

Welcome to BAE Systems

Mobility & Protection Systems, Sterling Heights, MI – October 2008



Systems Engineering in New Vehicle Development

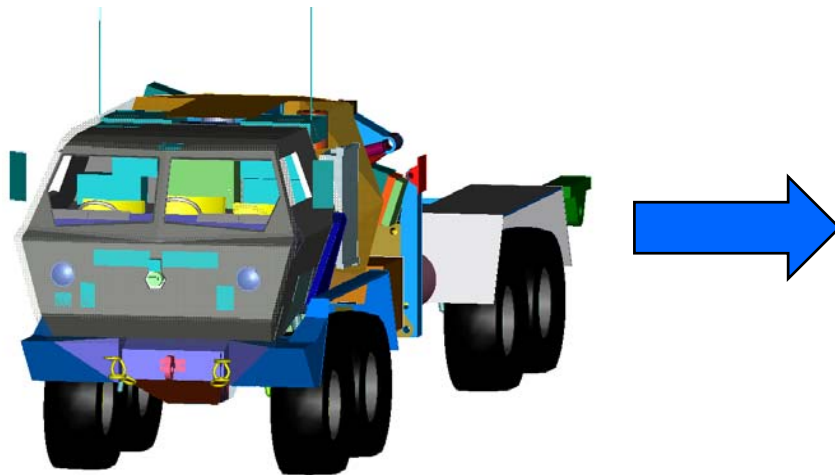
FTTS (Future Tactical Truck Systems)

Customer: US TACOM National Automotive Center (NAC), Warren Mi

Walter J. Budd
Chief Engineer
BAE M&PS
October 2008

MSV - Maneuver Sustainment Vehicle

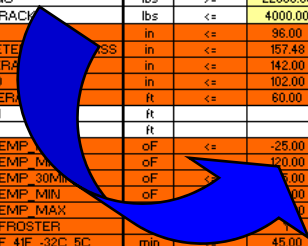
- 18 Month Project, Design, Build, Qualify New Vehicle
- Systems Engineering Approach
- Requirements Analysis
- Performance Parameters Linked Into Models



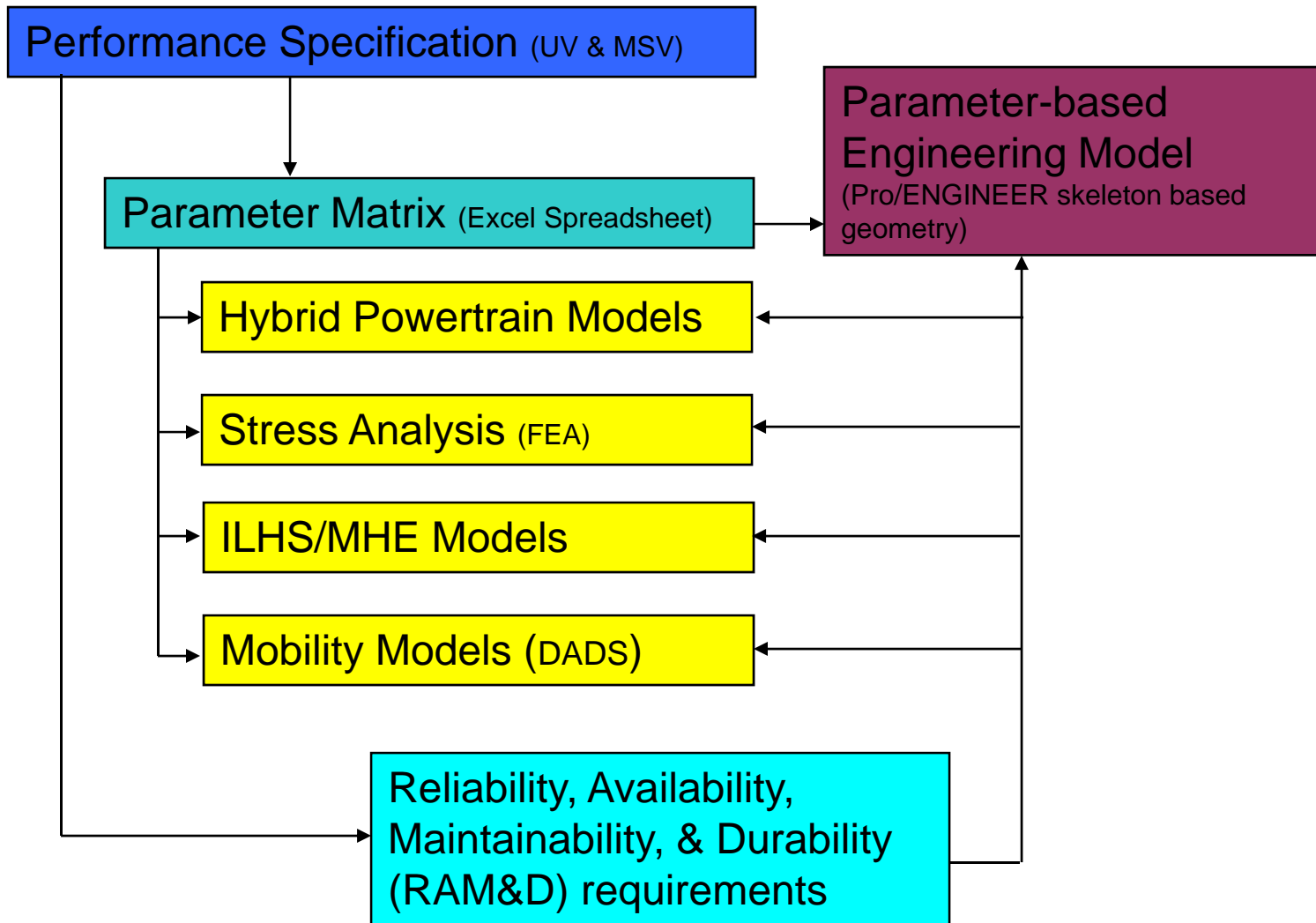
- Process Began With Customer Supplied 92 Page Performance Requirement Document
- Our Engineers Developed and Tracked 408 Given and Derived Requirements



