



Subsonic Rotary Wing

Susan A. Gorton, Principal Investigator

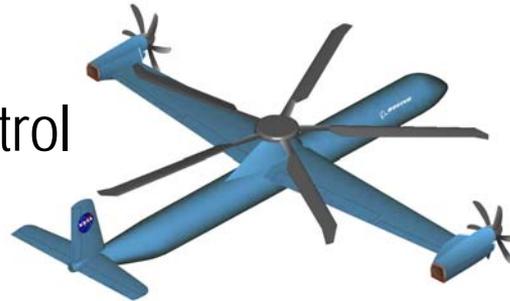
Barbara M. Esker, Project Manager

Isaac López, Project Scientist



Outline

- Rotary Wing Project objectives, structure
- Multidisciplinary Analysis and Technology
- Research areas
 - Propulsion
 - Flight Dynamics and Control
 - Aeromechanics
 - Acoustics
 - Materials and Structures
 - Experimental Capabilities
- NRAs
- Partnerships
- Future work



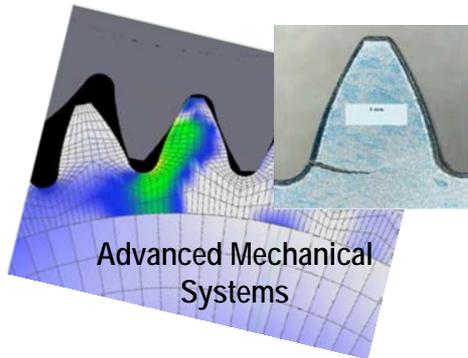
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Subsonic Rotary Wing (SRW) Project

Goal: Improve the civil benefits (ease of access, reduce congestion at airports, emergency and rescue services) of rotary wing vehicles

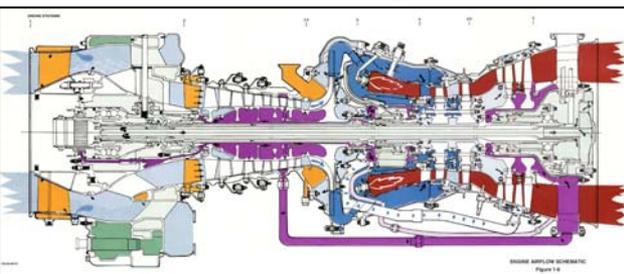


Civil Requirements (support NextGen)

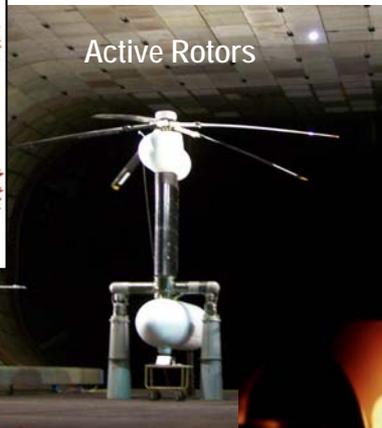
- Reduce airport congestion
- Community acceptance
- Reduce emissions
- Decrease cost, increase utility
- Safe operations for advanced concepts

Research Areas

- ➡ Increase speed and range
- ➡ Noise propagation and reduction
- ➡ Increase propulsion efficiency
- ➡ Increase payload
- ➡ Improve control systems

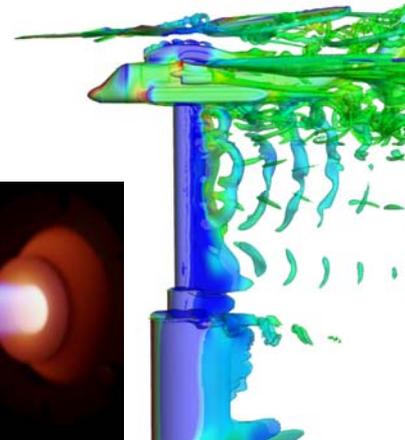


Engine Research



Active Rotors

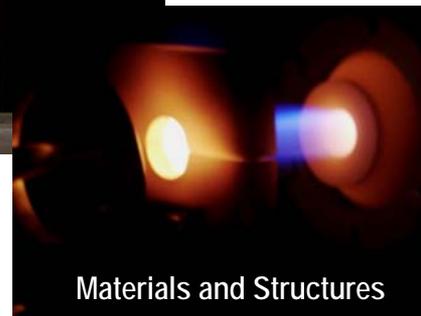
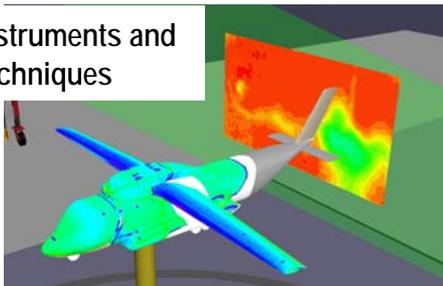
Computational Methods



Acoustic Research



New instruments and techniques



Materials and Structures



SRW Approach

Approach has three main components

- NASA in-house research
- Research with partners (Other Government Agencies, Industry, University)
- Sponsored foundational research through NASA Research Announcement (NRA)

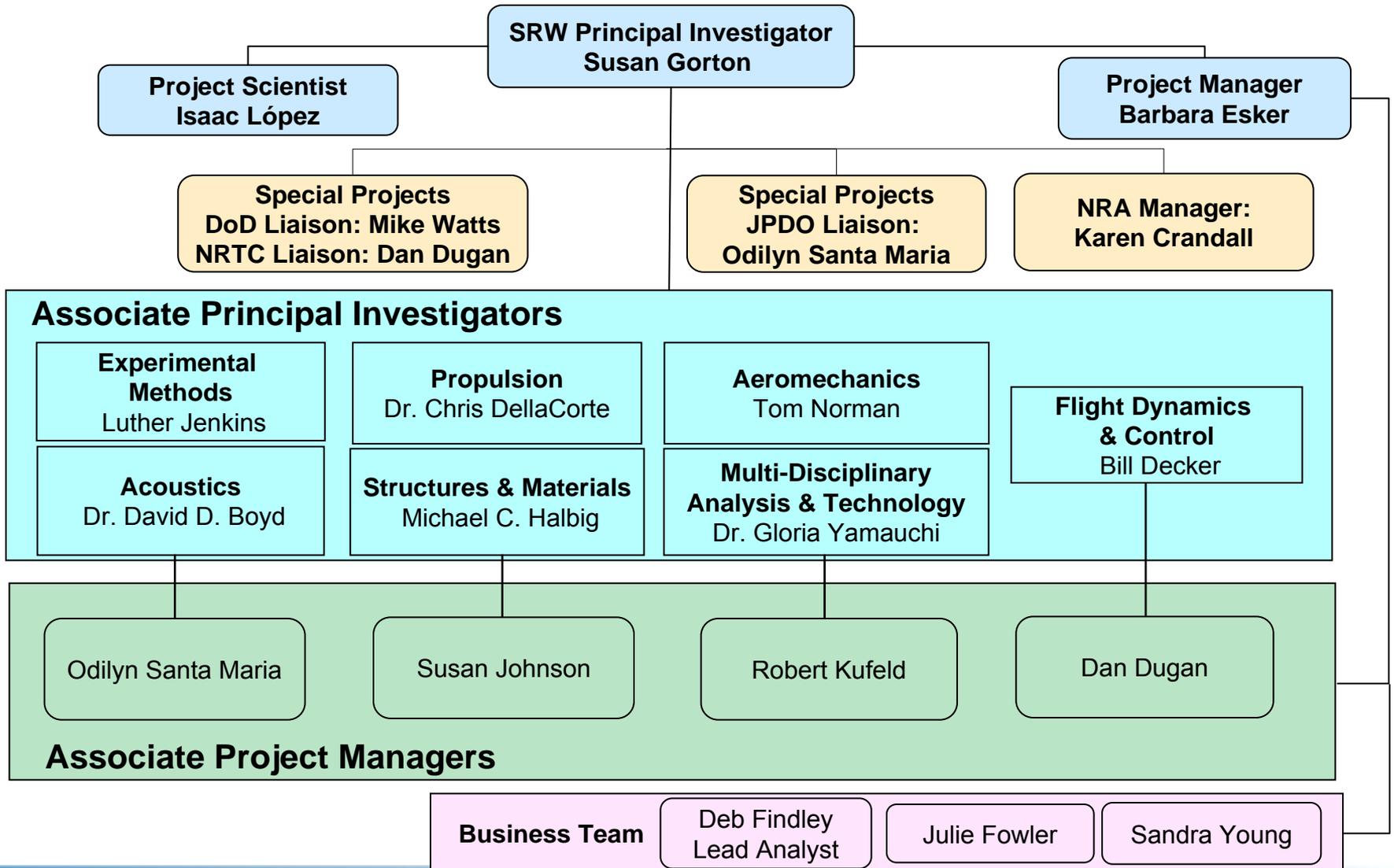
Technical Challenges require integration of disciplines to succeed

- Integrated Variable Speed Rotorcraft Concept
- Super-Integrated Control Design
- Advanced Structural and Propulsion Concepts for Interior Noise and Vibration Reduction
- Interactional Aeroacoustics Investigation
- Unified Experimental Techniques





