# What's the Buzz about CEBoK-S?

# Presented by Carol Dekkers, SCEC
# and Kevin McKeel, SCEC

**ICEAA** International Cost Estimating and Analysis Association

**CEBoK-S**

**Quality Plus Technologies, Inc.**

**LOGAPPS**

# Introduction

- ## Carol Dekkers

  - 20+ years experience in software development, estimation and measurement, ISO standards development, project management, agile methods (Heart of Agile leadership)

  - Lead author of CEBoK-S (ICEAA 2022 Educator of the Year)

  - Holds SCEC, PMP, CFPS (Fellow), CSM (current), P.Eng. (Canada) designations

  - Independent consultant, author, speaker, instructor (global clients)

  - Frequent speaker at ICEAA, IT CAST, IFPUG, Project Management, agile software development conferences

  - Email: dekkers@qualityplustech.com
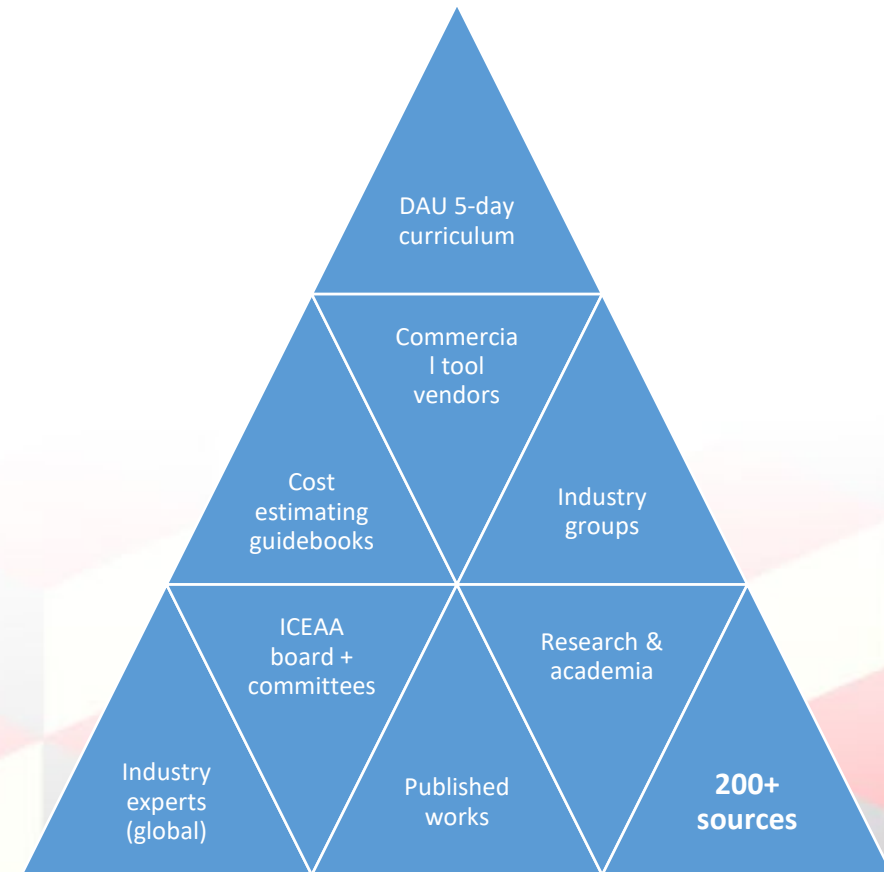
# Introduction

- **Kevin McKeel**

  - **20+ years experience as Software Estimator and functional size measurement SME**

  - **Certified Cost Estimator/Analyst (CCEA) –since 2002**

  - **Holds Software Cost Estimating Certification (SCEC)-since Dec 2024**

  - **2021 ICEAA Technical Achievement Award recipient**

  - **SAFe Architect**

  - **Frequent speaker at ICEAA, IT CAST and IT Project Management conferences on software estimation, NLP and AI**

