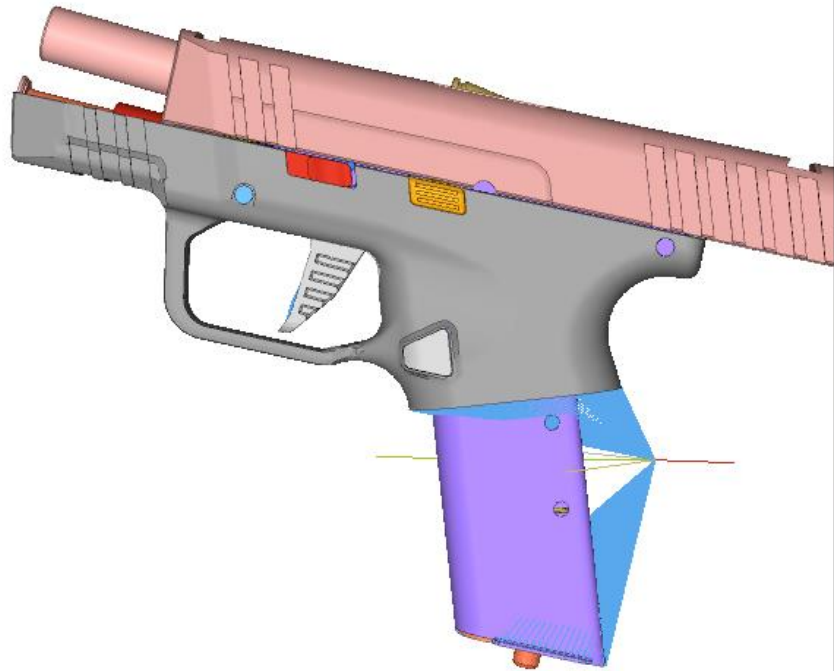




Altair Technology Conference

Israel 2019



From MBD to FSI – Complete firearm development

Konstantin Arhiptsov, Eitan Maler



About IWI

- Israeli Weapon Industries (IWI) a world leader in innovative small arms
- Designs, produces and sells small arms
- The IWI product range and accessories are deployed by the IDF and many other leading security organizations.



Tavor



X95



Negev



Galil



Jericho



Uzi

Simulations

- Synchronization is necessary for functionality.
- Short time events + very high impacts.
- MotionSolve, Radioss and HyperStudy.





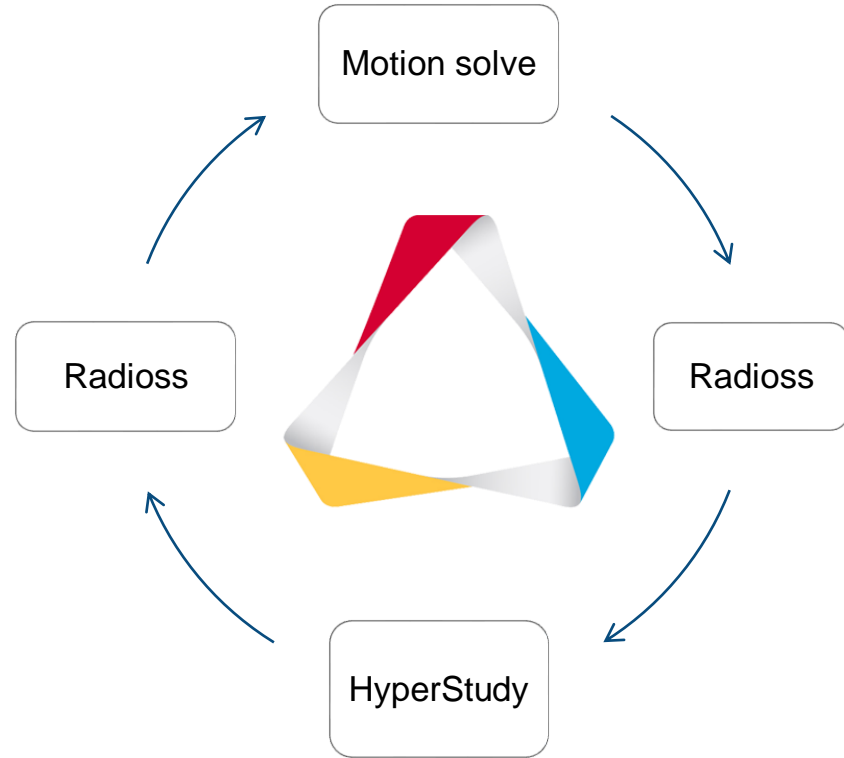
Motivation

- Every new product being simulated before single part is manufactured.
- Modeling correct boundary conditions is essential for understanding true behavior.



