Rebecca M. Brannon
Ph.D. (1992) University of Wisconsin
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Full CV:
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Two-page NSF style bio:
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50 word bio:
Dr. Brannon is an ASME fellow with 25+ years of experience in computational and theoretical mechanics, emphasizing high-rate destructive deformations of metals, ceramics, and rocks. Her models are applied to armor, ceramic hip-replacements, bunker surety, and shaped-charge jet well-bore completion. She is also known for her monographs on mathematics.

150 word bio:
For over 25 years, first as a principal researcher (and manager) at Sandia National Laboratories and more recently as an Associate (now emeritus) Professor of Mechanical Engineering at the University of Utah and ASME fellow, Dr. Brannon has developed practical engineering constitutive models for brittle and ductile material failure at high strain rates and large strains. Her research has investigated a wide range of materials including piezoelectric ceramics, armor ceramics, geological materials, energetic materials, and metals (usually for high-rate applications). Constitutive models she has developed are used in DoD and DOE production codes such as CTH and ALEGRA. Applications have included protective structures, underground structure integrity, electroactive power supplies, artificial hip implant rapid materials ranking, shock-induced vaporization, in-vivo measurements of callus strains, and other numerous other problems in the applied sciences. Dr. Brannon is particularly known for her monographs on tensor analysis, plasticity, code portability, code verification, and massive deformation kinematics in the material point method.

Single-page bios:
See subsequent pages of this document.

Bio essay suitable for Australian Research Council (ARC)

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For the entire 22 years following her Engineering Mechanics PhD in 1992 at the University of Wisconsin—Madison, Dr. Brannon has performed research in the general area of computational solid mechanics, with focus on nonclassical brittle and quasibrittle constitutive models for inert or electroactive ceramics, dry or saturated rock, and consolidated or distended granular media. This career research, funded in excess of several million dollars over her career, began first as a principal researcher and manager at Sandia National Laboratories (where publications are often not externally disseminated) and more recently as an Associate Professor of Mechanical Engineering at the University of Utah (where a sharp jump in external publications is evident and where Dr. Brannon was twice the top funded researcher in the Mechanical Engineering department over the last five years, which is unusual for a computational lab to outspend conventional instrumented labs). The current sabbatical appointment as a visiting faculty member at Johns Hopkins University provides funding for 70% research and seminar-based teaching, while the remaining 30% is dedicated to research management of projects still active at the University of Utah. A regular (non-sabbatical) academic year entails one class per semester (requiring about 20% time, as all lectures are fully developed), moderate internal and external service (such as academic boards and conference organizing, requiring 15% time), advising up to 9 PhD students (requiring 40% time) and two Masters students (10% time), and keeping current through focused research (15%). Summers have no teaching or service load, so that time is spent on focused research and program development, all of which has been well funded through multimillion dollar contracts and development funds. Dr. Brannon's designation as an ASME fellow was founded on her contributions of practical engineering constitutive models for brittle and ductile material failure at high strain rates and large strains. Her research has investigated a wide range of materials including piezoelectric ceramics, armor ceramics, geological materials, energetic materials, and metals (usually for high-rate applications). Constitutive models she has developed are used in DoD and DOE production-quality codes such as CTH and ALEGRA. Applications have included protective structures, underground structure integrity, electroactive power supplies, artificial hip implant rapid materials ranking, shock-induced vaporization, in-vivo measurements of callus strains, and other numerous other problems in the applied sciences. This work is facilitated by outstanding infrastructure at the University of Utah, which includes not only several support staff for administrative and daily computing tasks, but also a top-tier Center for High Performance Computing (CHPC). In the area of student development, Dr. Brannon is particularly known for her monographs on tensor analysis, plasticity, code portability, code verification, ferroelectric mechanics, porosity modeling, and massive deformation kinematics in the material point method. Almost without exception, these tutorial documents (available on Dr. Brannon's website, http://csmbrannon.net) reflect general mathematical and scientific principles that were applied during her time at Sandia National Laboratories – only specific details of specific applications have been withheld from open publications during this phase of her career.

The overall community recognition of Dr. Brannon's research is further confirmed by the fact that she has been heavily solicited for involvement in special journal issues, symposia, colloquia, workshops and congresses 40 times (35 in the last 10 years), giving 7 Keynote lectures, 2 plenary lectures, and 1 banquet talk. Additionally, Dr. Brannon's freely available tutorials in mechanics (downloadable from her website) have resulted in 56 documented testimonials (available upon request) from readers worldwide, including from highly respected computational-mechanics researchers such as Tinsley Oden, Ted Belytschko, and Tom Hughes, who have expressed their appreciation of this work.

