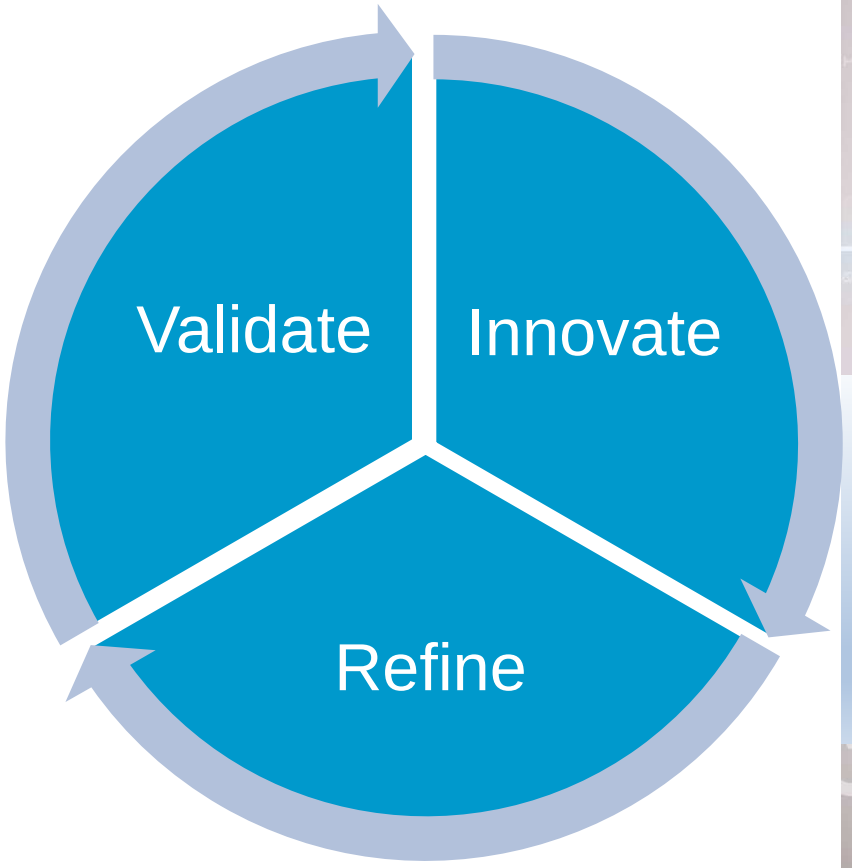
1243 ADT Scraper Tail Validation Project

Cynde Murphy/Wayne Tanner
Adaptive Corp.
October 2015

K-Tec History

- K-Tec started in 2000, when Ken Remple built his first pull-type scraper in his barn, due to frustration with lack of quality pull-type scrapers on the market
- Today the manufacture over 100 vehicles per year
- Sizes range from 25 to 63 yard capacity

