Occupant Centric Integrated Survivability

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Paul Rogers, PhD
Executive Director
TARDEC Research Business Group

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
14 DEC 2009	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Occupant Centric Integrated Survivability	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Paul Rogers	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA	**20450**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	TACOM/TARDEC
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)
	20450

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

Presented at the Armored Vehicle Survivability Conference, Munich, Germany, December 2009, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

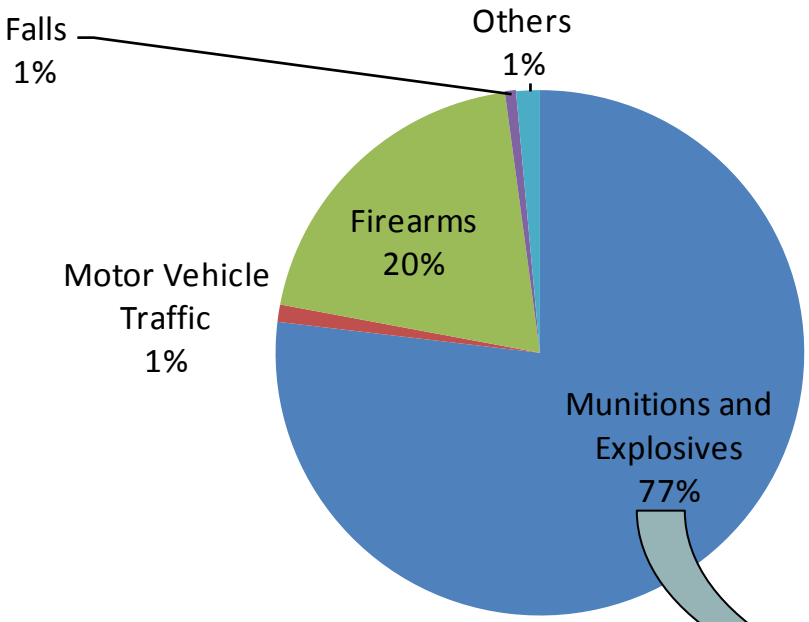
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**18**	

Purpose

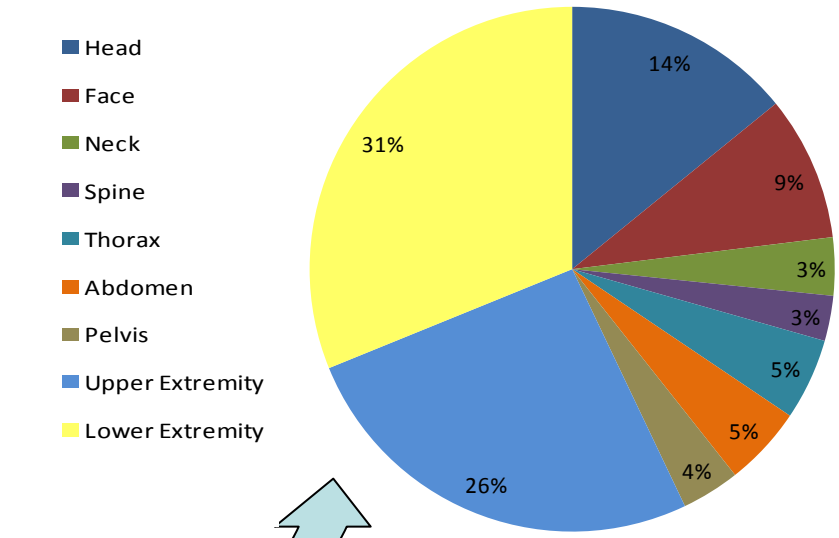
Understand how to balance vehicle "protection", "performance" & "payload" through an integrated survivability approach that starts with occupant protection.

