# Safety Engineering and Risk/Reliability Analysis Division Newsletter

*Vol. 8 - First Quarter 2021 Edition*

## Chair's Message

Hello SER$^2$AD Members,

Welcome to Year 2021! Despite challenges of fluctuating spread in some regions and concerns about its new variants, I am optimistic that the life will return to some sort of normal quite soon. The vaccination plan is moving forward very well; total 125 million of vaccine shots have been administered at USA by March 20, 2021.

The Texas power crisis highlights importance of the entities working on safety, security, reliability and resiliency of systems and infrastructures. The event involved three severe winter storms sweeping across the United States in February 2021, a massive electricity generation failure in the state of Texas, and resultant shortages of water, food, and heat. SERAD has been engaged to review the case and comment on the way which we can prepare and analyze to reduce such events' occurrence, and impact.

A brief update on current and future plans . . .

1. ASME IMECE 2021 conference will be held virtual on November 1–5, 2021. The deadline is extended for full paper submissions. Due to reduced cost of conference registration, and no travel cost, the number of abstract submissions are significantly increased comparing to the conference in previous year. The conference is also extended to the 5 days rather than original 4 days. The safety, risk and reliability track moves forward well within the conference organization.
2. Some engagements and collaborations are planned to enhance SERAD presence within ASME as well as other institutions outside of ASME:
    (a) SERAD was engaged in the joint rail conference (JRC) by organization of a topic on safety, and resiliency of the transportation systems. Thanks for Professor Ayyub for suggesting the ideas and his efforts so this happens. His team submitted total of 9 presentations to the conference. Further discussion was made with ASME Railroad Transportation Division, RTD, (The Sponsor of JCT conference) to have more RTD-SERAD intra-division collaborations.
    (b) An engagement is initiated with Institute for Risk and Reliability, Leibniz Universität Hannover, Germany. SERAD collaborated with the institute to sponsor the International Conference on Reliability Engineering and Risk Management (ISRERM 2022). The ISRERM conference will be held in Hannover, Germany, on 4 - 7 September 2022. Professor Michael Beer, the chair for the Institute attended SERAD EC March meeting and discussed the ideas for further collaborations.
    (c) A meeting was held with Professor Mehdi Ahmadian, the chair for VT Center for Vehicle Systems and Safety in Virginia Polytechnic Institute and State University (Virginia Tech). The objective was to get familiar with both sides' missions and activities and find common grounds for the collaborations in area of safety for the conventional vehicles and emerging technologies.

*Continued next page ...*

**In This Issue**

**Highlights**

**Research News**; Probabilistic Mandibular Reconstruction Analysis and Third in a series of articles on risk assessment

**Call for Papers**
Submit your new research and findings to Part A and Part B journal sections

**Editorial Page**
Bootstraps, Services, and the role of Regulation.

... *Chair's message. continued.*

3. A Special Issue has been planned about Risk, Resilience and Reliability for Autonomous Vehicle Technologies: Trend, Techniques and Challenges for ASME journal of Risk and Uncertainty in Engineering Systems. We encourage the research colleagues to consider this special issue for publication of their research results. The deadline is extended for the issue to 04/31/2021. The call for paper is enclosed in the newsletter **here.**
4. A new committee is created within SERAD titled "Awards and Fellowship Nomination Committee (AFNS)". The committee will administer all the division's awards as well as all the ASME Fellowship nomination process management for ASME fellow grade membership. The committee will promote the senior members of the community and the division to upgrade their membership to fellow grade through their application nomination. For any items related to this committee, please contact me at below email.
5. The division's pages on LinkedIn and Wikipedia will be officially ON soon. Thanks to Dr. Stephan Ekwaro-Osire, Outreach Chair (Stephen.Ekwaro-Osire@ttu.edu) of SERAD for all the efforts.

With promising news on getting the world to normal with spread of covid vaccination, I'll close this by wishing you health and safe days ahead.

If you have an idea or would like to discuss opportunities in the division, please send an email to

Mohammad Pourgol-Mohammad, Ph.D, PE
ASME SER$^2$AD Chair, 2020-2021

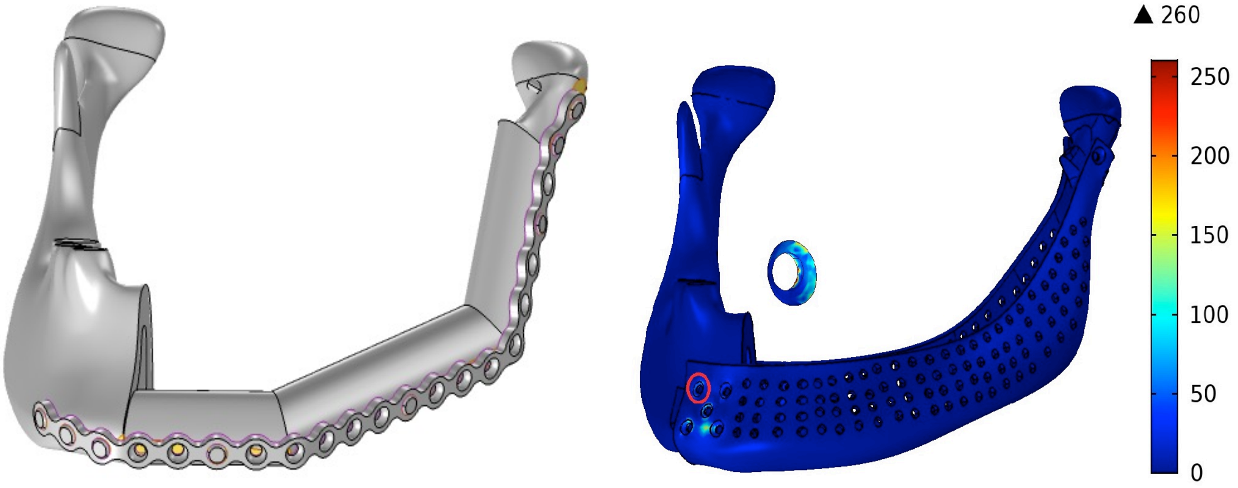
# Mandibular Reconstruction System Reliability Analysis Using Probabilistic Finite Element Method

In Memory of Late Dr. Sahand Kargarnejad

By Authors and Co-Advisers: Farzan Ghalichi and Mohammad Pourgol-Mohammad
Sahand University of Technology, Tabriz-Iran

> This is the latest research done by Dr. Sahand Kargarnejad. Sahand was the recipient of SERAD “2020 Honorable Mention” award. His prior to his passing, his promotion was under the review committee to be promoted to Assistant Professorship.

