FTTS Concepts & Analysis Overview

Briefer:
Mr. Roger Halle
TARDEC
Advanced Concepts
(586)574-5059
hallero@tacom.army.mil

Agenda

- Pre-Milestone A Development Process
- QFD Process
- Concepts Overview
- Analysis Overview
- Concluding Remarks

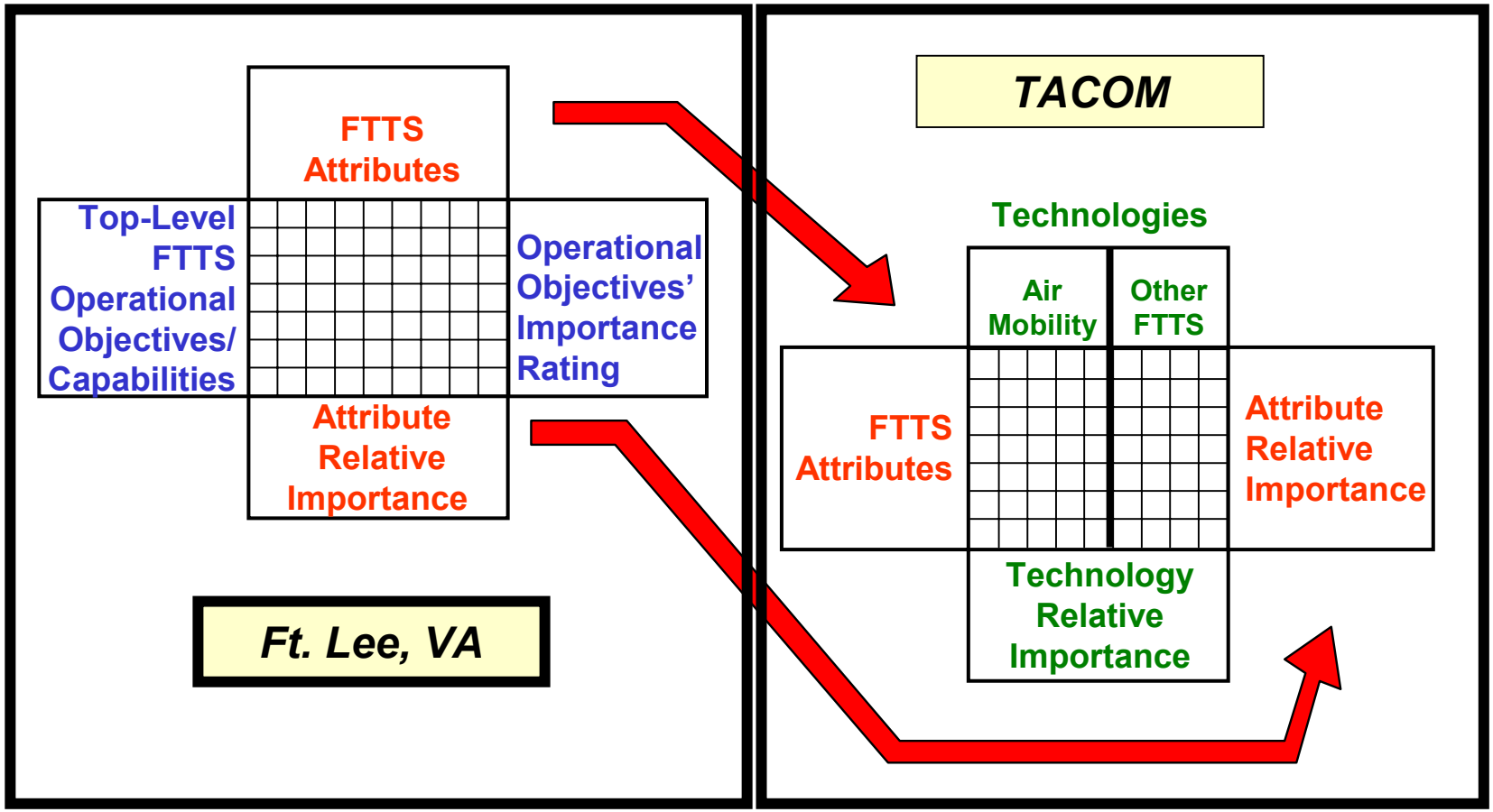
FTTS Pre-Milestone A Concepts Process

FTTS QFD Process

FTTS QFD Objective

- Define and Prioritize FTTS Objectives, Attributes, and Potential Technology Solutions

FTTS QFD Architecture



FTTS QFD Members

NEEDS
Non-Advocate Exploratory
Evaluation Decision Support

BOEING PHANTOM WORKS

SPEARHEAD OF LOGISTICS

PROJECT MANAGER TEAM HTV HEAVY TACTICAL VEHICLES

BOEING

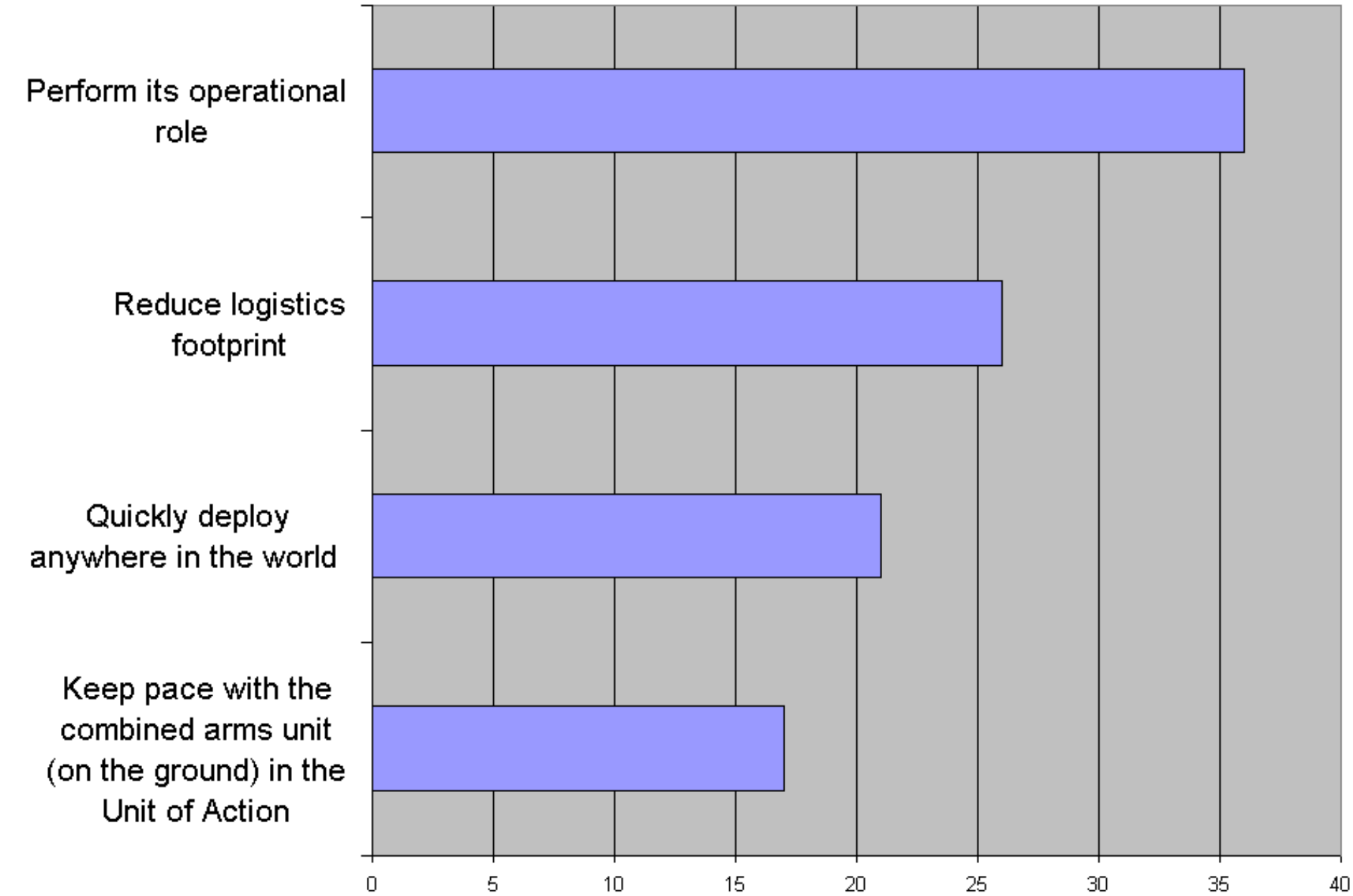
UNITED STATES ARMY
NAC
NATIONAL AUTOMOTIVE CENTER

