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John E Hurtado

Deputy Director and Chief Technology Officer, Combat Development Complex
Professor, Department of Aerospace Engineering

Texas A&M University, College Station, TX
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Education	*Texas A&M University,* College Station, Texas Doctor of Philosophy in Aerospace Engineering, August 1995 Focus: Dynamics and Control; Advisor: John L Junkins Master of Science in Aerospace Engineering, Texas A&M University, 1991 *San Diego State University,* San Diego, California Bachelor of Science in Aerospace Engineering, 1988
Academic Experience	Number of years of service at this institution: since January 2001 *Department of Aerospace Engineering,* Texas A&M University, College Station Associate Department Head and Director of Graduate Programs (November 2012-August 2014) Professor (September 2014-present) Associate Professor (September 2007-August 2014) Assistant Professor (January 2001-August 2007)
Administrative Experience	*College of Engineering,* Texas A&M University*,* College Station Deputy Director and Chief Technology Officer, Combat Development Complex (July 2019-present) Platform Lead, Precision Navigation & Timing (February 2019-June 2019) Interim Department Head of Nuclear Engineering (November 2018-August 2019) Associate Dean for Academic Affairs (September 2015-present) Senior Director for Interdisciplinary Engineering Programs, full-time appointment (January 2015-August 2015) Senior Director for Interdisciplinary Engineering Programs, half-time appointment (September 2014-December 2014)
National Lab Experience	*Professional Employment* Intelligent Systems, Sensors, and Controls & Experimental Structural Dynamics Sandia National Laboratories Albuquerque, New Mexico Principal Member of Technical Staff (1999-2000) Senior Member of Technical Staff (1995-1999) *University Summer Faculty Sabbatical* Navigation, Guidance, and Control (June 2013-August 2013) Water Power Technologies (June 2011-August 2011)
Licensure	None

Awards and Recognition

University

2012-2013 Thomas U McElmurry Teaching Excellence Award, Department level
2012-2013 William O. & Montine P. Head Faculty Fellow Award in the College
2012 Freshman Convocation Keynote Speaker, University-level distinction
2010 BP Tenneco Teaching Award, College level
2010 Association of Former Students, College-level Distinguished Achievement
2009 Thomas U McElmurry Teaching Excellence Award, Department level

National Laboratory

Sandia National Laboratories Individual Performance Award as a member of the Microchemlab Team for "Exceptional achievement in the development of breakthrough technologies and systems concepts and designs," February 1999.
Sandia National Laboratories Individual Performance Award for "Technical excellence in the development of advanced optimization methods," June 1998.
Sandia National Laboratories Individual Performance Award for "Excellence in modal testing of the EKV payload," July 1996.

Expertise

Analytical dynamics
Cooperative game theory with incomplete information
Efficient dynamic formulations for rigid, flexible, and variable-mass systems
Decentralized control methods for cooperating systems

Patents

Patent US 6,408,226 B1, June 18, 2002, "Cooperative System and Method Using Mobile Robots for Testing a Cooperative Search Controller," R.H. Byrne, J.J. Harrington, S.E. Eskridge, J.E. Hurtado.

Patent US 6,577,906, June 10, 2003, "Distributed Optimization System and Method," J.E. Hurtado, R.D. Robinett III, Clark R. Dohrmann.

Patent US 6,687,571, February 3, 2004, "Cooperating Mobile Robots," R.H. Byrne, J.J. Harrington, S.E. Eskridge, J.E. Hurtado.

His patented algorithms for swarm robotics were developed for unique miniature robots that the Smithsonian Institution obtained from Sandia National Laboratories for its permanent collection at the National Museum of American History.

Scholarship

Five Monographs
More than 120 Journal and Conference publications
Google Scholar citations 1401 and h-index 19

Impact

His expertise and new ideas in theoretical dynamics has led to a better and clearer understanding of dynamic principles in three dimensions, and to a clear development of dynamic principles for higher-dimensional rigid bodies.

His recent paper "Lagrangian mechanics of overparameterized systems" gives the first-ever clear understanding of minimal, redundant, and overparameterized descriptions for Lagrangian mechanics, which is a field that is more than 200 years old.

