in the wind tunnel versus the 11 for the 787. This will not only dramatically reduce the non-recurring cost to develop an airplane but also reduce the time it takes to bring a new product to market. Instead of developing a new airplane once a decade, we can potentially develop one in significantly less time, allowing us to be more responsive to market demand.



An even greater challenge lies in the area of acoustics. Today laboratory and/or flight tests must be conducted to determine the acceptability of candidate airplane configurations to meet community noise requirements. In the future we hope to do all the simulations within the computer.

This is a problem that is probably decades away from being addressable because noise covers a wide frequency. The numeric grid to capture the shorter wavelengths drives up the size of the problem dramatically – as does the requirement to model the landing gear, all flap and slat details, the engine (running!) – and it is all time-dependent. As the hardware continues to improve, we will incrementally work our way up to meeting this challenge.

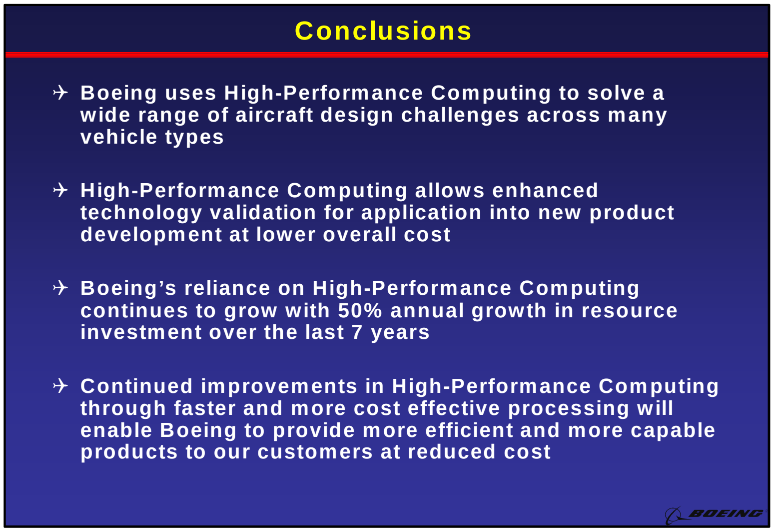
High-Performance Computing Usage at Boeing



Boeing is committing large amounts of resources to provide the necessary computing capability we require. During the development of the 787, we have nearly doubled the capacity of our high performance computing data center year after year. This is a big investment of capital, but one that we are willing to make because there is a measurable return for that investment. While our

High-Performance Computing usage has increased, the cost per unit has been dramatically reduced by 50% making our development tools more and more cost effective.

CONCLUSIONS



Boeing has made extensive use of High-Performance Computing in addressing a wide range of issues across all of its products. While High-Performance Computing is a valuable tool across the entire product cycle, its primary contribution has been in technology validation and its application into new product development.

Our reliance on High-Performance Computing continues to grow as better, faster and more cost effective processing is available. This will enable Boeing to deliver better value to our customers through products that are more efficient and capable at significantly lower cost.

Again, Mr. Chairman, I appreciate this opportunity to testify before the subcommittee.