PERFECT Proposers Day

Welcome and Program Description

BAA-12-24

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DARPA

Prevent technological surprise and Create technological surprise

- Sponsor revolutionary, high-payoff research
- Driven by the Program Managers
- Capabilities/Mission focused
- Diverse performers—looking for the best people with the best ideas
- Driven by quantitative milestones
- Flexible, rapid review and contracting

The questions that all DARPA programs must answer:

- Is it game changing?
- Will it have lasting impact on DOD and the warfighter?

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Ground Rules

Up until the deadline for receipt of proposals,

- Open communications between proposers and the program manager are encouraged.
- But: Any information given to one proposer must be available to all proposers.

Therefore:

- Presentations will be posted on a public website.
- These proceedings are being videotaped.
- The best way to get a question answered is to submit it to DARPA-BAA-12-24@darpa.mil, and to retrieve your answer from the Questions and Answers list via the MTO solicitations website. Note that any question that contains distribution restrictions, such as 'company proprietary', will not be answered.

Agenda

- Program Manager's Welcome and Program Overview.
- Contract Management.
- Fast Position Statements, Part 1.
- Break for lunch.
- Fast Position Statements, Part 2.
- Technical Area Panels.

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PERFECT Problem

The capabilities of military systems such as UAVs and ground vehicles, are constrained by the on-board computational capabilities.

On-board computational capabilities are constrained by the available electrical power.

Moore's Law continues to hold; Dennard scaling has stopped.

We need more power-efficient embedded computers.

A requirement for 50 GFLOPS/watt is easy to establish. Going up even to 1000 GFLOPS/watt, important new capabilities would be enabled.

Today, we're at about 1 GFLOPS/watt.

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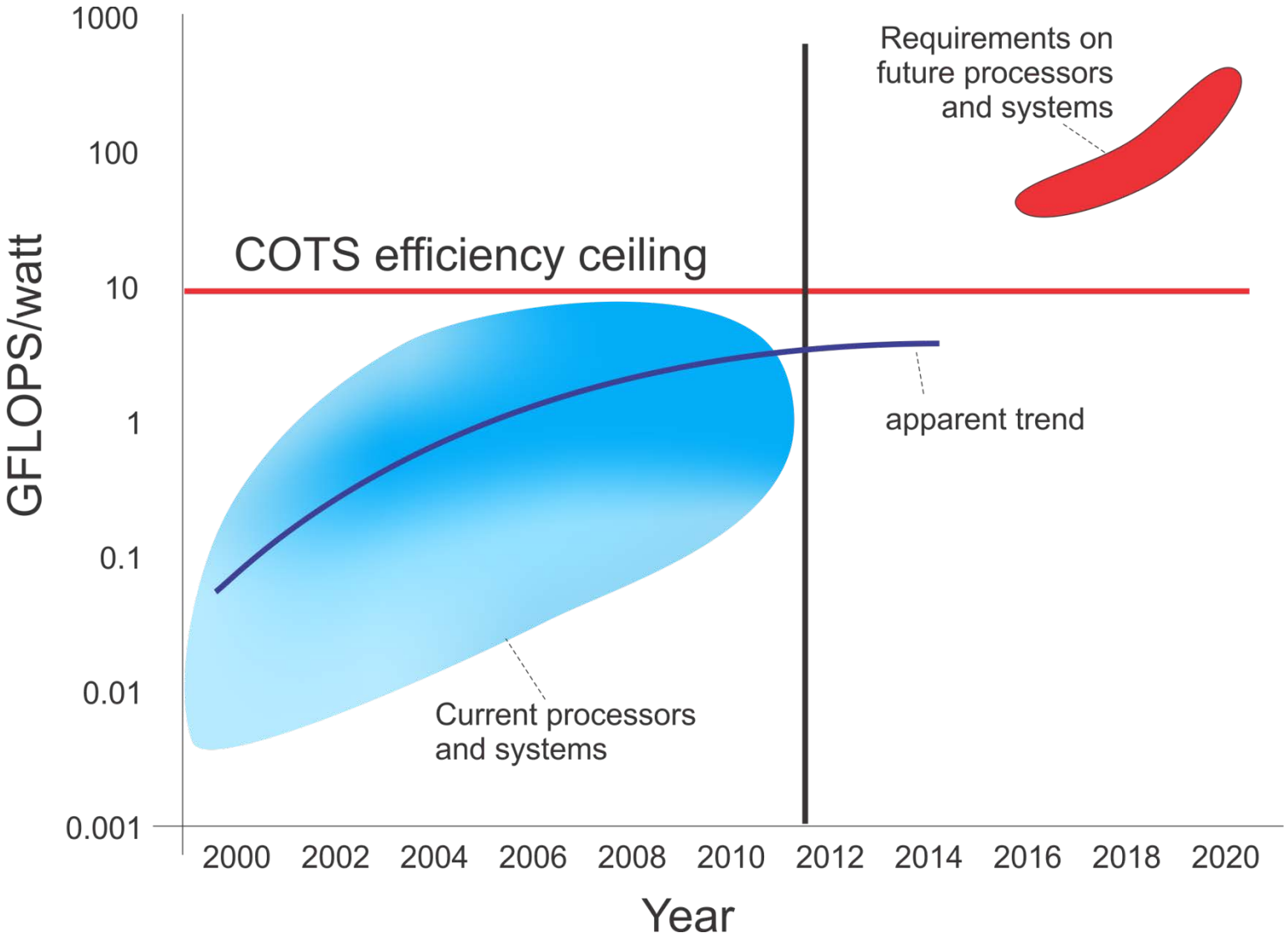
The Industry Roadmap Won't Get Us There