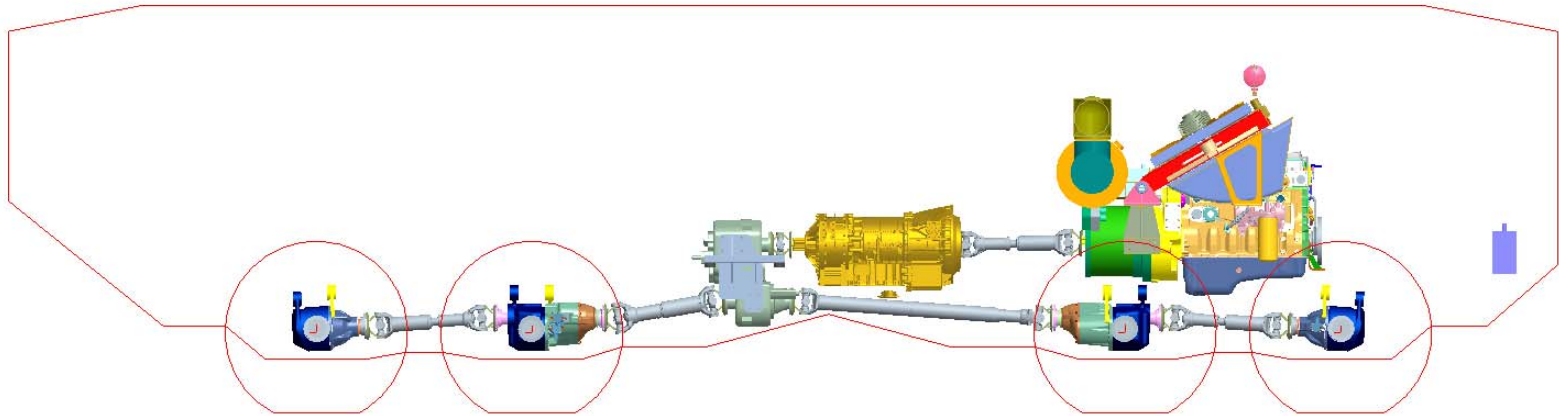
Specification	Priority	Level	Parameter Name	Units	Operator	Threshold (T)	Objective (O)	Units	Operator	Threshold (T)	Objective (O)	Weighting Factor (WF)	Design Value (DV)	Normalized Weighted Value	%	Design Value (DV)	Normalized Weighted Value	%	Pro/E	EM	VL	Mo		
11	3	.1 - Mission Profile	K - Key	MOBILE_IMPROVED_HARD	%	=	53.20	10.00	%	=	53.20	10.00		53.20		100%	10.00		100%					
12	3	.1 - Mission Profile	K - Key	MOBILE_IMPROVED_GRAVEL	%	=	7.70	20.00	%	=	7.70	20.00		7.70		100%	20.00		100%					
13	3	.1 - Mission Profile	K - Key	MOBILE_UNIMPROVED_CC	%	=	39.10	70.00	%	=	39.10	70.00		39.10		100%	70.00		100%					
14	3	.1 - .1 - .1	D - Design	CURB_WEIGHT	lbs	<=	28200.00	24200.00	kg	<=	12786.94	10973.19		16212.50	73%	13374.50	78%		WO					
15	3	.1 - .1 - .2	D - Design	GVW	lbs	<=	57592.00	53192.00	kg	<=	26116.61	24121.04		27801.00	94%	26838.57	89%		O					
16	3	.1 - .1 - .2	D - Design	SOLDIER_NUMBER		=	2.00	4.00		=	2.00	4.00		2.00	100%	2.00	50%		WO					
17	3	.1 - .1 - .2	D - Design	MASS_SOLDIER	lbs	=	343.00		kg	=	155.53			155.53	100%	155.53	100%		WO					
18	3	.1 - .1 - .3	D - Design	GCW	lbs	<=	101086.00	92400.00	kg	<=	45858.55	41915.57		46475.56	99%	50900.66	79%		WO					
19	3	.1 - .1 - .3	D - Design	MASS_CT	lbs	<=	20200.00	16200.00	kg	<=	9181.80	7363.63		6366.00	131%	13636.35	15%		WO					
20	3	.1 - .2 - Pay	08 - D - W - Weight	MASS_PAYLOAD	lbs	>=	26000.00	26000.00	kg	>=	11789.38	11789.38	0.04	11793.00	0.0400	100%	11789.38	0.0400	100%	WO				
21	3	.1 - .2 - Pay	08 - D - K - Key	MASS_CARGO	lbs	>=	22000.00	24000.00	kg	>=	9975.63	10882.50		10346.05	104%	11789.38	100%		WO					
22	3	.1 - .2 - Pay	08 - D - K - Key	MASS_FLATRACK	lbs	<=	4000.00	2000.00	kg	<=	1813.75	906.88		1446.95	120%	0.00	200%		WO					
23	3	.1 - .3 - .1	D - Design	WIDTH	in	<=	96.00		mm	<=	2438.40			2438.40	100%	2438.40	100%		WO					