Rotary Wing Project Management Structure





Multi-Disciplinary Analysis and Technology

Provides a focal point for the integration of discipline technologies. Analyses development at the system level and demonstrations of integrated components provide a path for maturing technology

Elements

- Multi-Disciplinary Design & Analysis
- Multi-Disciplinary Tech Challenges

Progress FY08

- In-house support of Joint Heavy Lift (JHL), LCTR2
- In-house evaluation of propulsion system requirements
- In-house, civil rotorcraft conceptual design code (NDARC)

Next Steps FY09

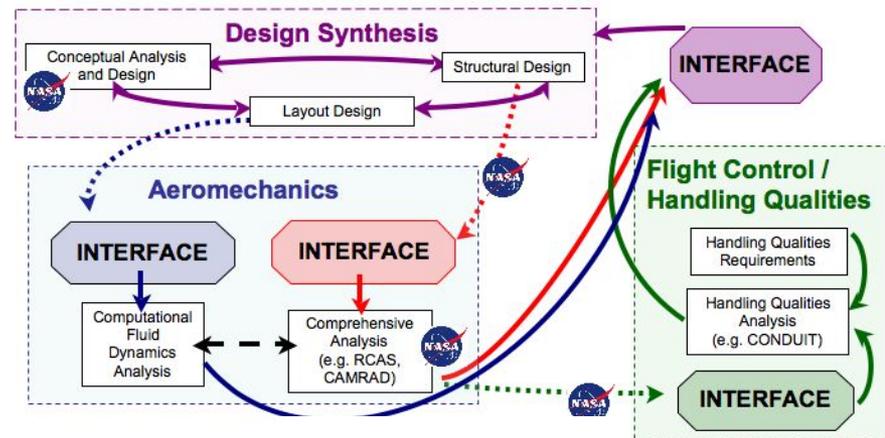
- Evaluation of rotary wing aircraft in the airspace system
- Evaluation of propulsion airframe integration effects
- Support of Airspace's NRA as appropriate



Systems Concepts Studies Integrated Analysis Environment



AFDD Project Focused on Developing **INTERFACES** in Design Process
 Objective: Reduce time for higher fidelity analysis of key areas
 Objective: Increase configuration level design and analysis of select concepts





Why large transport rotorcraft configurations?

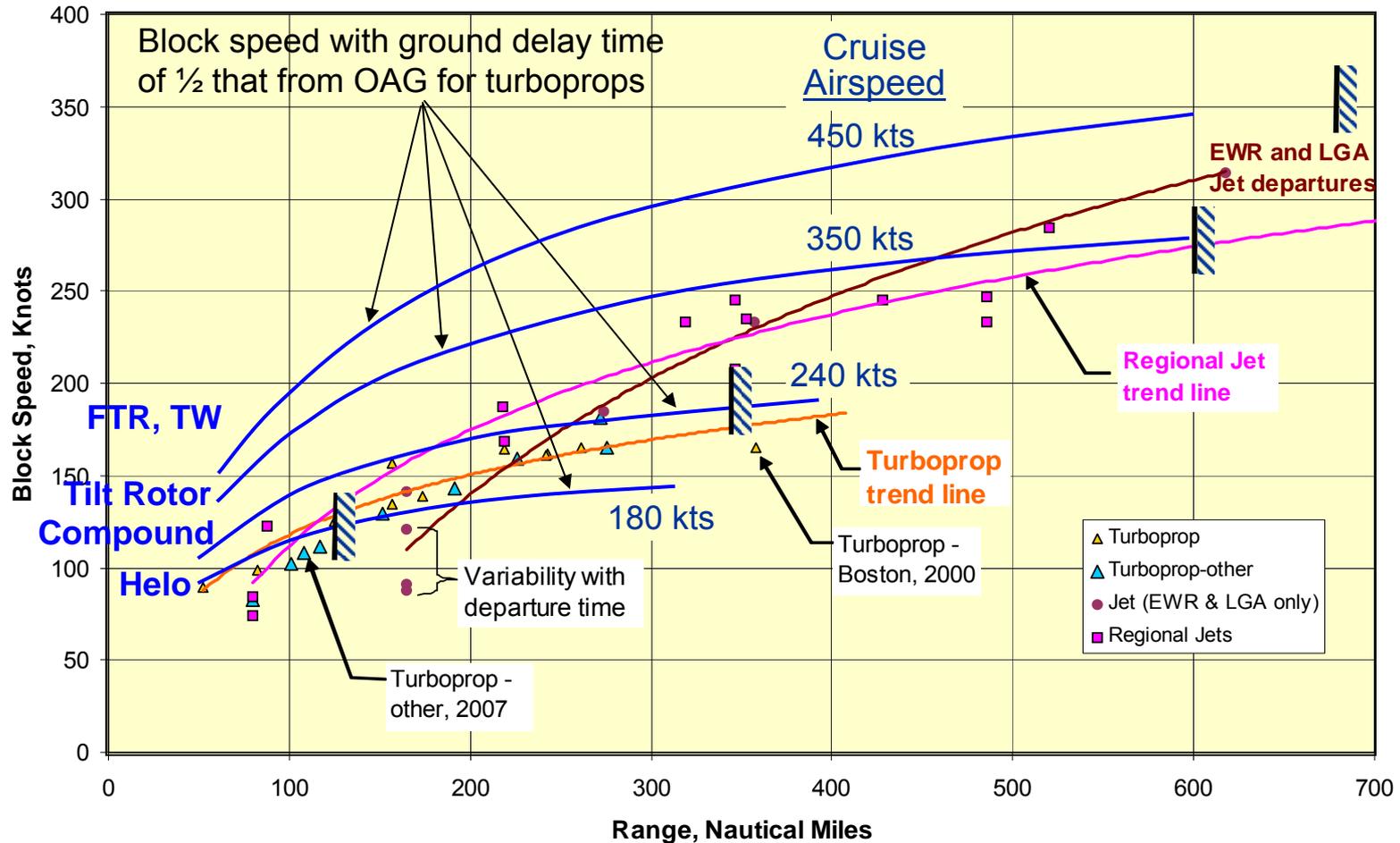
- NASA Aeronautics directed to support NextGen technologies and capabilities
- Congestion/capacity an issue in NextGen
- Vertical capability at one or both ends of a mission increases capacity, particularly in the 300-600nm flight range
- Simultaneous, Non-Interfering (SNI) approaches need to be evaluated in the current NextGen CONOPS

System studies to date have shown these types of configurations will improve capacity



The Rationale for Rotary Wing Transport Mission Range

Develop Civil Missions and Baseline Data



2008 Study by The Boeing Company for NASA



Variable/Multi-speed main rotor

- Enables high-speed configurations
 - single main rotor/compound rotorcraft
 - tiltrotor configurations
- Need about 50% reduction in main rotor rpm from hover condition to forward flight
 - maintain efficiency of powerplant system
 - no or minor weight penalty
 - creates many other technical issues (dynamics, low frequency vibration, flight controls, acoustics, aero-performance, etc)



Large Civil Tiltrotor 2nd Gen (LCTR2)

NASA's notional high-speed configuration

- Use to model configuration capabilities in the Airspace
- 90 passengers, 300 knots cruise speed, 1254 nm range
- Hover tip speed 650 fps/ cruise tip speed 350 fps