Advanced Concepts

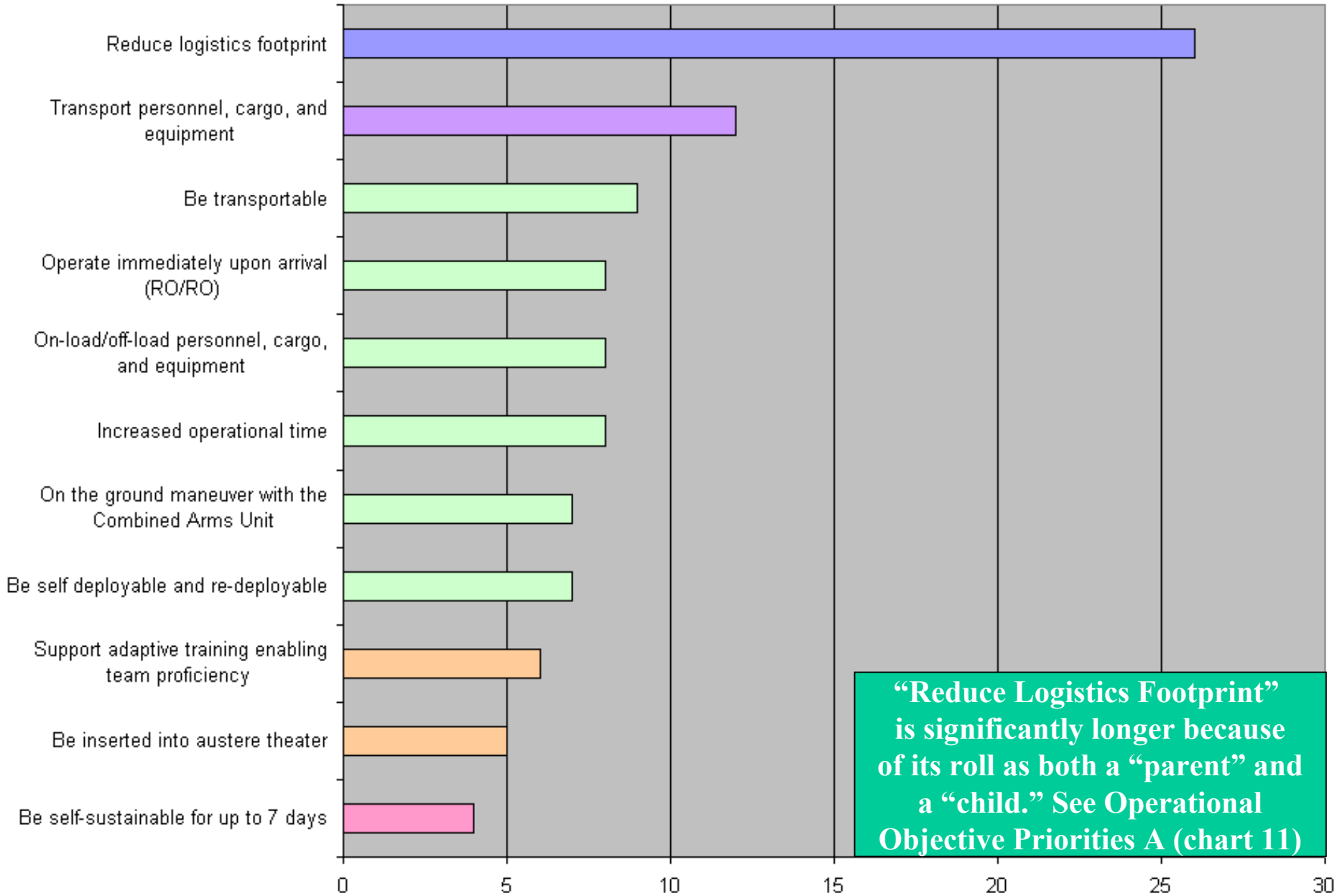
FTTS Operational Objectives

- **Quickly deploy anywhere in the world**
  - Be transportable by inter/intra-theater land, sea and airlift [anywhere in the world]
  - Be self deployable and re-deployable
  - Be inserted with combat units into austere theater through multiple unimproved entry points [without relying on fixed ports and staging bases]
- **Perform its operational role**
  - Operate immediately upon arrival (RO/RO)
  - Transport the personnel, cargo, and equipment to the "right place" at the "right time" to support the geographic combatant commander
  - On-load/off-load the personnel, cargo, and equipment
  - Increased operational time
- **Keep pace with the combined arms unit (on the ground) in the Unit of Action**
  - On the ground maneuver with the Combined Arms Unit over operational distances
  - Be self-sustainable for up to 7 days in low-end conflict and peace time military engagement
  - Support adaptive training enabling team proficiency
- **Reduce logistics footprint**

Operational Objective Priorities – “Parents”



Operational Objective Priorities – "Children"



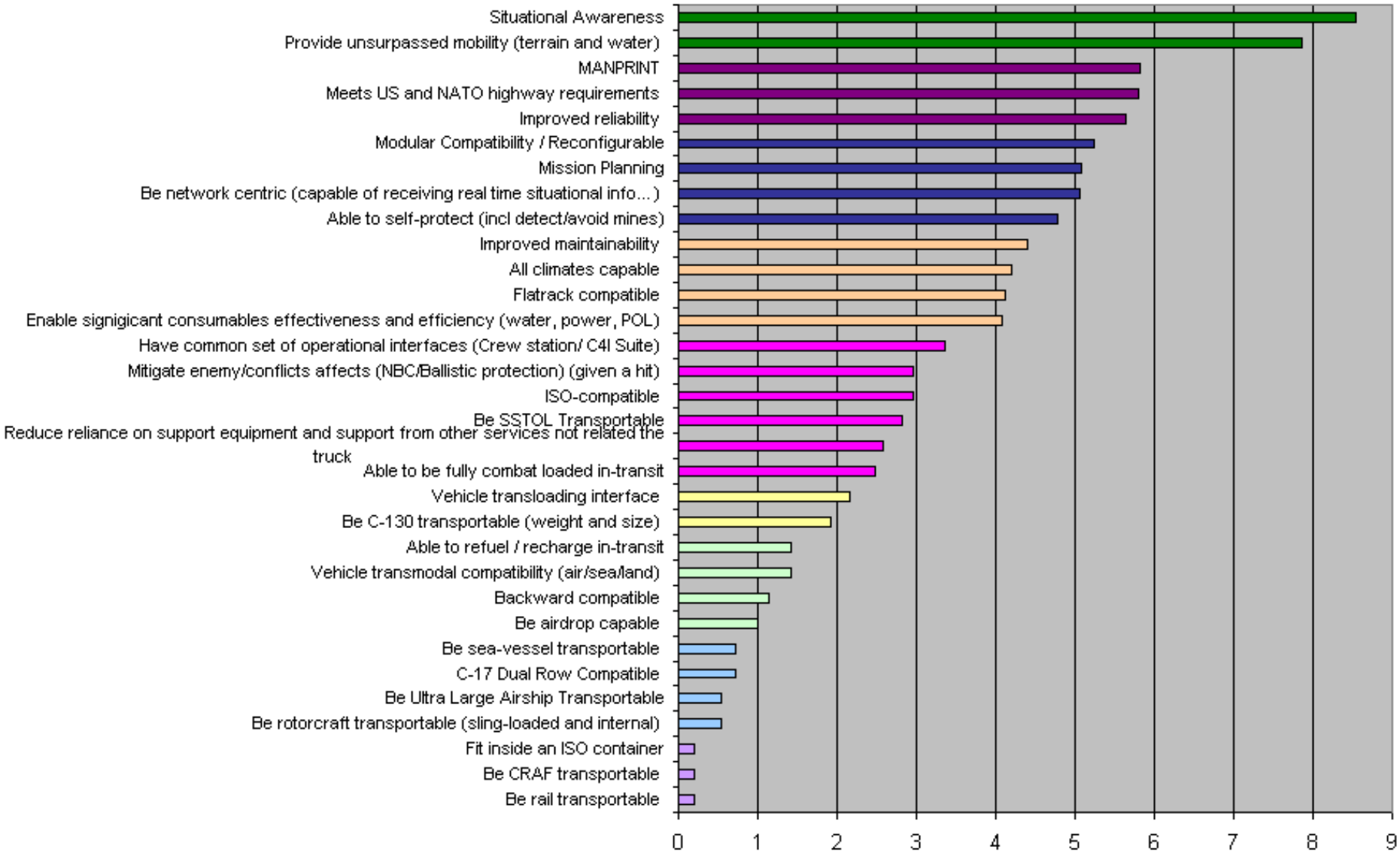
FTTS Attributes

- Be C-130 transportable (weight and size)
- C-17 Dual Row Compatible
- Be rail transportable
- Be sea-vessel transportable
- Be CRAF transportable
- Be rotorcraft transportable (sling-loaded)
- Be advanced vertical lift transportable
- Be SSTOL Transportable
- Be airdrop capable
- Fit inside an ISO container
- ISO-compatible
- Flatrack compatible
- Module compatible
- Shelter compatible
- Situational Awareness
- Be network centric (capable of receiving real time situational info…)
- Able to self-protect (incl. detect/avoid mines)
- Mitigate enemy/conflicts affects (NBC/Ballistic protection) (given a hit)
- Meets US and NATO highway reqm’ts.
- Have common set of operational interfaces (Crew station/ C4I Suite)
- MANPRINT
- Vehicle transmodal compatibility (air/sea/land)
- Vehicle transloading interface
- Enable significant consumables sustainment effectiveness and efficiency (water, power, POL)
- Backward compatible
- All climates capable
- Provide unsurpassed mobility (terrain and water)
- Reduce reliance on non-combat materiel requirements
- Be re-configurable (across proponents)
- Improved reliability
- Improved maintainability
- Mission Planning
- Able to refuel / recharge in-transit
- Able to be fully combat loaded in-transit