24	3	.1 - .3 - .2	P - Performa	HEIGHT_4METER	mm	<=	157.48		mm	<=	4000.00			4000.00	100%	4000.00	100%		WO					
25	3	.1 - .3 - .2	D - Design	HEIGHT_OVER	in	<=	142.00		mm	<=	3606.80			3606.80	100%	3606.80	100%		WO					
26	3	.1 - .3 - .2	K - Key	HEIGHT_C130	in	<=	102.00												WO					
27	3	.1 - .3 - .3	D - Design	LENGTH_OVER	ft	<=	60.00												WO					
28	3	.1 - .3 - .3	D - Design	LENGTH_PM	ft														WO					
29	3	.1 - .3 - .3	D - Design	LENGTH_CT	ft														WO					
30	3	.1 - .4 - .1	P - Performa	OPERATE_TEMP	oF	<=	-25.00												WO					
31	3	.1 - .4 - .1	P - Performa	OPERATE_TEMP_MIN	oF	<=	-120.00												WO					
32	3	.1 - .4 - .1	P - Performa	OPERATE_TEMP_30MIN	oF	<=	-50.00												WO					
33	3	.1 - .4 - .2	P - Performa	STORAGE_TEMP_MIN	oF	<=	-50.00												WO					
34	3	.1 - .4 - .2	P - Performa	STORAGE_TEMP_MAX	oF	<=	100.00												WO					
35	3	.1 - .4 - .3	D - Design	HEATER_DEFROSTER															WO					
36	3	.1 - .4 - .3	P - Performa	HEATER_25F_41F_32C_5C	min	<=	45.00												WO					
37	3	.1 - .4 - .3	P - Performa	DEFROST_OPERATE_90F_46C	hr	<=	1.00												WO					
38	3	.2 - Performance	D - Design	CG_VERTICAL_PAYLOAD	in	=	24.00												WO					
39	3	.2 - .1 - .1	K - Key	ACCELERATE_0_30MPH_48KPH	s	<=	12.00												WO					
40	3	.2 - .1 - .1	K - Key	ACCEL_REPEAT_10X_INTERVAL	s	<=	30.00												WO					
41	3	.2 - .1 - .2	P - Performa	SPEED_MAX_GOVERNED	mph	<=	70.00												WO					
42	3	.2 - .1 - .3	K - Key	TURN_TEST_170_200FT_RAD	deg	>=	0.50												WO					
43	3	.2 - .1 - .4	D - Design	ANGLE_APPROACH	deg	>=	41.00												WO					
44	3	.2 - .1 - .4	D - Design	ANGLE_DEPARTURE	deg	>=	39.00												WO					
45	3	.2 - .1 - .51	K - Key	COMPLETE_STOP_20MPH_32KPH	ft	<=	30.00												WO					
46	3	.2 - .1 - .K1	P - Performa	SERVICE_PAVEMENT_GRADE	ft	<=	30.00												WO					



