ICoTA
2015 Roundtable

Wednesday, October 21, 2015
Hotel Arts
119-12th Ave SW Calgary, AB

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Articulating Rotational Mast Improves Operational Efficiency for Coiled Tubing Operations on Multi-Well Pads

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Presentation Outline

- Introduction / Origins of the Articulating Rotating Mast (ARM)
- Conventional Coiled Tubing (CT) and Mast CT Setup
- Rig-In and Rig-out Tasks
- Concept to Construction of a Prototype and Challenges
- Field Trials and Results
- Improved Safety
- Cost Savings Delivered
- Conclusions and Recommendations

Introduction

- Increase in multi-well pads and quantity of wells
- Multi-well pads result in consecutive fracturing and coiled tubing operations
- Time between wells (TBW) defined as the time required to rig out from one well and rig into the next
- **Goals**
  - Improve efficiency, minimize TBW
  - Improve safety on location
  - Deliver cost savings

Conventional Coiled Tubing Unit Setup

- Injector is suspended by a crane
- Requires a 24-hour crane operator in B.C.
- Injector requires tie-down securement
- Rigging in and out typically requires re-spotting of all equipment
- Wind restrictions
- Safety hazard with suspended loads

Mast Coiled Tubing Unit Setup

- Injector supported by mast
- Limited by mast height
- Requires re-spotting for each well
- Restricted distance from wellhead
- Restricted payload

Rig-In and Rig-out Tasks

- Time Between Wells:
  - Tool down bottom hole assembly (BHA)
  - Disassemble lubricator stack, rack injector
  - Rig out blowout preventer (BOP), stump test/rig onto next well
  - Hang injector, assemble lubricator stack
  - Tool up BHA
  - Rig-in lubricator stack to BOP
- Repetition of each sub-task adds significant time to the overall operation
- Using a crane can minimize re-spotting compared to a mast unit

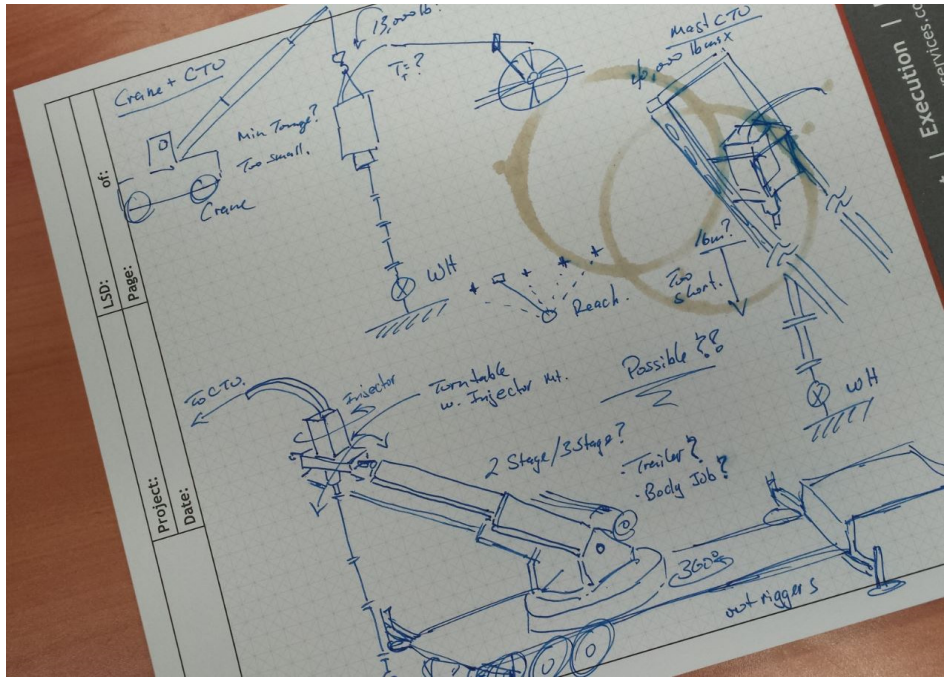
Concept Phase

Room For Improvement

- Service multiple wells on a pad while minimizing re-spotting of equipment
- Improve safety of field professionals
- Eliminate 24-hour Crane Operator
- Boom Truck Operator - 45 Ton or less

