IEEE FELLOW COMMITTEE

Recommendation Guide

"How to Write an Effective Nomination"
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IEEE
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IEEE FELLOW COMMITTEE RECOMMENDATION GUIDE

HOW TO WRITE AN EFFECTIVE NOMINATION

1. Introduction

This IEEE Fellow Committee Recommendation Guide specifies recommendations and guidelines for Nominators on how to write an effective nomination. This Recommendation Guide is consistent with higher-precedence governing documents (IEEE Fellow Committee Operations Manual, Forms, and Handbooks) and its goal is to guide prospective IEEE Fellow Grade Nominators on best practices when preparing a nomination.

This Recommendation Guide is to be used as a reference. There are no normative requirements (other than reiterations of requirements noted in the Nomination Form itself). In case of any discrepancy, the IEEE Fellow Committee Operations Manual, Forms, and Handbooks take precedence.

Amendments to IEEE Fellow Committee Recommendation Guides require approval of the Fellow Strategic Programs Subcommittee and the IEEE Fellow Committee Chair.

1.1 Changes from the Previous Versions of the Guide

This Guide has been updated to reflect the changes introduced in the 2021 Nomination Form (now in its second year of use) and also contains more detailed guidance and examples to help Nominators in writing an effective nomination. Additional revisions include an updated Table 1 to further clarify appropriate items of evidence and impact. Minor additions have been made throughout the narrative to improve readability and provide clarification. Furthermore, an expanded Annex containing several complete examples of Nominations for all four Nomination Categories can be found at the end of this Guide.

2. Fellow Grade Qualification

The IEEE Bylaws define the qualifications for elevation to Fellow Grade in terms of unusual distinction in the profession, an outstanding record of accomplishments, advancement or application of engineering, science, and technology, bringing the realization of significant value to society (see IEEE Bylaw I-104.2 for more details). As such, it is not possible to define a precise closed set of criteria that ensures elevation.

The elevation to Fellow Grade is a competitive process as IEEE Bylaw I-305.6 defines the maximum number of elevations that can occur in a calendar year as 0.1% of IEEE voting membership, in the preceding calendar year. Note the 0.1% elevations cap is applied across IEEE as a whole, as per IEEE Bylaws, and must not be interpreted as a per Society allocation or guideline.

3. The Nomination Form

The Nomination Form is a critical document during the Fellow elevation process, and as such, its content is key to the success of the nomination. It is reviewed and assessed by three separate audiences: the Fellow Grade References (References), the Society/Technical Council (S/TC) Fellow Evaluating Committee (FEC) members (Evaluators), and the IEEE Fellow Committee members (Judges). Please refer to the *Guide for S/TC-FEC Evaluators and IEEE Judges* for more information regarding the evaluation process.

The Nomination should not be written solely for experts in the Nominee's area of work, and any IEEE member who is experienced in any technical subject area within the IEEE fields of interest should be able to understand the importance and impact of the Nominee's contributions from the completed Nomination Form.

The best nomination packets are those that follow the instructions for completing the Nomination Form. Read the instructions carefully and do not deviate from them.

A well-documented case for elevation to Fellow Grade includes three fundamental aspects:

1. The *individual technical or educational contribution(s)* to the field made by the Nominee;
2. The *impact* from these contributions, which must have already occurred and be evident;
3. The verifiable *evidence* supporting the case.

Concise narratives that explicitly address these three aspects are more likely to be effective. Excessive narrative and flowery language can reduce the ability of Evaluators and Judges to identify the significance of the Nominee's contributions and their impact.

4. How to Request ORCID and Scopus Identifiers

4.1 ORCID

The Open Researcher Community ID (ORCID) is a permanent digital identifier used for name disambiguation purposes. The unique ORCID assigned to an author allows distinguishing an author from other authors with similar names. Since June 2015, an ORCID is required for any author publishing with IEEE. The implementation of this recent requirement is still ongoing across IEEE.

In order to create your ORCID, please go to https://orcid.org/register and register.

4.2 Scopus ID

A Scopus Author ID is issued by Elsevier and allows tracking and linking publications to the right author. The publications in the Scopus citation database include journal literature, trade journals, books, patent records, and conference publications.

A Scopus ID is automatically assigned to an author when his/her paper listed in the Scopus database is published. One may have more than one IDs in Scopus if publications from the same author show name variations and affiliations; however, multiple IDs can be merged. If you have never published or patented, you can skip this step as you don't have a Scopus ID.

Once an ORCID number is obtained, one can retrieve his/her Scopus ID and link it to ORCID as follows:

1. Log in you ORCID account.
2. Scroll down to the Section "Works" and:
   a. Click on "+Add Words"
   b. Click on "Search and Link"
   c. Click on "Scopus - Elsevier"
3. Select the profile in the list that matches you the best and follow the steps to confirm your profile name and papers.
4. Enter the email used for your ORCID account and click on "Send the Scopus ID to ORCID."
5. Click on "Send my publication list."

6. Click on "Return to ORCID" to see your Scopus ID. It will be listed under "Other IDs."

5. The Choice of the Nomination Category (Section 6.a of the Nomination Form)

The Nominator should choose the Nomination Category that best fits the Nominee's most impactful contribution and available evidence. The Nominator should first identify the contributions of their Nominee that have the most impact, and then select the one or two contributions that have the strongest available supporting evidence. Then, the choice of the Nomination Category should be based on what type of evidence is being presented; see Section 11 and Table 1 for more details. We also point out that the Fellow Manual states that "*Contributions by practitioners in the application of engineering, science, and technology shall be accorded equal recognition with theoretical developments*" so that "theory" and "practice" are to be considered at the same level.

While the entire career of a person may not be pigeonholed into one Nomination Category only, it is indeed easier to associate the evidence presented in support of one or two impactful contributions to a specific Nomination Category. On the other hand, it is also true that many impact results do not arise from a single major contribution but from a series of contributions with intermediate results. In these cases, the Nominator should also explain how these series of contribution and intermediate results have culminated towards the main impact results.

If a Nominator is unsure about which category may fit best, it may be useful to find other members previously elevated in each category. This can be done by accessing the "IEEE Fellows Directory" on the http://www.ieee.org/fellows website. Entering a Nomination Category in the search field will return a list of Fellows elevated under that Nomination Category.

5.1 The Four Fellow Nomination Categories

All Nomination Categories contain a mix of Nominees from various employment affiliation types (the following four types are tracked in the Fellow application: Industry, Academia, Government, and Other). The relevant evidence to present depends on the chosen Nomination Category, not on the affiliation type of the Nominee – see Section 11 for more details. Thus, Nominees in any of the four employment affiliation types but nominated in the same Nomination Category are expected to present similar types of verifiable evidence and will be evaluated on the basis of such evidence.

In the following subsections, we briefly describe the existing Nomination Categories and mention typical types of contributions and expected evidence. Statistics are averaged over calendar years 2015-2019.

5.1.1 Application Engineer/Practitioner (AE/P)

This Nomination Category accounts for 7% of all nominations. The composition of AE/P Nominees in terms of employment affiliation types is approximately as follows: 74% are in industry, 16% in academia, 7% in the government, and 3% are other.

AE/P may make significant technical contributions in the design and/or evolution into manufacturing of products or systems, the use, operation, or application of such products or systems, and the advancement of industry practices and standards. Key aspects to consider are innovativeness, originality, creativity, meeting market needs, regional as well as global impact on the profession or society at large, and advances in quality, reliability, cost effectiveness, and manufacturability.

Typical documentation is in the form of patents, contributions to industry practices and standards (IEEE or other), reports, and papers. Although a few impactful papers authored by the Nominee may exist in some cases, the quantity of scholarly publications is not meaningful for this category and lack thereof does not penalize the Nominee.

Aspects to cover when writing the nomination:

- What product development, advancement in systems, application or operation, project management or implementation activity, process design or improvement, manufacturing innovation, contributions to normative codes or standards and their implementation, etc., in the areas of technology application were the direct result of the Nominee's individual contributions?
- If contributions were made as part of a group such as a Standards Committee or a company team, what is the critical individual role the Nominee played?
- What innovation and/or creativity have been demonstrated? What has been the importance of the implemented technology development, advancement, or application?
- What is the most important tangible and verifiable evidence of the Nominee's contributions including relevant significant technical publications (patents, reports, articles) and presentations?

Example: Mr. Andersson invented a procedure to identify and locate hot spots in a transformer winding insulation. Such hot spots often occur before transformer failure. The proposed procedure has been implemented by TransformerX Inc. in their transformer monitoring equipment and has been employed consequently by several leading utilities worldwide. It is estimated that this procedure has saved utilities over $500M by identifying transformers requiring maintenance before they failed.

Typical items useful as evidence of contribution are: patents, technical reports, standards contributions, contributions to products and software tools, journal and conference articles if any. Impact of contributions can be supported by: citations, patent licensing revenues, media reports, press releases, peer recognition (e.g., company awards, invited keynote, inventor's hall of fame, etc.), reference and endorsement statements supporting specific claims and the nominee's individual role.

5.1.2 Educator (EDU)

This Nomination Category accounts for nearly 4% of nominations. The composition of EDU Nominees in terms of employment affiliation types is approximately as follows: 97% are in Academia and around 3% in Industry.

A Nominee in this category must have had an impact on engineering education. As an Educator, the Nominee's personal contributions can encompass the development of a new curriculum or courses that are innovative or unique. An accepted and widely used pioneering text is a significant useful contribution, as also published papers on engineering education matters. Publication of papers in the IEEE Transactions on Education or in other journals dedicated to engineering education and pedagogy constitute relevant evidence, but publications unrelated to the advancement of engineering education are to be considered of lesser importance. The contributions, again, will be judged based on uniqueness, innovation, wide acceptance, etc. Another important aspect to consider is the degree of acceptance (local, national, international) of such innovations. Note that it is not sufficient to have taught for many years or held an administrative role to qualify for Fellow elevation under this Nomination Category.

Aspects to cover when writing the nomination:

- What impact has the Nominee's contribution had on education in the field of interest of the IEEE?
- What unique and innovative curricula or courses has the Nominee personally developed that have influenced teaching outside the Nominee's home institution? What innovative and unique contributions has the Nominee made to engineering education as an administrator?
- Has the Nominee written a pioneering text in his/her areas of professional specialization?

Example: Prof. Balewa has developed a comprehensive undergraduate curriculum on Digital Signal Processing applications. It includes a set of courses based on his textbook "Fundamentals of Digital Signal Processing" accompanied by a series of laboratory exercises, Matlab routines, and demonstrations. His courses have been a crucial factor in doubling enrollments to the electrical engineering program at his university during the last decade. His book and curriculum have been adopted by several universities in the Nominee's country and globally.

