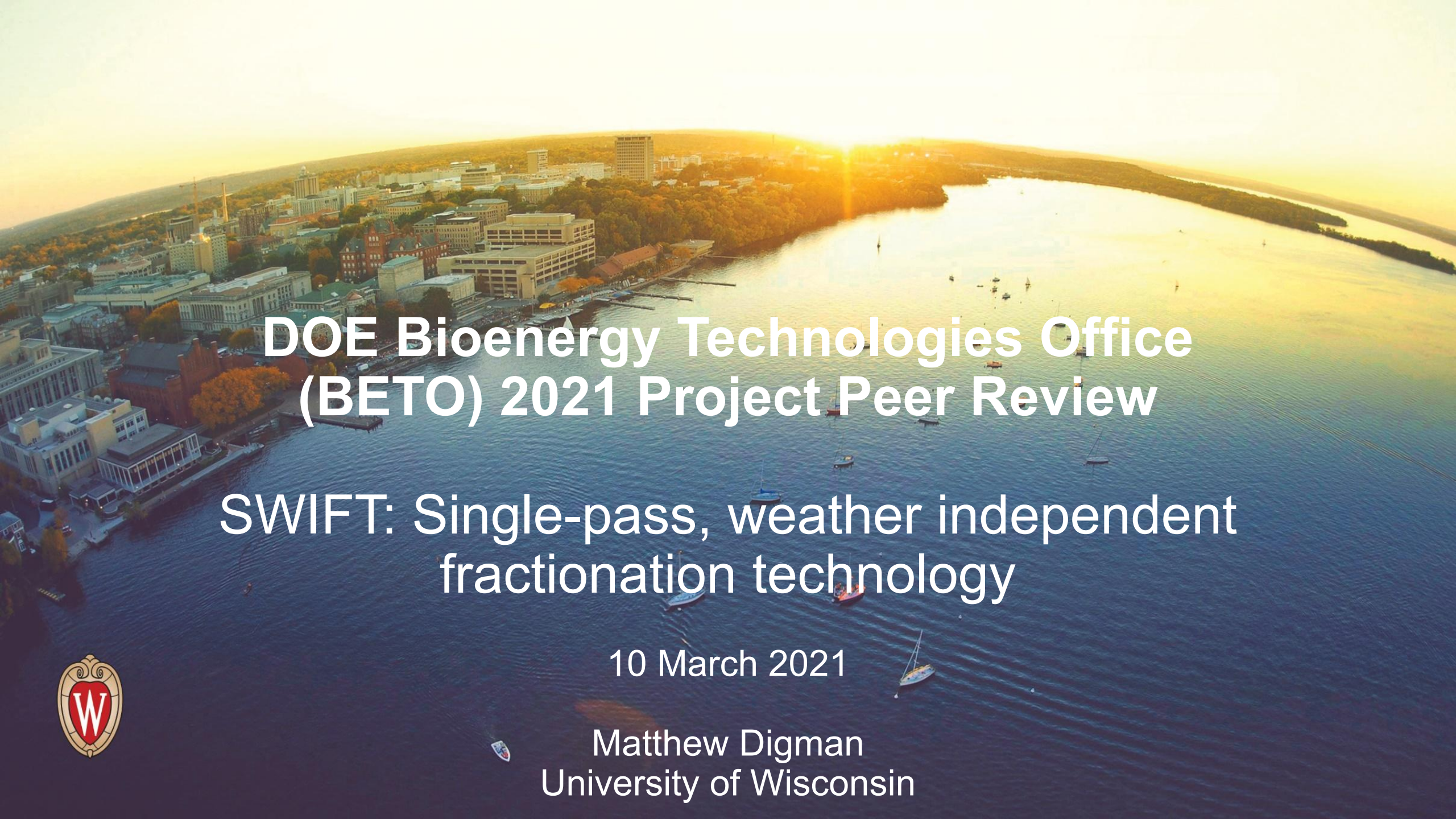


DOE Bioenergy Technologies Office (BETO) 2021 Project Peer Review

SWIFT: Single-pass, weather independent fractionation technology

10 March 2021

Matthew Digman
University of Wisconsin

Problem statement

An estimated 60% of the available corn stover will be collected at moisture contents that exceed 20% resulting in a lack of ability to produce a reliable feedstock with conventional harvest and storage systems.

