SAND2018-7973PE

Guidelines for Creating a Challenge Scenario

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Features of a Challenge

- Assesses of the **entire prediction stream** (Experiments, Theory, and Computations)
- Replicated **real-world engineering constraints** (namely limited data and time for prediction)
- Tests a **"toy problem"** that can be apparently simple (e.g. simple geometry) but physically difficult to predict (beyond intuition, requiring a predictive model to manage complex physical processes).
- **Does not specify methods** to that can be used
- **Requires blind predictions** (requirements of ethics that teams do not try to perform experiments or gain access to data from Challenge organizers beyond the Challenge information packet, though teams can use referenced data from other sources)
- **Verify experimental results** in more than one lab to demonstrate lack of bias in experimental results [May not be possible for some Challenges where a unique capability prevents duplication]
- **Quantities of interest are measurable** from both experimental and computational results
- **Calibration experiments could be replicated**, though not required for Challenge issuance [Enough detail is provided in order to limit "controversial" data]

Things to Consider

- **Experiments**
  - What calibration data is a "must-have," and what "would be nice"? Are the choice of calibration experiments / data limiting the possible computational approaches? If so, is that reasonable?
  - Will the experimental data itself be controversial? Be as clear and detailed as warranted – utilize standard methods wherever practical.
  - Are the boundary conditions of the problem reasonable to both test and model?
  - What pre-test measurements are needed for the model? Examples: geometry, microstructure.
- **Quantities of Interest**
  - Is this quantity measurable in the experiment and in the models?
  - Does the formulation of the question bias the participants towards a particular answer?
  - Does the quantity help us tease out salient features of predictions and the modeling choices?
  - Are there qualitative comparisons that should be made?
- **File Management**
  - File names and labels inside the data for both data going out and predictions coming in
  - Universality of the file type (e.g. tab-delimited ASCII text files, image file types, etc.) for data to be sent out and collected
  - Data storage. Can the participants easily access the data throughout the multi-year lifespan, and can other investigators later access the data well after the challenge is complete? Is the data presented in a self-explanatory way, with a clear "table of contents"?
  - Specification of units to be used
- **Timing**
  - Time for predictions will vary in each challenge
  - Anticipate receiving requests for extensions to the due date
  - If supplemental information is set out after the original challenge was sent out, consider adjusting the due date to give teams the appropriate time to adjust their models in light of new information
  - Consider how the timing aligns with the academic calendar.

A Checklist for Formulating a Challenge

- Ethics Statement: Clearly define the ethics of the blind-prediction (no experiments, use of previous related data is allowed if it can be disclosed, teams can pull from literature)
- Problem Definition
  - Precisely defining the problem of interest: What phenomena are you trying to interrogate?
  - Is there key background literature that should be shared among all participants?
  - Salient features of the problem that can be distilled down into experiments and numerical models
- Calibration Data and Challenge Scenario Descriptions
  - Geometry (drawings and actual measurements), boundary conditions, and descriptions of equipment used.
  - Where appropriate provide detailed material information so that the pedigree and history is understood.
  - Clear descriptions of all calibration data to eliminate ambiguity (sufficient provenance so the data can be used without need to clarification)
  - Post-test analysis of experimental specimens (calibration and Challenge geometries) such as fractography to help with blind predictions and for post-blind comparison
  - Clear definition of coordinate systems for experiments and predictions
- Quantities of Interest (QOIs)
  - Clear, unambiguous QOIs that can be measured in the experiment and predictions (apples-to-apples).
  - Specify units for numerical answers
  - Specify appropriate data spacing for independent variables (e.g. specify displacement data spacing to be 0.5 mm)
- File Management
  - Prescribe a file format for the QOI; recommend ASCII-tabs delimited for tabulated data
  - Prescribe file names (e.g. Q1_TEAMNAME.txt); instruct each team to give themselves a unique name for the blind predictions, preferably their institution, but these names should be reassigned to Team A through ___ once all the predictions are in for better legends in your compiled plots
  - Provide an specific
- Due Date: select a specific due date that give an appropriate amount of time necessary for teams to make reasonable predictions (not too much or too little)
- Fairness. Be open and honest. If a time extension is given or if new information emerges midstream, it should be offered to all teams.
- Utilize a registration process to track which teams have accessed the starting files, so you can update them if needed.
- A clear communication path in case there are any questions for the moderator.
- A moderator who is cognizant of all facets of the problem and can respond to questions quickly and fai