  - **Email: kevin.mckeel@logapps.com**

# Agenda

- **Background to CEBoK-S**

- **Cost Estimating Body of Knowledge for Software (CEBoK-S)**

  - Overview

  - Curriculum

- **Software Cost Estimating Certification (SCEC)**

  - Process

  - Benefits of Certification

- **Q&A**

# CEBoK-S Background

- **Specialized extension** of ICEAA Cost Estimating Body of Knowledge (CEBoK®) for software

- ICEAA + industry collaborative development effort over 10 years

  - 200+ sources

  - New content (updated/globalized/enhanced) for software cost estimating

- **Specialized extension** of ICEAA Cost Estimating Body of Knowledge (CEBoK®) for software

- An evolving body of knowledge to meet changing industry needs

- *Special thanks to Carol Dekkers, Lead Author of CEBoK-S. Much of this content obtained from her 2023 & 2024 ICEAA Workshop presentations*



Pyramid diagram with segments labeled: DAU 5-day curriculum; Commercial tool vendors; Industry groups; Cost estimating guidebooks; ICEAA board + committees; Research & academia; Industry experts (global); Published works; 200+ sources

# CEBoK-S in 30 seconds

- **Recognizes that software estimation is non-trivial and of growing importance as software cost can dominate software intensive programs**

- **"Encyclopedia of best practices"** consolidated into nine easy-to-digest PPT® modules that extend CEBoK® core concepts to software

- **Provides guidance to estimate a range of software development efforts** depending on what is being built and how

- Equips the cost professional with **software estimating techniques and tips** that will increase their software estimating skills and proficiency

- **A comprehensive package of independent lessons** that provide a set of processes, approaches, considerations, equations, and resources useful for preparing to take the certification exam, and as an on-the-job reference/usage

- **Supports our new formal certification:** ICEAA Software Cost Estimating Certification (SCEC)

# CEBoK-S Provisions

## CEBoK-S does:

- **Provide guidance** for the experienced cost estimator to estimate the costs and schedule of developing, procuring and/or sustaining the software involved in software intensive programs.

## CEBoK-S does NOT:

- **Endorse** any particular method of software sizing, software development methodology, software estimating methodology or commercial tool vendor;
- **Prescribe** the essential considerations in software cost estimating – **however, it provides guidance.**

*Adapted from the 2020 CEBoK-S Terms of Reference*

# For whom is CEBoK-S intended?

- Members of software acquisition communities (globally)

  - Acquisition professionals responsible for cost oversight

  - Contracting Officers

- Estimators at Original Equipment Manufacturers (OEMs)

- Cost analysts who prepare for or validate/review software estimates prepared by, prime/sub contractors

- Consultants and finance-oriented professionals who prepare or validate/review software estimates for commercial organizations, consulting firms, C-suite executives, or FFRDCs

- Students or professors who want to advance their knowledge of software cost estimating

*Adapted from the 2020 CEBoK-S Terms of Reference*

# CEBoK-S content

Lesson 1: Introduction to Software Cost Estimating

Lesson 2: Software Development Paradigms

Lesson 3: Five-Step Estimation Process

Lesson 4: Estimating Custom Software Development

Lesson 5: Software Sustainment

Lesson 6: Procured Software

Over 800 slides of page turning content!

