MULTI-TASK TREBUCHET
2009-2010

Competition Overview
The Multi-Task Trebuchet event involves the transfer of energy from the counterweight to the projectile being thrown. **The maximum amount of energy available to complete the tasks will be limited to that stored by raising the counterweight.**

1

Performance – Teams will research, design, build, test and compete with a trebuchet designed to meet energy, projectile, counterweight, and size characteristics of the event.

a. Distance: farthest distance thrown of a single projectile
b. Accuracy: nearest distance of projectile impacts to two ground level targets
c. Design Efficiency: greatest ratio of device performance score to device mass.

*The middle school devices will perform the first two tasks and earn points for design efficiency from that score.

Each team competing must consist of 4 (four) students (2 male, 2 female) who are active members of a MESA program.

Feedback and comments are welcomed; please see the attached *Activity Feedback Form*.

Scoring Summary
Final team rankings will be based on the total score derived by adding all of the task scores.

Device Performance	150 points
Design Efficiency	25 points
Total Points	175 points

Automated Event Scoring Software is available

2009-2010 MESA USA
Engineering Design Competition
Multi-Task Trebuchet (MTT)
Device Performance
150 points

Objective

Students will build **ONE** Trebuchet, meeting the criteria outlined in the rules, designed to perform the following tasks:

Middle School

(1) Distance - farthest distance thrown of a single projectile
(2) Accuracy – nearest distance projectile impacts to two ground level targets

Design Efficiency – greatest ratio of performance score to device mass

Materials

Hazardous materials may not be used in the construction or operation of the device, including but not limited to lead.
All other materials to build the device are legal and optional

Rules

General

1. Teams must design, build and operate their own trebuchet device.
2. The device must be solely powered by the energy available from the dropping counterweight.
3. All designs that conform to the energy rules will be allowed to participate. A simple trebuchet sketch is shown here. All teams should carefully review design configuration to ensure that no additional energy is applied to the tasks.

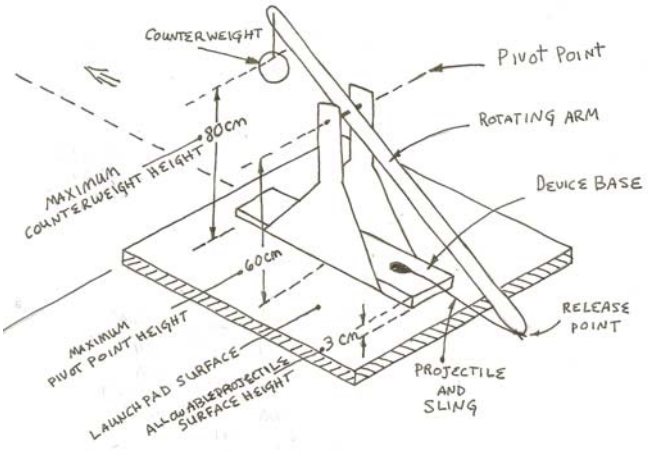
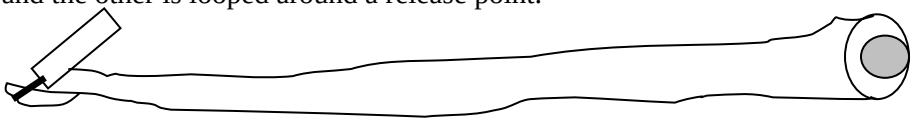
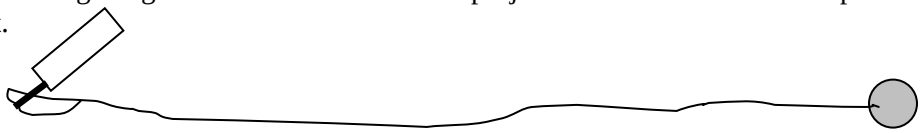


Figure 1

4. Use of a sling is required in the competition. Two types of slings are allowed in the competition:
   - Staff sling attached to the end of the throwing arm – one end of the sling is fixed to the end of the arm and the other is looped around a release point.



   - Single string sling attached to the individual projectile and the other end looped around the release point.



5. The device must incorporate a trigger mechanism that has a “ready-to-launch” position that allows it to be activated by a single student while standing in the Trigger Area to the side, 150 cm from the launch pad.