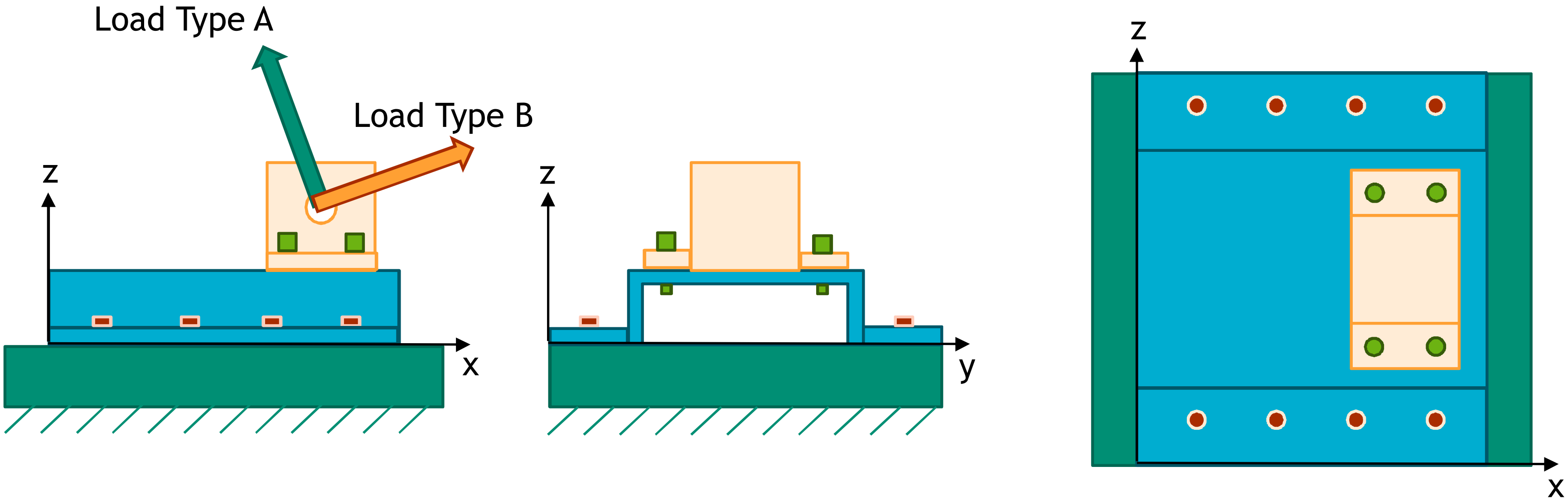
Example Challenge Scenario: Bolted Joints

Purpose:

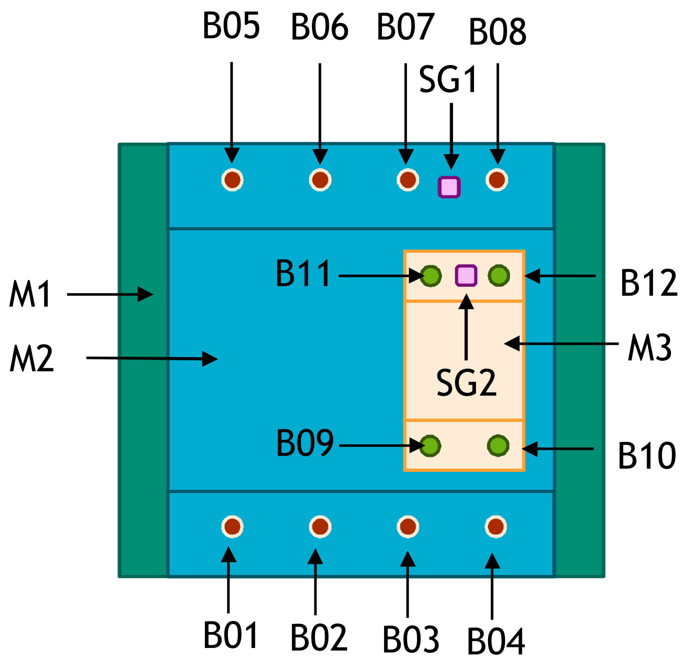
Compare different approaches to modeling deformation and failure of bolted joints

Overall Metrics:

Predict the deformation history and failure mode in a bolted structure subjected to two different off-axis loads



Example Challenge Scenario: Quantities of Interest



The structure will be pulled at two different angles relative to the structure (at 20º and 70º off vertical, Load Types A and B respectively) with a pin connection (details provided) at a rate of 0.5 mm/s. Details of structure will be provided.

Question 1: What is the global load versus pin displacement history for the structure through complete failure (load goes to zero) for Load Types A and B?

Question 2: Where does a crack first initiate in the structure? List component and location relative to provided coordinate system for both Load A and B. Note: Location will be approximate in experiments due in inability to see throughout the volume.

Question 3: What is (are) the main failure mode(s)? Provide the sequence of the failure of the structure. Examples: Fracture of lower bolts B04/B08; bolt pull out of upper bolts B09/B11 – B10/B12, or fracture of upper structure M3 at pin connection

Question 4: What is the engineering strain versus pin displacement history for two stacked 0º-45º-90º rosettes at locations SG1 and SG2? Note: the max/min strain recorded strain will be +/-30000-microstrain; a saturated value will be given for values outside the measurement range.

