DEFENCE R&D DÉFENSE

SIPES – Kinematic Modeling of the C7A2

Brenton Teed, Colt Canada
Franklin Wong, DRDC Valcartier

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Objectives

- To model the C7A2 rifle in MSC Adams and predict its mechanical dynamic behaviour.
- To familiarize Colt and DRDC with the modeling philosophy and process so that it can be used to evaluate future weapons concepts.

Mechanical Dynamics

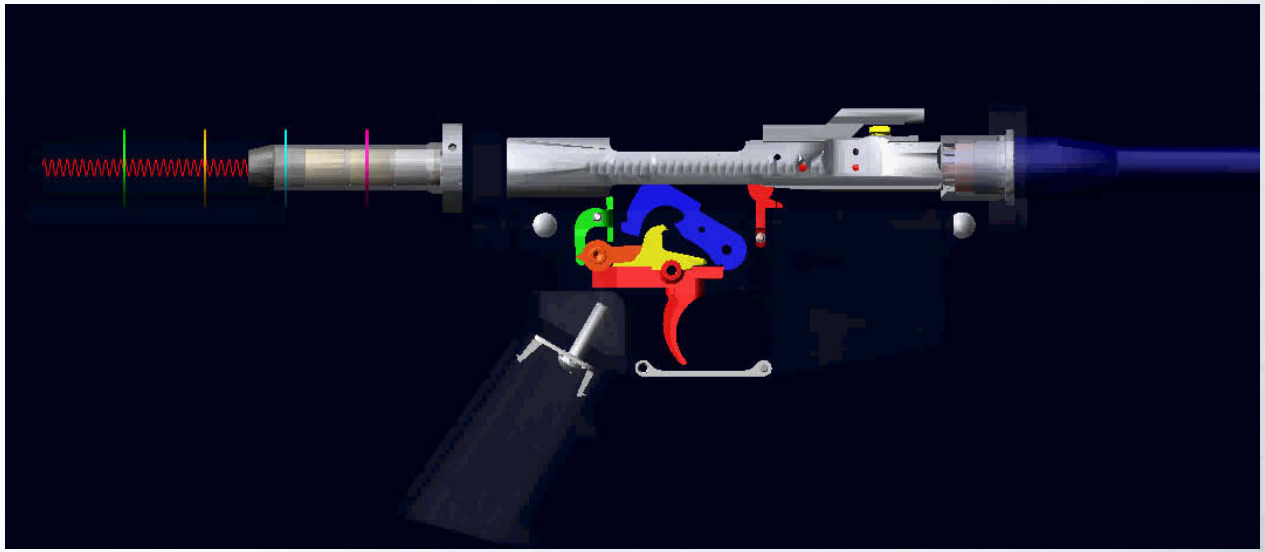
- Multibody dynamics and motion analysis software is used to study the dynamics of moving parts, and how loads and forces are distributed throughout mechanical systems.
- CAD-based tools are limited to evaluation of interference between parts and basic kinematic motion.
- Finite element analysis can be used to study linear vibration and transient dynamics, but is too inefficient to analyze the large rotations and highly nonlinear motion found in mechanical systems.
- Multibody dynamic analyses compute loads and forces that can be coupled with finite element analysis methods to compute the effects of parts stiffness or compliance on system behaviour.

Basic Modeling Process

1. Define the modeling objectives.
2. Import part geometries defined in consistent coordinates.
   - Add geometric features to critical components to aid positioning in MSC Adams.
3. Select and apply motion constraints
   - Document constraint parameters for later reference particularly in cases where they are changed to match observed behavior.
4. Select and apply forces
   - Develop S-force representation of the equivalent pressure-time profile of the combusting gun propellant.
5. Model set-up and analysis
   - Name component parts and geometries for clarity.
   - Add and name markers to ease application of constraints and forces.
   - Add and name markers for use in post-processing analysis.
   - Apply motion constraints and forces.
   - Add sensors to capture model position dependent events.
6. Run the model to produce the results as defined by the modeling objectives.
7. Post-process results
   - Produce graphs, tables and movie files to document the results in terms of the performance metrics.

