C2M2L Proposers' Day

LTC Nathan Wiedenman, Program Manager
Tactical Technology Office

March 7, 2012

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Proposers' Day – Agenda

Introduction	LTC Nathan Wiedenman
DARPA and TTO Overview	
Adaptive Vehicle Make Overview	
C2M2L-2 Solicitation Details	
DARPA BAA Process	Mr. Chris Glista
General Q&A Session	LTC Nathan Wiedenman Mr. Chris Glista

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Proposers' Day – Admin

- DARPA BAA posted on FedBizOps:
  - https://www.fbo.gov/spg/oda/darpa/cmo/darpa-baa-12-30/listing.html
- Please ask questions via the Adobe Connect chat for answer during today's session
- Questions may be emailed to:
  - DARPA-BAA-12-30@darpa.mil
  - Questions and answers will be posted on FedBizOps BAA site and AVM website
- Program background and latest info available at DARPA AVM website:
  - http://www.darpa.mil/Our_Work/TTO/Programs/Adaptive_Vehicle_Make_(AVM).aspx
- Language in the solicitation supersedes anything said today

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DARPA TTO Overview

LTC Nathan Wiedenman, Program Manager
Tactical Technology Office

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Who is DARPA?

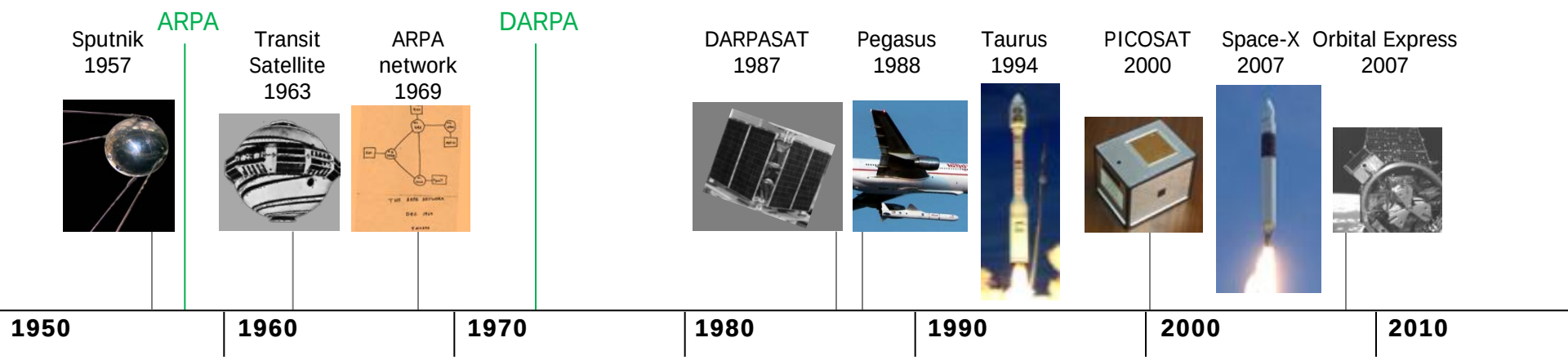
In 1958, Advanced Research Projects Agency
was created to pursue high-risk, high pay-off advanced technology.

In 1972, ARPA was renamed the
Defense Advanced Research Projects Agency.

DARPA breaks the gridlock of military competition for resources and recognition that hindered early U.S. space technology development.

DARPA's progressive, risk-tolerant leadership fostered:

- Cooperation among government agencies.
- Healthy competition in the marketplace.



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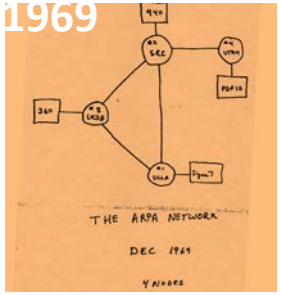
Unintended success of high pay-off investment

Original F1 engine too complicated for early launch requirements

Moon launch

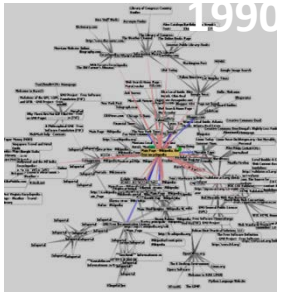
Four years later developed for heavy-lift manned missions



Original ARPAnet for sharing large volumes of lab data

The ‘internet’

Unplanned innovation turned it into the world wide web



Transit 2A satellite pioneered doppler navigation for specific military missions

GPS

Became global precision navigation technology for military and civilian use

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Organization

AEO
Adaptive Execution Office

- Agile Programs with Frequent Development Cycles
- Conduct Systematic Rigorous
- Assessments
- Explore New Contracting Approaches
- Develop Strong Relationships

DSO
Defense Sciences Office

- Physical Sciences
- Materials
- Mathematics
- Training & Human Effectiveness
- Biological Warfare Defense
- Biology

I2O
Information Innovation Office

- Global ISR
- Cyber
- Social Networks
- Computational Social Science
- Language Transparency
- Edge Finding
- Training/ Education

MTO
Microsystems Technology Office

- Basic Science Core
- Devices
- Integration
- Power
- Architectures
- Application

STO
Strategic Technology Office

- Comms & Networks
- Global Tactical ISR
- Energy
- Hybrid Warfare
- Extreme Environments

TTO
Tactical Technology Office

- Advanced Weapon Systems
- Advanced Platforms
- Advanced Space Systems

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Tactical Technology Office

Objective

To transform the future of warfighting through high risk, high payoff development of rapid, mobile, and responsive combat performance for advanced weapons, platforms, and space systems.

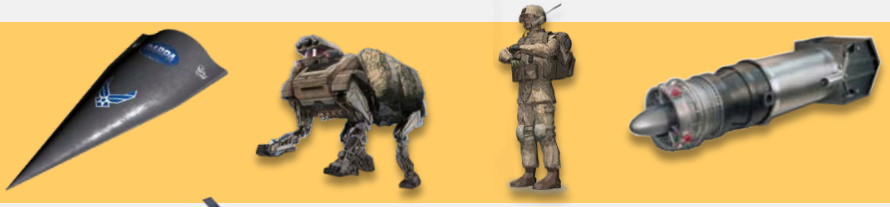
Goals

- Create highly capable systems that enable "order of magnitude" improvement in military capabilities in a rapidly changing technological landscape.
- Avoid technological surprise in areas of TTO emphasis.
- Develop tactical technologies and systems that enable "game changing" tactics, techniques, and procedures that address the entire spectrum of armed conflict.