Lesson X: Software Size

Lesson Y: Productivity

Lesson Z: Commercial Estimation Models

# CEBoK-S Terms

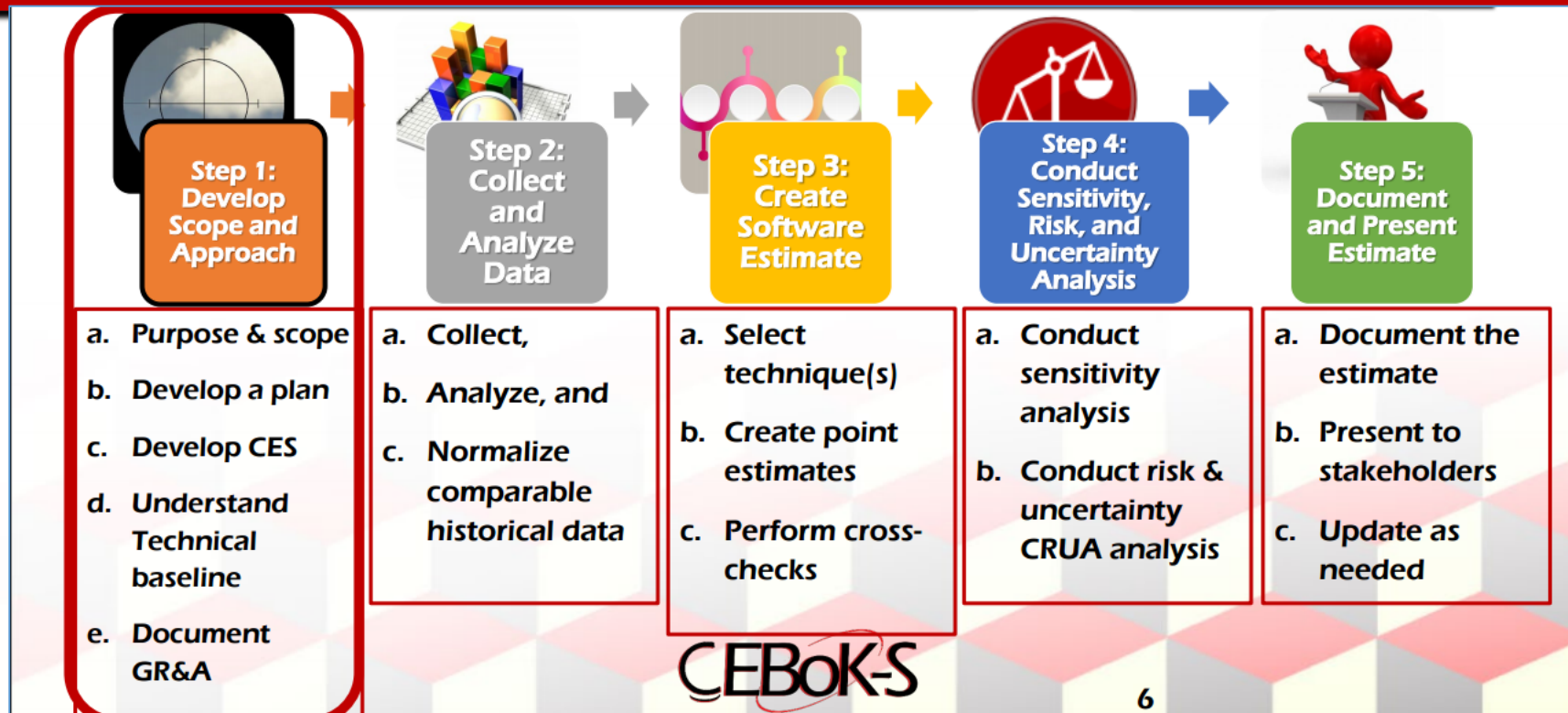| CEBoK-S Term | Definition | Examples | Synonym |
|---|---|---|---|
| Software Development Paradigm | "a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality. In software development, a paradigm **guides the way that developers view a given problem and organize the solution.**"[1] | Predictive or Plan-driven<br><br>Agile or Change-driven | Software development approach |
| Software development method | A structured series of steps and activities to develop software within a given paradigm | Waterfall, Scrum, Kanban, SAFe, hybrid | Software development life cycle (SDLC) |
| Cost estimating model | Commercial parametric software estimating tool or the COCOMO II model | TruePlanning, SEER-SEM, SLIM, COCOMO II tools | Parametric tools or OTS (Off-The-Shelf) Models |
| Cost Element Structure (CES) | Specifically refers to the hierarchical decomposition of costs, product or end capability. Capability-oriented, generally following the WBS practice rules from the GAO guide[2]. Estimates may be done at any level of the CES. | See lesson 3 | Cost estimating structure CES (DAU), WBS (GAO) or WBS (CEBoK) |
| Cost estimating Technique | The specific estimating approach and equation(s) used to create a software cost estimate | Parametric, analogy, engineering build-up, extrapolation from actuals, expert opinion | Cost estimating methodology |

# Sample CEBoK-S content

# Lesson 2: Software Development Paradigms

**1970-80's Predictive/Plan-driven**

Code & fix
Design-code-test-maintain
**Waterfall ***
**Spiral ***
**Incremental ***
**Evolutionary ***