Goals

1. Develop a corn stover harvest, storage and transportation process that is less weather dependent
2. Produce a corn stover feedstock with defined and measurable characteristics for superior conversion performance
3. Reduce corn stover feedstock delivery cost to $70 ($2016/dt)

Conventional combine fractionation

The state of technology involves multiple non-value added field operations: Grain harvest, stover windrowing, baling, bale retrieval, field-edge stacking, loading and all of these are weather dependent.

SWIFT Innovation

Stover and grain co -harvested, stored and transported

- Direct harvest increases control of feedstock properties
- Stable storage doesn't required field wilting
  - More consistent properties
  - Reduced ash contamination
  - Reduced loss
- More acres of corn able to participate in the stover market
- Higher transport density to end-utilization

SWIFT

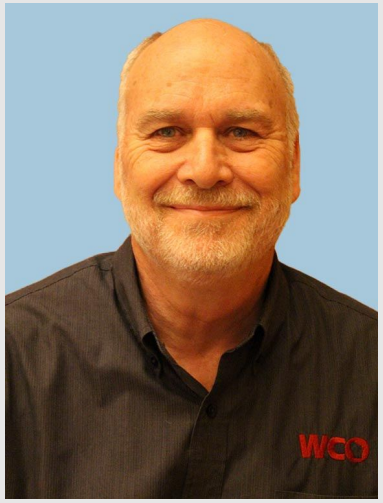
A single field operation that is very weather independent

Management

Management

Task		Deliverables
Task 1	Verification	Establish baselines, key performance parameters
Task 2	Harvest	Harvested and stored material to tasks 3, 4
Task 3	Hydrolysis	Identify fractions to isolate to inform tasks 4, 7, 8
Task 4	Virtual Verification	Inform design task 8
Task 5	Pith/Rind Separation	Impact of harvestable yield, task 6
Task 6	TEA/LCA	Inform SWIFT generation 2 (BP 3) tasks, Go-No/Go
Task 7	Harvest	Feedstock for tasks 8 and 9
Task 8	Fractionation	Fractionated feedstock for task 9
Task 9	Hydrolysis	Optimized hydrolysis yield to inform task 10
Task 10	TEA/LCA	Informed by tasks 7 - 9

Management



SWIFT Team	Institution	Primary tasks
Matthew Digman, Kevin Shinners	University of Wisconsin	1, 2, 5, 7, 8
Mehari Tekeste	Iowa State University	4
Lynn Wendt, Damon Hartley	Idaho National Labs	3, 9, 6, 10

Management

To-date our team communication has included:

a. Weekly team meetings at UW site

b. Bi-weekly team meetings between UW and ISU

c. Monthly meetings with John Deere Harvester Works

d. Quarterly meetings between UW, ISU and INL

e. Quarterly reporting to BETO TMs

Management

Risks

a. Marketability of the grain fraction recovered from stover

b. Computational limitations of virtual verification

c. Continuity of sample handling and processing between INL-UW sites

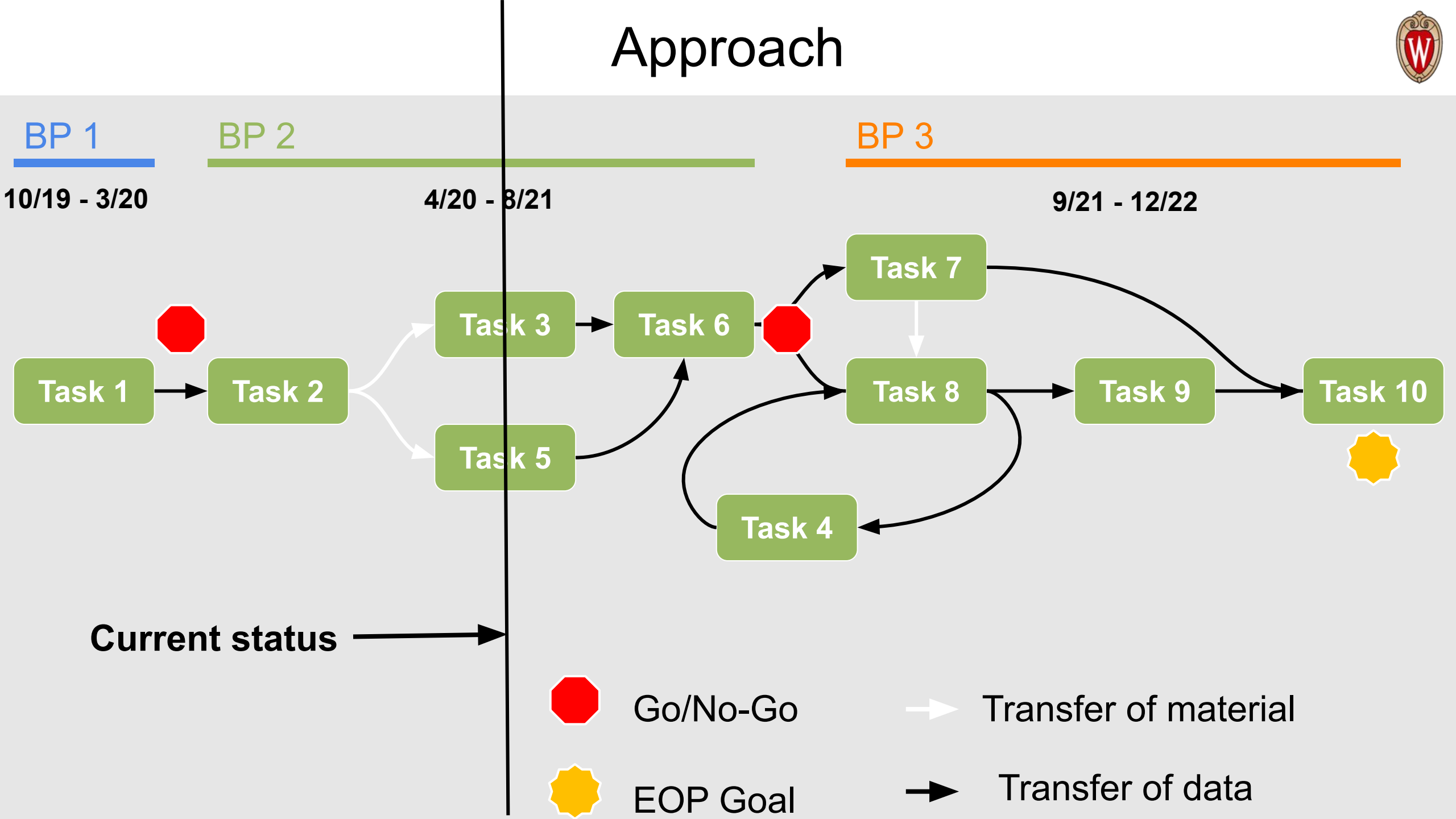
Management

Risk mitigation

a. Marketability of the grain fraction recovered from stover
    i. The UW team has explored and will continue to investigate changes in process variables on the forage harvester including cutterhead geometry, speed and grain moisture
    ii. The team is also investigating alternative combined stream harvest strategies
b. Computational limitations of virtual verification
    i. The ISU team has sought out capacity at INL
    ii. The team has proposed changes to the mesh size and simplifying assumptions
c. Continuity of sample handling and processing between INL-UW sites
    i. Two UW graduate students will work on-site at INL this summer