The aim of this study was to design for mandibular reconstruction of large lateral defect bite force range of $300 \pm 102$N. The performance of the models has been evaluated by numerical analysis considering the uncertainty of input parameters. Computer-Aided design was used to develop the models of three designs according to the patient's anatomy and to achieve to near symmetry of the mandible. Stress-strength modeling was utilized for the probabilistic physics of failure analysis under assumption of a quasi-static load. Monte-Carlo simulation was also applied for probabilistic finite element analysis and reliability assessment. The sensitivity analysis of the models was developed to reflect the significance of the variables in the models. The deterministic stress analysis shows that the highest stress and the second maximum stress are 110 MPa and 85 MPa for cortical bone around the screws, respectively. Also, it is determined that the maximum plate stress of the titanium conventional plate model is 580 MPa.



The Mandible Jaw Construction (a) Design by CAD (b) Finite Element Stress Analysis

The reconstruction system success rate was improved in all models by observing the anatomy of the patient's mandible in the plate designs by computer-aided design and additive manufacturing techniques. Based on the results, the reliability of plate strength and pull-out screws strength are 99.99% and 96.71% for the fibula free flap model, respectively, and 99.99% and 94.17%, respectively, for the customized prosthesis model. Probability sensitivity factors showed that uncertainty in the elastic modulus of the cortical bone has the greatest effect on the probability of screws loosening. Below is the finding of his research. The von Mises stress statistics are calculated for 4 mandible configurations of TCP, FFF, CP, and TI by probabilistic finite element method. The reliabilities, and Safety margin (stress vs. strength) are calculated and shown in Table 1.

Results of the probabilistic finite element method

| Response of the systems | TCP | | | FFF | | | CP | | | TI | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Statistics | Mean | SD | COV | Mean | SD | COV | Mean | SD | COV | Mean | SD | COV |
| Plate von Mises stress Ti64 (MPa) | 628 | 215.7 | 34 | 243 | 86.1 | 35 | 185 | 71.7 | 39 | 575 | 197 | 34 |
| von Mises stress of the cortical bone-screw I (MPa) | 147 | 49.7 | 34 | 69.9 | 26.7 | 38 | 78.1 | 28.5 | 37 | 129 | 43.7 | 34 |
| von Mises stress of the ) cortical bone-screw II (MPa | 73 | 27.3 | 37 | 37.4 | 13.5 | 36 | 39.7 | 14.4 | 36 | 97.1 | 32.8 | 34 |

The results of probabilistic analysis showed that the probability of plate fracture in all four models is low (the least probable model is the TCP model at 13%). As the results show, the failure probability of the FFF model, in both plate fracture and screw loosening (0.0001 and 0.0329, respectively), is the lowest among all the presented models. This result has been validated by available clinical reports.

**Table 1.** Results of the probabilistic finite element method

| Performance function | Failure modes | Failure criteria | TCP | | FFF | | CP | | TI | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Safety margin (SM); Reliability (R)* | SM | R | SM | R | SM | R | SM | R |
| 1 | Plate fracture | Compressive strength | 1.16 | 0.87 | 7.30 | 0.99 | 9.53 | 0.99 | 1.53 | 0.93 |
| 2 | First Loosen Screw | Yield Strength First Stressed Screw | -0.12 | 0.45 | 1.84 | 0.96 | 1.57 | 0.94 | 0.22 | 0.58 |

# Protective Systems

Ernie Kee, Martin Wortman, and Pranav Kannan
The Organization for Public Awareness of Hazardous Technology Risks

## 1 Introduction

This third article in a planned series of four on "Protection, Regulation, and Risk Assessment" provides details about the role of predictive models for protective systems, how they are developed, and how they are used to understand the efficacy of protection.[1] In particular, we focus on system reliability principles applied to protective system. We will appeal to these familiar principles so as to identify and highlight subtle pitfalls in state–of–the–art modeling that can lead to optimistic predictions of protection efficacy.

In the series' first article, we presented more details on our understanding of the need for risk assessment and views of different stakeholders on the efficacy of protection, even the need for protection. In the second article we provided details about what we believe should be the role of protective systems, how they are developed, and how expectations for their efficacy against harms can be evaluated. The fourth and final article is about regulation of protective systems and, depending on the choice of method, how different risk assessment methods can influence regulatory oversight and rules. In the last article of the series, we plan to detail our understanding of the results and possible pitfalls that we believe should be identified and presented in any assessment of risk, particularly in risk quantification.

## Predictive Modeling

We start with the observation that *catastrophic failures occur only when protections fail; and failure of protection is the result of inadequate design, stemming from design oversights or unreliability of the design in service.*

Design and operation of protective systems relies on *predictive models* that are forecasts of future system performance. Unable to know the future with complete certainty, engineers rely on probabilistic models that would help understand consequences of protective systems' unknown future performance. As a consequence, efficacy of protection must be estimated through one or more predictive models. In the following we review some basics of predictive modeling that, in many cases, underly design of protective systems. We will point out certain often overlooked pitfalls that result in optimistic predictions of protection efficacy.

The complexity of protective systems and their physics–based predictive models are so complicated that they become mathematically intractable. Because of this, engineers use predictive models based on reduced complexity that capture just the most important features required to support protective system design and operation. Therefore protective systems are normally modeled from the *operational physics*.

### Operational Physics

In the following, random quantities are defined on the filtered probability space $(\Omega, \mathcal{F}, \{\mathcal{F}_t\}_{t\geq 0}, P)$. Figures 2a and 2b illustrate one way one could think of the state of affairs as, out of an infinite variety of future paths the future may take, just one, possibly one not one thought of is observed, Figure 2a. Representations that help reduce complexities in technological system design are again illustrated in Figure 2b. In the figure, time-dependent physical processes nearest the real world are shown as $\omega$ in the space, $\Omega$ where they are observed.[2] System dynamics are known by the state of affairs as they are observed; it is clear that an unobserved and impenetrable reality lies under our understanding from observation and reduction to physical laws. Conceptually, we might think of the scenarios of time as passing through a "reality filtering machine" such as shown in Figure 2a that, from an infinity of possible future realities, the machine filters out the reality we observe. We assert that engineers are applying scientific principles in order to