Blast Injuries

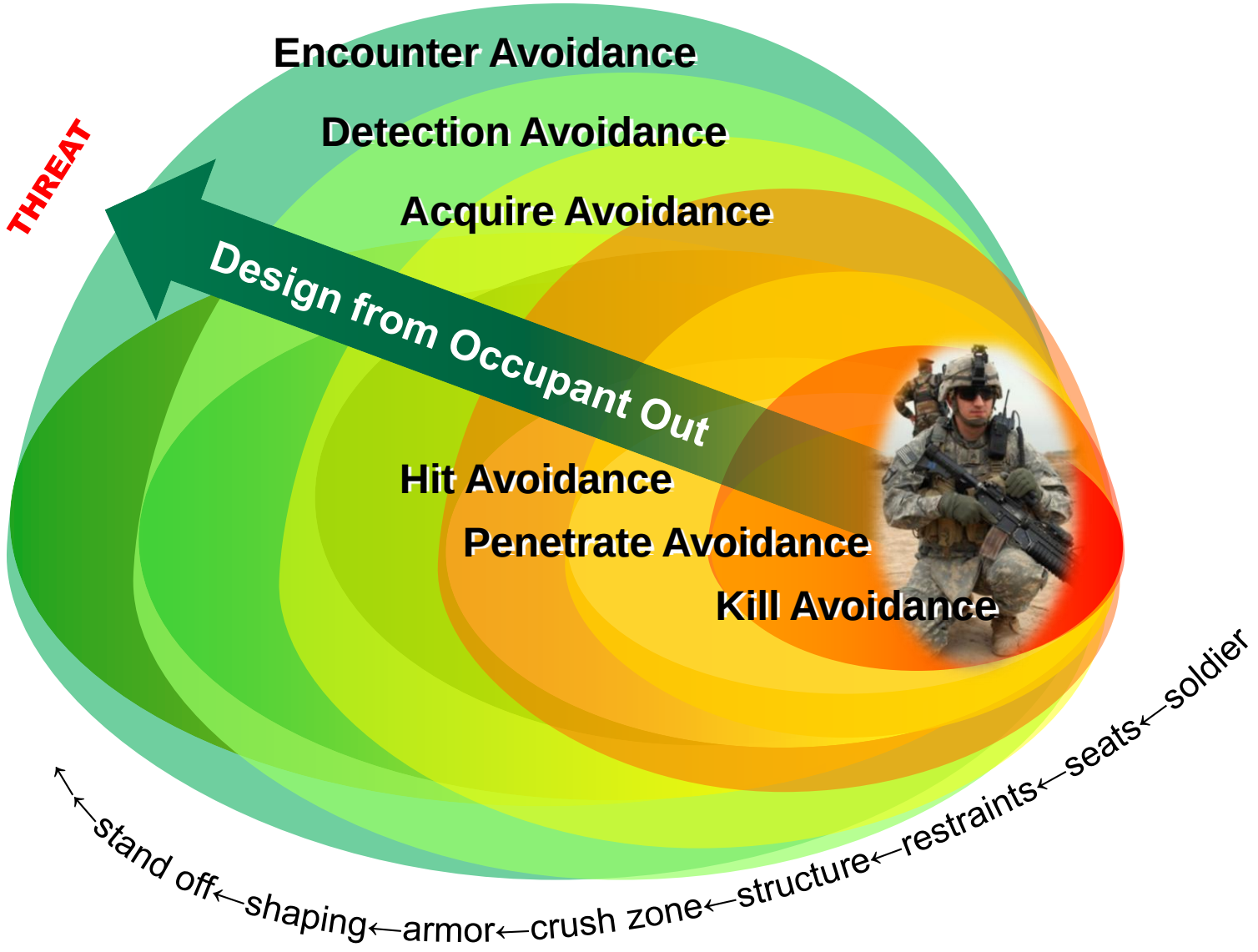
Cause Agent Breakdown 2002-2008



Munitions & Explosives Injuries by Body Region



Occupant Centric Survivability

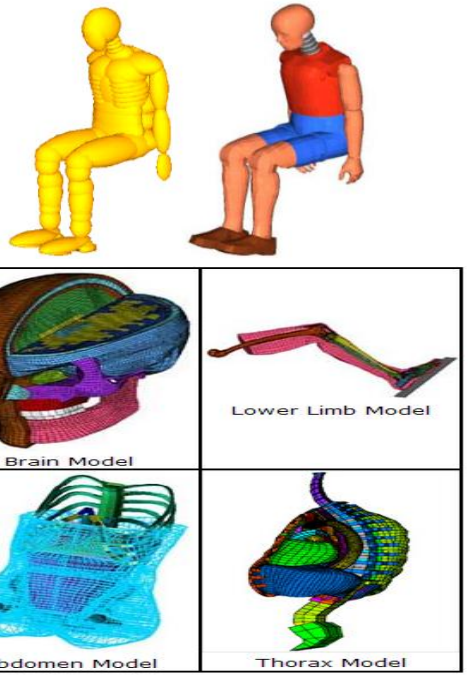


Building Blocks for Occupant Centric Design

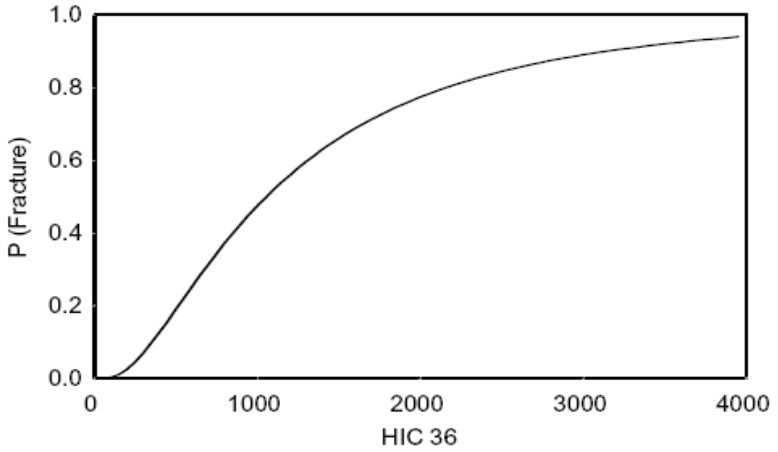
1. **Requirements – Injury Criteria….what are we willing to accept?**
2. **Platform Constraints**
3. **Occupant Packaging**
4. **External Threat Conditions**
5. **Technology/Design Standards Implementation**
6. **Space, Weight, Power, Cooling (SWaP-C)**
7. **Concept Substantiation**
8. **Prototype & Test**

