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# Field Demo of Eco-Friendly Creation of Propped Hydraulic Fractures

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# Outline / Summary

- Unaddressed challenges exist in hydraulic fracturing
- Innovative product has been created to supplement or replace classical fracturing fluids
- Product is applied to wells using quick and simple process
- Lab testing has been performed to prove concept
- Early field testing has provided promising results
- Next step is to perform additional field tests in relevant oil / gas wells

# Unaddressed challenges exist in hydraulic fracturing

**Overflushing of proppant at perforations**

**Proppant settling in low-viscosity fluids**

**Frac fluid damage to propped fractures**

**Large fluid volumes required to remove near-wellbore damage**

**In horizontal completions, high flow velocity near wellbore**

**Fracture conductivity loss near-wellbore**

- **Eliminates entire production benefits of fracture**

**Public concern about environmental impact of classical frac'ing fluids will continue to challenge industry**

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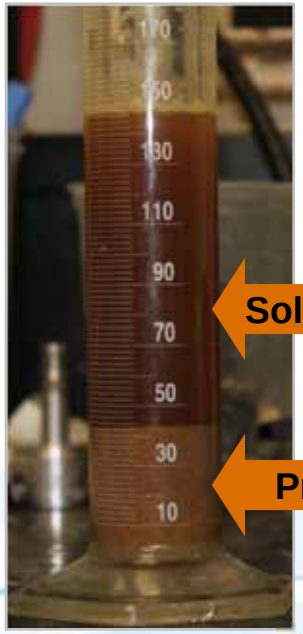
# Product has been created to supplement or replace classical fracturing fluids