Typical items useful as evidence of contribution are: books, journal and conference articles on engineering education, development and accreditation of new academic courses. Impact of contributions can be supported by: citations, degree of acceptance beyond own institution, peer recognition (e.g., education awards), reference and endorsement statements supporting specific claims and the nominee's individual role.

5.1.3 Research Engineer/Scientist (RE/S)

This Nomination Category accounts for nearly 80% of all nominations. The composition of RE/S Nominees in terms of employment affiliation types is approximately as follows: 80% are in Academia, 13% in Industry, 5% in Government, and 1% in Other.

For RE/S Nominees, sustained scholarly work is typically documented by significant (quality and quantity) scholarly contributions such as peer-reviewed publications, books, papers in technical reports, patents, or other publications. The focus of the evaluation is on inventions, discoveries, or advances in the state of the art made by the Nominee, all of which must confirm innovation, creativity, impact, and a distinct personal role of the Nominee.

Aspects to cover when writing the nomination:

- What inventions, discoveries or advances have been made by the Nominee in the state-of-the-art of the science and/or technology? How do they demonstrate innovation and creativity? What is the importance of the research results and impact of the contributions in advancing the state of the industry or technology? Have they had a substantial influence on the subsequent research literature? Have they found applications in the industry or been implemented in products or systems? Have they been commercialized or used by other organizations?

- What patents, reports, refereed journal papers, research monographs, commercial software packages and other tangible and verifiable evidence have resulted from the Nominee's R&D accomplishments?

Example: Dr. Chen was the first person to develop an algorithm for real-time state estimation for power transmission systems. Her 1990 paper on the topic has been cited over 200 times in the past 25 years and is recognized as one of the seminal articles in this area. Her algorithm has been integrated into several commercial energy management system software packages, including EnSaver and MyEnergy.

Typical items useful as evidence of contribution are: journal and conference articles, patents, technical reports, standards contributions, contributions to products and software tools. Impact of contributions can be supported by: citations, patent licensing revenues, media reports, press releases, peer recognition (e.g., company awards, invited keynote, inventor's hall of fame, best paper awards, invited papers, etc.), reference and endorsement statements supporting specific claims and the nominee's individual role.

5.1.4 Technical Leader (TL)

This Nomination Category accounts for around 10% of all nominations. The composition of TL Nominees in terms of employment affiliation types is approximately as follows: 51% are in the Industry, 28% in Academia, 17% in Government, and 4% in Other.

The individual contributions of TL Nominees can be exemplified through technical leadership of a team or company-wide effort that led to an important benefit to society, technical innovation, advancement of a device, and also idea or system leading to development, application and/or production. The technical innovation, risk involved, performance improvement, economic results, or other advantages must be above the norm. For TL Nominees, their leadership and technical role must be crucial for the successes of the cited accomplishments, and specific technical contributions by the Nominee which made the achievement possible must be present and supported by verifiable evidence.

As is the case for the AE/P category, having scholarly publications is not necessary for this Nomination Category and lack of publications does not penalize the Nominee.

A TL is neither a bureaucrat nor a project manager, so organizational positions alone cannot be used as sole evidence of accomplishments. Fellow elevation does not recognize members who had a successful career as a manager, executive or administrator unless extraordinary individual technical or educational accomplishments were made. Many awards and recognitions are available to recognize this very important segment of IEEE members.

Aspects to cover when writing the nomination:

- What outstanding engineering system implementation, application or scientific accomplishments have resulted from a team or company-wide effort led by the Nominee?
- What technical innovations, business and financial benefits and other advantages have been achieved?
- What technological and other challenges and problems, e.g., market acceptability, implementation difficulties, and financial risks have been faced and resolved?
- What were the crucial technical contributions and technological innovations provided by the Nominee?

Example: Mr. Das served as Chief Technology Officer for PowerNow Inc. from 2002-2009. During his time with the company, Mr. Das led the efforts to enable power distribution automation in over 500 substations in Southeast USA using the technology he had co-invented, developed, and patented with his PowerNow team. It has been confirmed that these upgrades significantly decreased the number and duration of the losses of power for customers in Georgia during Hurricane Katrina. Since 2009, Mr. Das has served as a consultant to several utilities to modernize their distribution systems. He currently serves as the chair of the PES substations committee and spearheaded the development of the standard C57-12.92-2010.

Typical items useful as evidence of contribution are: specific project/role to make case for leadership, patents, technical reports, standards contributions, contributions to products and software tools, journal and conference articles if any. Impact of contributions can be supported by: Citations, patent licensing revenues, media reports, press releases, peer recognition (e.g., company awards, invited keynote, inventor's hall of fame, etc.), reference and endorsement statements supporting specific claims and the nominee's individual role.

6. The Choice of the Evaluating S/TC (Section 6.b of the Nomination Form)

All Nominees must undergo an evaluation by a S/TC Fellow Evaluating Committee (FEC) before being evaluated by the IEEE Fellow Committee, regardless of whether the Nominee is a member of any Society or not. The Nominator should choose the Society or Technical Council whose fields of interest best match the Nominee's contributions and can provide to the IEEE Fellow Committee an independent, objective, and informed assessment of the importance and impact of the Nominee's contributions.

A Nominee may belong to several Societies, in which case it is recommended to select the *Society* that most closely aligns with the specific contributions listed in the nomination. Indeed, it is often the case that a more thorough evaluation can be provided by an FEC that is familiar with the Nominee's technical field and accomplishments. In the case in which Nominee's contributions are interdisciplinary and do not fall within the fields of interest of any single IEEE Societies, then a Technical Council may be selected as the evaluating body.

Note that the ranking and numerical score provided by the S/TC Fellow Evaluating Committee to the IEEE Fellow Committee is for informative purposes only and is not necessarily reflected in the final elevation recommendation made by the IEEE Fellow Committee to the Board of Directors.

7. The Choice of the Individual Contributions and Their Evidence

The Nominator must describe in this section the one or two most distinctive contribution(s) made by the Nominee. This should include a brief description of what the Nominee has invented, created, or discovered and the lasting impact of the contribution. Note that impact must have already occurred, and speculation on the Nominee's possible future impact is not helpful to strengthening the Nominee's case. Also note that elevation is based on comparing and ranking Nominees on the basis of specific one or two impactful contributions, not on their body of work. Being a prolific and well-cited author is not enough for elevation.

7.1 Technical or Educational Contributions (Sections 7.a/8.a of the Nomination Form)

A review of typical technical or educational contributions used in Fellow Nominations has been mentioned in Section 5.1 and its subsections. All Nominees must have had an individual and critical role in the development of the stated contributions.

Typical examples of technical contributions include but are not limited to inventions, discoveries, advances in the state of the art, improvements to the design and/or evolution into manufacturing of products or systems, the use, operation, or application of such products or systems, their implementation, and the advancement of industry practices and standards (IEEE or not).

Typical contributions to education in the fields of interest of IEEE include but are not limited to the development of a new curriculum or courses that are innovative or unique or accredited officially for the first time, authoring a widely used pioneering textbook, published books or papers on education and pedagogy or also in the popular press.

In describing the Nominee's contributions, Nominators should avoid jargon, define all acronyms, and briefly explain the state of the art before the Nominee's contribution, as some IEEE Judges may not be specialists in the same field of the Nominee. It is important to clearly describe the contribution in a way that any Judge can understand and appreciate. Overly specific descriptions with highly technical narratives hinder the ability of Judges to place the Nominee's contributions in context with other Nominations referred to other Societies.

As stated earlier, the availability of verifiable evidence of impact is critical for a successful nomination. Since impact often takes time to occur, it may take several years to ascertain the full weight of a contribution. Since impact must have already occurred and speculation on the Nominee's possible future impact is not helpful to strengthening the Nominee's case, it is strongly recommended that the Nominator chooses contributions that are not too recent and are corroborated by strong verifiable evidence of impact.

7.2 Verifiable Evidence of Technical Contribution (Sections 7.b/8.b of the Nomination Form)

The main goal of this Section of the form is to provide verifiable evidence that (a) establishes that the Nominee has indeed made the claimed contributions and had a critical individual role in its development; (b) confirms when the contributions were made; and (c) explains the evolutionary process that led to those important contributions. Demonstrating the actual impact of the claimed contributions is not to be argued here, but in Sections 7.d and 8.d of the form (Section 8 of this Guide).

Items of verifiable evidence should constitute *specific evidence* that the contributions claimed in the nomination were made by the Nominee. Providing a verifiable date for when the item of evidence was produced is also very important, especially when claiming that the Nominee was the first to discover/implement/propose something that later had great impact. The Nominator's choice of these items serves to focus the reader's attention to the most important pieces of evidence supporting the Nominee's individual role in the development of the claimed technical contributions.

A specific number of evidence items is not required anymore, but a simple listing of items is neither sufficient nor enlightening. Nominators are encouraged to provide a narrative describing the importance of each item in supporting the technical contribution and its impact and how the items form a cohesive story of the Nominee's prowess. An item of evidence may be (but is not limited to) a journal or conference article, a book, patent, report, standard, policy, product, service, press release, product, tools, software, demonstration, installation, etc. All presented items should refer directly to the Nominee's distinctive contributions as noted in Section 7.a/8.a of the Nomination Form. Table 1 lists appropriate types of evidence for each of the Nomination Categories. For all Nomination Categories, Nominators should consider using Endorsements for providing additional evidence and confirmation of the impact of the Nominee's contributions – see Section 14 of this Guide for more details. Endorsements are particularly useful to AE/P nominees that may have not have strong verifiable evidence of impact. For example, if the contribution has had significant financial savings, safety improvements, or initiated a new product line (as examples), an appropriate Endorser can provide verification of the claims made in the nomination narrative. This table is not intended to be prescriptive in nature, but is to be used as a guideline for selecting items of evidence that are well-suited for the category of nomination.

Table 1. Types of evidence of contribution and impact.