Problem definition

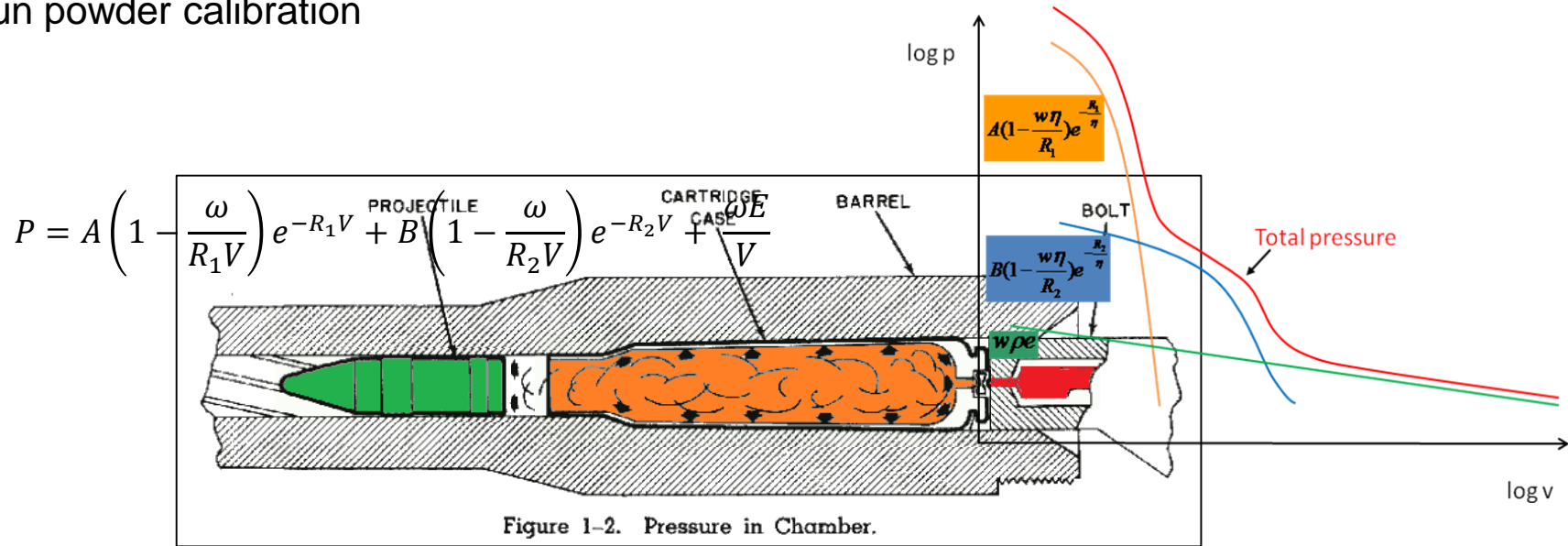
- Full magazine MBD simulation.
- One cycle Explicit simulation.
- Optimize Non Rigid Boundary conditions.
- Drop/Failure Simulation