Specification	Priority	Level	Parameter Name	Units	Operator	Threshold (T)	Objective (O)
11	3	.1 - Mission Profile	K - Key	MOBILE_IMPROVED_HARD	%	=	53.20
12	3	.1 - Mission Profile	K - Key	MOBILE_IMPROVED_GRAVEL	%	=	7.70
13	3	.1 - Mission Profile	K - Key	MOBILE_UNIMPROVED_CC	%	=	39.10
14	3	.1 - .1 - .1	D - Design	CURB_WEIGHT	lbs	<=	28200
15	3	.1 - .1 - .2	D - Design	GVW	lbs	<=	57592
16	3	.1 - .1 - .2	D - Design	SOLDIER_NUMBER		=	2.00
17	3	.1 - .1 - .2	D - Design	MASS_SOLDIER	lbs	=	343
18	3	.1 - .1 - .3	D - Design	GCW	lbs	<=	101086
19	3	.1 - .1 - .3	D - Design	MASS_CT	lbs	<=	20200

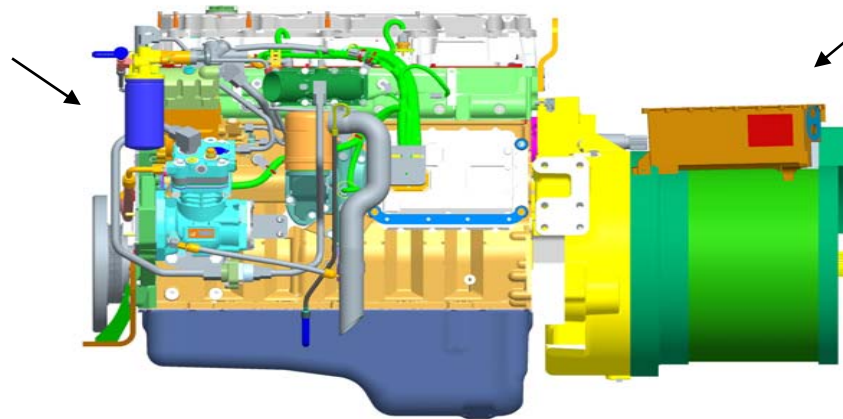


Propulsion Modules



Power Generation Hybrid System

CAT C9
1600 RPM
1850 N.m
450 Hp



UQM
1900 RPM
600 N.m
160 Hp

Combined Peak Torque

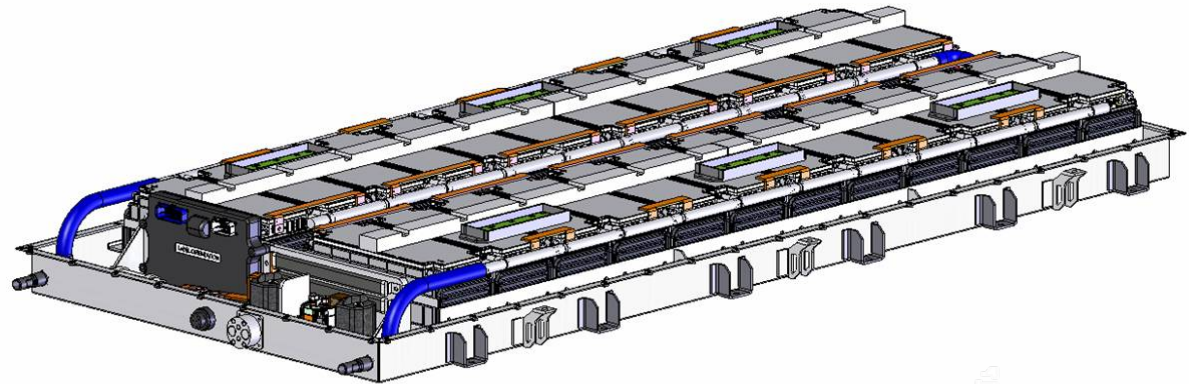
2446 N-m (1804 ft-lbf) @ 1600 RPM

Combined Peak Power

610 HP (455 kW) @ 2300 RPM

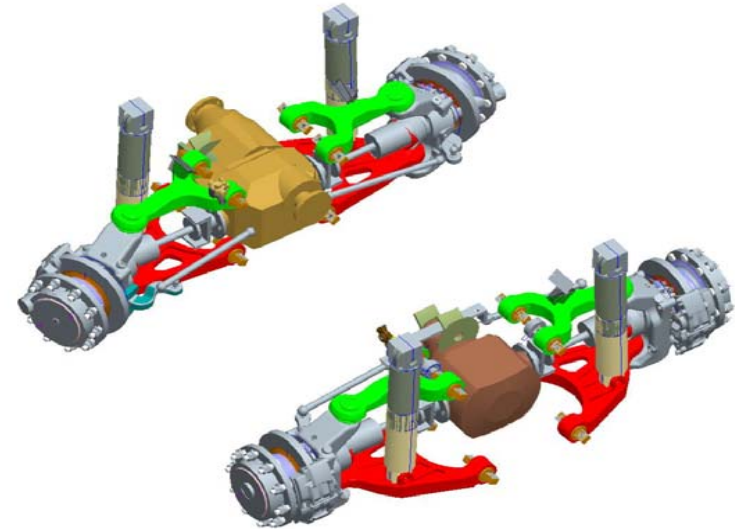
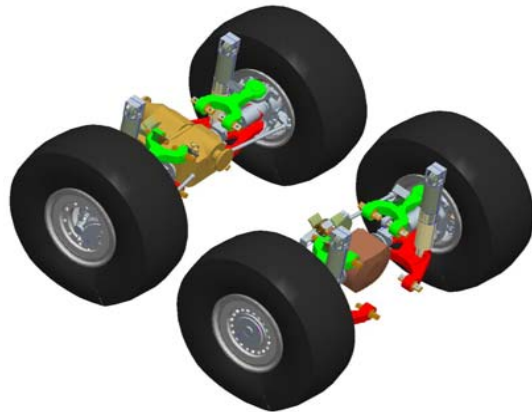
Battery Pack