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PERFECT Objective

The PERFECT objective: More effective embedded computers.

Example: process sensor data on-board a UAV, so real-time tracks can be sent to the ground.

A numerical Program goal: 75 GFLOPS/watt.
(The goal of 75 GFLOPS/watt should not get undue focus. Our goal is more effective embedded computing; GFLOPS/watt is only one of many relevant metrics.)

Non-objectives: non-embedded computing in general and exascale in particular.

Bear in mind the constraints of the DoD environment, especially verifiability and upgradeability.

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Technical Approaches & Support Areas

Here are some areas in which we expect to see proposals:

- Architectures – hardware and software.
- Concurrency – many, many threads.
- Resilience – dealing with soft errors.
- Locality – have operands near processing.
- Algorithms – we have new metrics for goodness.

These areas overlap, and they're not exhaustive. Proposals are not required to fall entirely, or even partially, within any of these areas.

There are two important support area:

- Simulation – predict performance of hypothesized systems.
- Test and Verification – Evaluation of PERFECT products.

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Technical Approach: Architectures

Hardware

- Due to program timeline, we're not considering post-CMOS designs.
- We expect to ride the industry fabrication curve down to around 7 nm.
- Near-threshold voltage operation – see next slide.
- Bring processing and memory closer together, in terms of energy.
- Application-specific processing.
- Design technologies: how to design energy-efficient and fault-minimizing computing hardware.

Software

- Tolerate/exploit what hardware will do to us: greater concurrency and fault tolerance.
- Design technologies: how to design energy-efficient and fault-masking computing software.