**Solid degradable polymer pastille**


2-8 mm

**High viscosity gel (partially-degraded polymer)**

**Soluble polymer remnants and settled proppant**




Photos: CSI Technologies



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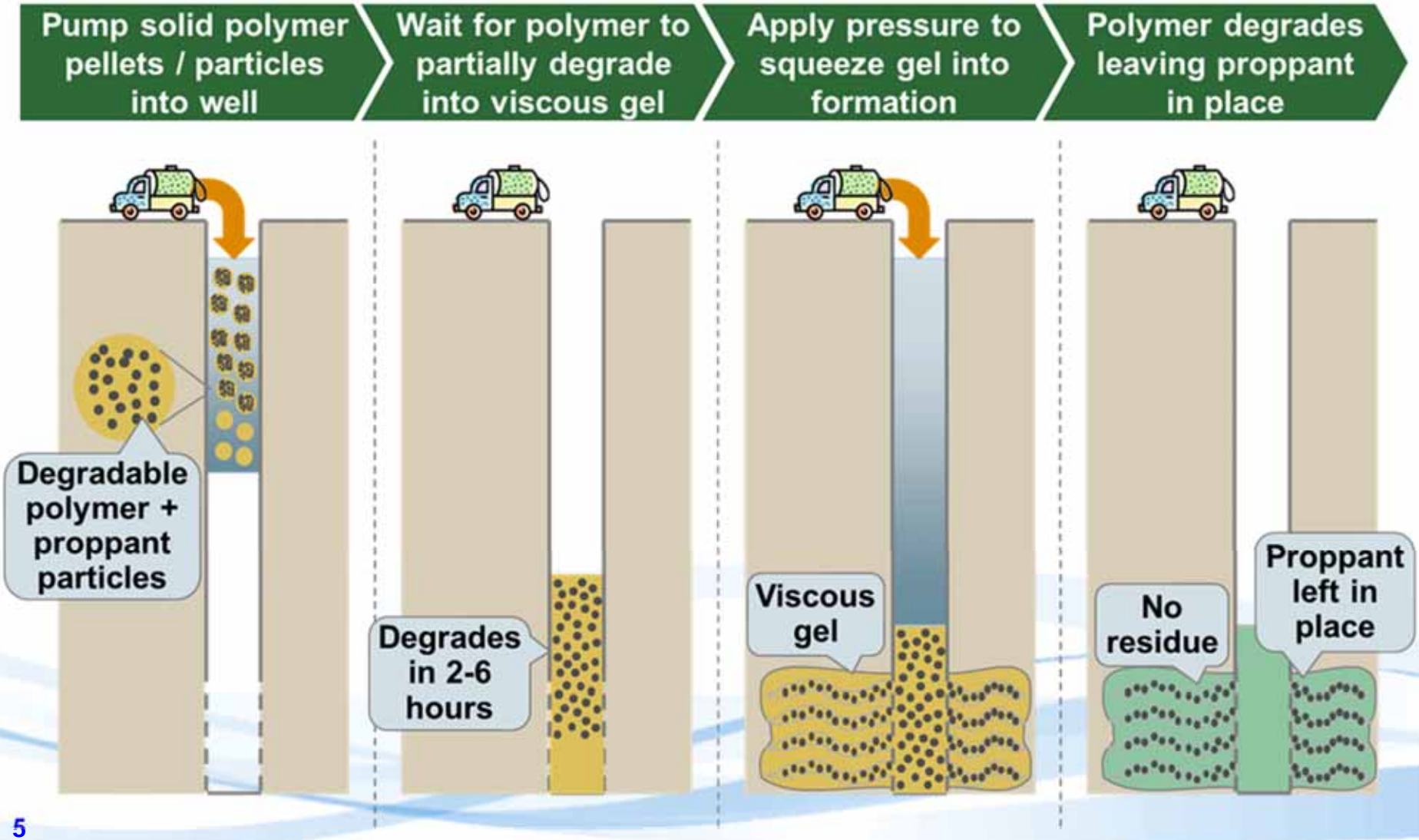
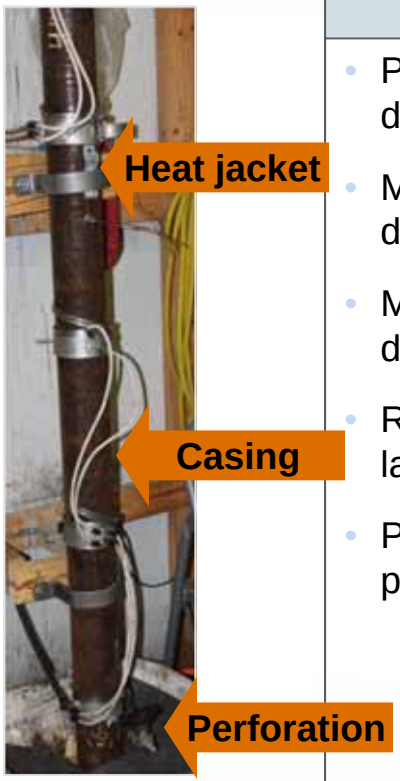
# Product is applied to wells using quick and simple process



# Lab testing has been performed to prove concept




## Activities

- Polymer chemistry tailored to degrade at appropriate temp
- Measured viscosity during degradation process
- Monitored occurrence of any damaging residue
- Re-created well conditions with large-scale mockup of casing
- Performed computer simulations of production and fracture properties

## Outcome

- Required: fluid ~ 10%, proppant ~20% of classical minifrac
- Organic acid formed by degraded polymer completely soluble in water and brines
- Viscosity when squeezed into formation higher than frac fluids used today
- Significant reduction in water use
- Less horsepower and fewer surface units required
- Modeled 40-day production is ~1,000 barrels higher than conventional minifrac

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Photo: CSI Technologies

# Eight field tests have been completed with generally positive results

## Well Conditions

- Bee County, TX well was drilled and produced in 2009 before suffering damage
- Traditional hydraulic fracturing treatment not justified by cost / benefit
- Well configuration:
  - Producing interval is ~8 feet thick at 4,500 feet
  - 4 1/2 casing; 2 3/8 tubing; retrievable packer