About Adaptive Corporation



Connecting Virtual Design to the Physical World

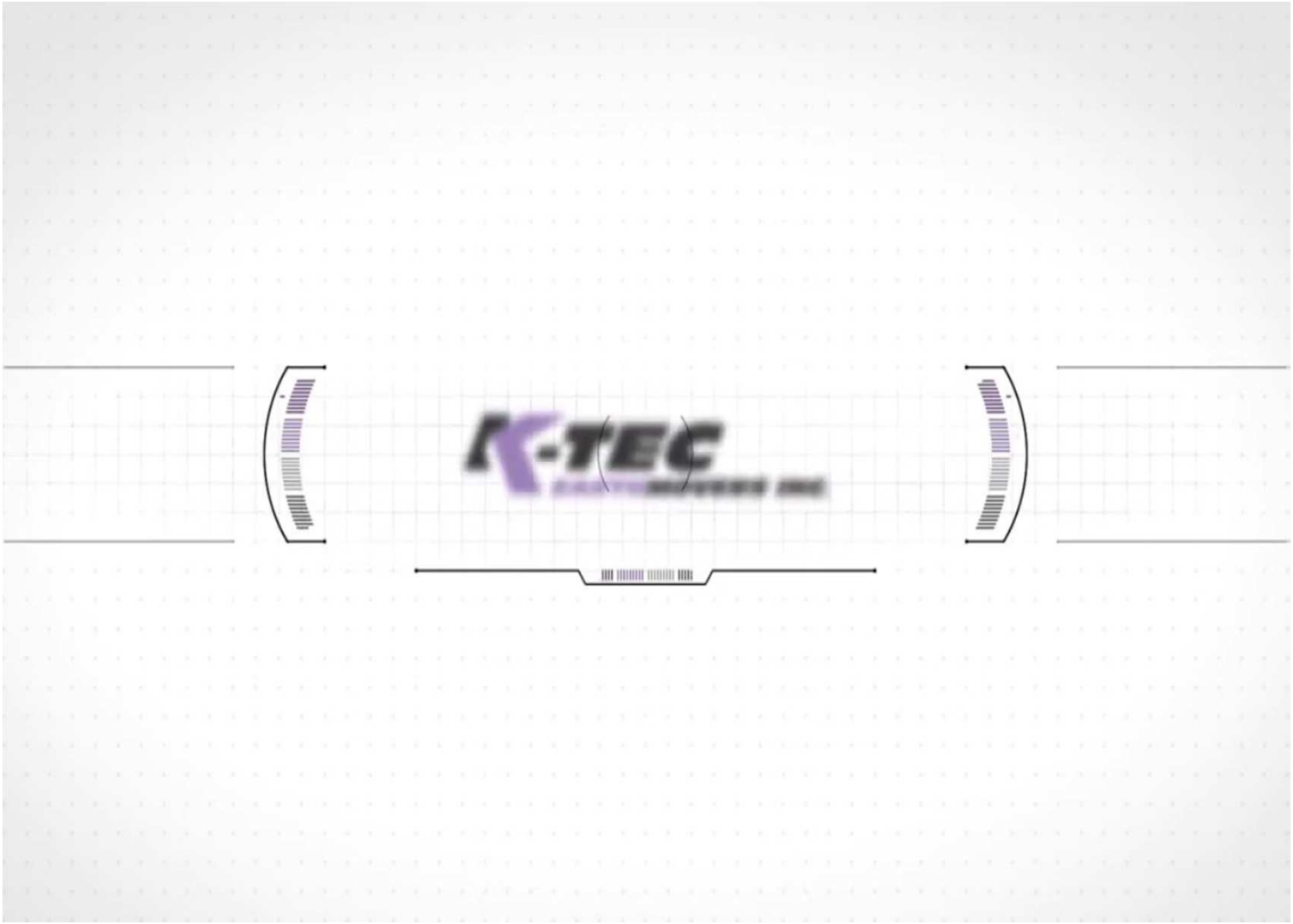
Software Partners

SIMULIA

MSC Software
Simulating Reality, Delivering Certainty™
BUSINESS PARTNER

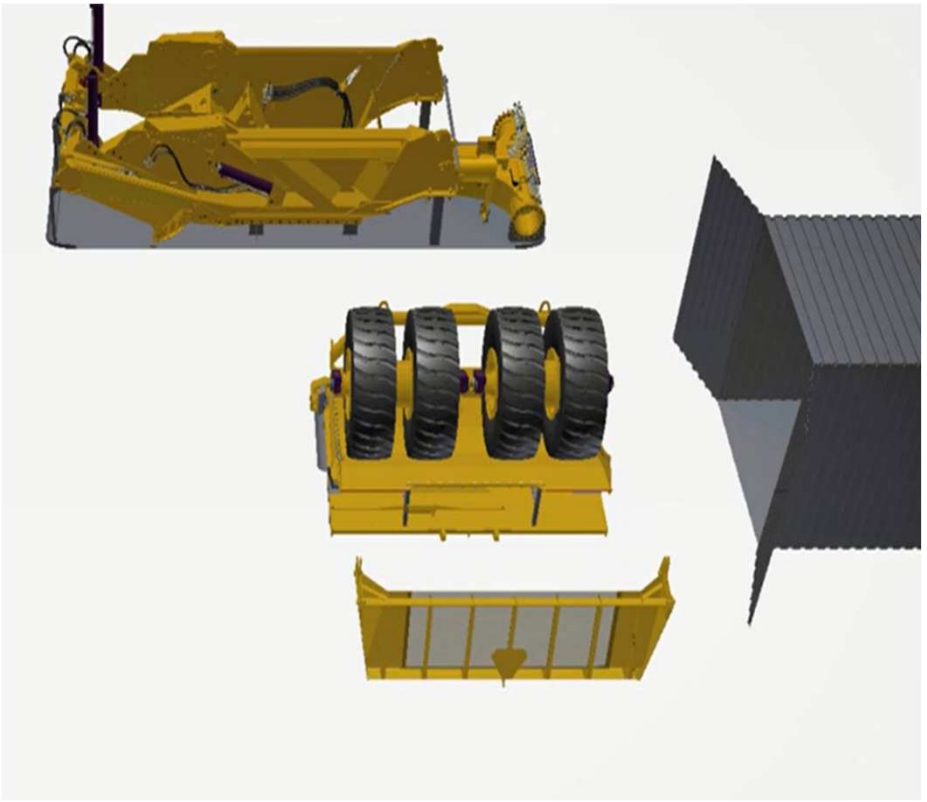
BETA
CAE Systems SA

1243 ADT Scraper in Action…



1243 ADT Design

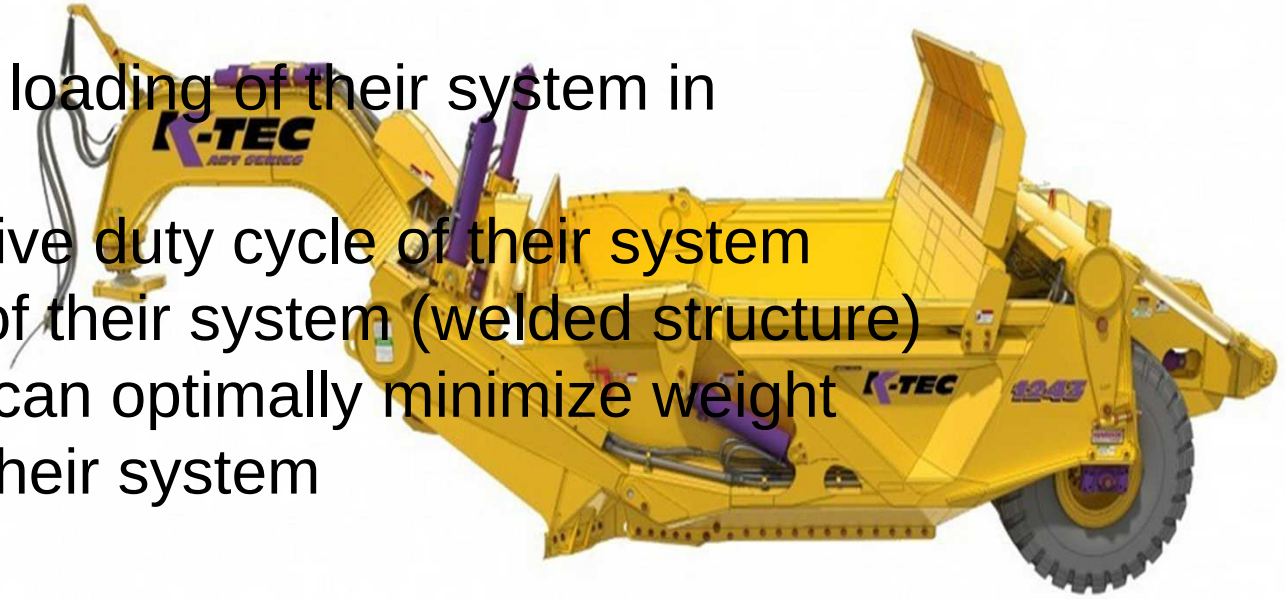
- New Concept to allow large design to assemble into shipping container
- Design sized using max/worst case static loading
- Final design approximately 20% over target weight



1243 ADT Scraper

Need to understand …

- ✓ Time history loading of their system in operation
- ✓ Representative duty cycle of their system
- ✓ Fatigue life of their system (welded structure)
- ✓ Where they can optimally minimize weight and cost of their system



1243 ADT Scraper Tail

Project Goals:

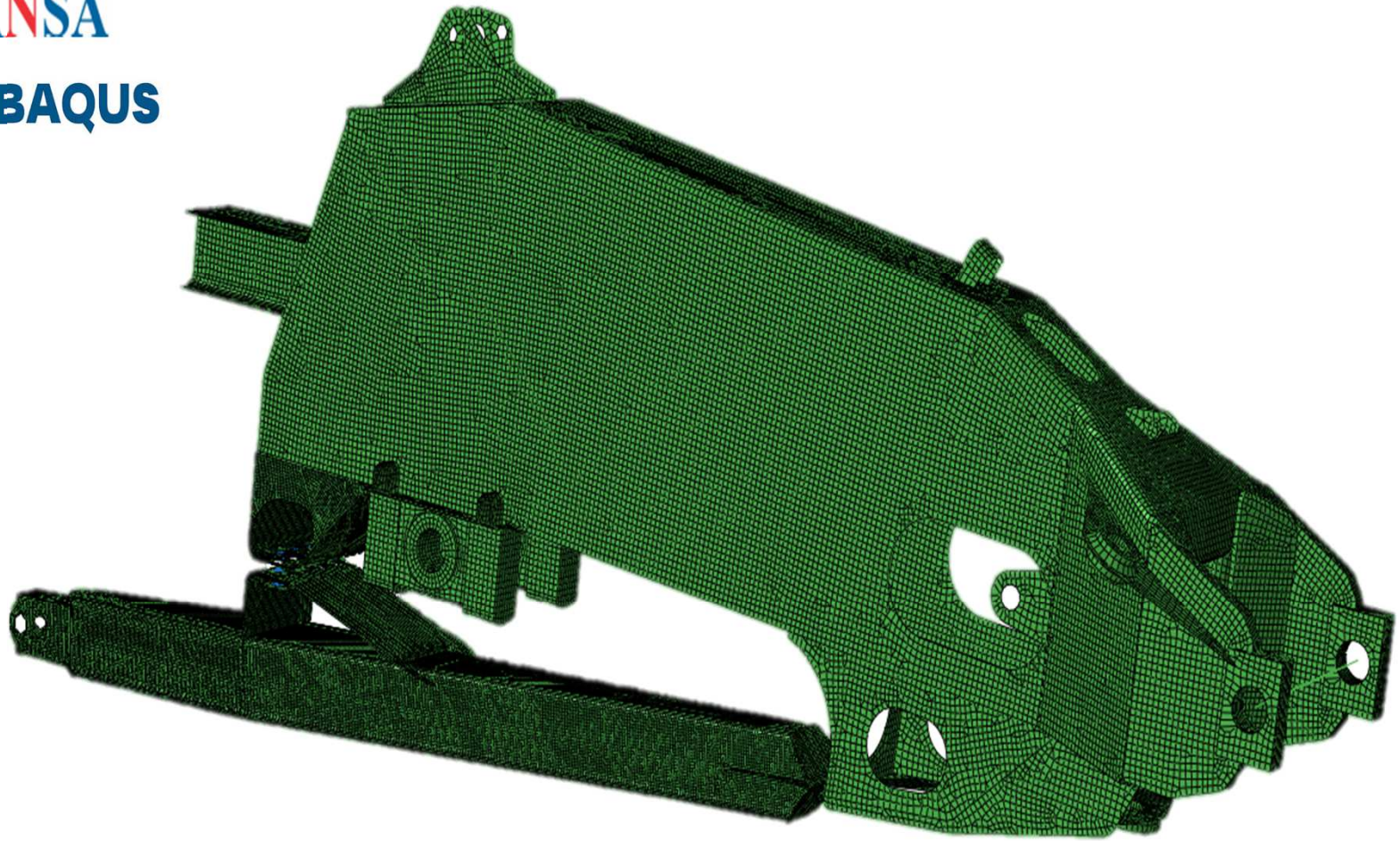
- Create FEM of Tail System
- Determine Load Time Histories on System via Measured Data
- Develop Duty Cycle from Load Time Histories
- Calculate Fatigue Life based on Duty Cycle/Load Time Histories
- Perform Optimization Based on Load Time Histories