Nom. Category	Types of Technical/Educational Contributions				Types of Evidence of Impact (Examples)	
	Scholarly Publications (Books, articles, conferences, etc., except tutorials/surveys)	**Non-Scholarly Books & Technical/Educational Documents**	**Patents**	**Standardization Work**	**Types of Evidence of Impact (Nomination Category Specific)**	**Types of Evidence of Impact of Stated Contributions (Common)**
AE/P	Impactful published application-based papers are helpful but not required. Note that lack of scholarly work **does not penalize** the Nominee.	Examples: tutorials, survey papers, position papers, white papers, articles in popular press, internal reports, books about practice in the field, and other documents describing the development/application of products, systems, facilities, services or software, etc.	Any type of document protecting Intellectual Property.	Any type of publicly available standard contribution. **Note:** It is essential to **articulate the individual role in the contributions** claimed for the nominee vis-à-vis those of colleagues in same company and Working Group.	Endorsements/References attesting to: - The individual role of the nominee in the team/initiative (if any); - The level of adoption of the technical contribution; - The financial impact of the technical contribution, e.g., generated revenues or costs reduction, etc. - The societal impact of the technical contribution.	**Scholarly papers (not tutorials/surveys)** a) Citations in scholarly literature; b) Citations in standards and patents, etc. **Books/Papers/Documents/Textbooks** (a) Citations in the literature; (b) Citations in standards and patents, etc. (c) Evidence of impact at local/national/international level. **Products, systems, facilities, services or software** a) Level of adoption (company-wide, national, international); b) Generated revenues or cost reductions; c) Advances in quality, reliability, efficiency, safety, growth, profitability, adoption, cost effectiveness, manufacturability, etc. **Patents:** a) Citations; b) Importance of Standards; c) Part of patent pools; d) Generated revenues from licensing, etc. **Standards:** a) Major contributor to a standard, family and/or generations of standards, etc. b) Leadership in creating a framework, architecture, design or building technical consensus for a standard, family and/or generation of standards. **Peer Recognition** a) Awards and recognitions (e.g., best paper; technical excellence; IEEE or other professional awards; election to technical leadership positions in standards working groups, technical committees or technical initiatives; induction to Inventor's Hall of Fame; engineering academy prizes; company awards; etc.) b) Invited papers, keynotes, etc. **Note:** Endorsers/References can strengthen and corroborate nominator's claims on impact and individual role of Nominee, technical leadership and influence on standardization, etc.
EDU	Examples: widely used pioneering texts, papers on engineering education, especially when published in journals dedicated to engineering education and pedagogy; highly subscribed MOOC courses, etc. Note that **publications unrelated to** the advancement of **education** in the fields of interest of IEEE **are of lesser importance.**	Examples: tutorials, survey papers, position papers, white papers, articles in popular press, and other documents describing innovative courses. Note that **documents unrelated to** the advancement of **education** in the fields of interest of IEEE **are of lesser importance.**	Any type of document protecting Intellectual Property, including Copyrights of textbooks.	Any type of publicly available standard contribution. **Note**: It is essential to **articulate the individual role in the contributions** claimed for the nominee vis-à-vis those of colleagues in same company and Working Group.	Level of adoption of textbooks, highly subscribed MOOC courses, highly subscribed/downloaded TED presentations, Level of outreach to underrepresented populations and/or regions, etc.	
RE/S	Examples: Scholarly cited articles, refereed papers in archival journals (preferably not survey papers), edited or authored books, papers in technical reports or other publications, etc.	Examples: tutorials, survey papers, position papers, white papers, articles in popular press, internal reports, etc.	Any type of document protecting Intellectual Property, including Copyrights of textbooks.	Any type of publicly available standard contribution. **Note**: It is essential to **articulate the individual role in the contributions** claimed for the nominee vis-à-vis those of colleagues in same company and Working Group.	Role of nominee in articles authorship, impact on literature (article citations), impact on technology (patent citations), impact on standards (standards citations), Impact on standards (contribution and/or reference of research results to standards), Impact on society at large (articles in popular press), etc.	
TL	Impactful published application-based papers are helpful but not required. Note that lack of scholarly work **does not penalize** the Nominee.	Examples: position papers, white papers, articles in popular press, tutorials, survey papesr, internal reports, books about practice in the field, and other documents describing advancement of a product, service, idea or system leading to development, application and/or production, etc. Note that the specific technical contributions by the nominee must be present and supported by verifiable evidence.	Any type of document protecting Intellectual Property.	Any type of publicly available standard contribution. **Note:** It is essential to **articulate the individual role in the contributions** claimed for the nominee vis-à-vis those of colleagues in same company and Working Group.	Endorsement/References attesting to: - The **role** of the nominee in the technical **leadership** of a team, company or industry-wide effort. - The **technical** contribution or innovation, technical risk, performance improvement, socio-economic benefits, or other relevant aspects; - The level of adoption of the technical contribution - The financial impact of the technical contribution, e.g., generated revenues, reduced costs, etc. - The level and/or extent of deployment of conforming products and services.	

8. Impact of Contributions and Their Verifiable Evidence

8.1 Impact of contribution (Sections 7.c/8.c of the Nomination Form)

The main goal of this Section of the form is to argue the importance and long lasting impact of the Nominee's contributions listed in Sections 7.a/8.a on the field (theory and practice), industrial ecosystem, engineering practice, engineering education, and society at large. Note that the task of providing the actual verifiable evidence to support the stated impact is left for Sections 7.d/8.d.

A contribution's impact is measured by the amount it has extended the boundaries of the current state of technology. Impact can be assessed by quantifying improvements in understanding, process, cost, reliability, safety, size, etc., and whether or not the contribution has been implemented in practice and with what success in terms of performance, popular usage, and degree of acceptance.

It is important that the Nominator writes this Section keeping in mind that Nominees are evaluated by Judges who may not be experts in the specific area of the Nominee's contributions. This requires attention to describe the contribution and impact in a way that any Judge can understand and appreciate. Overly detailed descriptions with highly technical narratives hinder the ability of Judges to place the Nominee's contributions in context with other Nominations who contributed to other fields.

8.2 Verifiable Evidence of Impact (Section 7.d/8.d of the Nomination Form)

The main goal of this Section of the form is to provide verifiable evidence to support the claims of impact made in Sections 7.c/8.c of the Form. The guidelines for evidence in this section are similar to the ones for items of evidence for technical contribution and of course depend on the specific contributions listed in Section 7.a/8.a of the Nomination form.

One effective approach is to choose evidence that documents a timeline of the evolution of the Nominee's contribution to the field. Similarly, items that provide a summative narrative or show how the contributions have been used outside of being merely cited by other authors are also effective. Verifiable items of evidence that can confirm how the Nominee's contributions have improved a device/process/control by making it faster/smaller/more efficient/cheaper/safer can show impact.

Sound evidence should provide an overview of how the contribution was initially introduced to the field, further technological developments, and adoption by the field at large. If possible, include links to products, tools, or online software which are based on or reference the Nominee's work. Online software download counts may indicate the breadth of usage. Items that are not in the archival literature can also be entered here, for example links to newspaper articles and company press releases. Contribution impact can pertain to a single item of evidence or can be based on the culmination of related evidence items. A high citation count for a paper is not necessarily indicative of high impact.

9. Awards (Section 9 of the Nomination Form)

Awards and prizes that the Nominee has won should be listed in this section, but priority should be given to those awards that are directly related to the contributions that are listed in Sections 7 and 8 of the Nomination form.

Two categories only are provided:

a) IEEE Awards
b) Non-IEEE Awards

The second category may include some forms of peer recognitions such as recognitions from a company or association, honorary degrees, academic awards for teaching and education, Fellowship in other organizations (e.g., OSA, ACM), induction in national academies, etc.

10. IEEE and Non-IEEE Activities (Section 10 of the Nomination Form)

Nominators should use this section to document the professional activities that the Nominee has undertaken over her or his career for IEEE and other professional organizations. Lack of IEEE activities does not disqualify a Nominee from consideration for IEEE Fellow elevation; indeed, every year Nominees who have not been active volunteers in IEEE are elevated.

Two categories only are provided:

a) IEEE Activities
b) Non-IEEE Activities

IEEE Activities include volunteering at the Institute, Society, Region, Section, Chapter level committee leadership roles, distinguished lecturer engagements, participation in IEEE editorial boards, IEEE Standards development, IEEE conference organization, etc. Roles such as conference chairs, TPC chairs, and steering committee membership should be emphasized relative to program committee memberships.

Relevant Non-IEEE Activities should be limited to roles within the technical and educational community at large, such as editorial roles, conference leadership roles, mentoring programs, etc.

11. A Review of Items of Evidence and Their Best Usage

11.1 Publications

If articles are used as evidence, it may be helpful to include citation indices as well, preferably from a source such as Scopus. Provide clear information on the *personal* publication contributions of the Nominee, particularly when joint work with co-authors, collaborative teams, standards committees, supervised post-graduates, etc., is involved. This may take the form of a sentence or two following each item, describing the Nominee's personal contribution into the identified accomplishments, and how it supports the narrative in the "Individual Contributions" section. This is particularly important because not all IEEE communities use the same convention regarding the order of authors' names.

If scholarly papers are used as items of evidence, it is perfectly legitimate to consider bibliometric indices as a means to assess impact; however, Evaluators and Judges do not use citations as the only means to assess impact. Although Nominators often stop at using citations only, other types of impact can be more powerful than citations: impact on technology or practice, inclusion in standards, impact on products, or impact on society at large. In addition to citation numbers, it is useful to include a narrative on how the contribution described in the article has changed the state of the art. Evaluators and Judges are also aware that citation counts for highly influential articles differ across technical areas, that a survey paper may have many more citations than a research contribution that has been more influential, and that "practical" papers tend to be less cited than theoretical ones. If possible, Nominators are encouraged to place the citation metrics in context with the technical field by citing publication citation or download statistics for a particular journal for reference.

A frequently made mistake by Nominators is to list items that are too recent (this is also relevant to patents and other types of evidence) often making it difficult to demonstrate that the contributions have had a lasting societal impact (which typically would require a relatively extended period of time, sometimes a decade or even more).

Tutorial papers are often highly cited, but cannot by themselves serve as confirmation of impact of technical contributions. However, they can be sometimes helpful to document the Nominee's maturity, especially if the paper is invited.

As mentioned in Section 5.1, AE/P and TL Nominees are not required to have scholarly publications and are not penalized for not having them. Nevertheless, many AE/P and TL nominations often use papers as items of evidence. In this case, lowly-cited papers can be used as evidence of contribution (Sections 7.b/8.b) but the Nominator must still provide verifiable evidence of impact (Sections 7.d/8.d). If the citation count of a paper (or patent) is objectively low, the Nominator should elaborate and provide verifiable evidence on other types of impact, e.g., inclusion in standards, licensing revenues, implementation in successful products, etc. Effective endorsements by the appropriate persons are key to strengthen these cases.