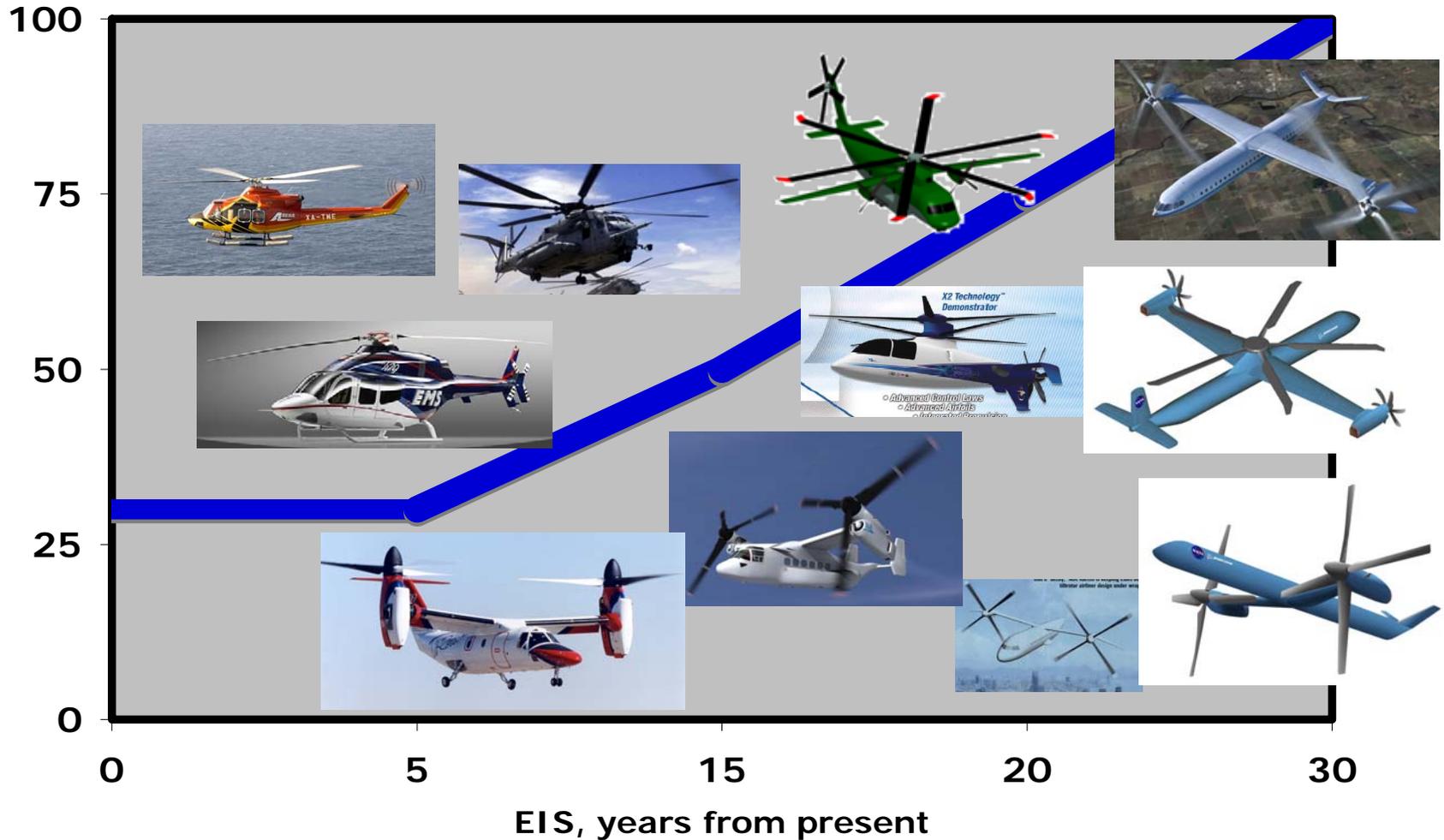
Circa October 2007



Portfolio Investment

Weighted heavily towards far-term applications

SRW technologies applicable across wide range of configurations.

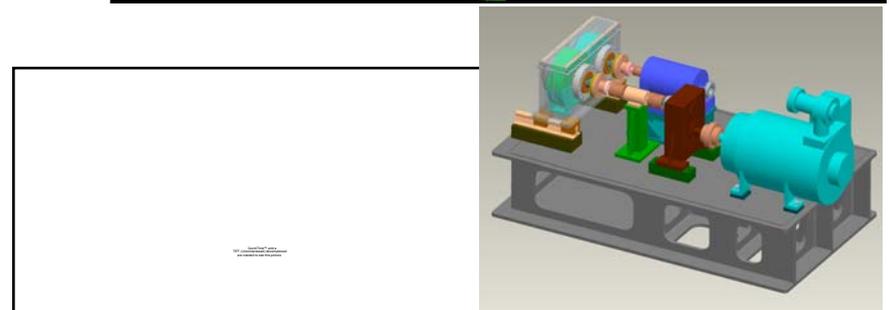
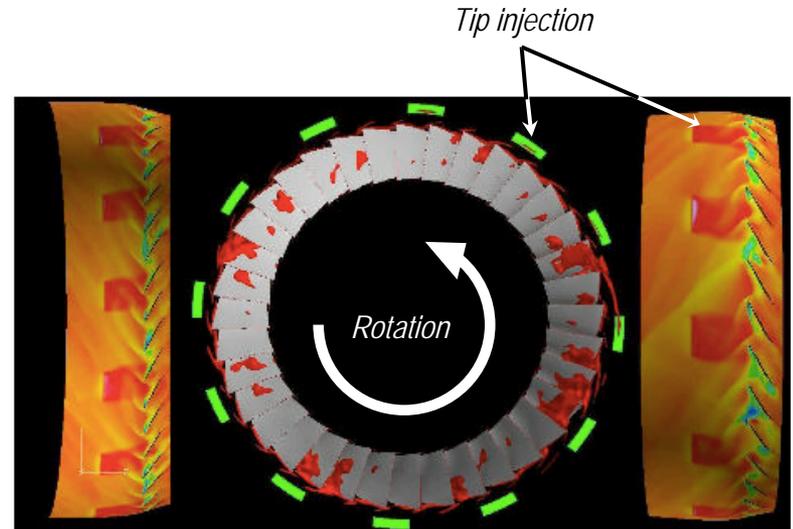
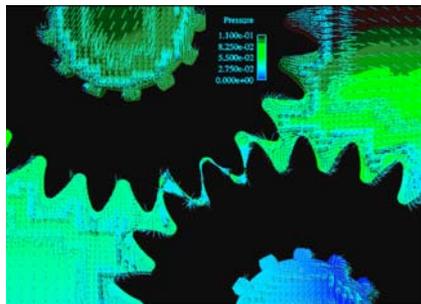
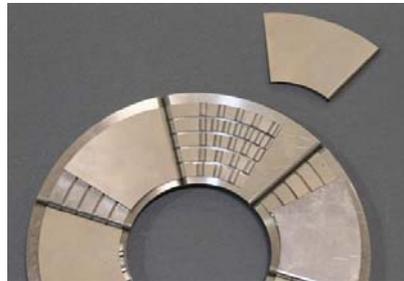




SRW Discipline: Propulsion

Advanced modeling tools/concepts essential to allow an engine/drive system to achieve a significantly larger speed range without sacrificing power and efficiency

- High efficiency, multi/variable-speed drive systems
- Oil free engine/optimized gearbox systems
- Wide operability engine systems for rotary wing applications



Windage facility
(under construction)

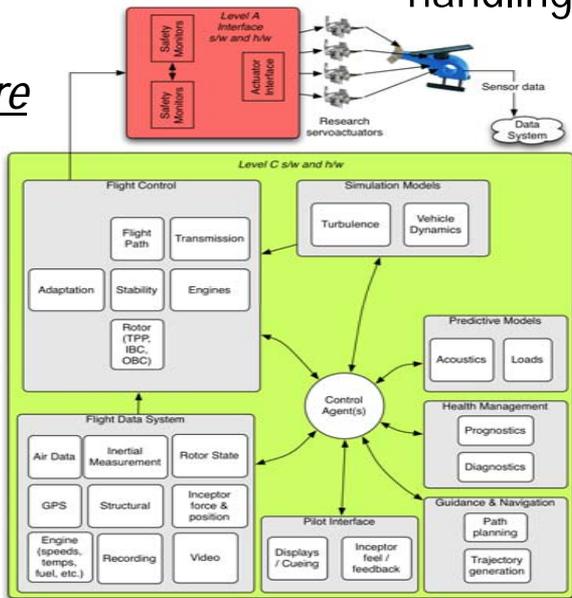
Conceptual variable / multi-speed drive
system for a tiltrotor aircraft



SRW Discipline: Flight Dynamics and Control

Flight dynamics and control research focuses on modeling, testing, and validating real-time control of integrated, advanced rotorcraft technologies with emphasis on heavy-lift handling qualities and control

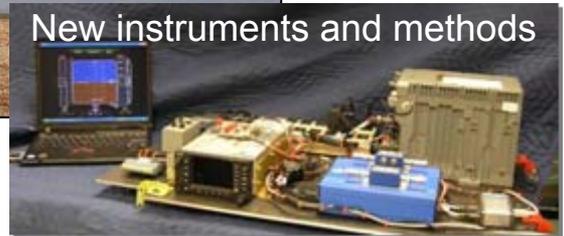
Control Architecture Modeling



Testing (simulation and flight)



Aris/Bell 206 Helicopter, Hollister, CA



New instruments and methods

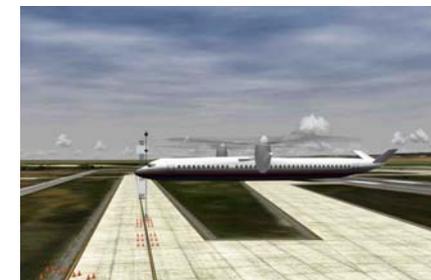
Validation



Assessment of Flight Procedures in Vertical Motion Simulator



LCTR2 precision hover simulation



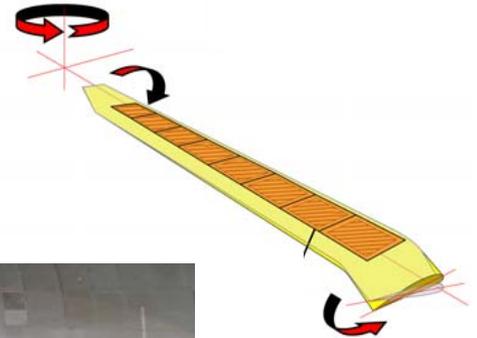
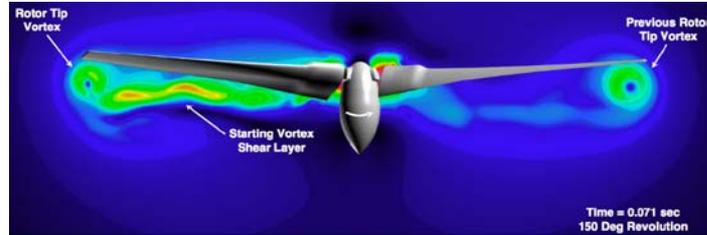