Create FEM of Tail System

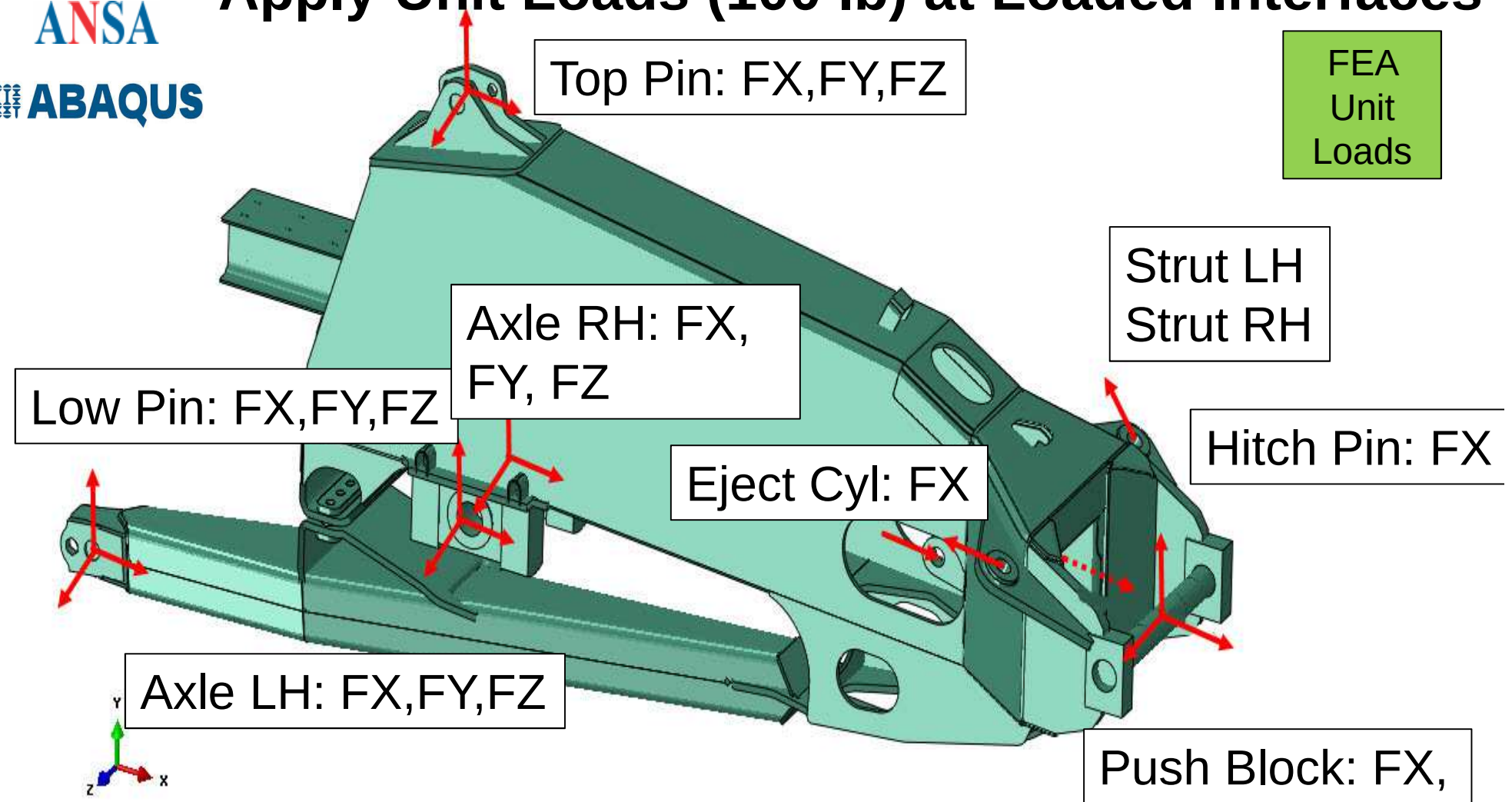
BETA CAE Systems SA

ANSA

ABAQUS



Create FEM of Tail System
Apply Unit Loads (100 lb) at Loaded Interfaces

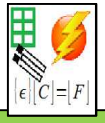


The True-Load™ Workflow

FEA Unit Loads

Virtual Gauge Placement **True-Load/Pre-Test**

Strain Measurement



Loading from Strains **True-Load/Post-Test**

INPUT 2: Duty Cycles: not just the most severe

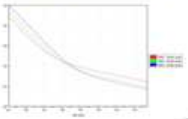
Design

FEA ANALYSIS: Abaqus, ANSYS, Nastran (MSC, NX, NEi), Ideas, Pro/E

INPUT 1: All stresses & temperatures

fe-safe

INPUT 3: Material Data +500 material database, strain-based, high temp. User can add own



RESULTS: Life Contours

Re-Design

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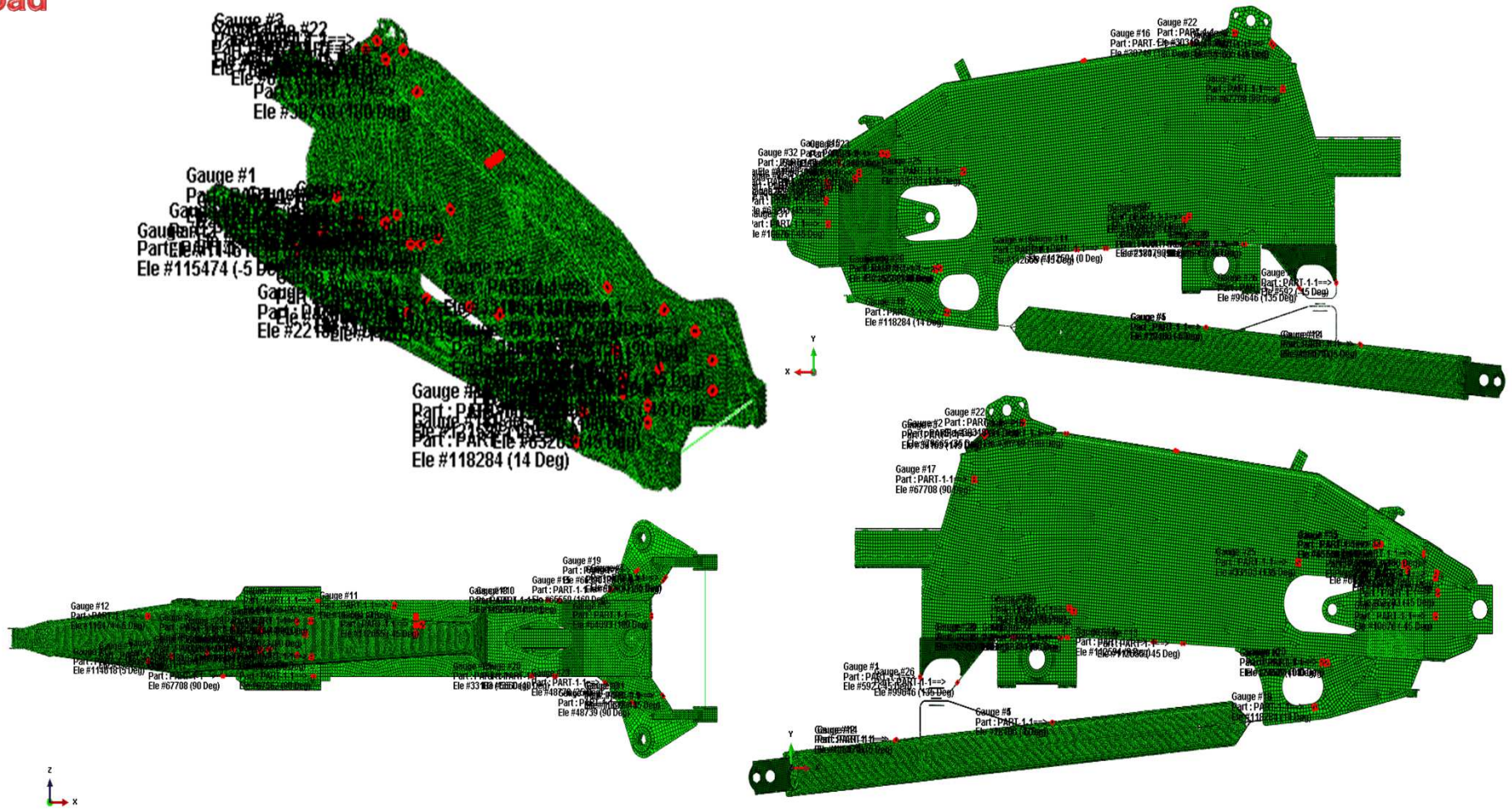
True-Load