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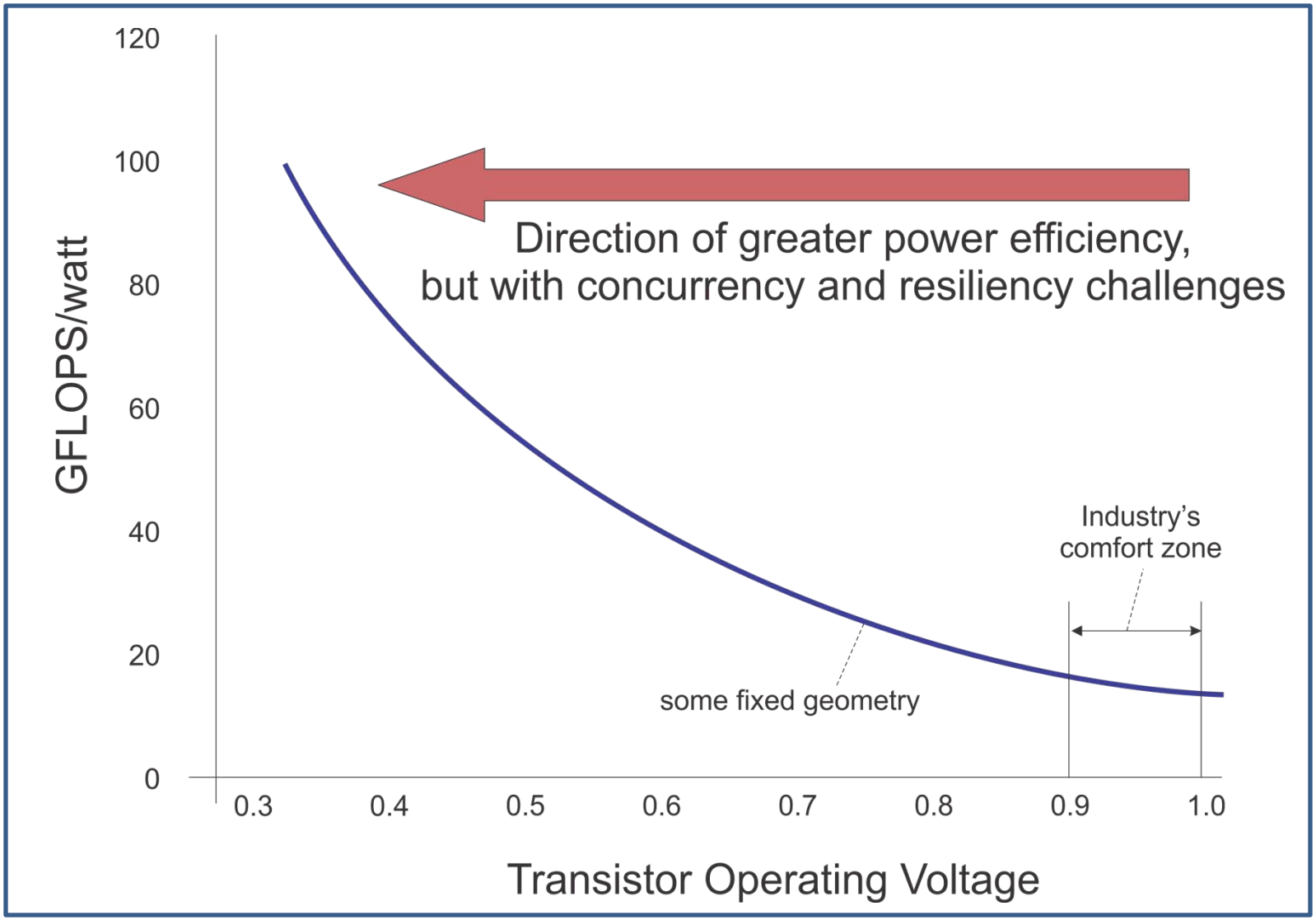
Near-Threshold Voltage Operation



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Technical Approach: Concurrency

Design hardware and software to support thousands to millions of concurrent execution streams.

Hardware:

- Processing cores and data stores of varying capabilities and efficiencies.
- Automatically synthesized processing elements that are optimized for the platform's workload.

Software:

- New languages and extensions to existing languages, compilers, and support software to specify and manage threads.
- Find the time and energy kernels of embedded DoD applications, and implement these in libraries.
- Concurrency extraction from low-level or high-level representations of an application.
- Heterogeneity management: either automatically or by programmer direction, place and re-place code and data in a complex hierarchy of processors and memories.

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Technical Approach: Resilience

The Resilience Program Element is focused on the issue of soft errors.

- Such errors are expected to increase as transistor operating voltage is decreased toward the threshold voltage.

Under this program, the art of system resilience design will be moved onto the same quantifiable basis on which performance architecture is currently done.

- This requires the ability to predict the resilience of designs so that quantitative tradeoffs are possible.
- This in turn requires accurate characterization of the resilience problem for plausible circuit/silicon designs.
- The creation of models may precede building and evaluating test hardware.

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Technical Approach: Locality

The Locality Program Element is focused on minimizing run-time data communication by arranging that operands be stored close – in terms of energy – to the referencing processors.

- The design of the memory hierarchy and the software to manage it.
- Languages that permit programmer control of data allocation and re-allocation.
- Languages that implement automatic control of data allocation and re-allocation.

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Technical Approach: Algorithms

Here “algorithms” refers to representations of software at a higher level of abstraction than source code.

For power efficiency:

- The power kernels of embedded applications will be investigated, by which we mean those recurring patterns of computation that are responsible for the consumption of the majority of energy in embedded applications.
- Then algorithms for these kernels will be developed that minimize energy consumption.

For resilience, algorithmic approaches to tolerance of soft hardware faults will be investigated, at both the kernel level and the system level.

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Support Area: Simulation

Since no operational hardware is to be built in this program, a simulation capability is required in order to measure and demonstrate progress.

The PERFECT simulation capability will predict the execution speed, energy consumption, and reliability of computer subsystems and systems. Multiple simulators with varying levels of fidelity and execution speed are anticipated.

The simulation capability developed will be made available to PERFECT program performers, and will be used by the Test and Verification contractor for evaluations.

The PERFECT simulation capability will be a major technology leave-behind of this program.

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Support Area: Test and Verification

This area is not being procured as part of the present BAA.

