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# Linear Inverse and Pendulum Calibration Evaluation

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**Pedestrian Protection Flex-Pli**

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# Linear Inverse and Pendulum Calibration Evaluation

## Presentation Topics

1. Testing Parameters
2. Linear Inverse Calibration
3. Pendulum Calibration
4. Summary

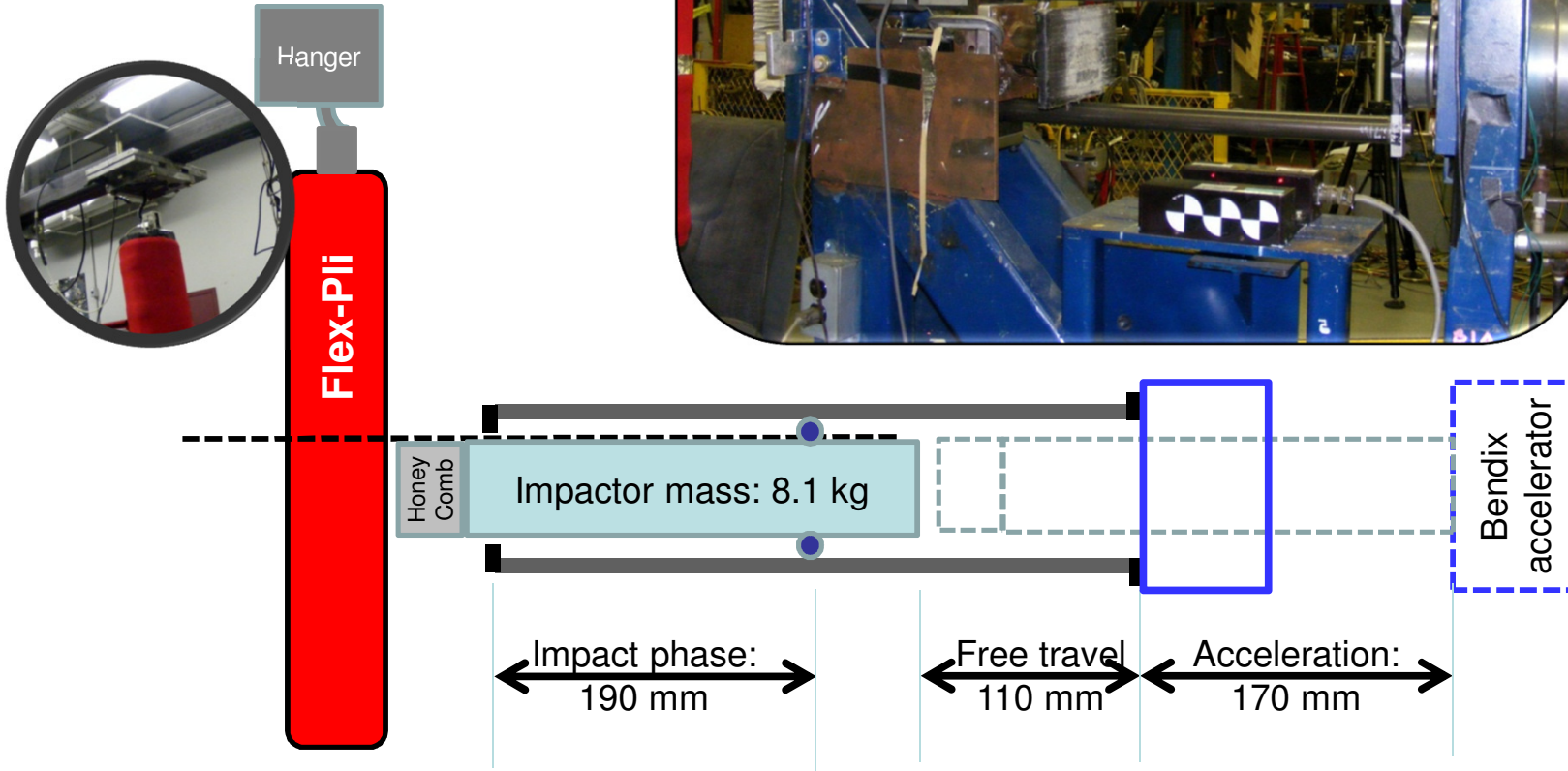
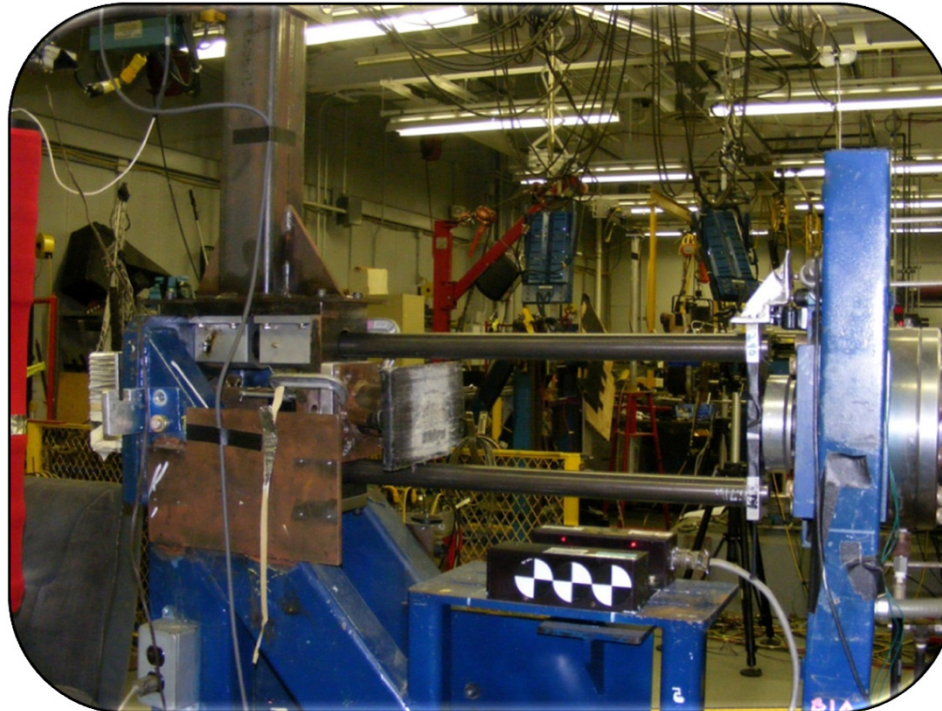


