Army Ground Vehicle Use of CFD and Challenges

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**The original document contains color images.**
Outline

• TARDEC/CASSI Introduction
• Simulation in the Army
• General Challenges
• Types of Analyses
• Working with the Government
• Tank Automotive Research, Development and Engineering Center (TARDEC)
  – Develops, integrates, and sustains the technology for all manned and unmanned DOD ground systems
  – The main Research and Development Engineering (R&DE) organization for ground systems integration and technology

• Consists of Three Major Business Groups:
  – Engineering Business Group
  – Product Development Business Group
  – Research Business Group
    • Includes CASSI (Next Slide)
Simulation in the Army

• Why the Army Needs Simulation
  – Pre Specification Work
    • Need to ensure specifications are technically feasible
  – Evaluation of Proposals and Oversight of Supplier Efforts
    • ‘Honest Broker’ - proposed solutions should be evaluated on a level playing field
    • Verify supplier analyses are reasonable
  – Rapid Response for Field Fixes
    • Determine how new equipment will affect vehicle performance
    • Provide initial assessment before starting formal contract process for proposed upgrades
  – Direct R&DE efforts through cooperation with industry
    • Form partnerships to direct development efforts in areas of interest to the Army
General Challenges

- Government does not always own the technical data package
  - May be difficult to get the CAD data
    - Vehicle may have to be scanned
  - System and component performance often not available
    - Flow rates, temperatures, heat rejection information may need to be estimated or measured experimentally
  - Contractors won’t or can’t share material thermal properties
    - Composite armor stacks
    - Anisotropic conduction
- Data management
  - Long program life cycle means that data needs to be stored and organized for long periods of time
  - Need to tracking a large number of different vehicle configurations and equipment lists
- Data exchange between software packages
Interior Thermal Analysis

- Harsh environment
  - 30 °F is 1% day in Iraq
  - 125 °F in summer
  - In-gear creeping speed
- Up-armored vehicles = heavy
  - Large thermal mass
  - High engine loads = high heat loads
- Open Hatch
- Use of Commercial Equipment
  - Lower temp spec ~95 °F
- Interested in Cool down Time

Challenge: Perform full transient analysis
Example of a capability add-on (Equip Pack 2)

Challenges:
- When will electronics have a thermal problem?
- Air temperature around equipment or surface temps?
- What are component heat rejection rates/duty cycles?

Prediction of equipment temperatures
Fire Suppression Modeling

- Goal: Extinguish flame in a fraction of a second
- Place extinguisher bottles into crew area at optimal point
- Challenges:
  - Very deep physics
  - Reacting flows
  - Determine effect on human occupants

Interaction of flame with suppressing agent
Blast Modeling

• Goal: Predict behavior of structure during mine blast event
  – Improve vehicle survivability

• Challenges:
  – Modeling soil mechanics
  – Fluid-structure interaction with highly deforming mesh
  – Modeling detonation waves
Grille Optimization

- Multidisciplinary ballistic grille optimizations
- Challenges:
  - Trade-off between ballistics protection, weight, and airflow performance
  - Large amount of cooling airflow through a small area results in high fan power or engine performance degradation

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Infrared Signature Modeling

- Delta apparent temperature from the background
- A vehicle does not have a single thermal “signature”
  - Normally plot metrics as histogram
  - Multiple view angles, times, and backgrounds
- Challenge: Calculating updated convection coefficients every 15 minutes using CFD

Histogram of Signatures

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Thermal Budgeting

Solar load that strikes exterior:
- ½ is convected away by wind
- ¼ is radiated away
- ¼ is conducted to interior

Solar load that is conducted to interior:
- 2/3 is convected into air
- 1/3 is radiated toward walls

Challenge: Identifying best “Bang for the buck” technologies to minimize HVAC size
Specialized Issues

- Exhaust plume modeling
- Amphibious water crossing / fording
- Acoustics signature / silent watch
- Gun tube heating

Automotive Issues

- Under hood Cooling
- HVAC System Design
- Defrost
- Fuel Economy
Working With The Government

- **Broad Agency Announcement**
  - Certain basic or applied R&D not for any particular vehicle
- **Education Partnership Agreement**
  - Encourage and enhance study in scientific disciplines at all educational levels
- **Ground Vehicle Gateway (GVG)**
  - Online portal that will help forward inquiries or proposals directly to NAC or TARDEC researchers
  - [https://tardec.groundvehiclegateway.com](https://tardec.groundvehiclegateway.com)
- **National Automotive Council**
  - *Army focal point for dual-use automotive/ground vehicle technology development*
- **Small Business Innovative Research Program (SBIR)**
  - Tap into the small business community’s innovativeness and creativity to help meet government R&D objectives
Example: Working w/ Government

- Need: Predict soldier thermal fatigue in CFD models
- Goal: Dual government/industry use
- CRADA (Cooperative Research and Development Agreement)
  - GM shares experience and “lessons learned”
  - TARDEC oversees implementation and pays development
  - Small business entity develops code and sells commercially

Soldier Thermal Fatigue Model
- Implement Berkley Human Comfort Model
- Develop soldier models w/ battle gear
- Metabolic heat rates by role (driver, gunner, commander)
- “Comfort” index generated from local skin temps and body core temp
Conclusion

- TARDEC is actively involved in using CFD in a variety of areas
- TARDEC faces many of the same challenges as the automotive industry
- Partnerships with industry play a large role in advancing technology