Preliminary work

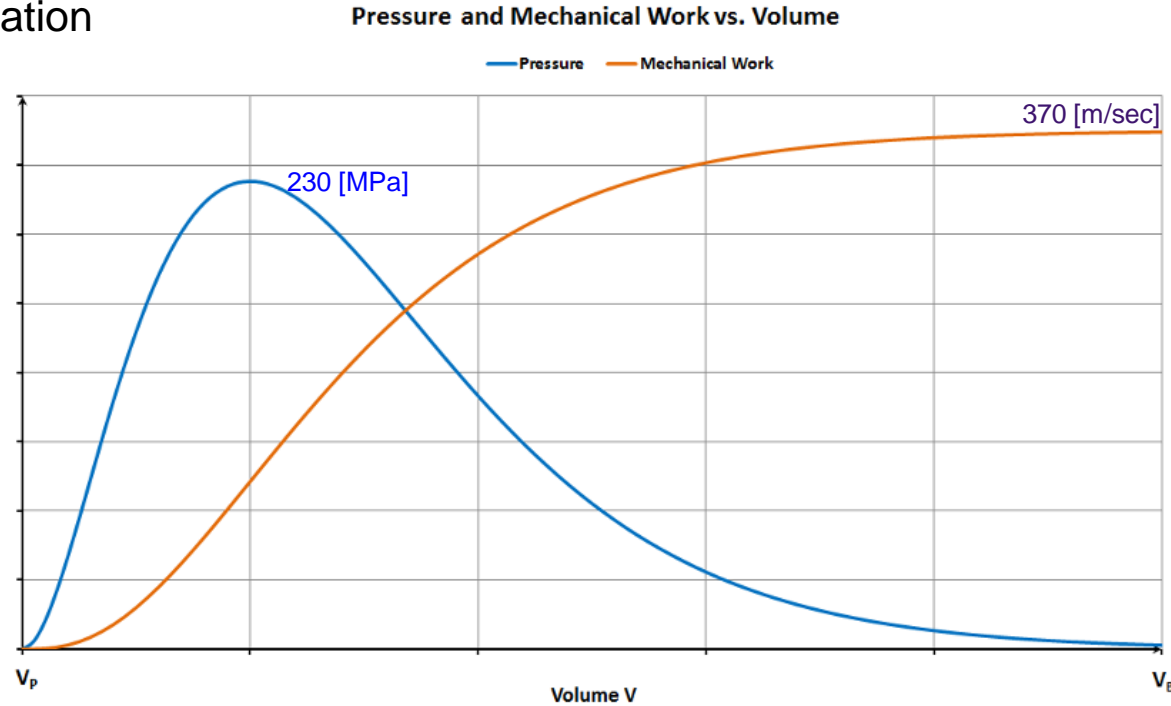
- Gun powder calibration





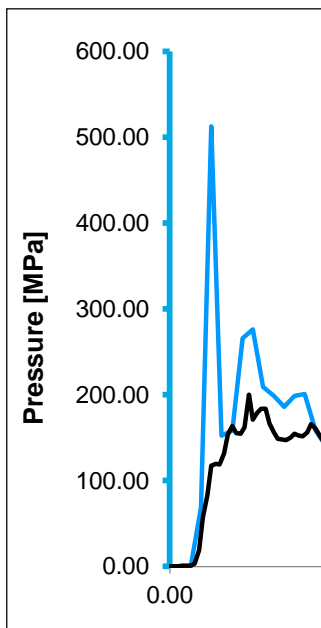
Preliminary work

- Gun powder calibration



Preliminary work

Gun powder calibration

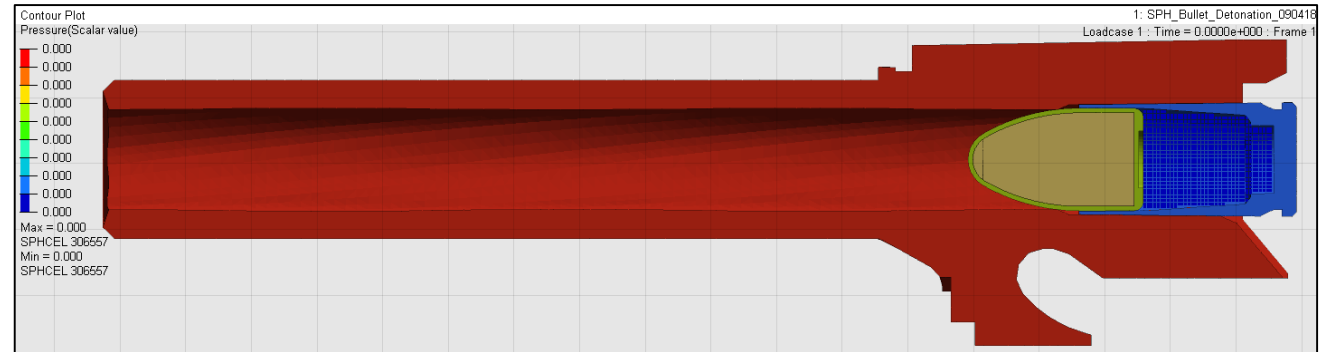
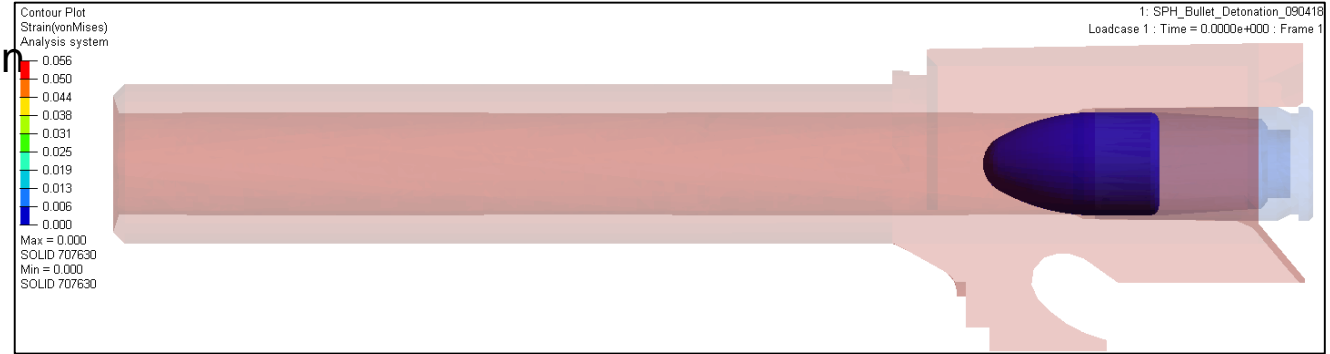


	A	B	R1	R2	w	E0	Response 1	Response 2
1	190.00000	250.00000	0.0900000	0.5000000	0.2000000	1680.0000	-277.76213	209.32007
2	221.35000	250.00000	0.0900000	0.5000000	0.2000000	1680.0000	-225.14655	194.65614
3	190.00000	275.00000	0.0900000	0.5000000	0.2000000	1680.0000	-282.85111	222.09027
4	190.00000	250.00000	0.1048500	0.5000000	0.2000000	1680.0000	-357.55978	272.97784
5	190.00000	250.00000	0.0900000	0.5825000	0.2000000	1680.0000	-293.64287	209.22499
6	190.00000	250.00000	0.0900000	0.5000000	0.2330000	1680.0000	-253.34409	197.70091
7	190.00000	250.00000	0.0900000	0.5000000	0.2000000	1957.2000	-365.70699	267.65228
8	176.02367	244.40991	0.0961533	0.5750000	0.1700000	1680.6844	-363.73111	255.86688
9	175.36000	243.14688	0.0968790	0.6694223	0.1920813	1680.9086	-381.13316	254.35487
10	190.76226	249.47385	0.0976374	0.6719971	0.1821219	1680.0267	-353.03839	251.23351
11	190.77017	249.12966	0.0968378	0.7505533	0.1774050	1680.0299	-355.51841	237.20837
12	190.80868	248.86379	0.0997516	0.7885713	0.1829999	1680.0321	-376.03282	255.53828
13	190.46060	248.05991	0.0983560	0.9500000	0.1688477	1680.1272	-380.52596	233.29437
14	190.52686	248.06477	0.0972028	0.8992631	0.1708913	1680.1181	-372.68421	235.45137
15	190.52222	247.95057	0.0965616	0.9046006	0.1696134	1680.1243	-373.73868	236.77994
16	190.53182	248.02716	0.0963152	0.9017760	0.1699531	1680.1191	-366.95678	236.13675



