



Agenda

Start	End	Duration	Item
7:30AM	8:30AM	1:00	Registration
8:30 AM	8:40 AM	0:10	Security Briefing DARPA Security
8:40 AM	9:00 AM	0:20	Human Use Briefing Ms. Lisa Mattocks, DARPA HSR
9:00 AM	9:45 AM	0:45	Contracts Management Office Briefing Ms. Jennifer Mack, DARPA CMO
9:45 AM	10:30 AM	0:45	Symbiotic Design for Cyber Physical Systems Briefing Dr. Sandeep Neema, Program Manager, DARPA I2O
10:30 AM	12:00 PM	1:30	Break/Informal Teaming Discussions
12:00 PM	1:00 PM	1:00	Q&A Session (Answer attendee questions)



Welcome to the DARPA Conference Center (DCC)!!!

Symbiotic Design for Cyber Physical Systems Meeting

This meeting is
UNCLASSIFIED

No Classified discussions Allowed

120 PM – Dr. Sandeep Neema

12 August 2019



DARPA Conference Center Badges (DCC)

- DCC white or red **CC** badges must be clearly displayed at all times
- **CC** badges grant access to the first floor areas (breakout & conference rooms, lobby areas, café, restrooms)-NO Escort required
- A **FN Green** “foreign national” badge authorizes roaming access to building lobby area, café, and restrooms-No Escort Required; However, No badge access to reenter conference area or breakout rooms
- Please conceal badges when leaving the building during breaks, etc.
- Return CC & FN badges to the registration staff at the end of the meeting.



- Authorized: Two way pagers, cell phones, laptop computers w/internet access,

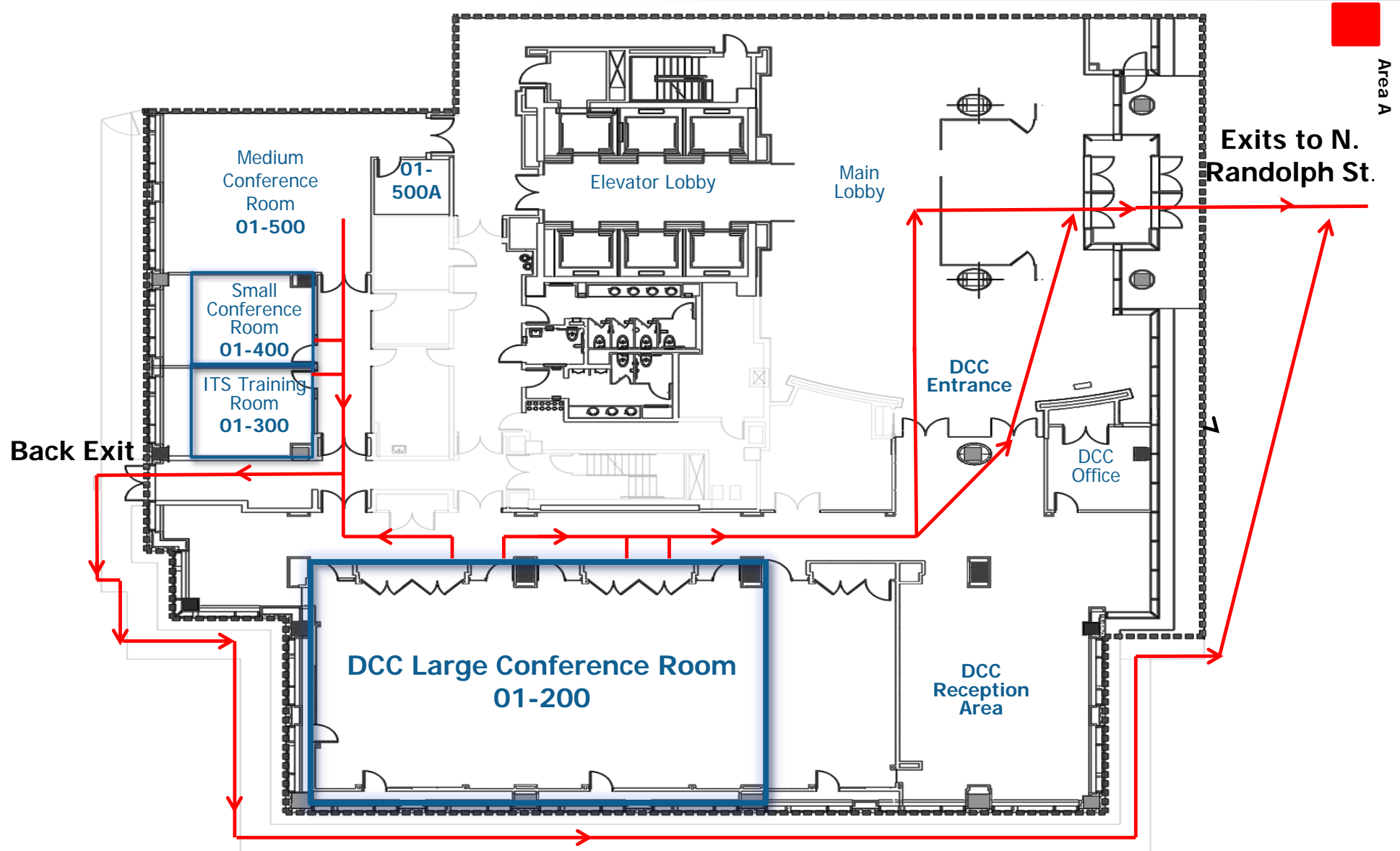


- Prohibited:
- **Photography, video and/or audio recording devices**
- **Apple/Samsung watches, Fitbits, Google glasses, etc.**



Evacuation Procedures

- Immediately walk, do not run, to the nearest of the two exit routes out of the DCC.
- Exit the building through the front or back exits as shown on previous map. Proceed out of the building to cross walk directly in front of building. Cross N. Randolph Street and walk south (to your left) to the sidewalk area "A" at the corner of N. Randolph and Glebe Road.
- Remain in waiting area until the "all clear" sign has been announced. Then you may return to the DCC.







- Remain calm, do not panic.
- Proceed to the nearest closable room (e.g. office, bathroom, conference room) and assist others who need help. Once in the room, immediately shut, lock and barricade the door.
- Turn cell phones to vibrate.
- Remain quiet and out of sight. Stay away from the door.
- If you see the shooter or hear gunfire, take action immediately! Run, hide or at the last resort, fight.
- Do not peek out of your room – wait for the police.
- Stay in the locked room and wait for further instructions or until the “all clear” notification is announced.



Denise Holden

Program Security Officer (PSO)

(571) 218-4277

Herbert Goldson

Program Security Representative (PSR)

(571) 218-4695

Human Subjects Research at DARPA

Lisa Mattocks
STO ADPM/HSR Action Officer

Proposers Day





Definition of Human Subjects Research in Federal and DoD Policies

Use of Human Subjects in an activity constituting a systematic investigation designed to develop and/or contribute to generalizable knowledge is considered Human Subjects Research, where:

The term "*human subject*" means a living individual about whom an investigator (whether professional or student) conducting research:

- (i) Obtains information or biospecimens through intervention or interaction with the individual, and uses, studies, or analyzes the information or biospecimens; or
- (ii) Obtains, uses, studies, analyzes, or generates identifiable private information or identifiable biospecimens.

Intervention: includes both physical procedures by which information or biospecimens are gathered (*e.g.*, venipuncture) and manipulations of the subject or the subject's environment that are performed for research purposes.

Interaction: includes communication or interpersonal contact between investigator and subject.