Approach

Approach


BP 1
BP 2
BP 3
10/19 - 3/20
4/20 - 8/21
9/21 - 12/22
Task 1
Task 2
Task 3
Task 5
Task 6
Task 7
Task 8
Task 9
Task 10
Task 4
Current status
Go/No-Go
EOP Goal
Transfer of material
Transfer of data

Approach

Our approach involves

- Optimizing harvester process variables to control chemical and physical properties of stover
- Informing an anatomical fractionation by tailoring hydrolysis conditions to fractions (cob, husk, lower-stalk, upper-stalk, leaves) or groups thereof
- Rapidly iterating fractionation system with virtual verification
- Validating choices with TEA/LCA

Impact

Impact

Reduce corn stover feedstock delivery cost to BETO's goal of $70/dt ($2016/dt)

1. Removing the need to dry corn grain for stable storage
2. Achieving regulatory weight-limited transport of grain and stover to the biorefinery
3. Employing a low-cost, single-pass harvest method that can reduce ash contamination to intrinsic structural ash of the standing plant
4. Expanding acreage able to participate in biomass harvest due to moisture-tolerant collection and storage approach
5. Reduction in pretreatment and hydrolysis costs by fractional utilization

Progress and outcomes

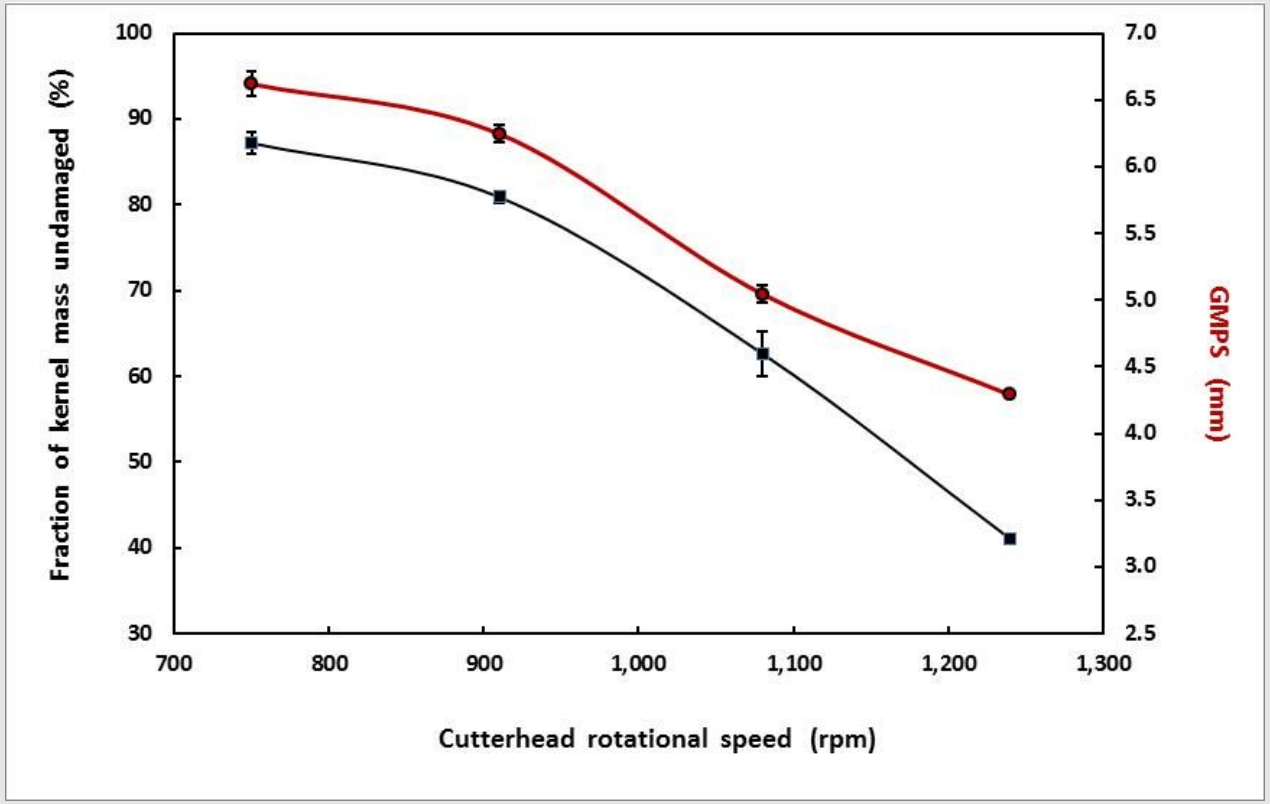
Progress and outcomes

A designed experiment was conducted that demonstrated the efficacy of the harvester to vary the chemical properties of corn stover