SRW Discipline: Aeromechanics

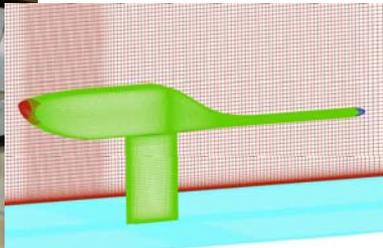
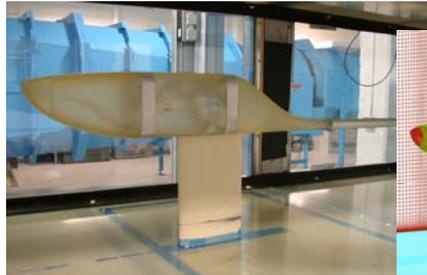
Rotorcraft aeromechanics research extends from first-principles modeling through testing and validation for isolated and multi-disciplinary phenomena

First-Principles Modeling

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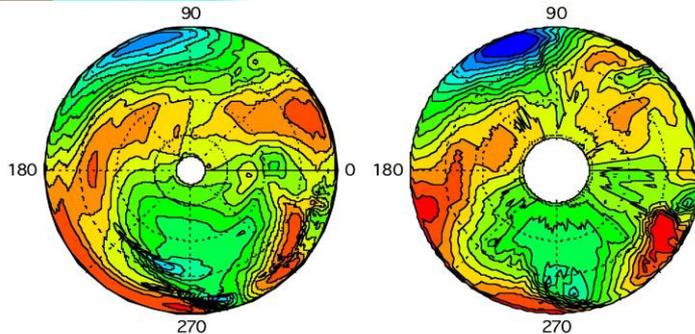


Testing (small, large and full-scale)



Validation

Coupled Solution



Flight Test

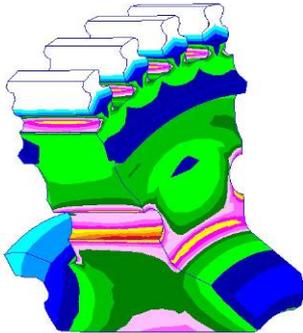




SRW Discipline: Materials and Structures

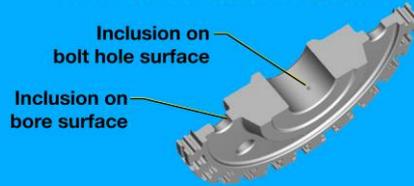
Materials and structures research focused on rotorcraft-specific issues in crashworthiness, advanced materials for airframes and engines, durability and damage tolerance

Calculation of Max Principal Stress for a Turboshaft HP Turbine Disk

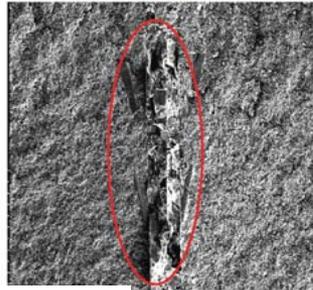


Validation

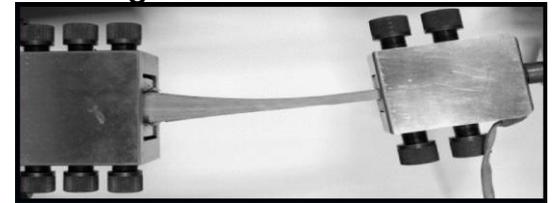
Probabilistic Fatigue Life Prediction for Advanced Turbine Disk Alloys



Inclined grain flaw in silicon nitride sample



Fatigue life for flexbeams



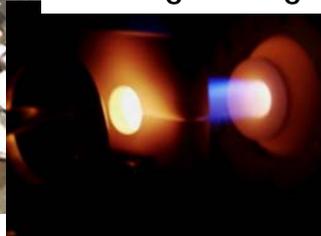
Self-healing coupon test

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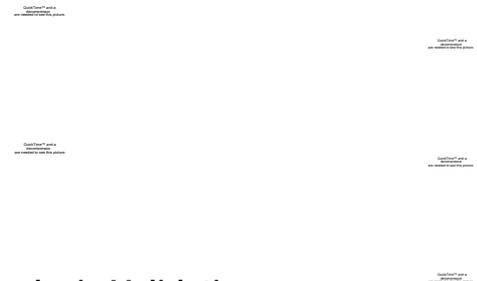


Erosion Test Rig

Thermal Barrier Coating Testing



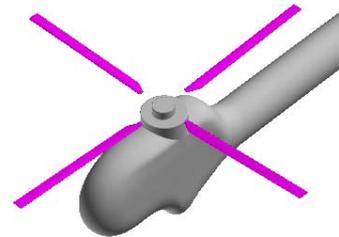
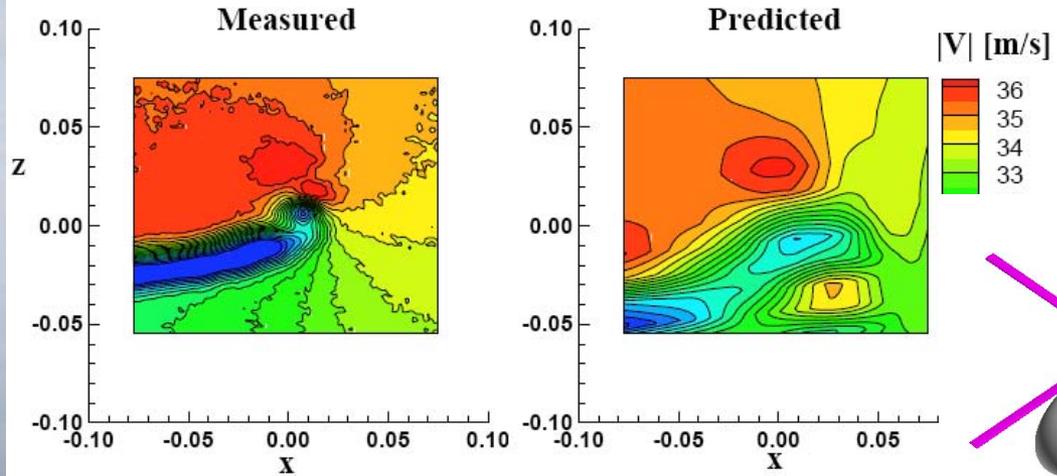
Crash Analysis Validation





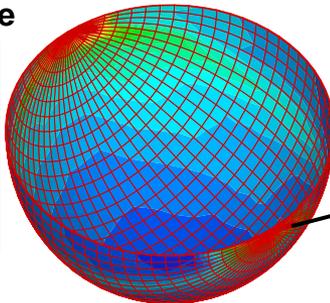
SRW Discipline: Acoustics

Rotorcraft acoustics research focus includes the study and control of source noise, interior noise, gear noise, propagation, and concepts for low-noise operations

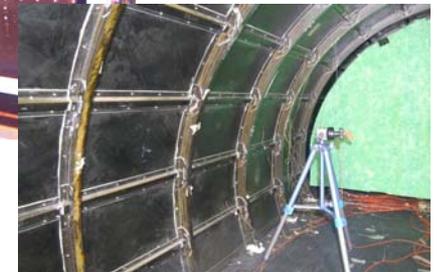
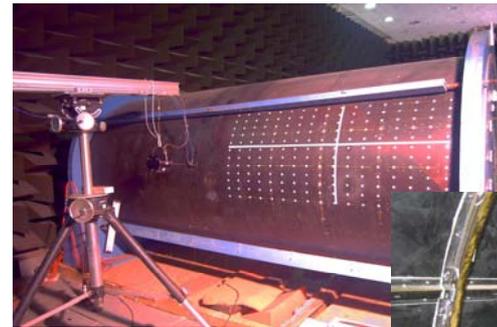
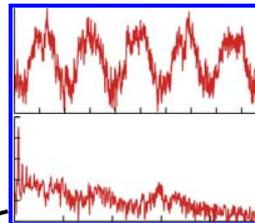


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Nose



Tail

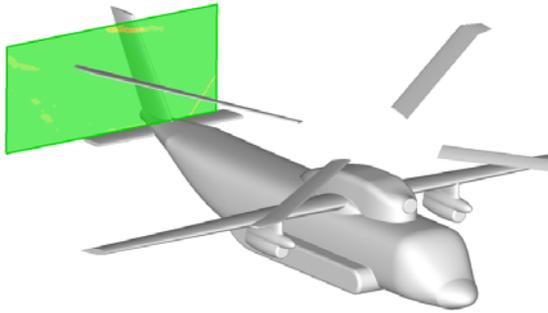




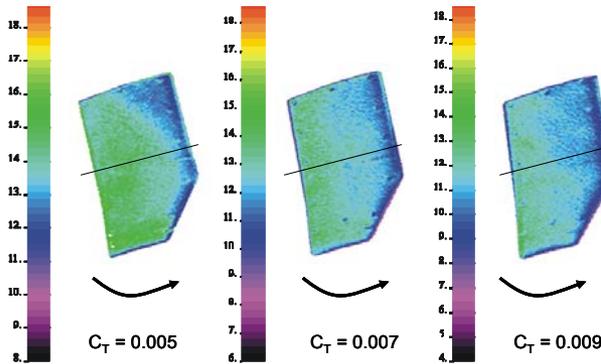
SRW Discipline: Experimental Capabilities