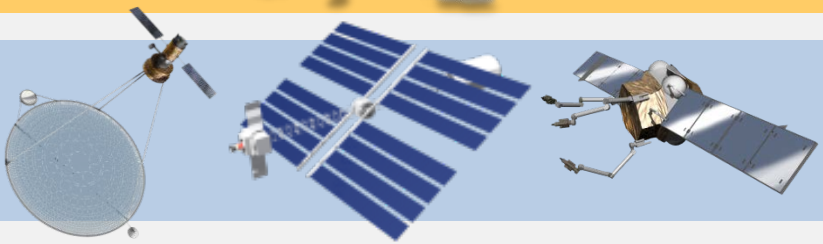
Focus areas

Advanced Weapon Systems
- Precision Strike
- Kinetic / Non-Kinetic Effects
- Responsive Engagement

Advanced Platforms
- Unmanned Systems
- X-Planes
- Manned Systems



Advanced Space Systems
- Resilience in Space Operations
- Assured Space Access
- Stability



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Adaptive Vehicle Make (AVM)

LTC Nathan Wiedenman, Program Manager
Tactical Technology Office

March 7, 2012

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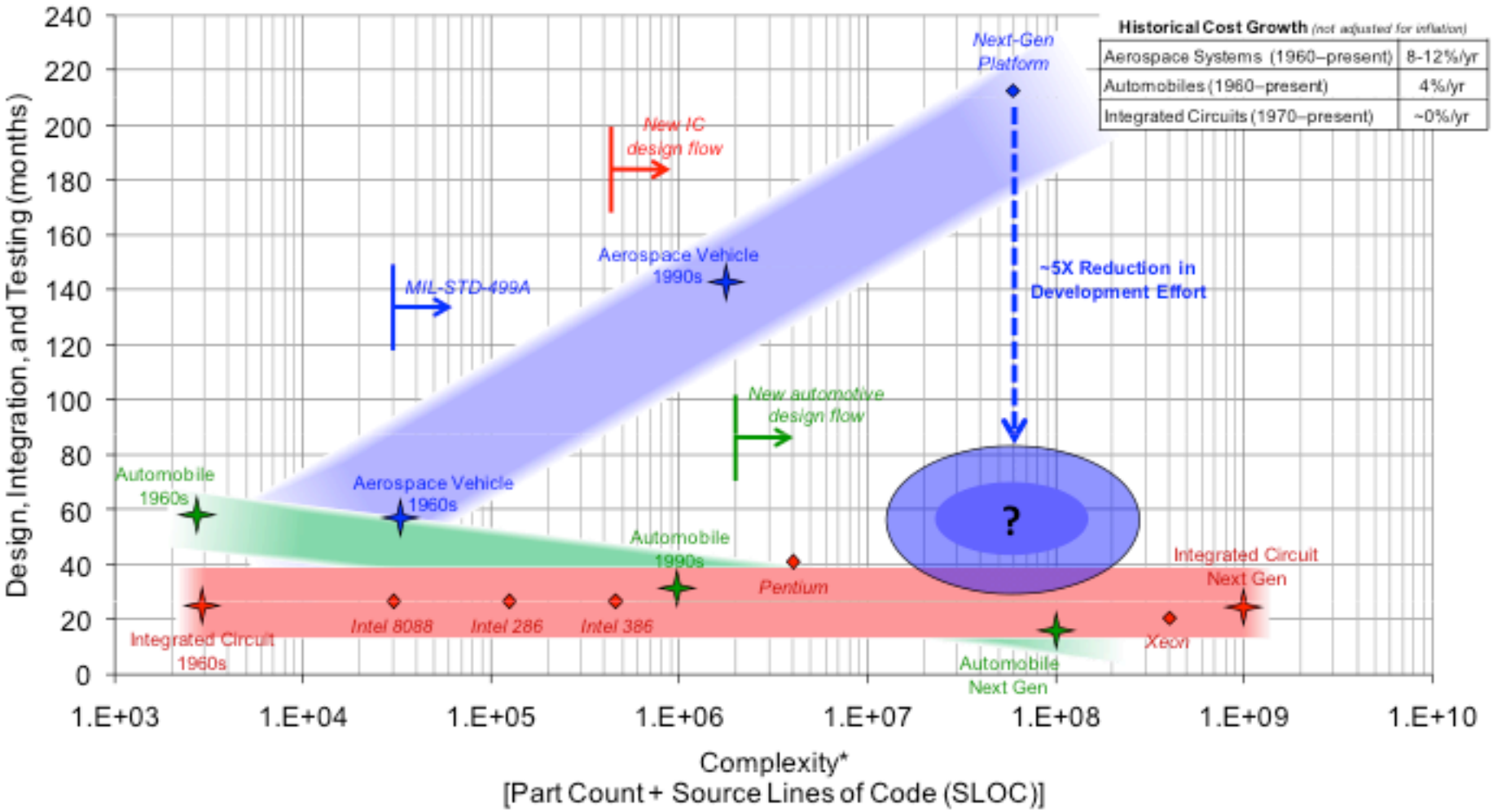
Historical schedule trends with complexity



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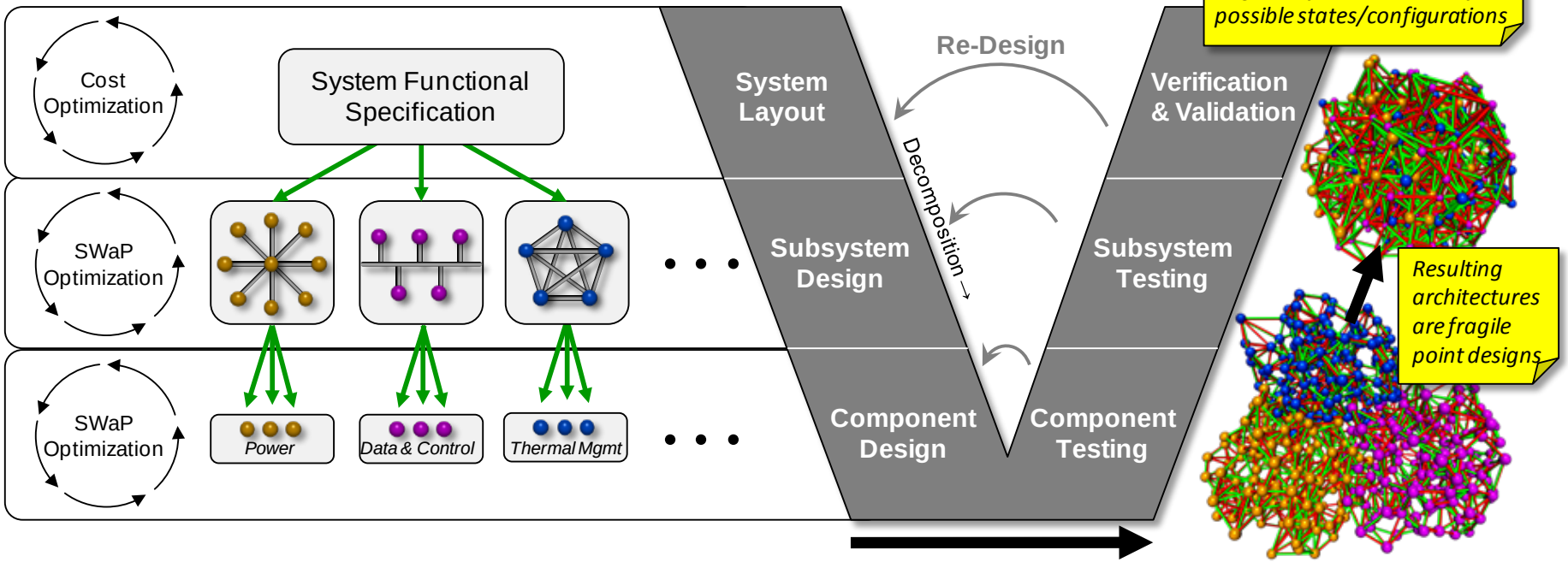
Status quo approach to managing complexity

MIL-STD-499A (1969) systems engineering process: as employed today

SWaP used as a proxy metric for cost, and dis-incentivizes abstraction in design

System decomposed based on arbitrary cleavage lines . . .