Components Controlling Firing Dynamics

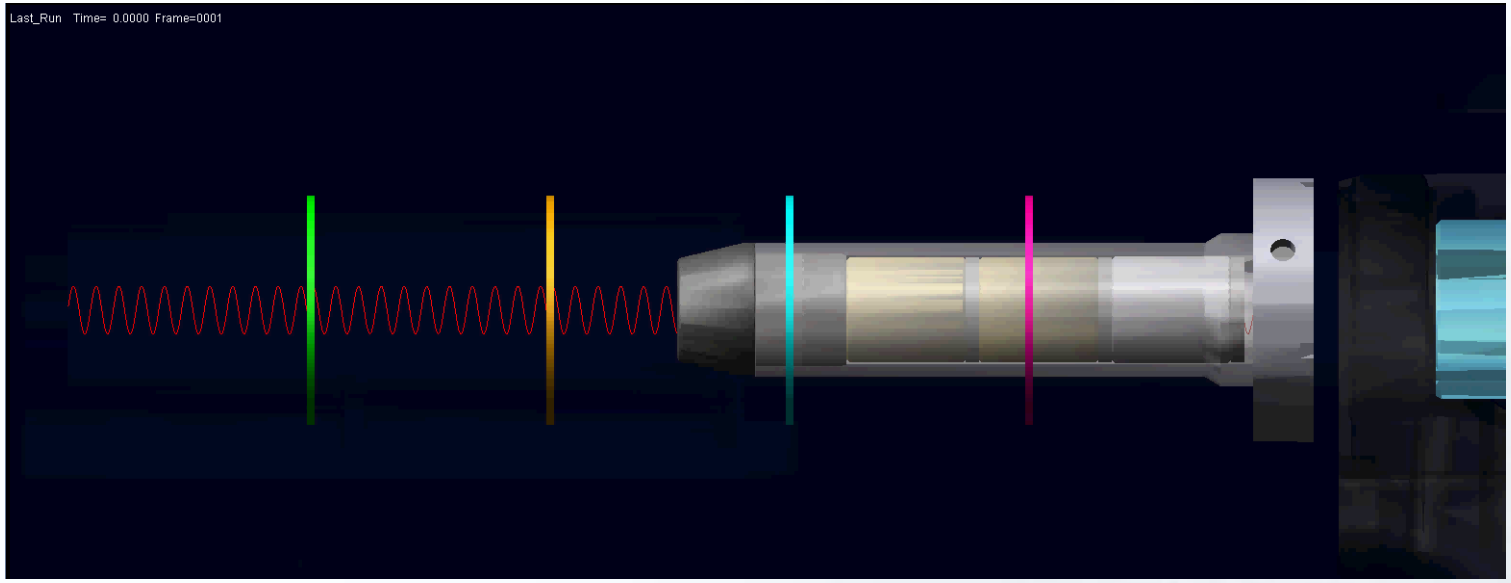
SPRING, EJECTOR & SAFETY DETENT
WEIGHT, BUFFER, HEAVY
INSERT, EXTRACTOR (BLACK)
SPRING, EXTRACTOR
EXTENSION, BARREL
BARREL, RIFLE, C7
BOLT
RING, BOLT
KEY, BOLT CARRIER
EXTRACTOR
PIN, EXTRACTOR
EJECTOR
PIN, CAM
NUT, BARREL
CARRIER, BOLT
PIN, FIRING
PIN, RETAINING, FIRING PIN
RECEIVER, UPPER



Modeling of Firing Mechanism

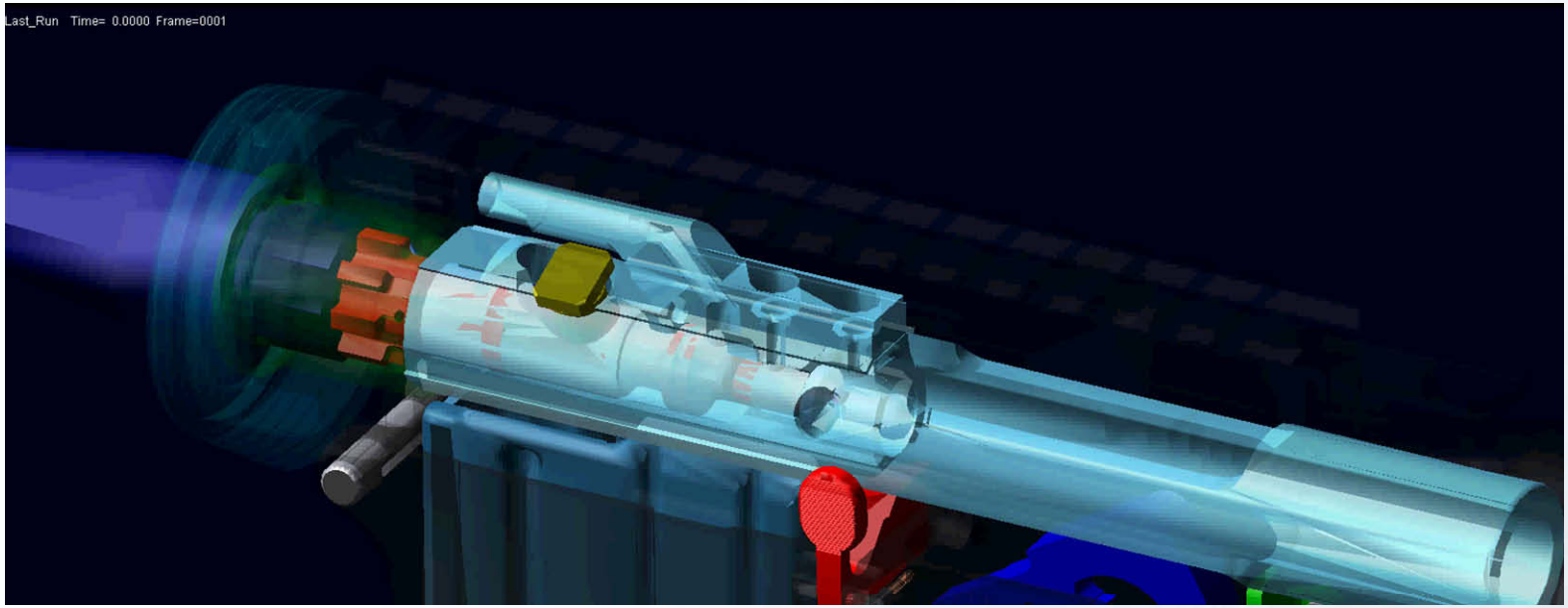
Complete rifle can be modeled to study charging, firing and ejection cycle as well as generation of recoil forces on soldier.