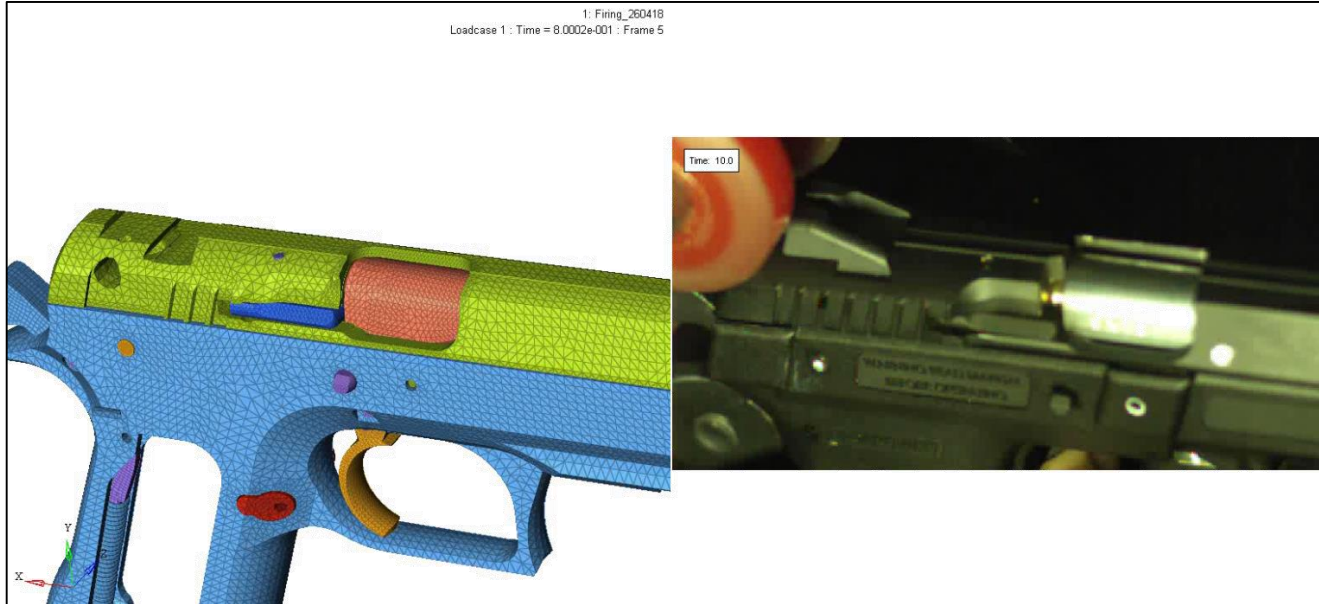
Preliminary work

- Gun powder calibration



Preliminary work

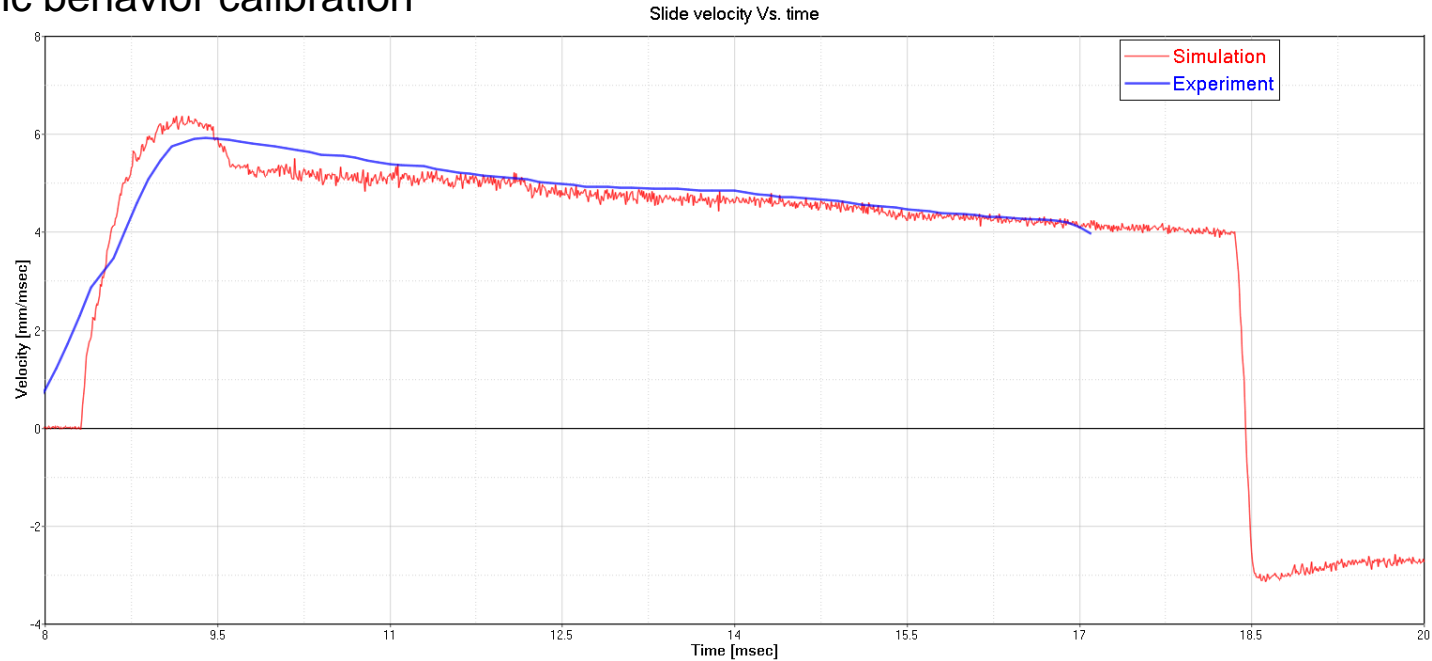
- Dynamic behavior calibration





Preliminary work

- Dynamic behavior calibration





Multi Body Dynamics

- Using scripted simulation



```
<Deactivate
  element_type=  "SENSOR"
  element_id=    "{sen_3001_distance.idstring}"
/>

<Activate
  element_type=  "SENSOR"
  element_id=    "{sen_3001_for_return.idstring}"
/>

<Simulate
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  duration=      "40"
  print_interval= "0.25"
/>

<!--.....system equilibrium.....-->

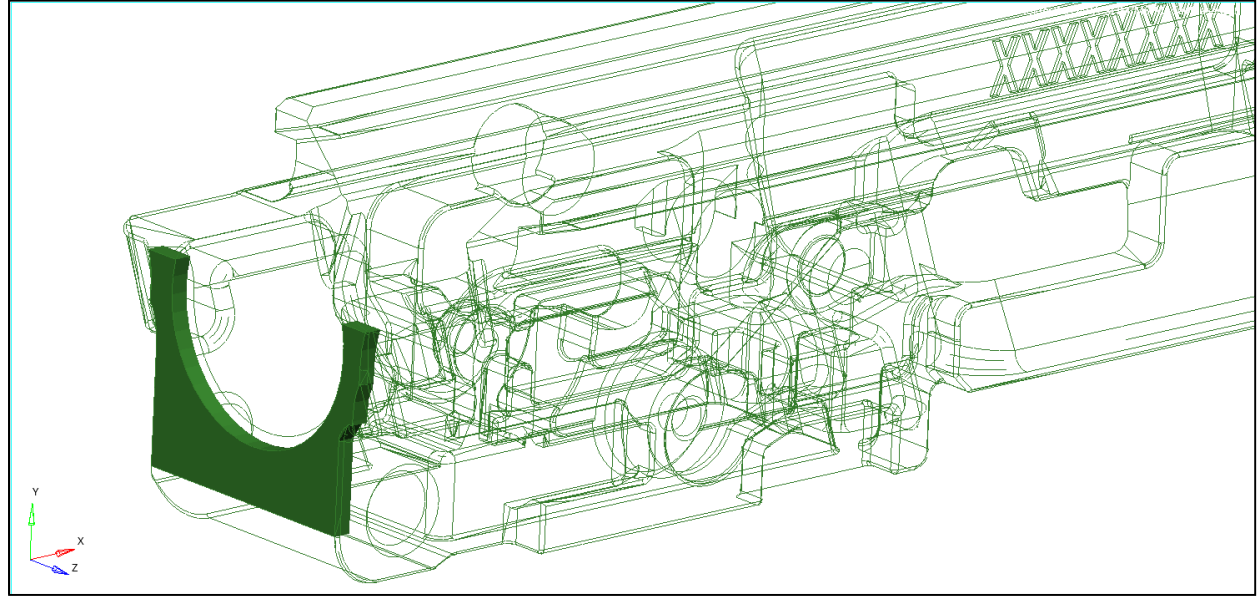
<Deactivate
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/>
```