Conventional V&V techniques do not scale to highly complex or adaptable systems–with large or infinite numbers of possible states/configurations



Resulting architectures are fragile point designs

. . . and detailed design occurs within these functional stovepipes

Unmodeled and undesired interactions lead to emergent behaviors during integration

SWaP = Size, Weight, and Power
V&V = Verification & Validation

Desirable interactions (data, power, forces & torques)
Undesirable interactions (thermal, vibrations, EMI)

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Adaptive Vehicle Make Vision

Shorten development times for complex defense systems [META]

- Raise level of abstraction in design of cyber-electromechanical systems
- Enable correct-by-construction designs through model-based verification
- Compose designs from component model library that characterizes the “seams”
- Rapid requirements trade-offs; optimize for complexity & adaptability, not SWaP

Shift product value chain toward high-value design activities [iFAB]

- Bitstream-configurable foundry-like manufacturing capability for defense systems
- Rapid switch-over between designs with minimal learning curve
- “Mass customization” across product variants and families

Democratize design [FANG]

- Crowd-sourcing infrastructure to enable open-source development of cyber-electromechanical systems [vehicleforge.mil]
- Prize-based Adaptive Make Challenges culminating in an Infantry Fighting Vehicle for testing alongside a program of record [FANG]
- Motivate a new generation of designers and manufacturing innovators [MENTOR]

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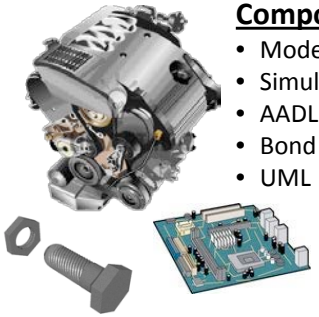
META Model-Based Design Tool Chain

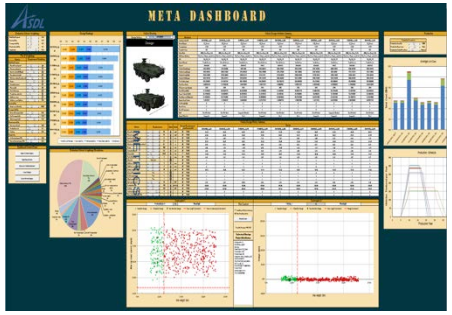


Component Models

- Modelica
- Simulink
- AADL
- Bond Graphs
- UML

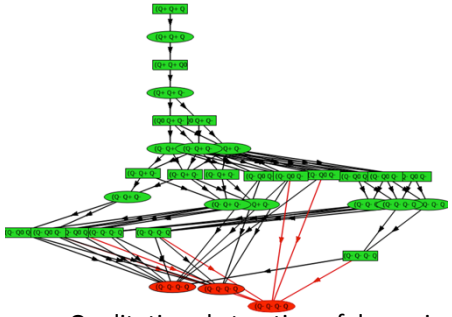
Semantic Integration

Static Trade Space Exploration



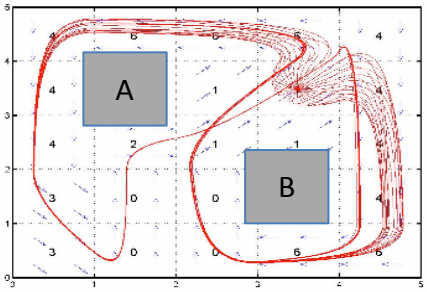
- Static constraint application
- Manufacturability constraints
- Structural complexity metrics
- Info entropy complexity metrics
- Identify Pareto-dominant designs
- 10^10 → 10^5 designs

Qualitative Reasoning



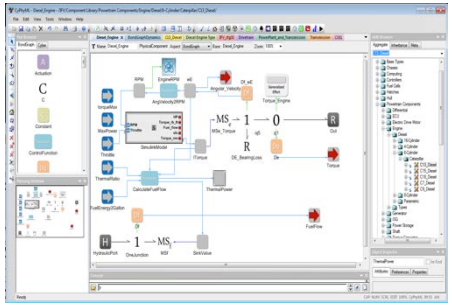
- Qualitative abstraction of dynamics
- Computationally inexpensive
- Quickly eliminate undesirable designs
- State space reachability analysis
- 10^5 → 10^3 designs

Relational Abstraction



- Relational abstraction of dynamics
- Discretization of continuous state space
- Enables formal model checking
- State-space reachability analysis
- 10^3 → 10^2 designs

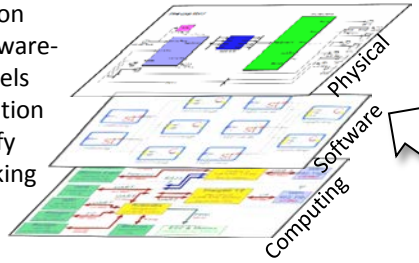
Ordinary Differential Equation Models



- Models are fully composable
- Simulation trace sampling to verify correctness probability
- Application of probabilistic model checking under investigation
- 10^2 → 10 designs

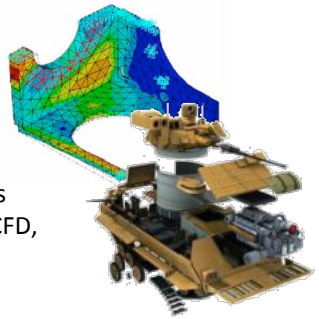
Embedded Software Synthesis

- Auto code generation
- Generation of hardware-specific timing models
- Monte Carlo simulation sampling to co-verify
- Hybrid model checking under investigation



CAD & Partial Differential Equation Models

- Generate composed CAD geometry for iFAB
- Generate structured & unstructured grids
- Provide constraints and input data to PDE solvers
- Couple to existing FEA, CFD, EMI, & blast codes
- 10 → 1 design



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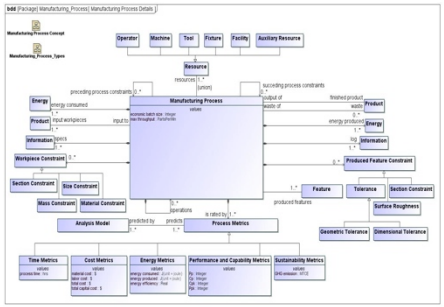
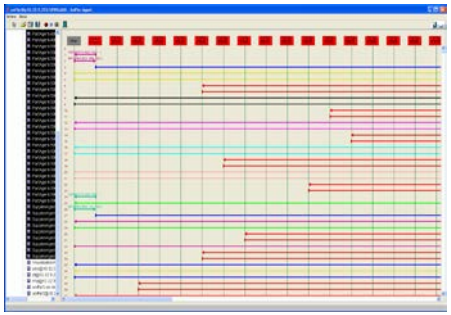
iFAB Distributed, Digitally Programmable Foundry