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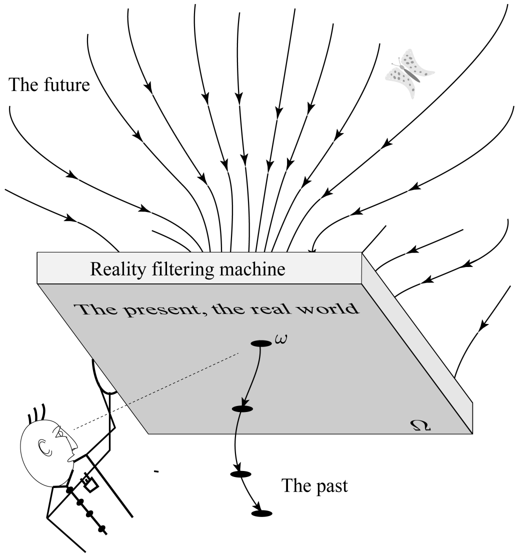
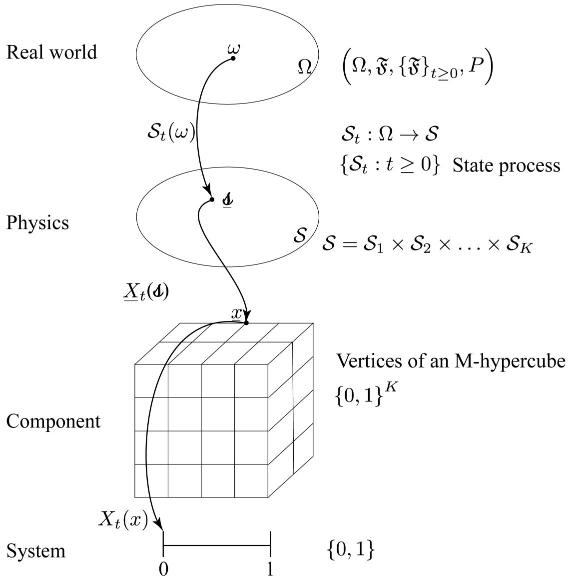
[1] The articles are planned to appear in successive issues of the ASME SERAD quarterly newsletter; the first appears in the 3$^{\text{rd}}$ quarter 2020 issue.

[2] Philosphers debate even the existence of time, (for example **?**), but we certainly observe the state of affairs as they appear around us.



**(a)** The observed state of affairs is just one of many possibilities out of an infinity of realities one may imagine.



**(b)** Abstractions from the “real world” to the “system level” of operational physics.

represent the state of affairs as numbers having engineering units. Examples would be differential equations or other representations of physical laws such as, thermodynamics, applied forces, electrostatic forces, and so forth. Such applications of scientific principles and laws of nature form the basis for modeling performance expectations of the systems they design and operate as shown in Figure 2b. At the operational level of abstraction, the system in operation is judged to be either “operating” or not, a very high level of abstraction of the state of affairs.

*Operational Physics* is terminology applied to a reductionist strategy used to overcome the burden associated with the complexity of physics–based engineering models. In short, operational physics captures system dynamics as they are projected on a binary state space. A protective system is decomposed into a finite number of components; the state space of each component is simply the set $\{0, 1\}$ where “1” indicates that the component is operational and “0” indicates the component is failed.

This modeling approach puts no particular restriction on how components are conceptualized, that is, a single component could represent a highly complex subsystem or have such fine granularity as to represent a molecular ensemble. Components must be mutually exclusive and have a union that forms the protective system under consideration; the state of each component, as operational or failed, is directly observable at a time $t \geq 0$.

As such, component state spaces are unit-less; and therefore, operational physics obscures, for example, the thermodynamics, mechanics, electro–magnetics, chemistry, and so forth, physical processes underlying protective system dynamics. That is, *Operational physics gains relative simplicity at the expense of detailed physics*. This is not to say that predictive models based operational physics are necessarily simple or mathematically tractable. In the following, we review assumptions required for such predictive models to yield to computational analysis.

Let a given protective system be decomposed into $K$ components and let $X_{t,i}$ denote the state (operational or failed) of component $i$ at time $t \geq 0$, $i = 1, ..., K$. Let, $S = \{0, 1\}$ be state space of component $i$. For $i = 1, ..., K$,

$$X_{t,i} = \begin{cases} 1, & \text{component } i \text{ is operational at time } t, \\ 0, & \text{otherwise.} \end{cases}$$

It follows that the system state vector $\underline{X}_t = [X_{t,1} \cdots X_{t,K}]$ holds the state of each system component at time $t$ and takes values in the set $S^K = \{0, 1\} \times \cdots \times \{0, 1\}$. Now, whether or not a protective system is operational at time $t$ depends on the operational state of its components. That is to say, the operability of a protective system is determined by its state vector. To this end, define the $X_t$ as the scalar valued system state at time $t$. Here,

$$X_t = \begin{cases} 1, & \text{the system is operational at time } t, \\ 0, & \text{otherwise.} \end{cases}$$

The system state $X_t$ is therefore some scalar function, say $g : S^K \rightarrow S$, of the system state vector $\underline{X}_t$. Or, $X_t = g(\underline{X}_t)$, where $g$ is the *system structure function* (or simply the *structure function*). It is a straightforward matter to reason that

$g$ is a Boolean is a multinomial function of degree–1 in the system state variables $X_{t,i}, i = 1, ..., K$, where

$$X_t = \begin{cases} a_1 X_{t,1} + \cdots + a_K X_{t,K} \\ +a_{1,2} X_{t,1} X_{t,2} + \cdots + a_{K-1,K} X_{t,K-1} X_{t,K} \\ +a_{1,2,3} X_{t,1} X_{t,2} X_{t,3} + \cdots \\ +a_{K-2,K-1,K} X_{t,K-3} X_{t,K-1} X_{t,K} \\ \vdots \\ +a_{1,2,\,...,\,K} X_{t,1} X_{t,2} \cdots X_{t,K-1} + \cdots \\ +a_{2,3,\,...,\,K} X_{t,2} X_{t,3} \cdots X_{t,K} \\ +a_{1,2,\,...,\,K} X_{t,1} X_{t,2} \cdots X_{t,K}. \end{cases} \tag{1}$$

Each coefficient is an integer from the set $\{-K, ..., K\}$. The structure function plays an essential role in reliability and protective system predictive modeling, and we will discuss it further in Section 1.1.

The collections $\{\underline{X}_t; t \geq 0\}$ and consequently, $\{X_t; t \geq 0\}$, are stochastic processes indexed over time. Any independence structure either among the elements of the state vector $\underline{X}_t$ or across time should not be generally anticipated. In the absence of an independence structure, ascribing a probability law to $\{\underline{X}_t; t \geq 0\}$ and consequently, applying statistical methods to observational data is effectively impossible. In section 1.3, certain structural independence assumptions are identified that, if justified, would significantly reduce the burden of analysis.[3] Before discussing simplifying probability assumptions, we introduce the standard approach to identify the structure function $g(\cdot)$ using Failure Modes and Effects Analysis (FMEA) and fault tree analysis.

