Breakout_B-10 (can map to issue name later)

Issue: https://github.com/CFDSI/Kickoff_Workshop/issues/#
Related Issues:

Issue Statement: Can common software be developed for data analysis of fields from higher order simulations?
Discussion topic:
Moderator: Saikat Dey
Note taker: DeAnna Sewell
Reporter: John Evans
Group Members:

- Mark Shephard
- Duane Rosenberg
- Corey Nelson
- DeAnna Sewell
- Saikat Dey
- John Evans
- Mike Kirby

Please address these topics in your discussion (moderators please make sure that there is enough time to cover all three before the session ends).

1. Describe the problem:

- The problem is a bit hard to define, so we instead pose questions to try to define the problem.
- What is a higher-order simulation, and what are the sorts of technologies we are looking to bridge?
    - There is a difference in definition between academia, the labs, and industry.
    - Higher-order includes: spectral and spectral element methods, compact FDM, FVM, p- and hp-FEM, DG-FEM, isogeometric methods, etc.
- Does the community even understand the role (or potential impact) of higher-order simulations, especially for complex, multi-physics simulations in the face of V&D and uncertainty?
    - Higher-order methods have classically been understood as being fragile.
- What are the deficiencies in existing pre-processing technologies for higher-order simulation, and are these deficiencies shared between methods?

    - Higher-order accuracy requires higher-order meshes.
- What are the deficiencies in existing post-processing technologies for higher-order simulation, and are they able to really expose the benefits of higher-order technologies?
    - Most visualization packages support only low-order (linear, bilinear, trilinear) interpolations or at most quadratic interpolations. Moreover, they were not developed for higher-order.

2. What are potential solutions?

- Standardizing inputs for pre/post software to for all methods to use
- Create educational resources for exploring the forest of high order methods
    - Provide a “thesaurus” of language for high order methods (e.g. node vs vertex, degree vs. order).

3. What can CFDSI do to help?

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4. Misc ideas so they don’t get lost (e.g., Did you find new issues? If yes, create the issues on GitHub!):

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5. Summary for report-back (Alternatively, just bold the key points above):

- **The Problems:**
    - High-order methods span a wide range of technologies which may use different geometric and analysis descriptions. Consequently, there has been no universal “standardization” for pre- and post-processing.
    - There many higher-order codes, with a wide range of input files.
    - There is a difference between “data” and “function standardization”.
    - There is a terminology problem. Different methods use different names for the same thing (e.g., order and degree).
    - Educating and training the future generation is a big problem because of the above.
    - The community often views the starting point as a mesh, but it’s really at the stage of creating a model (geometric and analysis).
    - Classical pre-processing technologies (e.g., mesh generation) have focused on low-order methods.
    - Classical post-processing technologies (e.g., visualization) have also focused on low-order methods.
    - We can interpolate to low-order meshes, but we end up losing a lot of

information (e.g., higher-order moments).

- **Potential Solutions:**
  - Standardizing inputs for pre-/post-processing software may help.
  - Standardizing or at least cataloging language (providing a “thesaurus”) may help.
  - Interpreter software may be a more sustainable option (“function standardization” rather than “data standardization”).
  - Educational modules could help young researchers get started with (and not misunderstand!) higher-order methods and to understand the relationship between different higher-order methods.
  - We should standardize descriptions of high-order field data (and meta-data) rather than point-wise data.
- **What Can CFDSI Do To Help:**
  - See potential solutions!
- **Misc. Issues:**
  - There is not a general consensus as to when and how high-order methods should be applied. This is the case for high throughput and high performance computing. This is a discussion in the exascale community.