Manufacturing Constraint Feedback to META Design

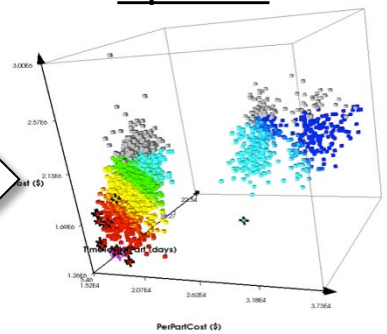
Static Process Mapping



Sequencing



Foundry Trade Space Exploration

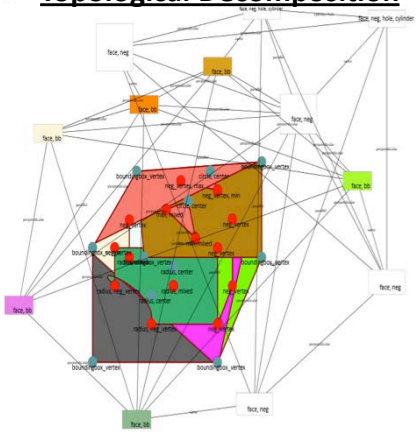


META Design

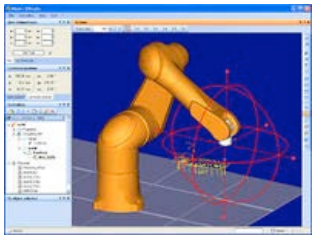
Constraints from Selected Configuration

Manufacturing Process Model Library & iFAB Foundry Data Bus

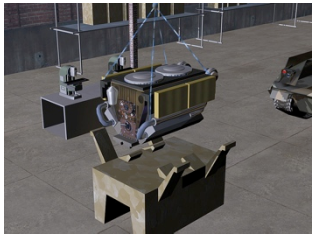
Topological Decomposition



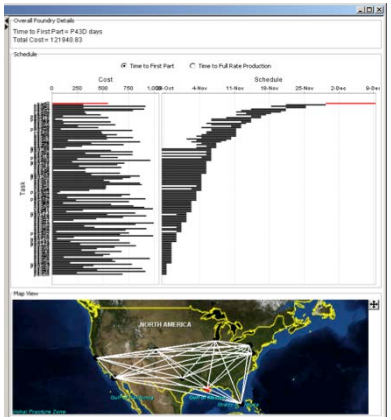
Kinematic Machine Mapping



Kinematic Assembly Mapping



Scheduling



Manufacturability Analysis Feedback to META Design

CNC Instructions

Human Instructions

Rock Island Arsenal Bldg 299 Final Ass'y

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Fast, Adaptable, Next-Generation Ground Vehicle (FANG)

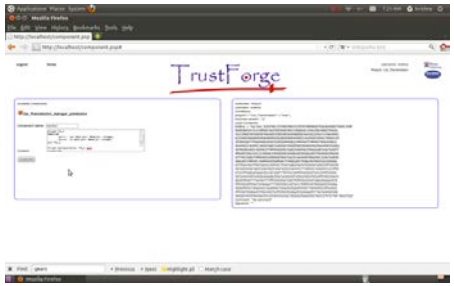
Communities

- Traditional industry
- Commercial entrants
- Component suppliers
- Small business networks
- Individual designers
- Hidden 5σ savants

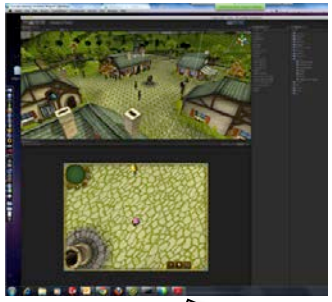
Incentives

- $1M drivetrain prize
- $1M chassis prize
- $2M full vehicle prize
- USMC ACV commitment for LRIP/FRP based on OT&E
- Potential for additional 3 x $50M "acquisition" prizes

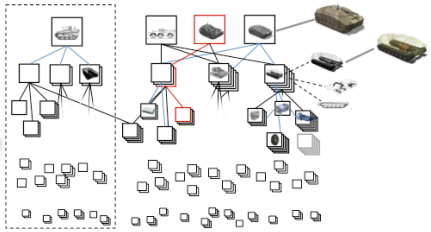
Reputation-Based Credentialing



Virtual World Interface

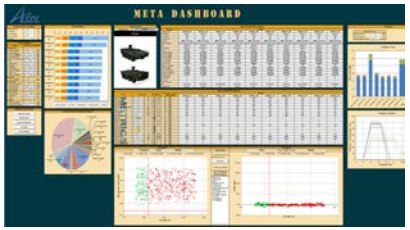


Branching Off Existing Designs

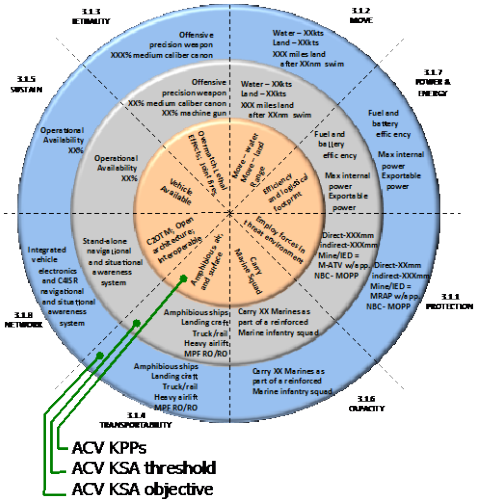


vehicleforge.mil

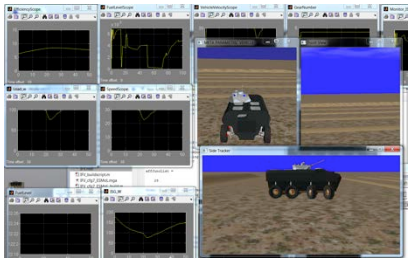
Design Trade Space Exploration



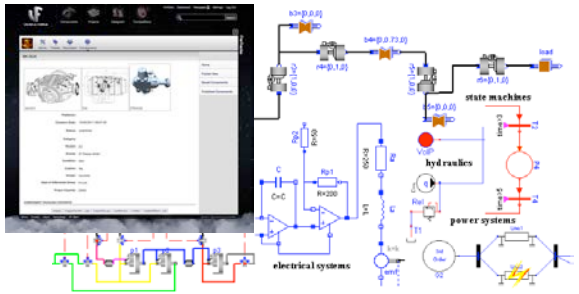
Marine ACV Program Requirements



Context Model Library



Component Model Library



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FANG Prize Challenges

Mobility/Drivetrain Challenge

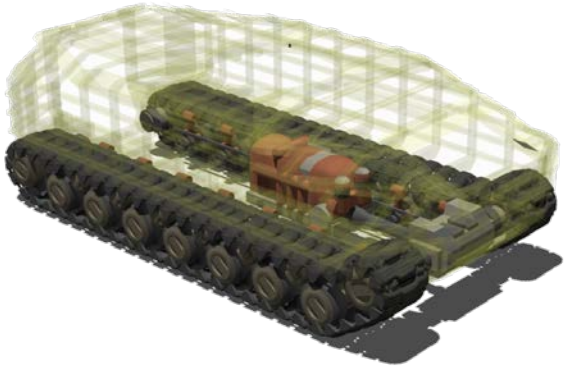
SCOPE
- Vehicle drivetrain to meet IFV speed, efficiency, terrain, reliability objective
- Available model library to include:
  - Hybrid-electric systems
  - Novel ground interfaces

PARTICIPANT POOL
- Global

INCENTIVE
- Prize $1M for winning design
- Winner(s) judged based on multi-objective weighting function

DESIGN AGGREGATION
- Use of META metalanguage required
- Use of vehicleforge.mil optional