## Treatment / Procedure

- Placed ~5 bbl particles into wellbore filled with water
- Pumped degradable polymer particles down until perforations plugged
- Waited ~6 hours for polymer particles to degrade into highly viscous gel
- Using small frac pump, displaced gel through perfs <2 bpm
- Waited ~7 days for polymer to completely degrade before swabbing

## Results

- Highly-conductive, propped fracture to connect with formation indicated from swab tests
- Swabbed well and measured fluid inflow >3X previous inflow

# Low-productivity, conventional wells make good candidates for SqueezeFrac field testing

## Ideal well criteria for field testing

**General conditions**
- Bottom-hole temp between 130-200F
- Evidence of near-wellbore damage
- Low productivity

**Geology**
- Target zone thickness < 20 feet
- Permeability at least ~ 0.1 millidarcy
- Sandstone or carbonate

**Well configuration**
- Casing capacity below packer > 3 bbl
- (Optional) Tubing out of well

## Degradable polymer particles (with proppant)

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# We have proven the concept in the lab and are in the process of field testing the technology

## Initial product development and lab testing is complete…

**Designed effective polymers**
- Optimal degradation timing
- Degrades into soluble fluid

**Developed computer simulations of treatment**
- Indicated potential for equal or greater productivity increase vs. classical hydraulic fracturing

**Tested ability to "squeeze" polymer using large-scale mockups**

## …And field testing is in progress

**Completed 8 field tests in Bee and Jefferson counties (Texas)**

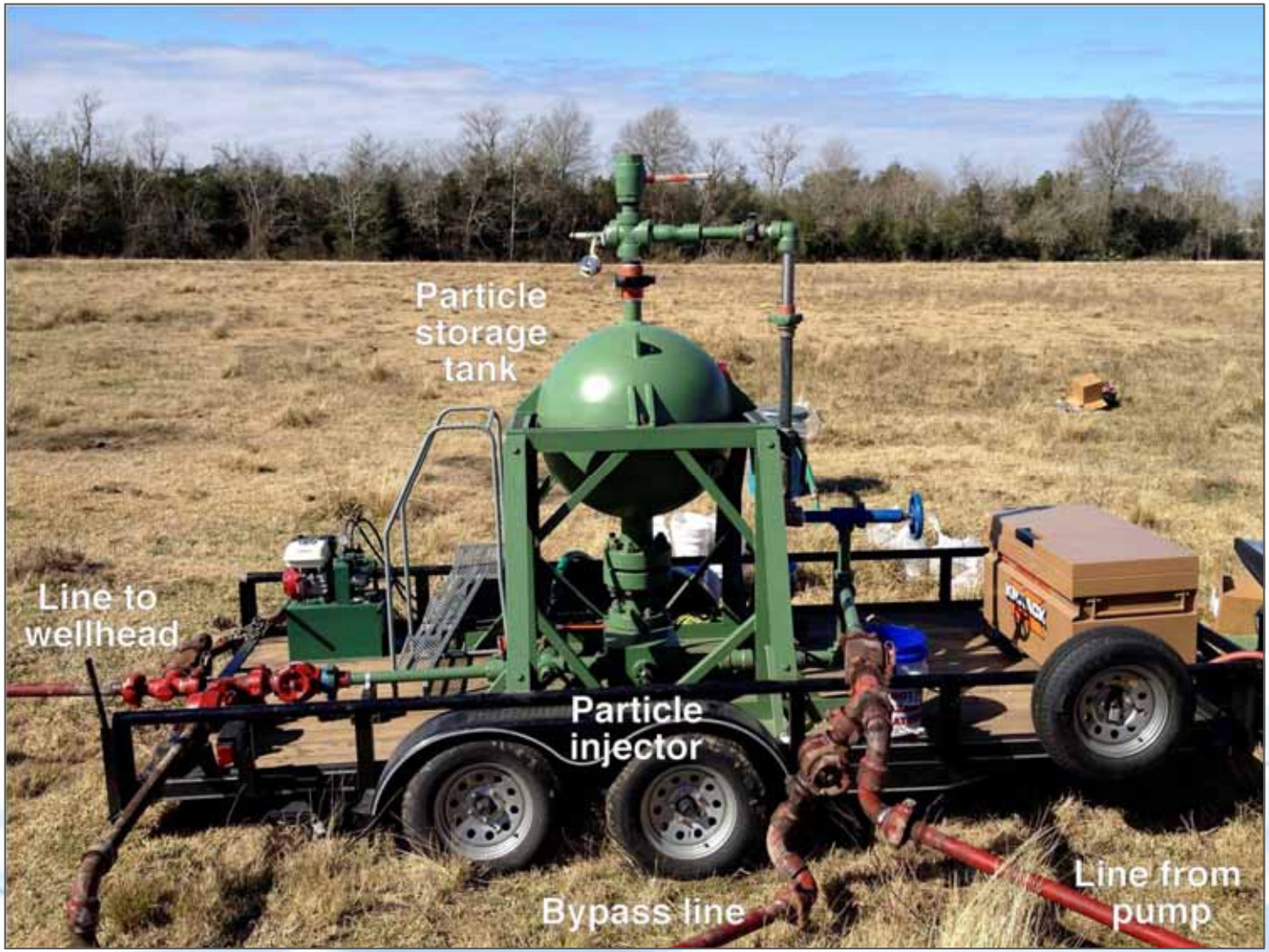
**Biggest challenge / learning has centered on procedure for injecting polymer**
- Particles are too large to move through normal triplex pumps
- We have developed a new injection method for the polymer particles