**1990's Predictive moving towards agile**

V-model
**Rapid application development (RAD)**
**Rational Unified Process (RUP) ***
**Dynamic Systems Development Method (DSDM)**
**Scrum ***
eXtreme programming (XP)
Object-Oriented (O-O)
**Iterative ***
Lean

**2001- today Agile/change-driven**

**Kanban ***
**Scaled agile framework (SAFe) ***
**Lean software development**
**DevOps / DevSecOps***
**Scrumban**
**Disciplined Agile Delivery (DAD) ***
**Large scale scrum (LeSS)**
**Water-scrum-fall ***

- Important to understand software development processes and terminology and how paradigms may affect software cost and schedule
- Does not impact software size (different ways to build/deliver software products) but can impact productivity
- Introduces agile methodologies/frameworks including Dev/Sec/Ops

# Lesson 3: 5-Step CEBoK-S Estimation Process



| Step 1: Develop Scope and Approach | Step 2: Collect and Analyze Data | Step 3: Create Software Estimate | Step 4: Conduct Sensitivity, Risk, and Uncertainty Analysis | Step 5: Document and Present Estimate |
|---|---|---|---|---|
| a. Purpose & scope<br>b. Develop a plan<br>c. Develop CES<br>d. Understand Technical baseline<br>e. Document GR&A | a. Collect,<br>b. Analyze, and<br>c. Normalize comparable historical data | a. Select technique(s)<br>b. Create point estimates<br>c. Perform cross-checks | a. Conduct sensitivity analysis<br>b. Conduct risk & uncertainty CRUA analysis | a. Document the estimate<br>b. Present to stakeholders<br>c. Update as needed |

CEBoK-S

6

- Streamlined, comprehensive process combining GAO Cost Estimating and DAU processes

- Specific to custom software development CER/SER. Similar approach (with obvious modifications) for procured and hybrid software development efforts

13

# Lesson 4: Estimating Custom Software Development

- Four fundamental software cost estimating techniques (Note: expert opinion not considered a primary estimating methodology)

- Case study examples of how to use and apply 5-step CEBoK-S

| Technique | Approach | Cost (Effort) Equation | General form | Estimate size | Sizing units | Estimate Productivity directly? | Estimate Complexity & Capability directly? | Formula for productivity | Linear equation when |
|---|---|---|---|---|---|---|---|---|---|
| 1. Parametric (based on derived CER) | Derive a CER | Effort = A*Size$^E$ | Non-linear | Yes | Any | No | No | $1/(A * size^{(E-1)})$ | E=1 |
| 2. Parametric (based on published CER) | Use published CER (COCOMO II)[2] | Effort = 2.94*KESLOC$^E$*EAF | Non-linear | Yes | KESLOC (modified for FP[1]) | No | Yes | $1/(2.94* KESLOC^{(E-1)}*EM)$ | E=1, and EM=A/2.94 |
| 3. Analogy | Productivity-based | Effort = A*Size | Linear | Yes | Any | Yes | No | 1/A | Always |
| 4. Wideband Delphi Expert Opinion | Solution WBS – based | Simple mean of individual expert estimates | Linear | Not necessary | N/A | N/A | N/A | N/A | Always |

Where: A = the reciprocal of **productivity**; productivity expressed in output size / input effort (hours or person months)
E = exponent on **size** representing the relative economies or diseconomies of scale, or constant returns to scale
EAF = Effort Adjustment Factor: Product of COCOMO II Effort Multipliers (EM)    Size = Software size

# Lesson X: Software Size

- **Cost estimators need to understand:**

  - Software size is a major cost driver

  - What are the types of software size and associated units of measure

  - Relationship of size to effort

  - What does the estimated size mean?