11.2 Patents

If the Nominee has relevant issued patents, a list of patents and/or patent applications as maintained on the U.S. Patent and Trademark Office, the European Patent Office [Espacenet], or another national patent office can be included. The Nominator should clarify:

- Whether the patent is classified as Design or Utility patent (US patents only). Utility patents typically describe functional use either by structure, method, or a combined set of these type claims. Design patents typically are ornamental, lacking functional components. An explanation of why a Design patent is included as evidence is highly recommended
- Which patent claims (independent or dependent) were contributed solely by the Nominee, in the case there is more than one inventor associated with a patent?

A summary statement describing the expected use or sale of patent IP should accompany each patent cited as evidence. General questions the Nominator should address are:

- Has the patent been sold or licensed to a third party for use? If yes, what revenues is it generating?
- Is the patent important for the assignee to remain on the cutting edge of the technology area being described? If yes, please explain the competitive edge the patent describes.
- Has the patent initiated new business for the assignee? If yes, please describe the new business venture in terms of how it is benefitting the assignee and the society at large.
- Has the inventor published a refereed technical publication in addition to the patent? If yes, please specify where the publication has appeared.
- Has the patent been often cited?
- Has the patent been deemed essential to products or standards?
- What is the specific contribution of the Nominee to the patent?
- Has this patent subsequently created a new family of IP? If yes, a brief summary of the family or families created would be provided and/or supported by a Reference or Endorser. *Example:* In 2008, the Nominee issued a US patent describing vertical semiconductor devices. The Nominee was responsible for the structure (encompassing Claims 1-10) while others cited in this patent were responsible for the method of fabrication, as also confirmed in the Endorsement provided by Ms. Smith. Presently there are an additional 350 US and EU patents referencing the 2008 patent and further improving upon the structure originally claimed in 2008. These vertical devices are today integrated in every semiconductor manufacturer, as confirmed in the Reference letter provided by Prof. Xiao.

Note that Endorsement and References that speak directly to the contribution are the most helpful; letters that restate information found in the narrative or use general supportive statements are less helpful.

11.3 Standards

Impact on standardization can be achieved in many ways: submitting influential contributions that were included in the issued Standard (especially if supporting mandatory features); led technical discussions and drove the Working Group to consensus; writing an influential paper containing findings that were adopted in a popular standard; an inventor whose forward-looking patents became later essential to popular standards. As Standards are the work-product of a group of people (not only those attending the standards meeting, but also those supporting their colleagues from the office), it is very important to demonstrate the individual role the Nominee had in the development of the standard.

11.4 Products

It is often difficult to provide evidence of impact of products and what to use varies widely depending on the type of product. Impact of products can be measured by popular usage, mentions in press releases, level of innovation versus state of the art, revenue stream generation, etc. The right Endorser could clarify these aspects, including shedding light on the individual role of the Nominee.

11.5 The value of peer recognition

Peer recognition can take many forms: awards and recognitions (technical, best paper, company recognitions, induction in national academies, inventor's hall of fame, etc.), invited keynotes, honorary degrees, invited papers, etc. Also notoriety in the popular press can be indicative of having had impact on a field, e.g. appearing in TV to discuss technology, being mentioned in newspapers articles, etc.

Peer recognition can sometimes help with the assessment of the impact of contributions, especially when they are directly related to the contributions listed in Sections 7.a/8.a of the form.

11.6 The case of contributions made on proprietary or classified technologies

Some Nominees have spent their career in the labs of defense contractors working on classified projects, or for companies which have preferred keeping their technologies as trade secrets and thus have forbidden publishing or patenting them. It is certainly true that for those Fellow Nominees whose careers have not enabled many of their contributions to be published in the open literature or made available publicly via some other means, it can be a difficult task not only to find enough Fellows to write References, but also to find sufficient evidence to document their impact on the field. In these cases, Endorsements can be especially helpful here as they allow providing additional evidence of technical impact.

Unfortunately, in some cases sufficient *verifiable* evidence of contributions and their impact cannot be provided. In these cases, it will be extremely difficult to make a case for elevating the Nominee, since the Fellow recognition depends critically on verifiable evidence of contribution and impact.

12. Guidelines for the proposed citation (Section 11 of the Nomination Form)

The citation must begin with "*for*" and not include any indication of a time period. The citation should be specific, but not too wordy (15 words at most). It should be concise, but broad enough to encompass the Nominee's contributions. For more details, see Section 14 of the Fellow Committee Handbook.

The IEEE Fellow Committee may alter the citation suggested by the Nominator, if needed.

Examples:

- For contributions to real-time state estimation for nonlinear systems (good).
- For contributions to the development of iterative recursive algorithms used for real-time state estimation in EMS systems (too wordy).

13. References (Section 12 of the Nomination Form)

The Nominator must secure at least three, but no more than five, References from IEEE Fellows who are able to assess the Nominee's contributions and their impact. References for Nominees in IEEE Region 9 may also be submitted by Senior Members that reside in Region 9. For Nominees in all other Regions, all References must be Fellows.

References are chosen by the Nominator to advocate for the Nominee and provide information about the value and impact of the Nominee's contributions. Thus, the References should be experts in the specific field of the Nominee's contributions. The Nominator should communicate in advance with each potential Reference to ascertain their familiarity with the contribution of the Nominee. While being familiar with the Nominee's contributions and impact is key, it is not necessary that References know the Nominee personally.

A good practice for the Nominator to follow is to choose References that are not affiliated with the Nominee but know and understand the Nominee's work. These References strengthen the nomination as they provide an independent opinion and verification.

It is often the case that References comment on the body of work of a Nominee, and this is not very useful. References should focus on the specific contributions listed in the nomination rather than on the career of the Nominee and provide specific examples of how the Nominee's contributions have impacted the technical field, the industry, research at other institutions, or resulted in new practices, products or standards.

The Nominator should encourage References to make specific statements with respect to their personal knowledge rather than blanket statements regarding contribution and impact. Furthermore Nominators should request that References follow the recommendations of the IEEE Fellow Committee Recommendation Guide on "Effective References and Endorsements."

14. Endorsements (Section 13 of the Nomination Form)

Anyone can submit Endorsements, regardless of IEEE membership or grade. The Endorsements are optional, and a maximum of three may be submitted. An Endorsement strengthens the nomination only when it supplements the Nomination Form with specific evidence about the Nominee's achievements and their impact on the profession or society and does not merely reiterate items in the nomination. Endorsements allow the presentation of additional evidence of technical impact for contributions that may have been proprietary at the time they were developed or not available for citation in the open literature.

Endorsements can be very helpful, particularly to those Nominees who have been nominated in the AE/P and TL categories – which include not only members from industry but also a substantial number of academics. They can also be very useful to support RE/S nominations when the Nominee performed proprietary or classified work for which there is little availability of public evidence, and to support EDU nominations, for example to attest to broad adoption of a textbook or educational leadership. In these cases, Endorsements are most effective when from a company officer, program director, committee chair for a technical community or standards body, or a colleague, and, more generally, anyone who can attest and verify the Nominator's claims on the impact and individual role of the Nominee.

The Nominator should encourage Endorsers to make specific statements with respect to their personal knowledge rather than blanket statements regarding contribution and impact, specifically verifying claims made in the narrative that cannot be confirmed elsewhere. Furthermore Nominators should request that References follow the recommendations of the IEEE Fellow Committee Recommendation Guide on "Effective References and Endorsements."

15. Things to avoid

15.1 Nomination

- Do not base a nomination on a body of work, rather focus the narrative on not more than two areas of impact.
- Do not provide items of evidence that do not directly support the areas of impact. Pieces of evidence that cannot be correlated with one of the impact areas are superfluous. For example, a paper that has many citations may not be relevant if it does not support the identified area of impact.
- Do not submit a nomination too early. Carefully consider when might be the right time to prepare a nomination, taking into account the Nominee's career progression and achieved accomplishments. Allow time for the Nominee's impact to be recognized and adopted as well as for the technical accomplishments to be implemented and utilized.
- Do not use the Education category unless the Nominee has been truly focused on improving technical and engineering education and achieved tangible significant results in the field. Being a good teacher or academic administrator does not constitute sufficient grounds for IEEE Fellow elevation.
- Do not use the Technical Leader category unless the Nominee contributed with creativity and technical innovation to resolving the challenges of the project, and both his/her leadership and technical role were crucial to the success of the project. A Technical Leader is not solely a manager, even if a successful one. Thus, organizational positions alone cannot be used as sole evidence of accomplishments.
- Large projects or research contracts awarded to the Nominee are not evidence of impact. Only the scientific, technical, or educational outcomes may be considered contributions. Similarly, general awards and recognitions are not items of impact unless they specifically pertain to the cited contribution.

15.2 References

- References are highly valued when provided by experts in the *specific* field of the Nominee's contributions, so do not choose the most famous References in the field if they do not know the Nominee's work and are not able to address the Nominee's specific accomplishments.
- Do not choose References from only one region of the world.
- Do not choose too many References from a single affiliation or all from the same company.
- Do not choose only References who have collaborated with the Nominee.

15.3 Endorsements

- Do not misuse Endorsements by using them as pseudo-References.
- Do not forget that Endorsements have a specific role: to strengthen the Nominee's contributions in those instances for which verifiable evidence is not available (as in the case of proprietary or classified work), or to provide additional information directly supporting the technical accomplishments or their impact as well as professional contributions that may be missed in the nomination.
- Do not have all Endorsement Forms from a single organization or institution.

16. Further Reading

For further details on the normative requirements for the IEEE Fellow nomination and evaluations process as well as the eligibility requirements of all the participants in the IEEE Fellow process, please see the IEEE Fellow Committee governing documents and Recommendation Guides posted at http://www.ieee.org/fellows. Also, please note that this Recommendation Guide does not replace the Help Guide for using the Fellow nomination web application.

The fellow evaluation process has never been as transparent as today and IEEE members have at their disposal several resources:

1. All Fellow principles are clearly specified in the Fellow Operations Manual. Nominators should start by reading section 17 of the manual and then move to the Fellow Guides.
2. All forms currently in use are specified in the Fellow Nomination and Evaluation Forms.
3. Additional details on how the IEEE and S/TC Fellow Committees operate are specified in two Fellow Handbooks:
   a. The Fellow Committee Handbook
   b. The Society/Technical Council Fellow Evaluating Committee Handbook
4. Three Fellow Guides have been Issued:
   a. How to Write an Effective Nomination
   b. Effective References and Endorsements
   c. S/TC-FEC Evaluators and IEEE Judges. Note that, although this Guide is intended for Evaluators and Judges, it can also be helpful to Nominators as it explains how evaluations are made and what evaluators and judges look for.

17. Annex – Nomination Examples

The following subsections provides an example of a nomination in each of the nomination categories. These are based on actual IEEE Fellows. These are only intended as guideline examples; a nomination that is written differently or with different types of contributions and evidence may also be successful.