**When polymer and proppant were injected, we realized a ~3X increase in fluid in-flow**

# Field testing results: Previous and scheduled jobs

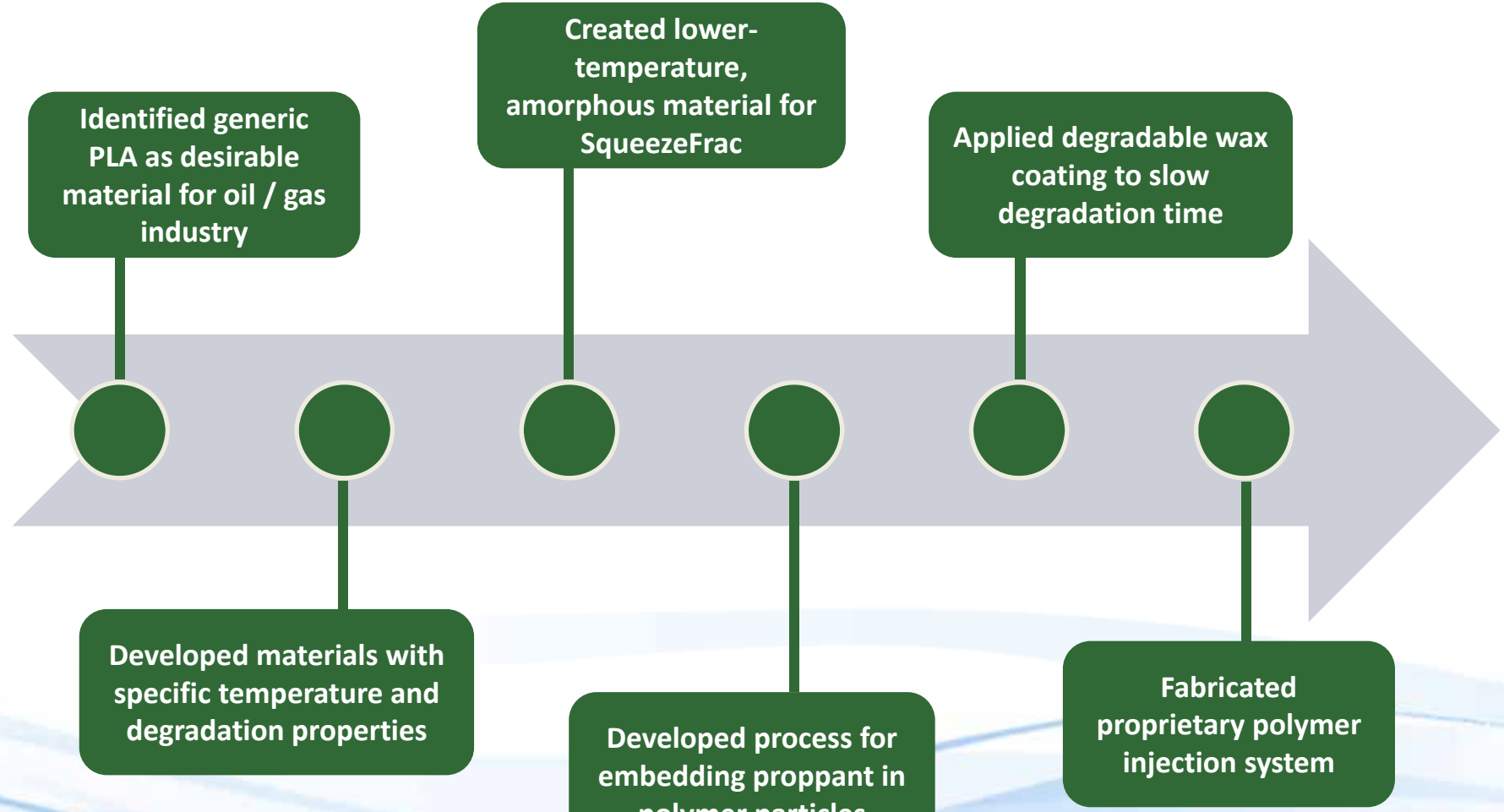
| Summary of field test results | | | | | |
|---|---|---|---|---|---|
| **County** | **Reservoir / Field** | **Depth** | **BHT** | **Approach** | **Results** |
| Bee, TX | Frio Sands | 4,500 ft | 155F | Particle slurry / frac pump | Particles not injected; no fracture created |
| Bee, TX | Frio Sands | 4,500 ft | 155F | Particles poured into wellhead | Conductivity improved; >3x fluid in-flow gain |
| Jefferson, TX | Upper Frio Sands | 7,400 ft | 174F | Particle slurry / gravel pump | Particles not injected; no fracture created |
| Jefferson, TX | Upper Frio Sands | 7,400 ft | 174F | Particle slurry / mud pump | Particles not injected; no fracture created |
| Jefferson, TX | Upper Frio Sands | 7,400 ft | 174F | Pressurized polymer injector | Temporary improvement in well productivity |
| Jefferson, TX | Upper Frio Sands | 7,500 ft | 175F | Pressurized polymer injector | Improvement in well injectivity; no production |
| Montague, TX | Caddo Lime | 6,100 ft | 160F | Pressurized polymer injector | Field test scheduled on Friday |
| Hardin, TX | Upper Frio Sands | 7,300 ft | 170F | Pressurized polymer injector | Field test scheduled |