Experimental Capabilities development is essential for validation of aeromechanics, acoustics, structural response, and propulsion fundamental methods

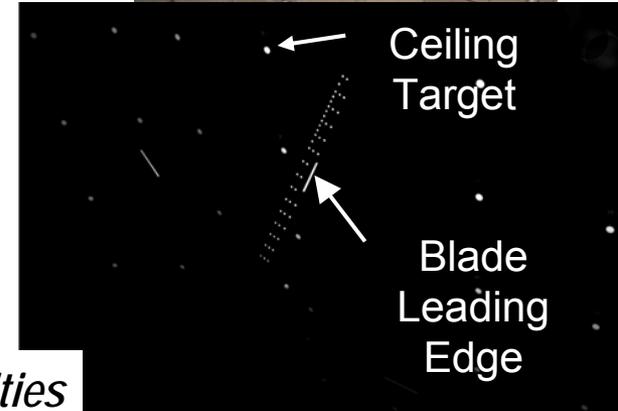
Large field rotor wake assessments



Blade/fuselage unsteady pressures



Deformed blade geometry



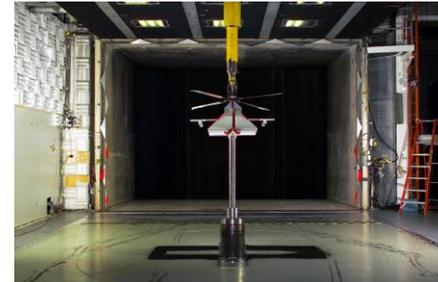
Targeted Primary NASA Rotorcraft Test Facilities



National Full-Scale Aerodynamics Complex



Transonic Dynamics Tunnel



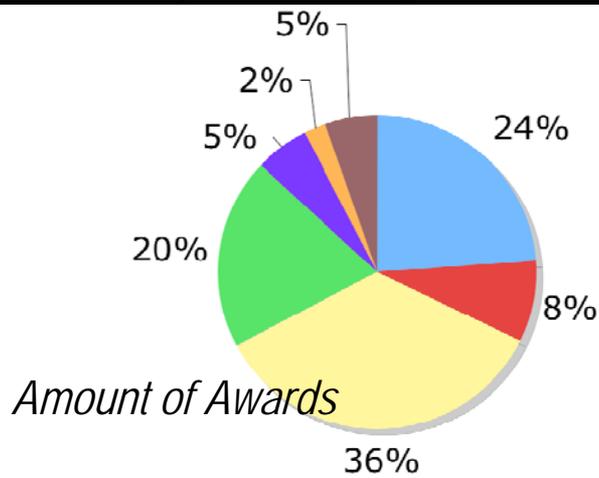
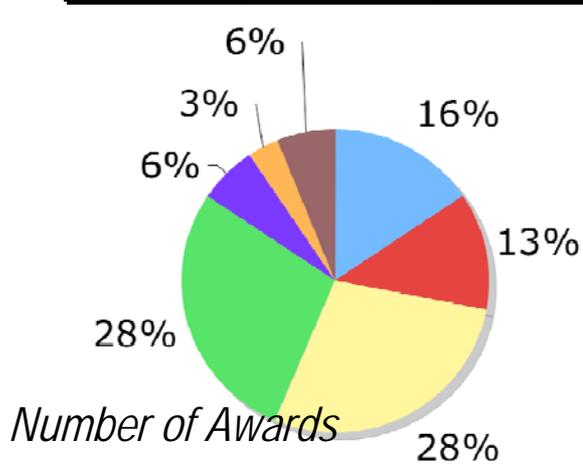
14- by 22-Foot Subsonic Tunnel

Subsonic Rotary Wing Project



NRA Investment by Technical Discipline; Number awarded, Total award value

NRA Round	Propulsion	Flight Dynamics & Control	Aeromechanics	Acoustics	Materials & Structures	Experimental Capabilities	Multi-Disciplinary/ System Design
Round 1	2 (\$1.255M)	0	2 (\$2.020M)	5 (\$2.442M)	2 (\$0.886M)	1 (\$0.373M)	0
Round 2	2 (\$0.845M)	4 (\$1.313M)	4 (\$2.514M)	0	0	0	2 (\$0.855M)
Round 3*	1 (\$1.800M)	0	3 (\$1.190M)	4 (\$0.745M)	0	0	0
Total	5 (\$3.900M)	4 (\$1.313M)	9 (\$5.724M)	9 (\$3.187M)	2 (\$0.886M)	1 (\$0.373M)	2 (\$0.855M)



- 1 Propulsion
- 2 Flight Dynamics
- 3 Aeromechanics
- 4 Acoustics
- 5 Materials & Structures
- 6 Experimental Cap
- 7 Multi-Disciplinary/Integrated Design

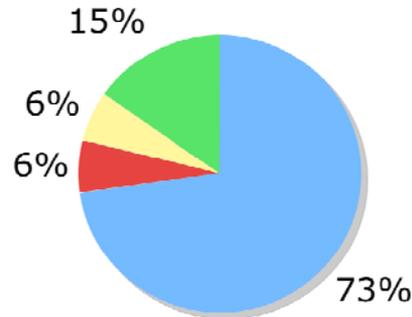
* Tentative figures - award negotiations on-going



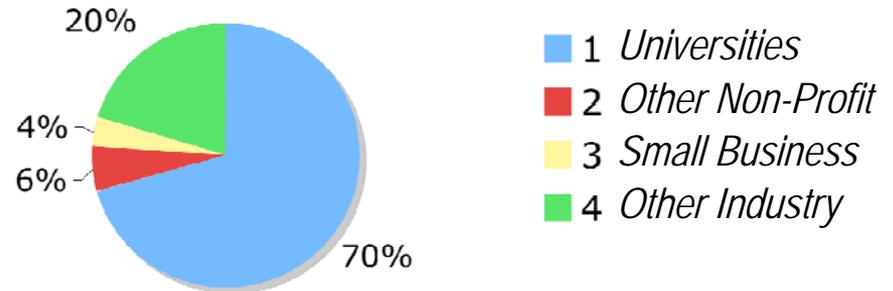
NRA Investment by Recipient; Number awarded, Total award value

NRA Round	Universities Number (Total Award Value)	Other Non- Profit Number (Total Award Value)	Small Businesses Number (Total Award Value)	Other Industry Number (Total Award Value)
Round 1	10 (\$6.147M)	2 (\$0.886M)	0	0
Round 2	10 (\$3.809M)	0	1 (\$0.450M)	2 (0.855M)
Round 3*	4 (\$1.229M)	0	1 (\$0.136M)	3 (\$2.370M)
Total	24 (\$11.185M)	2 (\$0.886M)	2 (\$0.586M)	5 (\$3.225M)

NRAs by recipient type



NRA Award Values by Recipient Type



* Tentative figures - award negotiations on-going



Partnerships

Completed last 6 months

- DARPA, SMART rotor testing
- AATD, composite crashworthiness modeling and drop testing (SARAP)
- Army, Vertical Motion Simulator Heavy Lift Simulation

On-Going

- ZFL, Army Individual Blade Control testing
- FAA, drive system health monitoring
- Army slowed rotor research
- Army, UH-60 Airloads research
- ONR, oil-free bearing testing
- Boeing, crashworthiness
- Army, Joint Heavy Lift
- AFRL, acoustic flight research
- Sikorsky, internal acoustics, sidewall transmission study
- Army/Boeing, Active Twist Rotor
- Army/Boeing, Small Scale Active Rotor
- Army, PSP, PIV and PMI

Under Negotiation

- Sikorsky, impact resistance
- JAXA active rotor prediction and test
- HART III active twist rotor
- KIST, oil-free engine technology

Emerging

- CRI, rotorcraft icing





On the Horizon

- IBC and UH-60 Airloads in NFAC (Army and Sikorsky)
- Fuselage drag reduction active flow control in 14x22 (Army)
- Drive train and propulsion facilities on-line (Army)
- Active Twist Rotor demonstration in TDT (Army)
- Full-scale drop test of MD530 (Boeing)
- Enhanced experimental capability (Army)
- Flight control simulations (Army, Hoh Aeronautics)
- Participation in HART III International Active Twist Rotor project (Army, DLR, DNW, ONERA, JAXA, Korea)



Summary

- Goals of Subsonic Rotary Wing are centered around civil applications of rotary wing technologies
- SRW project making measurable and significant progress in many research areas
- Partnerships are providing significant leveraging
- Execution of FY09 plan is critical



Backup slides



SRW FY08 Publications (1 of 6)