## 1.1 Structure Functions: FMEA and Fault Trees

In practical system reliability analysis, much engineering effort is given to developing structure functions. The modeling effort, here, sequentially requires: 1) identifying contingencies that might disrupt the specific operational requirements of a protective system, 2) decomposing (prospective) system designs into atomic[4] components that encapsulate the identified disruption contingencies, and then 3) craft an analytical structure function that describes the coordinated operational behavior of the atomic components. There are no set rules for determining how a given protective system design should be decomposed into components. Nonetheless, engineering reason dictates that each disruption contingency source be represented in at least one atomic component and, since no component should be assumed perfectly reliable, each atomic component should be encumbered by at least one of the identified disruption contingencies.

The engineering that underlies operational physics modeling typically begins with technology domain experts completing a system FMEA. System FMEA is the high-level analysis focused on system-related deficiencies, including system safety, system integration, interfaces or interactions between subordinate components, interactions with the surrounding environment, and other issues that could cause the overall system to not function as intended. In system FMEA, the focus is on functions and relationships that are unique to the system as a whole. Included are failure modes associated with component interfaces and interactions together with single-point failures, where a single component failure can result in complete system failure. System FMEA is regarded as a method (or procedure) is executed with committee discussions and analyses, survey forms and technical audits. Once an FMEA study is developed, the results are typically used to inform a fault tree analysis.

## 1.2 Protective System Reliability

It follows directly that when the $X_t$ is a random variable defined on a probability space that $E[X_t] = P(X_t = 1)$; in words, the probability that a protective system is operational at time $t$ is simply the expected value of the system state. Clearly, the expected system state $E[X_t]$ is a function and we will write that $R(t) \overset{\text{def}}{=} E[X_t]$. Similarly, we define the reliability of system component $i$ as

$$R_i(t) \overset{\text{def}}{=} E[X_{t,i}], i = 1, ..., K.$$

## 1.3 Independent Components

In the circumstance that all system components are mutually independent in probability law, it follows from (1) that the system reliability $R(t)$ is a linear combination of the component reliability functions $R_i(t), i = 1, ..., K$. We will use

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[3] We make no claim that these assumptions are reasonable.

[4] We use the terminology 'atomic' for system components that will not be decomposed to gain higher modeling granularity.

the notation $R_I(t)$ to indicate the system reliability function under the independent components assumption. Here, one need only replace $X_t$ with $R_I(t)$ and each $X_{t,i}$ with its respective $R_i(t)$ in (1). Under component independence, we will write that

$$R_I(t) \overset{\text{def}}{=} g(\underline{R}(t)), \tag{2}$$

where $\underline{R}(t) \overset{\text{def}}{=} [R_1(t) \cdots R_K(t)]$ is the vector of component reliability functions.

We do not generally endorse the assumption of independent components which is necessary for constructing the system reliability function shown in (2), even though it is often assumed for the purpose of computing numerical probabilities.[5] We emphasize that, rejecting component independence invalidates (2); that is, the system reliability function need not be a linear combination of only the component reliability functions.

### 1.4 Stationary Behavior

Under operating circumstances where the protective system is in stochastic steady–state, it can be reasoned that the system exhibits ergodic behavior. When in an ergodic regime, it follows that

$$\lim_{t \to \infty} E[X_t] = \lim_{t \to \infty} R(t) = u, \tag{3}$$

where $u$ is the constant fraction of time that the protective system is operational. Similarly, when component $i = 1, \ldots, K$ is in an ergodic regime, it follows that

$$\lim_{t \to \infty} E[X_{t,i}] = \lim_{t \to \infty} R_i(t) = u_i, \tag{4}$$

where, $u_i$ is the constant fraction of time that component $i$ is operational. When they exist, $u$ and $u_i$ are often referred to as "system availability" and "component availability" respectively. Without proof, we note that when all components $i = 1, \ldots, K$ are operating in ergodic regimes, then the system state is also ergodic.

Of course, a consequence of ergodic behavior is that for each component $i = 1, \ldots, K$ the component reliability function $R_i(t)$ is independent of time $t$, thus, dramatically reducing the observational data burden necessary for accurate statistical estimates of (now constant) reliabilities. Ergodic behavior is sometimes assumed when studying protective system reliability, but we caution that it is a very strong assumption and nearly impossible to demonstrate through direct observation.

### 1.5 Independent and Stationary Components

When it is assumed that all protective system components are mutually independent and operating in an ergodic regime, it follows directly from (2), (3), and (4) that

$$R(t) = R_I(t) = u = g(\underline{u}),$$

where $\underline{u} \overset{\text{def}}{=} [u_1 \cdots u_K]$ is the vector of component availabilities. In practice, each element $u_i$ of the component availability vector $\underline{u}$ is estimated as the ratio of the component's average "up time" to the sum of its average "up time" and "down time."

Noting that the assumptions of component independence and stationarity are typically questionable for any protective system comprised of a large number of components raises concerns about the usefulness of attempting to quantify $R(t)$ (or approximate it with $R_I(t)$) in the first place. Thus, we further note that practical interest in quantifying the system reliability function $R(t)$ is almost always motivated by analysts' quest for numerical probabilities. In particular, analysts are concerned with computing a numerical value for the probability that a protective system will actually operate properly when called upon. The requirement of "when called upon" will now be considered.

## 2 Protective System Reliability at the Instant of Initiating Event Arrivals

Protective systems by design stand ready to detect and arrest the consequences of infrequently arriving disturbances that might exceed to catastrophe. Such disturbances are called "initiating events" and can include equipment malfunctions, weather, seismic events, and human error. The arrival and nature of initiating events are not predictable with certainty. Here, we let $T_n$, $n = 1, 2, \ldots$ be the random variable designating the arrival time of the $n^{th}$ initiating

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[5] There are many sound reasons to reject component independence, chief among them certain types of common cause component failures. When independence.

event. Clearly, the sequence of initiating event arrival times $(T_n; n \geq 1)$ is order dependent and generally not independent of the protective system operating state (*i.e.,* an earthquake arrival could possibly cause the protective system itself to fail). The effectiveness of protection must be gauged by the likelihood that an arriving initiating event finds the protective system in the failed state. Take the random variable $Z_n \overset{\text{def}}{=} X_{T_n}, n = 1, 2, ...,$ to be the state of the protective system at the time of the $n^{th}$ arriving initiating event.