BUILD APPROACH
- iFAB foundry build for top design(s)



Chassis/Integrated Survivability Challenge

SCOPE
- Chassis and armor design to meet principal IFV-like survivability objectives
- Available model library to include:
  - Advanced armor concepts
  - Novel configs (monocoque, v-hulls)

PARTICIPANT POOL
- Global

INCENTIVE
- Prize $1M for winning design
- Winner(s) judged based on multi-objective weighting function

DESIGN AGGREGATION
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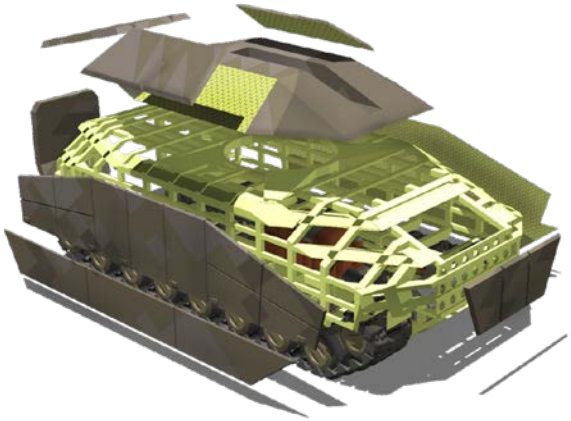

Total Platform Challenge

SCOPE
- Complete IFV based on core USMC objectives and distilled requirements

PARTICIPANT POOL
- Global

INCENTIVE
- Prize $2M
- Winner judged based on satisfaction of constraints and multi-attribute preference function (i.e., entirely objective approach)

DESIGN AGGREGATION
- Use of META metalanguage required
- Use of vehicleforge.mil optional

BUILD APPROACH
- iFAB foundry build for top design(s)

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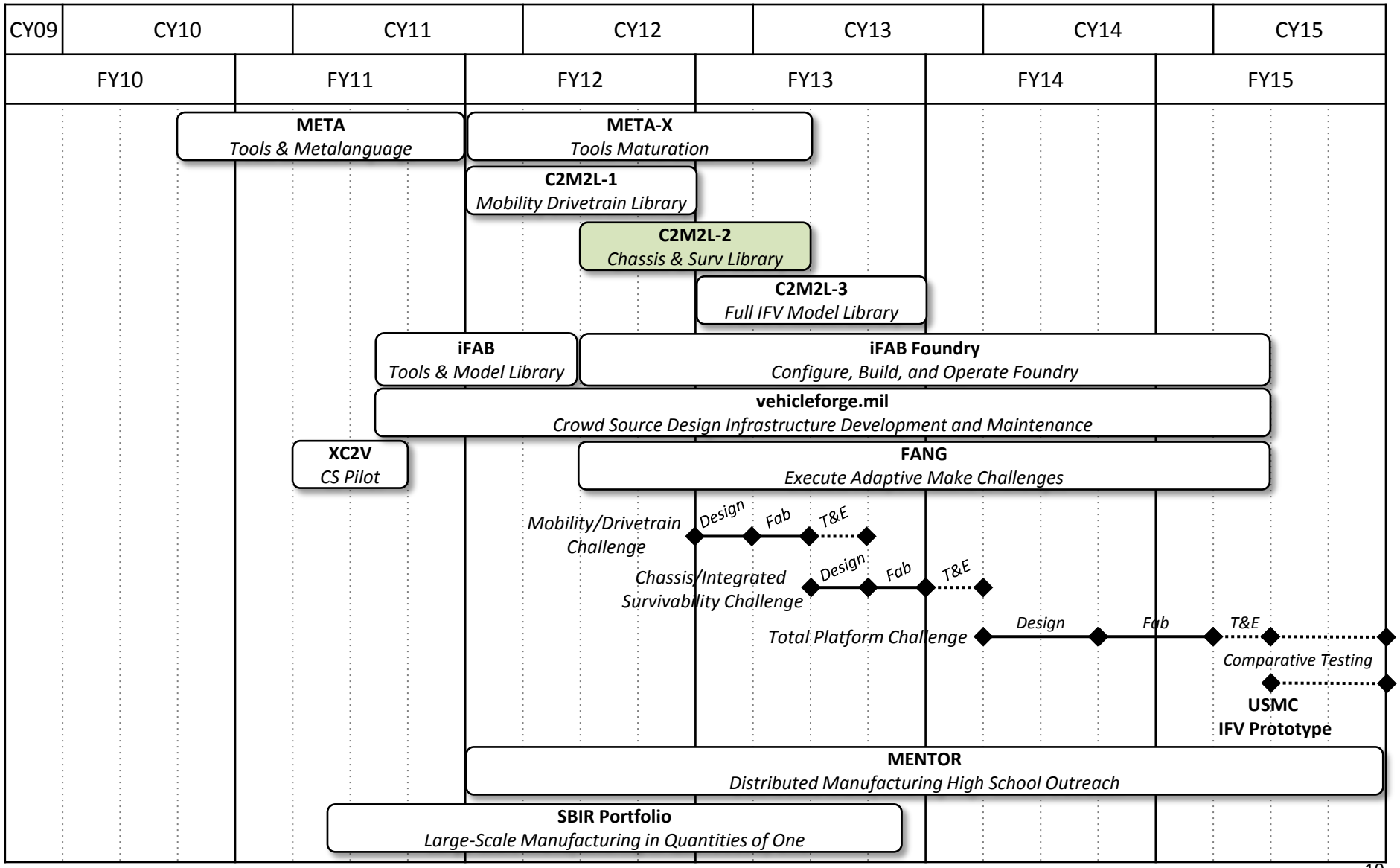
AVM Portfolio Schedule



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Adaptive Vehicle Make Performer Community

vehicleforge.mil

GE Research/MIT	Custom collaboration site linking to MIT DOME model repository and social network challenge platform
Georgia Tech GTRI	Collaboration site based on open source distributed version control system; teamed with RedHat
Vanderbilt University	Collaboration site derived from KForge software and information forge site platform
Univ of Pennsylvania	Credentialing users and contributions utilizing reputation-based quantitative trust management
Electrotank	Visual design engine to enhance open source collaboration for design of cyber-physical systems on vehiicleforge.mil

C2M2L-1

Boeing / L-3	Manufacturing model library to provide steps, processes, machines and tools
Boston Fusion	Two-sided network approach to elicit self sustaining model generation and maintenance
CSIR	High resolution 3-dimensional profiles of rough terrains and convert to usable context models
Intentional Software	Specific languages/representations generated by other C2M2L-1 performers to the existing iFAB AVM Workbench; Curation services
Penn State Univ – ARL	Complete manufacturing models for welding, casting, forging, handling, inspection and wire harnesses
Ricardo Inc.	Component model libraries through requirements definition to simulate system selection
Vanderbilt University	Semantic support of a C2M2L-1 technical area models by the semantic backplane infrastructure
XSB	iCOTS scalable system to transform data from web-based sources to translate to component models

iFAB

Boeing/General Motors	Manufacturing capability and process model library with describing foundry resources & human actors
Carnegie Mellon Univ	Distributed agents/process model approach for two-way interface between CAD and CAM systems
Intentional Software	Formal "meta meta" language to enable multi-domain co-design of artifact & manufacturing
Penn State ARL	Agent-based foundry configuration and trade space visualization
Univ of Delaware	Developing compositional cross-domain tool-chain analysis templates for composites manufacturing
Xerox PARC	Rapid construction and search of feasible manufacturability spaces and metrics for such spaces
Georgia Tech GTRC	Creating adaptable software libraries of manufacturing processes pertinent to the fabrication of electro-mechanical components and/or assemblies