Progress and outcomes

Kernel loss quantification with image analysis system

Progress and outcomes

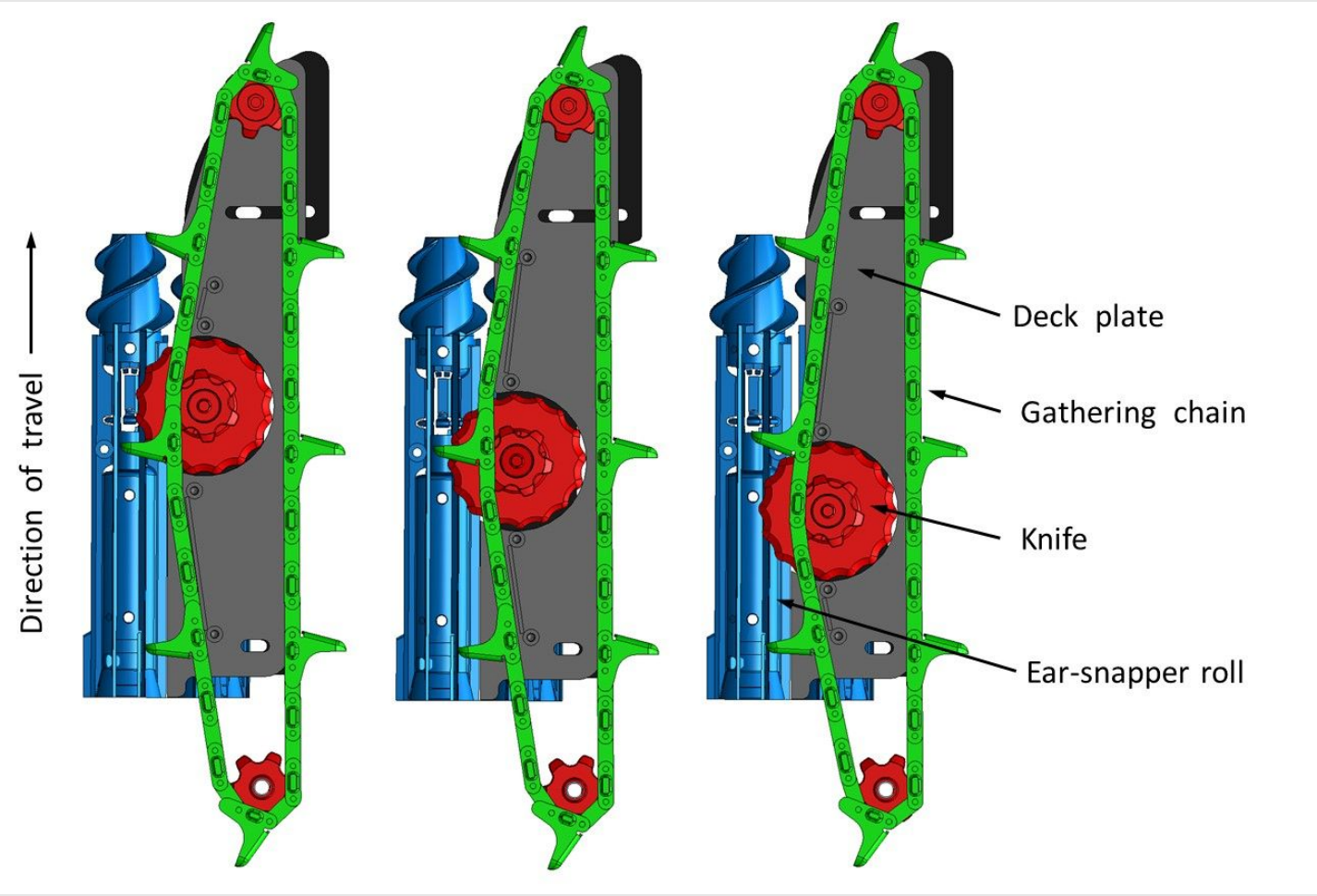


Understanding the process variables associated with kernel damage.

Progress and outcomes

Forage harvester with ear-snapper (left) and whole-plant header (right)

Progress and outcomes



Harvest	Treatment	Yield Mg DM / ha	Moisture %w.b
Early	Whole-plant	18.4	45
	Forward knife	17.2	40
	Rearward knife	16.9	35
Late	Whole-plant	19.1	37
	Forward knife	17.1	26
	Rearward knife	16.0	30