T-L Pre-test
* Identify Strain Gauge Placement Based on FEA Unit Loads

Virtual Gauge Placement **True-Load/Pre-Test**



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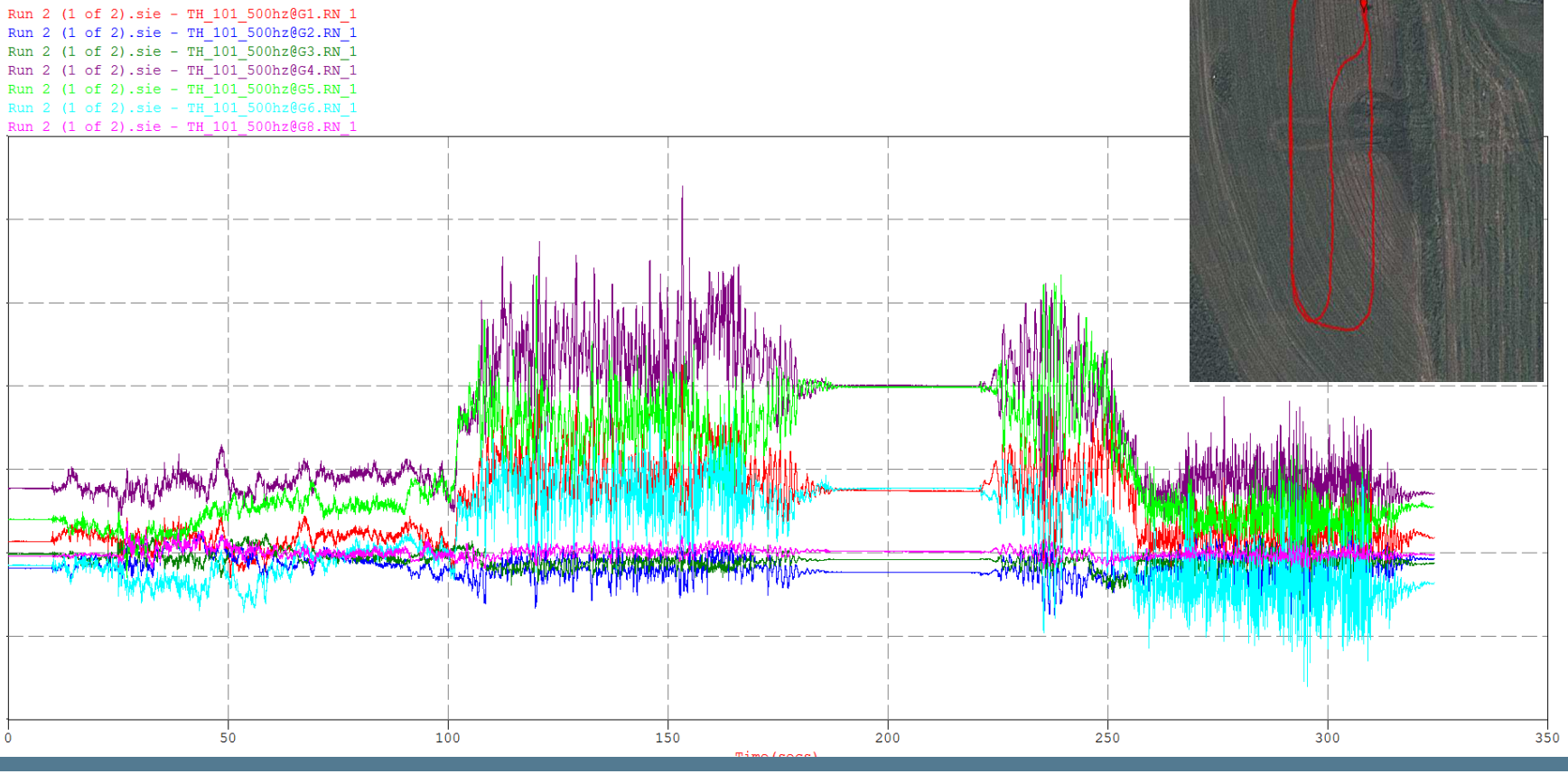
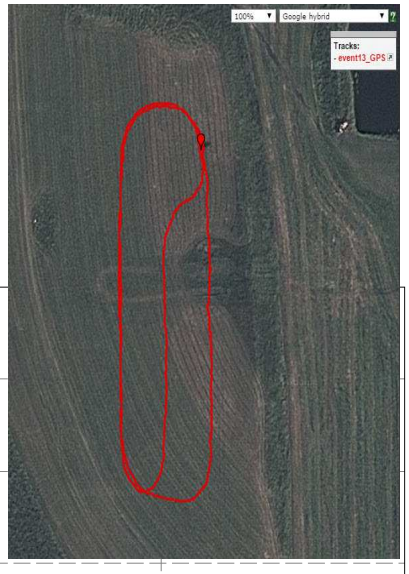
Strain Gauge Data Collection… on Various Terrains, Roads and Duty Cycles

Strain Measurement

True-Load





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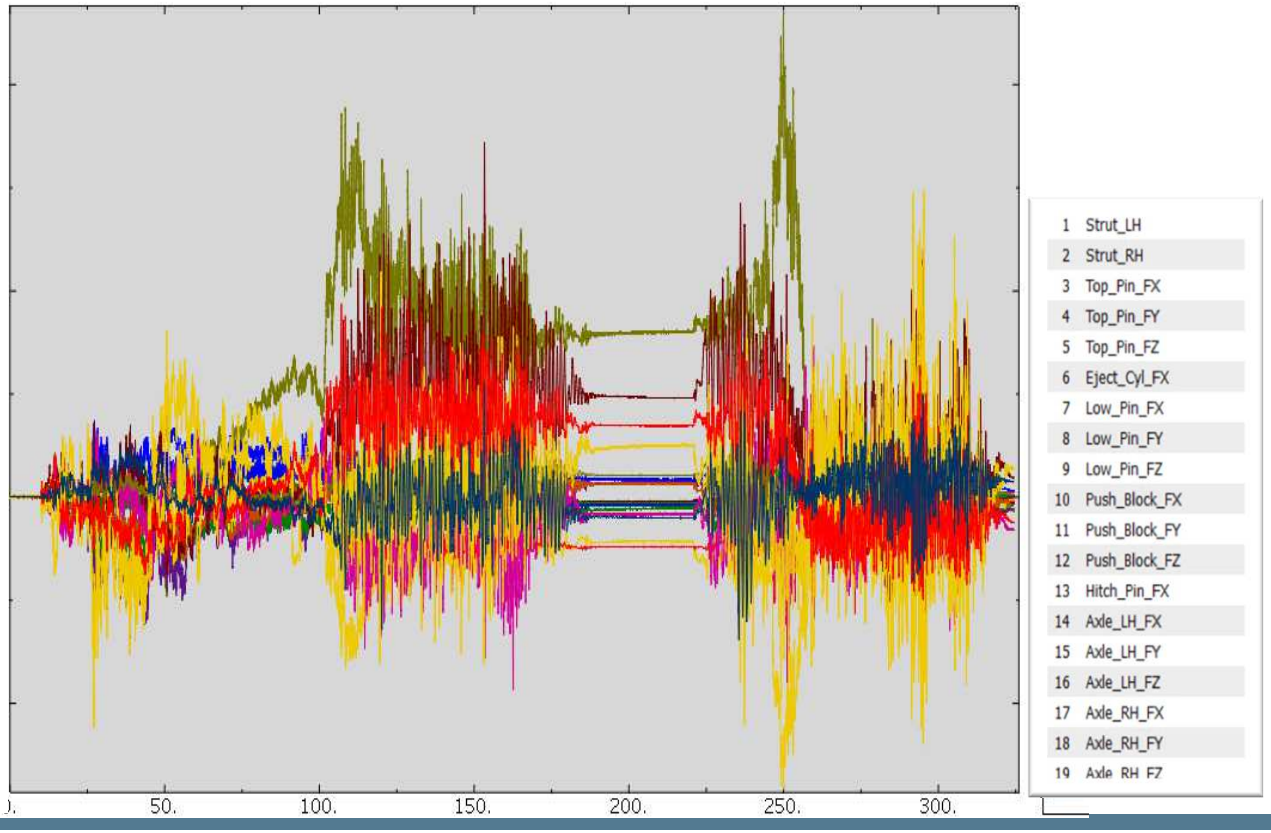
T-L Post-Test:

- **Calculate Loads from Strain Measurement**

Loading from Strains **True-Load/Post-Test**

True-Load

Event 2 Push Load with D8 Full



Unit Loads

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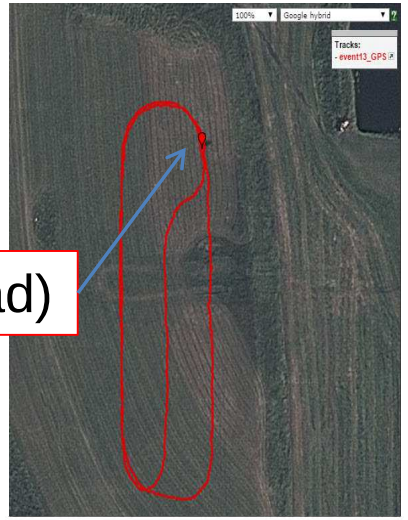
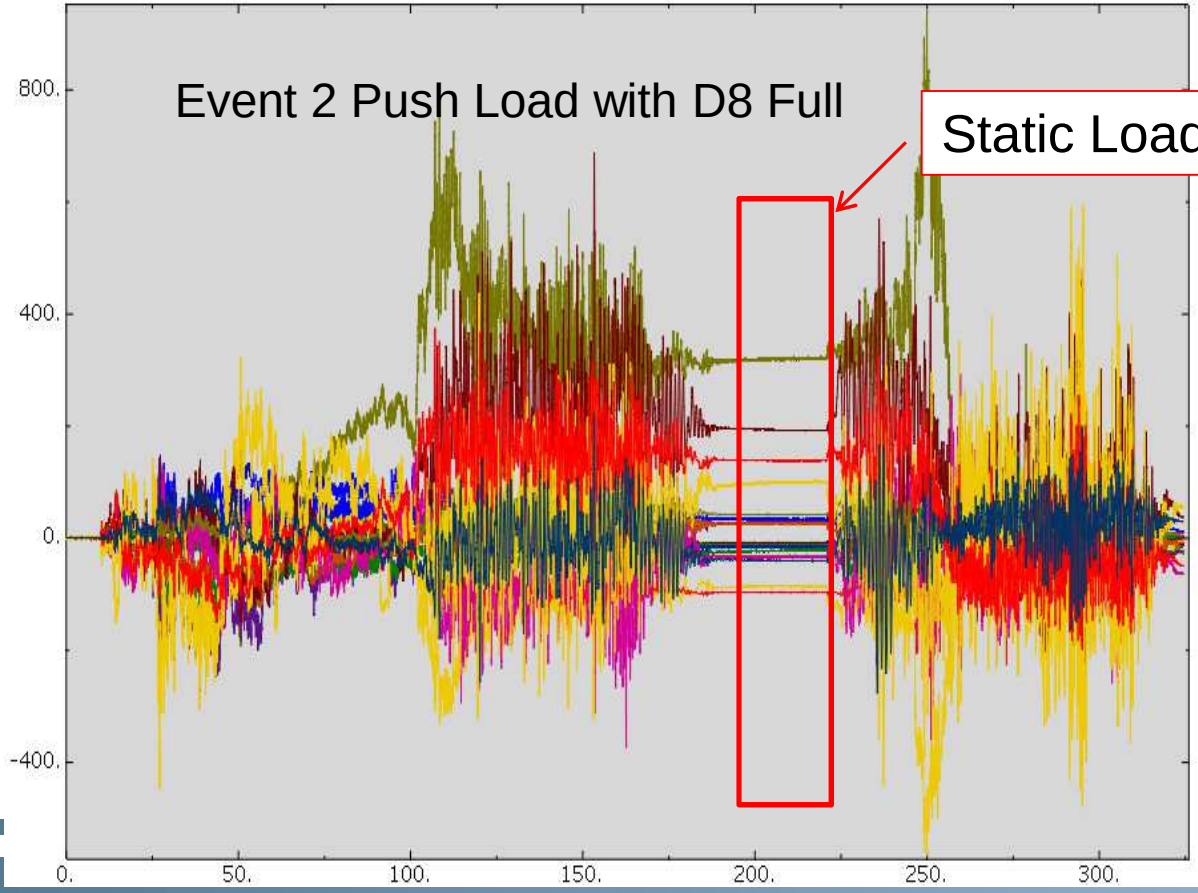
T-L Post-Test:

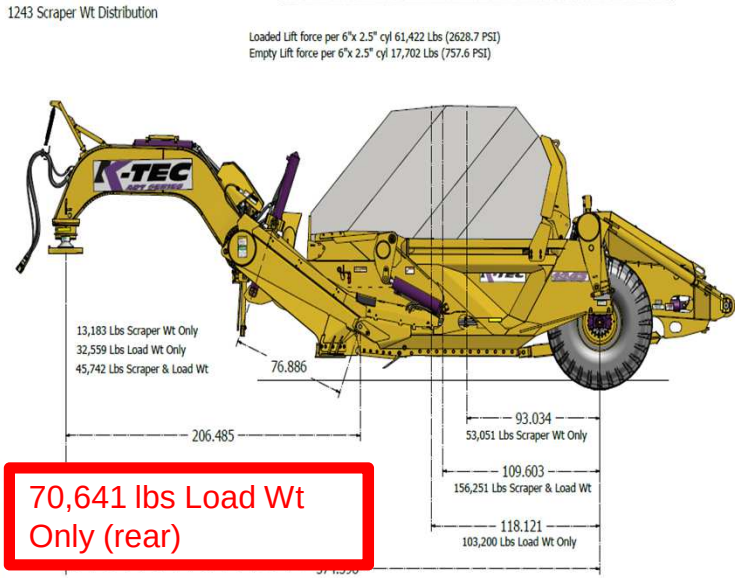
- **Unit Loads of Fully Loaded System vs Weight on Rear Axle of Fully Loaded System**

True-Load

Loading from Strains **True-Load/Post-Test**







70,641 lbs Load Wt Only (rear)

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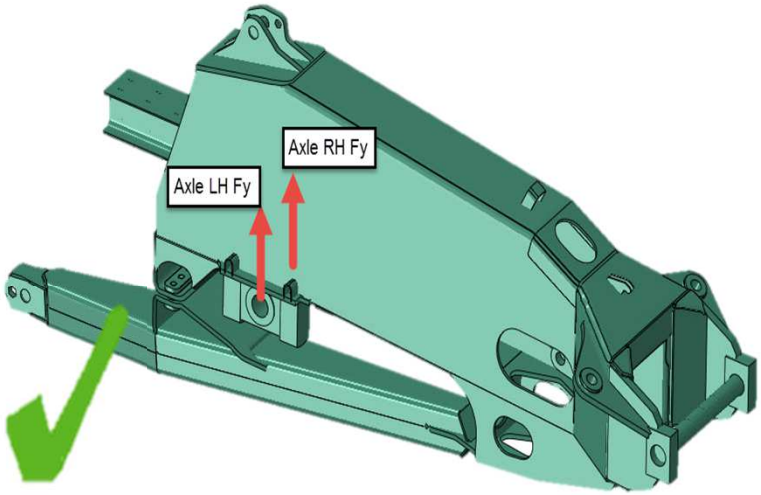
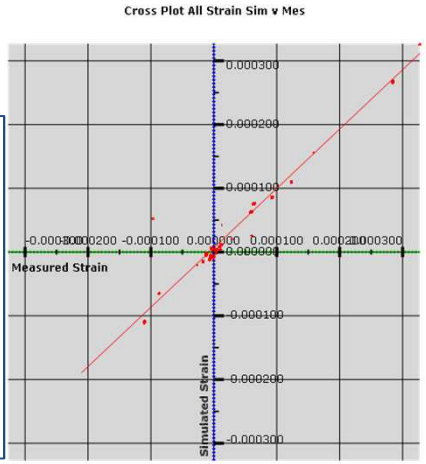
T-L Post-Test

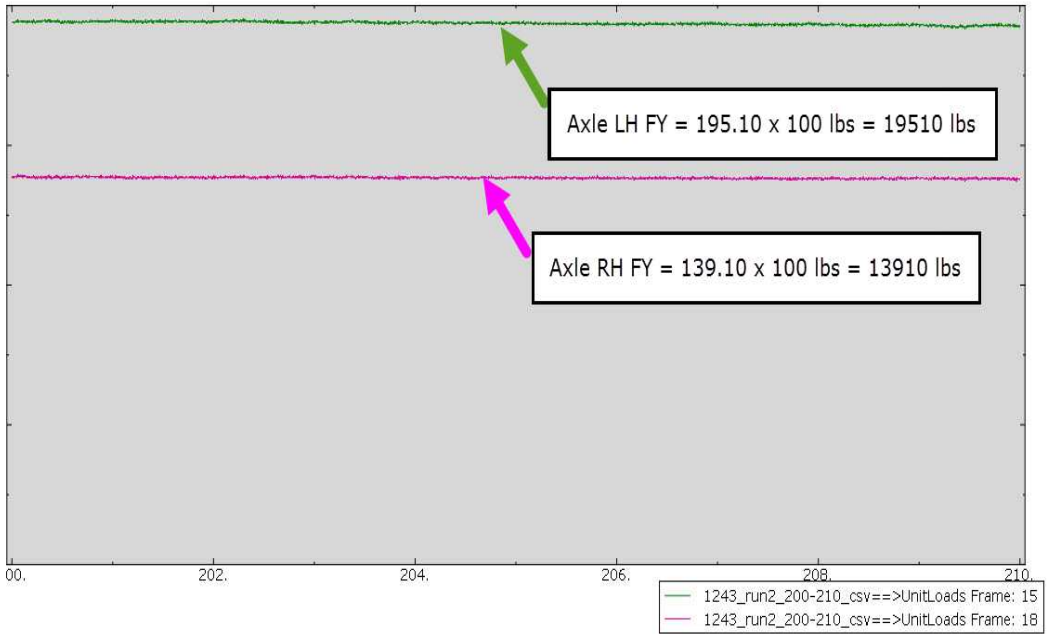
True-Load

Loading from Strains **True-Load/Post-Test**



Strain Gauge Sim vs Measured Cross-Plot





Total Vertical Load at Axle: 33420 lbs (~5.3% from Estimate Pay Load value of 35321 lbs)

This also demonstrates that the FEM Unit Load can simulate the Fully Loaded condition

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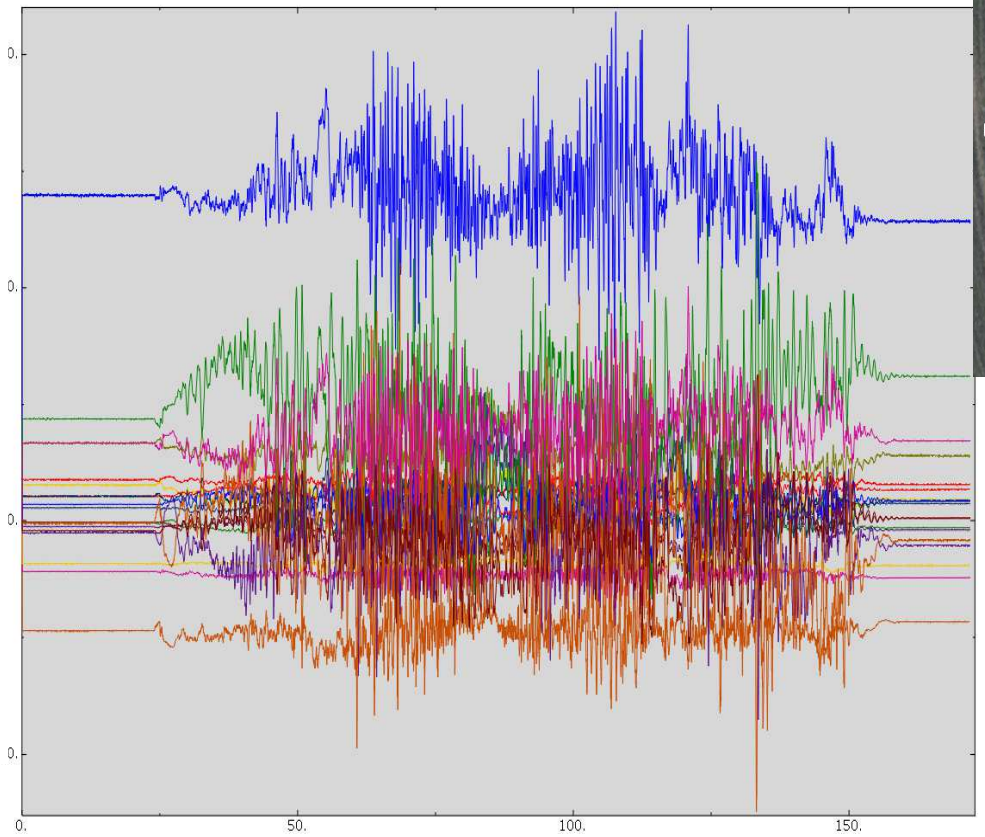
Loading from Strains **True-Load/Post-Test**