Performance of Advanced Heavy-Lift, High-Speed Rotorcraft Configurations	Wayne Johnson*, Hyeonsoo Yeo**, and C.W. Acree, Jr.*	Presented at the AHS International Forum on Rotorcraft Multidisciplinary Technology, Seoul, Korea, October 15-17, 2007.
Determination of Turboprop Reduction Gearbox System Fatigue Life and Reliability	Zaretsky, E.V.; Lewicki, D.G.; Savage, M.; and Vlcek, B.L	Society of Tribologists and Lubrication Engineers (STLE) in Tribology Transactions (Vol. 50, No. 4, October 2007, pp. 507-516),
Finite Element Development and Specifications of a Patched, Recessed Nomex Core Honeycomb Panel for Increased Sound Transmission Loss	Ferdinand Grosveld	NASA-CR-2007-214898
wave bearing topic	Fred Oswald	2007 ASME/STLE International Joint Tribology Conference San Diego, CA. Oct 22-24
Synergy of Drive Train Research Between Rotorcraft and Space Applications	Robert Handschuch	AHS Propulsion Specialists Meeting in Williamsburg, VA on 23-23 October 2007
Computational Fluid Dynamic Simulation of the V22 Isolated Tiltrotor	Neal Chaderjian	2007 Supercomputing Conference, Reno, NV on November 10-16, 2007
OVERVIEW OF NASA LANGLEY'S PIEZOELECTRIC CERAMIC PACKAGING TECHNOLOGY AND APPLICATIONS.	Robert G Bryant, NASA	JISSE 10 - SAMPE Japan Tokyo Big Sight, Tokyo, Japan Nov 27 - 30th, 2007
Vibration Transmission Through Bearings With Application to Gearboxes	David P. Fleming	NASA/TMÑ2007-214954
Vortex Filament Evolution Subject to Pulsed/Periodic Disruption	L. Young	AIAA Aerospace Sciences Meeting, Reno, NV, January 2008.
Algorithm and Turbulence Model Requirements for Simulating Vortical Flows	R.H. Nichols	AIAA 46th Aerospace Sciences Meeting, Jan. 7-10, 2008, Reno, NV, AIAA 2008-0337
A Multi-Code Python-Based Infrastructure for Overset CFD with Adaptive Cartesian Grids	Wissink, A.M., Sitaraman, J., Sankaran, V., Mavriplis, D.J., Pulliam, T.H.,	AIAA Paper No. 2008-0927, Jan. 2008. Presented at the AIAA 46th Aerospace Sciences Meeting, Reno, NV, Jan 2008
Towards Verification for Unstructured Grid Solvers	Eric Nielsen	AIAA Paper No. 2008-0666, Jan. 2008. Presented at the AIAA 46th Aerospace Sciences Meeting, Reno, NV, Jan 2008
Turbulence Modeling Treatment for Rotorcraft Wakes	Mark Postdam, AFDD, and Tom Pulliam, ARC,	AHS Specialist meeting in January 2008 at San Francisco, CA
The Rotor Azimuth Synchronization Program (RASP)	Gary Fleming, William Culliton	LAR-17581-1, disclosure number
Performance Analysis of Trailing-Edge Flaps in Helicopter Primary Control	Jaye Falls, Univ of MD Anubhav Datta, Elore Inderjit Chopra, Univ of MD	Presented at the AHS Specialist's Conference on Aeromechanics, San Francisco, CA, January 23-25, 2008.
Influence of Lift Offset on Rotorcraft Performance	Wayne Johnson	Presented at the AHS Specialist's Conference on Aeromechanics, San Francisco, CA, January 23-25, 2008.
Requirements for Next Generation Comprehensive Analysis of Rotorcraft	Wayne Johnson and Anubhav Datta, ELORET Corporation	Presented at the AHS Specialist's Conference on Aeromechanics, San Francisco, CA, January 23-25, 2008.
An Assessment of the State of the Art in Multidisciplinary Aeromechanical Analyses	Anubhav Datta, Elore Corp Wayne Johnson, NASA	Presented at the AHS Specialist's Conference on Aeromechanics, San Francisco, CA, January 23-25, 2008.



SRW FY08 Publications (2 of 6)

Suppressing Inplane, low frequency helicopter Harmonic Noise with Active Controls	Ben Sim, UARC Ames Research Center	Presented at the AHS Specialist's Conference on Aeromechanics, San Francisco, CA, January 23-25, 2008
Understanding far field near inplane high speed harmonic helicopter rotor noise in hover: governing parameter sand acoustic control possibilities	Baurav Gopalan Frederic Schmitz University of Maryland	Presented at the AHS Specialist's Conference on Aeromechanics, San Francisco, CA, January 23-25, 2008.
Assessment of predictive capability of aeromechanics methods	William S Bousman, Quercus Associates SL Thomas Norman, NASA	Presented at the AHS Specialist's Conference on Aeromechanics, San Francisco, CA, January 23-25, 2008.
Calculation of JVX proprotor performance and comparisons with hover and high speed test data	C. W. Acree, Jr. NASA	Presented at the AHS Specialist's Conference on Aeromechanics, San Francisco, CA, January 23-25, 2008.
Impact Modeling of Crushable Foams and Other Energy Attenuating Materials	Karen Jackson Edwin L. Fasanella	Crashworthiness Working Group (CWG) meeting that was held in conjunction with the Composite Materials Handbook (CMH)-17 Coordination Meeting Cocoa Beach, Florida January 14-16, 2008
Comprehensive Dynamic Stall Performance of a Variable Droop Leading Edge Airfoil with a Gurney Flap	M.S. Chandrasekhara, Naval Postgraduate School P.B. Martin, AFDD C. Tung, AFDD	Journal of the American Helicopter Society, Vol 53, No 1, Jan 2008, pp 18-25
NDesign, Fabrication, and Performance of Foil Gas Thrust Bearings for Microturbomachinery Applications, Ó	Rob Bruckner	ASME/IGTI Turbo Expo 2008; also NASA TM
patent for inventing a flow-stabilizing device for centrifugal compressors	Gary Skoch, Mark Stevens and Tom Jett	Patent number 7,326,027
Centrifugal and Axial Pump Flow Code-PUMPA User's Manual	Joseph Veres	NASA/TP-2007-214823
Low Cycle Bending Fatigue of AISI 9310 Steel Spur Gears	Robert Handschuh, Timothy Krantz, Brad Lerch and Chris Burke	Gear Solutions Magazine, January 2008 issue
Failure Mechanisms Identified and Life Prediction Approaches Established for Thermal and Environmental Barrier Coatings Under Thermal Gradients	Dongming Zhu & Mike Halbig	32nd International Conference on Advanced Ceramics and Composites held in Daytona Beach, Florida, January 26 through Feb 1, 2008
Oxidation Kinetics and Stress Effects for the Oxidation of Continuous Carbon Fibers within a Microcracked C/SiC Ceramic Matrix Composite	Michael C. Halbig, James D. McGuffin-Cawley, Andrew J. Eckel, David N. Brewre	Journal of the American Ceramic Society, February 2008 - Vol. 91 Issue 2 Page 351-689
Pitting and Bending Fatigue Evaluations of a New Case-Carburized Gear Steel	Timothy Krantz, Brian Tufts	Gear Technology Magazine, March 2008
Overview of the NASA Subsonic Rotary Wing Aeronautics Research Program in Rotorcraft Crashworthiness	Dr. Karen Jackson, Yvonne Fuchs, Sotiris Kellas	Special Symposium on Ballistic Impact and Crashworthiness of Aerospace Structures to be held during the 11th ASCE Earth and Space Conference, Long Beach, CA, on March 3-5, 2008.
Soft-Inplane Tiltrotor Aeromechanics Investigation Using Two Comprehensive Multibody Solvers	P. Masarati, D. Piatak, G. Quaranta, J. Singleton, J. Shen	Journal of the American Helicopter Society, Vol 53, No 2, April 2008, p179-192.
Prediction of Rotor Structural Loads with Comprehensive Analysis	H. Yeo and W. Johnson	Journal of the American Helicopter Society, Vol 53, No 2, April 2008, p193-209
Advanced Low Conductivity Thermal Barrier Coatings: Performance and Future Directions	D. Zhu and R. A. Miller	35th International Conference on Metallurgical Coatings and Thin Films 2008 (ICMCTF), San Diego, California, on April 30, 2008
Modeling and Simulation of Turbomachinery Automated Power Assessment for Helicopter Turboshaft Engines	Dr. Michael Hathaway Donald Simon and Jonathan Litt	7th Republic of Korea (ROK) Defense Modeling & Simulation Workshop hosted by the Korea Institute for Defense Analysis (KIDA), April 17-18, 2008 64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008
Vertical Drop Testing and Analysis of the WASP Helicopter Skid Gear	Fuchs, Y. T., and Jackson, K. E	64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008



