17028

Evaluation of Next Generation Military Vehicle Cooling Systems

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Outline

- Thermal Challenges in a Military Environment
- Traditional vs. Alternative Approach
- Thermal Testing
- Thermal Tool
- Pilot Project – Applying the Simulation
- Results
- Next Steps

Thermal Challenges

Military needs differ from most commercial applications

- Longer service life
- Shorter operational life
- Environmental extremes
- Worldwide operation
- Adverse operating conditions
- Both on- and off-road mission profiles
- Minimal maintenance during combat operation

Thermal Challenges

Cooling System Design Factors

- Severe shock & vibration
- Long term storage
- Challenging longitudinal & lateral slopes
- Corrosive battlefield atmosphere & fording
- Ground-hop capability
- Airside clogging of heat exchangers
- Ambient temperature extremes & high altitudes

Thermal Challenges

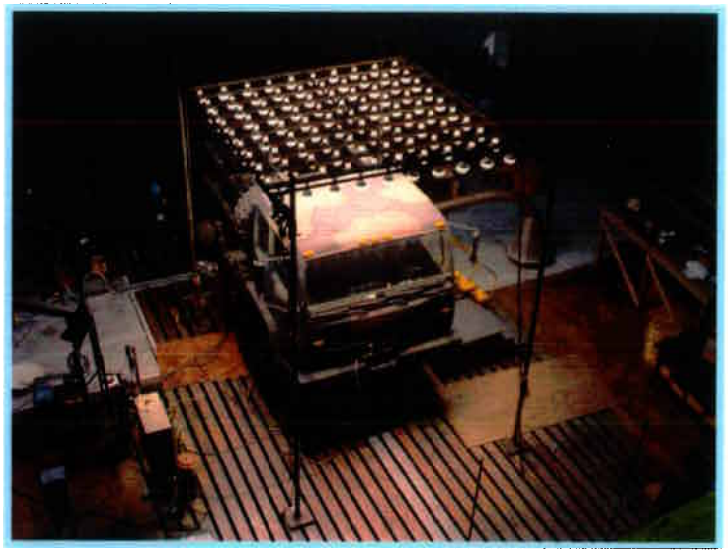
Military vehicles are facing ever increasing challenges of meeting cooling system requirements

- Additional armor
- Power upgrades
- Extremely hot environments
- Heat loads associated with hybrids
- Adverse operating conditions

Traditional Approach

Meet thermal challenges through thermal testing

- Optimize cooling system performance
- Select improved components – Radiator & Fan
- Conduct vehicle thermal testing
- Evaluate impact to cooling system



Alternative Approach

Share thermal challenge through an interactive technique

- Connect vehicle level simulation with vehicle test
- Link 1D simulations to testing process
  - Evaluate multiple vehicle variants/configurations
  - Accomplish rapid optimization of thermal system
  - Identify best candidates to test
  - Achieve thermal goals

Alternative Approach

Benefits:

- Minimize number of tests
- Maximize test results
- Save time
- Reduce cost
- Enhance cooling system performance capabilities

Thermal Testing

Objectives

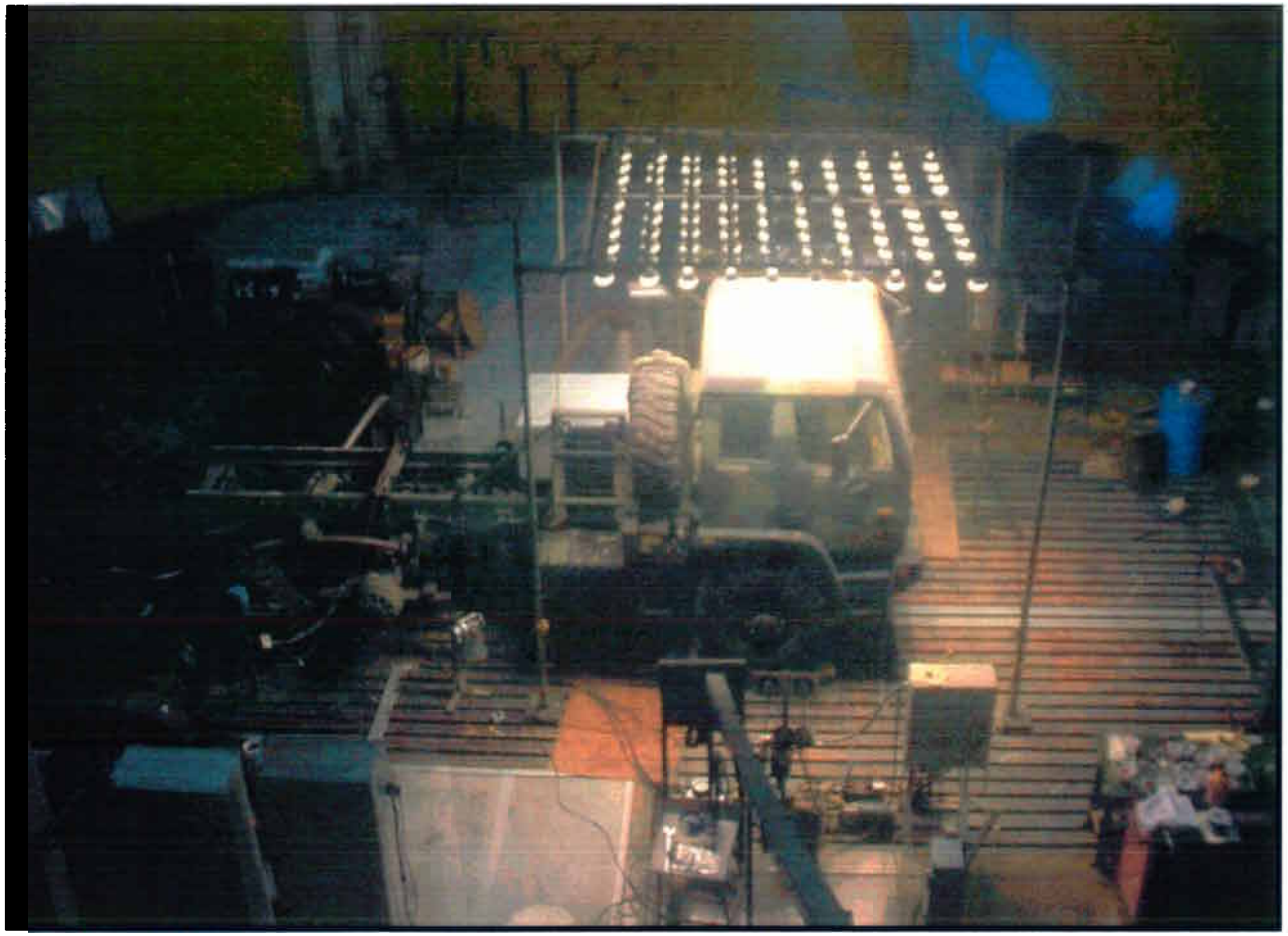
Maintain critical temperatures within specified limits while operating at:

- Full power
- Full load
- Ambient 120ºF

Specified Limits

- Engine Coolant 230ºF
- Engine Oil 275ºF
- Transmission Oil 300ºF

Thermal Testing



Test Conditions

- Full Power
- Full Load
- Ambient 120ºF
- 5 mph wind velocity
- Solar radiation

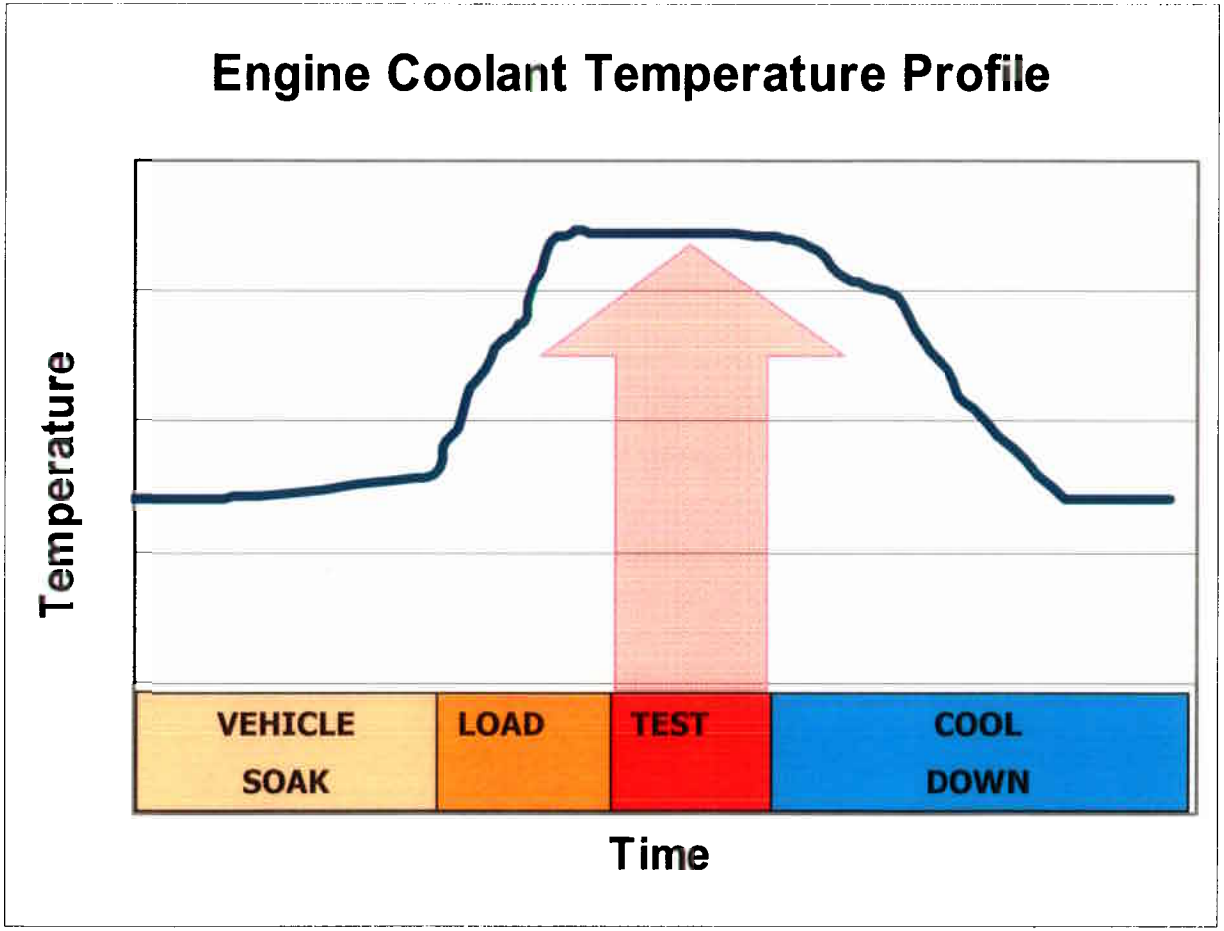
Data Captured

- Engine Coolant
- Engine Oil
- Transmission Oil

Results

Determine if vehicle cooling system meets requirements in various configurations

Thermal Testing

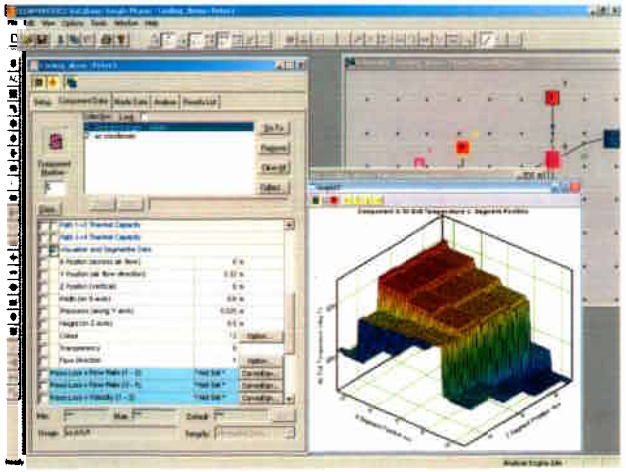


Thermal model simulates steady state conditions during cooling testing

Thermal Tool - Technology

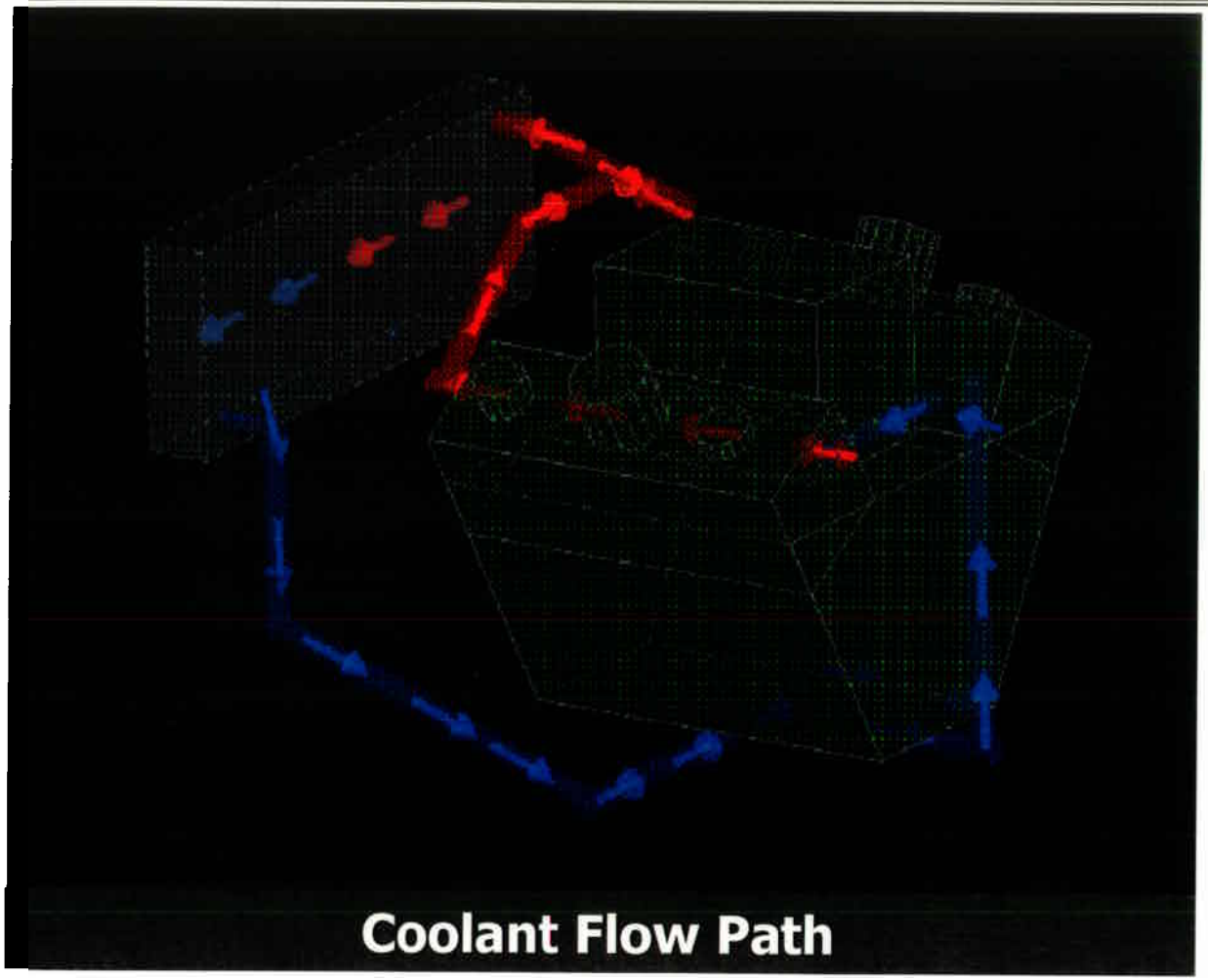
- Highly interactive tool with advanced features focusing on efficiency, accuracy, reliability and usability
- Facilitate connection between simulation and test process