Multi Body Dynamics

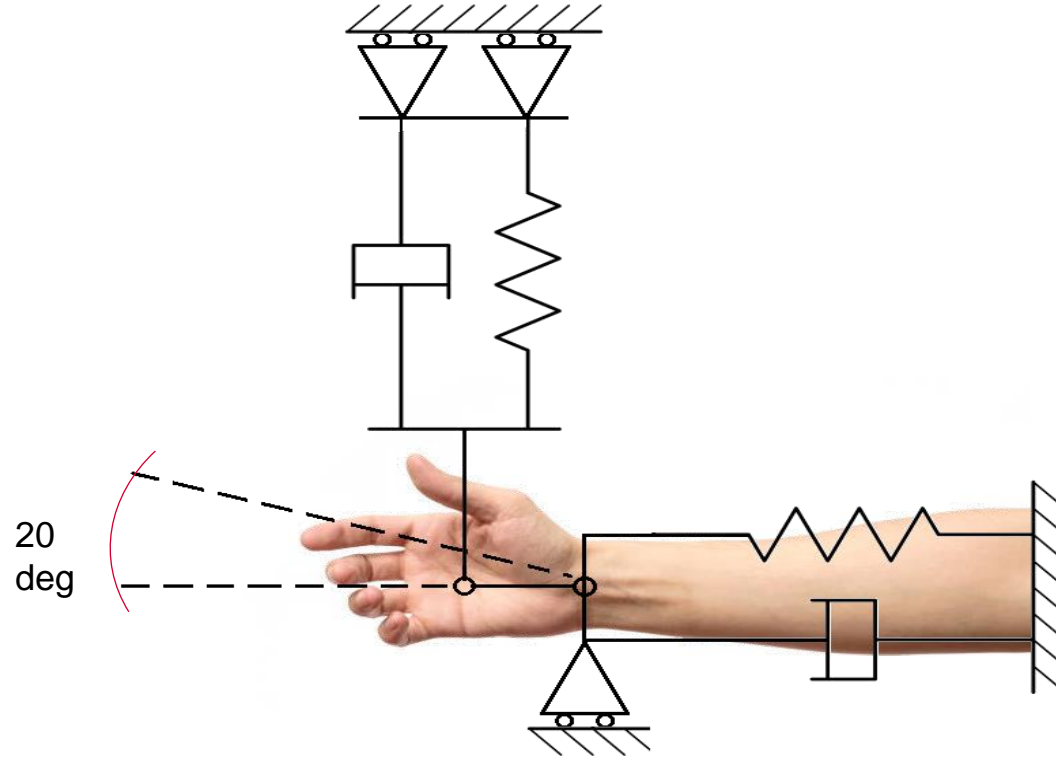
- Using localized contacts
- Meshing only valuable for contact regions
- Faster run times
- Less numerical problems
- Runtime –
40 msec in 12 minutes





Non Rigid Boundary Conditions (NRBC's)

- Human hand is a set of Spring-dampers



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Non Rigid Boundary Conditions (NRBC's)

Michael J. Fu, IEEE M. Cenk Cavusoglu

“Human Arm-and Hand Dynamics Model with Variability Analyses for a Stylus-base Haptic Interface “

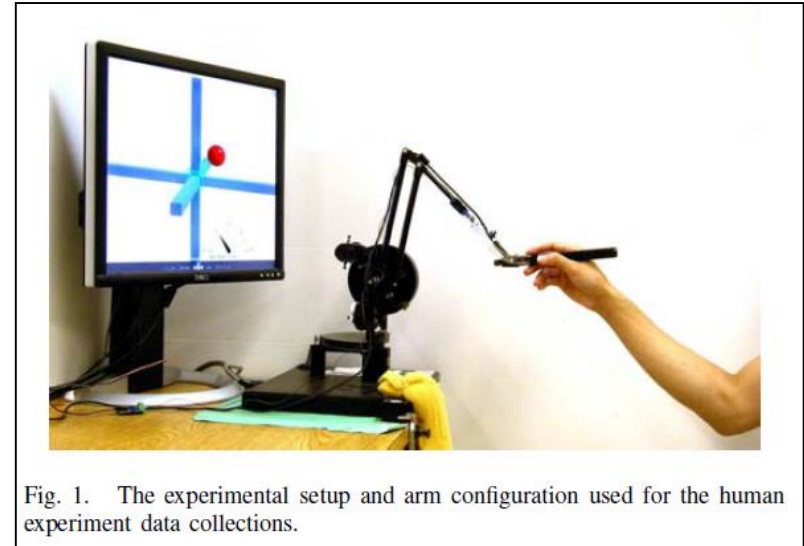
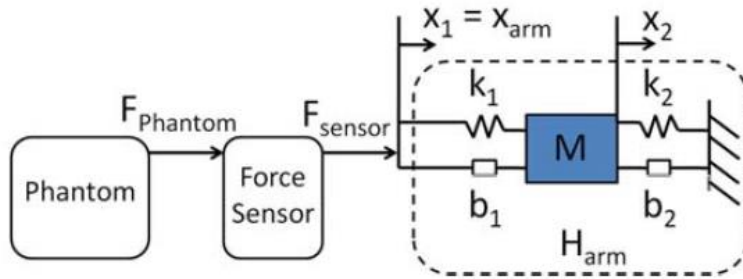


Fig. 1. The experimental setup and arm configuration used for the human experiment data collections.