  - Scope of size estimate

  - Questions to ask experts

  - How size is a source of uncertainty

- **No expectation for cost estimators to be(come) size experts!**

### Types of software size and units of measure

1. **Physical size:** Source Lines of Code (SLOC)
2. **Functional Size**
   - A. International Function Point Users Group (IFPUG) Function Points (ISO/IEC 20926) **
   - B. Nesma Function Points (ISO/IEC Standard ISO/IEC 24750) **
   - C. Common Software Measurement International Consortium (COSMIC) Function Points (ISO/IEC Standard ) **
   - D. Simple Function points
   - E. Object Points
   - F. Use Case Points
   - G. Requirements (Software Engineering Institute)

### Relationship of size to effort

Example chart based on COCOMO II: Source: https://www.javatpoint.com/cocomo-model



Effort versus product size
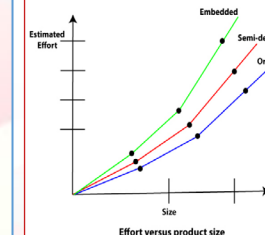
- Software size is one of the main drivers of **software development** effort and cost → use the best available estimate of size
- Relationship between size and software development cost (based on effort) is most often non-linear and displays diseconomies of scale
- Better size estimates → better effort, cost & schedule estimates

# Lesson Z: Commercial Estimation Models

- **Introduces four major commercial cost estimating software packages:**

  - **Non-exclusive (others available)**

  - **Each uses its own Parametric Cost Estimation (CER/SER) with own database(s)**

| Name | Developer | Selected Inputs | Selected Outputs | Key Advantages | Key Limitations |
|------|-----------|-----------------|------------------|----------------|-----------------|
| 1. COCOMO II Web-tool | Dr. Barry Boehm, USC Center for Systems and Software Engineering http://softwarecost.org/tools/COCOMO/ | Development: Size (SLOC or Function Points), language, software scale drivers (5) and cost drivers (17), labor rate Maintenance: ESLOC annual change, maintenance duration, understanding (1-50%),, unfamiliarity (0-1), labor rate | Development effort, (in person-months), schedule (calendar months), cost, staffing profile, acquisition phase and software effort distribution profiles

Maintenance Effort (person months), annual maintenance cost, total maintenance cost | • Free
• Many OTS tools based on COCOMO equations
• Widely used/respected
• Transparent calculations
• Wide number of COCOMO II related extension models including COCOTS (COTS), COSYSMO (Systems Eng,) etc. | • Subjective cost drivers,
• Calibration requires multiple data sources
• Simplistic output
• No variation by domain
• No guarantee of support – models, tools, and research no longer on public website at University of Southern California |
| 2. Galorath Inc. SEER for Software® (SEER-SEM®) | Dan Galorath, Galorath Inc. http://galorath.com/products/software/SEER-Software-Cost-Estimation | Platform, Application, Reuse Scenario, Development Method and Development Standard. Size in SLOC, Function Points or a variety of other size metrics. Many detailed parameters describing the people, processes, and constraints on the project | Development effort (in person-months or dollars) and duration (in calendar months), staffing by month, delivered defects and defect density

Maintenance effort and cost | Ability to calibrate model by "running it in reverse:" back into effective technology rating (ETR) through inputs of actual effort or costs; robust databases augmented with ISBSG D&E data. Knowledgeable customer support. | Large number of inputs requires tacit knowledge of the software system

Proprietary equations and data, (but available to clients with non-disclosure agreements (NDAs)), license fees;, |
| 3. Unison Cost Engineering : True Planning for Software | Unison Cost Engineering: https://www.unisonglobal.com/product-suites/cost-engineering/cost-engineering-models/ | Size, Language, Application, Degree of Reuse, Phases, Complexity Factors | Development effort (in person-months or dollars) and duration (in calendar months) | Ability to calibrate model by "running it in reverse:" back into productivity factor through inputs of actual effort or costs, robust databases augmented by ISBSG D&E data. Knowledgeable customer support. Sensitivity analysis capability for all quantitative inputs that allows users to see in real time how a particular input influences the overall cost/effort of their current project in context | Large number of inputs requires tacit knowledge of the software system.