17.1 Examples of Technical Leader Nomination

17.1.1 Example A of Technical Leader Nomination

7.a. Identify the first individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).

Steve Wozniak was the inventor of the Apple I computer, and along with Steve Jobs, founded the Apple Computer Company in 1976 to manufacture the Apple I computer. Along with the Apple II computer, which Steve also designed, these computers were the first broadly available personal computers. Many of the elements now common to all personal computers were first demonstrated in the Apple I and II computers. The Apple I, Apple II, and the Apple Macintosh computers are designated IEEE Engineering Milestones for their pioneering contributions to computing.

Steve designed several novel technical features in the Apple I. He structured it as a video terminal with a built-in monitor program. This was a major usability improvement compared to other front panel oriented PCs of the time. This was the first computer to use DRAMs (4KB). With the Apple II, Steve extended the video design to include color and designed the Sweet16 firmware subsystem to emulate 16-bit processors, which enabled the digital board to handle 48 KB of DRAM. He then designed a backplane bus for IO expansion which included reserved memory areas for IO devices and BIOS ROM extensions for the first “plug and play” functionality of the era.

7.b. Verifiable Evidence of contribution (maximum 400 words):

1) US Patent No. 4,136,359, Stephen Wozniak, issued Jan. 23, 1979: Microcomputer For Use with Video Display.

2) US Patent No. 4,210,959, Stephen Wozniak, issued Jul. 1, 1980: Controller for magnetic disc, recorder, or the like

The features essential for a personal computer were first encompassed by the Apple I and designed by Steve Wozniak. The Apple I defined the elements of a personal computer, thus making it affordable and useful for “normal” people. The cost reductions that made this possible were 1) an integrated and fully assembled working computer circuit board based on the powerful 1-MHz 6,502 microprocessor, 2) state-of-the-art but low-cost DRAM, 3) the clever sharing of components, 4) the use of a typewriter-style keyboard to replace the front panel, and 5) NTSC output to an owner’s existing TV. The Apple I was thus able to realize the goal of a low-cost, easy-to-use personal computer a fully-assembled circuit board with dynamic RAM, video interface, keyboard, mass storage, operating system and a high-level programming language. This affordable computer platform triggered a software industry that grew as the sophistication of these essential features grew, and the Apple I thus helped launch the personal computer revolution.

3) US Patent No. 4,217,604, Stephen Wozniak, received Aug. 12, 1980: Apparatus for digitally controlling PAL color display

4) US Patent No. 4,278,972, Stephen Wozniak, received Jul. 14, 1981: Digitally-controlled color signal generation means for use with display

The Apple II was the first low-cost computer to offer quick start-up, pre-addressed standard expansion slots, processor RAM-based bit-mapped NTSC color graphics and random-access storage in a compact package and was designed by Steve Wozniak, except for the computer case and switching power supply. Combined with a BASIC interpreter and assembler in ROM, gaming and graphics features, and an economy of design, this device spurred software and hardware suppliers to help create the worldwide personal computing industry. From its introduction in 1977 to the final production of the Apple II computer in 1993, 5-6 million Apple II computers were sold. The Apple II computer series was one of the longest running personal computer products (17 years).

7.c. Impact of contribution (maximum 200 words):

Prior to the Apple I, hobbyist computers were sold as kits that included components from different companies. Early hobby computers were programmed with front-mounted toggle switches, and indicator lights on the front panel provided output. Separate hardware was required to allow connection to a computer terminal. The Apple I computer was the first product that was sold as a single assembled piece of computer hardware that could be easily used in the home and that was marketed as a personal computer. Unlike earlier hobbyist computers, the Apple I was sold as a fully assembled circuit board containing more than 60 chips.

The Apple II computer was the first broadly successful personal computer, and it helped to create the personal computer industry and future generations of microcomputer-based consumer electronic products. Unlike its predecessors, the Apple II was a complete system: it consisted of built-in input (keyboard, cassette interface, and game paddles), built-in output (color graphics, sound, and cassette interface), and built-in software that executed out of ROM (monitor, BASIC interpreter, and mini-assembler). All of these components were included in a small, portable case that was usable with a standard color television set, and was additionally easily and inexpensively expandable.

7.d. Verifiable Evidence of Impact (maximum 200 words):

Today, Apple Computer, the company that Steve Wozniak and Steve Jobs founded in 1976 is one of the largest companies in the world. It has grown from its humble Apple I beginnings to a multinational technology company that designs, develops, and sells consumer electronics, computer software, and online services. It is considered one of the Big Tech technology companies. Its worldwide annual revenue totaled $265 billion for the 2018 fiscal year (see Endorsement by MM). As of January 2020, more than 1.5 billion Apple products are actively in use worldwide.

The impact of Apple and its founders on the personal computer industry has been commemorated in numerous recent books including:

1) Revolution in the Valley, Andy Herztfeld, O'Reilly Media, October 2011.

2) Fire in the Valley: The Birth and Death of the Personal Computer, Michael Swaine and Paul Freiberger, 3rd Edition, Pragmatic Bookshelf, October 2014.

3) The First Apple, Bob Luther, MassMedia mobi, August 2013.

17.1.2 Example B of Technical Leader Nomination

7.a. Identify the first individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).

Jim McDowall has made significant and lasting contributions in the development of standards for stationary batteries and grid energy storage systems. In the 1990s, he determined that the standard method of battery testing was causing premature replacement of batteries used in short-duration applications. Jim identified errors in current standards regarding battery testing procedures. These standards, which were developed when batteries were used primarily as back-up for power plants, were not sufficient for estimating battery lifetimes when batteries were being used in cycling applications. He was the first to establish that the "IEEE testing method ignores the changing efficiency of the battery at different discharge times." This is a critical observation and affected IEEE Standards 450 (lead-acid) and 1106 (Ni-Cd). Despite widespread resistance to change, he spearheaded new test procedures that led to a major revision of IEEE Std 450 in 2002, and subsequently of IEEE Std 1106 and IEEE Std 1184. This new procedure specified in all three standards is now globally accepted as standard practice. He served as chair/vice chair of nine IEEE Working Groups, as Chair of the IEEE PES Stationary Battery Committee for 6 years, and as Standards Coordinator for 9 years.

7.b. Verifiable Evidence of contribution (maximum 400 words):

Jim McDowall has addressed the shortcomings of earlier IEEE battery standards and led the development of new standards resulting in significant improvement in industry practices for the deployment of grid based energy storage. Examples include:

IEEE Std 1106-1995, IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications (Chair)
IEEE Std 1106-2005, ibid (Chair)
IEEE Std 1106-2015, ibid (Chair)
IEEE Std 1115-2000, IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications (Chair)
IEEE Std 1115-2014, ibid (Chair)
IEEE Std 1115a-2007, IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications, Amend 1: Additional Discussion on Sizing Margins (Chair)
IEEE Std 1660-2008, IEEE Guide for Application and Management of Stationary Batteries Used in Cycling Service (Vice Chair)
IEEE Std 1679-2010, IEEE Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications (Chair)
IEEE Std 1679.1-2017, IEEE Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications (Vice Chair)

Starting in 1985, he was also instrumental in developing procedures for sizing, installation, maintenance and testing of Ni-Cd batteries, now incorporated in IEEE Std 1106 and IEEE Std 1115. These best practices have been adopted worldwide for Ni-Cd batteries in telecom, industrial and utility applications, providing increased acceptance of this battery type and allowing system reliability to be improved. He also addressed shortcomings in IEEE battery testing procedures, which led to updating industry testing procedures. In addition to contributing for IEEE standards development, he also presented published recommended practice guides, developed tutorials and gave a number of presentations at events geared for practicing engineers. Examples his papers and presentations are listed:

J. McDowall, "Misleading Results Using IEEE Battery Testing Procedures," Proceedings of Battcon Conf 1999
J. McDowall, "Opportunities for Electricity Storage in Distributed Generation and Renewables," IEEE PES Transmission & Distribution Conference, 2001
J. McDowall, "Battery Life Considerations in Energy Storage Applications and Their Effect on Life-Cycle Costing," IEEE PES Summer Meeting, 2001
J. McDowall, "Integrating Energy Storage with Wind Power in Weak Electricity Grids," Proceedings of 24th International Power Sources Symposium, April 2005
B. Roberts, J. McDowall, "Commercial Successes in Power Storage," IEEE Power and Energy Magazine, vol. 3, no. 2, pp. 24 – 30, 2005
E. John, M. Holmberg, J. McDowall, "FACTS Devices with Battery-Based Energy Storage – Extending the Reach of Traditional Grid-Stability Systems," IEEE PES Transmission & Distribution Conference, 2012.

7.c. Impact of 1st contribution (maximum 200 words):

Jim McDowall has been the most influential leader in the development of standards for batteries for stationary batteries and grid energy storage systems within the IEEE. As standards coordinator for Power & Energy Society Energy Storage and Stationary Battery Committee, he has been instrumental in the development of number of standards that are widely adapted in the telecom and electric power industries. For example, in the mid-2000s, Jim McDowall became aware of a mismatch between the information provided by developers of new energy storage technologies and the expectations of prospective users. He proposed a new IEEE standard on the subject and chaired the working group for the project, leading to publication of IEEE Std. 1679-2010 on the characterization and evaluation of emerging technologies. Jim was the Vice Chair and major contributor for a subsequent project providing guidance for the application of IEEE Std 1679 for lithium-based batteries, recently published as IEEE Std 1679.1-2017. Jim is providing guidance on similar projects for sodium-beta, flow and alkaline batteries. His work has provided the industry with the necessary tools to make sound choices on the adoption of new technologies and is helping users avoid the safety and operational consequences of uninformed decisions.

7.d. Verifiable Evidence of Impact (maximum 200 words):

His impact is evident from the worldwide adaptation of the IEEE Standards and Best Practice Guide as standard industry practices. Many federal agencies such as the Nuclear Regulatory Commission, U.S. Fire Administration, Department of Energy, etc.

rely on IEEE standards for public safety regarding stationary battery installations. For example, the US Bureau of Reclamation of the Department of the Interior has published a manual on "Storage Battery Maintenance & Principles" that specifically cites IEEE Std. 1106 for guidance on the use of Nickel-Cadmium batteries on federal government land. The importance of these standards is also evident in the number of times, over several decades, that the standards have been revised and updated rather than abandoned. For example, IEEE Std. 1106 was first approved in 1995 and has been updated in 2005 and again in 2015, which is indicative of its relevancy. Jim's Endorsers will speak to the impact that his Standards work has had on the improved safety, efficiency, and reliability of energy storage systems in multiple applications.