Non Rigid Boundary Conditions (NRBC's)

Human Arm-and Hand Dynamics Model with Variability Analyses for a Stylus-base Haptic Interface

Michael J. Fu, IEEE M. Cenk Cavusoglu

TABLE I
ARM STRUCTURE PARAMETERS – GRIP FORCE DEPENDENT MODELS

X-axis	M (kg)	k_1 (N/m)	k_2 (N/m)	b_1 (N·s/m)	b_2 (N·s/m)
1N	0.2892	428.4	99.45	2.998	5.802
2N	0.2869	448.6	93.93	2.443	5.698
3N	0.2731	455.5	96.17	2.325	5.629
Y-axis	M (kg)	k_1 (N/m)	k_2 (N/m)	b_1 (N·s/m)	b_2 (N·s/m)
1N	0.4602	469.69	121.8	7.063	5.996
2N	0.3892	625.94	122.2	5.996	6.005
3N	0.4186	671.20	126.0	5.858	6.410
Z-axis	M (kg)	k_1 (N/m)	k_2 (N/m)	b_1 (N·s/m)	b_2 (N·s/m)
1N	0.2115	843.1	323.9	0.7093	19.42
2N	0.2525	868.3	332.8	0.5882	19.90
3N	0.2353	855.1	355.1	0.4925	20.56

TABLE II
NOMINAL ARM MODEL PARAMETERS

Axis	M (kg)	k_1 (N/m)	k_2 (N/m)	b_1 (N·s/m)	b_2 (N·s/m)
X-axis	0.2179	379.5	78.75	1.839	4.645
Y-axis	0.2692	552.4	105.3	3.609	6.430
Z-axis	0.2041	769.9	271.7	0.7764	18.06

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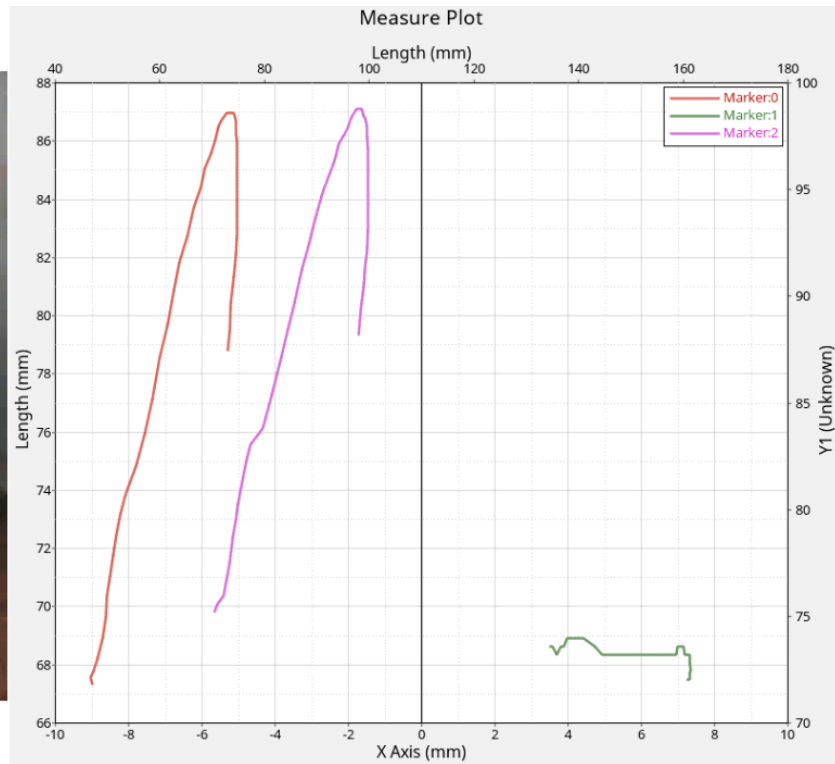
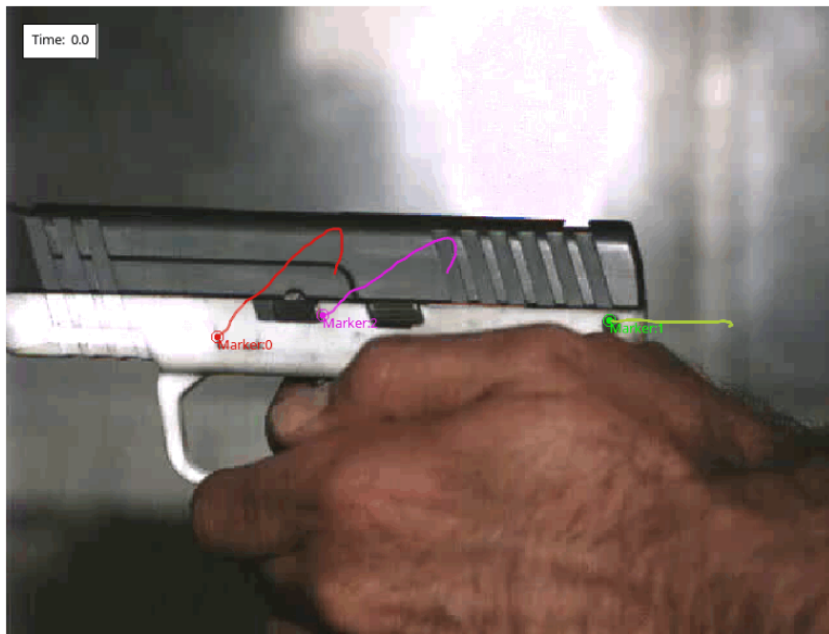