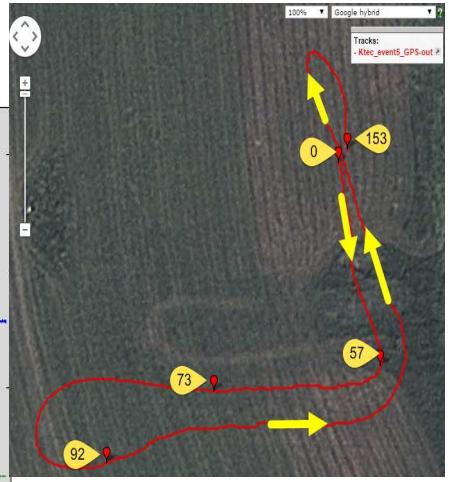
T-L Post-Test
Load Time History: Event 5: Haul across woops straight

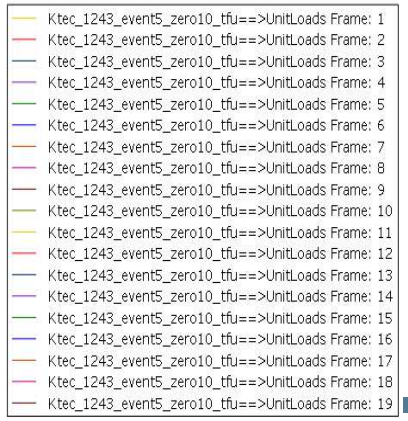
True-Load

K-Tec 1243 strain gauge testing events Sept. 9 '14

1. Self-load as much as possible
2. Push load with D8 full
3. Push load with D8 full around corner
4. Push load deep cut till full
5. Haul across woops straight
6. Haul across alternating woops
7. Haul high speed along dike loaded, record max speed
8. Haul high speed along road loaded, record max speed
9. Haul on rough road with scraper all up to cancel cushion ride.
10. Haul high speed along dike empty, record max speed
11. Haul high speed empty on rough haul road, record speed
12. Haul full load alongside of 4 – 1 slope
13. Haul full load down 4 – 1 slope then make right turn at bottom
14. Empty parked in straight line push on scraper block with D8
15. Empty parked in straight line pull on rear pin with D8
16. Loaded push at 45 deg. On roller push block from right with D8T max pressure (down & up)
17. Loaded push at 45 deg. On roller push block from left with D8T max pressure (down & up)
18. Lift back of scraper up off ground with dozer while loading.







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Loading from Strains **True-Load/Post-Test**

T-L Post-Test
Load Time History: Event 11: Haul High Speed
Empty on Rough Haul Road

True-Load

K-Tec 1243 strain gauge testing events Sept. 9 '14

1. Self-load as much as possible
2. Push load with D8 full
3. Push load with D8 full around corner
4. Push load deep cut till full
5. Haul across woops straight
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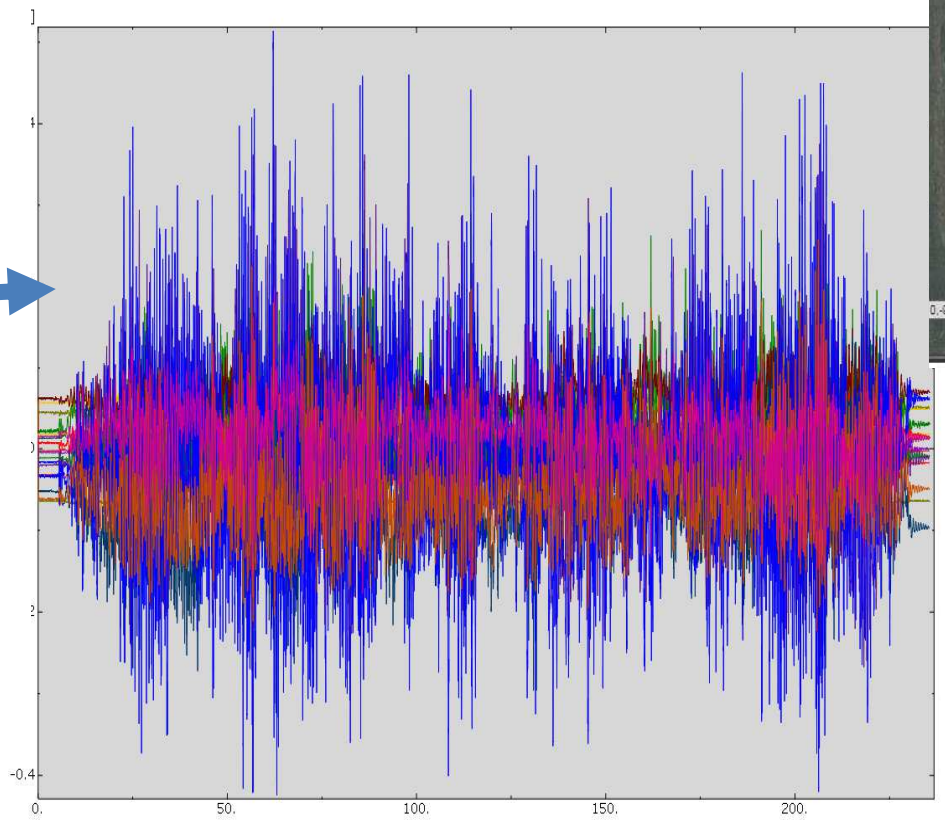

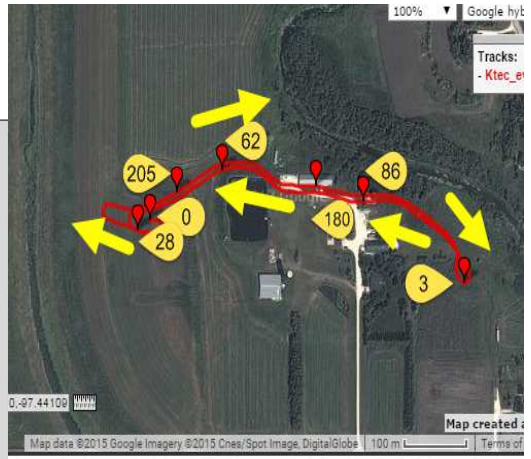

Ktec_1243_event11r2_zero10_tfu==>UnitLoads Frame: 1
Ktec_1243_event11r2_zero10_tfu==>UnitLoads Frame: 2
Ktec_1243_event11r2_zero10_tfu==>UnitLoads Frame: 3
Ktec_1243_event11r2_zero10_tfu==>UnitLoads Frame: 4
Ktec_1243_event11r2_zero10_tfu==>UnitLoads Frame: 5
Ktec_1243_event11r2_zero10_tfu==>UnitLoads Frame: 6
Ktec_1243_event11r2_zero10_tfu==>UnitLoads Frame: 7
Ktec_1243_event11r2_zero10_tfu==>UnitLoads Frame: 8
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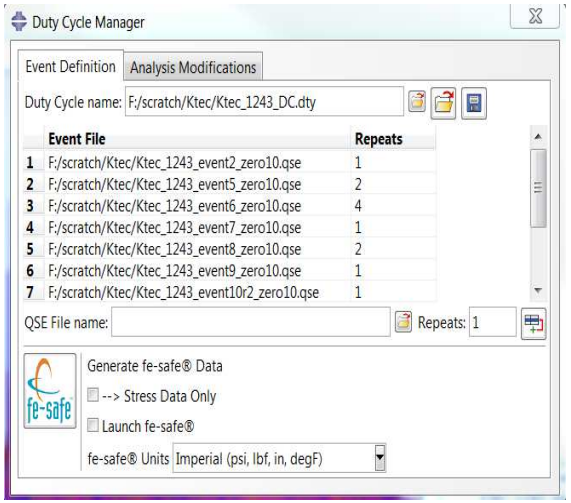
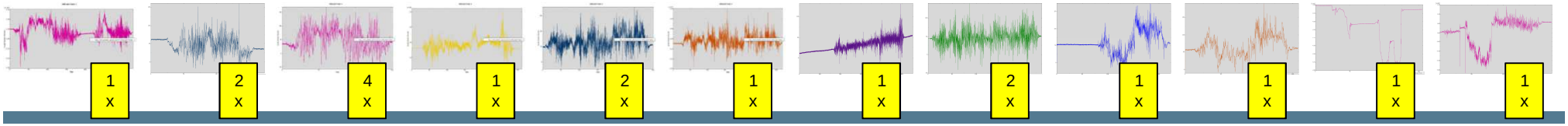
Duty Cycle Development