Equipment Specs

- Must handle 10kpsi well control equipment
- Maximize injector height
- Built to API 4f Wind Speed (140 km/hr)



Construction of a Prototype

- Trailer-based with stabilizers and outriggers
- Pivoting base
- Twin telescoping booms
- Rotating turn table and tilt crown at boom ends
- Auxiliary winch with hook
- Powered via wet kit
- Remote control (Can go in coil cab)

Construction of a Prototype

- Trailer-based with stabilizers and outriggers
- Pivoting base
- Twin telescoping booms
- Tilt function of crown at boom ends
- Auxiliary winch with hook
- Powered via wet kit
- Remote control (Can go in coil cab)

Testing Challenges and Redesign

Prototype Issues

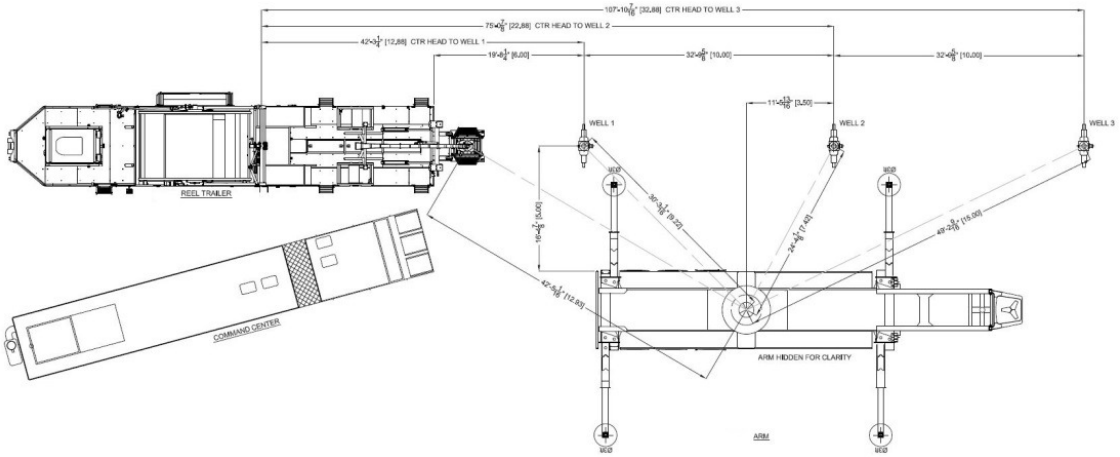
- Crown (Tilt) assembly failed
- Base structure (trailer frame) required further support and stiffening
- Control system issues

Changes to Prototype

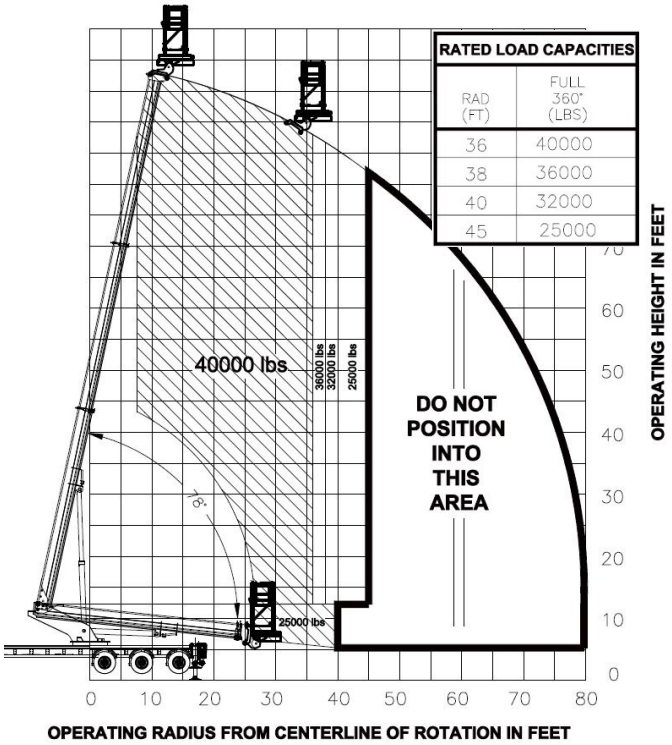
- Crown rotation changed to hydraulic cylinder tilt vs. machined shaft.
- Weld in additional structural members below turret
- Software and re-zero control system