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- Target



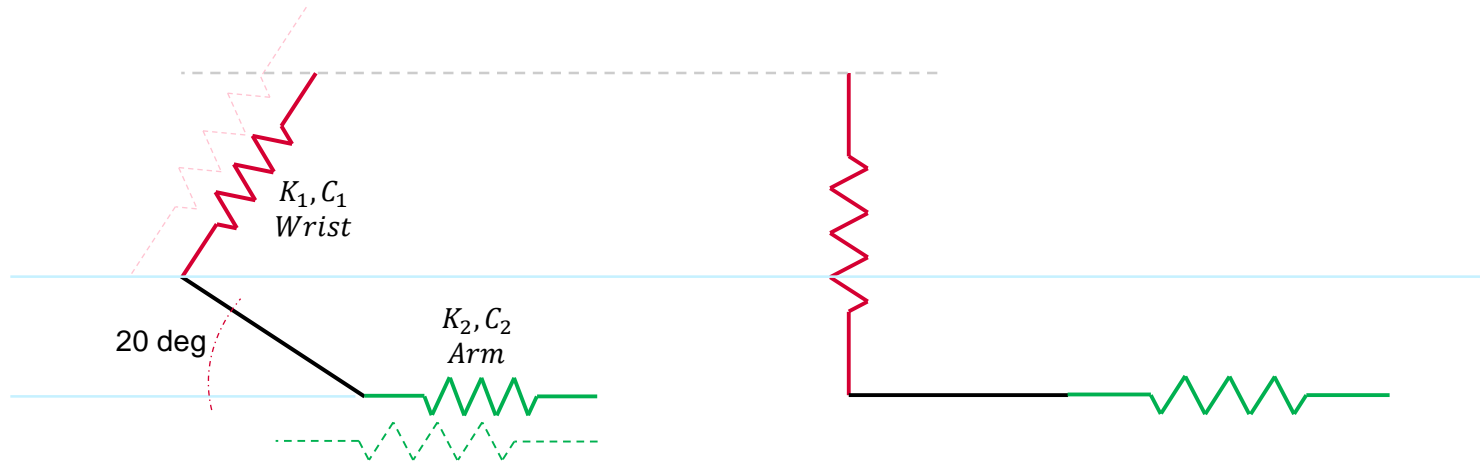
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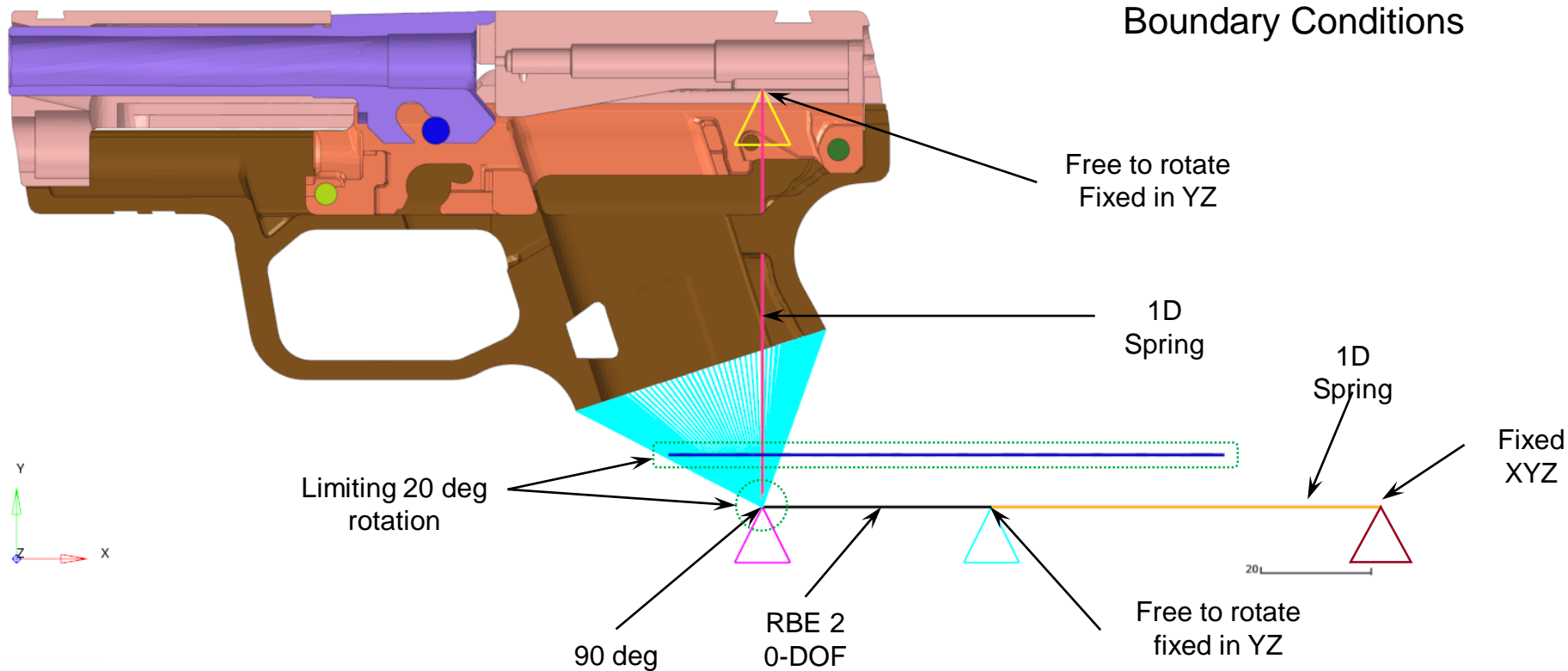


- Parameters





Non Rigid Boundary Conditions (NRBC's)