Private information: includes information about behavior that occurs in a context in which an individual can reasonably expect that no observation or recording is taking place, and information that has been provided for specific purposes by an individual and that the individual can reasonably expect will not be made public (*e.g.*, a medical record).

Identifiable private information is private information for which the identity of the subject is or may readily be ascertained by the investigator or associated with the information.

Identifiable biospecimens: is a biospecimen for which the identity of the subject is or may readily be ascertained by the investigator or associated with the biospecimen.

Any DARPA-funded research which involves humans as defined on this page MUST be considered HSR.



All DARPA human subjects research protocols must go through **two** reviews

1st review

Local Level (local IRB)



2nd review

DoD HRPO Level (Administrative Review)



HSR approval Process

- Principal Investigator submits protocol to local IRB for review and approval
- HSR package is then submitted for DoD HRPO review and approval
 - Includes local IRB approval letter
 - Federal Wide Assurance (of institution performing research)
 - Informed Consent Document
 - ***Make sure informed consent document includes statement that the research is being funded by DoD and thus the DoD has access to the data***
 - Recruiting Materials
 - Biosketches/CVs
 - Training Certifications
- DoD HRPO reviews entire package
 - May go back to PI with comments/recommendations/changes
- Once DoD HRPO gives approval, HSR research can begin
- Note that protected populations (i.e. military, pregnant women, etc) have special regulations that need to be followed.

Note – DoD HRPO review and approval can take anywhere from 3-6 months. Do not delay in starting this process!



- **If possible, submit an IRB approval letter and/or a Draft HSR Protocol with proposal.** Especially, in cases where humans are involved and you don't know that the work is really HSR. Having an IRB already look at it will help you and DARPA in moving forward faster.
- **If you do not have an internal IRB, you have one of three options**
 - Hire a commercial IRB
 - Work with the Contracting Agent to determine if they have an internal IRB that could assist
 - If work involves collaboration with other performers, considering using their IRB
- **If you have a contract involving subcontractors who are conducting HSR; they will also need to obtain HSR approval.** Any performer including subcontractors must receive HSR approval through the local IRB and the DoD HRPO before start of their research.
- **If you make changes to the statement of work, they also need to be approved.** If the changes are to the HSR portion of the work, the revisions will have to go through the local IRB for review, as well as DoD HRPO review for approval and concurrence.



Government HSR and ASR Action Officer

Ms. Lisa Mattocks
Lisa.Mattocks@darpa.mil
571-218-4424

HSR POC

Dr. Sahar Zafar
Sahar.Zafar.ctr@darpa.mil
703-362-3438

Symbiotic Design for Cyber Physical Systems

Jennifer Mack
DARPA Contracts Management Office

Proposers Day
Arlington, VA

August 12, 2019





DISCLAIMER

If DARPA publishes a Symbiotic Design Broad Agency Announcement (BAA) and it contradicts any information in these slides,

the BAA takes precedence!



BAA OVERVIEW

- BAA follows procedures in accordance with FAR 35.016.
- Any BAA (as well as any future amendments) will be posted on FEDBIZOPPS at www.fbo.gov.
 - Grants/Cooperative Agreements will **not** be awarded under this program
- Proposal due dates will be identified in the BAA
- BAA will cover all info needed to submit proposals. Follow instructions for proposal preparation and submittal.



BAA ELIGIBILITY

- All interested/qualified sources may respond subject to the parameters outlined in the BAA.
- Foreign organization/individuals – check all applicable Security Regulations, Export Control Laws, Non-Disclosure Agreements, and any applicable governing statutes.
- FFRDCs/UARCs and Government entities
 - Subject to applicable direct competition limitations
 - Must clearly demonstrate eligibility per BAA
- Real and/or Perceived Conflicts of Interest
 - Identify any conflict
 - Include mitigation plan



PROPOSAL PREPARATION INFORMATION

- Proposals consist of two volumes – Technical and Cost.
- Volume 1 - Technical and Management
 - BAA will identify a maximum page limit
 - Includes mandatory Appendix A – will not count towards page limit.
- Volume 2 – Cost - No page limit.
- Level of Effort Summary by Task Spreadsheet – Example an Attachment to BAA
- PowerPoint Summarizing the proposal effort is mandatory – Example a second Attachment to BAA
- The BAA will describe the necessary information to address in each volume –
 - Make sure to include every section identified.
 - If a section does not apply – put “None”
 - Include a working/unprotected spreadsheet as part of your Cost Volume submission.
 - Review individual TA descriptions, IP rights, and any deliverables for submission information



STATEMENT OF WORK (SOW) PREPARATION TIPS

Write a SOW as if it were an attachment to an award

- Don't use proposal (e.g. we propose to do . . .) or marketing language
- Break out work between any phases/time periods identified in the BAA
- Succinctly and clearly define tasks & subtasks
- Identify the primary organization responsible for task execution
- Identify measurable milestones and define deliverables
- Do not include any proprietary information!

NOTE: For cooperative agreements: SOW = RDD or Research Description Document. For Other Transactions: SOW = TDD or Task Description Document



PROPOSAL PREPARATION TIPS

- **Heilmeier's Catechism – Learn it. Know it. Live it.**
- **Substantial Time Commitment**
 - Propose substantial time commitment for key personnel
 - If PI is committed to multiple projects, consider co-PI(s) or document mitigation efforts to make up for PI's lack of commitment to effort
- **Risk – Do not be afraid to address Risk in Technical Volume**
 - Identify risk(s) to show an understanding of technical challenge(s)
 - Discuss metrics / potential mitigation plans / alternative directions
 - If conducted prior research, use data to support why approach will work
- **Page Limits – Depth better than breadth**
 - Focus on most critical/beneficial aspects
 - Don't restate problems at expense of explaining solution
 - Don't sacrifice SOW



PROPOSAL PREP CONT'D – INTELLECTUAL PROPERTY RIGHTS

- Government typically desires, at a minimum, **Government Purpose Rights** for any proposed noncommercial software and technical data. (SEE DFARS 227 for Patent, Data, and Copyrights)
- Data Rights Assertions – IF asserting **less than Unlimited Rights**:
 - Provide and justify basis of assertions (e.g. privately funded under IRAD project XYZ)
 - Explain how the Government will be able to reach its program goals (including transition) within the proprietary model offered; and
 - Provide possible nonproprietary alternatives
- IF proposed solution utilizes commercial IP – submit copies of license with proposal



ITEMS TO NOTE

- Fundamental vs. non-fundamental research
- Understand and comply with SAM, E-verify, FAPIIS, i-Edison and WAWF. Links can be found in the BAA.
- Subcontracting Issues
 - Non-Small Businesses: Subcontracting Plans required for FAR-based contracts expected to exceed the applicable threshold.
 - Subcontracting plans with <5% SDB goal – provide an explanation why
 - Subcontractor cost - Proposals must include, at a minimum, a non-proprietary, subcontractor proposal for EACH subcontractor. Include any internal price/cost analysis of subcontract value in proposal.
 - If utilizing FFRDC/UARC, Government entity, or a foreign-owned firm as a subcontractor, submit their required eligibility information, as applicable.