Thermal Tool



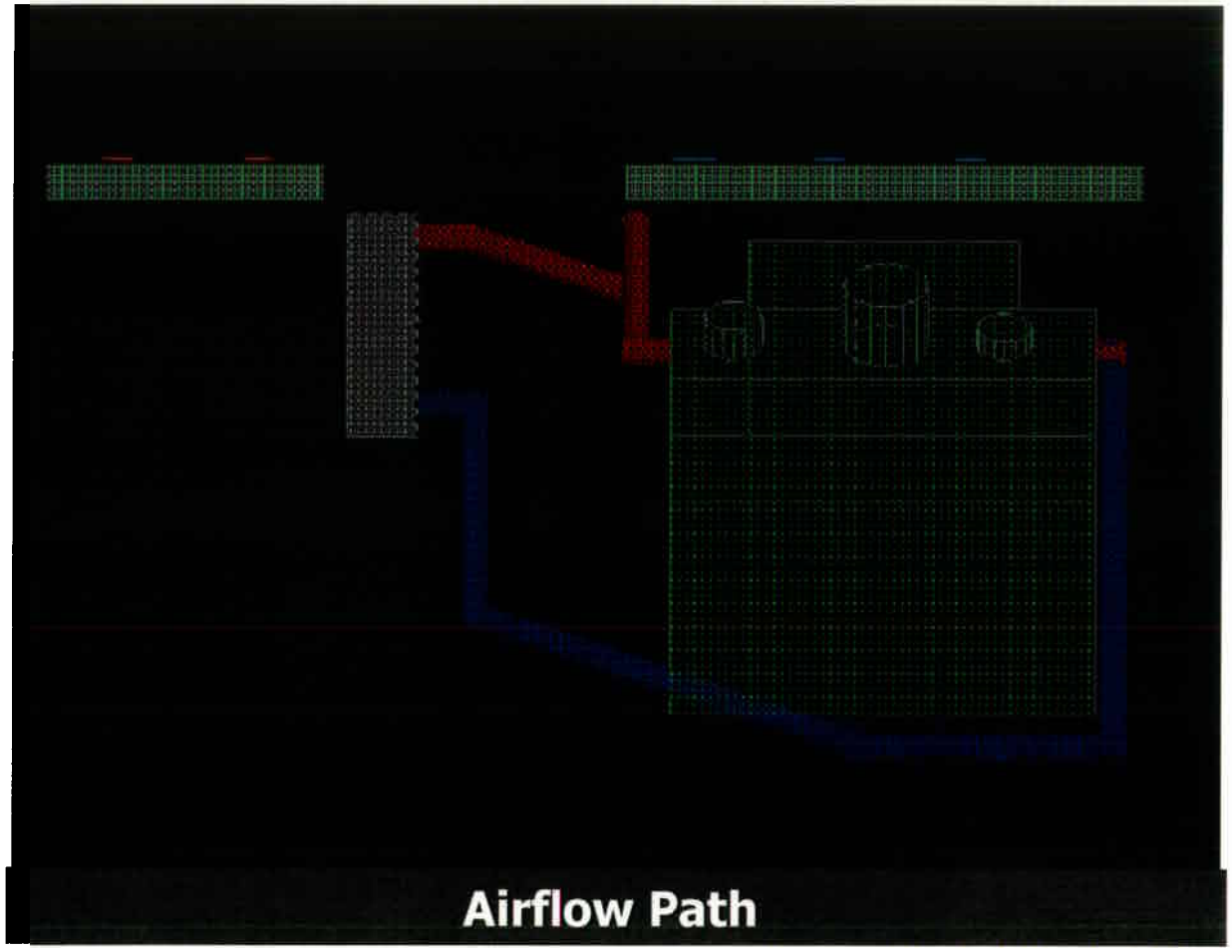
Thermal Test

Thermal Tool - Function



- Model the coolant and airflow heat balance
- Predict critical temperatures
- Produce same results as test

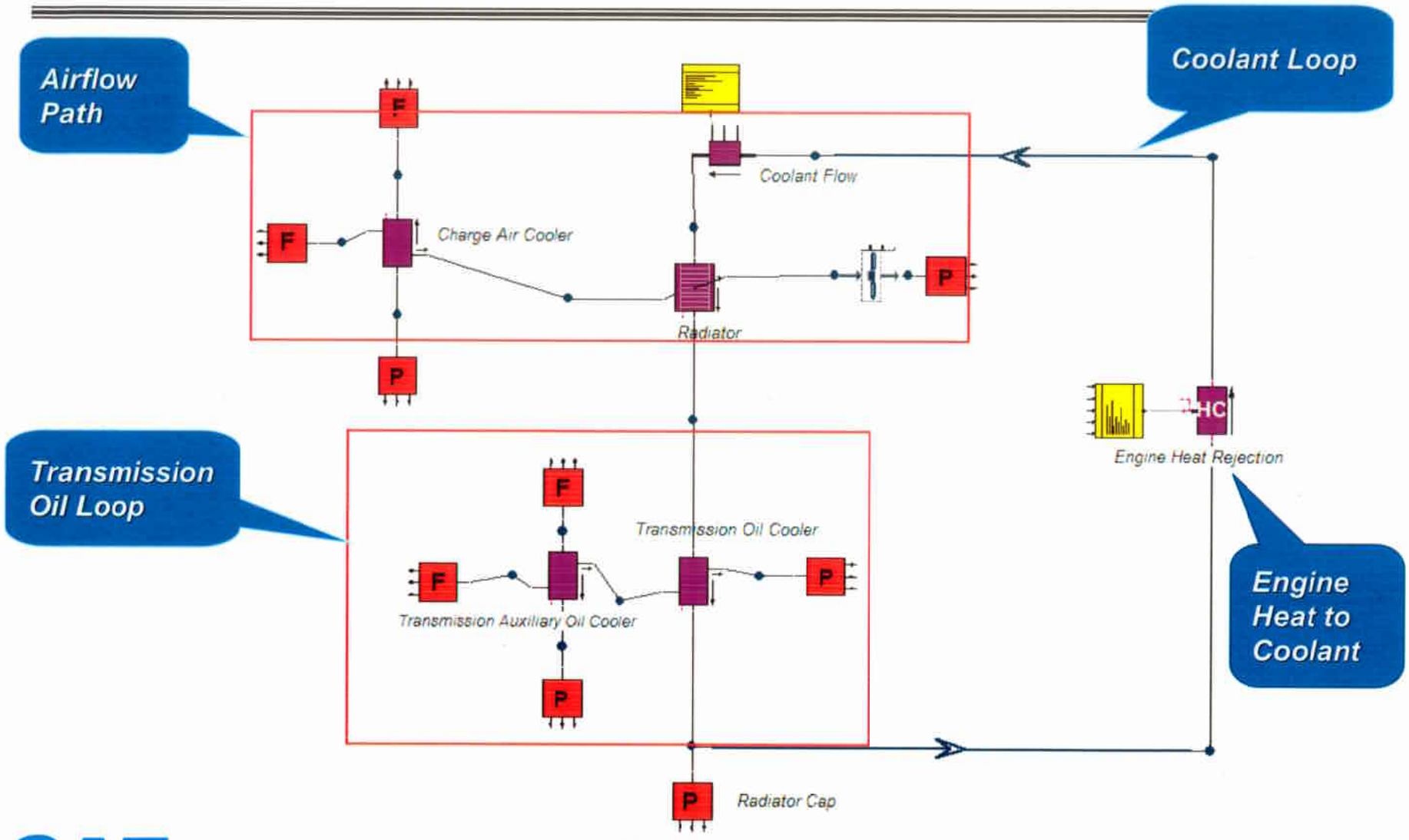
Thermal Tool - Function



Airflow Path

- Model the coolant and airflow heat balance
- Predict critical temperatures
- Produce same results as test