1. Requirements – Injury Criteria….what are we willing to accept?

Injury Assessment Tools



Example of One Criteria – Head Injury Criteria

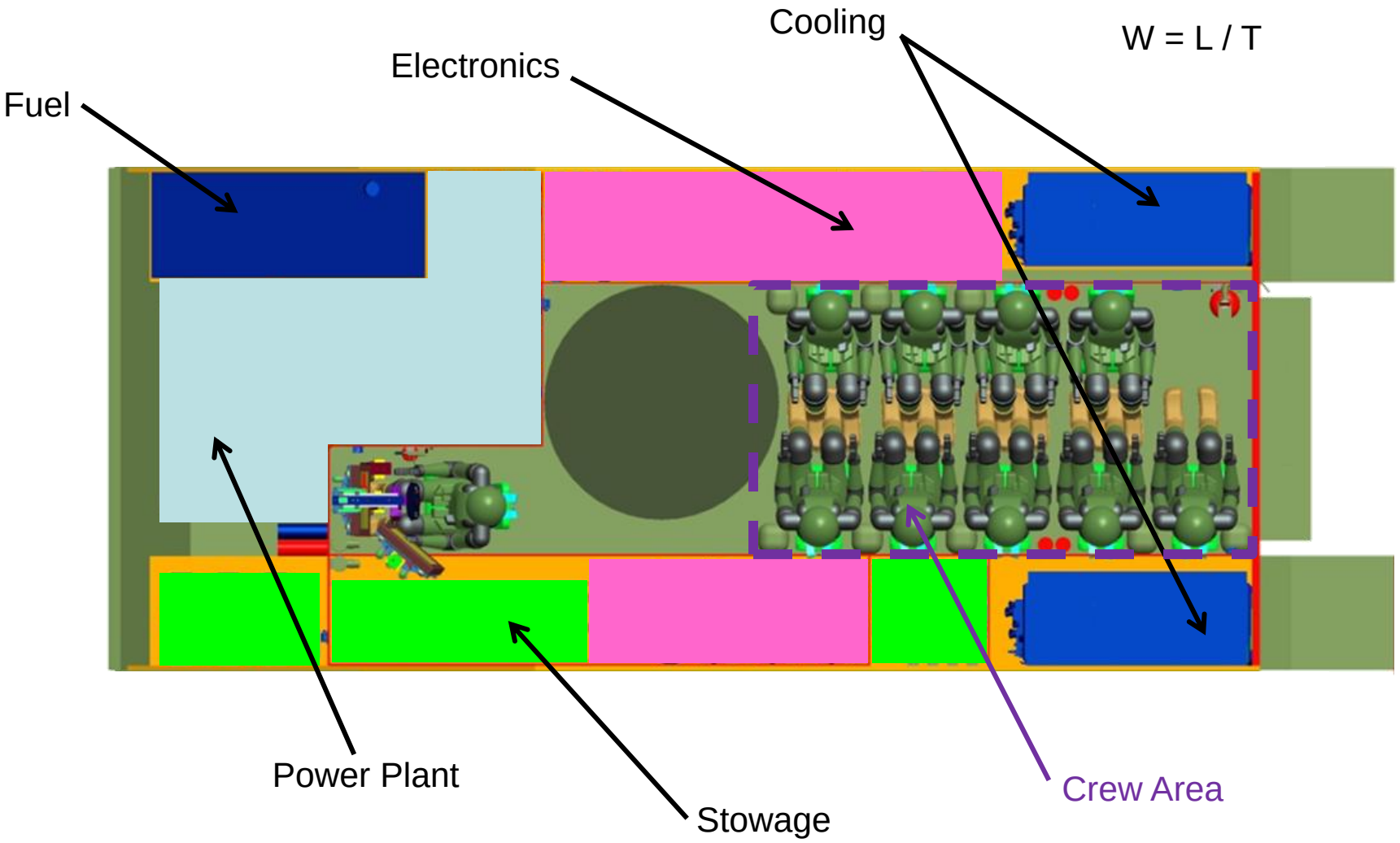


$$HIC = \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a dt \right]^{2.5} (t_2 - t_1)$$

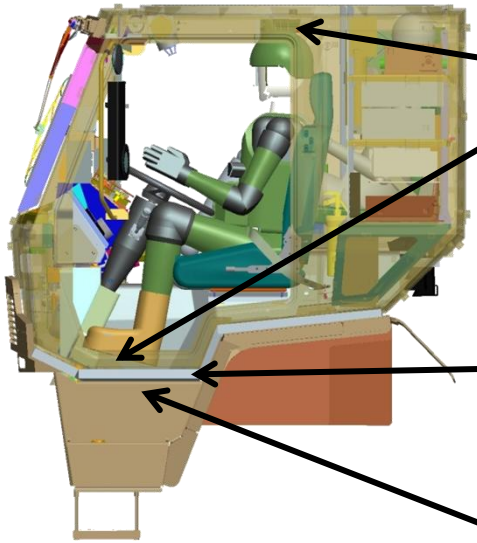
Using analytical instrumented test devices, we can determine occupant injury response & subsequent risk acceptance