Matrix A: Operational Objectives & Attributes

If the FTTS has this attribute, does it contribute directly to the FTTS operational objective? If so, to what extent? 9 = Strong 3 = Moderate 1 = Weak 0 = None/Negative Impact	(Hows) FTTS Attributes	Be C-130 transportable (weight and size)	C-17 Dual Row Compatible	Be rail transportable	Be sea-vessel transportable	Be CRAF transportable	Be rotorcraft transportable (sling-loaded and internal)	Be Ultra Large Airship Transportable	Be SSTOL Transportable	Fit inside an ISO container	ISO-compatible	Flatrack compatible
(Whats) Operational Objectives		1	2	3	4	5	6	7	8	10	11	12
Quickly deploy anywhere in the world												
Be transportable by inter/intra-theater land, sea and airlift [anywhere in the world]		9	3	1	3	1	1	1	9	1		
Be self deployable and re-deployable												
Be inserted with combat units into austere theater through multiple unimproved entry points [without relying on fixed ports and staging bases]		1	1		1		3	3	9			
Perform its operational role												
Operate immediately upon arrival (RO/RO)												
Transport the personnel, cargo, and equipment to the "right place" at the "right time" to support the geographic combatant commander											9	9

Attribute Priorities



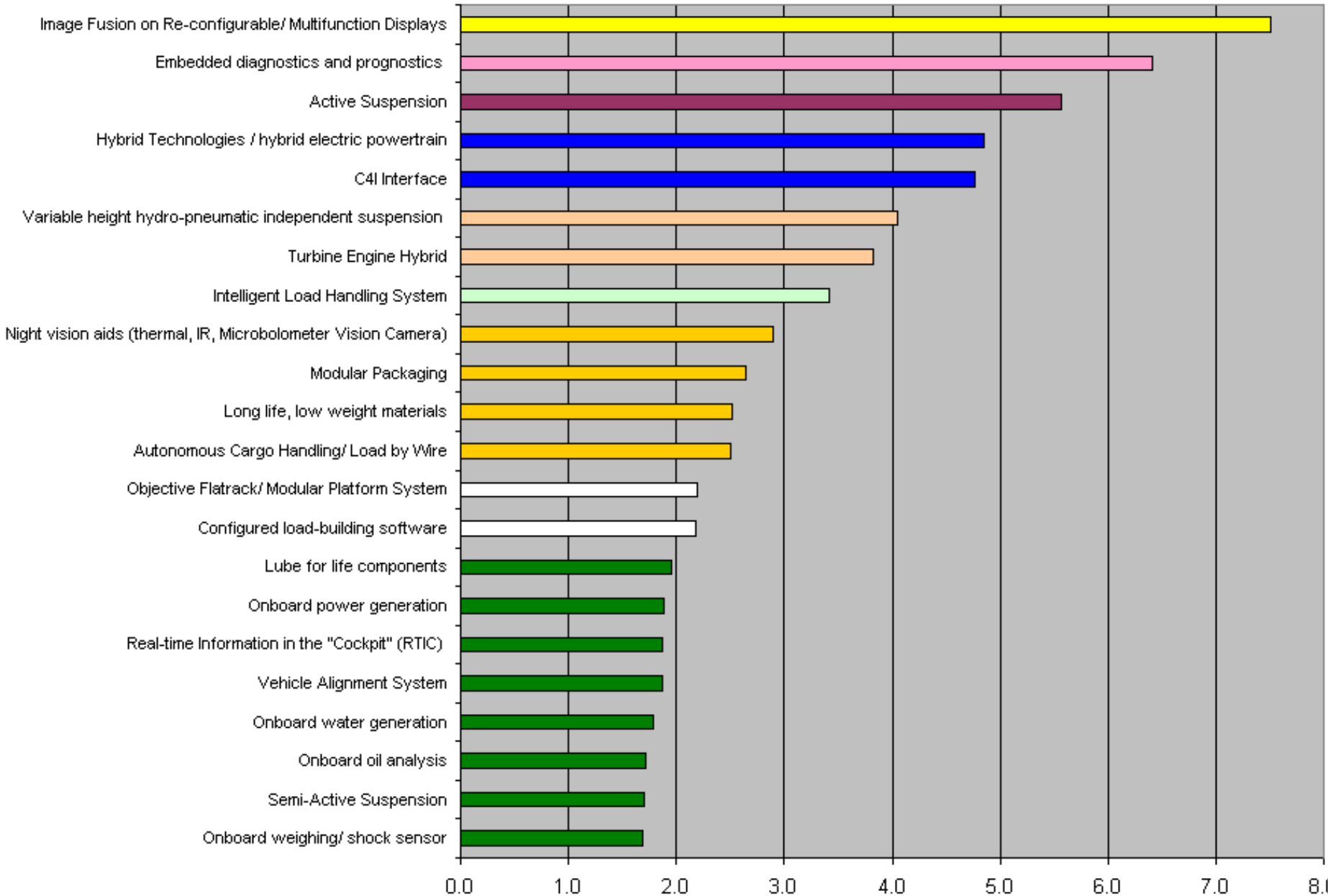
FTTS Technologies

- Propulsion Technologies (Engine/Transmission Combinations)
  - Advanced Low Emission High Density Diesel Engines/conventional transmission
  - Hybrid Technologies / hybrid electric powertrain
  - Turbine Engine Hybrid
  - Beltless Engines
- Suspension / Steering System
  - Active Suspension
  - Semi-Active Suspension
  - Improved conventional independent suspension
  - Variable height hydro-pneumatic independent suspension
  - Electronic Steering (in hub motors)
  - Ackerman Steering
  - Hybrid Ackerman Steering
- C4I
  - Drivers vision aids
  - Synthetic Vision / Pilot Aids / 3-D Imagery
  - Helmet Mounted Display & Tracking Sys.
  - Night vision aids (thermal, IR, Microbolometer Vision Camera …)
  - Peripheral vision aids
  - Image Fusion on Re-configurable/ Multifunction Displays
  - Speech recognition
  - Embedded diagnostics and prognostics
  - Real-time Information in the "Cockpit" (RTIC)
  - En Route Mission Planning and Rehearsal System
  - Robotics
  - Voice Communications Collision Avoidance
  - Movement tracking system
  - RF AIT (Radio Frequency Auto Id Technologies)