From the perspective of protection efficacy, the sequence of random variables $\{X_{T_n}; n \geq 1\}$ captures the protective system state (either operational or failed) at the epoch of each initiating event. Of course, the principle random variables of interest are $R(T_n) = E[X_{T_n}]$. However, because of the plausible intricate dependencies among the many random variables in $\{X_{T_n}; n \geq 1\}$, obtaining a numerical value for $R(T_n)$, $n = 1, 2, ..$ is generally infeasible. Numerical probabilities are attainable only when additional stochastic structure in introduced. We will now introduce structure leading to numerical probabilities for $R(T_n)$. Our purpose here is to reveal the strength of assumptions often imposed by analysts to obtain numerical probabilities associated with the efficacy of safety critical protection.

## 2.1 PASTA

Under that assumptions that initiating events occur according to a (not necessarily stationary) Poisson process, together with the **loa!** (**loa!**) condition, **?** in his 1982 article "Poisson arrivals see time averages," proves that at arrival time epochs in the sequence $\{T_n; n \geq 1\}$ initiating events see the time average behavior of the protective system state process $\{X_t; t \geq 0\}$ at $t \to \infty$. That is, initiating events are such that **pasta!** (**pasta!**).

In general, there is no reason to expect the probability that a protective system is operational at the time of an arriving initiating event should be given by the fraction of time that the system is operational. However, under the assumptions that initiating events occur according to a (not necessarily stationary) Poisson process, together with the **loa!** condition, it is well known (see Wolff 1982) that at arrival time epochs in the sequence $\{T_n; n \geq 1\}$ initiating events see the time average of the system state $\{X_t\}$. That is initiating event are such that **pasta!** applies. Here, with $N_t$ being the number of initiating events arriving in the interval $[0, t]$ and $\{N_t; t \geq 0\}$ being Poisson with rate $\lambda(t) > 0$. The lack of anticipation condition requires that the events $\{N_{t+u} - N_t = n; u, \geq 0, n \geq 1\}$ and $\{X_s = 1; s \leq t\}$ are independent for all $t \geq 0$.

The essential elements of engineering modeling that are needed to justify **pasta!** are 1) the independent increments which characterize Poisson arriving initiating events and 2) the **loa!** condition. Independent increments requires that the number of arriving initiating events in disjoint time intervals be independent. The **loa!** condition requires that the events $\{N_{t+u} - N_t = n; u, \geq 0, n \geq 1\}$ and $\{X_s = 1; s \leq t\}$ are independent for all $t \geq 0$. The **loa!** condition is often justified since the present protective system reliability is typically unaffected by initiating events that might occur in the future. The independent increments assumption, however, is not so easily justified.[6]

The time average $\bar{X}$ of the protective system state $X_t$ is given by

$$\bar{X} = \lim_{t \to \infty} \frac{1}{t} \int_0^t X_s ds.$$

In general, $\bar{X}$ is a random variable. But, under the circumstance that the protective system is operating in a stationary and ergodic regime, $\bar{X}$ converges to a constant and can be estimated as

$$\bar{X} \simeq \frac{1}{t} \int_0^t X_s(\tilde{\omega}) ds \tag{5}$$

when $t$ becomes large.[7]

We note that the **pasta!** result is not immediately evident through intuitive reasoning. Its proof appeals to the martingale calculus and Watanabe's characterization of the Poisson process. Acknowledging questionable model fidelity when assuming Poisson arrivals, one might fairly ask, "Is it possible to relax the Poisson assumption and still obtain a numerical probability that protection holds at the time of an initiating event?" The answer is, unfortunately, "No." Relaxing the assumption of independent increments in arrival of initiating events means that the intensity of the intensity of the stream of initiating events is to longer deterministic (*i.e.,* $\lambda(t)$ becomes a random variable that belongs to a stochastic intensity process $\{\lambda(t); t \geq 0\}$), putting numerical computation of $R(T_n)$ out of reach for any $n > 1$.

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[6] For example, seismic activity and hurricane arrivals are often modeled with self-exciting point processes. Also, initiating events that arise from the failure of maintained components do not exhibit memoryless "up times", which would be required under a Poisson assumption.

[7] Here, $X_t(\tilde{\omega})$ is the historically observable trajectory of the system state where $\tilde{\omega}$ is fixed and distinguishes the observable history from among all other possible outcomes $\omega \in \Omega$, $\Omega$ being the set possible beginning at time $t = 0$ when no history was observable.

## 3 Summary and Conclusions

We have described some of the primary challenges faced by engineers who are asked to quantify something like “risk” in a protective system design for which they are responsible. We described why results from traditional reliability analyses are inappropriate for use in a quantified “risk assessment” that includes frequency of initiating events that have Poisson arrival characteristics. The requirements for such an approach to be validated have been described for complex protective systems. A primary shortfall in such an approach has been shown to be **loa!** and the requirement for stationarity that will not be satisfied in protective systems that are under maintenance policies that require addressing failures. At this time we have found no practical “work around” or analytical method such as Markov state transition models, discrete event modeling, or other proposed “dynamic modeling”, that would overcome the inherent problems with quantification we describe in this article.

ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems
More Information: https://ascelibrary.org/journal/ajrub7 Contact Prof. Bilal M. Ayyub, Editor in Chief, ba@umd.edu

## ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering, Part B: Mechanical Engineering

**Alba Sofi, PhD**

**University "Mediterranea" of Reggio Calabria, Italy, e-mail: alba.sofi@unirc.it**

Established in 2014 by the current Editor-in-Chief, Professor Bilal M. Ayyub from the University of Maryland College Park, the ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering and Part B: Mechanical Engineering serves as a medium for dissemination of research findings, best practices and concerns, and for discussion and debate on risk and uncertainty-related issues in the areas of civil and mechanical engineering and other related fields. The journal addresses risk and uncertainty issues in planning, design, analysis, construction/manufacturing, operation, utilization, and life-cycle management of existing and new engineering systems.

Both Part A and Part B are listed in the Emerging Citation Sources by Clarivate Analytics, formerly Thomson Reuters, and are eligible for indexing in 2018. From 2016 onward, all articles will be included in Web of Science. They are also included in Scopus.

Part A has successfully secured an impact factor of 1.331 based on the latest Journal Citation Reports by Clarivate Analytics.

