1. Call to order

The meeting was called to order at 9:05 AM on 3 June 2016 by SC4 co-chair Marv Ziskin.

2. Welcome and introductions

Each of the attendees introduced her/himself. Recently-appointed SC3 co-chair Kevin Graf introduced himself. (See Attachment 1 for list of attendees.)

3. Approval of agenda

Following a motion by Kevin Graf that was seconded by C-K Chou, the agenda was approved as presented. (See Attachment 2.)

4. Approval of the January 2016 SC3/4 meeting minutes

Following a motion by Ralf Bodemann that was seconded by Robert Cleveland, the January 2016 SC3/4 meeting minutes were approved (see http://www.ices-emfsafety.org/meetings/minutes- tc95-sc4/), with the caveat as detailed in the action item below.

**ACTION ITEM:** Marv Ziskin will check with Ron Petersen on item 11-b of the January 2016 SC3/4 meeting minutes. Specifically, he will confirm the statement that “the skin temperature rises rapidly after removal of the source.”

5. Chairmen’s Reports

Marv Ziskin presented the Chairmen’s Reports for SC3/4 (see Attachment 3), including the main
goals and active tasks of SC3/4. He reviewed the ongoing revision and merging of IEEE Stds C95.1-2005 and C95.6-2002 (see Item 6b below). He noted the completion of IEEE Std C95.1-2345-2014, which replaced NATO RF Standard STANAG 2345. Ziskin also listed the major SC4 standards (C95.1-2005, C95.1a-2010, and C95.1-2345-2014) and noted that all C95.XX standards are available free of charge thanks to the US Air Force, US Army, and US Navy. C-K Chou voiced a reminder that this free availability may end shortly. Ziskin then reviewed the ongoing ICES literature review, including mention of the approved review criteria document “Guidelines for the Systematic Review of Scientific Literature on Health and Electromagnetic Fields (0-300 GHz)”, the literature review working groups organized by Antonio Faraone, and the publications database managed by Joe Elder (see Items 6c and 6d below). Ziskin then expressed special recognition of Pat Reilly, whom the IEEE-SA Awards and Recognition Committee presented the IEEE Standards International Award for his significant contributions.

6. Progress on revision of C95.1-2005
   a. Update on NATO standard C95.1-2345

NATO standard C95.1-2345 has been approved and accepted as noted in the Chairmen’s Reports. C-K Chou noted Klauenberg has provided him with additional material on this topic. C-K Chou plans to present this material at the SC6 meeting.

   b. Update on the revision of C95.1-2005 and C95.6-2002

Marv Ziskin led discussion on the status of IEEE Stds C95.1-2005 and C95.6-2002. Both of these standards are scheduled to expire on 31 December 2018, and the Project Authorization Request (PAR) for the revision of C95.1-2005 and its merger with C95.6-2002 expires 31 December 2016. The intended merger of C95.1 with C95.6 will incorporate the material from C95.6 into C95.1, extending the range of frequencies covered by C95.1 down to 0 Hz. Following a motion by C-K Chou which was seconded by Ralf Bodemann, SC3/4 voted to approve the plan to apply for a 3-year extension to the existing PAR for C95.1. For the consideration of the committee, Peter Zollman mentioned the possibility of also merging C95.2 into C95.1.

   ACTION ITEM: Apply for a 3-year extension to the existing PAR for C95.1.

   c. Literature Review

Antonio Faraone presented a status report on the ongoing IEEE/ICES literature review which kicked off in February 2015 (see Attachment 4). The intent is to produce a series of special issue white paper publications and the inclusion of this material in the revision of C95.1-2005. Faraone discussed the review criteria document “Guidelines for the Systematic Review of Scientific Literature on Health and Electromagnetic Fields (0-300 GHz)” which was presented in draft form at the January 2016 SC3/4 meeting, and later issued in March 2016 for circulation to all reviewers. Faraone then presented the current list of review topics and lead reviewers. The list of review topics was selected based on the topics covered in Annex B of C95.1-2005 (topic B.5.3 “Review of 3 kHz to 100 kHz studies” will not be included in the current review). Faraone commented that the review schedule
has not yet been detailed and the process of reviewing papers has not yet begun. This prompted the following action item:

**ACTION ITEM:** Faraone will organize a conference call with all the lead reviewers to identify an appropriate review schedule and move the review forward.