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General - continued

6. Wheeled devices are not allowed.
7. Once performance competition begins, student teams may not have contact with non competitors. Student teams are solely responsible for interaction with judges and addressing problems with devices.

Counterweight

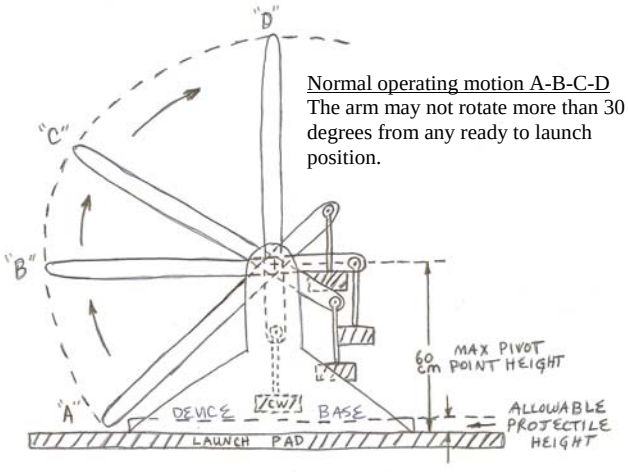
8. The counterweight mass must not be greater than 1.5 kg.
9. The maximum height that any portion of the counterweight may be raised above the launch pad surface during operation is 80 cm. See Figure 1.
10. The counterweight must be detachable for mass measurement. All materials used to attach the counterweight must either be included with the counterweight measurement or remain attached to the rotating arm during inspection.

Projectiles

11. The projectiles must be of a material and contents that will not harm a gymnasium surface upon impact. The projectiles should be durable enough for repeated throws during testing.
    a. Metals, liquids and sports balls are not allowed as part of the projectiles or attached slings.
    b. Recommended materials: commercial hacky sacks/footbags or cloth, balloons or similar materials.
    c. Required contents for non-commercial projectiles: rice, beans or salt.
12. The projectile(s) to be thrown must have a mass greater than 40 grams.
13. The projectiles must begin in contact with a horizontal surface no higher than 3 cm above the launch pad surface. The launch pad itself or facility floor may serve as this horizontal surface.

Rotating Arm

14. The rotating arm must include its own pivot point.
15. The maximum height of the rotating arm pivot point must not exceed 60 cm from the launch pad surface. See Figure 1 or 2.
16. The pivot point of the rotating arm may not move vertically during operation.
17. With the counterweight, projectile and sling removed, the rotating arm must balance in all positions of the arm's full operating motion used during each task. The arm may not rotate more than 30 degrees from any ready to launch position.



Normal operating motion A-B-C-D
The arm may not rotate more than 30 degrees from any ready to launch position.

18. The rotating arm must not flex in such a way as to store additional energy for the task when placed in the "ready-to-launch" position.

Construction and Repair

19. The device must use the same parts for all tasks. Altering the arrangement of parts is allowed. EXCEPTION: Separate slings may be used with each task.
20. Repairs are allowed, replacement parts and materials only, no new or alternate parts. All repairs must be done in the impound area under supervision of a judge. The addition of new or alternate parts is NOT allowed.

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Safety

21. Standard safety practices including the use of protective eyewear must be observed. Use of helmet is recommended.
22. Students must operate their device in a safe manner. The device may not be activated while team members, judges or spectators are behind the device or in the competition area. Teams using UNSAFE PROCEDURES may have trials disqualified at the discretion of the judges.
23. The device must be sturdy enough as to not pose a danger to students, officials or spectators during operation, as determined by the judges.
24. Except for the rotating arm, sling and projectiles, no part of the device may extend outside the launch pad dimensions as seen from above or any side during operation. Teams must allow their device to come to rest without assistance. Only the flat wood surface will be provided. Teams may not modify the surface of the launch pad. Trials will be disqualified for each violation.