## Journal of Risk and Uncertainty contents

| Issue | | | Issue Date |
|---|---|---|---|
| Latest Issues | | | |
| Volume 7-Issue 2 | Part A | Part B | (June 2021, in progress) |
| Volume 7-Issue 1 | Part A | Part B | (March 2021) |
| 2020 Table of Contents | | | |
| Volume 6-Issue 4 | Part A | Part B | December 2020 |
| Volume 6-Issue 3 | Part A | Part B | September 2020 |
| Volume 6-Issue 2 | Part A | Part B | June 2020 |
| Volume 6-Issue 1 | Part A | Part B | March 2020 |

## Latest State of the Art Reviews: Part A

"Structural System Reliability: Overview of Theories and Applications to Optimization" by Junho Song, Won-Hee Kang, Young-Joo Lee, Junho Chun

"Probabilistic Inference for Structural Health Monitoring: New Modes of Learning from Data" by Lawrence A. Bull, Paul Gardner, Timothy J. Rogers, Elizabeth J. Cross

"Scale of Fluctuation for Spatially Varying Soils: Estimation Methods and Values" by Brigid Cami, Sina Javankhoshdel, Kok-Kwang Phoon, and Jianye Ching

"Social Indicators to Inform Community Evacuation Modeling and Planning" by William Seites-Rundlett, Elena Garcia-Bande, Alejandra Álvarez-Mingo, Cristina Torres-Machi, and Ross B. Corotis

"Assessment Methods of Network Resilience for Cyber-Human-Physical Systems" by Sisi Duan and Bilal M. Ayyub

## Latest Review Articles: Part B

"Path Integral Methods for the Probabilistic Analysis of Nonlinear Systems Under a White-Noise Process" by Mario Di Paola and Gioacchino Alotta

"Sensemaking in Critical Situations and in Relation to Resilience - A Review" by Stine S. Kilskar, Brit-Eli Danielsen, Stig O. Johnsen

## Latest Special Collections: Part A

"Special Collection on Bayesian Learning Methods for Geotechnical Data" Ka-Veng Yuen, Jianye Ching, Kok Kwang Phoon

"Special Collection on Resilience Quantification and Modeling for Decision Making" Gian Paolo Cimellaro and Nii O. Attoh-Okine

## Latest Special Issues And Special Sections: Part B

"Special Section: Nonprobabilistic and Hybrid Approaches for Uncertainty Quantification and Reliability Analysis" by Matthias G. R. Faes, David Moens, Michael Beer, Hao Zhang, Kok-Kwang Phoon

"Special Section on Response Analysis and Optimization of Dynamic Energy Harvesting Systems in Presence of Uncertainties" by Agathoklis Giaralis, Ioannis A. Kougioumtzoglou, Pol D. Spanos

"Special Section on Uncertainty Management in Complex Multiphysics Structural Dynamics" by Sifeng Bi, Michael Beer, Morvan Ouisse, Scott Cogan

"Special Section on Resilience of Engineering Systems" by Geng Feng, Michael Beer, Frank P. A. Coolen, Bilal M. Ayyub, Kok-Kwang Phoon

"Special Issue on Human Performance and Decision-Making in Complex Industrial Environments" by Raphael Moura, Michael Beer, Luca Podofillini

## Recognitions & Awards

### Recognitions for Papers

| | Part A |
|---|---|
| Editor's Choice Paper | "Probabilistic Inference for Structural Health Monitoring: New Modes of Learning from Data" by Lawrence A. Bull, Paul Gardner, Timothy J. Rogers, Elizabeth J. Cross |
| Most Read Paper | "Structural System Reliability: Overview of Theories and Applications to Optimization"" by Junho Song, Won-Hee Kang, Young-Joo Lee, Junho Chun |
| Most Cited Paper | "Resilience Assessment of Urban Communities" by Omar Kammouh, Ali Zamani Noori, Gian Paolo Cimellaro, Stephen A. Mahin |
| Editor's Choice Collection | For each issue of the journal, the Chief Editor may select a paper to be featured on the journal homepage in the ASCE Library. The paper is available for free to registered users for 1 to 4 months, depending on how frequently the journal is published. A list of Editor's Choice selections is available here. |
| | **Part B** |
| Most Read Paper | "Damage Classification of Composites Based on Analysis of Lamb Wave Signals Using Machine Learning" by Shweta Dabetwar, Stephen Ekwaro-Osire, João Paulo Dias |
| Most Cited Paper | "Structural Life Expectancy of Marine Vessels: Ultimate Strength, Corrosion, Fatigue, Fracture, and Systems" by Bilal M. Ayyub, Karl A. Stambaugh, Timothy A. McAllister, Gilberto F. de Souza, David Web |
| Featured Article | "The Application of Downhole Vibration Factor in Drilling Tool Reliability Big Data Analytics–A Review" by Yali Ren, Ning Wang, Jinwei Jiang, Junxiao Zhu, Gangbing Song, Xuemin Chen |

### Outstanding Reviewers

| Part A 2019 Outstanding Reviewers | Part B 2019 Reviewers of the Year |
|---|---|
| Eleni Chatzi | Ekaterina Auer, *Hochschule Wismar* |
| ZhiQiang Chen | Ioannis Kougioumtzoglou, *Columbia University* |
| Ziad Ghauch | |
| Ahmed Lasisi | |
| Edoardo Patelli | |
| Xiaobo Qu | |
| Balaji Rao | |
| Mohamed el Amine Ben Seghier | |

### Best Paper Award

Starting in 2019, the Best Paper Award will be given annually to one paper in Part A and one paper in Part B appearing in the preceding volume year. Papers are evaluated by the Editorial Board members based on the following criteria:

- fundamental significance
- potential impact
- practical relevance to industry
- intellectual depth
- presentation quality.

ASCE and ASME post the winning paper's information on the journal website as well as on social media. The winning papers are made freely available from the ASCE Library (Part A) and from the ASME Digital Collection (Part B) for one year to anyone interested once registered and logged in to download. Moreover, ASME offers the authors a one-year free subscription to Part B.

The award is typically presented to the authors in attendance at the ASME Safety Engineering and Risk Analysis Division (SERAD) award reception meeting at the annual International Mechanical Engineering Congress & Exposition (IMECE). Due to Covid-19 outbreak, IMECE2020 has been converted into a virtual event event and SERAD award ceremony has been held on-line. The recipients of the 2019 Best Paper Award will receive the award's certificate/plaque by mail.

The selection process for the 2020 Best Paper Award will start early next year.

# Calls for Papers

## Part A: active Calls for Special Collections

Special Collection on "Risk Assessment for Large Scale Geotechnical Systems" (SC045A). Paper submission deadline: April 30, 2021.

## Part B: active Calls for Special Issues

Special Issue on "Uncertainty Quantification and Management in Additive Manufacturing" (SI046B). Paper submission deadline: February 1, 2021.