Faraone suggested the possibility of providing incentive (financial or otherwise) to encourage reviewers. C-K Chou questioned the viability of this option, and whether the amount of compensation we could offer would provide worthwhile incentive.

d. **Literature Review – IEEE Database at ieee-emf.com (Joe Elder)**

Joe Elder presented on the IEEE Database available at ieee-emf.com (see *Attachment 5*), which Elder’s significant efforts have helped to grow and maintain. As of 31 May 2016, the database contained 6304 citations, over 5624 of which were linked to pdf files.

7. **ICNIRP/ICES Harmonization Initiative**

C-K Chou discussed the status of the ICNIRP/ICES harmonization initiative. As summarized by Chou, different nations and regions have adopted the ICNIRP, ICES or alternative guidelines. The WHO has encouraged a unified standard, and recent leadership change in ICNIRP may lead to increased collaboration between ICES and ICNIRP.

Discussion ensued concerning material presented at the May 2016 ICNIRP International NIR Workshop, and how ICES should best collaborate with ICNIRP. Mike Wood commented that ICNIRP is actively reviewing their exposure guidelines, plans to release an updated draft within two months for public review, and intends to update their guidelines within 2016. Mike Wood recommended that ICES proactively engage with ICNIRP concerning these guideline revisions as soon as possible rather than waiting for their public review.

**ACTION ITEM:** Ralf Bodemann and C-K Chou will be proactive in engaging ICNIRP concerning their ongoing guideline revisions and the harmonization of the ICES and ICNIRP guidelines. C-K Chou will personally reach out to his contacts in ICNIRP.

Within the aforementioned discussion, Joe Elder and Antonio Faraone commented that the draft guideline revisions presented at the May 2016 ICNIRP workshop were excluded from the material ICNIRP later posted online. Elder shared this material with those present and discussion ensued. Elder and Wood commented that ICNIRP does not plan to incorporate recent findings of the NTP report into their current guideline update.
8. Technical Presentation: “Quantifying complex EM fields with respect to human exposure” by Peter Zollman

Peter Zollman presented on the topic of quantifying complex EM fields, and implications this may have with respect to evaluating human exposure (see Attachment 6). In related material, Zollman previously presented a strategic approach to standardizing spatial averaging at SC1.

Zollman asked how human exposure may depend on field parameters missed by an isotropic evaluation, questioned details of the MPE definition/implementation, and posited that we may need to revisit the metrics for complex EM field evaluation prior to performing a more specific evaluation like the ongoing assessment of spatial averaging schemes. Zollman also reviewed and compared the ICNIRP and ICES language defining RL/MPE evaluation of human exposure, concluding that the ICES definition was generally easier to apply, but that its traceability to human exposure was more ambiguous. Zollman proceeded to explore examples of human exposure to multiple incident waves, considering both incoherent and coherent scenarios and consequential WB/localized exposures. He demonstrated that the ICNIRP and ICES evaluations could produce different results and inaccurate results. He also observed that when multiple fields/rays are incident to a point in space, the consequential exposure value for a body in that location may be different for WB/local exposures.

Discussion ensued, led by Peter Zollman and Antonio Faraone, on how these values would be measured/applied in practice, whether C95.1 and C95.3 together are conservative, and whether these standards rigorously define a consistent method for evaluation of complex fields. Zollman questioned whether complexities of evaluating (ie measurement & computation) real fields are taken into account in defining and applying the MPEs. Faraone noted that he is most concerned with whether the standards are conservative. Zollman acknowledged that conservative evaluation methods are useful for design/installation but challenged their use without considering uncertainty for post-hoc policing of in-situ exposures where high confidence in exceedance is more relevant.