Thermal Tool – Function



Pilot Project – Medium Tactical Vehicles

M1093 Cargo Truck

M1098 Wrecker

M1087 Expandable Van

M1090 Dump Truck

Commonality

Chassis

Drive Train

Differences

Payloads

Mission Requirements

Common Chassis

Material Handling Equipment

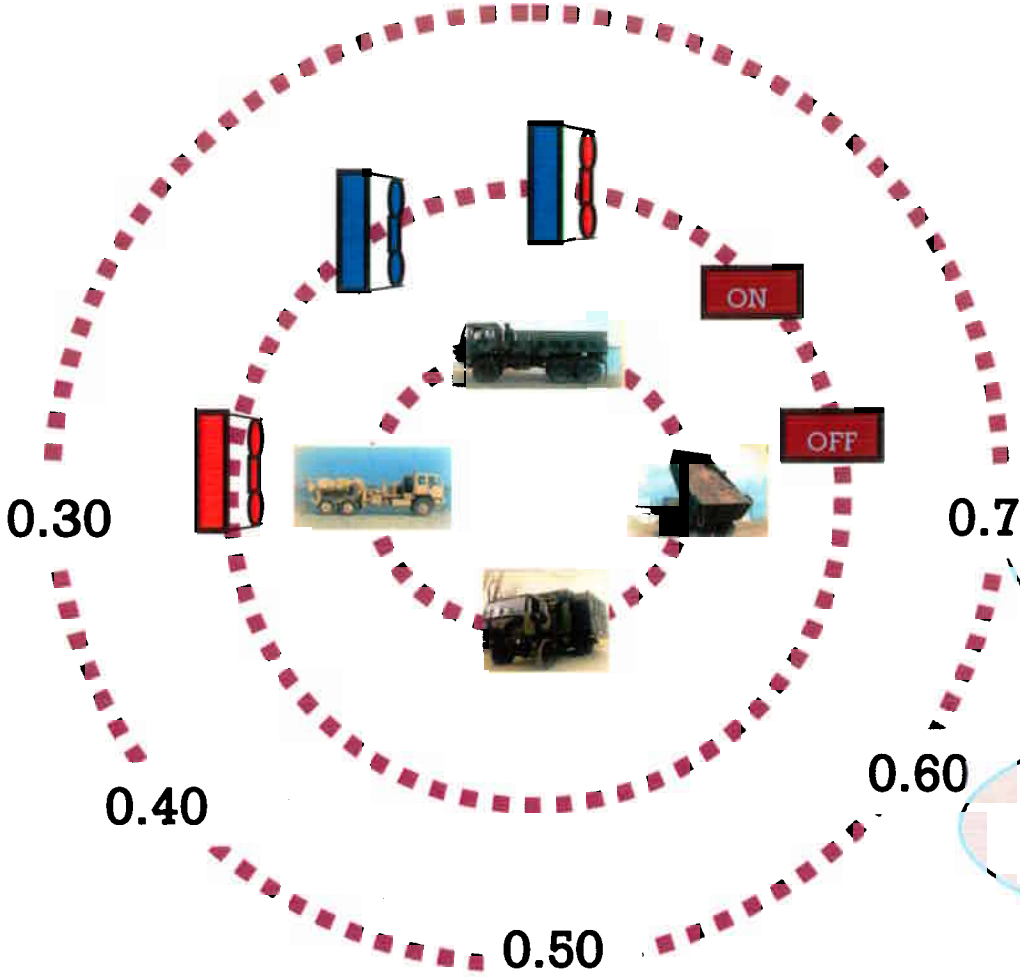
Load Handling System

MTV

M1088A1 Tractor

SAE Unclassified

Pilot Project – Test Matrix



Four Variants
Cargo
X-Van
Wrecker
Dump

Five Configurations:
Radiator/Fan (Base/Replacement)
Air Conditioning (on/off)

Five Tractive Effort/Weights
in high ambient temperatures

Tradition approach only captured 40% of the desired data within this test matrix.

Pilot Project – Work Completed

Major objectives have be accomplished

- Captured test data from four MTV variants

M1093 Cargo Truck

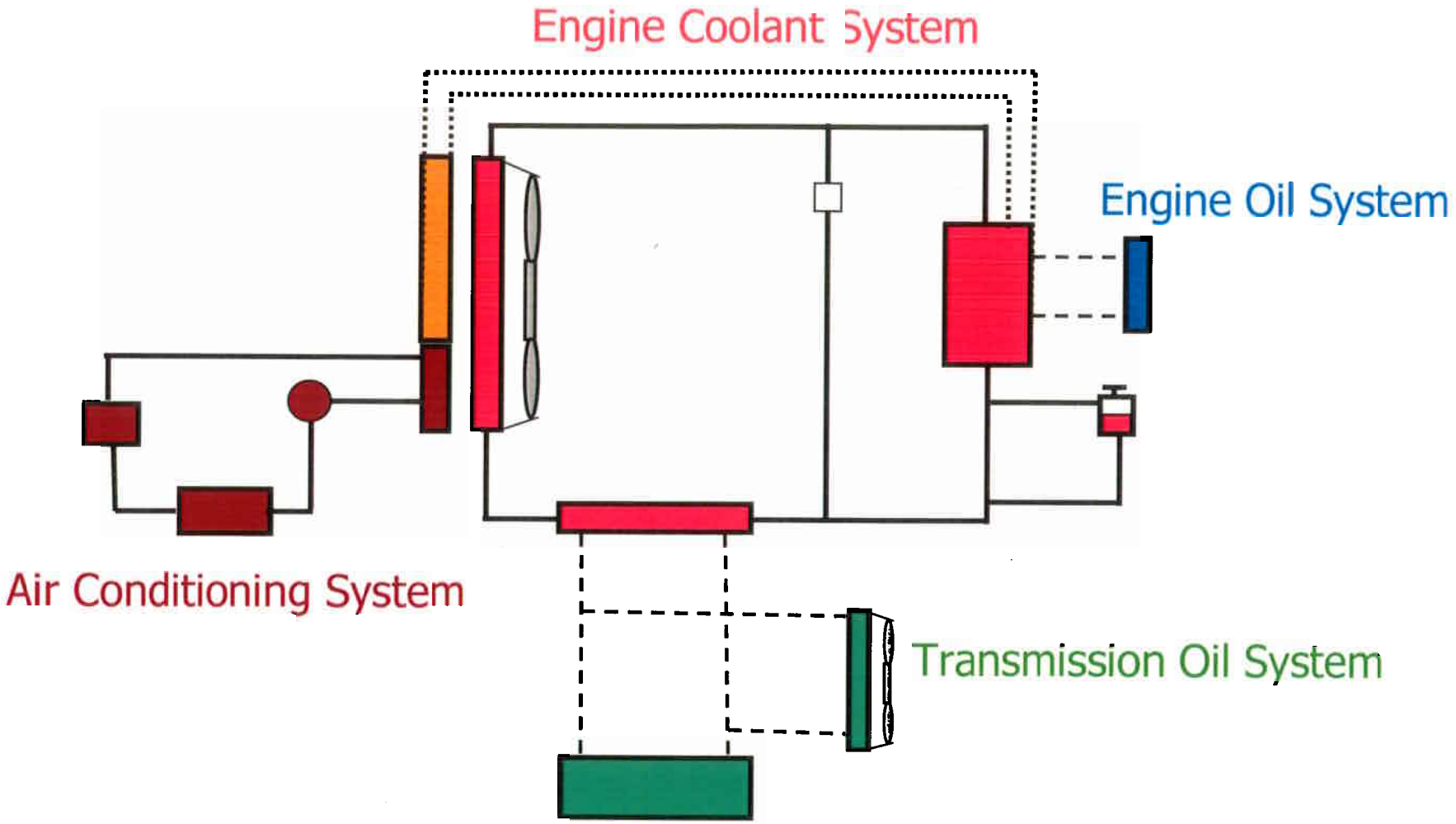
M1087 Expandable Van

M1098 Wrecker

M1090 Dump Truck

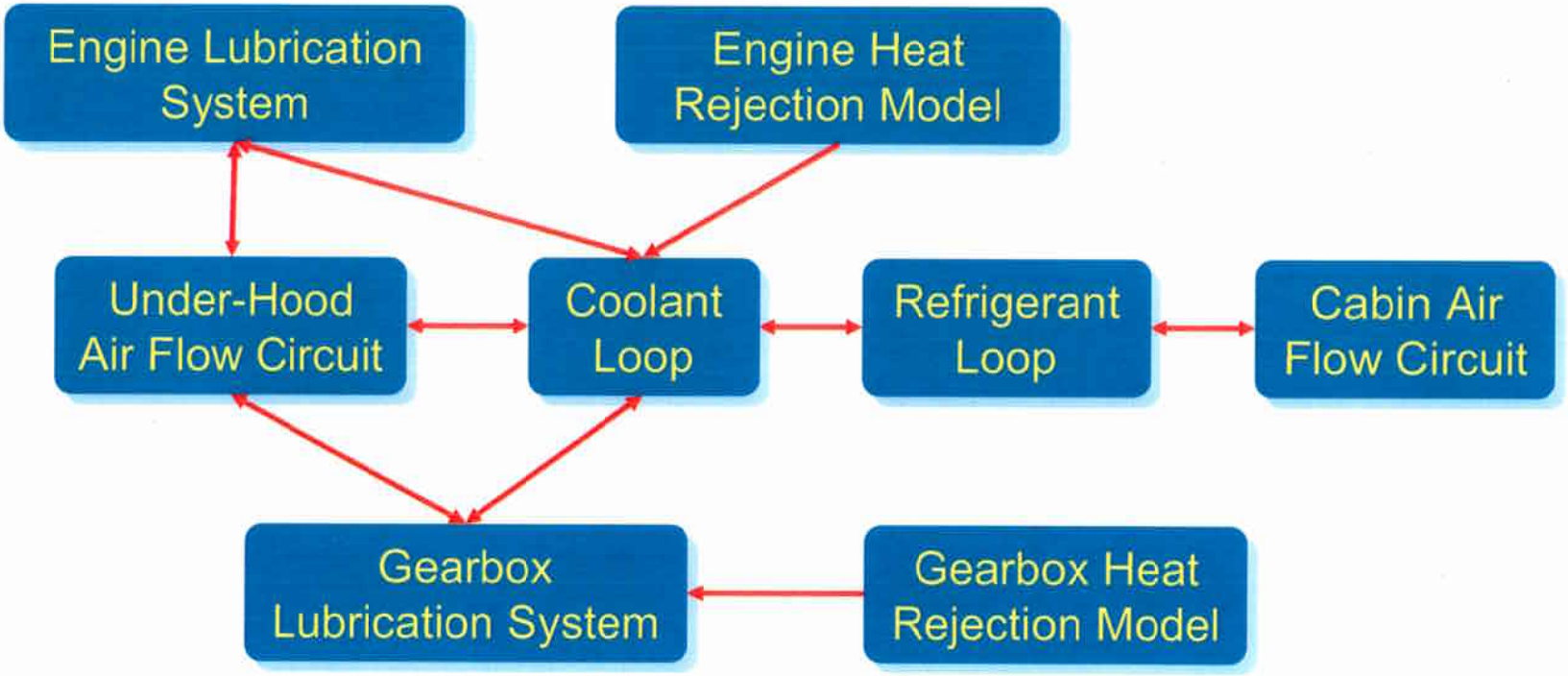
- Developed several thermal models
- Validated models using actual test data