Inspection, Impound and Operation

25. The trial order for performance events will be randomly selected.
26. Device inspection will take place prior to being impounded for the performance events. Inspection will include demonstration of device operation for all tasks to the judges.
27. Devices must be in testing condition prior to device inspection. If devices are disqualified during inspection check, design changes will not be allowed. Only devices passing inspection will be allowed to participate in the performance tasks.
28. All repair materials, slings and projectiles to be used during the competition must be impounded with the device. Devices will be released for trials but will remain impounded between tasks.
29. Each device must be ready for competition when called or forfeit that trial.
30. The team member responsible for launch will indicate to the judge that the device is in the "ready-to-launch" position.
31. Students must wait until the judge gives the "START" order. If the device moves prior to this, a "False Start" will be declared by the judges.
32. Only one "False Start" will be allowed per task trial. Two "False Starts" during a trial attempt disqualifies that trial.
33. Students may not touch or interfere with the device once it has been released. If the trigger mechanism fails it is considered a "False Start".
34. If during operation a device is found to violate rules those trials will be disqualified.

Tasks and Measurements

35. Distance Task:
    a. Two throws will be measured as the distance from the launch line to the point of initial impact of the projectile, measured in meters.
    b. The longest throw will be the official best throw.
    c. Projectiles landing outside the 5 meter width of the competition area receive zero points
36. Accuracy Task:
    a. Four throws - Two throws at each fixed distance horizontal target – 6.25 and 10 meters.
        i. First two throws at Target 1 (6.25 m with a 125 cm radius)
        ii. Second two throws at Target 2 (10 m with 200 cm radius)
    b. The distance will be measured from selected target center to the point of initial impact of the projectile, measured in centimeters. Each target is worth equal points.
    c. The nearest throw for each target will be official best throw for that target. One throw for each target must be counted.
    d. Projectiles not landing within the identified target radius will receive zero points.

37. Design Efficiency:
    a. The device mass will be measured as a part of the device inspection with the projectiles, counterweight and slings removed.
    b. The Total Performance score from the Distance, Accuracy and Strength tasks will be divided by the device mass in kilograms to determine Device Efficiency in points per kilogram.

Assigning Scores to Performance

1. The Total Performance Score will be determined by the sum of the points earned in each task and performance efficiency

2. Scores for each task equal the ratio of each device's performance relative to the winning device's performance on that task. Those scores are weighted according to the maximum points for each task:
   Middle School Tasks: 75 points each

3. Ties are allowed in each task

Distance Task: (distance measured in xx.xx meters)
1. Task winner =
   Farthest or Winning distance (**D_w**) receives 75
2. Task Points =
   Team distance (**D_t**) divided by (**D_w**), times 75

$$\text{Task Points} = D_t \Big/ D_w \times 75$$

Example
Distance Task:
Winning Distance (**D_w**) = 16.54 m
Team 5 Distance (**D_t**) = 13.23 m
Middle School Score =
(13.23/16.54) x 75 = 59.99 pts

Accuracy Task – Two Targets: (distance measured in xxx centimeters)
1. Task winner (**D_{min}**) =
   Nearest combined distance from impacts to Target 1 and Target 2 in centimeters receives 75 points.
2. Projectile initial impact must be closer than 125 cm for Target 1 and 200 cm for Target 2 to receive points.
3. Team Distance (**D_t**) =
   Best Target 1 distance (D_{t1}) + Best Target 2 distance (D_{t2})
4. Task Points =
   325 cm minus Teams distance (D_t), divided by 325 minus (D_{min}), times 75

$$\text{Task Points} = \left[(325 - D_t) \Big/ (325 - D_{\min}) \right] \times 75$$

Example
Accuracy Task
Winning Combined Impacts (**D_{min}**)
Target 1 + Target 2 = 16 cm
Team 5 Target Impacts (**D_t**)
D_{t1} = 20, D_{t2} = 8 => **D_t** = 28 cm
Team 5 Points
Middle School Score =
(325-28)/(325-16) x 75 = 72.09 pts

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Assigning Scores to Performance – continued

Total Performance Score:

1. Middle School Performance Score = Distance + Accuracy

Example
Total Performance Score:
Middle School Score =
59.99+72.09 = 132.08 pts

Design Efficiency Score:

1. Design Efficiency (DE) = Total Performance Score divided by the designed device mass (M_d)
2. Device mass is measured in kilograms without projectiles, counterweight and slings.
3. Design Winner = Highest Design Efficiency (**DE_w**) receives 25 pts
4. Design Score = Team Performance Efficiency (**DE_t**) divided by (**DE_w**) times 25 pts