# We have developed proprietary equipment to inject polymer particles into a wellbore under pressure (I)



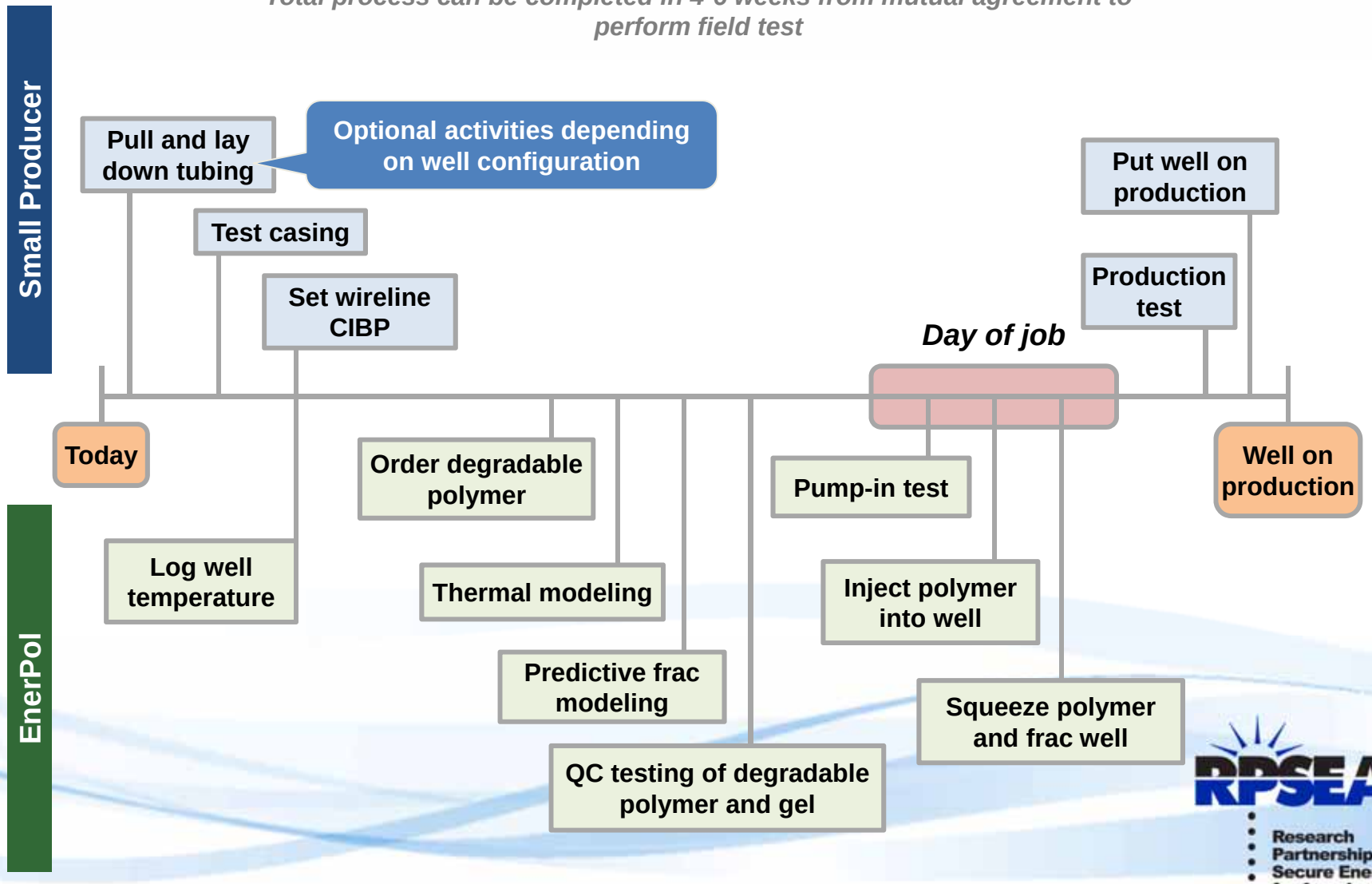
# We have developed proprietary equipment to inject polymer particles into a wellbore under pressure (II)

# We have also made significant steps forward on polymer chemistry and manipulation



# Typical field test timeline

*Total process can be completed in 4-6 weeks from mutual agreement to perform field test*

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# Conclusion / Next steps

## Conclusion:

- Viability of the product and process has been confirmed through laboratory and early field testing

## Next steps:

- Complete additional field tests
  - Ideal well candidates are mature assets in need of re-frac or that have near-wellbore damage
  - Target geographies are: South Texas, East Texas, Gulf Coast, and Mid-Con
- Further explore application of technology in unconventional wells
  - Degradable polymer can be used to place proppant at perforations and in wider frac in horizontal completions

**Questions?**



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