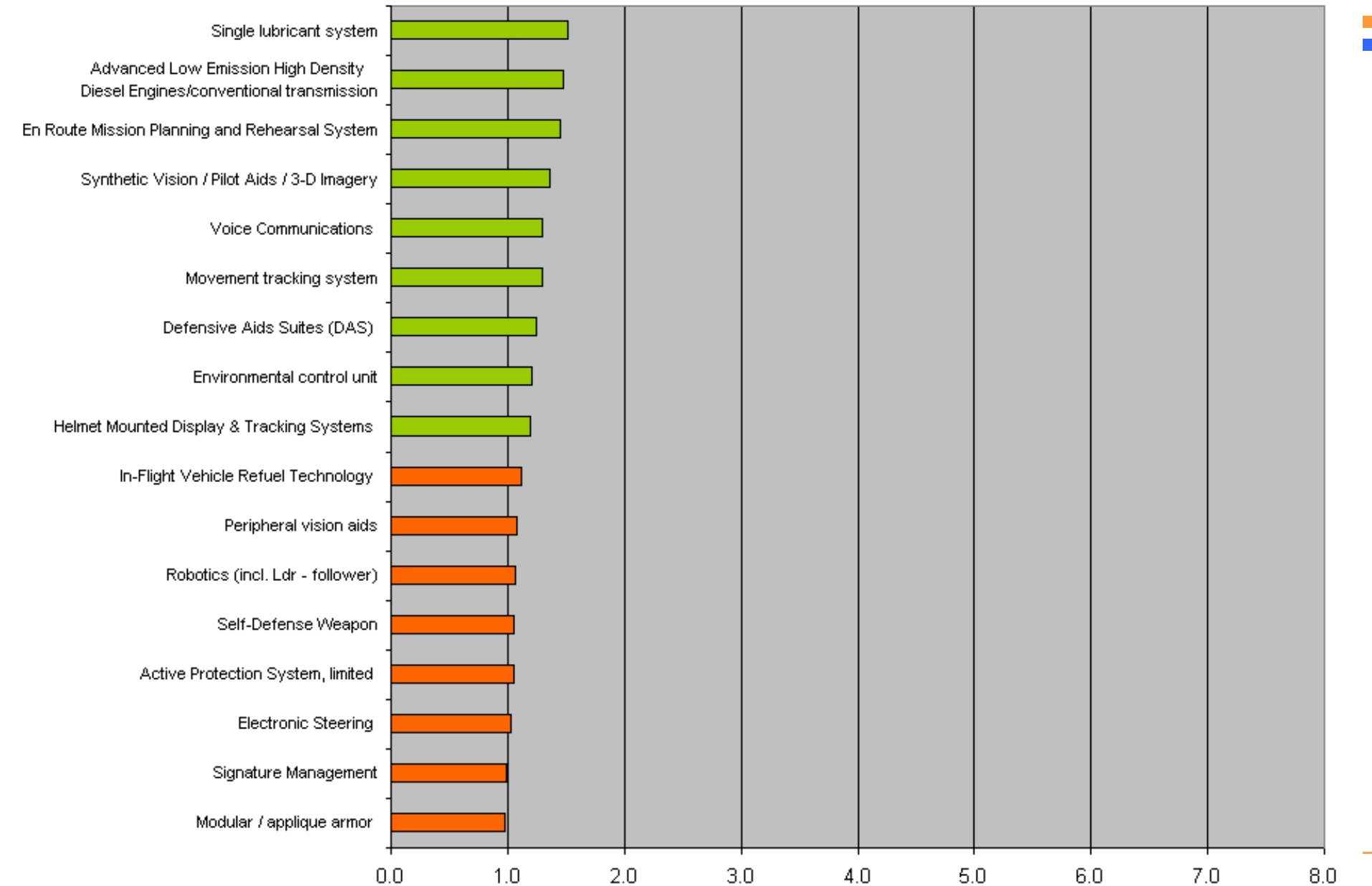
FTTS QFD Technologies

- **Mission Modules / Materiel Handling**
  - Smart Distribution System
  - Intelligent Load Handling System
  - Modular Packaging
  - Smart Tie Down
  - Configured load-building software
  - Flatrack
  - CAIK
  - FAIK
  - MAIK
  - EDS-A
  - RPAD
  - Objective Flatrack/Modular Platform System
  - Vehicle Alignment System
- **Truck Specific Technologies**
  - Environmental control unit
  - Long life, low weight materials
  - Onboard oil analysis
  - Single lubricant system
  - Lube for life components
  - Onboard water generation
  - Onboard power generation
  - Onboard weighing/shock sensor
- **Survivability**
  - Base cab armor
  - Modular/appliqué armor
  - Active Protection System, limited
  - Defensive Aids Suites (DAS)
  - Self-Defense Weapon
  - NBC Overpressure
  - Signature Management
- **Aircraft/Vehicle Interfaces**
  - Autonomous Cargo Handling/Load by Wire
  - C4I Interface
  - In-Flight Vehicle Refuel Technology
  - External Aircraft-to-Vehicle Refuel Technology
  - In-Flight Battery Charging Technology
  - In-flight load attenuation

Technology Priorities High



Technology Priorities Medium



Technology Linkage to Attributes

- 58 Technologies in the areas of Propulsion, Suspension/Steering System, C4I, Mission Modules/Materiel Handling, Truck-Specific, Survivability, and Aircraft-Vehicle Interface were examined
  - Most of the 16 C4I technologies score in the top half; Image Fusion on Re-configurable/Multifunction Displays, Embedded Diagnostics & Prognostics, C4I Interface, Night Vision Aids, and Real-Time Information in the Cockpit score significantly above other C4I items
  - Active & Semi-Active Suspension score significantly better than Improved Conventional Suspension
  - Hybrid Technologies / Hybrid Electric Powertrain scores significantly better than other propulsion alternatives
  - Smart Distribution technologies
  - All 8 of the truck-specific technologies score in the top half
  - Objective Flatrack scores significantly better than CAIK, FAIK, …; without CAIK, FAIK, … compatibility, however, the attribute of backward compatibility becomes an issue

Technology Linkage to Attributes

- Autonomous Cargo Handling / Load by Wire rises above other aircraft-vehicle interface items; other items (x) are unique contributors to desirable attributes
- The lack of survivability technologies is a reflection of the process rewarding breadth over depth; Defensive Aids Suite scores above other survivability items, yet without the other survivability technologies then the attributes of Able to self-protect (avoid the threat) and Mitigate Enemy Affects (Given a Hit) become issues
- Electric Steering scores significantly better than the Ackerman and Hybrid Ackerman alternatives
- In-flight Vehicle Refuel Technology and In-Flight Battery Charging Technology were the only technologies that satisfied the need to refuel/recharge in transit
- Being C-17 Dual Row Compatible and Rail Transportable are fall outs of strict weight and height requirements of the C-130
- Being Sea Vessel Transportable lowers the weight and height requirements of the C-130, but requires that the truck be able to maneuver in order to drive onto the ship

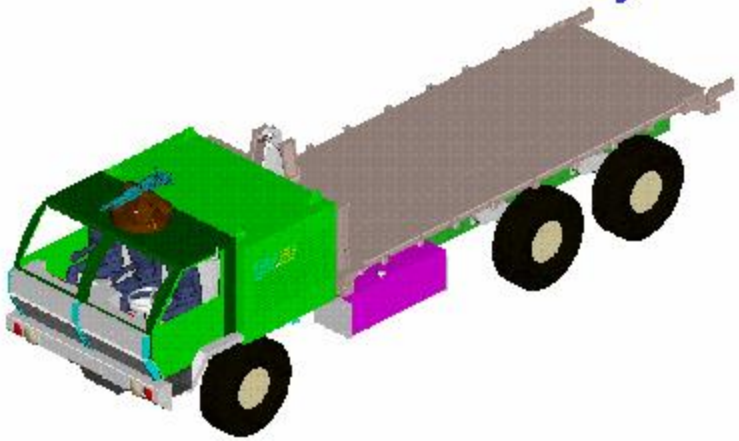
FTTS Concepts

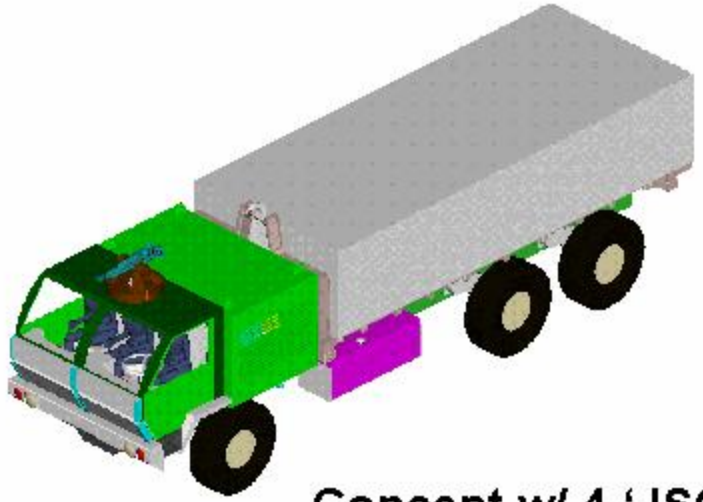
CAD Deliverables to date & Applications

FTTS Maneuver Sustainment Vehicle Concepts

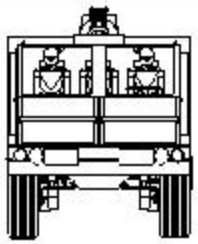
- **5 FTTS 11 Ton Payload Configurations Completed**
  - **GVW, range, fuel consumption, protection level, payload center of gravity, calculated**
- **Powered Trailer 11 Ton Payload Configuration Concept Completed**
- **Concepts submitted to Ft. Knox (MMBL) for inclusion in FCC2 CEP, June 01**
- **Concept animated June 01 and shown at Transportation School Regiment Week**
- **3 FTTS 12/16 Ton Payload Configurations Refined**
- **Manned & Robotic 2.5 Ton Payload Concepts completed**
- **Manned 7 Ton Payload Concept completed**
- **Powered Trailer 7 Ton Payload complete**
  - **GVW analysis complete**
- **Robotic 7 Ton Payload initiated**
- **FTTS Utility Vehicle**
- **1 FTTS UV Concept Complete**