Special Issue on "Probabilistic Approaches for Robust Structural Health Monitoring of Wind Energy Infrastructure" (SI047B). Paper submission deadline: March 15, 2021.

Special Issue on "Autonomous Vehicle Technologies: Risk, Resilience, and Reliability" (SI049B). Paper submission deadline: March 1, 2021.

# Social media (Twitter and LinkedIn)

The ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems in its two parts is now also active on Social Media. Follow our pages on Twitter and LinkedIn:

Twitter: ASCE-ASME Journal of Risk and Uncertainty

LinkedIn: ASCE-ASME Journal of Risk and Uncertainty

https://chinahow.guide/wechat-registration-sign-up/

to stay up-to-date on latest issues, highlighted journal content, active calls for special issues and special collections, recognitions and awards.

## Journal's Newsletter

The Journal's Newsletter is sent out on a quarterly basis. To receive updates on the Journal's progress and announcements, subscribe to the Newsletter here: Subscribe to the Journal Newsletter

# Submission

Part A: Submit to Part A here

Part B: Submit to Part B here

State-of-the-Art Reviews (Part A) and Review Articles (Part B) on topics of current interest in the field of risk and uncertainty are especially welcome.

Please contact the Editor or Managing Editors by email if you are interested in guest editing a Special Collection (Part A) or a Special Issue (Part B).

| | |
|---|---|
| Editor | Bilal M. Ayyub, University of Maryland, ba@umd.edu |
| Managing Editors | Sankaran Mahadevan, Vanderbilt University, sankaran.mahadevan@vanderbilt.edu<br>Kok-Kwang Phoon, National University of Singapore, kkphoon@nus.edu.sg |
| Associate Managing Editors | Eleni Chatzi, ETH Zurich, chatzi@ibk.baug.ethz.ch<br>Ioannis Kougioumtzoglou, Columbia University, iak2115@columbia.edu<br>Alba Sofi, University Mediterranea of Reggio Calabria, alba.sofi@unirc.it<br>Xiaobo Qu, Chalmers University of Technology, xiaobo@chalmers.se |

**IMECE ®**
**International Mechanical Engineering Congress & Exposition®**

# 2021 Student Paper on Safety Innovation Challenge Contest

*by the*

## ASME - Safety Engineering, Risk and Reliability Analysis Division (SERAD)

Annually, SERAD hosts a challenge to undergraduate and graduate students to submit papers on Safety Engineering, Risk and Reliability Analysis topics, including papers already submitted to the ASME International Mechanical Engineering Congress & Exposition (IMECE) 2021. The papers are peer-reviewed by experts in these areas. The top winning papers in each of the undergraduate and graduate groups will be presented in a special SERAD session at the ASME IMECE 2021 and honored at a SERAD awards banquet during the conference. Recognitions also include cash honorariums for first place winning authors, and reimbursement with a limit for the conference-related expense (registration) for all students presenting their paper at the special session.

### Submitting Papers to the 2021 SERAD Student Paper Contest

*Participants*

- Undergraduate and graduate students
- An academic sponsor/advisor is required.

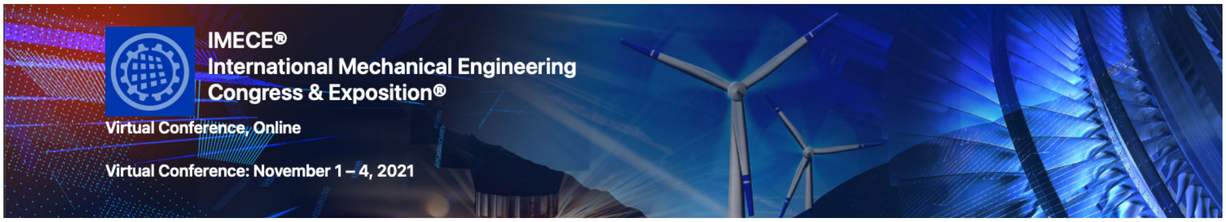
*Important Dates*

- Student paper submission by **May 28, 2021**.
- SERAD announces 1st and 2nd place winners in respective undergraduate and graduate group on **June 25, 2021**.
- Presentation Only Abstract Submission by 1st and 2nd place winners by **July 9, 2021**.
- SERAD special session for student contest, and awards banquet in **November 1-5, 2021** during IMECE 2021 which will be virtual.

*Submittals*

- Initial submittals must be previously unpublished work, but can be papers used for academic credits.
- Submittals are not required to follow ASME’s conference paper format, although it is encouraged. Suggested paper size is 4-6 pages including figures.
- Recommendation and statement of student status from the academic sponsor is required with submission.
- Submittals and questions regarding 2021 student contest: Prof. Stephen Ekwaro-Osire (stephen.ekwaro-osier@ttu.edu) or Prof. Jeremy M. Gernand (jmg64@psu.edu).

*Sponsor*: FM Global


IMECE®
International Mechanical Engineering Congress & Exposition®
Virtual Conference, Online
Virtual Conference: November 1 – 4, 2021

## Call for Papers

### Track 14: Safety Engineering, Risk, and Reliability Analysis

### Track Description

The Track contains a collection of Topics in the broad area of safety engineering and risk analysis, which are individually organized by leaders in the field. The topics give a comprehensive coverage of experimental, computational, and analytical approaches to the safety question. Safety Engineering, Risk, and Reliability Analysis - is organized by the Safety Engineering, Risk, and Reliability Analysis Division (**SERAD**) of the ASME.

### Track Objectives

Authors and presenters are invited to participate in this event to expand international cooperation, understanding, and promotion of efforts and disciplines in the area of Safety Engineering, Risk, and Reliability Analysis. Dissemination of knowledge by presenting research results, new developments, and novel concepts in **Safety Engineering, Risk, and Reliability Analysis** will serve as the foundation upon which the conference program of this area will be developed.

### Track Topics

1. General Topics on Risk, Safety and Reliability
2. Reliability and Risk in Energy Systems
3. Reliability and Safety in Industrial Automation Systems
4. Reliability and Safety in Transportation Systems
5. Models and Methods for Probabilistic Risk Analysis
6. Probabilistic Risk Assessment of Protective Systems
7. Machine Learning for Safety, Reliability, and Maintenance
8. Reliability and Safety of Deep Learning-based Components
9. Big Data and IoT Applications in Reliability, Maintenance, and Security
10. Crashworthiness, Occupant Protection, and Biomechanics
11. Congress-Wide Symposium on Prognostic and Health Management: NDE and prognostics of structures and systems
12. Users, Technology, and Human Reliability in Safety Engineering
13. Student Safety Innovation Challenge
14. Plenary Session

### Journal Publication

Authors of selected papers presented at the conference will be invited to submit updated and expanded versions of their papers for publication consideration in the **ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part B: Mechanical Engineering**.