Zollman expressed the view that it is important to improve our understanding of the relationship between the rate of energy deposition in a body (WB & localized) when exposed to non-plane-wave RF fields in order to review evaluation approaches such as spatial averaging and quantify uncertainties involved and ensure that the best metrics are expressed and evaluated in the C95 standards. Simple approaches may still be found to be applicable subject to revised uncertainties.

The questions raised by Zollman elicited the following action item:

**ACTION ITEM:** Robert Cleveland will circulate material from Zollman’s presentation to members of SC1/SC4 and ask for input on whether we need some targeted studies to inform ICES as to whether changes should be made to C95.1 and/or C95.3. Specifically, should changes be made to definition 3.1.20 “equivalent plane wave power density” of C95.1, the language describing MPEs for frequencies between 100 kHz and 300 GHz in C95.1, and/or the measurement methodology detailed in C95.3.
9. **New Business**

Discussion ensued concerning our stance on the recent NTP study. The following statement was drafted through collaborative discussion of those present:

> *IEEE/ICES is presently undertaking a scientific evaluation to revise the C95.1 standard. The NTP study will be included in that scientific evaluation.*

Ian Brooker motioned to accept the statement as written, seconded by Art Thansandote. The motion was approved.

10. **Date and Place of Next Meeting**

The next SC3/4 meeting will take place on 11 January 2017 in Plantation, Florida.

11. **Adjourn**

Motion to adjourn by Art Thansandote at 2:06 PM, seconded by Ralf Bodemann.
## Attendance List

**TC95 (SC3/SC4): Friday 3 June 2016 – 0900 – 1530 h**

<table>
<thead>
<tr>
<th></th>
<th>Last Name</th>
<th>First Name</th>
<th>Affiliation</th>
<th>Country</th>
<th>IEEE Member?</th>
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<tbody>
<tr>
<td>1</td>
<td>Bodemann</td>
<td>Ralf</td>
<td>Siemens</td>
<td>DE</td>
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<td>2</td>
<td>Brooker</td>
<td>Ian</td>
<td>Tyco International</td>
<td>IE</td>
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<tr>
<td>3</td>
<td>Chou</td>
<td>C-K</td>
<td>Independent Consultant</td>
<td>US</td>
<td>Yes</td>
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<tr>
<td>4</td>
<td>Cifra</td>
<td>Michal</td>
<td>The Czech Academy of Sciences</td>
<td>CZ</td>
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<tr>
<td>5</td>
<td>Cleveland</td>
<td>Robert</td>
<td>EMF Consulting</td>
<td>US</td>
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<tr>
<td>6</td>
<td>Elder</td>
<td>Joe</td>
<td>Independent Consultant</td>
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<tr>
<td>7</td>
<td>Faraone</td>
<td>Antonio</td>
<td>Motorola Solutions, Inc.</td>
<td>US</td>
<td>Yes</td>
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<td>Gettman</td>
<td>Ken</td>
<td>NEMA</td>
<td>US</td>
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<td>Graf</td>
<td>Kevin</td>
<td>Exponent</td>
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<td>Joseph</td>
<td>Wout</td>
<td>Ghent University/iMinds</td>
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<tr>
<td>11</td>
<td>Thansandote</td>
<td>Art</td>
<td>Health Canada (Retired)</td>
<td>CA</td>
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<td>12</td>
<td>Wood</td>
<td>Mike</td>
<td>Telstra</td>
<td>AU</td>
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<td>13</td>
<td>Ziskin</td>
<td>Marvin</td>
<td>Temple University</td>
<td>US</td>
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<td>14</td>
<td>Zollman</td>
<td>Peter</td>
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<td>UK</td>
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<td>Gabriel</td>
<td>Sami</td>
<td>Vodafone Group</td>
<td>UK</td>
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<td>Reza</td>
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Approved Agenda