Proprietary equations and data, (but available to clients with NDAs); license fees |
| 4. QSM, Inc. SLIM-Estimate® | Larry Putnam, Senior, Quantitative Systems Management (QSM) http://www.qsm.com/tools | Size (if non-SLOC, must enter conversion factor), Productivity Index, Solution Method (constrained vs. unconstrained) | Development effort (in person months), duration (in calendar months), cost, required peak staff, mean time to defect (MTTD), probability of completing project on time and under budget | Equations published in Larry Putnam, Sr. **Measures for Excellence** (1991). Ability to visualize where estimate falls relative to history, using robust historical database; ability to customize estimate to any degree of confidence along various dimensions. Knowledgeable customer support. | Flexibility in non-SLOC measures of size (a strength) is possible with customer-supplied conversion factors (productivity indices).

Proprietary equations and data, (but available to clients with NDAs); license fees |

16

# CEBoK-S coverage

- **CEBoK-S provides guidance to estimate software acquisition and sustainment of the Software-intensive program work breakdown structure (WBS) as highlighted**
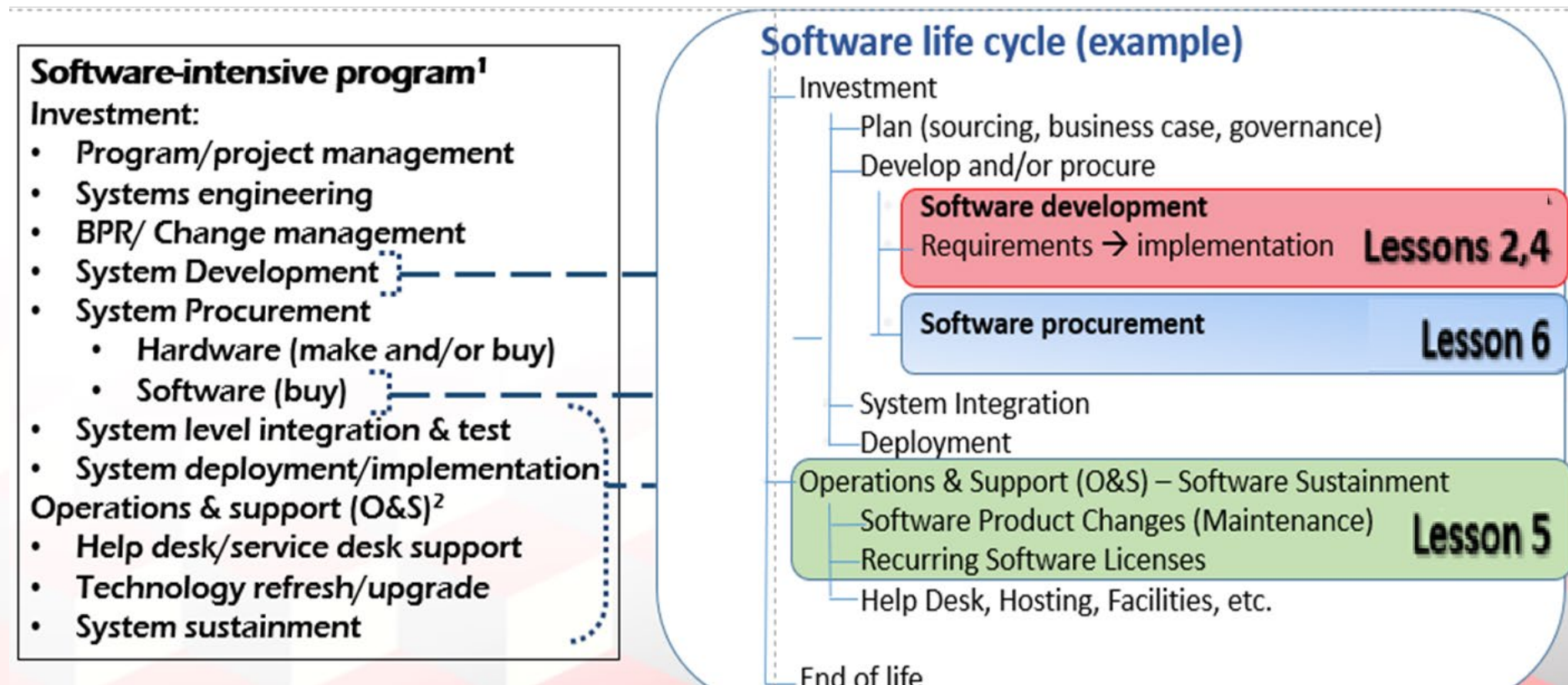
# SCEC
# (Software Cost Estimating Certification)