Although the evolution of linear systems are well understood in many ways, his recent paper "The motion constants of linear time-invariant dynamic systems" gives the first-ever treatment of complete motion constants.

The Euler-Poinsot problem is the most classic among famous rigid body rotational motion problems. Nevertheless, his recent manuscript "State Transition Matrix, Motion Constants, and Ergodicity of the Euler-Poinsot Problem" breaks new ground: he gives a novel and original state transition matrix for the rigid body attitude; he presents for the first time a complete set of motion constants; and he uses these original results to derive explicit conditions that determine whether the ensuing motion is periodic or ergodic.

His new rigorous analytical dynamics development for variable mass systems allows the student or expert or anyone in between to investigate systems such as rockets or gas-filled balloons with a process that is no more challenging than the traditional Lagrange equations.

Mentorship	Advised the research of 42 graduate students (9 PhD; 9 female; 7 Hispanic) Graduate Student Fellowship (12 students; 25 total Fellowships)
Teaching	*Undergraduate* Aerospace Engineering 210, Sophomore-level dynamics; Aerospace Engineering 310, Junior-level dynamics *Graduate* Aerospace Engineering 622, Graduate-level dynamics; Aerospace Engineering 627, Graduate-level structural dynamics; Aerospace Engineering 628, Graduate-level spacecraft control; Aerospace Engineering 633, Graduate-level multibody dynamics
Professional Membership	American Institute of Aeronautics and Astronautics (Associate Fellow) American Astronautical Society (Member)

An introduction to five significant papers authored by John E Hurtado

2018 *Analytical Dynamics of Variable-Mass Systems*, Journal of Guidance, Control, and Dynamics, Vol. 41, No. 3, pp. 701–9, March 2018. doi 10.2514/1.G002917

John E Hurtado presents a few new, equivalent mathematical expressions, each of which is able to generate the governing equations of motion for variable-mass systems: one is Lagrangian-like, another Appellian-like, and a third is Kanian. His approach allows the contributions from mass variation to naturally occur from a proper kinematic development. One key to the entire development is his introduction of a new kinematic partial derivative operator. The operator is intuitive and its use is straightforward. The impact of this work is that developing the equations of motion for all variable mass systems, from rockets to gas-filled balloons, can now be done with a process that is no more challenging than using the traditional Lagrange equations.

2016 *State Transition Matrix, Motion Constants, and Ergodicity of the Euler-Poinsot Problem,* Nonlinear Dynamics, Vol. 85, Iss. 3, pp. 2049–63, August 2016. doi 10.1007/s11071-016-2814-1

John E Hurtado and his co-author Andrew Sinclair present a novel and original state transition matrix for rigid body attitude. The approach is clever in that the attitude matrix is considered in place of a more common state vector. They also present, for the first time, a complete set of motion constants, and they use these original results to derive explicit conditions that determine whether the ensuing motion is periodic or ergodic.

2013 *The motion constants of linear autonomous dynamical systems,* Applied Mechanics Reviews, Vol. 65, Iss. 4, July 2013

John E Hurtado and his co-author Andrew Sinclair present the first-ever treatment of complete motion constants for linear autonomous systems. A motion constant is a scalar function of the system states that is rigorously constant throughout the evolution of the system. An n-dimensional system will commonly possess n-1 independent functions. Curiously, although the evolution of linear systems is well understood in many ways, there has never been a plenary treatment of the motion constants for linear systems. These authors motivate their topic by conveying to the reader the ubiquitous nature of motion constants in the study of mechanics.

2011 *Lagrangian mechanics of overparameterized systems*, Nonlinear Dynamics, Vol. 66, pp. 201-12

John E Hurtado and his co-author Andrew Sinclair present an elucidation on minimal, redundant, and overparameterized descriptions within Lagrangian mechanics. Minimal and redundant coordinate system descriptions are commonplace, and their Lagrangian formulations are well understood. This is not true for over parameterizations. So, although overparameterized system descriptions are more suitable in some instances, viz., to avoid coordinate singularities or to simplify the equations of motion, their Lagrangian formulations are nebulous. These authors make clear the distinctions between these different descriptions and uncover the hallmark of overparameterized Lagrangian formulations. Pedagogically, their article strengthens the connection between classic over parameterizations in modern aerospace engineering and the 200-year-old field of Lagrangian mechanics.