IEEE/ICES TC95 Subcommittee 3
Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0 – 3 kHz

and

IEEE/ICES TC95 Subcommittee 4
Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 3 kHz – 300 GHz

0900 – 1530 h
Friday, 3 June 2016
Culture and Convention Center Het Pand
Ghent, Belgium

1. Call to Order
2. Introduction of those Present
3. Approval of Agenda
4. Approval of Minutes (January 2016 Meeting)
5. Chairmen’s Reports
6. Progress on revision of PC95.1-2005
   a. Update on NATO standard C95.1-2345
   b. Update on the revision of C95.1-2005 and C95.6-2002
   c. Literature surveillance
7. ICNIRP/ICES Harmonization Initiative
8. Technical Presentations
   a. Quantifying Complex EMFs with Respect to Human Exposure
9. New Business
10. Date and Place of Next Meeting
11. Adjourn
IEEE / ICES
Subcommittee - 4

Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 3 kHz – 300 GHz
Subcommittee - 4

SC-4 Co-Chairmen

Art Thansandote, Ph.D.
Marv Ziskin, M.D.
Subcommittee - 4

Aims:

To Protect Public

To Prepare International Safety Standards

Literature Surveillance

Update Standards when New Information is available
Major Task of SC – 3/4

Ongoing Revision of
C95.1-2005 RF Safety Standard (3 kHz – 300 GHz)
to incorporate
C95.6-2002 LF Safety Standard (0 Hz – 3 KHz).

Goal:

C95.1-xxxx Safety Standard (0 Hz – 300 GHz)
Editorial Working Group

Members: From both SC3 and SC4

Meetings: Face to Face - Occassional
           Teleconferences – Several each year

Tasks: Prepare Drafts
       Address Comments
Major Hurdles

1. Defining appropriate limits for contact currents

2. Choosing approach to establishing thresholds for adverse health effects:

   C95.6 - Based on Statistics
   C95.1 – Based on Absolute

Threshold Resolution: Retain both approaches
Progress on Standards

Combined C95.1 and C95.

Limits have been developed.

Literature review update needed
IEEE Standard for Military Workplaces—Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz

IEEE Technical Committee 95

Sponsored by the IEEE International Committee on Electromagnetic Safety (SCC39)

IEEE
3 Park Avenue
IEEE Std C95.1-2345™-2014
New York, NY 10016-5997
USA
Progress on Standards

NATO Standard C95.1-2345

NATO has ratified the adoption of IEEE C95.1-2345 as a NATO standard.

The publication of IEEE C95.1-2345-2014 has generated awareness and international recognition of ICES.
IEEE Standard for Military Workplaces—Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz

Will now replace previous NATO RF Standard

STANAG 2345

Special Thanks to B. Jon Klauenberg
Active IEEE SC-4 Standards

**IEEE C95.1™-2005**
Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

**IEEE C95.1a™-2010**
This amendment to IEEE Std C95.1-2005 specifies ceiling values for induced and contact current requirements, clarifies distinctions between “localized exposure” and “peak power density.

**IEEE C95.1-2345™-2014**
Military Workplaces--Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz
Progress on Standards

All C95.XX Standards are now available free of charge.

http://standards.ieee.org/about/get/index.html

Thanks to
US Air Force,
US Army
US Navy
Literature Review
International Committee on Electromagnetic Safety (ICES)

Procedures for Systematic Review of Scientific Evidence for Human Exposure to Electromagnetic (EMF) Fields (0–300 GHz) Standard Setting

Technical Committee 95 - Subcommittees 3 and 4
ICES Literature Review
Working Group

Members

- Antonio Faraone, Chair
- Bill Bailey
- Jerry Bushberg
- C-K Chou
- Joe Elder

- Ken Foster
- Marty Meltz
- Ron Petersen
- Mike Repacholi
- Marv Ziskin
The biological effects of RF exposure have been studied for more than 60 years.