Design Score = $\frac{DE_t}{DE_w} \times 25$

Example
Design Efficiency Score:
Winning Design Efficiency (**DE_w**) based on:
Team Performance Score = 147.65 pts
Team Device Mass = 4.32 kg
Winning **DE_w** = 147.65 / 4.32 = 34.18 pts/kg

Team 5 Design Efficiency (**DE_t**) based on:
Team 5 Performance Score = 133.9 pts
Team 5 Device mass = 5.73 kg
Team 5 **DE_t** = 133.9 / 5.73 = 23.35 pts/kg
Team 5 DE Score = (23.35/34.18) x 25 = 17.07 pts

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Device Inspection and Impound (teams called according to drawn competition order)

Measurement Equipment:

- Projectiles & Counterweight mass - Postal Scale (>1500 gram , with +/- 1 gram accuracy)
- Device mass – Scale (~10kg, with +/- 5 gram accuracy)
- Meter sticks
- 30-100 meter reel tape

Station 1 - Sign-in, take photo of team with trebuchet and sign with school name for visual record

Station 2 - Measure pivot point and counterweight height during each task. Ensure arm balances horizontally and vertically. Ensure counterweight is sole energy source.

Station 3 - Weigh projectiles and counterweight. Ensure sling is incorporated. Check counterweight and projectiles for illegal materials. Weigh trebuchet for design efficiency score.

Station 4 - Place trebuchet on platform to ensure within dimensions of platform. Check trigger mechanism and distance. Check projectile height at launch position. Conduct test launches to ensure device stays on platform, and that trebuchet is safe to compete.

Station 5 - Impound trebuchet and all projectiles and slings and guide students to student seating area.

Competition Management (teams called according to drawn competition order)

Team In-the-hole

Team moves from the student seating area and gathers device from impound area.

Team On-deck

Team moves from impound area to On-Deck area and prepares device for next task.

Team Up

Team moves from On-Deck area to Launch Pad and prepares device for launch.

1. Judge – DIRECTS team to prepare device for task.
2. Students – PREPARE device for launch and indicate “ready-to-launch” status and WAIT.
3. Judge – MONITOR, VERIFY and RECORD the following as needed:
   a. counterweight height (80 cm)
   b. pivot point height (60 cm) and no vertical movement (Y/N)
   c. projectile launch surface (3 cm) and position (touching launch surface Y/N)
4. Judge – PREPARES other judges for throw marking.
5. Judge – DIRECTS team to “throw when ready”.
6. Students – TRIGGER device operation.
7. Judge – MARKS and RECORDS the following:
   a. False Starts & Violations, as needed
   b. Distance (meters xx.xx meters) OR Accuracy (xx cm) OR Strength success (Y/N)
   c. Projectile mass (xxx cm)
   d. Performance and Rule Violation Comments

Event Area Set-Up
The host center will be responsible for the set-up of the device performance test area. The ideal venue for testing is a school gym or similar facility with a smooth, even floor. A recommended setup is shown on page 23.

Launch Pad
The Launch Pad is intended to provide a consistent surface for teams to work on at the competition and to protect gymnasium floor surfaces from damage. A 4' x 4' piece of finish grade plywood will be used, or equivalently two adjoining 2' x 4' pieces of finish grade plywood. Arranging thin felt padding on the on the bottom of the plywood will protect the gymnasium floor from damage.

Distance Lane
Description:
The Distance Task Lane should be centered on the launch pad and stretch 45 meters with a width of 5 meters. The center of the lane should be clearly marked for student aiming.

Suggestions:
- Carefully marking 1 meter divisions along the center-line will allow judges to use a meter stick to complete measurements between marks.

Accuracy Target
Description:
The Accuracy Targets are arranged on the floor of the event area. They should clearly mark the center of the target. Judges must be able to easily mark and measure the distance between the target center and the initial impact point of the projectiles.

Suggestions:
- The center should be marked on masking tape fixed to the floor
- A small suction cup with a flag or a clear bull's-eye helps spectators enjoy the event
- Large circles of plastic picnic table cloth (red/black) with a small (20 cm diameter) circle of another color (black/red) marking the centers are excellent. The center of the small circle should be cut out (5 cm diameter) and the entire circle taped down to the floor.