The TAV contractor independently evaluates the work products of other contractors, using the simulation facility.

The TAV conducts yearly Feasibility Assessment Demonstrations (FAD) that assess whether the Program is on track to its objectives.

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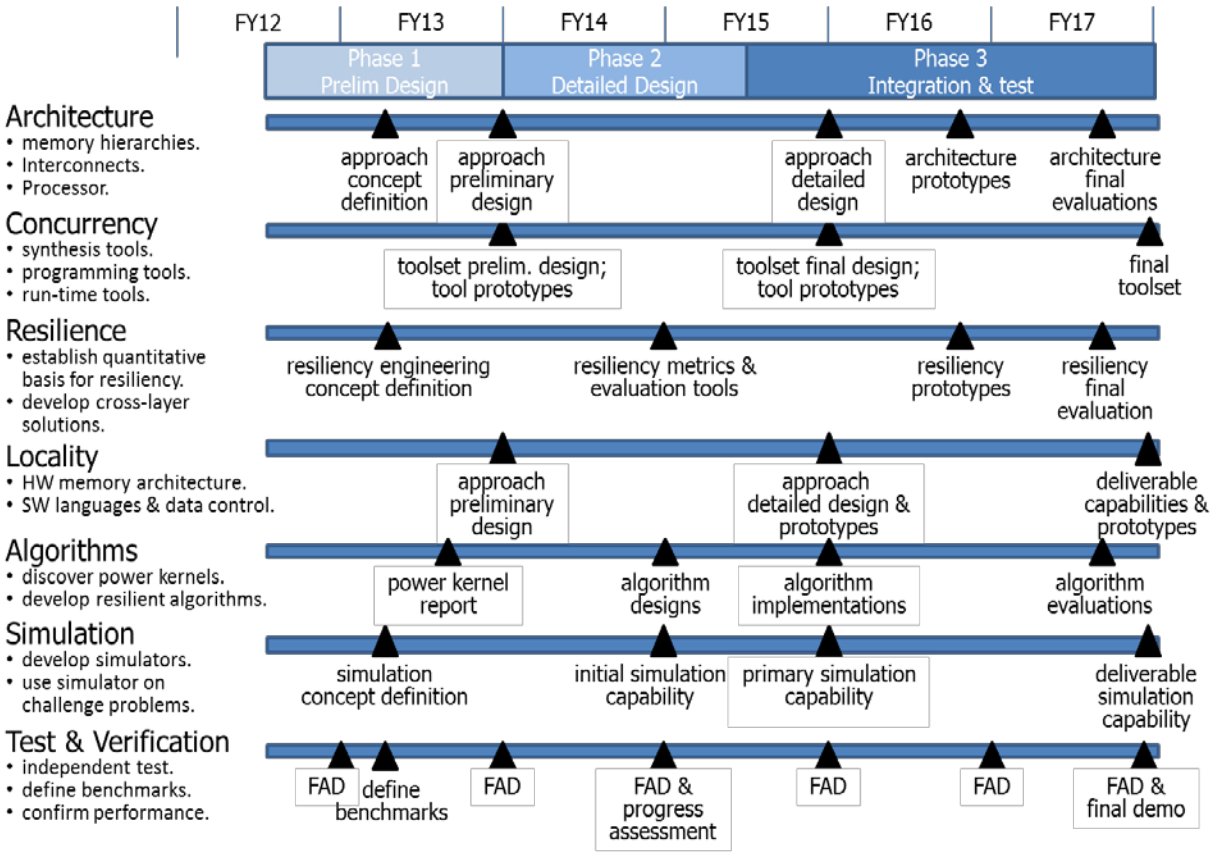
Programmatics



Some efforts may naturally terminate early. Some efforts may unnaturally terminate early.

Teaming is good when the combined effort is more effective than separate parts.

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Near-Term Program Schedule

Abstracts due (optional):	Feb. 23
Responses to abstracts (our intention):	Mar. 8
Proposals due:	Apr. 16
Notification of intent to negotiate (our intention):	May 14
Contract awards (approximate):	Aug. 1

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Technology Transition

PERFECT will build no operational hardware – we don't have that kind of money.

We may build test chips.

We will wrap up PERFECT with a demo (in simulation) of highly effective computation using the power available on a UAV.

We expect that the suite of methods and products and simulation capability left behind by PERFECT will be sufficient for national security contractors to build systems with efficiencies of at least
75 GFLOPS/watt.

Proposers specify their own tech transition path. Examples:

- Open source.
- Productize or publicize.

When successful, this Program will produce a demand-pull from DoD.

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