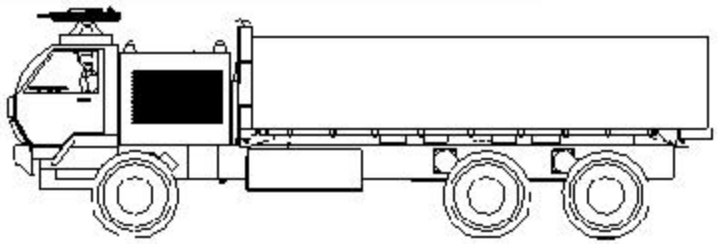
FTTS MSV 7 Ton Payload

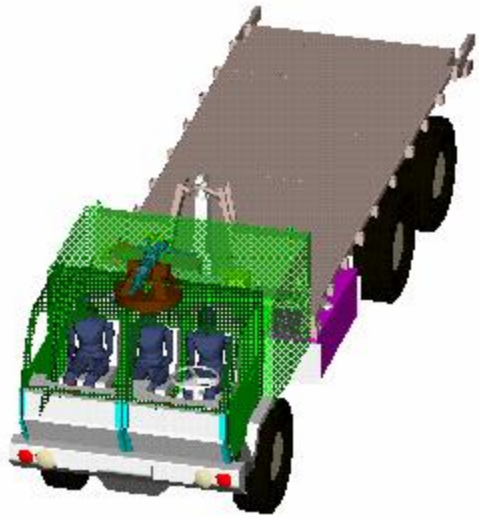


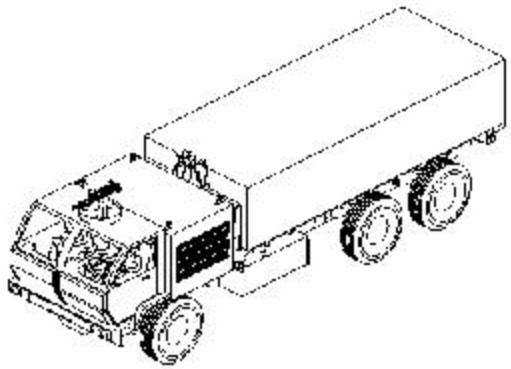


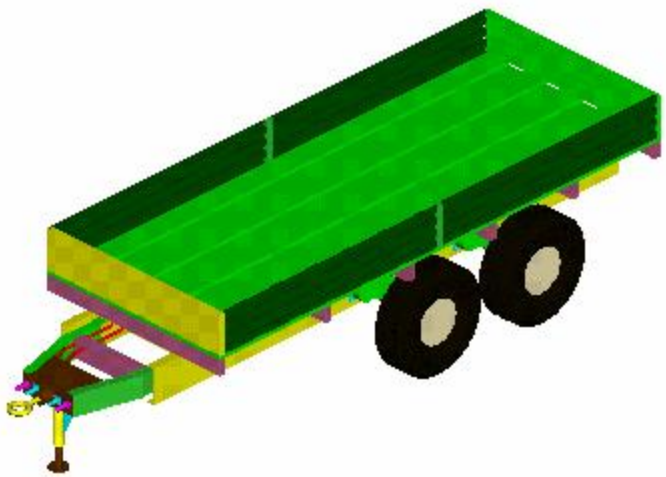
Concept w/ 4 ‘ ISO







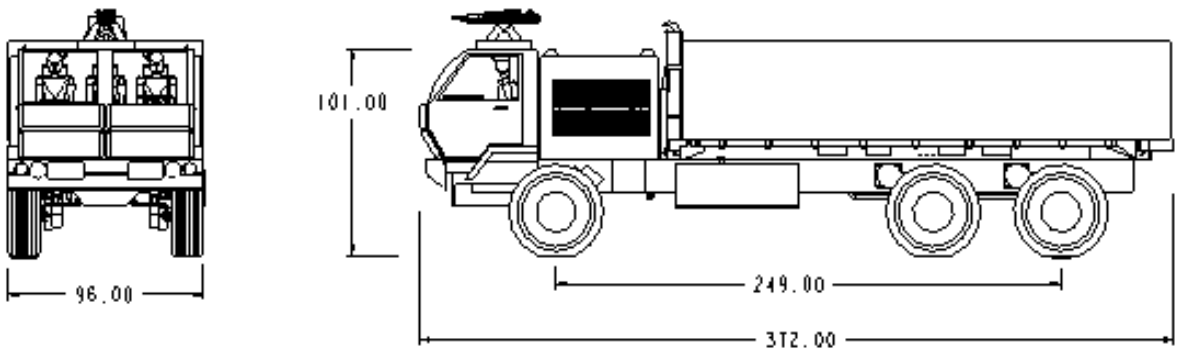




FTTS MSV 7 Ton Characteristics

Cab Seating: 3 Man
Axle Configuration: 6 X 6
Curb Weight: 23,827 lbs (10,808 kg)
Gross Vehicle Weight Rating (GVWR): 37,827 lbs (17,158 kg)
Length: 372” (9,450 mm)
Width: 96” (2,438 mm)
Height (cab): 102” (2,590 mm)
Wheel Base: 249” (6,325 mm)

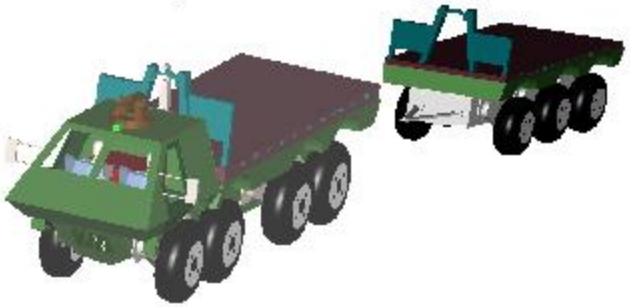
Maximum Speed: 65 mph (105 kph)
Tires: 395/85R20
Number of Tires: 6
Central Tire Inflation: Yes
Fuel Capacity: 120 gal (455 liter)
Cruising Range: TBD
Air transportability: C130, C141, C-17,C-5, CH-47 & CH-53
Engine: Cummins 400 hp Diesel
Transmission: Series Electric Drive
Suspension: Independent, trailing Arm



FTTS (11 Ton Payload)
Technology Range Overview

Concept 1: Emerging Technologies

Electronic Steering
Hybrid Electric Drive
Variable Height Suspension
Advanced Diesel Engine
Combat Hybrid Power System



Concept 2: Improved Conventional Technologies

Ackerman Steering
Advanced Transmission
Independent Suspension
Diesel Engine

Concept 3: Hybrid

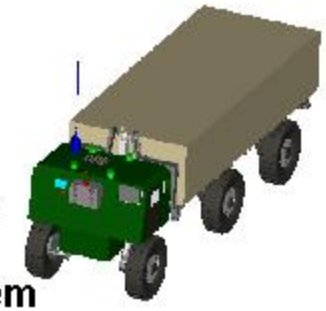
Ackerman & Electronic Steering
Electric Drive
Variable Height Suspension
Diesel Engine
Combat Hybrid Power System
(CHPS) Architecture

Concept 5: Sideloader

Concept 2 with Side Loader

Concept 4: Robotic Technologies

Semi-Autonomous
Hybrid Electric Drive
Variable Height Suspension
Advanced Diesel Engine
Combat Hybrid Power System



FTTS MSV Refined Concepts

MSV 2 Concept

Advanced Conventional

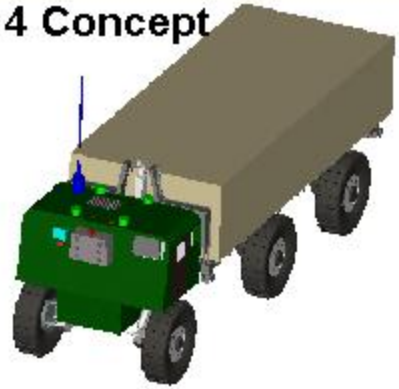
Cab: 2 Man
Axle Configuration: 8x8
Weight: 32,550 lbs (14,795 kg)
GVW: 59,540 lbs (27,063 kg)
Tires: 16R20
Engine: Cummins 600 hp Diesel
Transmission: Allison Automatic
Suspension: Arvin Meritor Independent

MSV 3 Concept

Hybrid Electric

Cab: 2 Man
Axle Configuration: 8x8
Weight: 26,315 lbs (11,960 kg)
GVW: 53,305 lbs (24,230 kg)
Tires: 16R20
Engine: MTU 199
Transmission: Series Electric
Suspension: Independent Trailing Arm

MSV 4 Concept

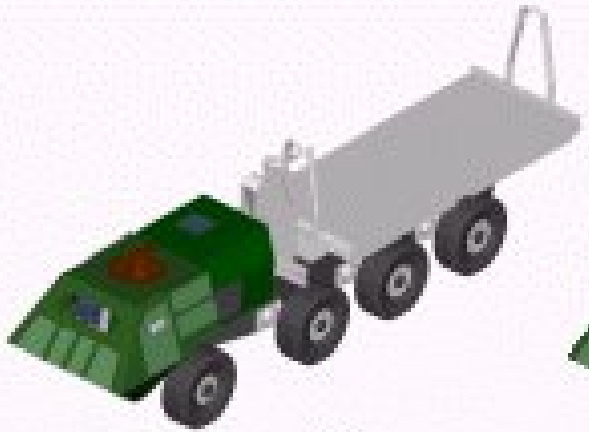


Robotic

Cab : 1 Man Backup
Axle Configuration: 6x6
Weight: 18,554 lbs (8,430 kg)
GVW: 44,804 lbs (20,365 kg)
Tires: 16R20
Engine: MTU 199
Transmission: Series electric
Suspension: Independent Trailing Arm