Buffer Dynamics Modeling & Design



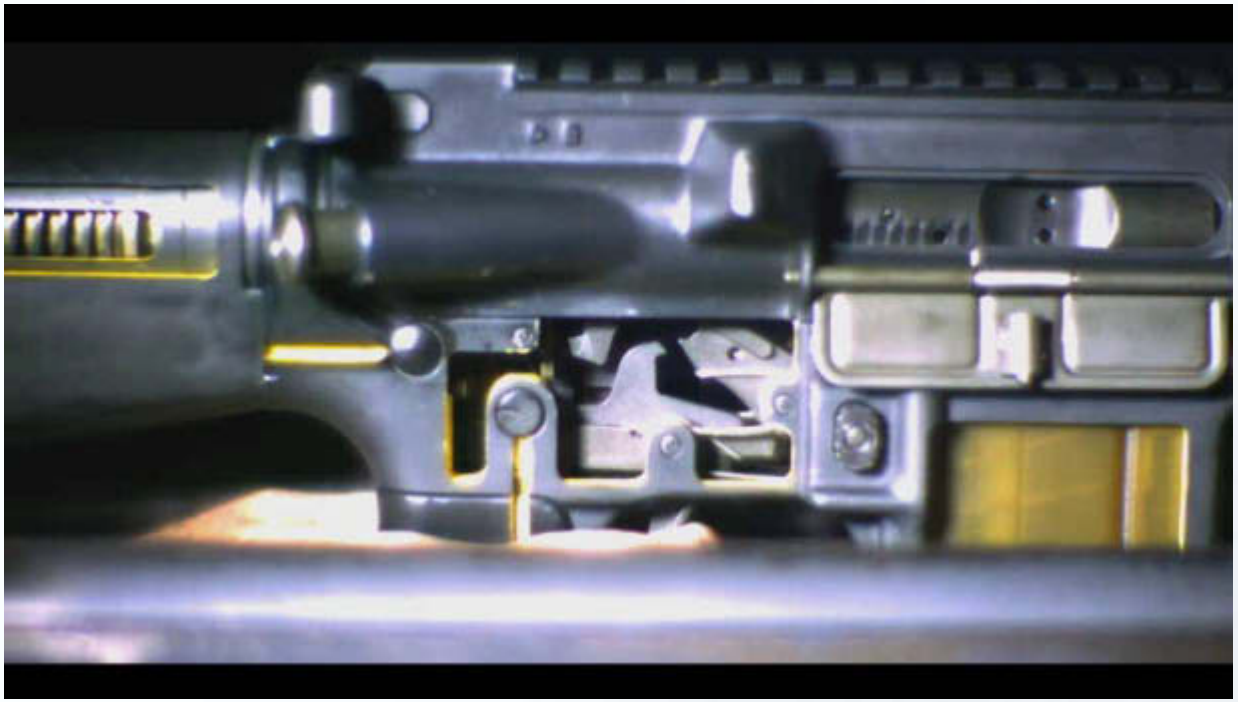
Buffer component properties can be varied over a range of values to gain a better understanding of their role in maintaining a consistent firing cycle.

Bolt Dynamics Modeling



Once the dissipative factors in the mechanism have been tuned, a highly detailed analysis of all the moving components can be made to gain a better understanding of the firing mechanism design. Lessons learned can be applied to future designs.

Validation of Mechanism Modeling



The data obtained from highspeed video of cut-away guns is used to tune and validate modeling results.

Way Ahead

- Force-time function will be developed based on interior ballistics data and data from high speed video.
- Adams model of C7A2 will be run with the force-time function and a series of friction and contact values to predict the speeds and positions of the bolt, bolt carrier and buffer body. Cam pin and buffer bumpers and weight motions will be tracked.
- High speed video measurements of the bolt, bolt carrier and buffer body speeds and positions will be made on a C7A2 equipped with seven different upper receiver and barrel assembly combinations.
- Friction and contact values will be adjusted to match numerical and experimental results.
- C7A2 results provide a baseline analysis capability that will be used to evaluate future assault rifle concepts.