Abstract Submission: March 22, 2021
Paper Submission: April 29, 2021
Acceptance Notification: June 15, 2021
Final Paper Submission: July 30, 2021

### Track Chair

**Andrey Morozov**
*University of Stuttgart, Germany*

### Track co-Chairs

**Mihai A. Diaconeasa**
*North Carolina State University, USA*
**Ernie Kee**
*University of Illinois Urbana-Champaign, USA*
**Bill Munsell**
*Munsell Consulting Services, USA*
**John Wiechel**
*SEA Limited, USA*

IMECE®

## Grab your Bootstraps!

*Oh, if you ain't got the do re mi folks, you ain't got the do re mi,*
*Why, you better go back to beautiful Texas, Oklahoma, Kansas, Georgia, Tennessee.*

(Woody Guthrie, 1940)

The American folksinger, poet, artist, and lyricist wrote the song "Do Re Mi" in 1940 during the Dust Bowl in the Great Plains.[8] He is telling citizens from dust bowl states to stay home because they would be turned back at the California border if they had insufficient resources to live without support in their state.[9] The Dust Bowl was probably the result of farming practices on the Great Plains exacerbated by drought.[10] But Woody Guthrie's dust bowl lesson is that, before moving entire populations into non-drought stricken states, it is best to think about "pulling yourself up by your bootstraps"

Now consider the winter storm of 2021 whereby loss of electrical power resulted in several deaths and hardships in Texas and across the American Southwest. Power bought across state interconnects ran up to about $1,000 per kwh. Much criticism, most recently from the US Energy Secretary, has been directed at the Texas utility commission, ERCOT, for its perceived "independence" from the national electrical grid as the reason for a sustained electrical grid imbalance.[11] However, such criticism is unhelpful in finding solutions to a public need for reliability of technological systems in the face of rare and consequential externalities. Among other less important contributors, the root causes most relevant to the Texas electrical grid imbalance are; deregulation of electrical production, and the Texas electrical grid size compared to its population distribution. ERCOT has no regulated requirements, beyond contracts negotiated with their customers, for merchants to maintain electrical production through extreme externalities such the freeze, hurricanes, tornados, seismic events, and so forth. Therefore coal plants have no reason to prevent coal piles from freezing in a rare event like the recent winter cold blast; and merchants supplying natural gas from their feeder lines would not add freeze protection unless electrical producers pay for gas contracts during extreme cold.

Greater reliance on connected grids is not a solution; if this were true, Alaska and Hawaii would have even worse performance than California or Texas which is not the case.[12] Texas, like California covers a large land area with three very large population centers; and although the California blackout record is much worse than Texas, by a factor of two, its grid is not viewed as "separate." It seems most likely that should California have a grid management strategy similar to Texas, all other issues aside, the California grid performance would improve, coming close to matching Texas.

Although Alaska has its own grid and covers a much larger land area than Texas, it really has just one major population center in Anchorage. Of course, a major power outage in Alaska is certainly not out of the question, but the grid is much more manageable, given the population distribution. Obviously, Hawaii has some high population centers but they are supplied by separated electrical grids on the relatively small islands they are located.

In this newsletter, research news over the past year, some writing is been focused on protective systems; described as technological systems required by regulation. Such systems are put in place to protect citizens from harms due to a technological system failure. ERCOT, as the utility regulatory authority, could define a protective system that would require reliable excess capacity to be available to the grid; the level of required excess capacity would be maintained by each merchant as recommended by engineers who understand electrical grid dynamics and where power reserves are needed. If adopted, such regulations would require that merchants build, operate, and maintain excess capacity to respond to known externalities; readiness of excess capacity would be verified by regulations for inspection and enforcement. The costs incurred by merchants should be paid back by customers at a guaranteed rate of return through a "use tax."

What are your thoughts? Let's talk!
Ernie Kee, SER$^2$AD Editor
Send your feedback/thoughts on this or any reliability subject to me at erniekee@illinois.edu.

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[8] Woody Guthrie is a primary inspiration of many folk singers including Nobel laureate Bob Dylan.

[9] John Steinbeck's Pulitzer Prize winning novel "Grapes of Wrath" was published one year expressing the citizens' plight in print.

[10] For a review of causes see, Schubert, S.D., Suarez, M.J., Pegion, P.J., Koster, R.D. and Bacmeister, J.T., 2004. On the cause of the 1930s Dust Bowl. Science, 303(5665), pp.1855-1859.

[11] see `https://www.npr.org/2021/02/26/971840872/energy-secretary-granholm-texas-outages-show-need-for-changes-to-u-s-` for example. Accessed 14 March 2021.

[12] Service interruptions are higher in Alaska:`https://www.eia.gov/todayinenergy/detail.php?id=35652`, Blackouts by state: `https://www.statista.com/statistics/1078354/electricity-blackouts-by-state/`.

# SER$^2$AD Committee

**Table 2.** 2018–2019 SER$^2$AD Committee Membership

| Executive Committee | | Appointments | |
|---|---|---|---|
| Position | Person | Position | Person |
| **Chair** | Mohammad Pourgol-Mohammad, pourgol-mohamadm2@asme.org | **Nominating Chair** | Mohammad Pourgol-Mohammad |
| **1st Vice-Chair** | Xiaobin Le, lex@wit.edu | **Award Chairs** | Jeremy Gernand, jmg64@psu.edu<br>John Weichel, jwiechel@sealimited.com |
| **2nd Vice-Chair-Treasurer** | Arun Veeramany, arun.veeramany@pnnl.gov | **Newsletter Editor** | Ernie Kee, erniekee@illinois.edu |
| **3rd Vice Chair-Membership** | Stephen Ekwaro-Osire, Stephen.Ekwaro-Osire@ttu.edu | **Webinars / Outreach Chair** | Open |
| **4th Vice-Chair-Secretary** | Mihai Diaconeasa madiacon@ncsu.edu | **Student Program Coordinator** | Deivi Garcia, deivi.garciagarzon@gmail.com |
| **Past Chair** | Jeremy Gernand jmg64@psu.edu | **Technical Content Coordinator** | Giulio Malinverno, giulio.malinverno@gmail.com |
| **MECE 2021 Track Organizers** | Andrey Morozov, andrey.morozov@tu-dresden.de<br>Ernie Kee<br>Bill Munsell, bmunsell@att.net<br>Mihai Diaconeasa | | |