ITEMS TO NOTE CONTINUED

- Proposals typically must be valid for a minimum of 120 days –recommend putting in a longer time period
- TFIMS-2 Usage
- Document files must be in .pdf, .odx, .doc, .docx, .xls, and/or .xlsx formats
- Submissions must be written in English



ABSTRACT/PROPOSAL SUBMISSION

- Abstracts are submitted via the DARPA BAA Submission website.
- FAR based contract and OT proposals: Required to be submitted by via DARPA's web-based upload system for unclassified portion of proposal. Submission must be in a single zip file not exceeding 50 MB.
- Assistance Instrument proposals: Will **not** be applicable to this BAA
- Follow submission procedures outlined in the BAA. DO NOT submit proposals except as outlined in the BAA (e.g., email/fax submissions will NOT be accepted).
- DO NOT wait until the last minute to make submissions – the submission deadline(s) as outlined in the BAA will be strictly enforced!
- DO NOT forget to FINALIZE your proposal submission in the DARPA submission tool!



EVALUATION / AWARD

- No common Statement of Work - Proposal evaluated on individual merit and relevance as it relates to the stated research goals/objectives
- Evaluation Criteria (listed in descending order of importance) at a minimum will be: (a) Overall Scientific and Technical Merit; (b) Potential Contribution and Relevance to the DARPA Mission; and (c) Cost Realism.
- Evaluation done by scientific/technical review process. DARPA SETAs with NDAs may assist in process.
- Government reserves the right to select for award all, some, or none of the proposals received, to award portions of a proposal, and to award with or without discussions.



COMMUNICATION

- Prior to Receipt of Proposals – No restrictions, however Gov't (PM/PCO) shall not dictate solutions or transfer technology. Unclassified FAQs will be periodically posted to this BAA's DARPA web page.
- After Receipt of Proposals – Prior to Selection: Limited to PCO – typical communication to address proposal clarifications.
- After Selection/Prior to Award: Communications range from technical clarifications/revisions to formal cost negotiations. May involve technical as well as contracting staff.
- Informal feedback for proposals not selected for funding may be provided once the selection(s), if any, are made.



TAKE AWAY

- Submit abstracts/proposals before the due date/time - Do NOT wait until the last minute (i.e. hour) to submit.
- Read and understand the BAA - Follow the BAA when preparing proposals.
- Be familiar with Government IP terms from the DFARS Part 227.
- Submit working/unprotected spreadsheet(s).
- The Contracting Officer is the only Government official authorized to obligate the Government.

Symbiotic Design for Cyber Physical Systems

Sandeep Neema, I2O

August 12, 2019





Innovation in Design – Creativity



Source: Netflix, AlphaGo Movie

Can AI creatively solve the kinds of problems that innovation requires?



Develop symbiotic AI-based technologies for *correct-by-construction** design of military-relevant cyber-physical systems (CPS) in order to

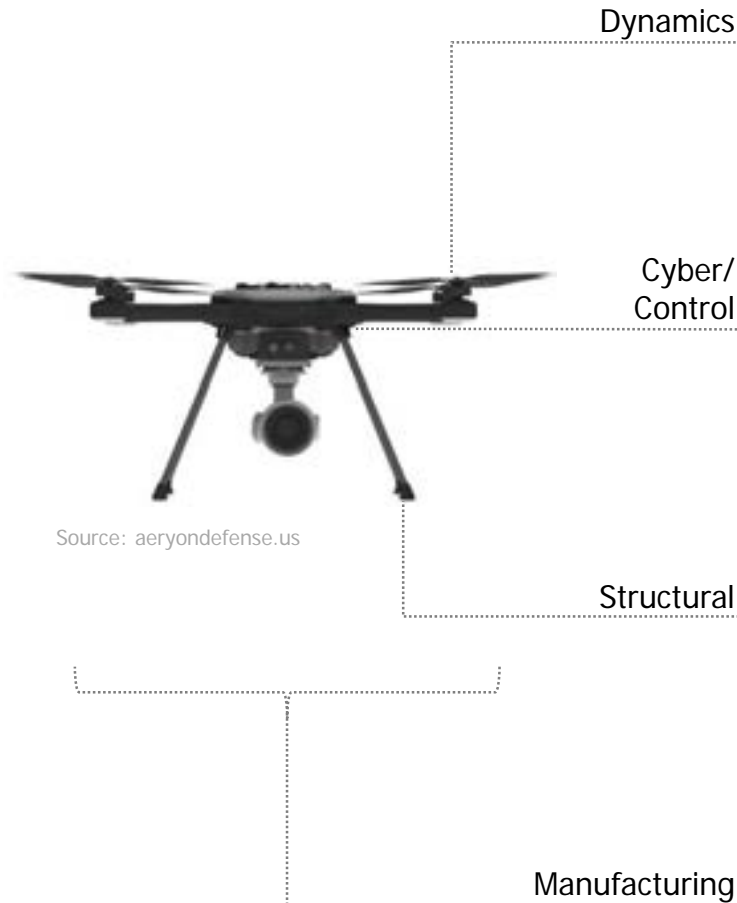
- reduce the time from inception to deployment from years to months; and
- increase innovation

*ability to predict properties of system with high fidelity prior to construction, eliminating need for costly design-test-redesign cycles

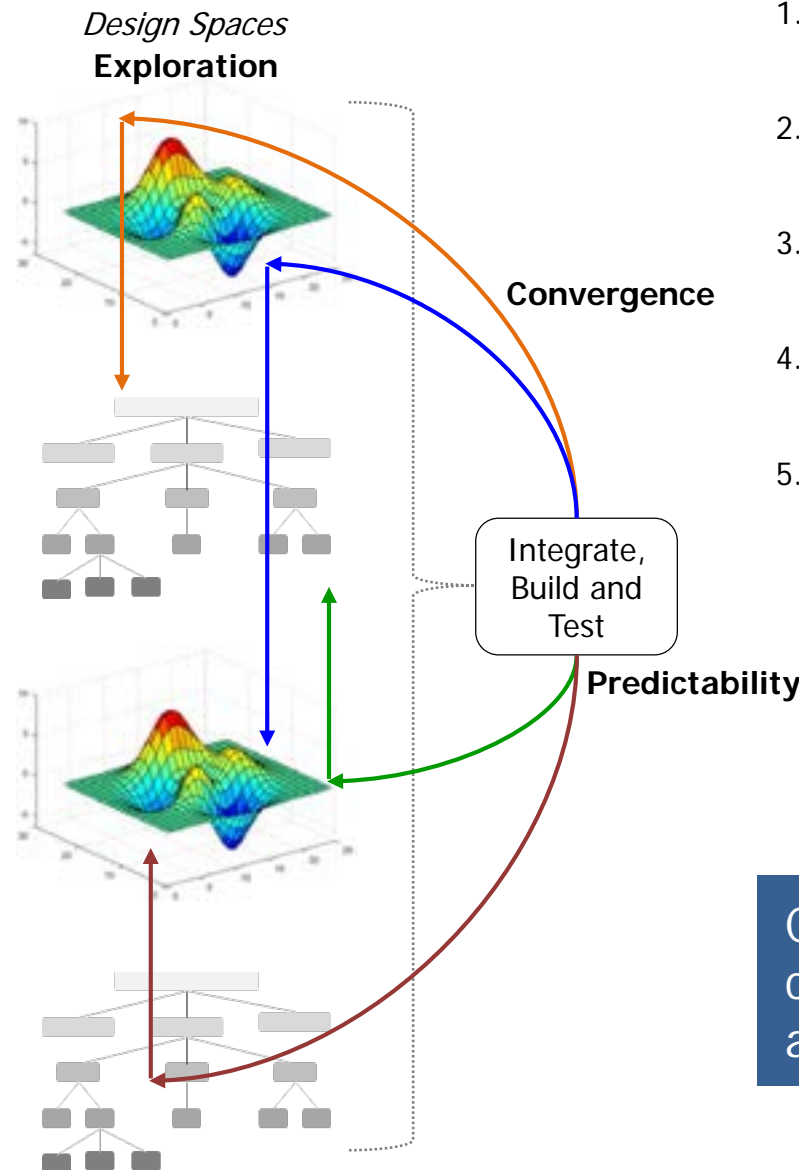


How is design done today?