17.2 Examples of Educator Nomination

17.2.1 Example A of Educator Nomination

7.a. Identify the first individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).

Professor Barbara Oakley's lasting contribution to the field lies in her efforts to make math and engineering education accessible to a wide audience. She employed engineering approaches to incorporate aspects of societal interaction and the human condition to communicate difficult concepts in a manner that is easier to teach and helps students become more effective learners. This work was embodied in her LHTL approach: "Learning How To Learn: Powerful Mental Tools to Help You Master Tough Subjects." This new, engineering-based approach formed the framework for her widely successful massive open online course (MOOC) taught through UC San Diego-Coursera with her colleague Dr. Terrence Sejnowski, the Francis Crick Professor at the Salk Institute. LHTL is currently the world's most popular MOOC, with 1.5 million registered learners from over 200 countries in its first 2 years. Unlike most MOOCs, which decline in popularity after an initial peak, LHTL continues to attract 10,000 new learners a week. Her research and teaching on how to do robust and effective online coursework has been globally disseminated so that many others can design similarly

7.b. Verifiable Evidence of contribution (maximum 400 words):

1. The Massive Open Online Course (MOOC) "Learning How to Learn." https://www.classcentral.com/course/learning-how-to-learn-2161, Rated 4.9/5.0 with 14,610 reviews.

Learning How to Learn is the world's largest and most popular online course, reaching 1.5 million enrolled students in the first two years alone, with many of the students using the course to help them to switch into or support careers in STEM. The course is so exceptionally useful that it is included by the US Department of Education as one of the handful of MOOCs that is to be accepted for continuing education credit by all US K-12 teachers. This is an extraordinary example of responsiveness to a strong educational need, external impact, and successful implementation of the neuroscience-based engineering concept to enhance learning in the STEM disciplines.

2. "A Mind for Numbers" Dr. Oakley's book, published by Tarcher-Perigee in 2014 (100+citations/Google Scholar) describes effective learning in the STEM disciplines. It is the book upon which the MOOC "Learning How to Learn" was based. In a rare coup

for the world of engineering, the book has become an international bestseller, climbing to The New York Times list of best-selling science books, selling over 100,000 copies, and being translated into 11 different languages. A Mind for Numbers introduces students to their untapped potential for learning in the STEM disciplines in part by leading them through Dr. Oakley's own inspirational story—a particular exemplar for women in STEM. She learned the STEM disciplines, not by following her initial passions, but rather, by learning to broaden her passions. Through her writing, teaching, and mentoring, Dr. Oakley is allowing millions of students around the world the opportunity to follow in her footsteps.

3. "Turning student groups into effective teams" by Barbara Oakley, Richard M Felder, Rebecca Brent, Imad Elhajj in Journal of Student Centered Learning, vol. 2, no. 1, pp. 9-34. (900+ citations/Google Scholar). This paper is a guide to the effective design and management of team assignments in a college classroom where little class time is available for instruction on teaming skills. Topics discussed include forming teams, helping them become effective, and using peer ratings to adjust team grades for individual performance. A Frequently Asked Questions section offers suggestions for dealing with several problems that commonly arise with student teams, and forms and handouts are provided to assist in team formation and management.

7.c. Impact of contribution (maximum 200 words):

There are many challenges in education, but perhaps the most important challenge of all is that teachers and students worldwide often have little means of learning about the best ways to learn. Disadvantaged students worldwide frequently have access to cell phones, but have little direct, face-to-face contact with top quality teachers or professors who are cognizant of the latest in research in how to leverage students' brains to learn more effectively. Even in highly industrialized countries, students may be expected to take up to 16 years of education—yet rarely are these students presented with course material that can help them to be more effective learners. Students are taught what to learn—not how to learn. LHTL has broken new ground in many different areas. It has been used in programs to help refugees in Jordan, Somalia, and Afghanistan. It is being used by mentally disabled students with IQs of 70 and below in a newly devised "Inclusive Education Certificate Program" (based out of Colorado Springs), that allows these students, for the first time, to actually attend college rather than to become incarcerated in isolated facilities. The course is translated or being translated into over two dozen different languages.

7.d. Verifiable Evidence of Impact (maximum 200 words):

It is unusual for engineering texts to make the break to mainstream literature, but that is exactly what Barbara Oakley has accomplished. In addition to print and e-print versions, three of her books (A Mind for Numbers, Learning How to Learn, and Mindshift) are also available as audiobooks from Audible, the leading audiobook purveyor. Her book A Mind for Numbers is also available from Amazon as Abre tu mente a los números (Spanish), Una mente per i numeri (Italian), (K)ein Gespür für Zahlen (German), and On ne naît pas brillant, on le devient (French). Book translations can also be found in Chinese, Japanese, Polish, Portuguese, Russian, Turkish, and Ukrainian. This wildly popular book indicates how deeply effective and impactful Prof. Oakley's melding of engineering and psychology to explain the science behind how to grasp complex subjects has become. Students and teachers are both receptive audiences for her straightforward approach to becoming an effective learner.

17.2.2 Example B of Educator Nomination

7.a. Identify the first individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).

Dr. Cindy Finelli has provided leadership and vision for engineering faculty development for nearly 20 years. She is known nationally and internationally for her research on the development and assessment of ethics in engineering students and organizations. She has extended this focus to include effective teaching strategies and dissemination of these practices to engineering faculty worldwide. She is a recognized expert on best practices for encouraging academic integrity in students. She led the development of the US National Science Foundation sponsored Leadership Virtual Community of Practice learning community for faculty developers across the nation. In addition, she has designed and conducted a variety of faculty development programs and seminars promoting evidence-based teaching that have been offered at numerous university and conference venues. These widespread electrical engineering education activities were an outgrowth of faculty teaching resource centers that she had established at her home institutions. These centers have served as a framework for the establishment of similar centers globally. In her role as founding director of these two engineering teaching centers, she worked diligently to establish a culture of teaching and learning, to promote instructional change among engineering instructors, and to support the work of other faculty development centers and programs.

7.b. Verifiable Evidence of contribution (maximum 400 words):

[1] Finelli, C. J., Ott, M., Gottfried, A. C., Hershock, C., O'Neal, C. M., & Kaplan, M. L. (2008, Oct). Utilizing instructional consultations to enhance the teaching performance of engineering faculty. Journal of Engineering Education, 97(4), 397-411.

Dr. Finelli is lead author on this paper about the impact of instructional consultations informed by a range of data. The study showed that the efficacy of instructional consultations varies depending on the kind of data used to guide them, with midterm student feedback data having the largest positive impact.

[2] Finelli, C. J., Daly, S. R., & Richardson, K. M. (2014, Apr). Bridging the research to-practice gap: Designing an institutional change plan using local evidence. Journal of Engineering Education, 103(2), 331-361.

Dr. Finelli is lead author of this paper which was invited for a special issue of the Journal of Engineering Education on the "Complexities of Transforming Engineering Higher Education." From 53 proposals for papers, the special issue editors invited eleven papers; after peer review, only six were published. In this article, Dr. Finelli and her co-authors reported three research studies that together informed the design of faculty learning communities as a sustainable structure for faculty development at her institution. The process used by her research team has been adopted by other institutions to build administrative support for faculty development efforts.

[3] Finelli, C. J., Nguyen, K. A., DeMonbrun, R. M., Borrego, M., Prince, M. J., Husman,

J., Henderson, C., Shekhar, P., & Waters, C. K. (2018). Reducing student resistance to active learning: Strategies for instructors. Journal of College Science Teaching, 47(5), 80-91.

Dr. Finelli is lead author on this paper addresses the student resistance to active learning by analyzing data survey data from more than 1,000 undergraduate students in 18 introductory engineering courses where active learning was implemented. The study found that students' perceptions of their instructors' use of explanation and facilitation strategies can have a significant impact on student resistance.

7.c. Impact of contribution (maximum 200 words):

Her mission is to promote excellence in learning and teaching by conducting and cultivating engineering education research, facilitating the adoption of research-based teaching practices, seeking continual improvement of teaching and student learning, and providing local, national, and international leadership for engineering education. Dr. Finelli's research in evidence-based college level teaching has resulted in concrete evidence that using those strategies is correlated to greater levels of student engagement and participation, improvements in the value and positivity students have towards the instruction, and higher student evaluations of teaching. Her work has identified practical strategies instructors can use in the classroom to lower student resistance to new educational approaches. In the first ten years of service, the center she established at Michigan reported interaction with 74% of the engineering teaching faculty; over 25,000 students had provided feedback to their instructors through the midterm student feedback service; and almost 10,000 participants had attended workshops and seminars. The successful outcomes of her efforts with faculty teaching resource centers have been disseminated widely and have been adopted by numerous institutions nation-wide.

7.d. Verifiable Evidence of Impact (maximum 200 words):

[1] Finelli, C. J., & Borrego, M. (2019). Adoption of research-based instructional strategies in engineering and computer science. In S. Laursen (Ed.), Levers for change: An assessment of progress on changing STEM instruction (p. 69-79). Washington, DC: American Association for the Advancement of Science.

Dr. Finelli was commissioned to contribute to report for the American Association for the Advancement of Science. The report assessed the state of reform in STEM undergraduate instruction and to identify effective levers for changing undergraduate teaching and learning both within and across STEM disciplinary clusters. This report synthesized her own research and that of others about the current state of instruction in STEM and offers suggestions to promote instructional change.

[2] She was co-developer of the Comprehensive Assessment of Team-Member Effectiveness (CATME) tool. CATME was released publicly in 2005 and has since been used by more than 1.4 million students of more than 20,000 faculty at more than 2400 institutions in 87 countries. The primary publication of the validation of that instrument received the 2013 Maryellen Weimer Scholarly Work on Teaching and Learning Award from the Teaching Professor, recognizing outstanding scholarly contributions with the potential to advance college level teaching and learning practices.

17.3 Example of Research Engineer/Scientist Nomination

17.3.1 Example A of Research Engineer/Scientist Nomination

7.a. Identify the first individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).