Thermal Tool - Thermal Systems

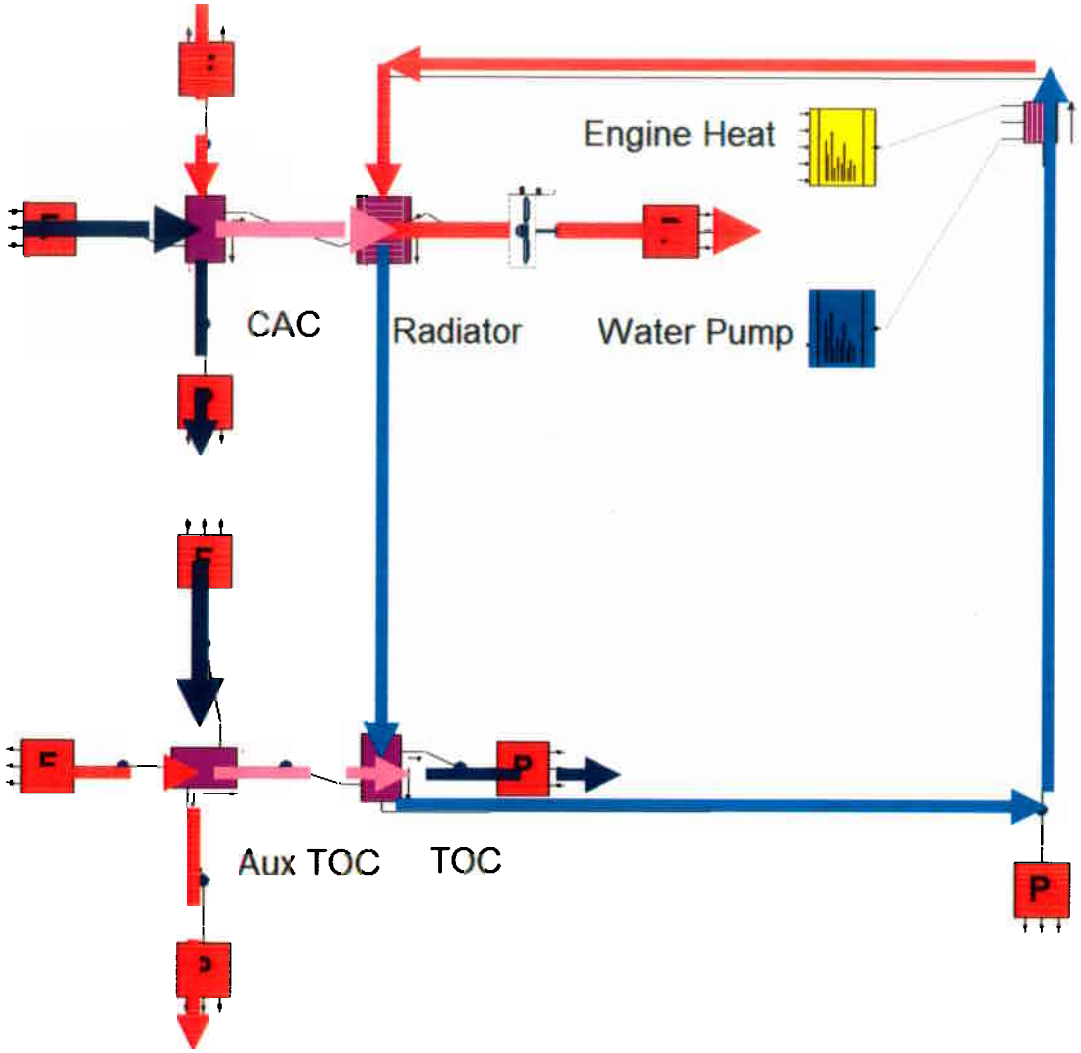


Thermal Tool - Responsibilities

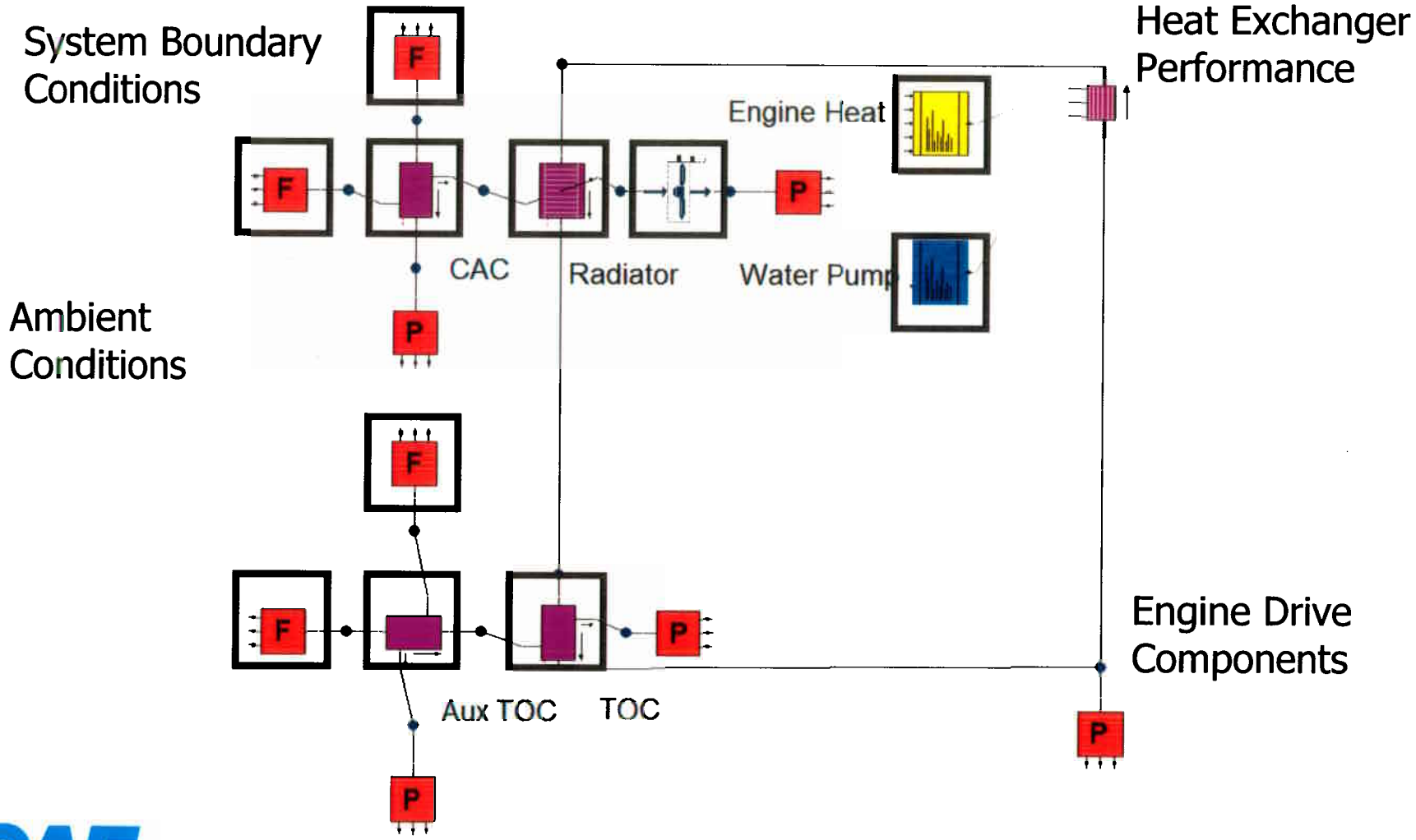
Thermal system interaction:



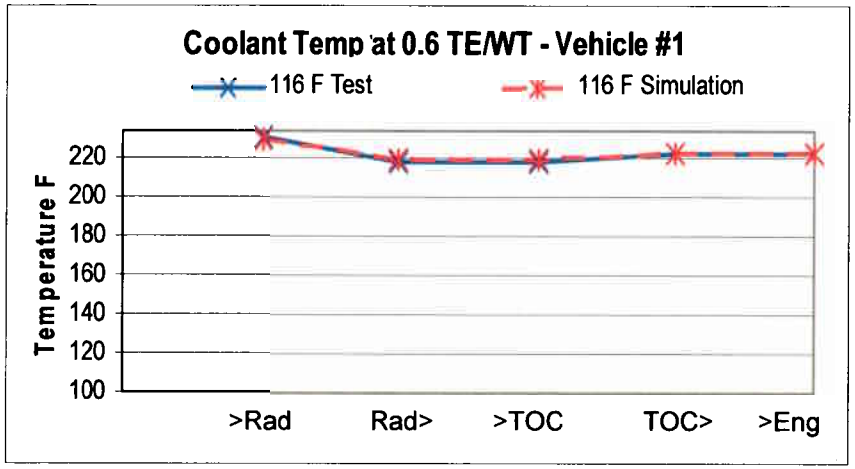
Thermal Tool - 1D Model Set Up

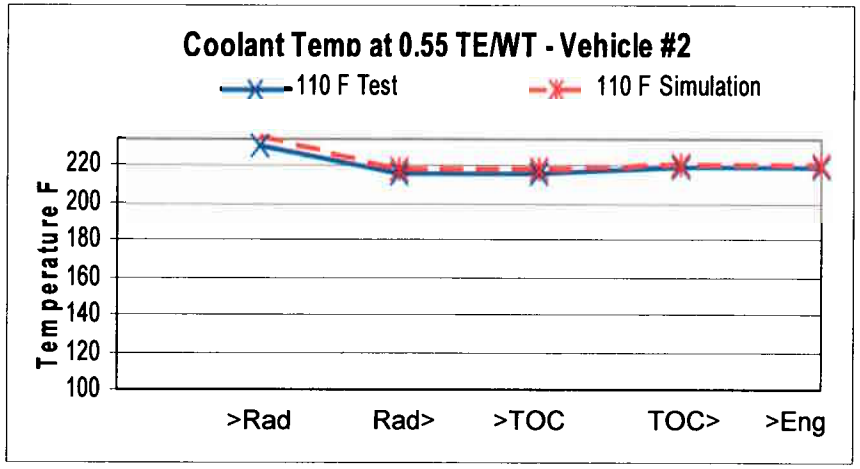


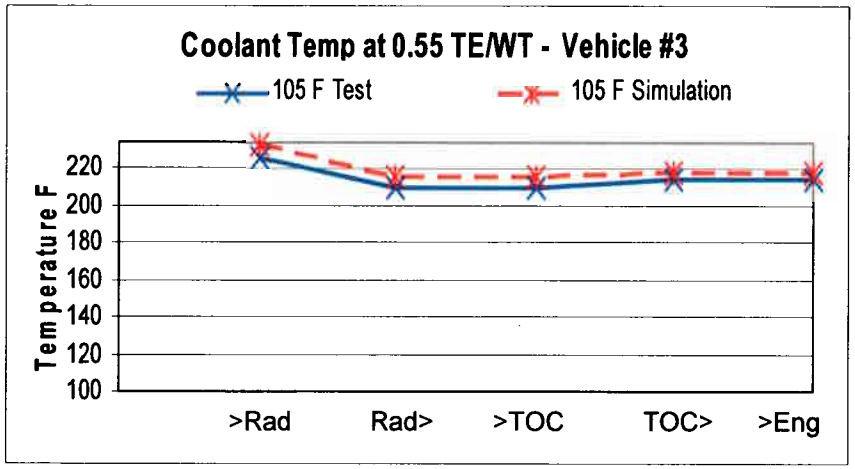
Thermal Tool - 1D Model Set Up

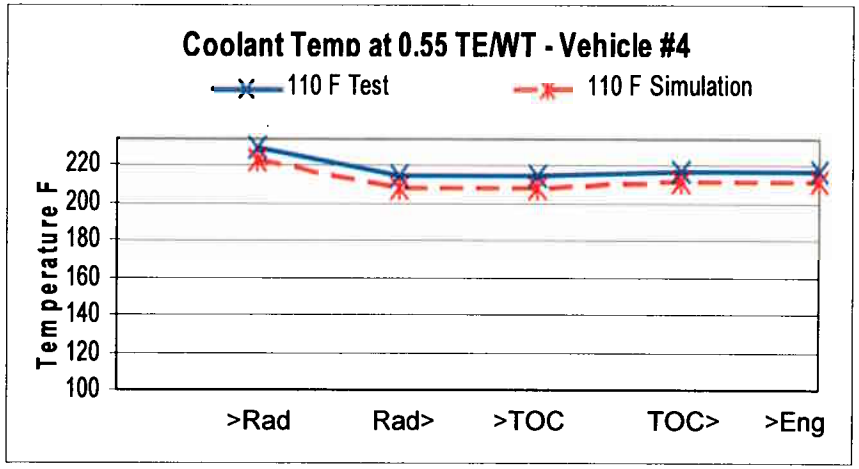


Results – Coolant Temperature

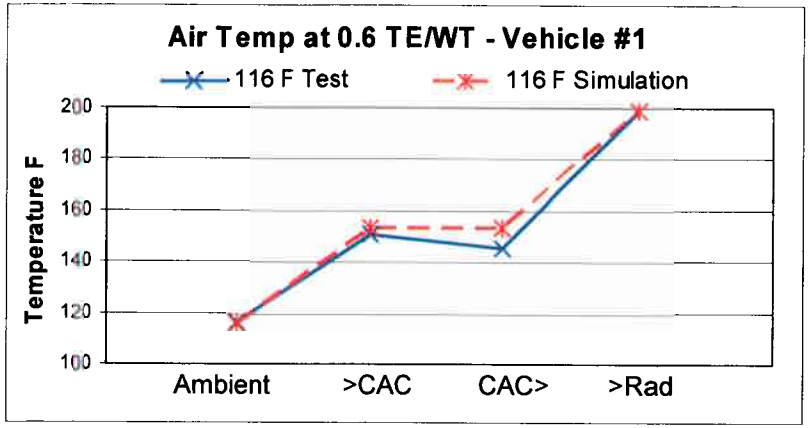


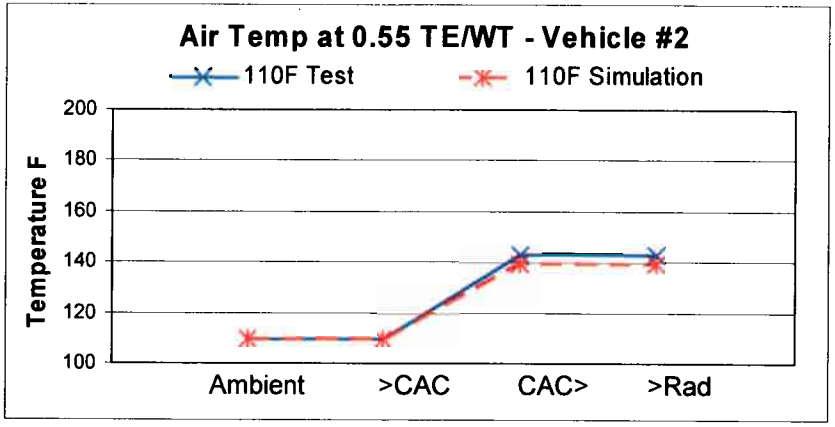


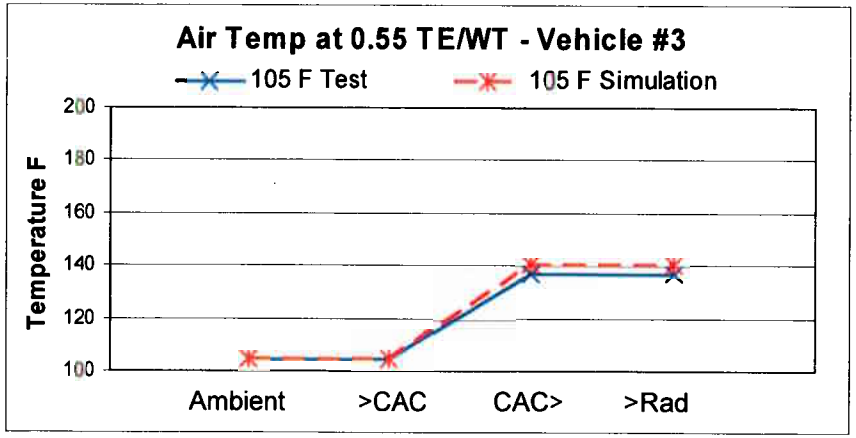


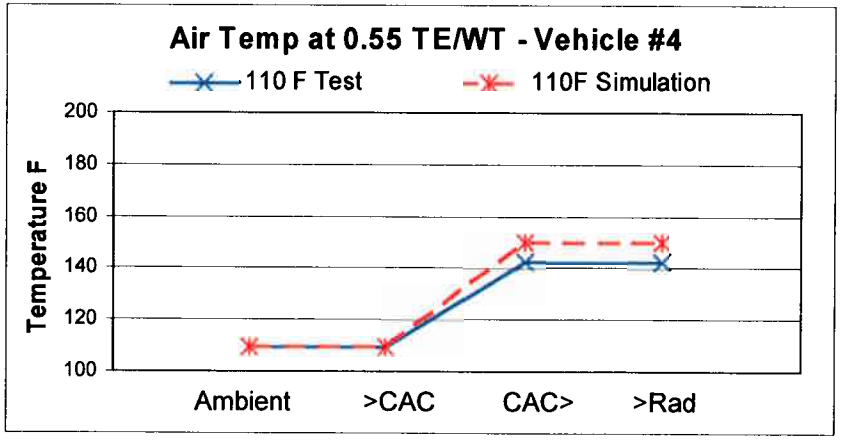


Results – Air Temperature

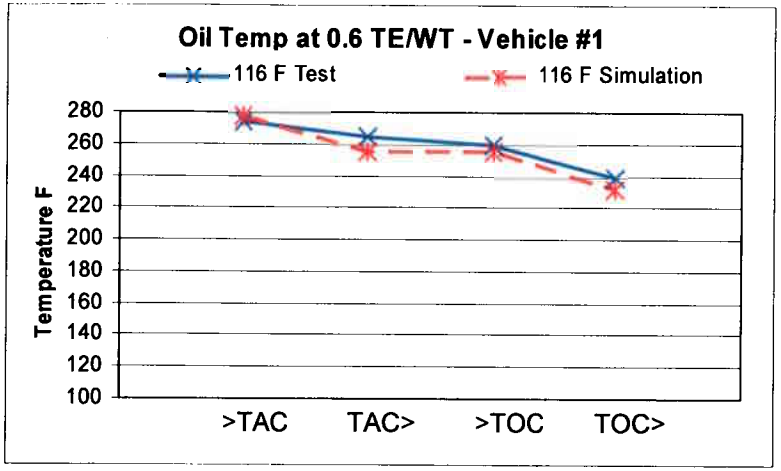


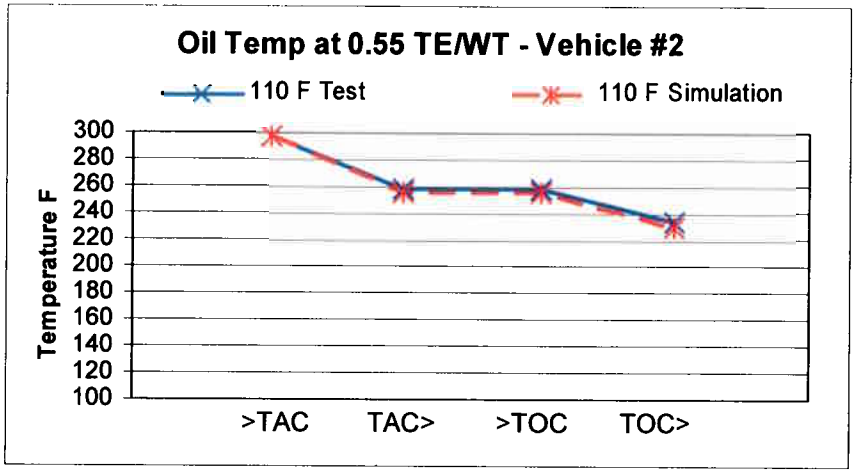


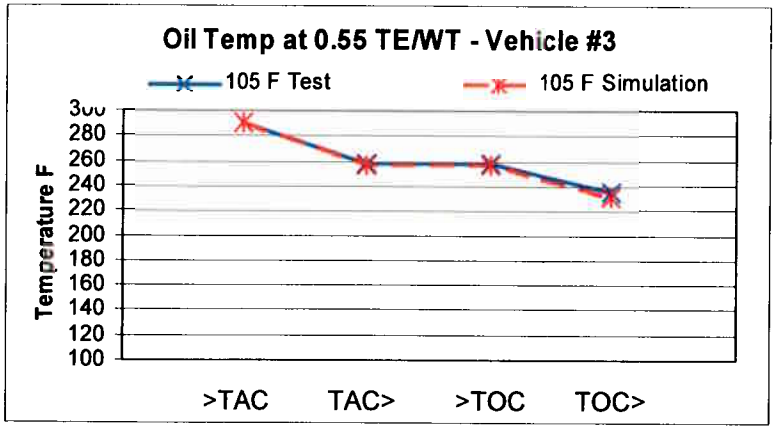


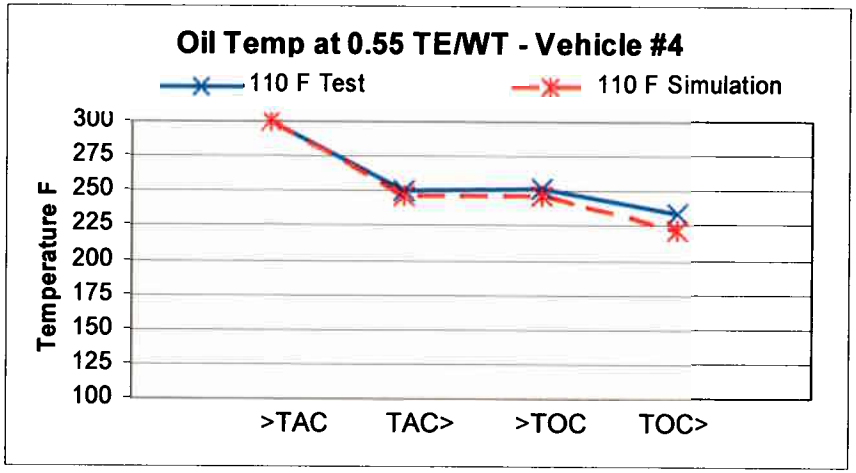