2. Platform Constraints

Example Personnel Carrier



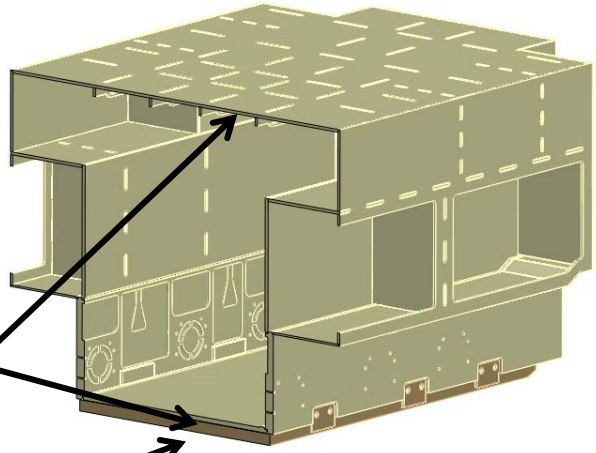
3. Occupant Packaging

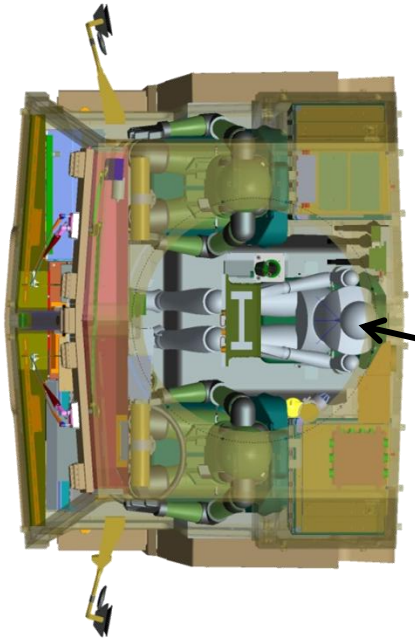


Clearances

Energy Management

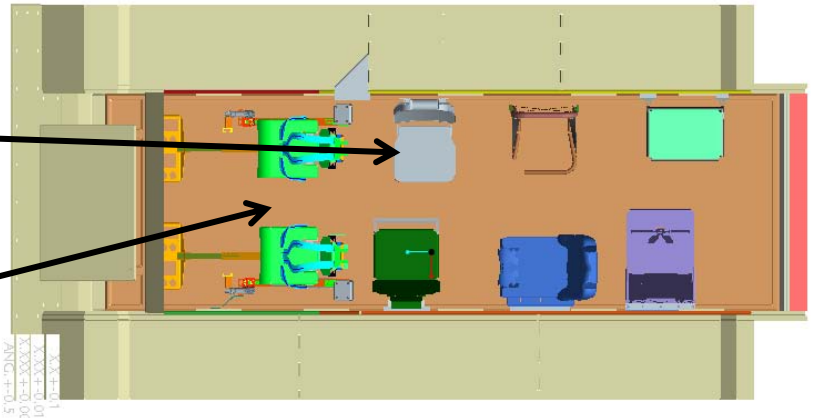
Crush Zones





Seating

Human Factors



4. External Threat Conditions

Stand-Off

Blast

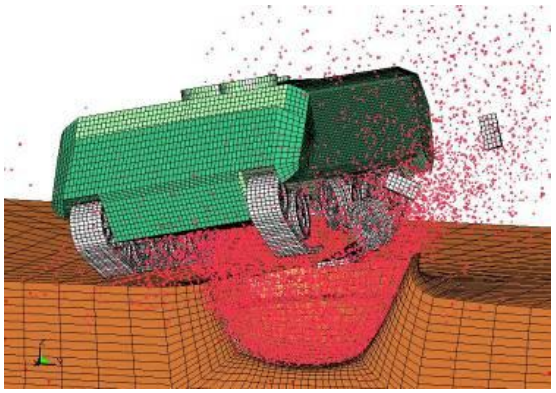
Fragments

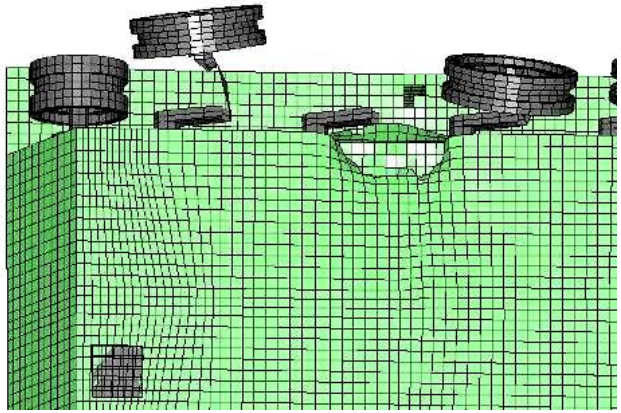
Employment

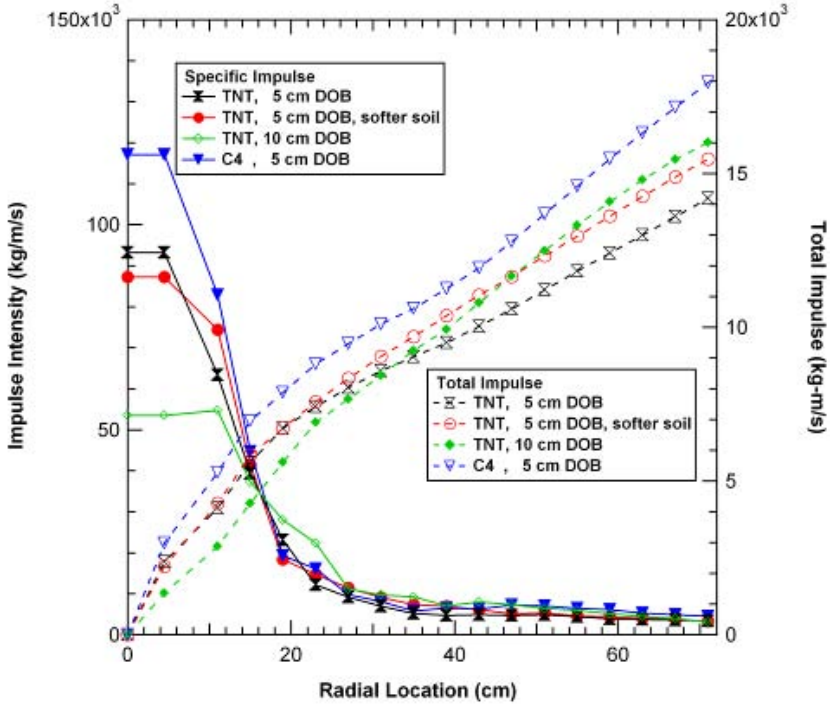