Example: military-grade small unmanned aircraft system (R80D SkyRaider)



Source: aeryondefense.us



1. Alice is tasked to build a UAV with mission-specific performance objectives (e.g., range, endurance, speed, payload)
2. Alice decomposes the design problem into sub-problems (i.e., domains) and recruits a team to address each sub-problem
3. Each team produces design artifacts from domain-specific design spaces
4. Alice integrates them into an overall system-level design and builds a prototype
5. Integration uncovers numerous issues triggering change
 - a) Weight of system plus payload exceeds the lift
 - b) Power requirements for propulsion and payload exceeds power available in the battery
 - c) Acoustic coupling of motors induces high dynamic stress on the frame material
 - d) Light weighting requires use of carbon composites which can not be manufactured in-house

CPS design today – constrained by challenges in predictability, convergence, and exploration – is *construct by correction*



Today vs. Future of CPS Design

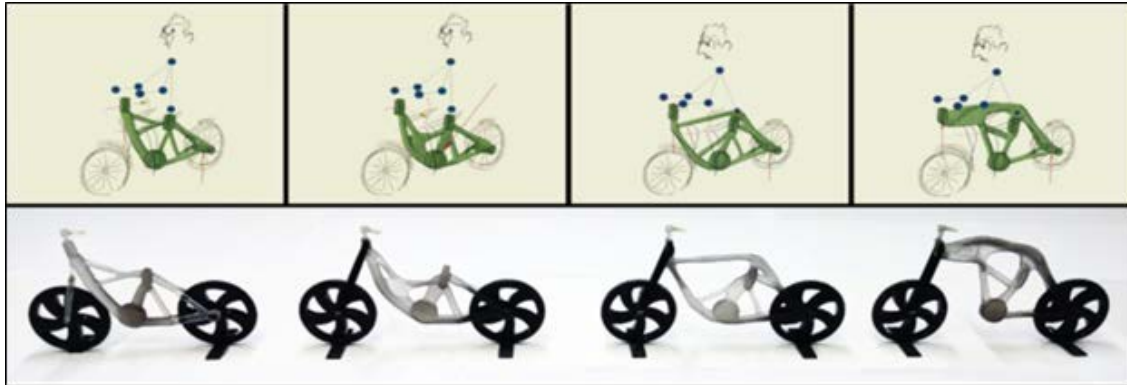
Challenge	Limiting Factors	State of the Practice	State of the Art		Symbiotic Design
		Model-based Design Tools	Commercial: Autodesk Dreamcatcher for CAD	DARPA: META Tools	
Predictability	Model construction (cost and fidelity)	Manual	Manual	Manual	Automated
Convergence	Model composition (intra-domain and cross-domain)	Manual	N/A	Partially automated	Automated
Exploration	Co-design (domains jointly explored)	Single	Single	Multiple	Multiple
	Designs explored	10's (manual)	1,000's (automated)	100's (partially automated)	1,000,000's (automated)
Cognitive Load	Interaction complexity	High	Medium	Medium	Low



State of the Art in CPS Design

Commercial (Autodesk Dreamcatcher for CAD)

Manually specify baseline geometry and loading requirements

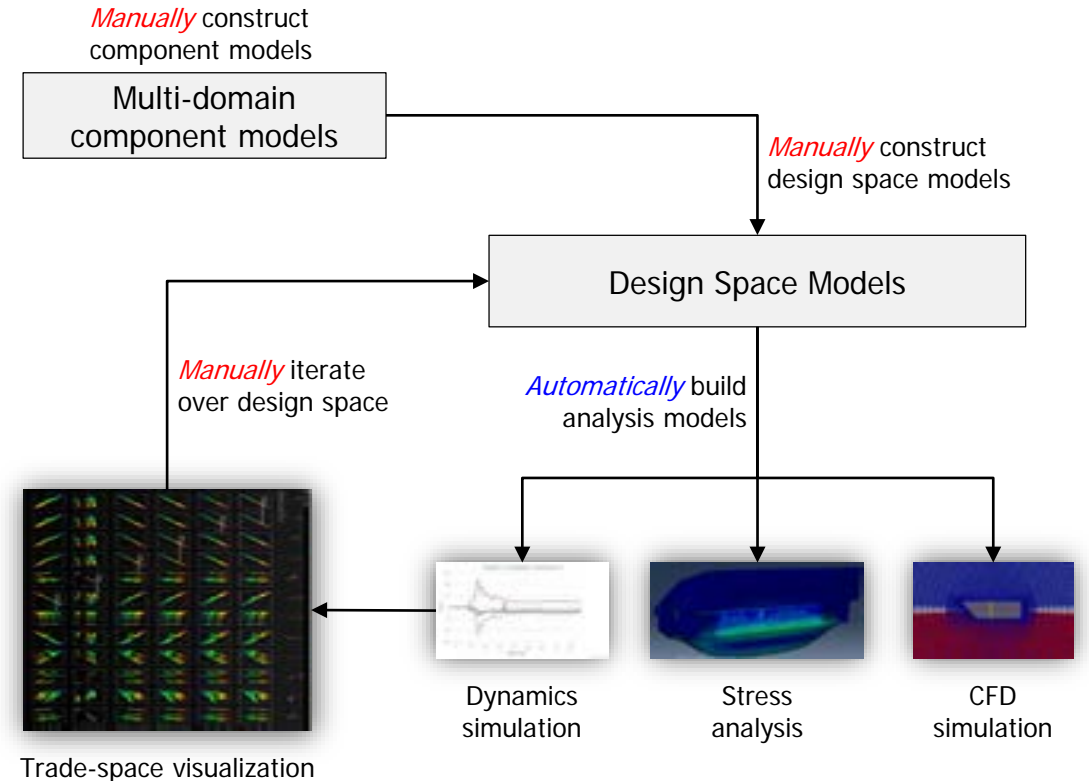


Source: Autodesk Dreamcatcher Project

Automatically evolve many variations of the baseline geometry satisfying loading requirements

Parametric topology optimization
Limited to single domain (geometry)

DARPA (META Tools)

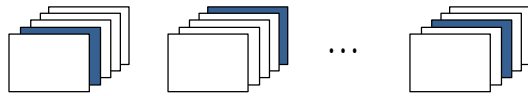


Source: Vanderbilt University

Rule-based model transformations
Manual design space construction and exploration

Design Space Construction

Predictability Challenge: Automate construction of design spaces



New Insights:

- Novel machine learning approaches for mining large code corpora in DARPA MUSE program

Design Composition

Convergence Challenge: Automate composition of partial designs

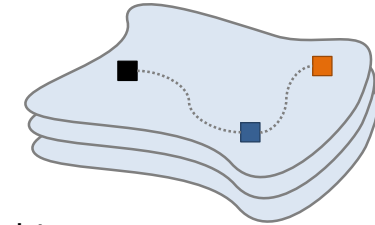


New Insights:

- Deductive model composition toolchains prototyped in DARPA META program
- Early results in combining deductive and inductive synthesis

Design Space Exploration

Exploration Challenge: Automate exploration of high-dimensional design spaces



New Insights:

- Recent results in scalable design-space exploration using learning-based approaches
- AlphaGo inspired approaches for exploration

Symbiotic Exchange



Cognitive Load Challenge: Natural and anticipatory interfaces to enable effective human-machine partnership

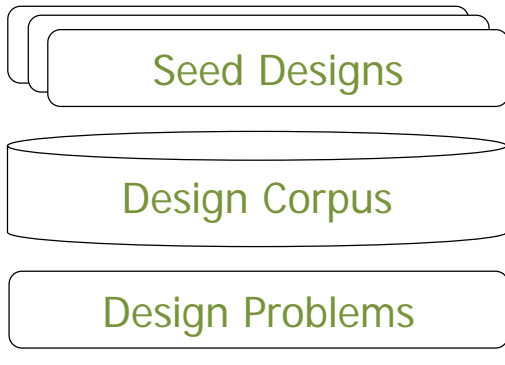
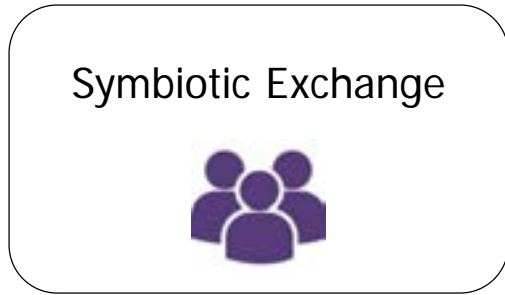
New Insights:

- Visualization and interpretation of high-dimensional data
- Cueing reinforcement learning by reward modeling
- Sketch-based interfaces



Achieving correct-by-construction at scale with symbiotic design

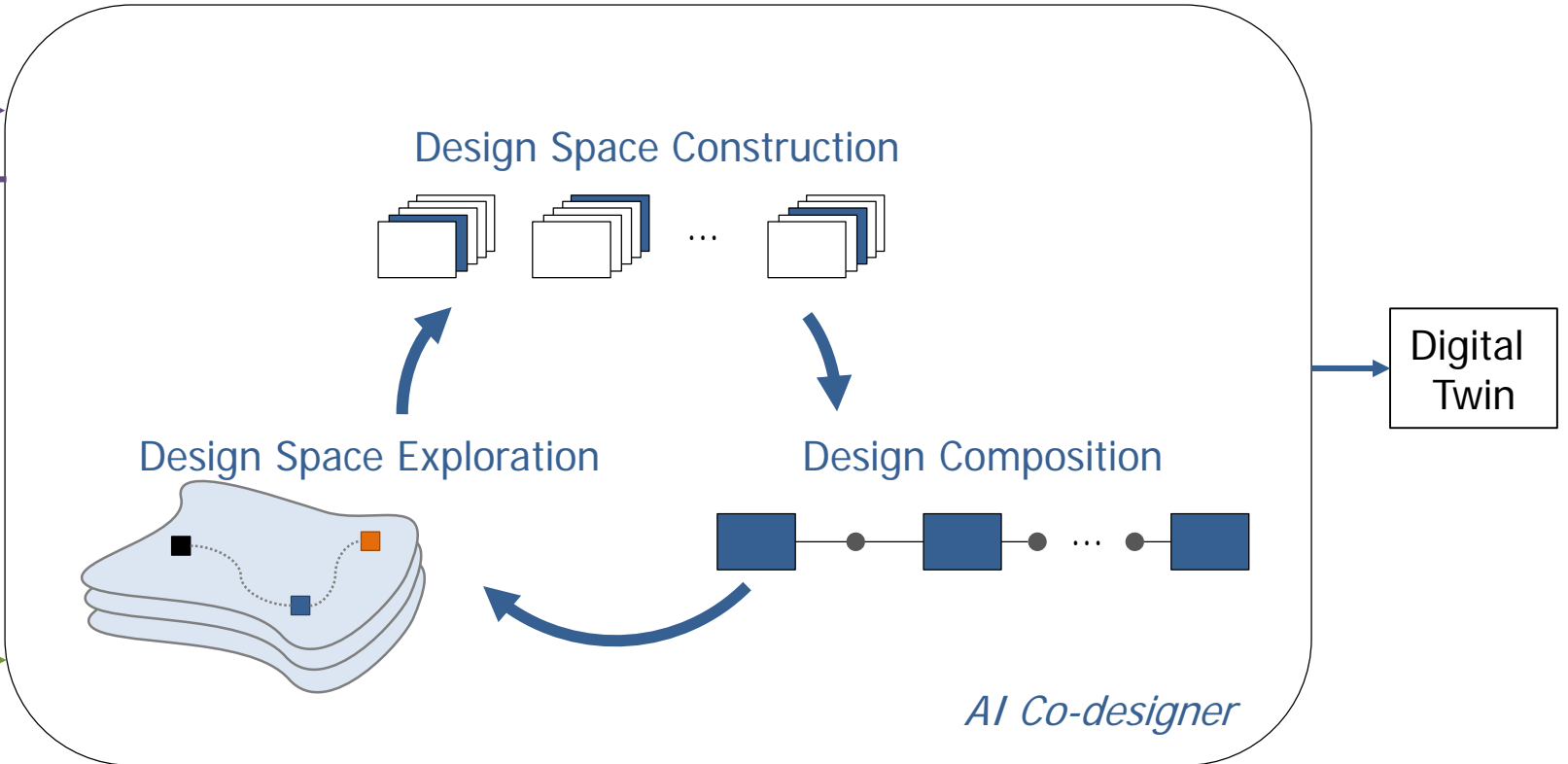
Humans



Data

Machines

Distribution Statement A. Approved for public release. Distribution unlimited.





UUV Design Space



Source: Hydroid Remus

UUV
Design Problem



UUV Architecture
with
representative
subsystems

$$\text{Design Space} = (M^C)^N$$

N : number of subsystems
 C : number of components per subsystem
 M : number of options per component

(Simplified example with same C and M for each subsystem)

Combinatorically
Large Design
Space

Design Space $\sim 10^{30}$

UUV Example:
 $N = 5, C = 10, M = 4$



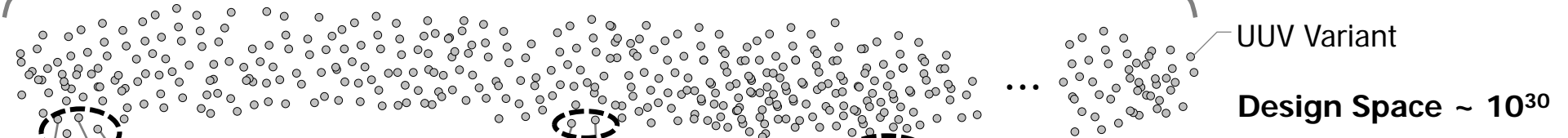
Symbiotic Design flow

↓ Humans provide
Seed Design



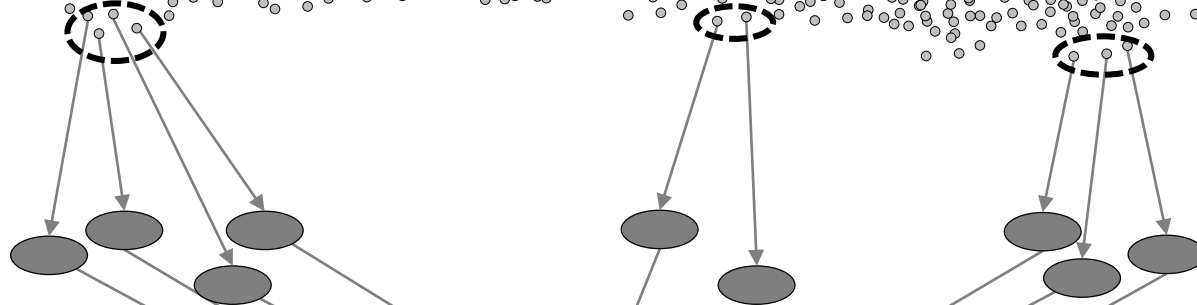
↓ Computer mines design corpora
Humans curate design options