**Four, 45A*h
NiMH Batteries
Used To Support
The Hybrid
Power
Requirements**



MANUFACTURER		COBASYS
TYPE		NiMH
MODEL		4500 SERIES
VOLTAGE	V	336
CAPACITY	Ah	45
COOLING		LIQUID, INTEGRATED
DRY WEIGHT	Kg	330
No. of BATTERIES		28
DIMENSIONS: L x W x H	MM	1900 x 600 x 310

Custom Designed Independent Suspension Axles

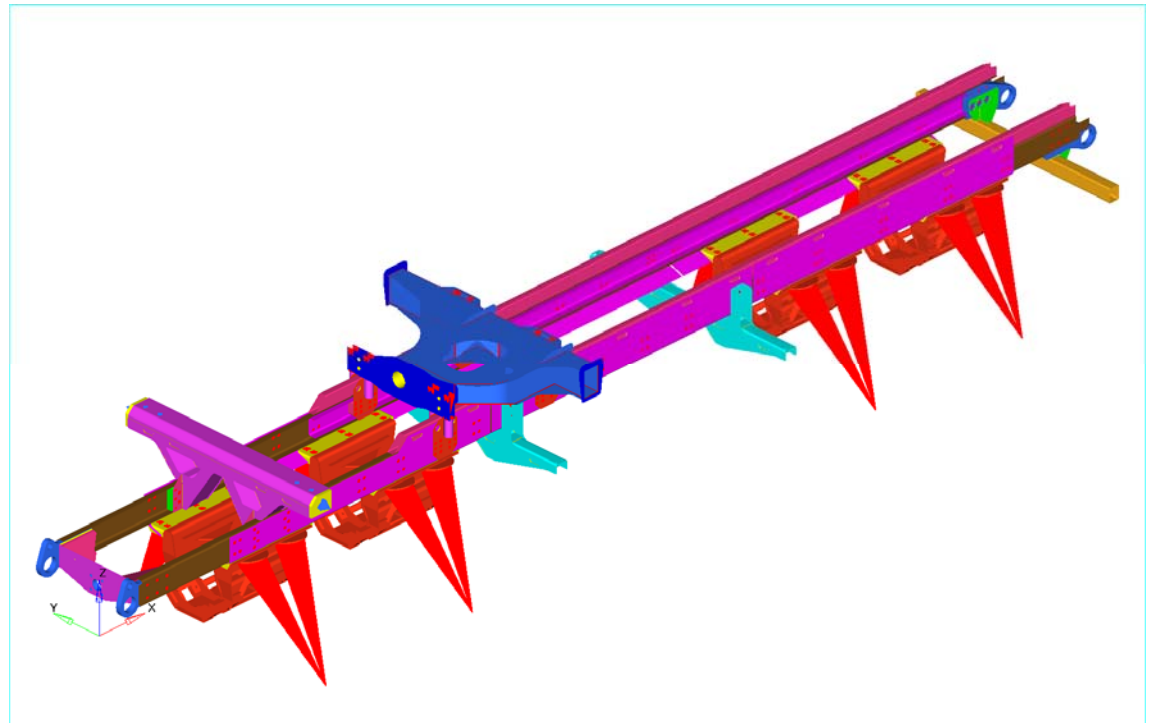


- Independent Suspension SLA
- Axle Differential Ratio: 2.077
- Wheel Hub Planetary Ratio: 3.55
- Hydraulic Disc Brakes - ABS