True-Load



- Based on input from customer
- 1 duty cycle = 1.07 hours of operation
- Direct fe-safe interface

Event #	Event Name	#repeats	time min (absolute)
2	F	1.00	5.41
5	F	2.00	5.73
6	F	4.00	8.00
7	F	1.00	5.17
8	F	2.00	10.00
9	F c	1.00	5.27
10	F	1.00	9.17
11	F s	2.00	7.87
12	F	1.00	3.70
13	F t	1.00	2.09
16	L v	1.00	2.00
18	L loading	1.00	1.00
	Total		65.40

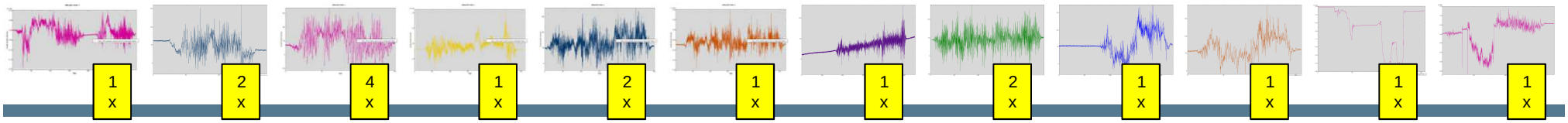


Fatigue Life Calculations

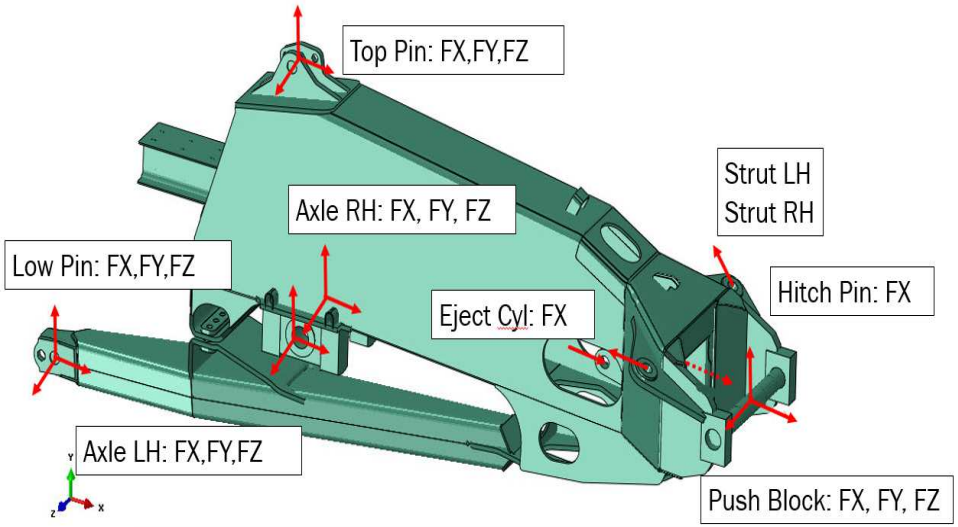
Datasets = Unit Load ABAQUS Results file (*.odb)

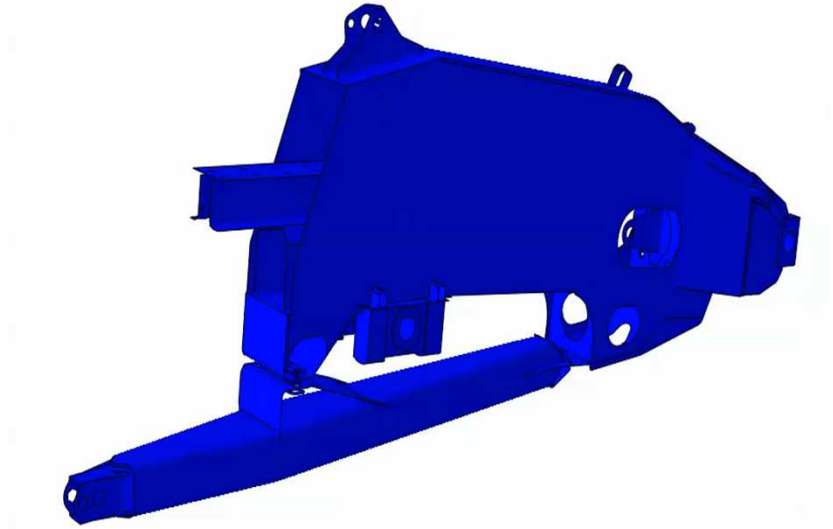
Fatigue Loading = Repeats of Events in Duty Cycle (*.ldf)

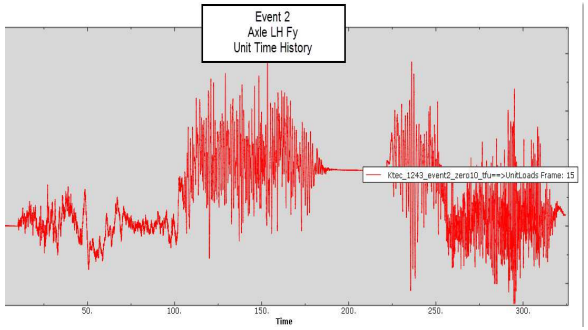
- 1 Elastic block per road event (there are 12)
- Duty Cycle:
  - Each elastic block/road event is repeated accordingly to create Duty Cycle
  - Each block includes datasets (unit loads) from 19 unit loads
  - Each block Datasets (unit loads*) are scaled according to T-L
    - *Unit Time Histories
  - Entire Duty Cycle= 1.1 hours of operation

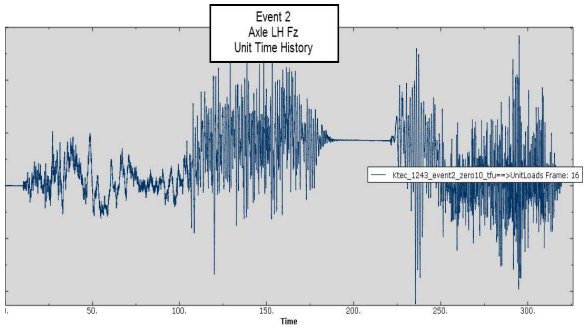


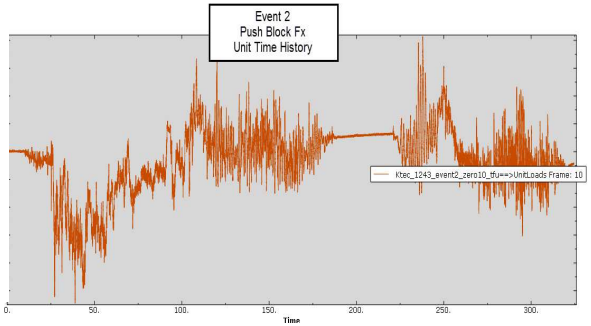
1	Strut_LH
2	Strut_RH
3	Top_Pin_FX
4	Top_Pin_FY
5	Top_Pin_FZ
6	Eject_Cyl_FX
7	Low_Pin_FX
8	Low_Pin_FY
9	Low_Pin_FZ
10	Push_Block_FX
11	Push_Block_FY
12	Push_Block_FZ
13	Hitch_Pin_FX
14	Axle_LH_FX
15	Axle_LH_FY
16	Axle_LH_FZ
17	Axle_RH_FX
18	Axle_RH_FY
19	Axle_RH_FZ









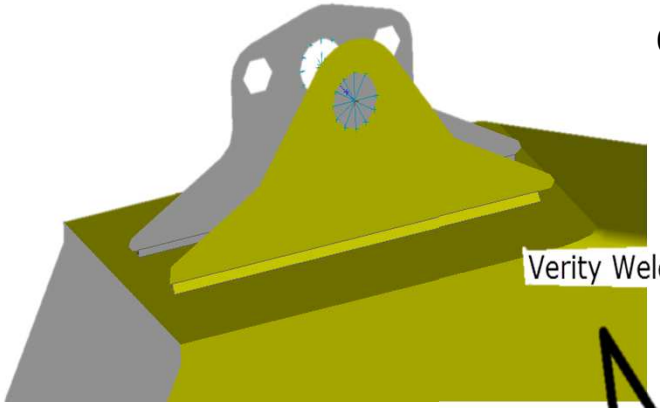


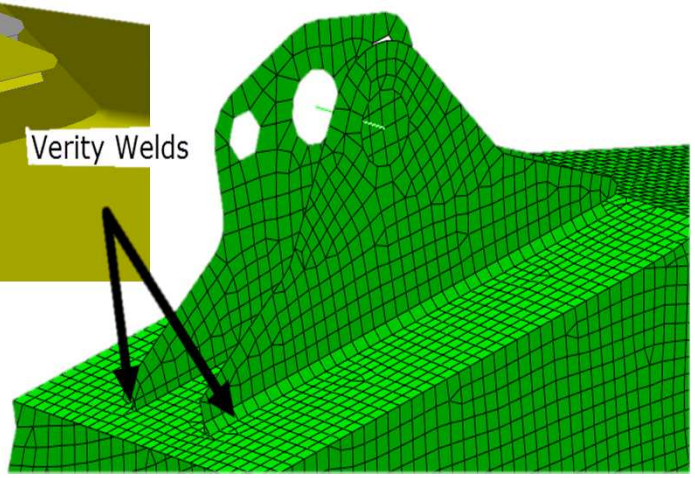
Step: Derived Step, F:/scratch/Ktec/Ktec_1243_event2_zero10.qse
Time 0.0
Primary Var: S, Mises
Deformed Var: U Deformation Scale Factor: +2.000e+01