*Preliminary results

Novel harvesting attachment to control chemical properties of corn stover

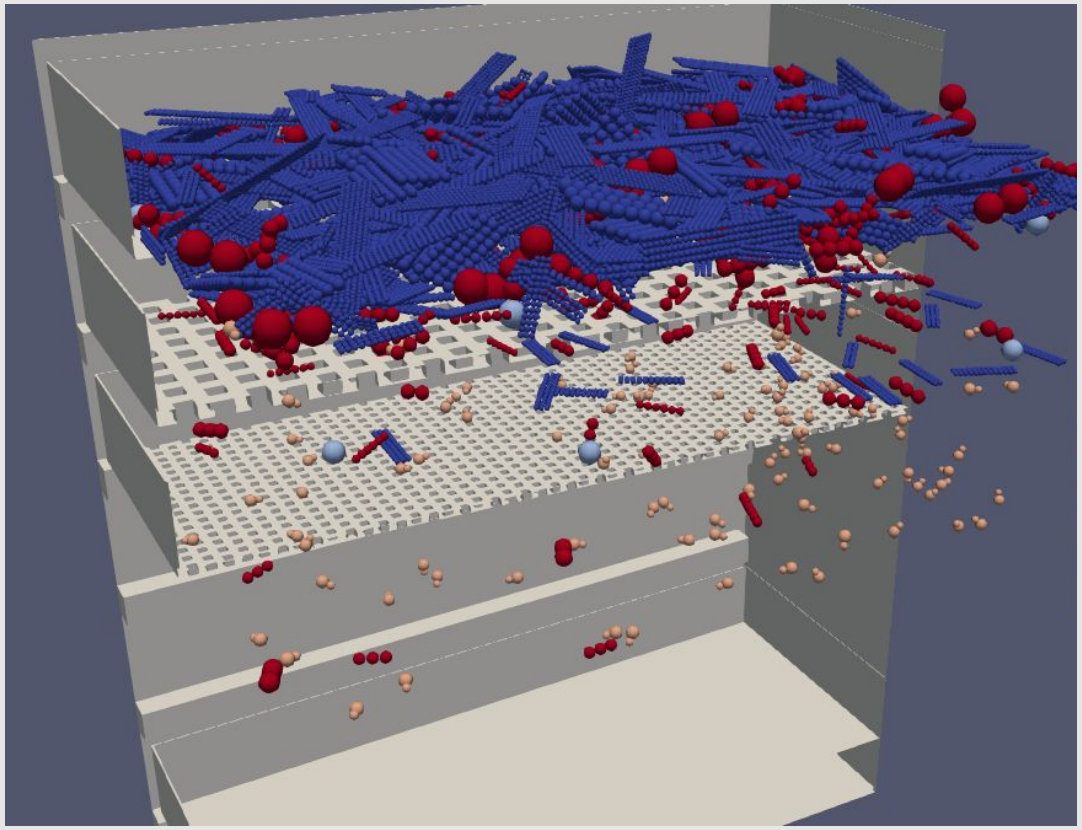
Progress and outcomes

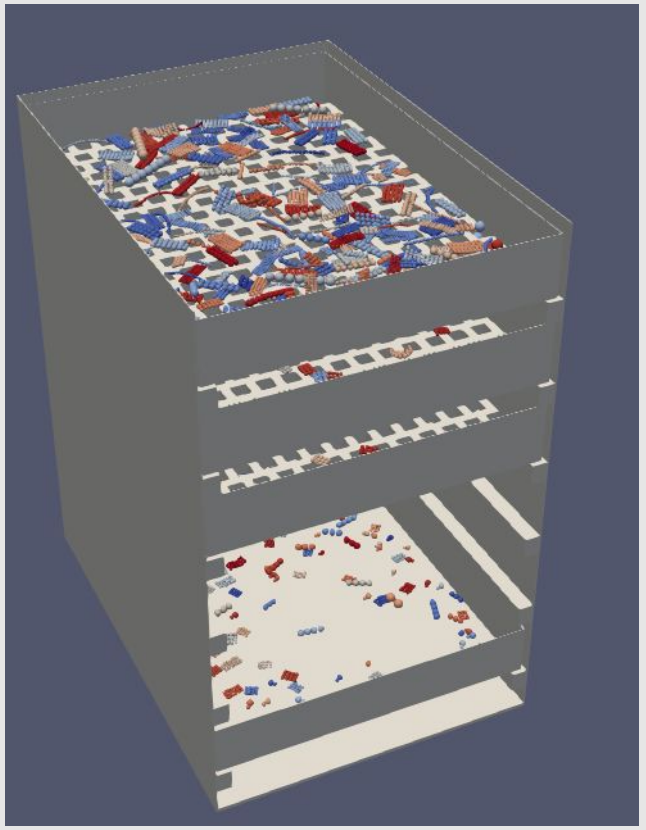
Risk mitigation: Field tested a modified conventional combine that harvests whole-plant corn and threshes but does not separate grain from stover

Progress and outcomes

Harvested and stored 30 tonne DM of whole-plant corn, 1.5 tonne in pilot-scale storage (200 L), 0.15 tonne in mini-silos (19 L) and 5 tonne in baled format.

Progress and outcomes





ISU and UW teams collaborated to characterize SWIFT particles and calibrated using the ASABE standard mechanical separation process.

Progress and outcomes

UW team began the exploring processes and process variables for anatomical fractionation.

Summary

Summary

1. Project team is working in a coordinated way
    a. UW-ISU physical characterization
    b. UW-INL chemical characterization
    c. ISU-INL modelling approach and infrastructure sharing
    d. UW-Deere harvester modifications and technology transfer
2. First year of harvest has been completed, biomass stored in multiple formats
3. Direct personnel collaboration planned for summer of 2021

Quad Chart Overview

Timeline

- 01/01/2020
- 12/31/2022

	FY20 Costed	Total Award
DOE Funding	$100,871	$1,604,008
Project Cost Share	$24,870	$335,261

Project Partners*

- Iowa State University
- Idaho National Labs

Project Goal

Develop a corn stover harvest, storage, transportation and fractionation process that is less weather dependent and has defined and measurable characteristics for superior conversion performance.

End of Project Milestone

Verification that the SWIFT process can reduce feedstock delivery cost by 40% ($116/ton DM, $2016).

Funding Mechanism

DE-FOA-0002029, AOI 2a, 2019

Responses to Previous Reviewers' Comments

1. This is the first project review.

Publications, Patents, Presentations, Awards, and Commercialization

1. None to report at this time.