Initial Field Trials

- First few jobs on small pads, 3 to 5 wells
- TBW improved over historical data with crane
- ARM positioning dependent on pad layout
- 30 m reach, 15 m radius from pivot center
- Height capacity: 27 m (90 ft) below stripper
- Additional TBW improvement with two BOPs

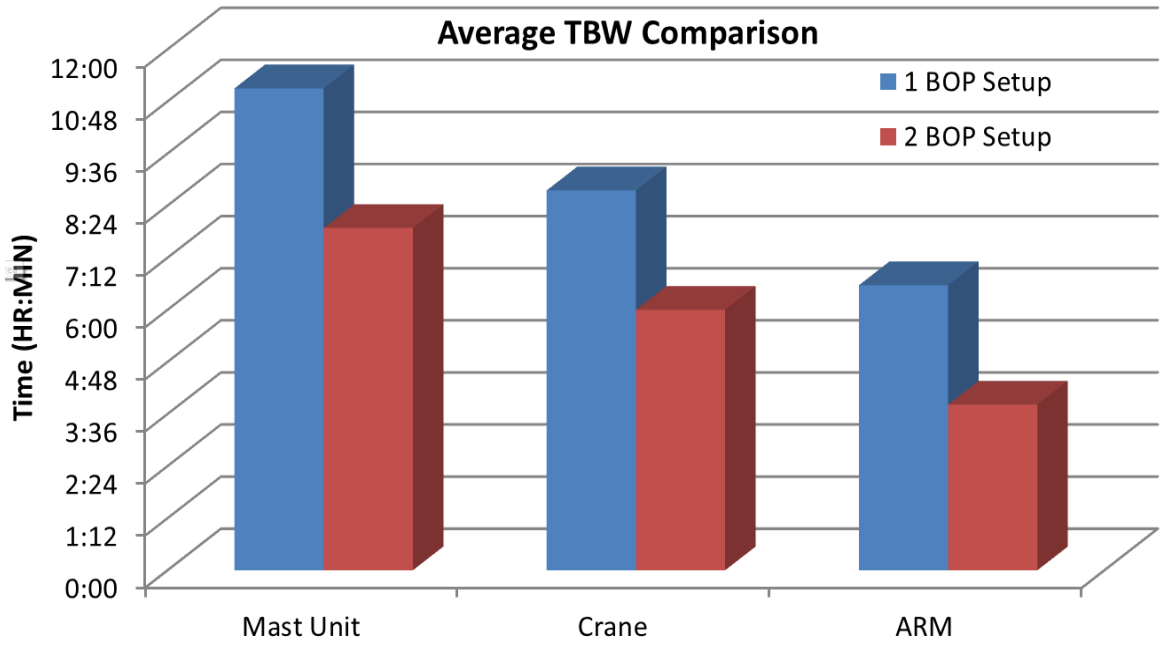


Initial Field Trials

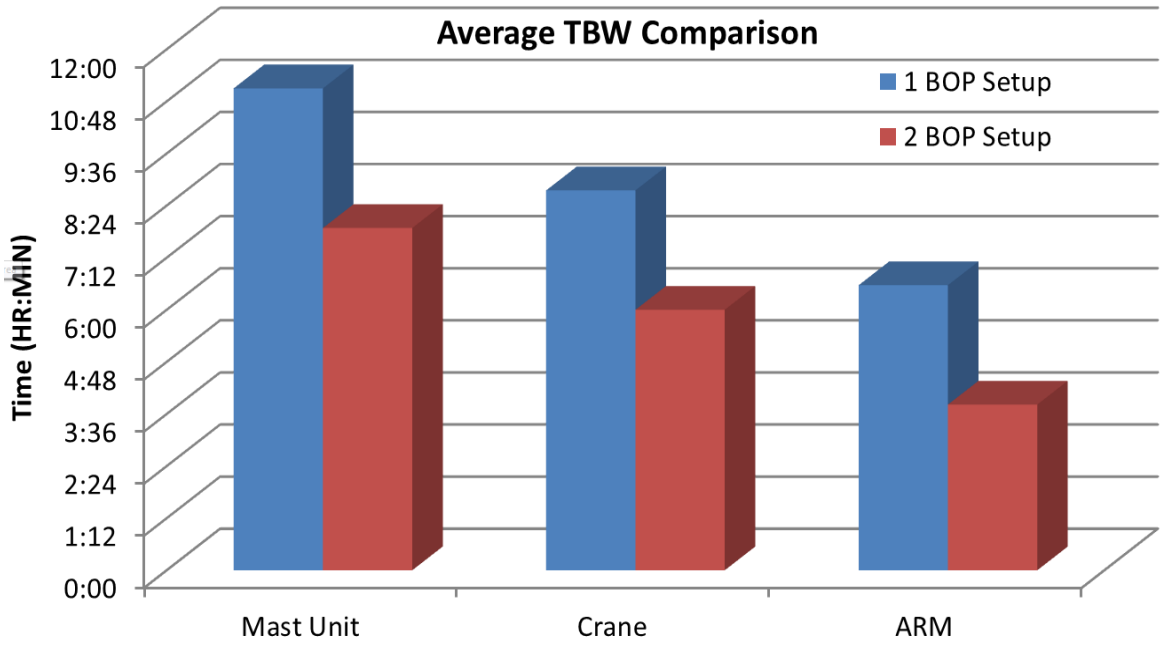


Results

- TBW post-job data analyzed for mast, crane, and ARM setup with 1 BOP vs. 2 BOP setup
- Crane data set: Northeast British Columbia, bridge plug millouts
- Mast data set: Saskatchewan Frac Through Coil with average 2-well/pad



Results



TBW - 1BOP Setup

- Lowest TBW: 4 hr, 37 min.
- 24% Improvement ARM vs. Crane
- 41% savings Improvement ARM vs. Mast

TBW - 2 BOP Setup

- 3 hr, 49 min (extrapolated)
- 32% Improvement ARM vs. Crane
- 53% Improvement ARM vs. Mast

Improved Safety

- Elimination of load bearing wire rope
- Elimination of four ground anchors
- No issues with side loading
- Reduction of required boom length
- Increased geometric stability on well
- Reduced wind effects
- Improved communication between ARM operator and crew
- Improved line of sight versus view from crane cab

Improved Safety

Cost Savings Delivered

Crane and Crane Operator

- Elimination of crane in CT operations
- ARM operator does not require a crane ticket
- Operator is not required to man controls at all times
- ARM operating rates are less than a 3rd party crane

Reduction in TBW

- Quicker lubricator stack assembly
- Reduction or elimination of full or partial disassembly of lubricator stack
- Elimination or reduction of re-spotting CT equipment

Conclusions

1. Efficiency:
    - Purpose built for multi-well pad completions
    - 41% faster (Mast CTU vs. ARM)
    - 24% faster (Conv. w. Crane vs ARM)
2. Safety:
    - Minimize hazards
    - Reduce human requirements for rigging in and out
3. Cost Savings:
    - Eliminate the need for a crane operator for CT operations.
    - Time savings equates to saved costs
4. Future Improvements:
    - 15 kpsi pressure control gear work capable
    - Increased reach & load capacities
    - Crown / injector interaction improvements

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Acknowledgements / Thank You / Questions

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