Size (kg's)

What are we concerned with?

5. Technology/Design Standards Implementation



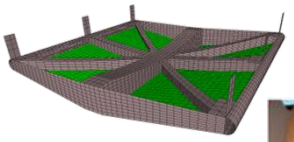


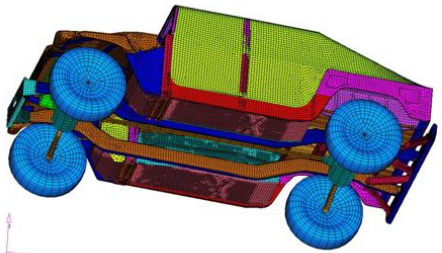


Based on injury criteria, platform constraints, occupant packaging, external threat conditions, we model the baseline effects and resultant occupant injury

5. Technology/Design Standards Implementation

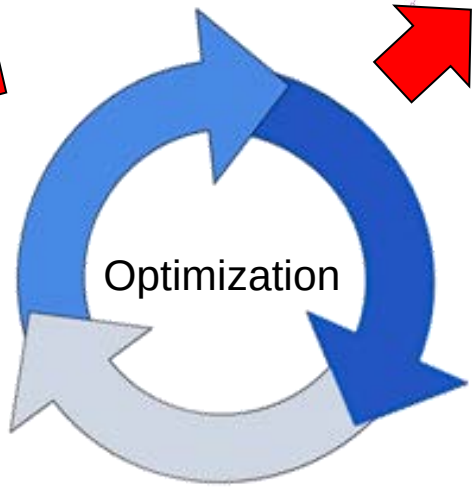
Technology/Design Standards Introduction