META-X

Dassault Systèmes	Extension of commercial CATIA/DELMIA PLM suite to enable probabilistic certification of correctness
Vanderbilt University	Open source implementation of complete META tool chain for compositional design of complex cyber-physical systems
PARC/CyDesign	Web-based, mass-market tool chain for correct-by-construction design of complex cyber-physical systems

MENTOR

AST2	Distributed design infrastructure with holographic interface, network of FabLab-type printing facilities
Georgia Tech/Dassault	Sophisticated distributed manufacturing front-end based on Dassault CAD, low-cost 3D printer network
O'Reilly Media	Novel approach to assembly of complex 3D shapes from 2D media, use of MAKE Magazine, Maker Faires

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AVM solicitation and execution philosophy

- Disaggregated technical content across multiple BAAs and technical areas
  - Selection of best-of-class performers in each tech area; teaming not required
  - Enable participation by small/non-traditional businesses, academia, non-profits
- International proposers welcomed and encouraged
  - DARPA will work closely with performers to ameliorate any ITAR issues
- Program-wide PI meetings
  - Held bi-monthly in a major U.S. metropolitan area with easy access by air
  - Principal forum for delivery of performer results
  - May be made open to industry/public
- IP rights
  - Unlimited Rights to the Government, except on Commercial Items
  - Will require substantiation of commercial availability of Commercial Items
  - Inclusion of heritage intellectual property must be done with care!
  - DARPA will promulgate all deliverables under an open source license
- Pre-publication review
  - No pre-publication review on university work performed on campus

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C2M2L-2

LTC Nathan Wiedenman, Program Manager
Tactical Technology Office

March 7, 2012

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C2M2L-2

- Domain-specific models needed to enable the design, verification, and fabrication of the chassis and survivability subsystems of the FANG Infantry Fighting Vehicle (IFV)
- Three C2M2L-2 Technical Areas:
  - TA 1 – Component Model Library
  - TA 2 – Context Model Library
  - TA 3 – Manufacturing Model Library
- Prior C2M2L-1 solicitation/on-going effort addresses the drivetrain and mobility subsystems of the FANG IFV
- A subsequent C2M2L solicitation is anticipated to address the remaining subsystem domains needed

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Program scope and structure

- Approximately $15.0 million available funding
- Multiple awards anticipated
- Period of performance – 12 months from the date of award
- Offerors may submit proposals to one, several, or all of the technical areas
- Offerors encouraged to submit separate proposals for each one or include as priced options core proposal
- No a priori constraints on:
  - Number of performers per tech area
  - Distribution of funds per tech area or performer

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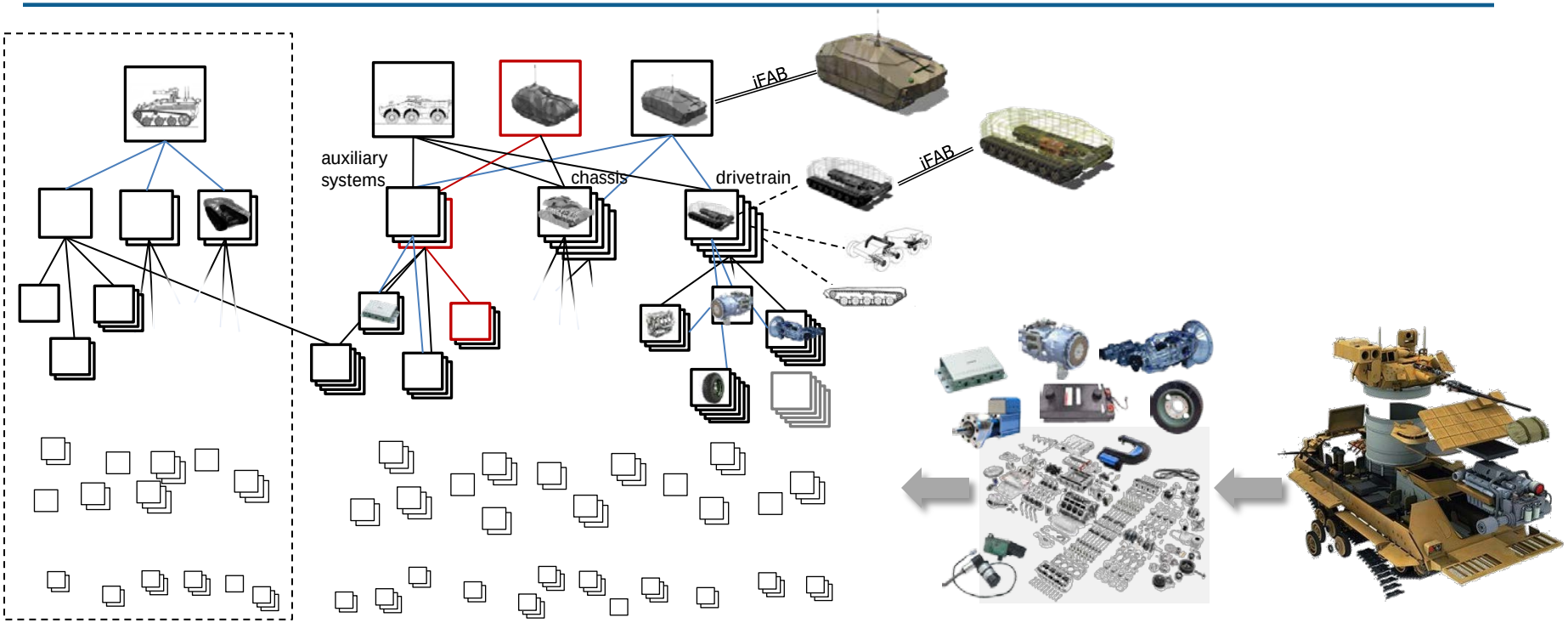
Component model library scope



Components – both hardware and software

	Unique Parts (upper limit)	Total Parts (lower limit)	Library Parts (unique x 5)
Drivetrain	3,000	8,000	15,000
Chassis/Armor	5,000	12,000	25,000
Other	7,500	10,000	37,500
Total	15,500	30,000	72,500

Note: Estimates are at the numbered part level. Cables and circuit boards counted as single part. Excludes variable mission equipment, software.