FTTS MSV Unit of Action Modules

TUAV Carrier



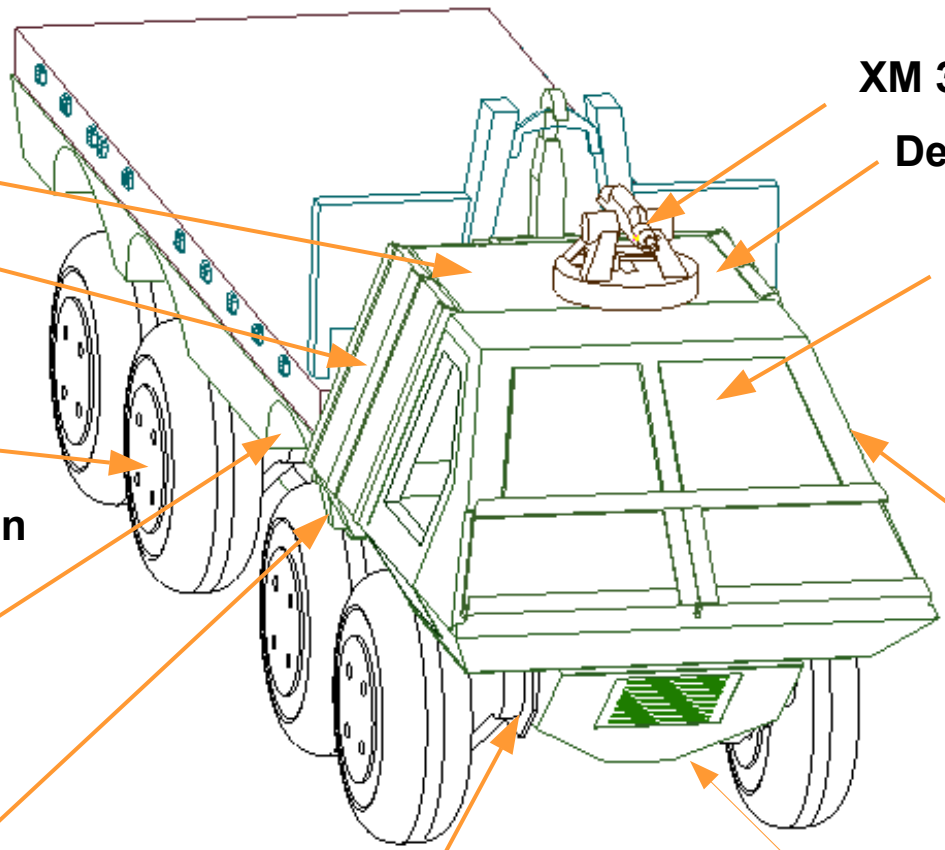
Cargo

Water Tanker

Fuel Tanker

Fuel Station

FTTS Survivability Technology



Armor
- Modular
- Hvy MG
- Frag

8 independently controlled in hub electric motors for graceful degradation

All electric mode
- limited silent operation
- no smoke plume

Redundant Power
- Diesel
- Limited battery

Variable Height Suspension
- Hull for reduced Signature

XM 307 (OCSW)

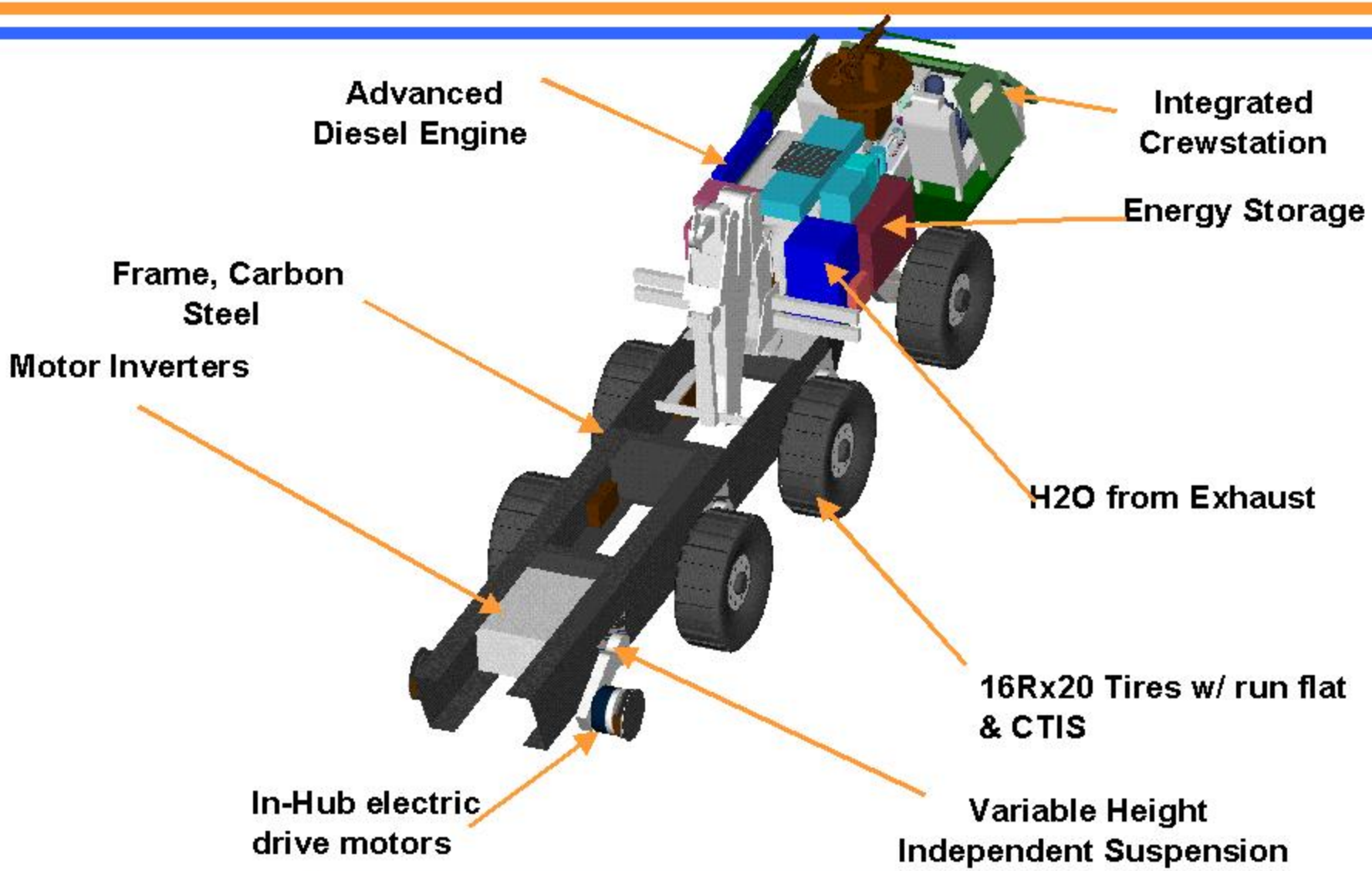
Defensive Aids Suite

Transparent Armor

NBC
- Carbon filter
- Overpressure

Mine Blast Protection
- Shaping - V
- Spall Liner
- Applique

FTTS MSV 3 Mobility Technologies

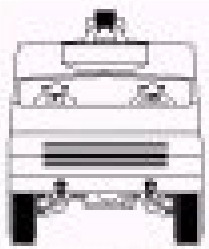


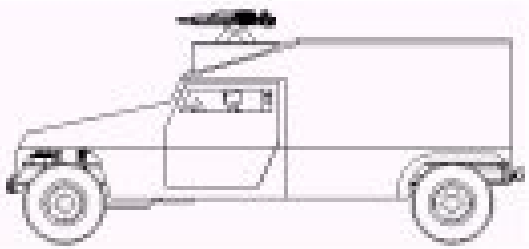
FTTS-Utility-Concept

FTTS-U-SPT

FTTS-U-AMB

FTTS-U-C2



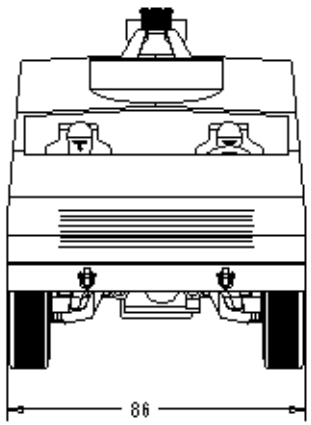


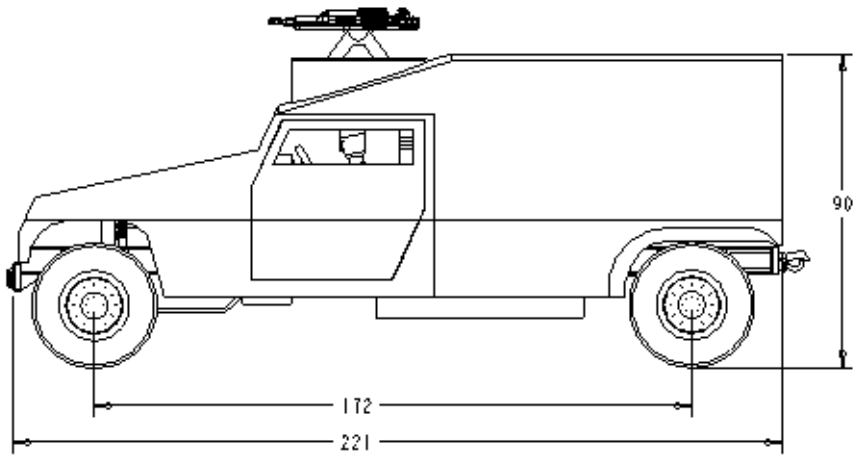
FTTS-U (Troop Carrier)