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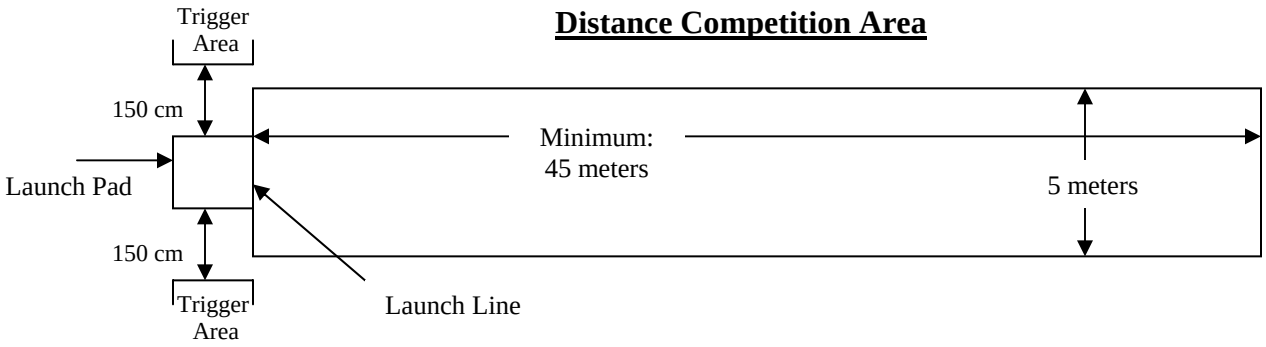
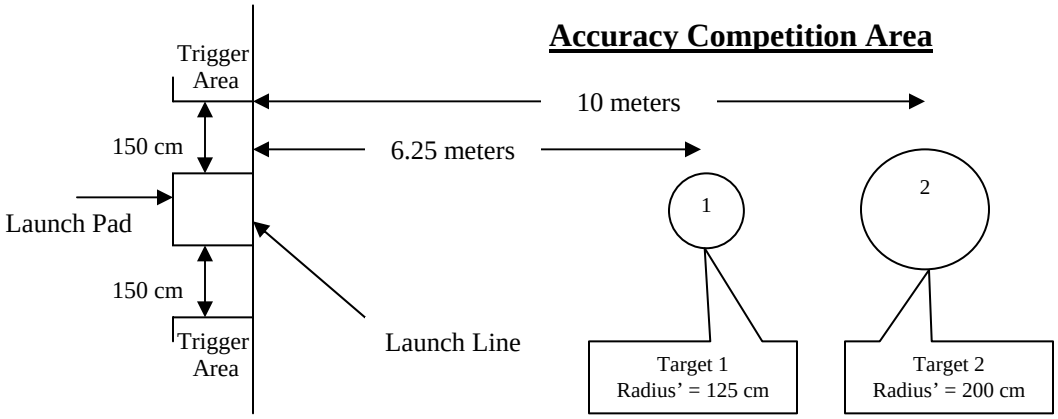
Distance Competition Area



Accuracy Competition Area



Overview

The Multi-Task Trebuchet competition involves the following performance components with their maximum points in parentheses: Device Performance (150 pts) and Design Efficiency (25 pts). The purpose of these guidelines is to outline the procedures for effectively judging this competition.

Preliminary Assignment

All judges need to read and become familiar with all rules, judging guidelines, and scoring criteria regarding their assignment.

Judging the Device Performance

The device performance is the most valued component of the competition (150 points maximum). In addition to the rules, the judge must be aware of the equipment and track specifics, what specifically is being judged, and how to assign a score to each task.

Judging Requirements and Assignments

In order to properly and consistently judge all components of the competition, the following judging team should be utilized. Please refer to "Judging Guidelines" for additional details.

Lead Judge Responsibilities:
Oversee all components of the competition and provide final rulings on event related issues.