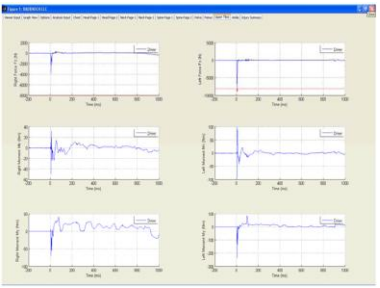


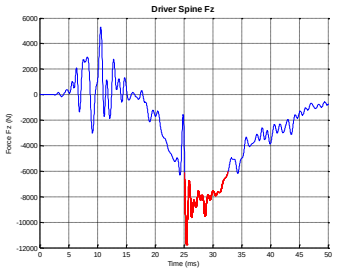
Platform Response

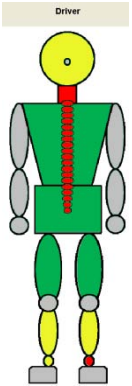
Occupant Response

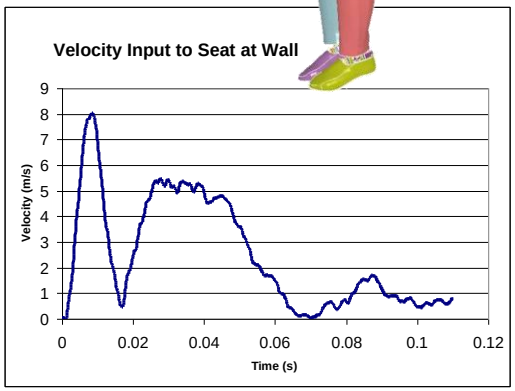


Injury Analysis





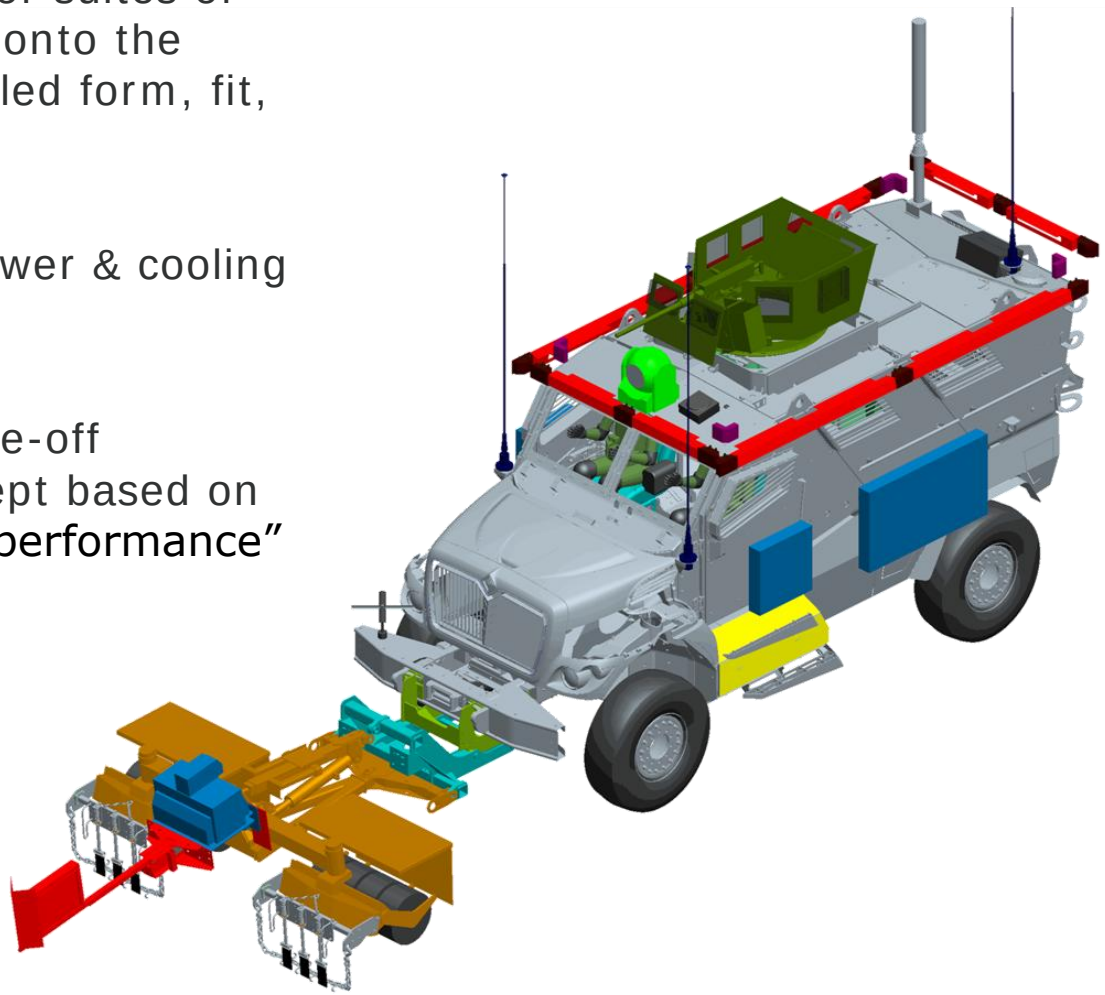




			Driver			
Criterion	Symbol	Threshold Values	Value	Duration	IARV	Pass/Fail
Upper Neck Nij	Nij	Nij >= 1	1.28	0.00	128%	Fail
Upper Neck Tension Curve	+Fz (N)	4170N @ 0ms, 3670N @ 35ms, 1100N @ 60-100ms	4162.27	0.00	127%	Fail
Upper Neck Compression Curve	-Fz (N)	4000N @ 0ms, 1100N @ 30-100ms	6108.00	0.00	153%	Fail
Upper Neck Twist Moment	Mz (Nm)	|Mz| >= 78Nm	81.73	0.00	105%	Fail
Spine DRIz	DRIz	DRIz >= 17.7	24.60	0.00	139%	Fail
Spine Lumbar Compression Curve	-Fz (N)	6673N @ 0ms, 3800N @ 30-100ms	11708.41	0.00	175%	Fail
Left Lower Tibia Compression Force	-Fz (N)	-Fz >= 6900N for 27yr old	6977.90	0.00	101%	Fail