Elements of a Component Model

Physical attributes • size and shape • mass properties • elastodynamics	Undesirable emissions • thermal • electro-magnetic • vibrational
Interfaces • data • power • mechanical	Performance • blackbox model • failure modes

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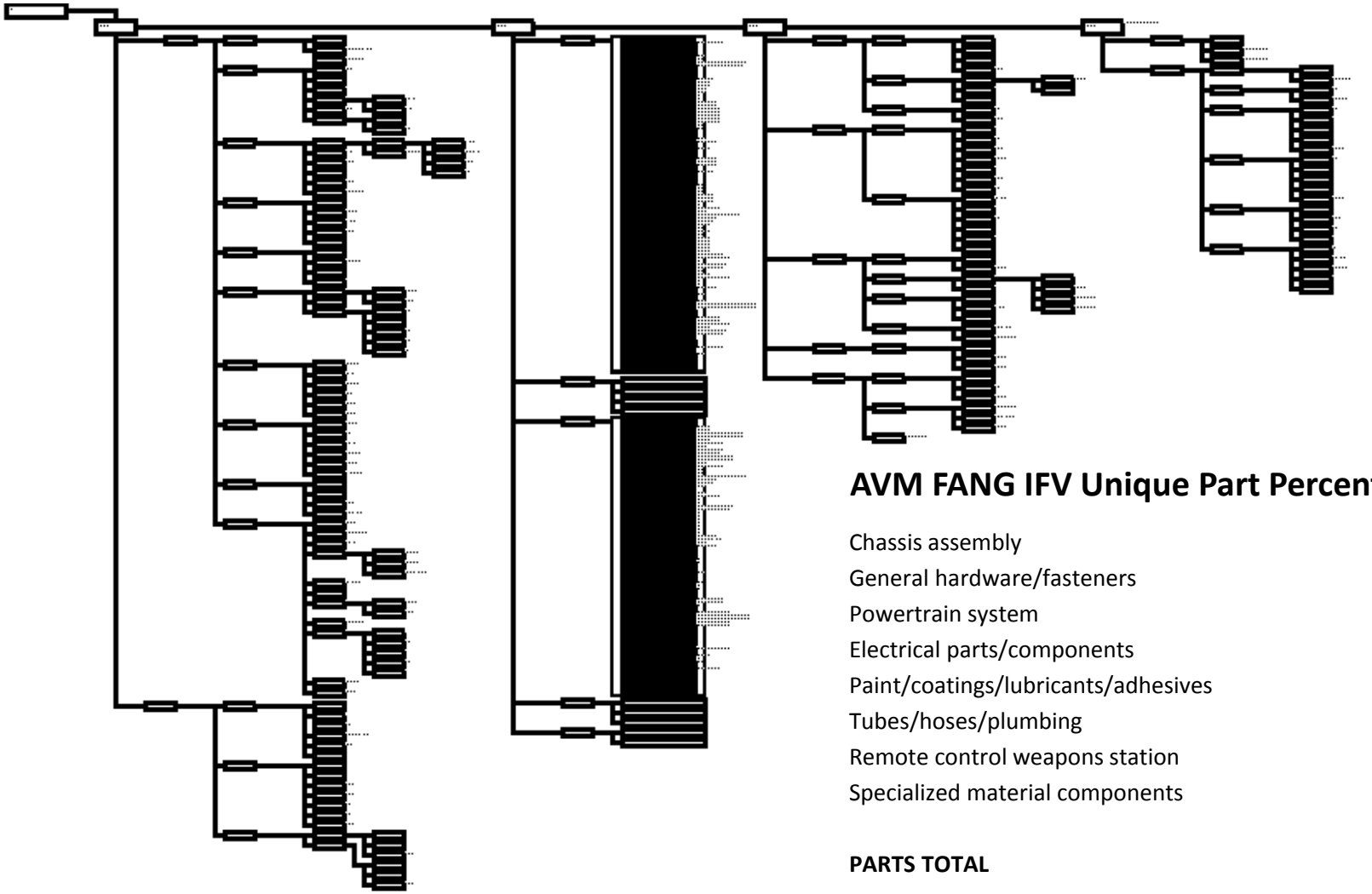
Notional FANG vehicle component breakdown

Drivetrain

Chassis

Auxiliary

Weapons Station



AVM FANG IFV Unique Part Percentages

Chassis assembly	30%
General hardware/fasteners	23%
Powertrain system	19%
Electrical parts/components	12%
Paint/coatings/lubricants/adhesives	8%
Tubes/hoses/plumbing	3%
Remote control weapons station	4%
Specialized material components	1%
PARTS TOTAL	**~15,550**

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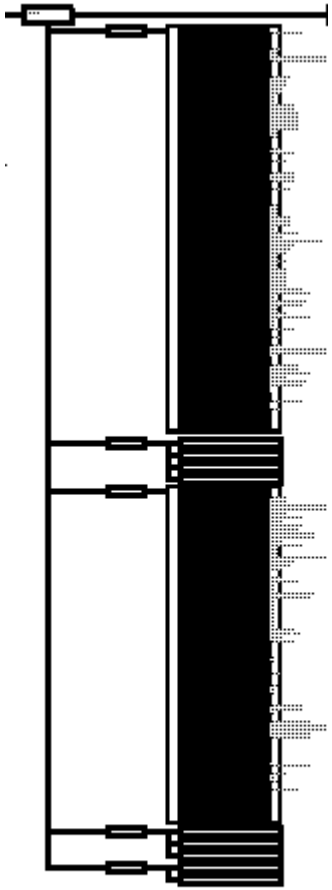
Notional chassis/survivability subsystems

Chassis



- Hull
- Chassis
- Frame/panels
- Monocoque structure
- Modular armor panels
- Mountings/inserts
- Routing for hydraulics, electrical, airflow and filtration
- Subsystem volumetric compartment placeholders
- Crew compartment
- Crew accommodations
  - Seats
  - Restraints
- Subsystem mounting placeholders
- Hull penetrations for drivetrain/grills/hatches
- Hatches
- Blow-out panels

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C2M2L-2 TA1 – Component Model Library

- Component models relevant to the chassis/survivability subsystems of an amphibious infantry fighting vehicle.
- Modalities of interaction between components
  - Well-defined formal semantics
  - Often serve as context models for other components
- Optimization - cost of characterization vs. level of accuracy
- Expected if applicable:
  - Relational information
  - Composability
  - Aggregations
  - Utility services
  - Validation/verification
- Supplied in a suitable domain-specific or multi-domain modeling language

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C2M2L-2 TA1 – Key Elements

Key Element	Sub Element
Physical Attributes	• Outer mold-line • Mass properties • Elastodynamic properties
Component States	• Nominal modes and states • Degraded modes and states • Failure modes and states
Desirable interactions	• Mechanical interface & structural load-bearing characteristics • Data interface • Power interface
Undesirable interactions	• Thermal source and sink characteristics • Electromagnetic source and sink characteristics • Vibrational source and sink characteristics, spurious friction and stresses • Acoustic source characteristics • Effect of moisture, humidity, corrosives, and particulates
Performance	• Black-box performance model • Performance limits • Failure modes/states impact on performance and other model parameters
Uncertainties	• Error bounds on each model data element • Probability distribution of model data uncertainties • Uncertainty in shape of probability distributions • Differentiation between proved and posited component properties

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C2M2L-2 TA1 – Key Elements (cont.)