Essay with extra focus on Brannon's involvement in the Material Point Method

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In collaboration with original Uintah code developers (especially Jim Guilkey, now with Schlumberger Technology Corporation), Dr. Brannon has been responsible for development and guidance of the material point method (MPM) part of the open source computational platform Uintah, where her algorithms have significantly improved its performance in the area of extremely large deformation kinematics. Uintah is a highly successful open-source computational platform suitable for complicated fluid-structure interaction problems, and it is gaining considerable traction worldwide. It is also one of the most advanced codes freely available. The additional benefit of the Uintah is its systematic procedures for verification and validation, leading to very high quality code. Dr. Brannon has been instrumental in improving the verification aspects of Uintah through significant expansion of verification test problems that are run nightly and must be passed before version-controlled changes in the code are allowed. Part of the verification focus has been far more rigorous convergence testing, resolution of kinematic errors through implementation of Brannon's polar decomposition algorithm, elimination of the MPM's long-standing extension instability that had (prior to this enhancement) caused anomalous non-physical numerical fracture, an ability to impose affine deformations for constitutive-model verification (with superimposed rotation to check frame indifference), and routines capable of extracting a material point's entire deformation history to visually depict stress states actually reached in a simulation in comparison to stress states used for model calibration (i.e., to show how far the model is exercised from known domains). Dr. Brannon has consistently participated in the ASME Verification & Validation symposium, and she has recently published one of the only journal articles on the topic of verification in solid mechanics, where she derived body force fields for two deformations using the so-called "method of manufactured solutions" to rigorously demonstrate convergence of the MPM in extremely large deformation contexts. Incidentally, Dr. Brannon studied under Prof. Howard "Buck" Schreyer, who is a coauthor of the most-cited (seminal) journal article about the Material Point Method.

Dr. Brannon was the lead or co-lead on several research projects cooperating with Sandia National Labs. Much of the outcomes of these projects cannot be publicly disclosed, yet the high impact of this research is clearly evident in an unusually high number of invited presentations and the continuous funding of this work by not only Sandia National Labs, but also other government agencies such as the US Army Research Laboratory. This funding followed Dr. Brannon to her academic position, resulting in 8 large and heavily peer-reviewed government reports over the last 10 years, available through US-DOE report servers (such as http://www.osti.gov/bridge/highlights.jsp).

Dr. Brannon's large (>$1M USD) five-year grant by Schlumberger Technology Corporation additionally produced substantial but propriety results not evident by her publication record, including a 700+ page final project report in December of 2013. Of course, this final report was preceded by four annual reports (each containing, on average, around 150 pages) prepared during last five years.

During the last five years, Dr. Brannon has also performed contract research with Army Research contractors, and Idaho National Laboratory, with active collaborations extending to Lawrence Livermore National Laboratories, University of Washington, the United States Air Force Academy, and the University of Queensland, Australia. Dr. Brannon is in the final year of a large (>$1M USD) grant from the US Office of Naval Research (ONR), in collaboration with the University of Colorado—Boulder. While cooperation with non-university organizations results in some publications, a great deal of such work is documented in export-controlled or proprietary reports.

Career accomplishments pertinent to an Australia MPM-focused proposal

I have been working on constitutive modelling, numerical implementation of constitutive models, and the material point method since finishing my PhD thesis in 1992. Most notably, I developed theory and code for the Kayenta geomodel while at Sandia Labs where I was also involved in the general assessment of the material point method. More recently I have strongly influenced current trends in MPM through a new interpolation method (CPDI) that has eliminated the long-standing extension instability (anomalous material separation) in MPM, as well as a second-order enriched version (CPDI2) that enriches fields near material interfaces to prevent anomalous stress jumps. I am also responsible for guidance of the development of material point method section of open source Uintah code, as it pertains to compatibility of MPM with advanced large-deformation constitutive models, which has led to enhancement of continuum kinematics updates that had previously caused material inversion.

My expertise in the material point method, numerical algorithms and constitutive modelling directly align with the tasks detailed in the proposal. My significant knowledge of Uintah code and the ability to connect the research team in Australia with the researchers in the US (both in government and academics) is an additional advantage.