FTTS-U-SPT (Troop Carrier)

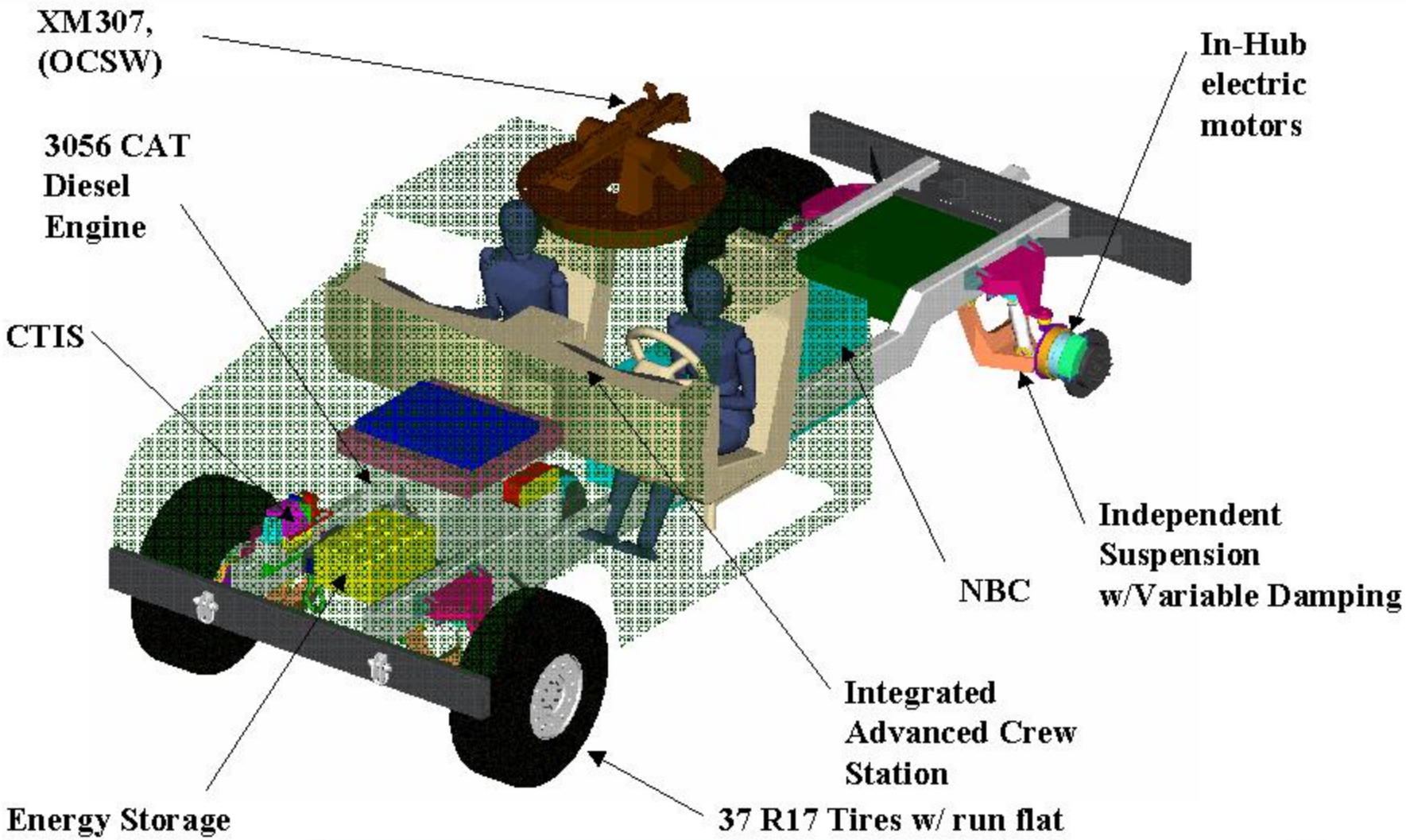
Cab Seating: 2 Man
Axle Configuration: 4 x 4
Curb Weight: 9,072 lbs (4,124 kg)
Gross Vehicle Weight (GVW):
14,772 lbs (6,715 kg)
Length: 221" (5,613 mm)
Width: 86" (2,184 mm)
Height: 90" (2,286 mm)
Track: 74" (1,880 mm)

Maximum Speed: 65 mph (105 Kph)
Tires: 37X12.50 R17 LT Wrangler MT/R
Central Tire Inflation: Yes
Fuel Capacity: 45 gal (170 liters)
Air Transportability: C130, C141, C17
Engine: 3056 CAT
Transmission: Electric Drive
Suspension: Independent w/Variable Damping

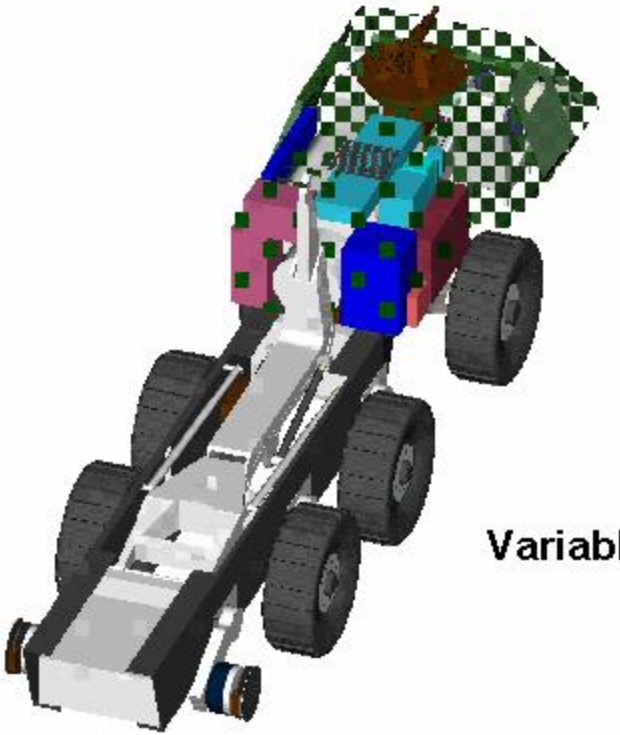




FTTS-U Technologies



FTTS & FCS HTI Potential



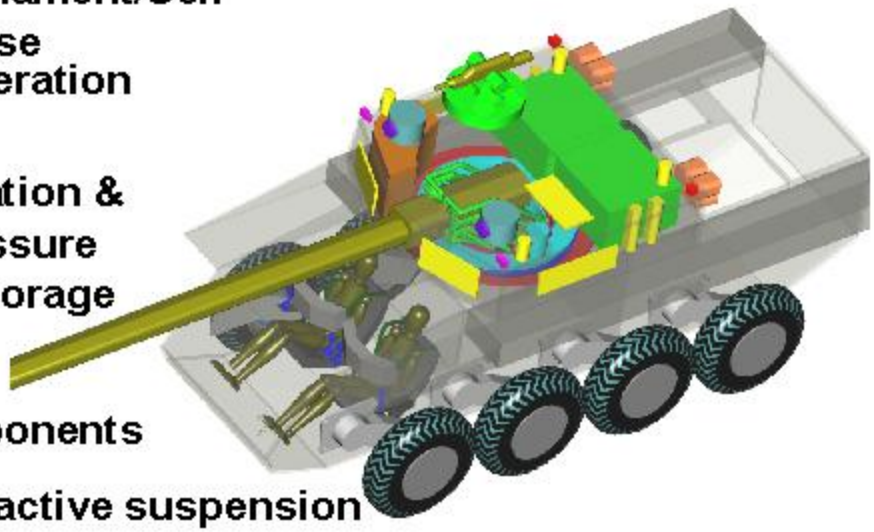
Integrated Crew Stations

Secondary Armament/Self Defense

Water Generation

NBC Filtration & Overpressure

Energy Storage



C4I Components

Variable height, semi-active suspension

Central Tire Inflation System

Electronic Architecture

Electric drive components

FTTS Analyses

FTTS Analyses Overview

Mobility

- Dynamic Analysis & Design System (DADs) - (TARDEC)
- ✓ NATO Reference Mobility Model (NRMM) - (TARDEC)

Operational

- ✓ VCAM (Vought Combined Arms Model) - (Lockheed Martin)
- Future Combat Command & Control (FCC2) CEP - (MMBL)