Prof. Ilic's most significant contribution to the field of power system dynamics and control is her thorough and rigorous approach to developing and documenting power systems dynamic model-based controls for mitigation of voltage instabilities leading to blackouts. She was one of the first researchers to formalize the complete differential-algebraic model structure of electric energy systems as hierarchical dynamical systems for control design. In this approach, she explicitly exploited temporal and spatial decompositions to define primary, secondary, and tertiary regions of control. Ilic was the first to formalize the end-to-end modeling of electric energy systems as hierarchical dynamical systems in normal operation. Motivated by the real-world blackouts caused by voltage problems, she analyzed the conditions for the existence and uniqueness of equilibria in nonlinear decoupled active and reactive power networks. This enabled her to propose new controls using the proposed nonlinear dynamical models in standard state space form. Examples of these controls include applications to excitation control and system-wide voltage control. Much of her work in this area has been adopted and validated on actual electric power systems (New York Power Pool, Electricite de France).

7.b. Verifiable Evidence of contribution (maximum 400 words):

[A.1] M. Ilić, R. Marino, S. M. Peresada, D.G. Taylor, "Feedback linearizing control of switched reluctance motors," IEEE Transactions on Automatic Control, 32 (5), 371-379, 1987 (549 citations/GS).

This paper is the first to introduce the concept of feedback linearization to power engineering problems that exhibit classes of nonlinearities suitable for feedback linearization. By translating the models via the feedback linearization approach, controls were developed that were robust over a wider range of operation. This work provided the framework for the later extension of feedback linearization control to application in the bulk electric power system. This work was one of the earliest applications of nonlinear control to power engineering problems which heretofore had been addressed only through linear control.

[A.2] J.W. Chapman, M.D. Ilic, C.A. King, L. Eng, H. Kaufman "Stabilizing a multimachine power system via decentralized feedback linearizing excitation control," IEEE Transactions on Power Systems, 8 (3), 830-839, 1993 (427 citations/GS)

This paper extended feedback linearization to multi-machine power system excitation system voltage control. This work showed that multiple excitations systems across distributed geographical areas could be simultaneously controlled to alleviate voltage instabilities. This increased operating range included heavily burdened transmission systems that were previously highly susceptible to conditions leading to cascading failures (i.e. blackouts). Chapman was Ilic's Ph.D. student. The co-authors King, Eng and Kaufman were with New York Power Pool, Niagara Mohawk Power, and Empire

State Electric Energy respectively. This collaboration between academic (Chapman, Ilic) and industry (King, Eng, Kaufman) authors indicates the importance and impact of this work.

[A.3] M. Ilic, J. Christensen, K. L. Eichorn, "Secondary voltage control using pilot point information," IEEE Transactions on Power Systems, 3 (2), 660-668, 1988 (122 citations/GS).

This early paper posed power system voltage control as a series of hierarchical control regions that could be coordinated to provide decentralized control by augmenting generator control (via the excitation system) with transmission system based voltage controllers, such as synchronous condensors and capacitor banks that are strategically placed at pilot buses which are selected to provide improved observability and controllability. This is one of the first works to propose the use of "pilot" points that could serve as both geographic indicators of stability problems and points at which control actions are most effective throughout the bulk electric power system. Co-author Eichorn was with Central Illinois Light Company which indicates the importance of this control approach to the industry.

7.c. Impact of contribution (maximum 200 words):

Her work on hierarchical voltage control frameworks has spurred the development of secondary and tertiary voltage control systems at a number of utilities worldwide including the New York Power Pool, Électricité de France, the National Transmission System Operator (GRTN) of Italy, and the Northeast Electric Power Grid (NCPG) of China. Ilic's use of pilot buses for secondary voltage control initiated a substantial investment in this approach of control throughout the industry and now nearly every system uses this approach. Her team also introduced the concept of tertiary voltage, control which is the first time voltage and reactive power control was studied as a holistic power system level objective.

7.d. Verifiable Evidence of Impact (maximum 200 words):

The following two papers provide evidence that the theoretical work initially developed by Ilic and her students have been successfully integrated into application to provide improved control and performance of the bulk electric power grid.

[A.4] C. A. King, J. W. Chapman, M. D. Ilic, Feedback linearizing excitation control on a full-scale power system model, IEEE Transactions on Power systems 9 (2), 1102-1109, 1994 (150 citations/GS).

This paper provides a follow-up to the previous paper [A.2] from the electric utility standpoint (King was with New York Power Pool). In this paper, the developed feedback linearization excitation control developed by Ilic and her student Chapman is shown to be able to effectively stabilize a series of faults in the Northeast Power Coordinating Council System which includes New York City.

[A.5] M.D. Ilic, X. Liu, G. Leung, M. Athans, C. Vialas, P. Pruvot, "Improved secondary and new tertiary voltage control", IEEE Transactions on Power Systems, 10 (4), 1851-1862, 1995 (119 citations/GS).

This paper, published eight years after the concept of secondary voltage control (in [A.3]), provides an example of the application of the developed control in the French electric power grid. The co-authors Viaslas and Pruvot are with Electricite de France.

17.3.2 Example B of Research Engineer/Scientist Nomination

7.a. Identify the first individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).

Dr. Yifeng Wu has made fundamental contributions to GaN RF power transistors for high-performance wireless communications.

As a Ph.D. student, Dr. Wu began the groundwork on developing GaN transistors. Working to develop the GaN epitaxial structures and exploring a new device fabrication process, Dr. Wu achieved a breakthrough in 1996 by demonstrating GaN high-electron-mobility transistors (HEMTs) with >200V breakdown and high trans-conductance, resulting in an output power of 1.1 Watt/mm. This benchmark was improved to 3 Watt/mm in 1997. This result was a threefold improvement over GaAs transistors, which had been the primary device for wireless communications until this point.

In his career as a device scientist at WideGap Tech and Cree, Dr. Wu continued to move the technology forward. After observing a discrepancy between the dc and ac characteristics of the GaN HEMTs, he traced these differences to electron trapping. He then developed a new surface passivation without plasma damage to resolve the issue, again tripling the performance to 10W/mm. In subsequent efforts on electric field optimization by field plates, Dr. Wu increased the power density to 40W/mm in 2006. These works solidified GaN as the preferred device for RF power devices for generations of wireless communications to come.

7.b. Verifiable Evidence of contribution (maximum 400 words):

[1] Wu et al, 1996, "Very high breakdown voltage and large transconductance realized on GaN field effect transistors", Applied Physics Letters, 69(10), pp.1438-1440.

As the 1st author and main contributor, Dr. Wu developed GaN high-electron-mobility-transistors (HEMTs) with breakdown voltages >200V along with a large transconductance, remarkably higher than the 35V value of previous matured devices. This enabled the 1st demonstration of microwave amplification using a GaN transistor with a power density above that of the incumbent GaAs. The importance of this work lies in the device epitaxial structure with its key metrics and the successful fabrication process that preserved the excellent properties of GaN, which serves as fundamental basics for future development work and commercialization of GaN microwave devices today.

This paper and a sister paper in EDL published at the same time [Wu et al, 1996, Measured microwave power performance of AlGaN/GaN MODFET, IEEE Electron Device Letters, 17-9, p. 455-457] were cited 580 times (407+173) per Google Scholar.

[2] US Patent # 6,586,781, Y Wu, N Zhang, J Xu, and L McCarthy, "Group III nitride based FETs and HEMTs with reduced trapping and method for producing the same", Issued on Jul 1, 2003.

Previously unexpected discrepancies between the dc and ac characteristics of the GaN HEMTs were observed and traced it to electron traps in the devices. As the 1st inventor of this utility patent, Dr. Wu and co-workers developed a new SiN passivation method focusing on the least surface damage, effectively resolving this difficult problem. This patent itself is cited 283 times by other patent applications per Google scholar. This patent has been licensed to multiple companies in the GaN device technologies.

[3] Wu et al, 2001, Very-high power density AlGaN/ GaN HEMTs, IEEE Transactions on Electron Devices, 48-3, pp. 586-590, Device work published by Dr. Wu & co-authors using the method described in the patent resulted in 2-3x improvement in power density, reaching 9.8W/mm. This paper was cited 646 times per Google Scholar.

[4] Wu et al, 2004, "30-W/mm GaN HEMTs by field plate optimization", IEEE Electron Device Letters, 25(3), pp.117-119.

This work by Dr. Wu and his co-authors increased the power density of GaN HEMTs to 30W/mm by electric field engineering through optimization of a field plate. The result is 20-30 times that of the incumbent GaAs devices, which also used field plates. This paper was cited 1,150 times per Google Scholar.

7.c. Impact of contribution (maximum 200 words):

GaN electronics is now under rapid deployment in 4G and 5G wireless base stations. In spite of its excellent electrical properties, it took a significant effort to innovate reliable and efficient GaN transistor designs on a material system that lacked a native substrate. For RF power, demonstrating high power density at high frequency was the "ticket to the game." The impressive progress in power density of Dr. Wu in the early 2000's gave a tremendous impetus to the field. This culminated with the demonstration of a transistor with a power density of 40 W/mm. This was a remarkable achievement and a record that has lasted to this day. There are many technical innovations behind this extraordinary result. Perhaps the most important one was the design of field plates for electric field management. This was also important to achieve the reliability goals, a stumbling block for a long time.

All GaN transistors produced in the world use optimized passivation similar to that developed by Dr. Wu to ensure performance and reliability. Furthermore, all high power GaN transistor products today use field plates, such as those introduced for HEMT by Dr. Wu for optimum performance.

7.d. Verifiable Evidence of Impact (maximum 200 words):

Strategy Analytics forecasts that the GaN RF device market is projected to break $1 billion by 2021 (https://news.strategyanalytics.com/press-releases/press-release-details/2021/Strategy-Analytics-RF-GaN-Revenue-Pushes-Past-1-Billion-in-2020/default.aspx). Dr. Wu was the first to demonstrate a GaN microwave power HEMT and has set several world records for the highest power densities of any solidstate transistor. Many of the developments lauded in the RF GaN field have been directly or indirectly developed by Dr. Wu.

Dr. Wu has written a large number of impactful papers in GaN transistor design for RF applications and has over 100 patents to his name. Dr. Wu's work on pushing the limits of GaN electronics has been cited more than 15000 times, and he has an h-index of 59. His high profile in the field was recognized when he was invited to co-author an IEEE Proceedings paper on GaN devices:

Mishra, U. K., Parikh, P., & Wu, Y. (2002). AlGaN/GaN HEMTs - an overview of device operation and applications. Proceedings of the IEEE, 90(6), 1022-1031. Cited by 1347 (Scopus)

He has also played a key leading role in at least three GaN companies so far: Wi-Tech, Cree, and Transphorm. These companies have led the commercialization of GaN technologies.

17.4 Example of Application Engineer/Practitioner Nomination

17.4.1 Example A of Application Engineer/Practitioner Nomination

7.a. Identify the first individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).