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A Computational Approach for Model Update of an LS-DYNA Energy Absorbing Cell	Horta, L. G., Jackson, K. E., and Kellas, S.,	64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008
Multi-Terrain Vertical Drop Tests of a Composite Fuselage Section	Kellas, S. and Jackson, K	64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008
Modeling Requirements for Analysis and Optimization of JVX Proprotor Performance	C. Acree	64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008
Continued Development of a Mach Scale Swashplateles Rotor with Integrated Trailing Edge Flaps	P. Copp, I. Chopra, University of Maryland	64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008
Application and Validation of Unstructured Overset CFD Technology for Rotorcraft Gearbox Windage Aerodynamics Simulation	R. Kunz; R. Noack; M. Hill; L. Long; P. Morris Penn State Robert Handschuh, ARL	64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008
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In-flight Array Measurements of Tail Rotor Harmonic Noise	C. Sargent; F. Schmitz Univ of MD B. Sim UARC, Army	64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008
Concepts for Multi-Speed Rotorcraft Drive System	M. Stevens, NASA R. Handschuh, D. Lewicki, ARL	64th American Helicopter Society (AHS) Annual Forum, Montreal, Canada, April 29-May 1, 2008
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A Modular Approach to Euler/Navier-Stokes based Aeroelasticity of Helicopter Rotor Blades	Guru Guruswamy	AIAA 49th Structural Dynamics Conference, April 2008
Rotor Airloads Prediction Using Unstructured Meshes and Loose CFD/CSD Coupling	R. Biedron and E. Lee-Rausch, NASA Langley Research Center, Hampton, VA	AIAA-2008-7341 26th AIAA Applied Aerodynamics Conference, Honolulu, Hawaii, Aug. 18-21, 2008
Analysis of Interference Fit Life Factor for Roller Bearings	Fred Oswald, Erwin Zaretsky, Joseph Poplawski	STLE Annual Meeting may 2008
An Experimental Investigation of Helicopter BVI Noise	Koushik, S., and Schmitz, F. H., Univ of Maryland	AIAA Aeroacoustics Conference, Vancouver, Canada, May 6-9, 2008.
A Numerical Investigation of Turbine Noise Source Hierarchy and Its Acoustic Transmission Characteristics	Dale van Zante	AARC Turbine Noise Workshop, Vancouver, Canada, May 2008
Validation of Ray Tracing Code Refraction Effects	Heath, S.L.; McAninch, G.L.; Smith, C. D.; Conner, D. A	AIAA Aeroacoustics Conference, Vancouver, Canada, May 5-7, 2008. AIAA 2008-2994
Comparison of ALE and SPH Simulations of Vertical Drop Tests of a Composite Fuselage Section into Water	Jackson, K. E., and Fuchs, Y. T.,	Proceedings of the 10th International LS-DYNA Users Conference, LSTC, Dearborn, MI, June 8-10, 2008, pp15-1 through 15-20.
Soft Soil Impact Testing and Simulation of Aerospace Structures	Fasanella, E. L., Jackson, K. E., and Kellas, S.	Proceedings of the 10th International LS-DYNA Users Conference, LSTC, Dearborn, MI, June 8-10, 2008, pp15-1 through 15-20.
Computational Modeling of Variable Droop Leading Edge in Forward Flight	Jeremy Bain, Ga Tech	AIAA Flow Control Conference, Seattle, June 23-26, 2008
An Optics-Based Tip-Path Plane Tracking System for Rotorcraft Applications	Sickenberger, R. and Schmitz, F.	AIAA Guidance, Navigation, and Control Conference, 18-21 Aug. 2008, Honolulu, Hawaii, 2008
ASSESSMENT OF COMPOSITE DELAMINATION SELF-HEALING VIA MICRO-ENCAPSULATION	T. Kevin OOBrien, Scott R. White	To be published in Proceedings of American Society for Composites 23rd Technical Conference Memphis, Tennessee, Sept. 2008



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Measurements of the High Temperature Dynamic Coefficients of the Elastic Wave Bearing Support	Moraru, L., Ene, N., Dimofte, F., Afje, A.	Society of Tribologists and Lubrication Engineers (STLE) Annual Meeting, Cleveland, May 18-20, 2008
An Investigation of the Behavior of a Dual Clearance Squeeze Film Damper	Moraru, L., Dimofte, F., Keith, T.	Society of Tribologists and Lubrication Engineers (STLE) Annual Meeting, Cleveland, May 18-20, 2008
A Thermo-Hydrodynamic Analysis of a Wave Journal Bearing	Ene, N., Dimofte, F.	Society of Tribologists and Lubrication Engineers (STLE) Annual Meeting, Cleveland, May 18-20, 2008
Wave Motion Optimization in Periodically Distributed Shunted Piezocomposite Structures	Manuel Collet, Kenneth A. Cunefare, and M. N. Ichchou	accepted for publication, International Journal of Intelligent Materials Systems and Structures, November, 2007
Vibration And Wave Propagation Control of Plates With Periodic Arrays of Shunted Piezoelectric Patches	A. Spadoni, M. Ruzzene, K.A. Cunefare	Proceedings of ICAST 2007, October 5-7th, Ottawa, Canada
Broad-band Vibration Attenuation In Plates With Periodic Arrays Of Shunted Piezoelectric Patches	L. Airoldi, M. Ruzzene	To be presented at Acoustics '08, Paris June 29 § July 4, 2008
Experimental Assessment of Negative Impedance Shunts for Vibration Suppression on a Beam	B. Beck, K.A. Cunefare, M. Collet	SPIE Smart Materials and Structures Conference, San Diego, CA, USA March 9-13th
Piezo-shunt power-flow optimization for composite beam stabilization	M. Collet, K.A. Cunefare, B. Beck	SPIE Smart Materials and Structures Conference, San Diego, CA, USA March 9-13th
An Experimental Study of Fretting of Gear Teeth	Dr. Timothy Krantz	Society of Tribologists and Lubrication Engineers Annual Meeting held in Cleveland, Ohio May 2008
Signal Detection Theory Applied to Helicopter Transmission Diagnostic Thresholds	Paula Dempsey	NASA TM
Analytical Assessment of Performance, Handling Qualities and Added Dynamics in Rotorcraft Flight Control	Ron Hess	Correspondence Paper in the IEEE Transactions on Systems, Man, and Cybernetics Part A
Chapter 44: Rotorcraft Systems Health Management.	Paula Dempsey	textbook, System Health Management with Aerospace Applications, a reference text for System Health Management (SHM) field. The planned publication data for the book is May 2010
A Foil Thrust Bearing Rig for Evaluation of High Temperature Performance and Durability	Dykas, B.D., Tellier, D.W.,	Army Research Laboratory, ARL-MR-0692
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Compliant Foil Journal Bearing Performance at Alternate Pressures and Temperatures	Bruckner, R.J., Puleo, B.J.,	NASA / TM-2008-215219
Gas Foil Bearing Misalignment and Unbalance Effects	Howard, S.A.,	NASA / TM-2008-215176.
Misalignment in Gas Foil Journal Bearings: An Experimental Study.	Howard, S.A.,	NASA / TM-2008-215223.
Textbook-Efficiency Multigrid Solver for Three-Dimensional Unsteady Compressible Navier-Stokes Equations	NIA: Liu	submitted to the Journal of Computational Physics documenting a portion of work performed under the MUTE NRA.
Modeling of a Turbulent Line Vortex	Larry Young	AIAA 5th Theoretical Fluid Mechanics meeting, June 23-26, 2008, in Seattle, WA
Modeling Requirements for Analysis and Optimization of JVX Proprotor Performance	Wally Acree	NASA/TM-2008-214581
Compliant Foil Journal Bearing Performance at Alternate Pressures and Temperatures	Dykes, Howard, Bruckner	International Gas Turbine Institute at the ASME Turbo Expo 2008, June 9-13, in Berlin, Germany
Design, Fabrication, and Performance of Foil Gas Bearings for Microturbomachinery Applications	Dykes, Howard, Bruckner	International Gas Turbine Institute at the ASME Turbo Expo 2008, June 9-13, in Berlin, Germany
Misalignment in Gas Foil Journal Bearings: An Experimental Study	Dykes, Howard, Bruckner	International Gas Turbine Institute at the ASME Turbo Expo 2008, June 9-13, in Berlin, Germany
Coupled CFD and Particle Vortex Transport Method: Wing Performance and Wake Validations	Phuriwat Anusonti-Inthra, National Institute of Aerospace and Matt Floros, US Army Research Laboratory	38th Fluid Dynamics Conference and Exhibit, Seattle, June 2008 AIAA paper 2008-4177