2004 *Hamel coefficients for the rotational motion of an N-dimensional rigid body*, Proceedings of the Royal Society of London Series A: Mathematical, Physical and Engineering Sciences, Vol. 460, No. 2052, pp. 3613-30

John E Hurtado and his co-author Andrew Sinclair present the first-ever generalized treatment of Hamel coefficients. Hamel coefficients, which are also commonly known as structure constants, are a critical part of developing rotational equations of motion using Lagrangian techniques. In this work, these authors create the Hamel coefficients for higher-dimensional rigid bodies, and their developments pave the way for a generalization of Euler's rotational equations of motion.

An introduction to three teaching monographs authored by John E Hurtado

Graduate — *Kinematic and Kinetic Principles*
ISBN 978-1-300-12622-5

This graduate-level text on dynamic principles stands apart from others in several ways. Most notable is the format. The text is written using a novel and unique 1-page, 1-topic format. This helps to focus the reader's attention on the topic at hand while creating a curiosity for what follows. Secondly, the key concept of angular velocity is developed in a new and rigorous way. The angular velocity *matrix*, rather than the angular velocity *vector*, is established as the true fundamental entity. This obviates the need for drawings found in most texts that illustrate and use an idea of angular velocity while deriving the same. Moreover, this author's presentation of angular velocity holds true in higher-dimensional spaces. Also, careful attention is paid to establish a consistent and unambiguous notation. Finally, explicit connections between Newton/Euler methods, Langrangian methods, and Kanian methods are presented, and the advantages of each are extolled. Particle dynamics, rigid body dynamics, and flexible body dynamics are covered.

Junior — *A Kinematic and Kinetic Primer*
ISBN 978-1-312-18678-1

This junior-level text introduces the dynamic principles that govern arbitrary rigid body motions in a rigorous way. The subjects and their treatment lay somewhere between a sophomore-level introduction and a graduate-level dissection. For example, point mass and three-dimensional rigid body dynamics are addressed using Newton and Euler principles, but advanced methods like Kane's approach are not mentioned. Furthermore, Euler angles are presented to describe rigid body attitude but quaternions are not covered. Additional material includes a chapter on rigid body gyroscopic motion, which is followed by a brief discussion of linearization and stability. The linearization of nonlinear models leads nicely into chapters on single and multiple degree of freedom systems modeled by linear, second order ordinary differential equations. The focus is on the response of such systems to a wide variety of inputs and the system frequencies and mode shapes. The books wraps up with two specialty chapters: the first briefly presents a Galerkin approximation approach to writing equations of motion for flexible bodies; the second introduces Lagrange's equations.

Sophomore — *Mostly Planar Motion*
ISBN 978-1-300-57993-9

This sophomore-level text introduces dynamic principles in an approachable but rigorous way. One feature of this book is the development of a step-by-step systematic approach that allows students to address new problems with confidence. Another feature is that governing equations of motion for systems are emphasized over specific numerical answers to specific questions. This helps prepare students for system analysis techniques that are commonly a part of junior- and senior-level courses. A third feature is that students are shown how to manipulate the governing equations of motion to solve dynamics problems: sometimes algebraic techniques are required (e.g., given the forces solve for the instantaneous acceleration), sometimes integral calculus techniques are required (e.g., given the forces solve for the position trajectory), and sometimes numerical techniques are required (e.g., when the governing equations are nonlinear ODEs). Particle dynamics, rigid body dynamics, and variable mass dynamics are covered.

A discussion of research interests of John E Hurtado

Pursuit & Evasion Games	John E Hurtado and his PhD students are developing techniques for addressing incomplete information games. Complete information games, wherein the objectives of every participant are known, are most commonly discussed in the literature. In theory, the optimal controls for all participants in complete information games can be computed, and no player has an incentive to deviate from their optimal control. A different scenario is the case where the objectives or strategies of participants are not globally known. This represents a type of incomplete information game, and in this case a participant must estimate the objectives of another and have a method for refining that estimate.
Variable-Mass Systems	John E Hurtado continues to investigate the dynamics, navigation, and control aspects of variable-mass systems. His has recently extended his analytical dynamics approach to address infinite dimensional systems and systems described using a hybrid set of coordinates. Moreover, he is investigating Noether invariants for this class of systems.
Motion Constants	John E Hurtado and his colleague Andrew Sinclair are developing a novel method to discover the motion constants of nonlinear autonomous systems. Their idea leverages the complete motion constants of linear autonomous systems and the embedding method known as Carleman linearization. Carleman linearization is a rigorous technique that transforms a finite dimensional system of nonlinear ODEs into an infinite dimensional system of linear ODEs. Hurtado and Sinclair have shown in trial cases that the motion constants of the Carleman representation are able to capture the motion constants of the original nonlinear system.