- **SCEC exam candidates need at least two years of software cost-related experience and will need to purchase the CEBoK-S material to take the certification exam.**

- **CEBoK-S provides testable material for the SCEC (and is a great resource for):**

  - **Identifying best practices with software development and procurement effort and cost estimation, sustainment, and maintenance.**

  - **Estimating cost and schedule for software products, including custom development (agile, waterfall and hybrid methodologies), Commercial-Off the Shelf (COTS), Government Off-the Shelf (GOTS), software as a service (SaaS), and others.**

  - **Reviewing and validating 3rd party software size estimates, development costs, and sustainment and maintenance schedules.**

  - **QA Checklist**

  - **Covers Software Development (and Software Sustainment) cost and schedule estimating**

18

# Steps to SCEC Certification

- ICEAA SCEC Certification Application (2-year experience requirement)

- Base costs (payable to ICEAA):

  - $595 CEBoK-S materials ($745 non-members)

  - $350 SCEC exam fee ($515 non-members), $150 Exam Re-Take

  - $150 ICEAA 1-year membership

- SCEC Exam → 60 multiple choice questions (70% threshold)

- 5-year certification, with ICEAA recertification process

- Helpful Links

  - https://www.iceaaonline.com/certification/

  - https://www.iceaaonline.com/application/

- Licensed training providers (trainer must be SCEC)

  - Logapps

  - Quality Plus Technologies, Inc.

# Summary: CEBoK-S and SCEC Benefits

- Software → increasing impact on programs and thus in the cost estimation/acquisition world ($$$B USD)

- Traditionally, software cost estimation "assumed" to be trivial → unnecessary consequences (litigation, cancellation, overruns, overoptimism, mistrust)

- CEBoK-S provides professional, proven, and relevant body of knowledge for cost estimators worldwide

- SCEC establishes basic knowledge of CEBoK-S

- Career Advancement

# NEXT STEPS:
## CEBoK-S and SCEC Opportunities...

- **PURCHASE YOUR COPY OF CEBoK-S:**

  - Comprehensive reference materials

  - Should be base knowledge for all software cost estimators

- **COORDINATE CEBoK-S TRAINING AT YOUR COMPANY/AGENCY:**

  - Approximately 2.5 days of concentrated exam content review (all 9 modules) – contact ICEAA

- **BECOME AN SCEC (SOONER THAN LATER!):**

  - Exam question bank is expanding → exam complexity will increase

  - SCEC is available to everyone (new DAU certification limits participation)

- **INCREASE THE VALUE OF YOUR CCEA/PCEA AND OUR PROFESSION:**

  - A rising tide floats all boats!  Spread the word about the value of professional, data-founded estimating

- **HELP TO CREATE SOFTWARE DEVELOPMENT SUCCESS:**

  - Professional, data-founded, software estimates →realistic contracts →on-time and on-budget deliveries

- **VOLUNTEER:**

  - ICEAA Software SIG seeks volunteers: curriculum and marketing

# CEBoK-S Contributors

- Carol Dekkers, Quality Plus Technologies, Inc. - Lead Author and Project Manager CEBoK-S

- Kevin Cincotta, MITRE and Dave Brown, Technomics – Senior advisors and reviewers

- Rick Collins, Technomics - ICEAA 2019-2021 President

- Megan Jones, ICEAA Executive Director

- ICEAA CEBoK-S Review Group (ISRG):
  - Jennifer Kirchhoffer – Tecolote Research
  - Dr Wilson Rosa, US DHS CAD
  - Dan French - Cobec Consulting, Inc.
  - Arlene Minkiewicz - Unison Cost Eng.
  - Denise Nelson – The Boeing Company
  - Sanathanan Rajagopal - Sirius Analysis
  - Dr Christian Smart - Galorath, Inc.
  - Eric van der Vliet - CGI
  - Harold van Heeringen - METRI Group
  - Brian Glauser – Unison Cost Eng.

# Questions ?