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Performance Optimization of the NASA Large Civil Tiltrotor	Acree, Yeo and Sinsay	NASA/TM-2008-215359
Role of HPC in Advancing Computational Aeroelasticity	Guruswamy, G. P	Paper-14, International Conference on Aerospace Science and Technology (INCAST), Indian Institute of Science, Bangalore, India, June 26-28, 2008
Characterization of the Internal Flow Dynamics of Combustion Powered Actuators	Ashok Rajendar ¹ , Thomas M. Crittenden ² , and Ari Glezer ³ Georgia Institute of Technology, Atlanta, Georgia, 30332	4th Flow Control Conference 23 - 26 June 2008, Seattle, Washington AIAA-2008-3760
Pilot Modeling with Applications to the Analytical Assessment of Flight Simulator Fidelity	Ron Hess	AIAA Modeling and Simulation Technologies Conference August 18-21, 2008
Computational Modeling of Variable Droop Leading Edge in Forward Flight	J. Bain, L. Sankar and J. Prasad, Georgia Institute of Technology, Atlanta, GA; O. Bauchau, Georgia Institute of Technology, Atlanta, GA; D. Peters, Washington University, St. Louis, MO; C. He, Advanced Rotorcraft Technology Inc., Mountain View, CA	4th Flow Control Conference 23 - 26 June 2008, Seattle, Washington AIAA-2008-3872
Signal Detection Theory Applied to Helicopter Transmission Diagnostic Thresholds	Paula Dempsey	NASA Technical Memorandum 215262, June 2008
Performance Optimization of the NASA Large Civil Tiltrotor	C. W. Acree, Jr. NASA Hyeonsoo Yeo Jeffrey Sinsay AFDD AMRDEC	NASA/TM-2008-215359, June 2008
Computational Investigation of the Effects of Gurney Flap on the Forward Flight Characteristics of Helicopter Rotors	Byung-Young Min*, Lakshmi N. Sankar, Nischint Rajmohan a and JVR Prasad ^a School of Aerospace Engineering, Georgia Institute of Technology, Atlanta, GA, 30332-0150	AIAA Guidance, Navigation, and Control Conference, 18-21 Aug. 2008, Honolulu, Hawaii, 2008
System Identification of Large Flexible Transport Aircraft	Colin Theodore Boeing Seattle Authors	AIAA AFM conference Aug 18-21
Vibration Response Models of a Stiffened Aluminum Panel Excited by a Shaker	Randolph Cabell, NASA	Proceedings of Noise-Con 2008: The National Conference and Exposition on Noise Control Engineering, Dearborn, Michigan, July 28-30, 2008.
Vibroacoustic Response Data of Stiffened Panels and Cylinders	Randolph Cabell, Jake Klos, Ralph Buehrle, and Noah Schiller NASA	Proceedings of Noise-Con 2008: The National Conference and Exposition on Noise Control Engineering, Dearborn, Michigan, July 28-30, 2008
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Analysis method for residual compressive strength	Wade Jackson	submitted to American Society for Composites Journal
NConcepts for Variable/Multi-Speed Rotorcraft Drive System	Mark Stevens	TM 215276-0, E-16558-0
A New Experimental Approach to Study Helicopter Blade-Vortex Interaction Noise	S. Koushik and F. Schmitz, University of Maryland, College Park, MD	AIAA-2008-3070 14th AIAA/CEAS Aeroacoustics Conference (29th AIAA Aeroacoustics Conference), Vancouver, British Columbia, May 5-7, 200
Hybrid Unsteady Simulation of Helicopters: HUSH	S. Ananthan and J. Baeder, University of Maryland, College Park, MD; J. Sitaraman, National Institute of Aerospace, Hampton, VA; S. Hahn and G. Iaccarino, Stanford University, Stanford, CA	AIAA-2008-7339 26th AIAA Applied Aerodynamics Conference, Honolulu, Hawaii, Aug. 18-21, 200
The Merits of Coupled CFD /CSD Analysis for Prediction of Aerodynamic and Structural Rotor Loads During Maneuvering Helicopter Flight	Prof James Baeder, University of Maryland	34th EUROPEAN ROTORCRAFT FORUM 16th S 18th September 2008 Arena & Convention Centre, Liverpool, UK
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Chapter 4.9 Rotorcraft Health and Usage Monitoring (HUMS)	Paula Dempsey, GRC	SAE Aerospace Information Report (AIR) Lessons Learned from Developmental and Operational Turbine Engine Monitoring System
A Foil Thrust Bearing Rig for Evaluation of High Temperature Performance and Durability	Dykas, B.D., Tellier, D.W.,	Army Research Laboratory, ARL-MR-0692
Design, Fabrication, and Performance of Foil Gas Thrust Bearings for Microturbomachinery Applications	Dykas, B.D., Bruckner, R.J., DellaCorte, C., Edmonds, B., Prah, J.,	NASA / TM-2008-215062.
Compliant Foil Journal Bearing Performance at Alternate Pressures and Temperatures.	Bruckner, R.J., Puleo, B.J.,	NASA / TM-2008-215219.



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Gas Foil Bearing Misalignment and Unbalance Effects	Howard, S.A.,	NASA / TM-2008-215176.
Misalignment in Gas Foil Journal Bearings: An Experimental Study.	Howard, S.A.,	NASA / TM-2008-215223.
Analytical Assessment of Performance, Handling Qualities and Added Dynamics in Rotorcraft Flight Control	Ron Hess	IEEE Transactions on Systems, Man and Cybernetics, Part A
A Parametric Study of Foil Journal Bearings by Temperature, Pressure, and Working Fluid	B. Puleo, R. Bruckner,	IECEC presentation, AIAA-2008-5734.
Report on the Joint Eglin Acoustic Week III	Watts, Michael E; Conner, David A; Smith, Charles D.	Presented at the American Helicopter Society Next Generation Vertical Lift Technologies Specialist Meeting, Oct. 15-17, 2008, Dallas, TX
Current Results of Testing PVD Coatings for Wave Bearings for Use in Aerospace-Transmissions	F. Dimofte, N. M. Ene, R. F., Handschuh, T.L., Krantz, K.-D., Bouzakis, A., Asimakopoulos, and M., Batsiolas	The Coatings Meeting, Oct 1-3, 2008, Kassandra, Greece
Tests of Bearings and Gears With PVD Coatings for Aerospace Transmissions; Results and Problems, A Keynote to 2008 The Coatings Meeting	F. Dimofte and T.L. Krantz.	The Coatings Meeting, Oct 1-3, 2008, Kassandra, Greece
A Finite Element Analysis for Predicting the Residual Compressive Strength of Impact-Damaged Sandwich Panels	Ratcliffe, James G.; Jackson, Wade C.	NASA TM 2008-215341, August 2008
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A Parametric Study of Foil Journal Bearings by Temperature, Pressure, and Working Fluid,	B. Puleo, R. Bruckner,	AIAA-2008-5734, presented at the International Energy Conversion and Engineering Conference, August 2008
Theodore, C. R., Ivler, C. M., Tischler, M. B., Field, E. J., Neville, R. L., and Ross, H. P	System Identification of Large Flexible Transport Aircraft	Proceedings of AIAA Atmospheric Flight Mechanics Conference and Exhibit, Honolulu, Hawaii, Aug. 18-21, 2008, AIAA-2008-6894
Overview of the NASA Subsonic Rotary Wing Aeronautics Research Program in Rotorcraft Crashworthiness	Jackson, K.E., Fuchs, Y. T., and Kellas, S	accepted to the Journal of Aerospace Engineering, Special Issue on Ballistic Impact and Crashworthiness of Aerospace Structures, September 26, 2008.



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No.	Title	Author	Reference ID
1	Civil Tiltrotor Missions and Applications; A Research Study, Supporting Documentation for U. S. Policy Making Decisions	Boeing Commercial Airplane Co., Bell Textron, Inc, Boeing Vertol	NASA CR-177451, November 1987
2	Civil Tiltrotor Missions and Applications; Phase II: The Commercial Passenger Market, Summary Final Report	Boeing Commercial Airplane Group, Bell Helicopter Textron, Inc, Boeing Helicopters	NASA CR-177576, February 1991
3	Civil Tiltrotor Missions and Applications; Phase II: The Commercial Passenger Market, Final Report, Book Two: Sections 4 and 5, Proprietary	Boeing Commercial Airplane Group, Bell Helicopter Textron, Inc, Boeing Helicopters	NASA CR-177576, February 1991
4	Civil Tiltrotor Missions and Applications, Phase II: The Commercial Passenger Market Final Report, Supporting Documentation for U. S. Policy Making Decisions	Thompson, R., Neir, R., Reber, R., Scholes, R., Alexander, H., Sweet, D., and Berry, D.	NASA CR-177591, October 1991
5	Advanced Tiltrotor Transport Technology: Cost/Benefit/Risk Assessment Phase I Final Report	Alexander, H. R., Allen, E. M., and Bartie, K. M.	NASA CDCR-20001, August 1994
6	Technical Memorandum: Civil Tiltrotor Community Noise: Aircraft Size versus Community Improvement	Boeing Defense and Space Group, Helicopters Division	P2T12-1994-NAS2-13625, Phase II, Task 12, November 1994
7	Report to Congress § Volume 1, Final Report	Civil Tilt Rotor Development Advisory Committee	Report to Congress in accordance with PL102-581, December 1995



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No.	Title	Author	Reference ID
8	Report to Congress S Volume 2, Technical Supplement	Civil Tilt Rotor Development Advisory Committee	Report to Congress in accordance with PL102-581, December 1995
9	Civil Tiltrotor Feasibility Study for the New York and Washington Terminal Areas	Stouffer, V., Johnson, J., and Gribko, J.	NASA CR-2001-210659, January 2001
10	Evaluation of the National Throughput Benefits of the Civil Tiltrotor	Johnson, J, Stouffer, V., Long, D., and Gribko, J.	NASA CR-2001-211055, September 2001
11	Aviation System Capacity Program: Short Haul Civil Transport Project. Noise Reduction and Terminal Area Operations	Guilianetti, D.	NASA/TP-2003-212800, November 2003
12	Technology Development for Runway Independent Aircraft	Smith, D. E., Wilkerson, J., Montoro, G. J., Coy, J., and Zuk, J.	American Helicopter Society 39 th Annual Forum, Phoenix, AZ, May 2003
13	NASA Heavy Lift Rotorcraft Systems Studies	Johnson, W., Yamauchi, G. K., and Watts, M. E.	NASA/TP-2005-213467, December 2005