Judges Needed:

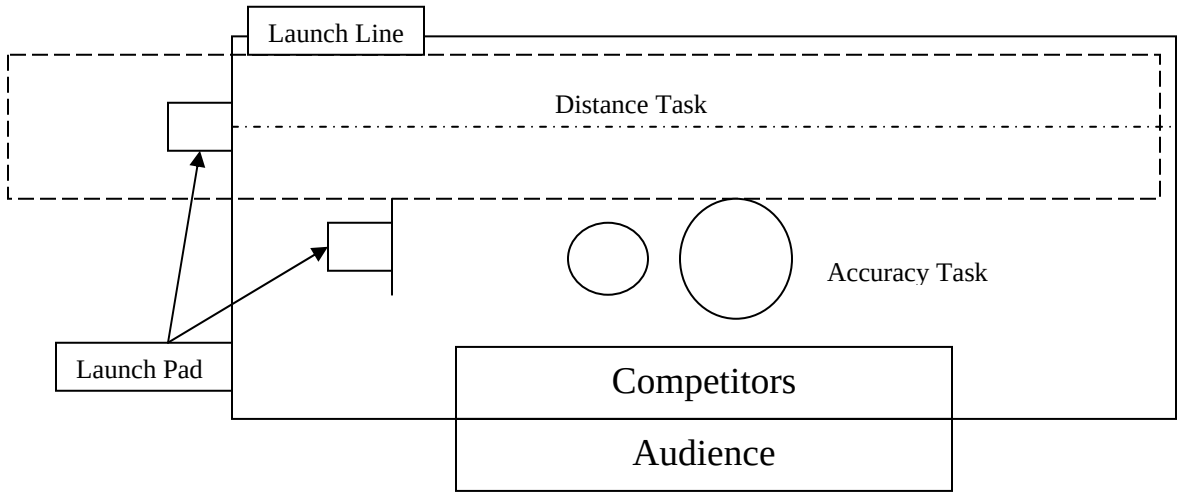
Component & Responsibilities	Middle School
Performance Testing and Impound [1]	6

[1] Performance Judges must complete the device inspection checks and measurements as well as monitor any potential changes in configuration which may provide an unfair energy advantage during the competition.

Event Area Set-Up

The host center will be responsible for the set-up of the device performance test area. Please refer to the test area illustration for specific requirements.

The ideal venue for testing is a school gym or similar facility with a smooth, even floor. A recommended setup is shown below.



Performance Task Management
All participating teams will be seated in an area separate from the general audience. Under the direction of the lead judge, only one team will be allowed in the testing area at any one time. Team members will be escorted by judges to each of the respective testing areas. The judges and host center staff must ensure that the test area is not disturbed once it is configured.

Based on a pre-determined order, teams will be summoned to the test area in the following order and will be repeated until all tasks are completed:

1) Team Up
2) Team On-Deck
3) Team In-the-hole

"Quiet" time will be requested during the performance of each task.

Safety
In accordance with school safety requirements, all team members will be required to wear safety goggles during all phases of device performance testing. Use of helmets is recommended.

Automated Event Scoring
The 2009-2010 Multi-Task Trebuchet Competition Committee has prepared a Microsoft Access based scoring tool to simplify the judging portion of the event. All states, regions, centers and teacher/advisors are encouraged to utilize this tool to streamline scoring and event management.

Overall Winners

Highest combined score in Device Performance.

Component Winners

Device Performance

Distance: ..... 1st, 2nd, & 3rd Place
Accuracy: ..... 1st, 2nd, & 3rd Place
Strength (HS only): ..... 1st, 2nd, & 3rd Place
Bonus: Design Efficiency ..... 1st, 2nd, & 3rd Place

Award Notes:

Medals will be awarded to members in the overall category. Ribbons will be awarded for individual categories.

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Resource Materials
Activity Feedback Form

Thank you for taking the time to give the MESA USA Event Committee feedback! Please email comments to your state representative (see list below).

We are very interested in all elements of this event. Please encourage students, teachers/advisors, judges and staff members to share positive experiences and constructive criticism. Please include ideas related to some or all of the following areas:

- Overall Difficulty
- Performance Tasks
- Bonus: Peformance Efficiency
- Rules
- Judging
- Scoring
- Event Management
- Other _____

Please identify the general area and provide detailed comments. Please feel free to include any photos or video from your respective activity.

Colorado.....Christopher Bonilha..... chrtopher.bonilha@ucdenver.edu