Student development: the completed PhD graduates of John E Hurtado

Andrew Sinclair	(May 2005) Andrew Sinclair is a Research Scientist at the Air Force research Laboratory, Kirtland AFB.
Rajnish Sharma	(Dec 2008) Rajnish Sharma is a tenure-track Assistant Professor of Engineering, with a concentration in Aerospace, at the University of Maryland Eastern Shore.
Lesley Weitz	(Dec 2009) Lesley Weitz is a Principal Simulation and Modeling Engineer at The MITRE Corporation's Center for Advanced Aviation System Development (CAASD).
Kevin Brink	(Dec 2010) Kevin Brink is a Senior Research Engineer in the Munitions Directorate at the Eglin Air Force Research Laboratory.

Carolina Restrepo	(Aug 2011) Carolina Restrepo is a NASA Aerospace Engineer in the Integrated Guidance, Navigation and Control Analysis Branch.
Julie Parish	(Aug 2011) Julie Parish is a Senior Member of Technical Staff, in the Navigation, Guidance, and Control Department of Sandia National Laboratories, Albuquerque, NM.
Neha Satak	(May 2013) Neha Satak is CEO at Astrome Technologies Pvt. Ltd in Bangalore, India. Astrome is developing the technology to provide high speed broadband internet from space to remote areas.
Brian Owens	(Dec 2013) Brian Owens is a Senior Member of Technical Staff in the Analytical Structural Dynamics Department of Sandia National Laboratories, Albuquerque, NM.
Kurt Cavalieri	(Dec 2014) Kurt Cavalieri is a Senior Member of Technical Staff in the Navigation, Guidance, and Control Department of Sandia National Laboratories, Albuquerque, NM.
Tim Woodbury	(May 2019) Tim Woodbury joined Southwest Research Institute in San Antonio, TX.

College-wide academic development achievements of John E Hurtado

ITDE	(Fall 2014) Designed and built the Bachelor of Science degree in Interdisciplinary Engineering (ITDE) and guided its complete approval. This bachelor degree allows students a high degree of flexibility in creating a specialized engineering degree plan that is not provided in a traditional department degree program.
ZLP	(Spring 2015) Designed and built the Zachry Leadership Program (ZLP) and guided its complete approval. This program allows helps students become future leaders who are well-versed in our free enterprise system, collaborative in their decision-making, and humbly self-confident in their behaviors.
ENGR[x]	(Fall 2015) Designed and built the Engineering X Program (ENGR[x]) and guided its complete approval. This program gives every student the opportunity to broaden their college experience through high-impact extra-curricular activities, which will help them become prepared for their professional lives. He conceived of the ideas Engin*hearing – the sound of your favorite engineering equations* and *Reflection Poetry Night*.
EnMed	(Fall 2015) Co-designing the engineering aspects of the Engineering and Medicine (EnMed) curriculum and student admission process, and guiding its complete approval. The EnMed track is an integrated educational and research engineering and medical program with a focus on invention, innovation and entrepreneurship.
50 Eqn	(Fall 2016) Guided the concept and inclusion of fifty impactful engineering equations in the engineering quad (E-Quad).
McAllen ITDE	(Fall 2016) Designed the initial draft for a Bachelor of Science degree in Interdisciplinary Engineering (ITDE) for the McAllen teaching site.

Entre-preneur	(Summer 2017) Guiding the development of the college's participation in the university-wide entrepreneurship minor and guiding its complete approval.
Art	(Spring 2018) Designing and building an engineering and art curriculum that celebrates the inclusion of art in the new Zachry Engineering Education Complex.