Design Space



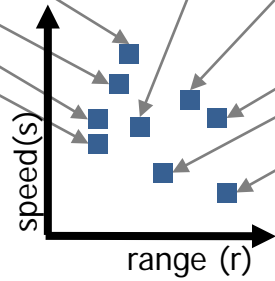
↓ Computer composes domain models
Humans provide rules and examples

Models



↓ Computer simulates and analyzes models

Evaluation Results



$$(s, r) = f(h, n, c, m, b)$$

$s = \text{speed}; r = \text{range}; h = \text{hull form};$
 $n = \text{navigation sensors}; c = \text{control algorithm};$
 $m = \text{mission payloads}; b = \text{battery}$

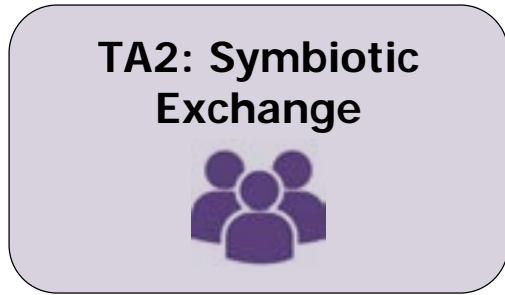
Exploration

Computer learns f ,
searches for "best" design
Humans guide search

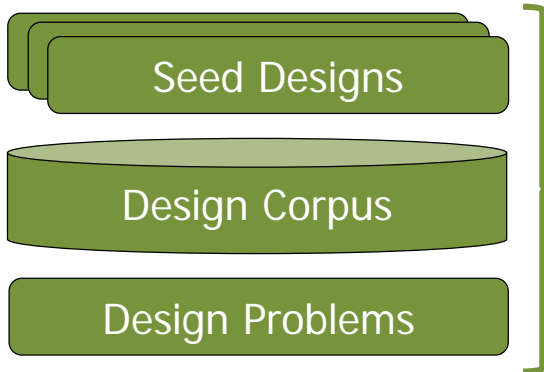


Program Structure

Humans



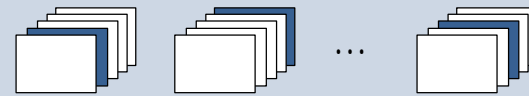
TA3: Program Evaluation



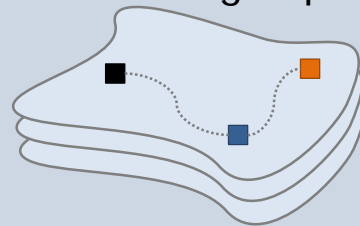
Data

TA1: AI Co-Designer

TA1.1: Design Space Construction



TA1.3: Design Space Exploration



TA1.2: Design Composition



Digital Twin

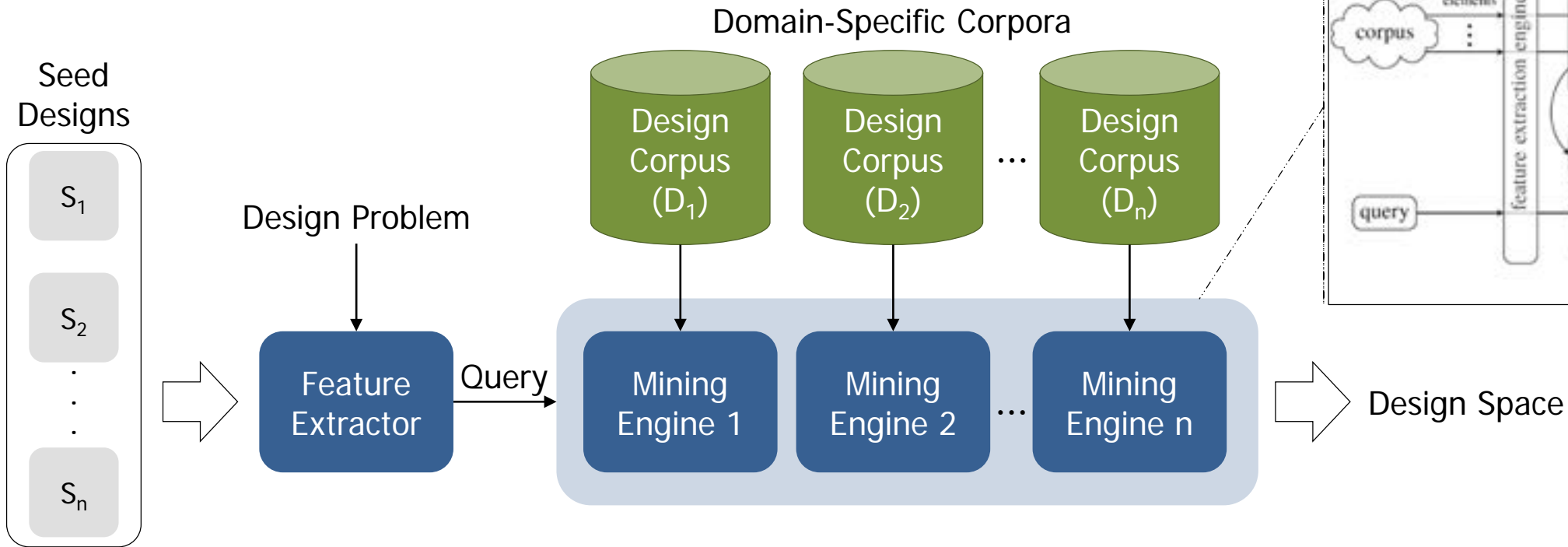
Machines



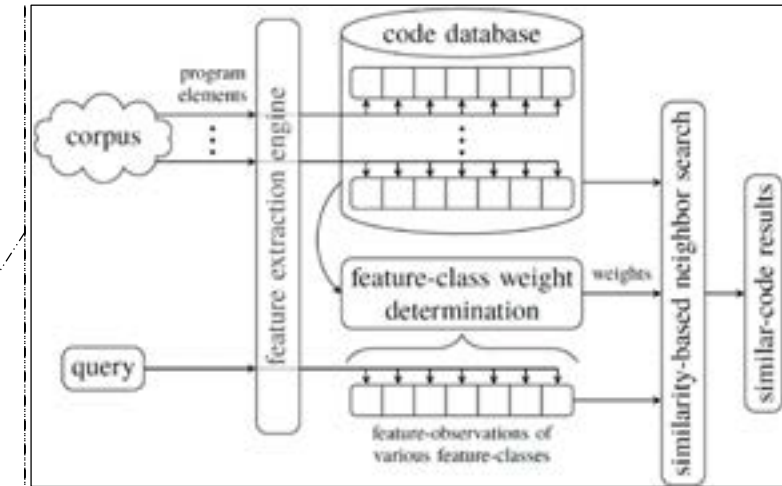
Overall Programmatic

- Three Phases – Phase I (18 months); Phases II and III (15 months each)
- Three Technical Areas (TAs): AI Co-Designer (TA1); Symbiotic Exchange (TA2); and Program Evaluation (TA3)
 - TA1 has three sub TAs: Design Space Construction (TA1.1); Design Composition (TA1.2); and Design Space Exploration (TA1.3)
- Anticipate multiple awards in technical areas (TAs) 1 and 2 and no more than two awards in TA3
 - Each proposal may only address a single TA, but proposers may submit multiple proposals
 - Proposers selected for award in TA3 as prime will not be selected for award in any other TA
- Strong interaction among all performers is critical to program success
 - Associate Contractor Agreement (ACA)