Cost

- Unit Production Cost Estimates - (TACOM)

Other

- ✓ Crew Station Human Factors/ Task Analysis - (ARL-HRED)
- Cargo Handling Equipment - (ARDEC Log R&D)

Mobility Analyses Performance Metrics

- **Vehicle Dynamics (DADS)**
  - **Max longitudinal and lateral slope**
  - **Max obstacle avoidance lane change speed**
  - **Max vertical step height (depth)**
  - **Ride quality at Driver's Station**
    - **Six Watt speeds vs. terrain RMS**
    - **Three g. peak load speeds vs. half round bump radii**
- **Vehicle Mobility (NRMM)**
  - **Percentage of terrain maneuverable and causes of NOGO conditions**
    - **ground clearance, tractive effort, trailer impacts**

Mobility Analyses Approach

- **Use M&S (DADS) to compare FTTS Concepts 1, 2 & 3 with baseline HEMTT 977**

- **Quantify mobility technology performance**
  - **Skid steer vs. Ackerman steer**
  - **Hub motor drive vs. standard power train drive**
  - **Active suspension vs. passive suspension**
  - **Combinations of these**
  - **Coupled trailer vs. autonomous detached follower**

Scenarios

- **Germany**
  - Dry
  - Wet
  - Wet/Slip
  - Snow
- **Middle East**
  - Dry
  - Sand

Terrains

- **Primary Roads**
  - Paved Roads
- **Trails**
  - Around trees
  - Around large obstacles
  - RMS up to 3.0
- **Secondary Roads**
  - Dirt and Gravel Roads
- **Cross-country**
  - Through trees
  - Over large obstacles
  - RMS up to 5.0
    - 3.0-5.0 (0.2% in Germany)
    - 3.0-5.0 (6.8% in Middle East)

FTTS MSV NRMM Conclusions

Ride quality results (6 Watt Speeds) over 3" RMS

- **ALL Active FTTS Variants modeled were able to obtain 6 Watt speeds**
- **in excess of 30 - 32mph (at the drivers station).**
- **FTTS Independent Suspension w/o active control: 24mph.**
- **The HEMTT reached 6 Watts at 16 mph over the same profile**

Independent Suspension

- **slight increase in Mission Rating Speeds (MRS)**
- **higher % no-goes**

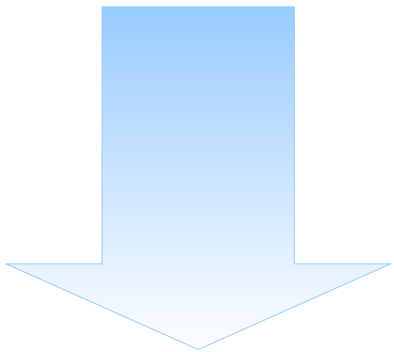
Active Suspension

- **significant increase in MRS**
- **lower % no-goes**

Ackerman Steering of FTTS MSV 2 better than FTTS MSV 3

FTTS MS Mobility Analyses End Use

FTTS mobility performance (cross country speeds, slope negotiation, vertical obstacle, ..) can be weighed against cost and FCS mobility parameters and op tempo support requirements



Impact the FTTS MNS/ORD/PD

e.g.
(FTTS shall negotiate a 32” vertical obstacle,...)
(Driver will absorb no more than 6 watts of energy traversing rough cross country terrain at 25 mph..)

Collaboration with the Army Research Laboratory

Crew Station Human Factors/ Task Analysis - (ARL-HRED)

Baseline

Interviewed current heavy tactical truck operators and maintainers to identify:

- Features to preserve, change, or add in future designs
- Capabilities needed to support FCS missions
- Design requirements for the modular truck concept

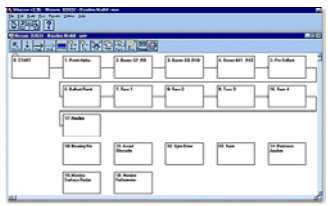
FY 02-03 - Model

- Assisting TARDEC in crew station design with human figure modeling and workload modeling support.
- Workload modeling based on the task analysis developed by HRED and on information gathered during the user interviews.

FY 03 Validate HFTT - Soldier Interface

- Design, conduct, and interpret studies to validate the workload modeling, possibly using TARDEC simulators or other surrogates for notional future truck systems.

IMPRINT Workload Models



Human Figure Models

FTTS Operational Modeling

- **Lockheed Martin's FCS Force Platforms, Technologies, Operations and Re-supply structure**
- **Blue Tactical Platforms**
  - HEMTT LHS Baseline (11T payload)
  - TARDEC FTTS MS Concepts 1,2 & 3 (10T payload)
  - No trailers
- **Vignette**
  - SW Asia
  - Secure airfield and resupply an FCS Battalion in the Forward Area over a 4-7 day period
  - Medium capable RED force
- **Metrics (MOE's)**
  - Quantity of supplies delivered to forward area
  - Time to deliver
  - FTTS and HEMTT vehicle losses

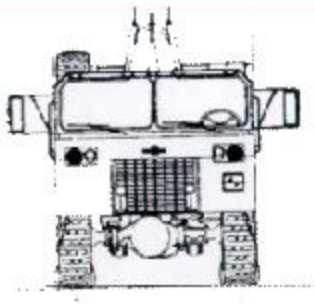
FTTS Operational Modeling Technology Evaluation

- **Assess Mobility Technology benefits**
  - Increased fuel economy (hybrid electric drive)
  - Increased cross country speed (independent suspension, ground clearance, power to wgt ratio, etc)
- **Assess Survivability benefits**
  - Fewer vehicle losses/more supplies delivered
    - Armor (HMG & Artillery Fragment protection)
    - Signature management (RF/thermal)
    - Fixed & Limited **APS (RPG only)**
- **Assess C4I benefits**
  - % time LOS communication possible (supply tempo)

FTTS Operational Modeling Results (Phase I)

- **Mobility**
  - Increased fuel economy of concepts 1 & 3 translates into a 25% increase in Class (fuel) supplied to FASC
  - Increased cross country speed had no effect due to route selection
  - Idle fuel consumption is a major contributor impact of total fuel consumption
- **Survivability**
  - FTTS Armor results in a 10% survivability increase (14 FTTS v. 15 HEMTT losses)
  - Limited APS results in a 36% survivability increase survivability (10 FTTS v. 15 HEMTT losses)
  - Self Defense weapon (OCSW) needs target acquisition tailored for hand held ambush threat to be effective
- **C4I**
  - Line of Sight Communication available 55% of the time

Representative VCAM Output
Day 3 Sufficiency



HEMTT 977

	On Hand	Required	Arrived	Suff/Short	% Suff
Total		177.23	140.87		79.48%
Fuel	-7.25	162.55	126.65	-35.90	77.91%
Water	1.22	11.58	12.22	0.64	105.53%
Ammo	0.00	0.00	0.00	0.00	0.00%
MRE	-0.40	3.10	3.10	0.00	100.00%

FTTS 1

			With APS		
	On Hand	Required	Arrived	Suff/Short	% Suff
Total		169.29	165.90		98.00%
Fuel	-4.80	160.10	151.70	-8.40	94.75%
Water	6.01	6.79	11.10	4.31	163.48%
Ammo	0.55	0.00	0.00	0.55	0.00%
			Without APS		
	On Hand	Required	Arrived	Suff/Short	% Suff
Total		181.99	153.20		84.18%
Fuel	-16.80	172.10	139.00	-33.10	80.77%
Water	6.01	6.79	11.10	4.31	163.48%
Ammo	0.55	0.00	0.00	0.55	0.00%
MRE	-0.40	3.10	3.10	0.00	100.00%

VCAM Phase I Operational Modeling Conclusions

- **Technology Specific**
  - FTTS delivers more supplies than the baseline in the scenario modeled due primarily to survivability technologies (armor & limited APS)
  - FTTS mobility improvement was not significant to supply performance due to terrain and routes selection
  - VCAM did not directly link C4I technology contributions to supply performance
- **Operational Insights**
  - Tactical Mistakes
    - Insufficient Escort On 1st Sortie Attempt
    - Did Not Provide A Sanitized Route (Sortie 2)
      - Free of Mines
      - Cleared of Booby Traps
  - Routing Near Any Population Center Should Be Avoided At All Costs
  - FASC Should Be Moved Preemptively As Time/Terrain Permit
  - Rear Area Security Remains a Key Issue
    - Static Preemptive UAV Orbits Over Built Up Areas Could Be Required

FTTS STO Path Forward

- **FTTS MSV**
  - **Execute Operational Modeling**
    - **VCAM Phase II**
  - **Incorporate initial mobility results into designs**
    - **Suspension/Steering refinement**
    - **Rerun DAD's & NRMM with updated designs**
  - **Link survivability technologies to FCS O&O**
- **FTTS UV**
  - **Complete technology assessments**
  - **Complete range of designs**
  - **Conduct requested analyses**
- **Current Fleet**
  - **Continue to support NAC & PEO in technology application**