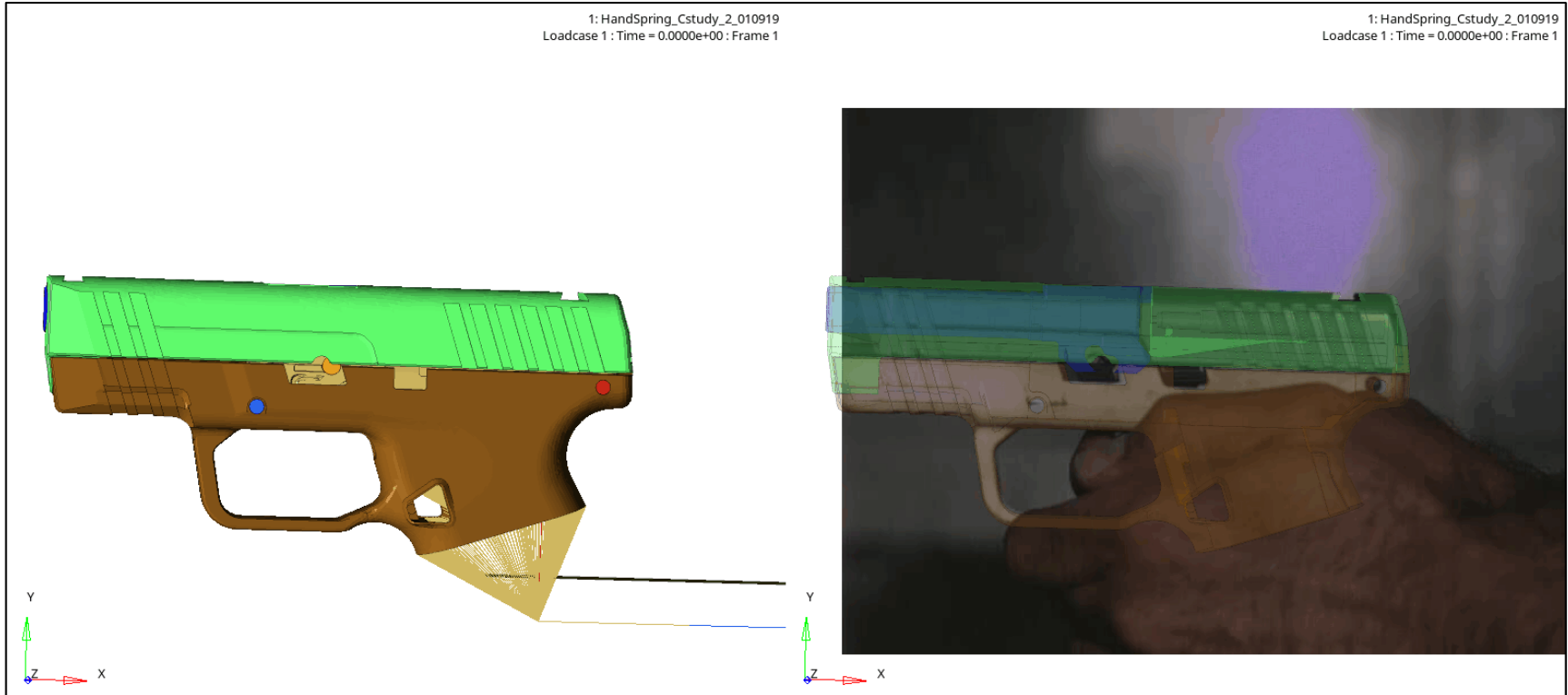
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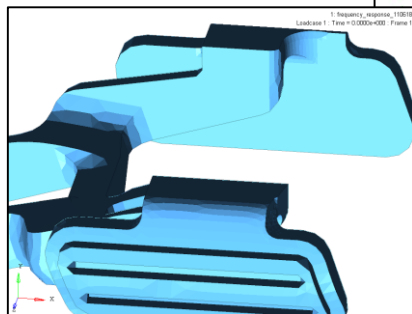
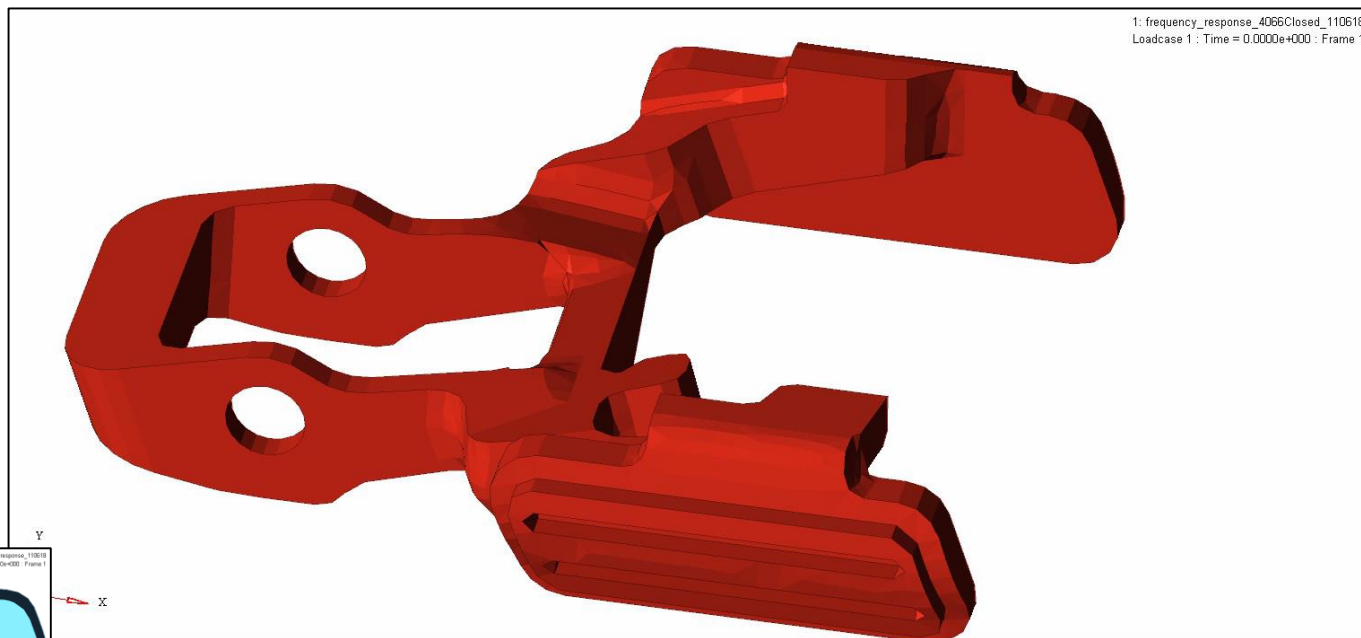
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NRBC's Results



Bonus



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Conclusions

- Complete firearm development using Altair HyperWorks
- HyperStudy – a valuable tool
- NRBC's – better approximation to the real conditions