Goal: Develop technologies to automatically and incrementally construct design space for a given specification and seed designs



From DARPA MUSE

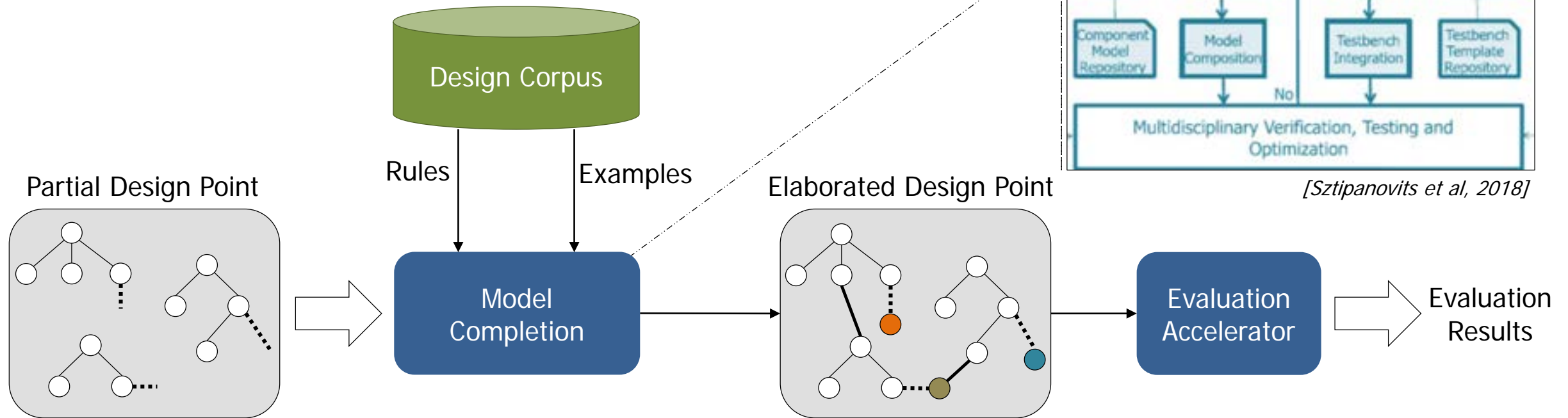


[Kashyap et al, 2017]

Challenges

- Query generation from seed designs and design problem
- Mining heterogeneous model-based design artifacts
- Incremental construction of design space

Goal: Develop technologies to automatically compose and evaluate a design point



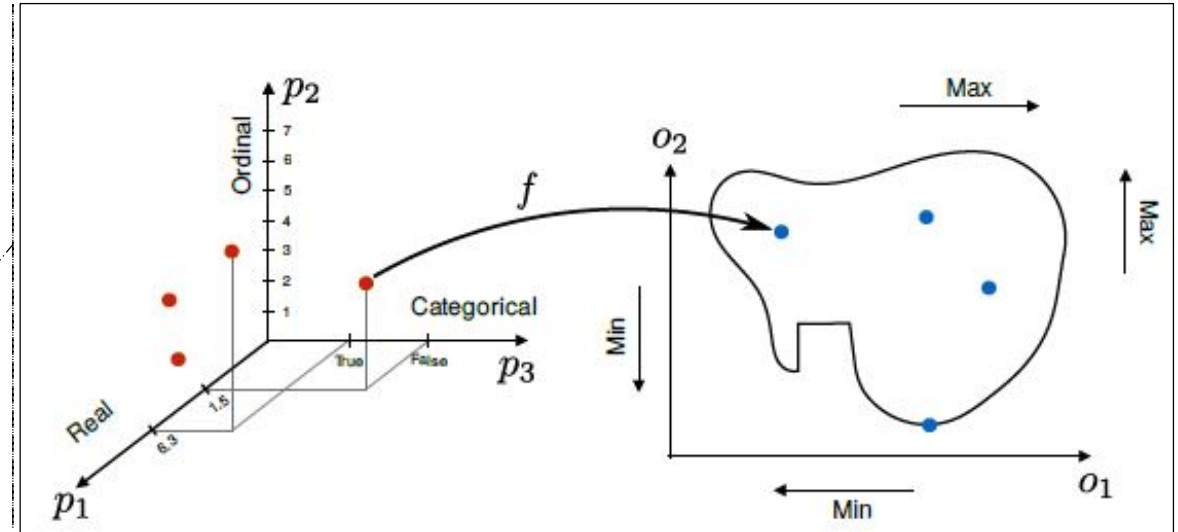
Challenges:

- Automated model completion in heterogeneous domains
- Automated cross domain reasoning and model learning
- Accelerated design analysis and simulation



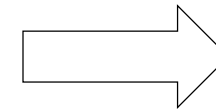
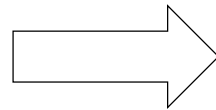
TA1.3: Design Space Exploration

Goal: Develop technologies to explore high-dimensional multi-domain combinatorial design spaces



[Nardi et al, 2018]

Evaluation Results
Design Space



Next Design Point

Challenges:

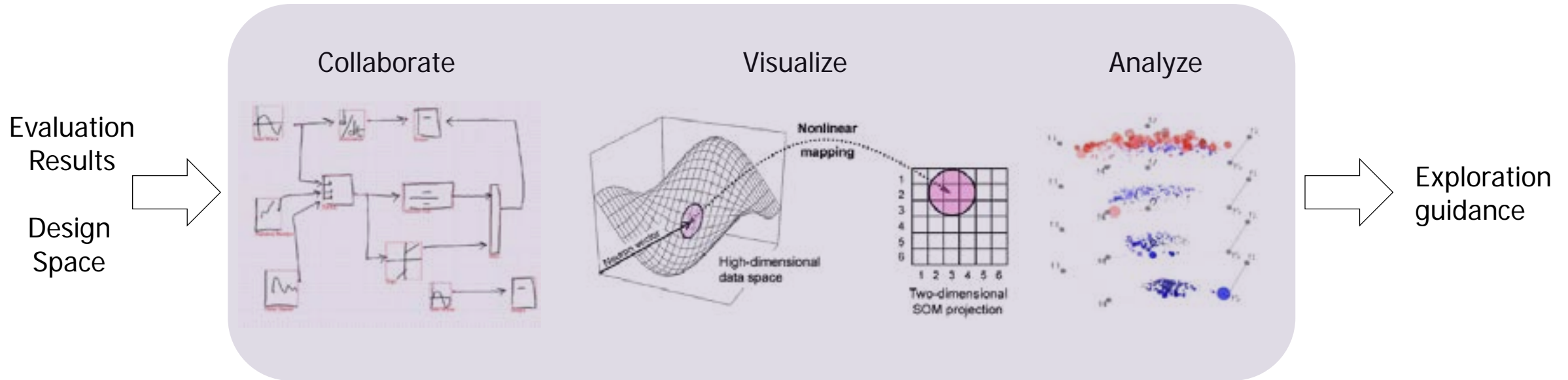
- High-dimensionality of the space
- Heterogeneous domain models
- Objective functions defined over multiple abstraction layers



TA1 Programmatic

- Proposals for a comprehensive solution to all three sub-TAs TA1.1, TA1.2, and TA1.3, are strongly encouraged, though not required
- Proposals that do not address all the sub TAs, must clearly identify and describe interfaces for other sub TAs, and should describe a plan to participate in integrated TA1 team composed of different performers
- Address all TA3 design challenge problems
 - Describe at least one example of a design challenge problem (proxy for TA3 design challenge problem)
- The output from TA1 will be a digital representation of the design (digital twin), and collaboration with TA3 will be necessary to define the languages and formats for the digital representation.