Key Element	Sub Element
Static and dynamic relationships	• To “peer” components (e.g., dependencies) • To self at other levels of abstraction • To context models • To manufacturing models • Assumptions about other components or contexts
Model composition rules	• Design patterns/templates • Assumptions/guarantees • Contracts
Services	• Version control • Indexing and search • Model translation
Supporting model data	• Model data sources • V&V methods, history, and results

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C2M2L-2 TA2 – Context Model Library

- Context models – environment within which a system, subsystem, or component must function
- Context of interest (not limited to):
  - Terrain (land and water) influence of structural/material performance
  - Atmosphere
  - Thermal
  - Moisture
  - Corrosion
  - Foreign particulates models
  - Survivability performance of chassis/modular armor as exposed to direct fire, indirect fire, and mine/IED threats
- Survivability models
  - Must instantiate context models that represent survivability events and enable characterization of system responses
  - AVM/C2M2L-2 is to remain entirely open and unclassified: models that represent blast and ballistic threat characteristics are not classified unless explicitly tied to evaluation of a specific armor or survivability package
- Should specify interaction between the environment and hull/survivability subsystem elements
- Applied across the different levels of abstraction
  - At component level - contexts provided by other components
  - At overall system level - mission environment

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C2M2L-2 TA3 – Manufacturing Model Library

- Manufacturing models for fabrication of the chassis/survivability subsystems of an IFV
- The manufacturing model library will need to include:
  - Material removal – grinding, machining
  - Forming and shaping - swaging (for example preparing hydraulic line fittings)
  - Soft hose forming (for example for custom liquid cooling routing)
  - Machine assembly - hard automation, positioning/part presentation, aligning, sorting, transport, dithering for insertion
  - Fixturing – e.g. welding large hull components as well as small elements, subsystem assembly
  - Permanent joining and assembly - welding (multiple types), pressing, crimping
  - Human operations – assembly, disassembly, inspection
  - Finishes - acid washing, electroplating, painting (CARC and other)
  - Inspection and metrology - dynamic testing, polishing
  - Pressure testing
  - Electrical and wiring – routings, brackets and other methods of securing
- Range of processes should include custom and COTS parts from TA1 component models
- Manufacturing model characterizes a particular foundry element:
  - Capabilities
  - Costs
  - Constraints

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C2M2L-2 TA3 – Key Elements

Key Element	Sub Element
Domain of applicability	• Assembly • Mechanical • Electrical • Electronic • Structural • Hydraulic • Pneumatic • Metrology • QA/QC
Range of applicability	• Tolerances • Geometries • Material types
Speed	• Speed • Product throughput • Reconfiguration time
Cost	• Consumables • Operation
Quality	• Defect rate

Key Element	Sub Element
Uncertainties	• Error bounds on each model data element • Probability distribution of model data uncertainties • Uncertainty in shape of probability distributions
Relational Information	• To product components • To other manufacturing elements/processes (e.g., dependencies)
Services	• Version control • Indexing and search • Model translation
Cost	• Consumables • Operation
Quality	• Defect rate

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Proposal details

- Proposals intended to be simple, flexible, but technically specific
  - Single integrated technical and cost volume
  - No page limits, but be concise
  - FAR (CPNF, CPFF, FFP-Milestone Payable) and OTA contract vehicles acceptable
  - DARPA will work with international proposers on applicability of certain clauses
- Proposal evaluation criteria
  - Technical Merit
  - Potential Contribution and Relevance to the DARPA Mission
  - Potential to Accomplish Technology Transition
  - Realism of Proposed Costs
- Opportunity for question and answer during proposal preparation period
  - Questions directed to the respective BAA mailbox: DARPA-BAA-12-30@darpa.mil
  - Questions of general interest will be answered via a FedBizOpps posting
  - No one-on-one discussions will be held with the Program Office

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Proposal timeline

- BAA released— 24 February 2012
- Proposers' Day—7 March 2012
- BAA questions deadline—10 April 2012
- BAA question responses posted—13 April 2012
- Initial round of proposals due—24 April 2012
- Selection notification sent— early May 2012 (est.)
- Contract award—early August 2012 (est.)

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Proposers' Day – Agenda

Introduction	LTC Nathan Wiedenman
DARPA and TTO Overview	
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BAA Process

DARPA Contracts Management Office

C2M2L-2 Proposers' Day

March 7, 2012

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BAA Specifics

- BAA and any amendments posted in FEDBIZOPPS
- BAA covers all info needed to propose
- TIME PERIOD – BAA is open until August 24, 2012
- **Initial Selection Round Proposals are due April 24, 2011**
- Instructions are detailed in the BAA (**Follow closely**)
- **Following the proposal instructions assists the evaluation team to clearly understand what is being proposed and supports a timely negotiation.**
- **ALL** questions to DARPA-BAA-12-30@darpa.mil

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BAA Background

- Federal Acquisition Regulation (FAR) Part 35

  http://farsite.hill.af.mil

- "A general announcement of an agency's research interest including criteria for selecting proposals of all offerors capable of satisfying the Government's needs."
- For the acquisition of basic and applied research <u>not related to the development of a specific system or hardware procurement.</u>

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BAA Background (cont.)

- Used when proposals with varying technical and scientific approaches can be expected
- Proposals need not be evaluated against one another since they are not submitted in accordance with a common work statement.
- Primary basis for selecting proposals shall be technical, importance to agency programs, and fund availability.
- Cost realism shall also be considered

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BAA Background (cont.)

- Contractors SHALL NOT subcontract technical or scientific work without the contracting officer's knowledge

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IMPLICATIONS

- FAR PART 15 “Contracting By Negotiation” does not apply in full
  - No “competitive range” determination
  - No mandatory “discussions”
  - No opportunity for proposal revision
- “Cost and Pricing Data” (certification required for all FAR-based contract proposals greater than $700K)
- Subcontract consent and key personnel clauses to be included in awards

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Communications

- **ALL** questions to DARPA-BAA-12-30@darpa.mil
- After Receipt of Proposals – Government (PM/PCO) may communicate with proposers to understand the meaning of some aspect of the proposal that is not clear or to obtain confirmation or substantiation of a proposed approach, solution, or cost estimate
- Informal feedback may be provided once selection(s) are made – no “ranking” provided

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Applicant Eligibility

- All interested/qualified sources may respond
- International participants/resources may participate to the extent authorized by applicable Security Regulations, Export Laws, etc.
- International Traffic in Arms Regulations (ITAR)
  - Identify in proposal modeled items believed to be subject to ITAR regulations
- Small Business Participation Encouraged, Teaming Not Required

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Applicant Eligibility (cont.)

- Government agencies/labs, FFRDCs cannot propose to this BAA in any capacity, **UNLESS** they can clearly demonstrate the work is not otherwise available from the private sector AND they also provide written documentation citing the specific statutory authority (as well as, where relevant, contractual authority) establishing their eligibility to propose to government solicitations

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Organizational Conflict of Interest

- All facts relative to a potential conflict of interest must be disclosed.
- Examples of conflicts listed at FAR Part 9.505
  - Provided Systems Engineering and Technical Direction
    - Contractors MAY NOT simultaneously provide SETA support and be a technical performer at DARPA without waiver approved by DARPA Director

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Award Instrument

- Proposers without DCAA-approved cost accounting systems are not eligible for cost-reimbursement contracts. May receive fixed price contracts or OTs with performance-based payments.
- **No grants or cooperative agreements**
- Section 845 Other Transaction – must meet eligibility criteria
  - 1/3 cost share or non-traditional defense contractor participating to "a significant extent."

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Rights to Technical Data and Computer Software

- Assert rights to all technical data & computer software generated, developed, and/or delivered to which the Government will receive less than Unlimited Rights
  - Assertions apply to Prime and Subs
  - Justify "Basis of Assertion"
  - Use defined "Basis of Assertion" and "Rights Category"
  - Assessed during evaluation under the "Potential to Accomplish Technology Transition" Evaluation Factor

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