## Robin Round Calibration Testing

- Ford received 2 Flex-Pli impactors (E-leg and SN01).
- Ford completed 3 Linear Inverse and 3 Pendulum repeat calibration tests on each leg impactor.
- Pendulum and Linear Inverse calibration tests were set-up in accordance to the August 2011 REV 3 Flex-Pli Manual
  - The Linear Inverse test set-up targeted the BAST test set-up distances for impact to hard stop and free travel to impact.



# Bendix Impactor Setup for Linear Inverse Calibration





# Linear Inverse Test Results

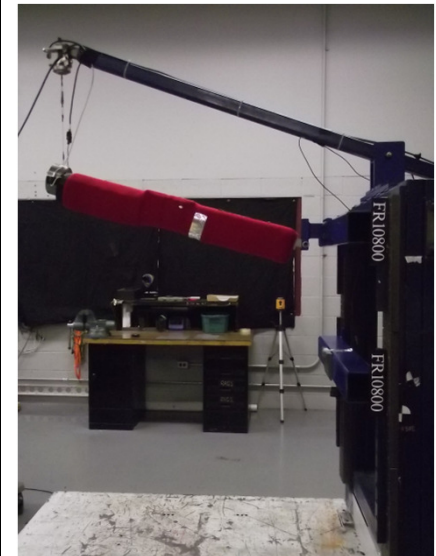
INVERSE CALIBRATION CORRIDOR PROPOSALS								
Calibration Corridor Proposals		Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	PCL	MCL
Original Upper		277	269	204	120	10.5	6	23
Original Lower		237	223	176	98	8.5	4.5	18
Prop JARI Upper		270.96	256.18	193.21	112.17	9.8	5.68	21.81
Prop JARI Lower		230.96	210.18	165.21	90.17	7.8	4.18	16.81
Prop BAST Upper		272	252	192	108	10	6	21
Prop BAST Lower		233	216	167	93	8	4	17
FORD CALIBRATION RESULTS								
BAST corridor proposal was used to evaluate calibration results								
Leg Impactor - Ford Run #	Velocity	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	PCL	MCL
SN01 - Ford Test 1	11.26	250.9	231.6	177.5	99.2	8.4	4.94	18
SN01 - Ford Test 2	11.20	248.2	230.5	177.1	100.5	8.1	4.92	17.7
SN01 - Ford Test 3	11.04	249.5	230.5	176.9	101	8.2	4.99	17.9
E leg - Ford Test 1	11.04	252.4	235.1	180.4	100	-	5.2	17.8
E leg - Ford Test 2	11.01	257.5	235.1	181.2	104.3	-	5.1	17.4
E leg - Ford Test 3	11.00	258.8	241.8	184.8	102.1	-	5.1	17
Ford Mean (SN01 & E leg)		252.9	234.1	179.7	101.2	8.2	5.0	17.6
StdDEV		4.3	4.3	3.1	1.8	0.2	0.1	0.4

The E-leg ACL pot was broken, no data was measured



# Pendulum Calibration Results

PENDULUM CALIBRATION CORRIDOR PROPOSALS							
Corridor Proposals	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	MCL	PCL
Original Upper	272	211	160	108	11	26	5.4
Original Lower	235	185	135	94	9	23	4
Prop JARI Upper	272.5	216.8	167.3	111.9	10	24	5.2
Prop JARI Lower	235.4	190.9	142	97.3	8.1	20.8	3.8
Prop BAsT Upper	272	219	166	111	10.5	24	5
Prop BAsT Lower	235	187	139	90	8	20.5	3.5
FORD CALIBRATION RESULTS							
BAsT corridor proposal was used to evaluate calibration results							
Leg Impactor - Ford Run #	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	MCL	PCL
SN01 - Ford Test 1	252.4	199.4	149.6	100	8.75	22.5	4.55
SN01 - Ford Test 2	252.9	199.3	148.8	99.1	8.85	22.75	4.73
SN01 - Ford Test 3	254.6	200.3	149.4	99.2	8.75	22.84	4.73
E leg - Ford Test 1	252.2	200.2	148.9	97.2	-	22.4	4.2
E leg - Ford Test 2	256.7	205.2	153.7	102	-	22.4	4.6
E leg - Ford Test 3	257.1	205.2	153.7	102	-	22.5	4.7
<b>Ford Mean (SN01 &amp; E leg)</b>	<b>254.3</b>	<b>201.6</b>	<b>150.7</b>	<b>99.9</b>	<b>8.8</b>	<b>22.6</b>	<b>4.6</b>
<b>StdDEV</b>	<b>2.2</b>	<b>2.8</b>	<b>2.4</b>	<b>1.9</b>	<b>0.1</b>	<b>0.2</b>	<b>0.2</b>



The E-leg ACL pot was broken, no data measured.



## Summary

### 1. Ford Test Results:

- Both the SN01 and E-Leg impactors met the proposed BAST calibration corridors using the inverse and pendulum calibration methods.
- The linear inverse calibration results for ACL and MCL fell on the low end of the corridor

### 2. Calibration Finalization:

- The effect of vehicle testing should be evaluated to the proposed calibration corridors. The planned TF-RUCC vehicle and calibration testing round robin should address this item.
- The SN01 and E-Leg impactors are master legforms; the influences from the manufacturing process should be considered to confirm consistency in leg impactors.

### 3. Femur Data Channels:

- How does an “out-of-spec” femur influence the tibia and knee injury measurements?
- The femur channels may be useful in CAE correlation and analysis.



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# Thank You!



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