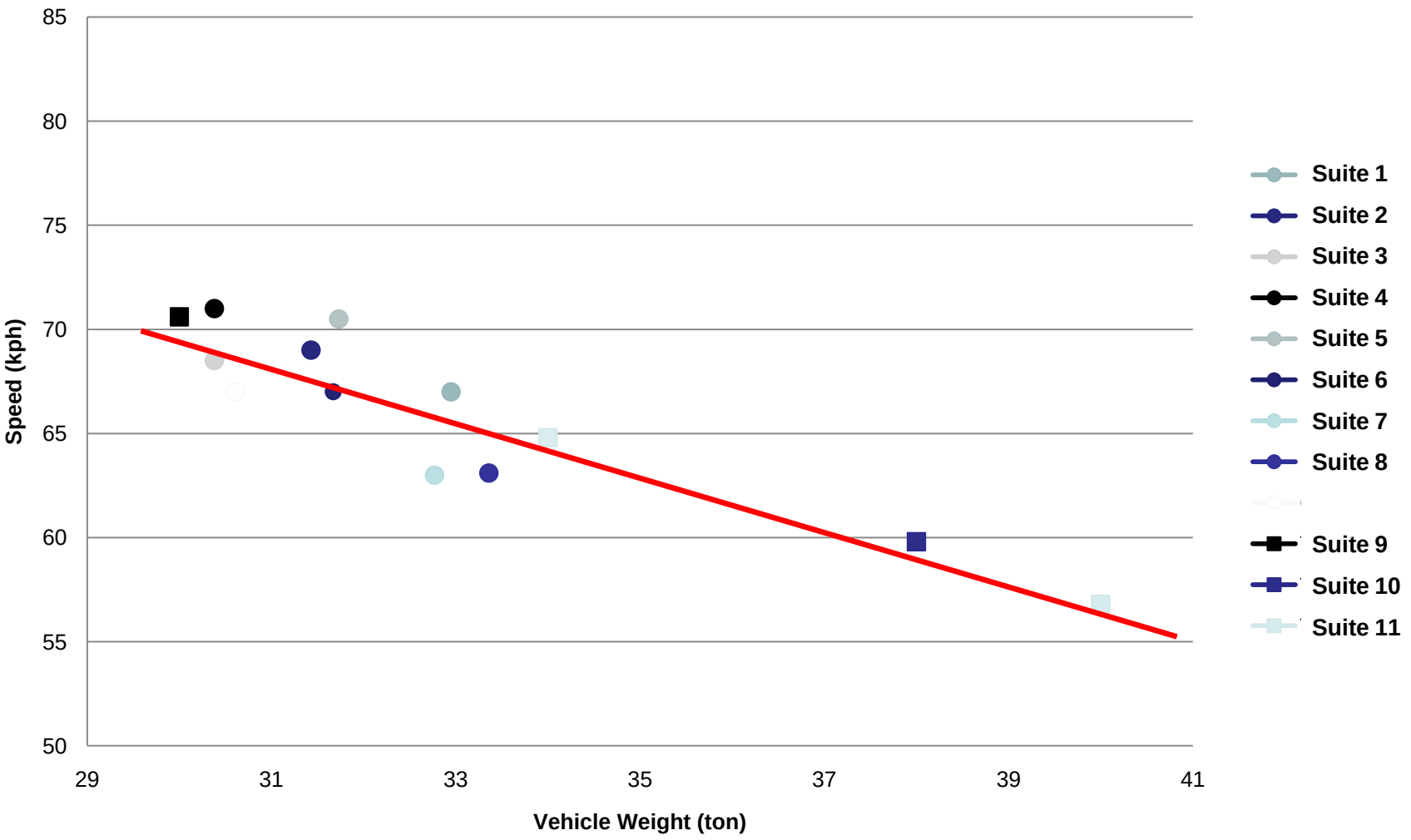
6. Space, Weight, Power, Cooling (SWaP-C)

- Proposed technologies and/or suites of technologies are integrated onto the candidate platform for detailed form, fit, function
- Begin the space, weight, power & cooling (SWAP-C) analysis
- Iterative physics based trade-off assessments to refine concept based on SWAP-C and "protection", "performance" & "payload" .
  - Braking
  - Turning
  - Lane Change
  - Thermal Signature
  - Cooling
  - Acceleration
  - Data Flow
  - Human Factors
  - Power
  - Etc

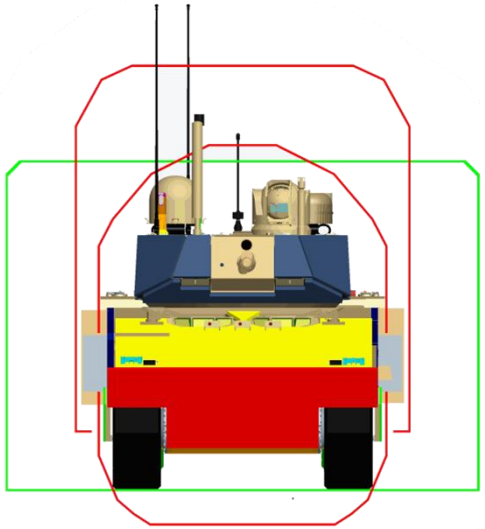


Example Mobility - Top Speed

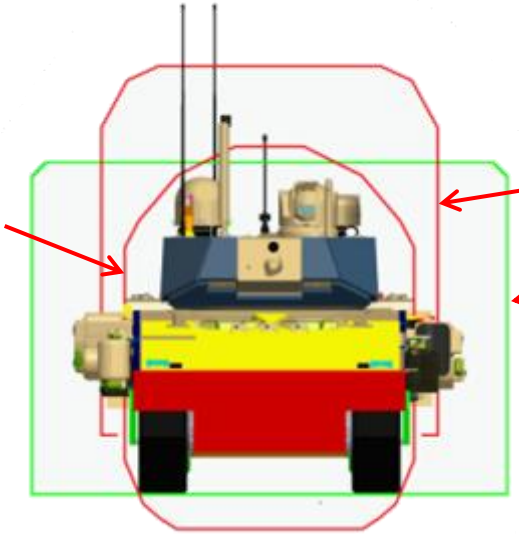
Top Speed Decreases as Proposed Protection Suite (weight) Increases