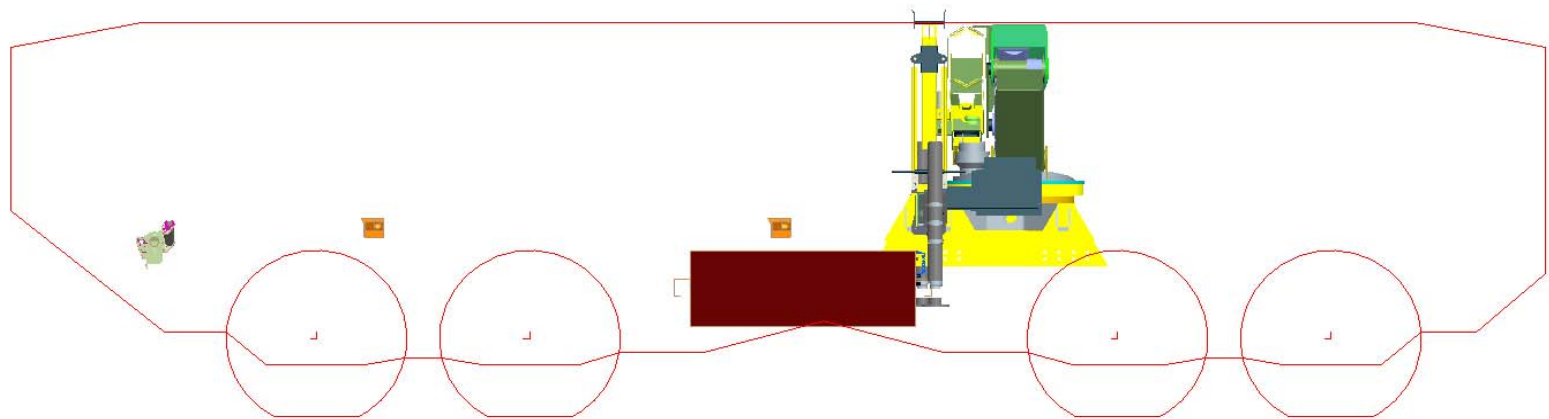
All-New Frame Was Required

Inputs from:

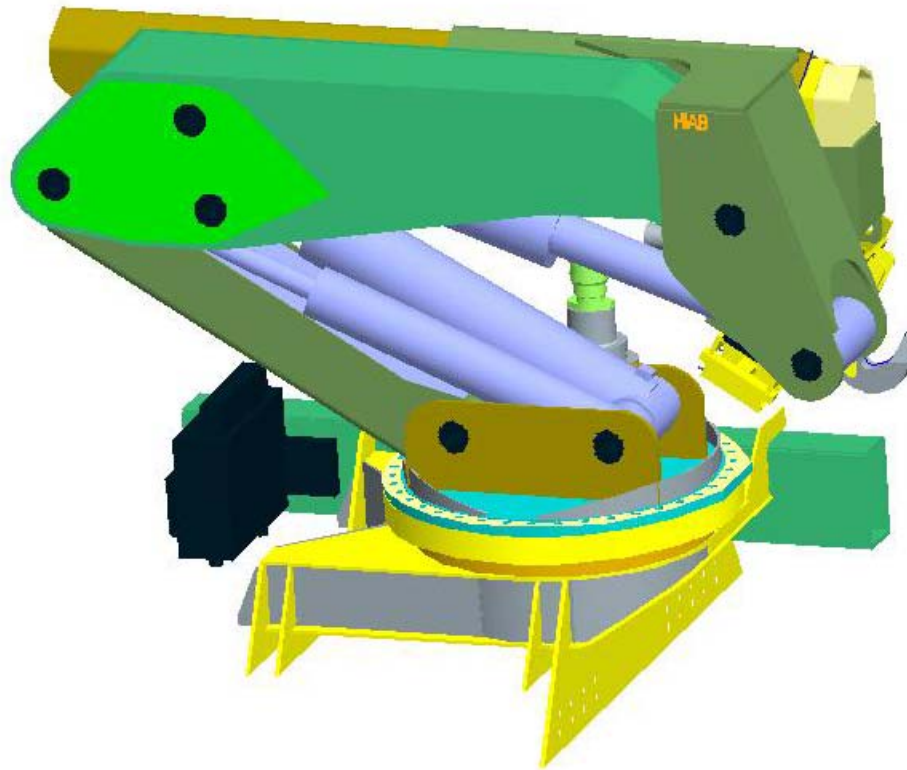
- Automotive Loads
- 13 Ton Load Carry
- Lift/Unload 13 Ton Cargo