Green Material (M1): Mild Steel
Blue Material (M2): Al 2024
Orange Material (M3): A286 Steel
Red Bolt: ¼-20 Grade 8
Green Bolt: 3/8-16 Grade 5

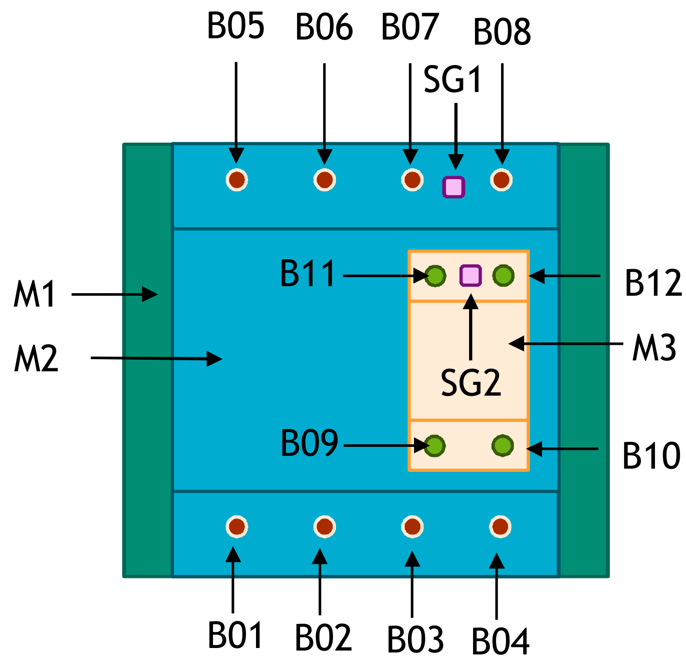
Example Challenge: Problem Definition

The bottom piece M1 is a thick wedge (not shown here, but drawing provided) with relative angle of 20° and a threaded hole pattern, allowing for both the 20° and 70° pulls depending on how the M2 structure is bolted to M1. The M1 piece had a 2”-12 threaded hole to attach to an 110-kip (500-kN) MTS load frame.

The 3/8-16 bolts are torqued to 23 ft-lb (31.2 N-m), and the ¼-20 bolts are torqued to 9 ft-lb (12.2 N-m). The 3/8-16 bolts use a grade 5 nut. There were no washers or lubricant used.

The 18-8 stainless steel, 1.25-in (31.75-mm) clevis pin was purchased commercially from McMaster-Carr (https://www.mcmaster.com/#92390A841).

The clevis on the load frame was custom-made (drawing provided) from 316 stainless steel.



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Example Challenge Scenario: Provided Information and Files

- Experimental Considerations:
  - Pin and clevis information
  - Fixture design
  - Drawings of specimens and fixtures
  - Strain gage information
- Calibration Data:
  - Material certifications for materials M1, M2, and M3.
  - Heat treatment, microstructure, and hardness data for materials M1, M2, and M3.
  - Tensile and notched tensile tests or fracture toughness tests for materials M1, M2, and M3 (in multiple orientations).
  - Tensile and shear tests using a bolt test fixture following a NASA standard NASM1312-2 with bolts hand tightened and torqued to same values in the Challenge geometry with inserts made from the correct materials.
  - Images of fractured specimens (shape and fracture surfaces)
  - Pre-test geometry measurements
- QOI files:
  - Question 1: Submit an ASCII tab delimited file named "Q1_TEAMNAME.txt" with your team name inserted with two columns of data for D_(mm) and F_(N) for the pin displacement in mm and load in N. The data spacing on the pin displacement is every 0.5 mm.
  - Question 2: Complete Table, returning values in an ASCII tab delimited file named "Q2_TEAMNAME.txt" with your team name inserted with two columns and 4 rows for Load Types A and B. Locations should be given relative to the reference configuration.
  - Question 3: Submit a text file describing the sequence of failure named "Q3_TEAMNAME.txt" with your team name inserted.
  - Question 4: Submit two ASCII tab delimited files named "Q4_SG1_TEAMNAME.txt" and "Q4_SG2_TEAMNAME.txt" with your team name inserted, one file for each strain gage, with four columns of data for D_(mm), e0_(micro-strain), e45_(micro-strain), and e90_(micro-strain) with the pin displacement in mm and strains in micro-strain. The data spacing on the pin displacement is every 0.5 mm.

Question 2		
Items	A	B
Component		
X_(mm)		
Y_(mm)		
Z_(mm)		

Example Challenge: Dates and Ethics Statement

Challenge Issuance: August 1, 2018

The following deadlines are in effect:

(1) Any concerns regarding the challenge or sufficiency of the supplied data should be communicated to Sharlotte Kramer, slkrame@sandia.gov and copied to Brad Boyce blboyce@sandia.gov by **September 1 2018.**

(2) Predictions must be e-mailed to slkrame@sandia.gov and copied to blboyce@sandia.gov by midnight, **December 1, 2018** (4 months after challenge was issued). Experimental results with compiled predictions will be e-mailed to all participants by **January 15, 2019**.

Ethics: Detailed material property data has been included in the challenge. **By participating in the Challenge, all participants agree to not perform any mechanical experiments for the purpose of calibrating or validating their models.** IN ADDITION TO THE MATERIAL PROPERTY DATA PROVIDED, YOU ARE WELCOME TO USE ANY EXISTING PUBLISHED INFORMATION. PLEASE KEEP TRACK OF WHICH ADDITIONAL DATA YOU DRAW FROM, IF ANY.