Results – Transmission Oil Temperature



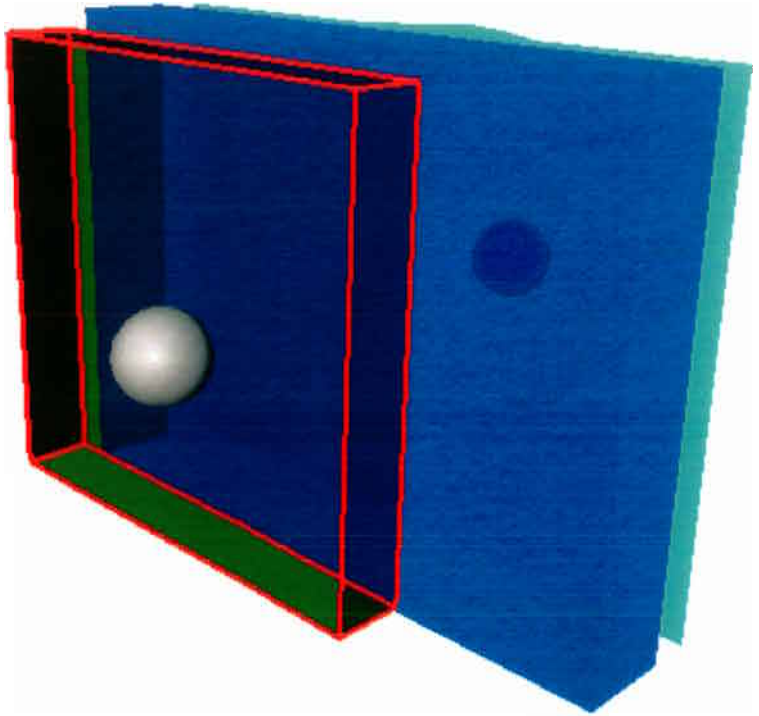






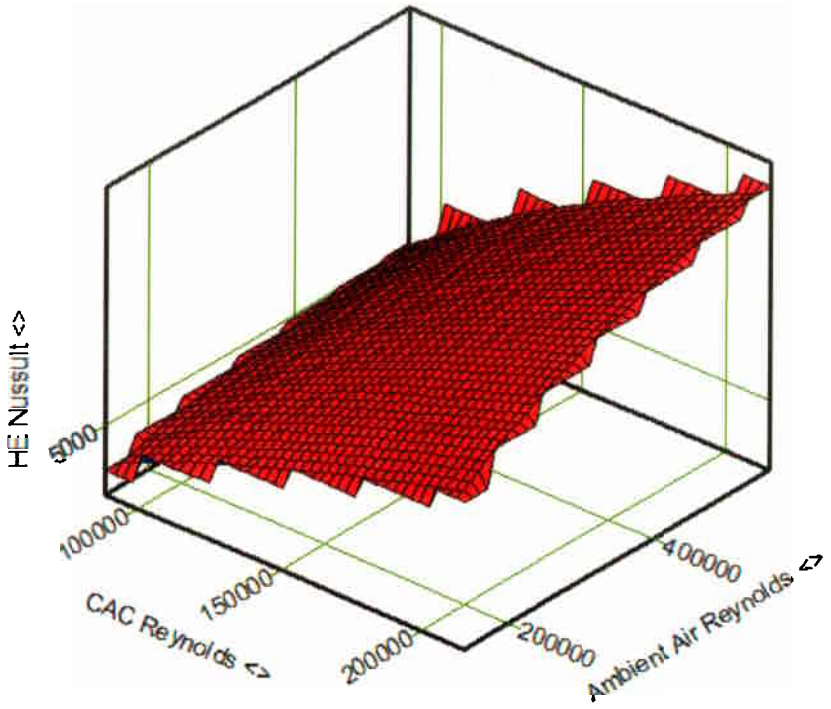
Next Steps – Additional Variables

- Performance
  - Equal or better than existing exchanger under same operating conditions
- Variable Geometry
  - Height, width, and depth
- Variable Location

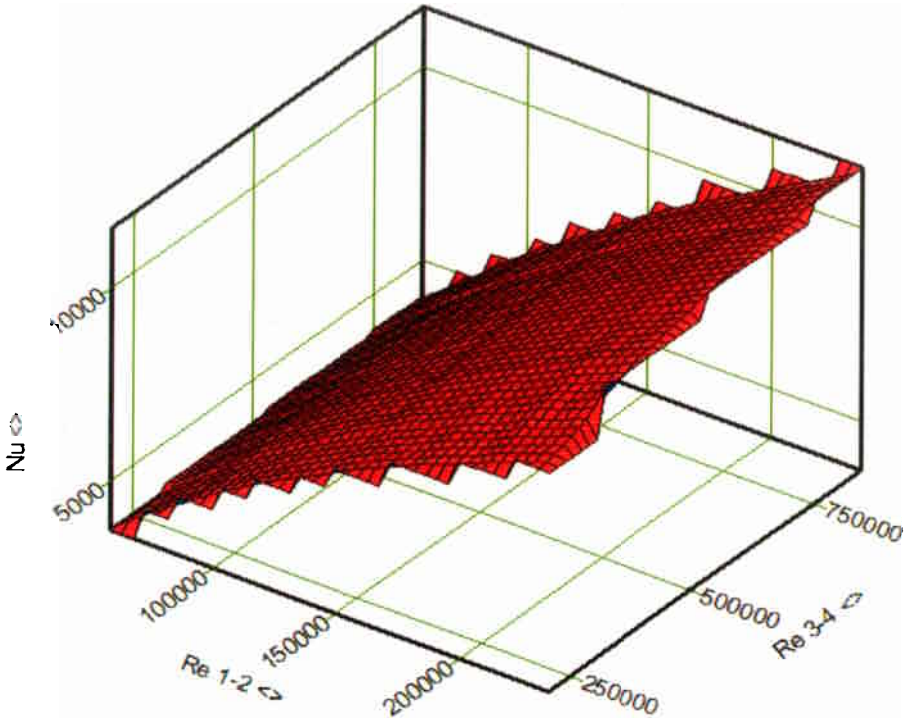


Next Steps - Performance Input

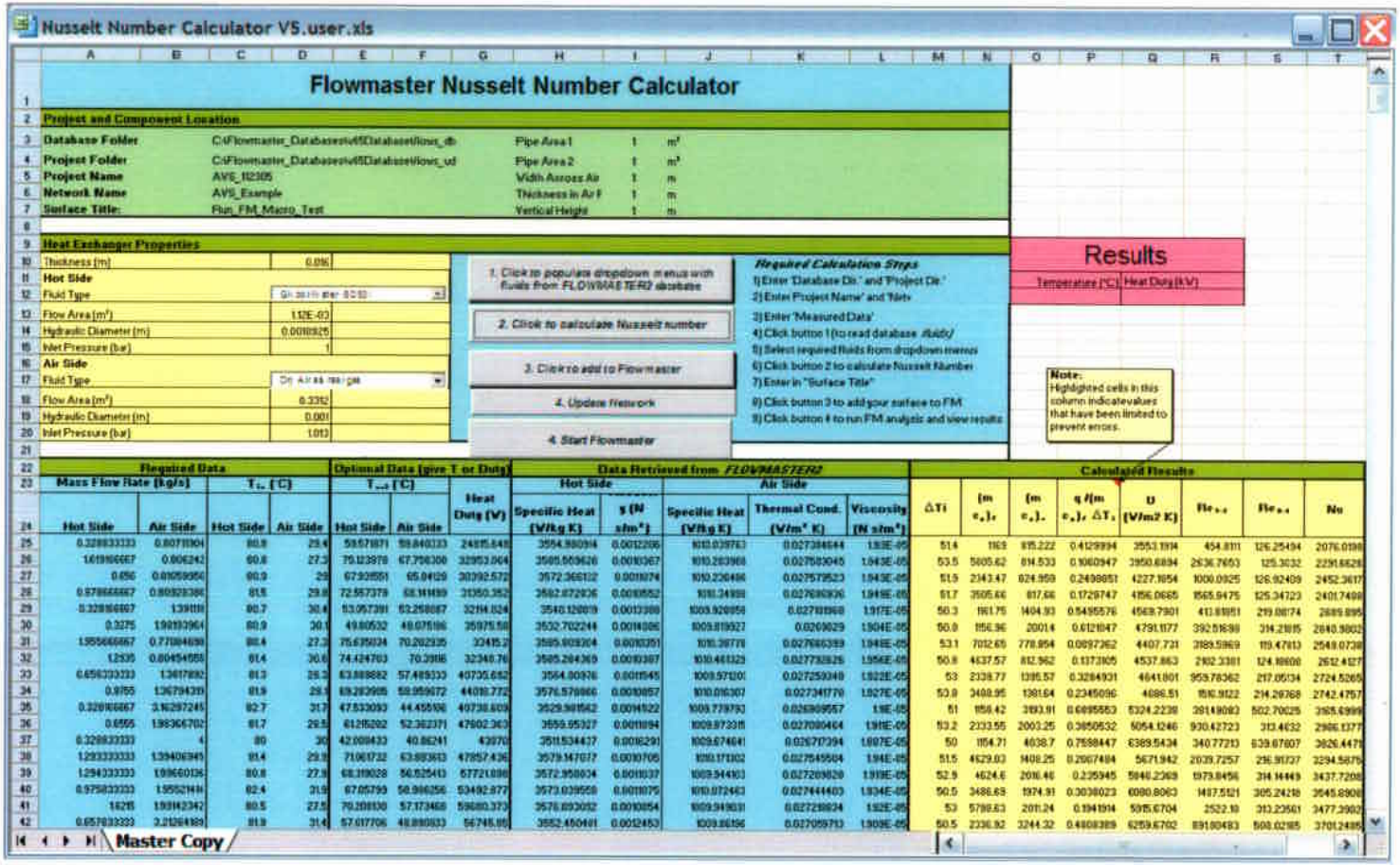
Charge Air Cooler Nusselt Number vs. Re12 vs Re34 V3



CAC Nu v Re1-2 v Re3-4



Next Steps – Automated Approach



Next Steps - Results

Top Tank Temperatures

	Vehicle A	Vehicle B	Vehicle C
Heat Exchangers			
X	180 °F	200 °F	210 °F
Y	180 °F	200 °F	210 °F
Z	180 °F	200 °F	210 °F

Next Steps - Observations

- Simulation accurately represents cooling system performance
- Thermal simulation simplified complex interactions
- Initial validation process utilized:
  - Pre-processed component test data
  - Comprehensive vehicle test data
- Process enables rapid and accurate analysis
  - Heat exchanger options
  - Multiple vehicle variants
- Validating process for future heat exchanger evaluation

Thanks for attending!

Questions?

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