Current IEEE website contains 5567 entries and with 2965 relevant to biological effects of RF exposure (as of June 11, 2014)

http://ieee-emf.com/IEEEdatabase.cfm
Outline

- IEEE ICES Database
- Validity of published articles
- Weight of evidence, percentage, and positive only evaluation
- Established vs. possible effects
- Basis of standards
- Conclusions
Literature Evaluation

• You are most welcome
  • to join us
  • in this endeavor.
IEEE ICES Literature Review
June 2016 Status Report

Antonio Faraone, C-K. Chou, Joe Elder
Timeline

- **Kick-off February 2015**
  - Identified topics and (lead) reviewers, defined (initial) review time-span 2003-2014
  - Provided/suggested literature search resources

- **June 2015 decision: Develop “review criteria” document**
  - Formed “Criteria Task Group”
  - Presented draft at January 2016 ICES meeting soliciting peer inputs

- **March 2016: Issued “review criteria” document**
  - Circulated to all reviewers

- **May 2016: special issue update**
  - Bioelectromagnetics quoted $45k to host topic white-papers
  - IEEE Engineering in Medicine and Biology Transactions quoted $30k
  - IOPscience Physics in Medicine and Biology – TBD
Criteria Task Group

- Bill Bailey
- Jerry Bushberg
- C-K. Chou
- Joe Elder
- Antonio Faraone
- Ken Foster
- Rob Kavet
- David Maxson
- Marty Meltz
- Ron Petersen
- Mike Repacholi
- Marv Ziskin
Topics & Lead Reviewers

Topics numbered per the current C95.1 Annex B

- **B.5.1 Thermoregulation**
  - M. Ziskin

- **B.5.2 Animal behavior, neurochemistry, neuropathology**
  - B. J. Klauenberg

- **B.5.3 Review of 0 Hz to 100 kHz studies**
  - Kavet & Reilly

- **B.6.1 Teratogenicity, reproduction, and development**
  - Bushberg

- **B.6.2 Hematology and endocrinology**
  - Pioli

- **B.6.3 Blood brain barrier (BBB) permeability**
  - Elder

- **B.6.4 Eye pathology**
  - Kojima

- **B.6.5 Auditory pathology and RF hearing**
  - Ravazzani & Parazzini

- **B.6.6 Membrane biochemistry**
  - Sheppard

- **B.6.7 Calcium studies and neuron conduction**
  - Sheppard

- **B.6.8 Other types of animal studies**
  - Faraone

- **B.6.9 Human provocation studies**
  - J. Withmore

- **B.7.1 Animal cancer bioassays**
  - Repacholi

- **B.7.2 Other animal and *in vitro* studies addressing cancer**
  - Vijay

- **B.7.3 Epidemiology studies (cancer and other endpoints)**
  - Erdreich

- **B.8 Mechanisms**
  - Balzano

- **Dosimetry and exposure system quality evaluation**
  - Faraone
IEEE DATABASE  @ ieee-emf.com

SC3/4 Meeting
Ghent, Belgium

June 3, 2016
“The primary purpose of the IEEE (Institute of Electrical and Electronics Engineers) database (ieee-emf.com/) is to provide a comprehensive database of the world’s English language literature on radiofrequency (RF) energy to support the review and revision, if needed, of RF safety standards published by IEEE. The goal is to identify all peer-reviewed research papers and other relevant reports such as peer-reviewed review articles and letters to journal editors. In March 2011, the database had over 5000 references of which over 3200 are research papers. Each entry has a brief description of the experimental approach/model and results; in addition, many of the research papers have a link to abstracts in PubMed. The database can be searched by a number of ways (author, study type, key word, year, frequency range, etc.). The core of the database is available without charge to the public; however, members of IEEE ICES (International Committee on Electromagnetic Safety) who are writing reviews of specific research areas have access to a password-protected area to support their work.”
On May 31, 2016, Database had

- 6304 citations distributed in 2603 projects and

- 5624 papers (PDF files).