Dr. Namuduri’s contribution to engineering and society is the electrification of several automotive accessories for internal-combustion passenger vehicles to improve fuel economy, safety, and comfort. His primary contributions included electrification of power steering and suspension. He developed a patented method for sinusoidal commutation of permanent magnet brushless motors using low-cost sensors for the fuel-saving electric power steering (EPS) application to achieve smooth, torque-ripple-free (TRF) steering feel. Dr. Namuduri developed analytical models for the parasitic torque ripples in brushless motors and novel control methods to minimize them. In addition, TRF-EPS technology enabled many advanced active safety and convenience features such as lane keeping control, smart parking assist, and autonomous driving. Dr. Namuduri also electrified automobile suspension through a novel, Magneto-Rheological (MR) Fluid-based real time controllable damper having no moving mechanical valves and a high-bandwidth current controller to achieve smooth ride and safe handling. He developed rapid electromagnetic design and multi-objective optimization methods used for materials selection and actuator development. In addition, he developed a 42V brushless motor-based regenerative suspension damper for recuperating damping energy to improve vehicle fuel economy. Both of these inventions have been installed on commercial passenger vehicles.

7.b. Verifiable Evidence of contribution (maximum 400 words):

Electric Power Steering:

[1] “Torque ripple free electric power steering,” US Patent 6498451, 2000

Dr. Namuduri quantified the effect of current and position sensor errors on the torque ripple in sinusoidal brushless motors to establish acceptable sensor accuracy for meeting the electric power steering system torque ripple requirements. In the patent Dr. Namuduri contributed the sinusoidal commutation scheme for brushless motors having low-cost, non-absolute position sensors. This invention reduced torque ripple in electric power steering systems from 18% to 3% to keep the oscillations and acoustic noise within acceptable levels.

[2] “Low ripple torque control of a permanent magnet motor without using current sensors,” US Patent 6498449, 2000

This patent provided the design to eliminate the parasitic torque ripples in electric power steering system due to motor current sensor errors by adopting voltage-based torque control of the brushless motor.

[3] Shaotang Chen, C. Namuduri and S. Mir, "Controller-induced parasitic torque ripples in a PM synchronous motor," IEEE Transactions on Industry Applications, vol. 38, no. 5, Sept.-Oct. 2002.

This paper provided further elaboration on the systematic analysis of possible sources of torque ripple in a PM synchronous machine drive resulting from limitations in the motor controller. It takes into account the effects of finite encoder resolution, controller CPU word length, current sensing errors, and inverter pulse width-modulation switching. Approaches for analyzing and calculating torque ripple from each of those sources have been developed. Characteristics of the various parasitic torque ripples are discussed. Experimental and simulation data to verify important results are also presented.

Suspension Damping System:

[4] Magnetorheological Fluid Damper with Optimum Damping, US Patent 6390252, 1999

[5] C. S. Namuduri, M. A. Golden and J. Praeckel, "Concurrent research and development of a magnetic ride control system," IECON'03. 2003, Vol.3.

The patent describes the design features to maximize and shape the controllable range of a Magneto-Rheological (MR) damper that has no moving mechanical valves and provides continuously variable damping. The real time controllable damper has a high-bandwidth current controller to achieve smooth vehicle ride and safer handling. Namuduri developed rapid electromagnetic design and multi-objective optimization methods used for materials selection and actuator development. The integrated approach of developing the innovative Magnetic Ride Control system was presented at the 2003 IECON and won the Best Technical Presentation Award in the Automotive Power Electronics and Drives Session.

7.c. Impact of 1st contribution (maximum 200 words):

Dr. Namuduri was a key member of the team that developed the first commercially produced electric vehicle: the EV1 from General Motors. His innovations enabled production of the fuel-efficient TRF-EPS technology to reduce oil consumption significantly, leading to a cleaner environment. It is also a key enabler for advanced active safety and convenience features such as lane keeping, smart parking assist, and autonomous driving. These features are now widely used in several millions of passenger vehicles globally including GM, Audi, etc. in premium, luxury, and performance models. In addition to the mentioned contributions, other examples include the Fast Torque Response MGU for the GM Belt driven Alternator-Starter (BAS) Hybrid (2007); and the Chevrolet VOLT High Voltage PTC Cabin Heating System (2010).

7.d. Verifiable Evidence of Impact (maximum 200 words):

Chandra Namuduri has been issued 168 US patents (with several more pending) out of which 20 Patents being in actual use in General Motors Global Products. The TRF-EPS technology was transferred to Delphi – Saginaw (now owned by Nexteer), enabling GM to introduce the TRF-EPS systems on the 2002 Opel Meriva and 2003 Chevrolet Malibu. The TRF-EPS system provided a 4 to 5% improvement in fuel economy and was a GM industry first with this system on midsize vehicles in North America. The MR Suspension Damping technology was recognized as the Best New Technology by Popular Science Magazine in 2002 [December 2002, p. 62, "Cadillac's Magnetic Suspension"] and Canadian Automotive Journalists in 2003 ["Best New Technology: MagneRide System" http://www.ajac.ca/car-of-the-year-winners-list.asp#].

Namuduri has received seven GM "Boss" Kettering Awards – GM's highest and most prestigious technical recognition. He has also received Four Charles McCuen Special Achievement Awards, which is GM Global R&D's highest technical honor.

17.4.2 Example B of Application Engineer/Practitioner Nomination

7.a. Identify the first individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).

Rath Vannithamby at Intel invented and patented a novel device-assisted adaptive transmission-reception cycle technique to improve the device power efficiency that is of paramount importance for smartphones and IoT devices.

His approach differed significantly from the traditional approach of using a fixed transmission-reception cycle. When the device runs QoS applications, it benefits from a shorter cycle, and other times a larger cycle is beneficial to save power. Only the device knows if it is low in battery or running QoS applications. Rath's device-assisted mechanism enables the device to enjoy QoS when needed and save power otherwise. The cellular industry realized the need for this mechanism several years after, and Rath actively worked with other companies, created a study item "enhancements for Diverse Data Applications (eDDA)" in 3GPP to enable the first adaptive transmission-reception cycle mechanism based on device-assistance. Rath generated a series of supplementary patents that are needed to complete the complex cellular system design to provide power-efficiency for both smartphones and IoT devices. This breakthrough technology got adopted in 4G LTE specifications and helps save power in hundreds of millions of devices, and became the foundation for the power save mechanisms for the most recent 5G IoT.

7.b. Verifiable Evidence of contribution (maximum 400 words):

Mustafa Demirhan, Ali Koc, Shweta Shrivastava, Rath Vannithamby, "Adaptive DRX cycle length based on available battery power," Patent No: US 7760676, Filed: 06/20/2006, Issued: 07/20/2010 [153 citations]

Rath invented a new adaptive discontinuous reception (DRX) technology, which has well spread to other companies, and six years later became the standard for adaptive DRX cycle length configuration for LTE. Note that the author list is in alphabetic order and Rath was responsible for claims 1-3, 6-7, 10, 13. His approach differed from traditional approach where the base station directs the device to use fixed DRX cycle without knowing the needs at the device which could lead the device drain battery power faster. A series of complementary inventions of Rath needed for the complete design of the complex LTE infrastructure and procedures for this feature, were covered in US Patents 9042286, 9277440, 9439208 in ISLD-201703-007 and 9007972, 9713164, 9949243 in ISLD-201703-079, that are declared in ETSI database as essential patents.

A.T. Koc, S.C. Jha, R. Vannithamby, M. Torlak, "Device power saving and latency optimization in LTE-A networks through DRX configuration," IEEE Transactions on Wireless Communications, Volume 13, Issue 5, May 2014 [95 citations]

This influential paper demonstrates the necessity of optimizing DRX configuration based on the application traffic running on smartphones with diverse data applications such as Facebook to maintain a tradeoff between QoS and power savings. In the paper, Rath was responsible for the adaptive switching protocol. Rath's US Patent 9538547 declared essential in ETSI database ISLD-201703-007 proposes a cross-layer technique to better support application-traffic while saving power.

X Chen, N Ding, A Jindal, YC Hu, M Gupta, R Vannithamby, "Smartphone energy drain in the wild: Analysis and implications," ACM SIGMETRICS 2015 [86 citations]

This seminal paper produced several unexpected outcomes, e.g., 14.6% of smartphone battery power is wasted just for listening to paging channel. For this paper, Rath was responsible for the cellular functions modeling. The findings have tremendous implications to phone-vendors and application-developers to extend smartphone battery life. To improve device power subject paging, Rath invented extended paging cycle. Rath's US patents 9794876, 9763235 in ISLD-201703-007 and 9294714 in ISLD-201703-176 declared essential in ETSI patent database.

7.c. Impact of contribution (maximum 200 words):

Rath has made significant contributions to three generations (from 3G to 5G) of cellular systems and networks. In particular his contributions on radio resource allocation techniques to efficiently support diverse internet data applications over cellular data networks are very valuable in solving the vital smartphone power efficiency problem. He is widely recognized as a pioneer of the device-assisted adaptive discontinuous transmission-reception mechanism to optimize and find the best tradeoff between latency and power efficiency based on user preference. His breakthrough technology is a key aspect in efficiently supporting diverse applications including social networking and stock-updates that generate frequent background traffic and consume battery power. He patented his inventions and also published several seminal papers in this topic. Rath's work impacted LTE specifications that give connectivity for billions of devices worldwide today. His contributions on device power efficiency technology development is even more valuable and impactful for massive-IoT devices in emerging beyond 5G systems, as it may be harder or impossible to recharge these devices.

7.d. Verifiable Evidence of Impact (maximum 200 words):

Gupta, M., Jha, S. C., Koc, A. T., & Vannithamby, R. (2013). Energy impact of emerging mobile internet applications on LTE networks: Issues and solutions. IEEE Communications Magazine, 51(2), 90-97.

Power efficiency is a key metric for IoT and mobile devices. Rath and his team performed a feasibility study, a detailed design, and algorithm development for device power efficiency for Intel client product based on IEEE 802.16. Leveraging the outcome of these studies, Rath conducted research to investigate the device power saving capability of 4G LTE networks and published the results in the ComMag paper cited above. The paper quantified the inefficiencies in the original LTE protocols, and introduced a novel device-assisted adaptive transmission-reception cycles with impressive power saving gains. Rath showed his technique can increase the power saving by a remarkable 26%. He patented this invention along with other supplementary techniques that are needed for the complete design of the complex LTE-A system. Rath brought his ideas to 3GPP standards committee and played a leadership role in influencing other companies and the standards body to standardize this technique into the 3GPP Release 11 specifications captured in Technical Specifications 36.300, 36.321, 36.331. His Endorsers provide further information in this respect.