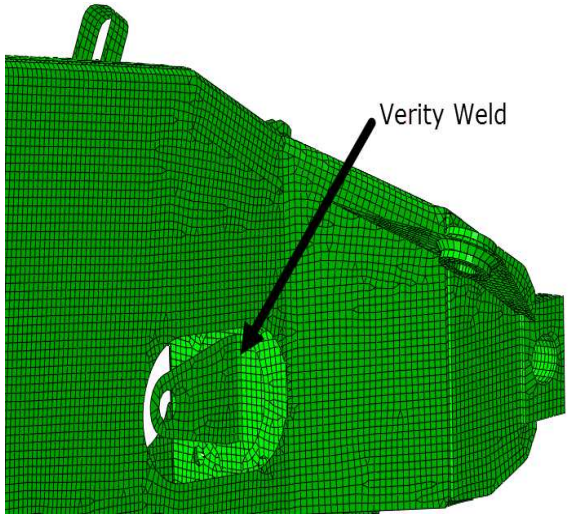
Fatigue Life Calculations

Verity and A36 Parent Material

- Weld geometry was defined in FEM at critical locations
- Verity welds defined within fe-safe for fatigue calculations

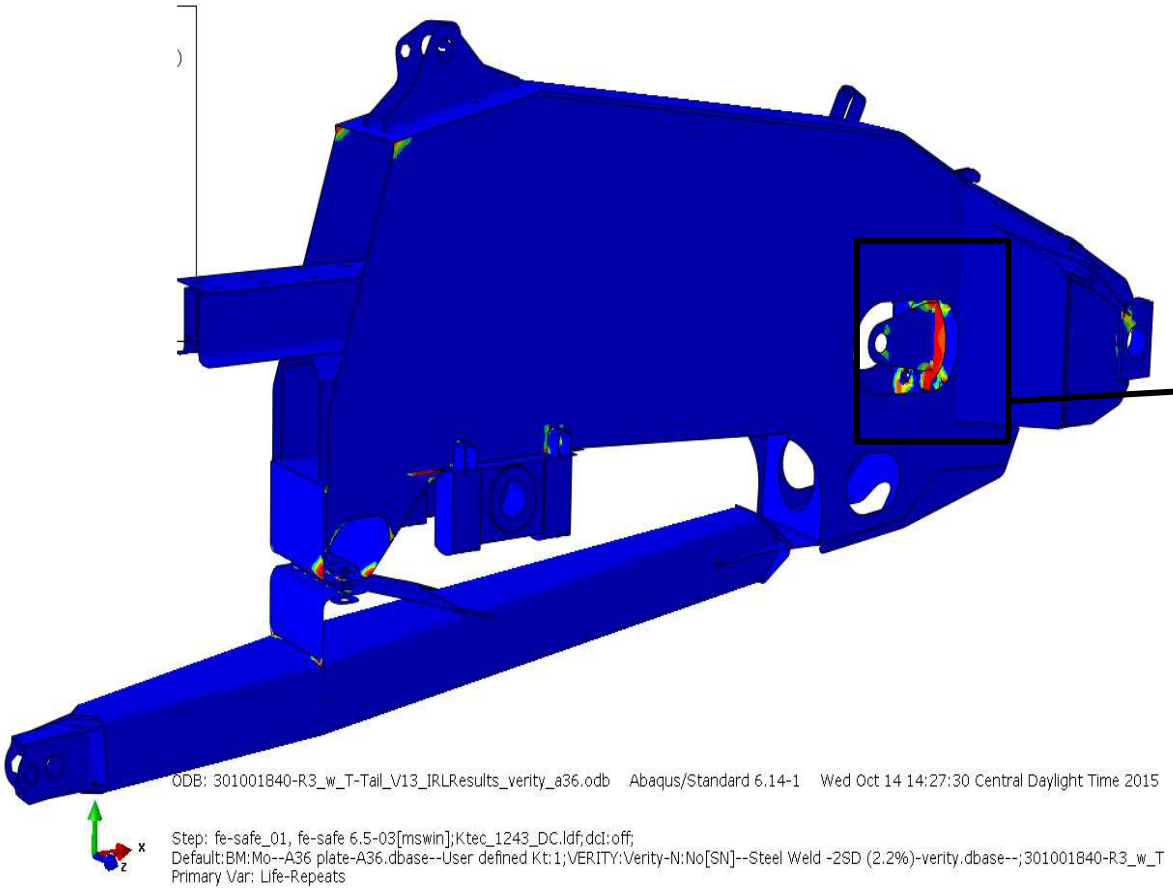


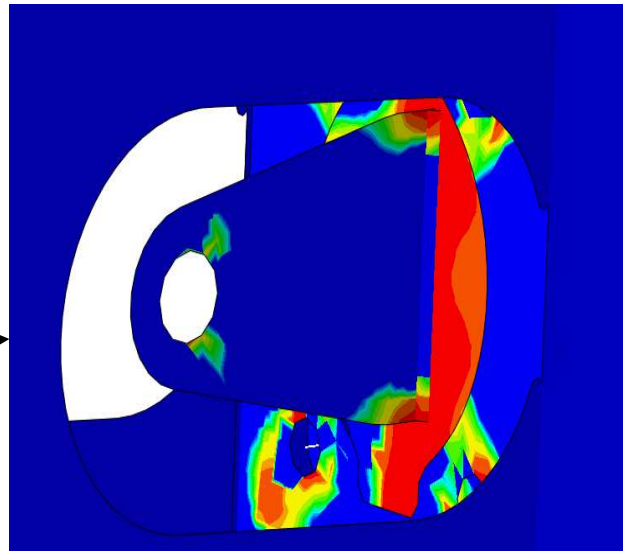




- Remaining structure defined with A36 fatigue properties

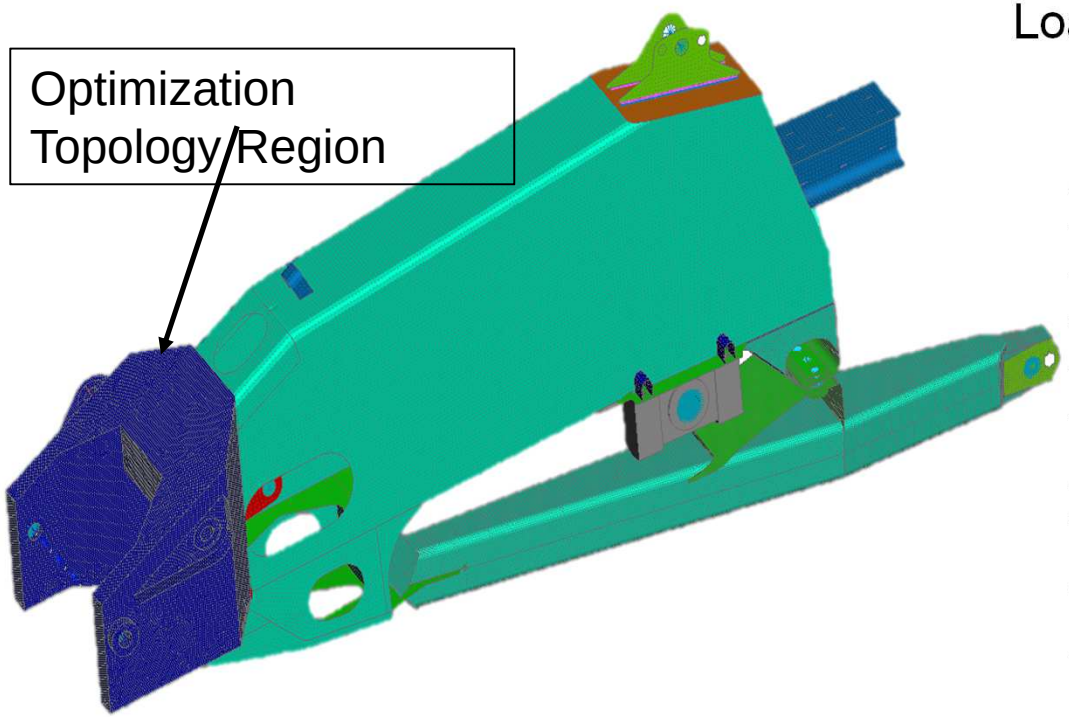
Fatigue Life Calculations





Identify Low Life Welds

Next Step...Optimization



Load Cases:

Highest strain amplitudes in rear of structure

Unit loads (static points) snapshots in

Event #	Event Name	static time
2		108.38
5		114.20
6		82.78
8		141.78
9		166.43
12		134.878
13		36.234
16		97.002
18		142.58
	Total	

Questions?