- about 89% of citations have PDF file
Strategic approach to standardising spatial averaging

Peter Zollman BSc CEng FIET
Introduction

• Real world human exposure is often to multiple-RF source, multiple-ray incident EM fields over a range of frequencies.

• A point of interest may lie in different parts of the Source-Environment Plane (see IEC 62232) for each RF source.

• The RF fields are incident from many directions and with various polarisations.
Introduction

• Exposure guidelines tend to define field limits with relevance to free space plane wave fields from CW sources.

• They may offer only limited guidance on how to normalise complex field situations to these limits.
Introduction

• Spatial averaging is a measurement & computation technique.
• Several approaches have been defined globally.
• No clear agreement on what is the “best” scheme and no universal rationale for selecting between schemes.

Need clear context within which to review and commission research and further develop standards.
Context – Evaluating human exposure to complex EM fields

To define valid protocols to establish numeric values for field strength parameters in multi-ray/frequency EM field environments:

1. which best represent the power dissipated / currents (whole body / localised) in the human body exposed in that environment and;
2. which may be compared with relevant limits expressed in terms of simpler “plane wave” field(s) and;
3. to do so with known confidence and;
4. to characterise the limitations of each protocol.
Step 1
Establish human exposure “story”

Establish set of “reference” translations of complex incident field to “equivalent” limit values expressed in terms of a plane wave considering

- Source-Environment plane / Frequency
- Influence of body directivity/screening
  - Relevance for localized exposure
    - Maximum exposure
    - For specific point on human body
  - Relevance for WB exposure
- Influence of field polarisation

Data from the MMF-GSMA Dosimetry Program Phase 2 work packages 5, 6, 7 should be informative
Step 2
Establish sets of reference incident field cases

Establish a range of incident field cases (and/or Monte Carlo constraints) considering
- Frequency
- Source-Environment plane
- Range of sources
- Coherent / non-Coherent

Representative of the range of relevant evaluation cases within scope of ICES / IEC.
Step 3
Establish sets of models for measurement probes

Create computer models of “perfect” and realistic measurement probes/antennas

- Frequency
- Source-Environment plane
- Coherent / non-Coherent
- Polarization
- Signal bandwidth
- Directivity

Representative of the range of relevant evaluation cases within scope of ICES / IEC.

*Thoughts:*
*Consider $E^2$, $H^2$, perfect E & H vector, others....?*
Step 4
Subject probe models to reference field cases

Model the reference field scenarios with the range of probe models and compare with the reference outcome to characterize uncertainties and dependencies as point evaluations.

*Thoughts:*
Consider the interpretation of the point measurement for localised and whole body evaluation.
Don’t simplify at this stage.
Don’t overestimate at this stage.
Step 5  
Use probe models / reference cases to test spatial averaging

Use the probe models to evaluate the different spatial averaging schemes for the reference field scenarios to establish which schemes may be better under what circumstances.

Evaluate sources of uncertainties.

*Thoughts:*  
The averaging scheme plane needs to be defined in relation to the source. For multiple-source exposure, is a single vertical line the better approach?

*If measured signals are time-variant, what determines whether a single point evaluation is better/worse than a spatial averaging measurement performed over a significant time?*
Reflect on the findings from the previous steps and see if the observations and practical experience throws up any potential errors/omissions.

If so – revisit relevant steps including specific new research.

If not – update standards / dosimetry handbook appropriately.
Round up

• Evaluating levels of human exposure in every-day complex EM field cases is beyond what is defined explicitly in exposure guidelines.

• Need to establish a framework
  • to place/interpret the literature and text books which probably already have many of the required answers;
  • to identify gaps in understanding to target new research.

• Due to the range of potential scenarios and the challenge of real-world measurement uncertainty, a framework for repeatable relevant modelling is required.

• Modelled findings can then be sanity-checked against experience before progressing to drafting well-justified standards’ amendments.
THANK YOU

See you in SC4 for some technical stuff!

Peter Zollman
pzollman@theiet.org