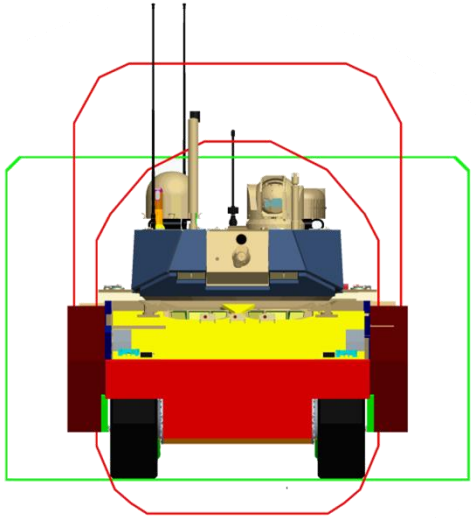
Example Transportability Impacts



Suite 5

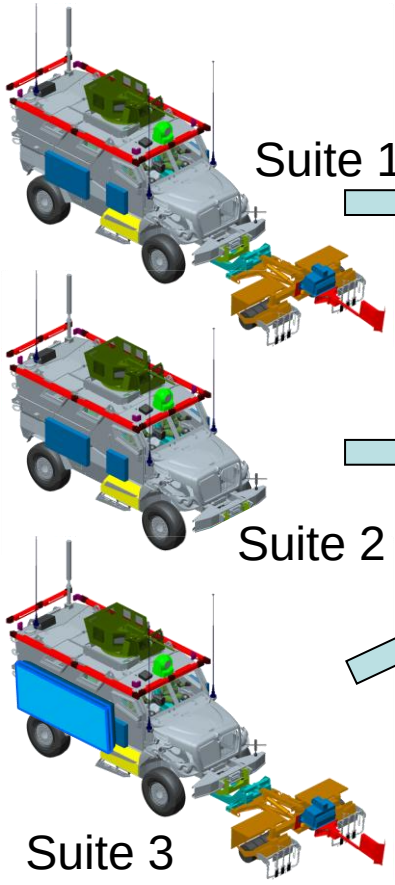


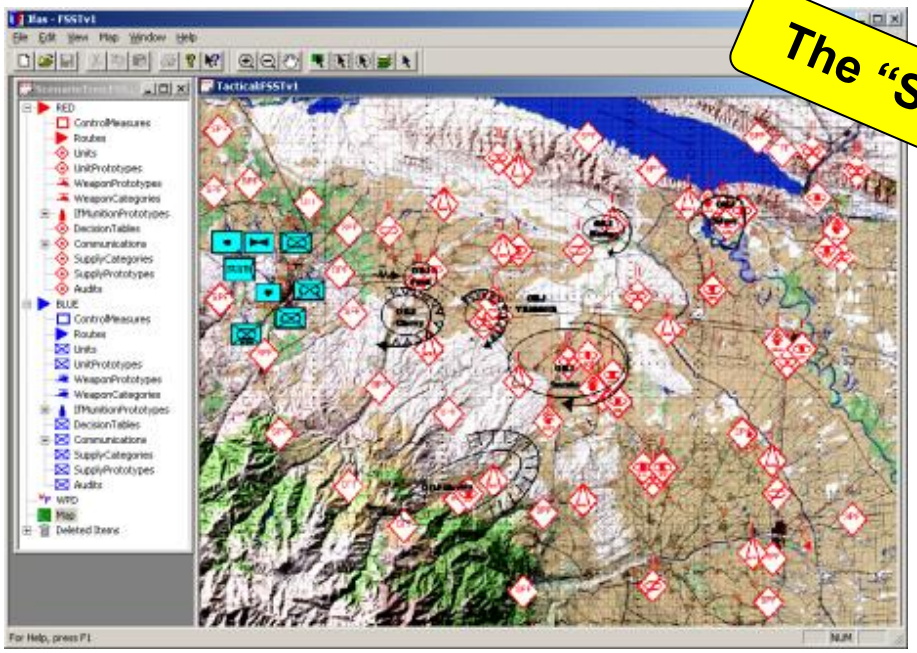
Suite 6



Suite 7

7. Concept Substantiation





The "So What" test"

High resolution force-on-force model provides engagement results in multi-day scenarios. Assess loss exchange ratios resulting from survivability suite changes to the candidate platform(s) taking into account:

- Environment
- Maneuver
- Engagement
- Engineer
- Command & Control
- Surveillance
- Communications
- Rearm

7. Concept Substantiation

Concept substantiation via operational force-on-force modeling address trades and suite composition with sufficient fidelity to capture synergy and interference among technologies:

- Compare relative benefits of various technologies – APS vs. soft-kill CMs;
- Identify optimum combinations of other-than-armor survivability concepts;
- Isolate contribution of specific technologies – SigMan, Smoke;
- Identify benefits of tactical countermeasures – cued counterfire, maneuver.
- Performance of suite combinations against specific threats;
- Benefits and burdens of survivability technologies – laser filters, active sensors;
- Effect of design decisions on overall survivability – APS dead zones, armor vulnerabilities.

8. Prototype & Test

Baseline Platform Assessment

Technology Fabrication/Integration

Subsystem Component Test

Full-Up System Assessment

Conclusion

- The change in threat has necessitated a change in the way survivability is looked at.
- The Occupant Centric approach ensures we focus on the soldier first and build the necessary protection around the occupant from the inside out.
- The disciplined integrated survivability modeling process allows assessment of multiple survivability technologies over numerous threat environments in a manner providing system level technology contribution to survivability.
- The Occupant Centric approach optimizes & balances the critical attributes of system performance, payload & protection related to technology cost and risk, life cycle costs, and system burdens such as weight, volume, power, costs, or other quantifiable measures that impact the system or force.