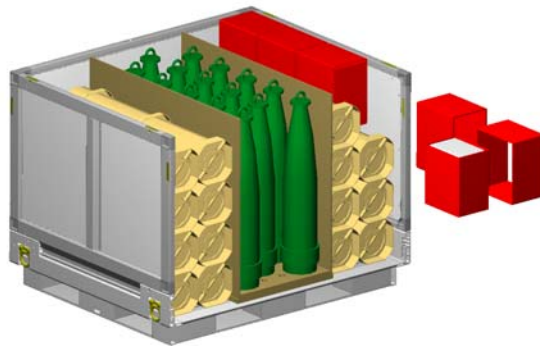
Material Handling Equipment



Material Handling Equipment



Get supplies to the soldiers as quickly and as safely as possible



- Load/Unload Cargo



- Load/Unload Trailer

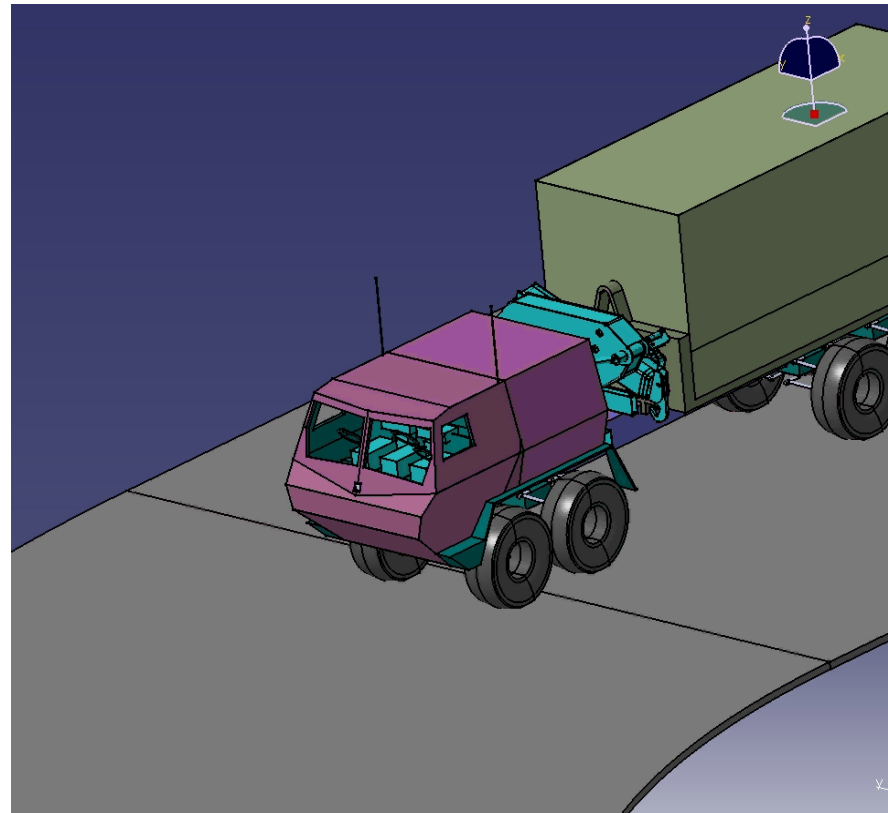


- Load/Unload ISO Containers

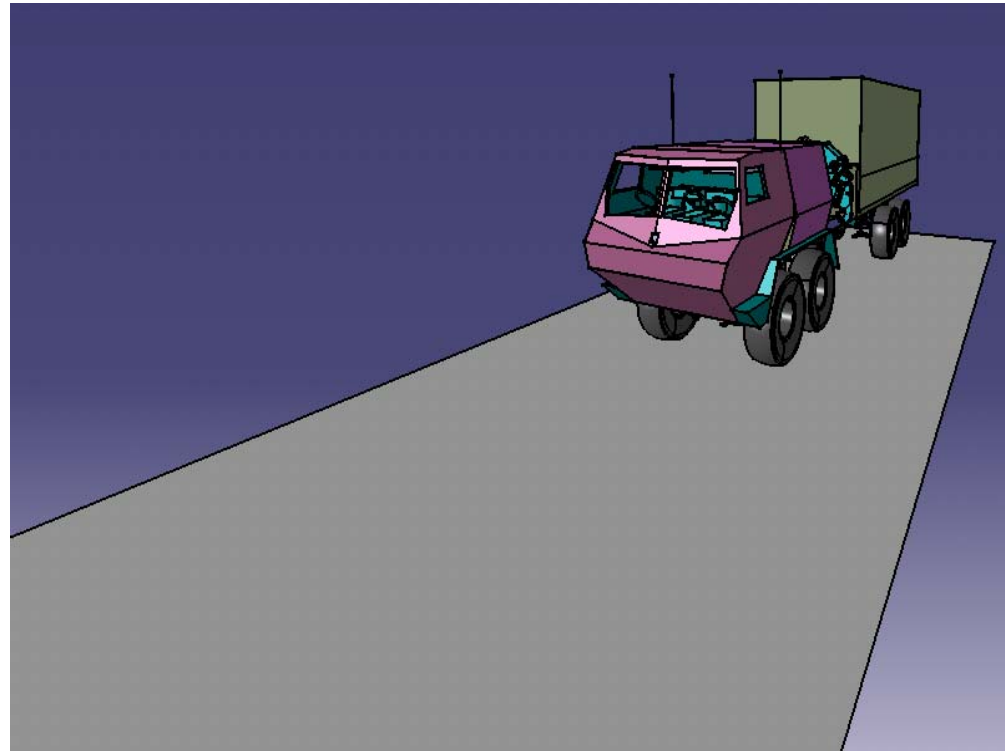


Challenge

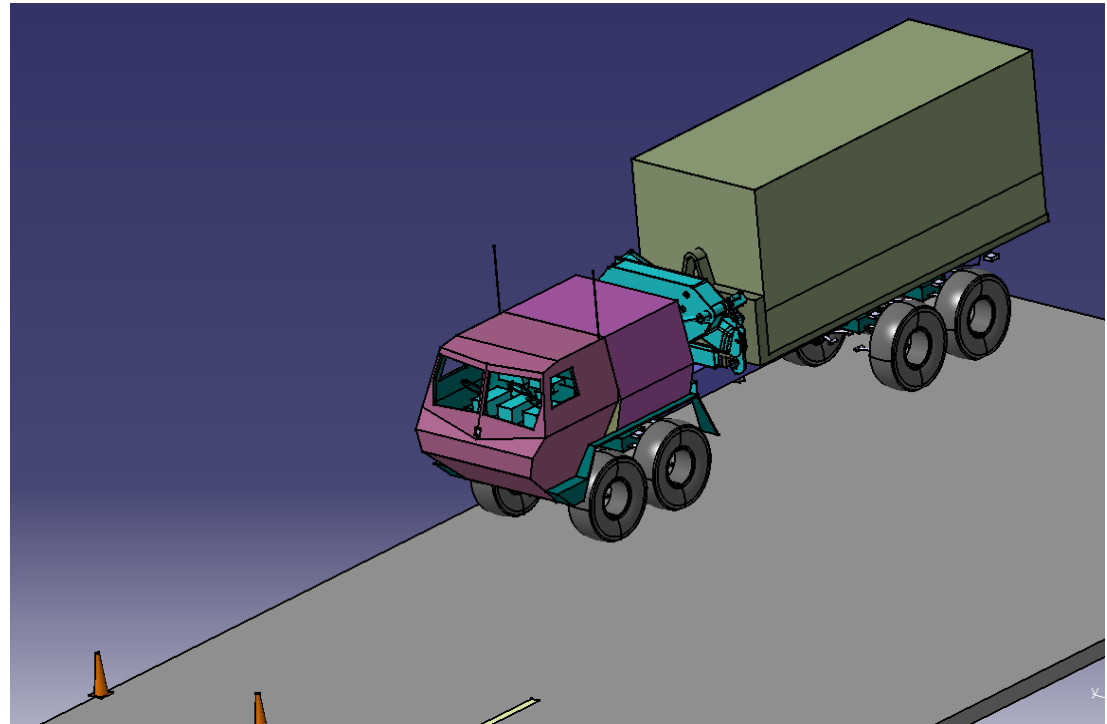
- *Create* multibody simulation that represents several truck and suspension variants
- *Different* suspension designs (not just parameter values)
- Make it *easy* to run different trucks on all possible roads and obstacles



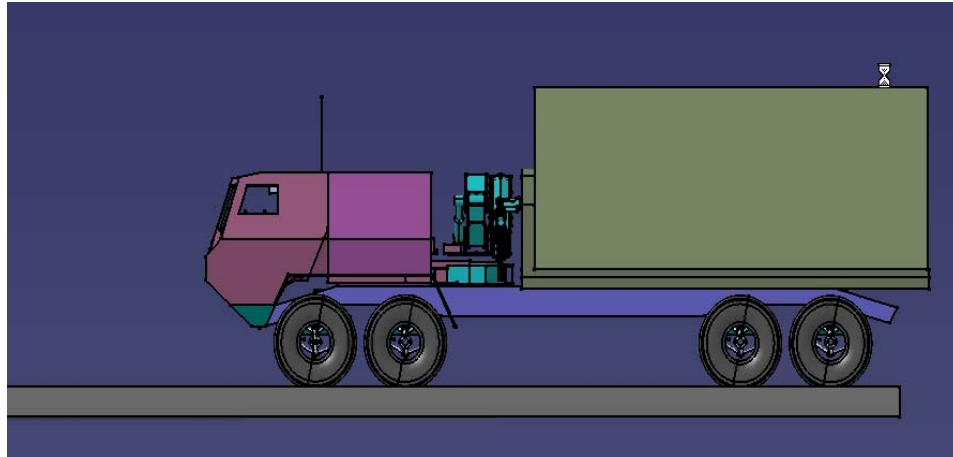
- Model as a series of rigid bodies with joints and force elements
- Tire forces modeled for both hard and soft surfaces
- Driving scenarios to test limit handling in loaded condition



- Lane change stability test
- Predict handling stability and peak roll and lateral accelerations



- Predict roll, sliding and dynamic loads
- Verify safe operating limit for field tests
- Avoid dangerous tests that could endanger drivers and prototype equipment







MSV: Measured and tested to the limits





**MSV
Core
Team**

- Lessons Learned
 - Value Of The Systems Engineering Process
 - Importance Of Model Validation
 - Benefits To BAE Systems
 - Benefits To The Customer