Goal: Develop technologies to enable effective partnership between human and machines to solve complex design problems



Challenges

- Visualization and understanding of high-dimensional design spaces
- Shaping and guiding exploration
- Interaction complexity of engineering design tools



TA2 Programmatic

- Address both augmented anticipatory interfaces to off-the-shelf commercial tools, as well as design space visualization and manipulation interfaces
- Address all TA3 design challenge problems
 - Describe at least one example of a design challenge problem (proxy for TA3 design challenge problem)
- Work closely with both TA1 and TA3 performers
 - Develop interfaces and integrate with the tools developed by the TA1 performers



TA3: Program Evaluation

Goal: Evaluate the design and symbiosis technologies by designing CPS

Evaluator tasks

- Develop challenge problems that serve as surrogate/proxy of DoD relevant design problems
- Develop system specifications, requirements (performance envelope), and evaluation metrics for challenge problems
- Provide performer accessible design corpora for different design domains
- Evaluate the design (digital twin) provided by tech developers
- Optionally, build and test a physical prototype of the design (in phase 3)

Evaluation approach

- Execute short duration (2-3 weeks) design challenges (hackathons)
- Compete team of engineers using traditional design approaches against team paired with AI-codesigner
- Evaluate and compare the performance and innovativeness of the design produced by the two teams
- Track and compare the efforts required by the two teams
- Conduct cognitive load studies on both teams (need IRB approval for evaluation)

TA3 Proposers should plan to support all TA1 and all TA2 teams



TA3 Programmatic

Design Challenge Problems

- Relevant to DoD concerns and push the envelope in terms of performance objectives
- Provide a surrogate version to enable fundamental research

Design Hackathons

- Organize and host design hackathons (2 weeks in duration)
 - Appropriately scoped design challenges, in which a team of engineers using traditional design approaches can be competed against a team paired with the AI-codesigner
 - Allocate engineering resources to execute the design challenges

Design Corpus

- Describe a plan to gather and curate a corpus of design artifacts
 - Should include, but not be limited to, architecture models, dynamics models, CAD models, source code, design specifications, component meta-data, operation logs, and problem reports
 - Should articulate approach to leverage open-source artifacts where possible, and supplement with problem specific design data
- It is expected that data for core R&D to be shared with TA1 and TA2 performers can be open and accessible with no CTI (Controlled Technical Information)

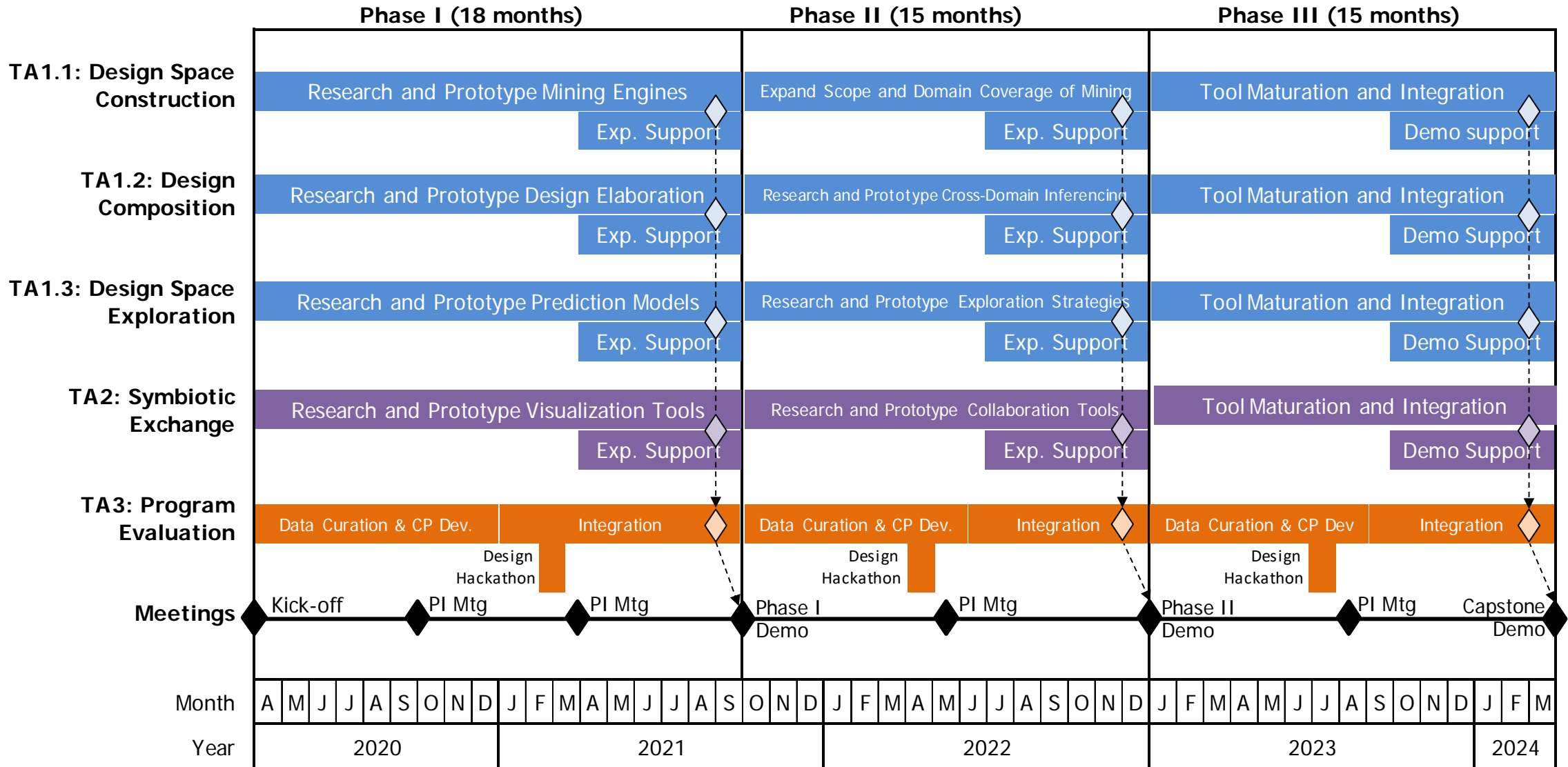


Metrics

TA	Metric		Current	Phase 1	Phase 2	Phase 3
TA1.1: Design Space Construction	Design space size (mined design variants)		N/A	100's	1,000's	10,000's
TA1.2: Design Composition	Autocomplete partial designs (completeness/accuracy)	Connections	Manual (100%/100%)	50%/80%	90%/90%	100%/95%
		Interface Components		40%/80%	70%/90%	90%/95%
		Functional Components		20%/80%	50%/90%	80%/95%
TA1.3: Design Space Exploration	Domains jointly explored		Single	Multiple (2)	Multiple (3)	Multiple (4)
	Designs explored (combinatorial + parametric)		10's (Manual)	1,000's (Automated)	100,000's (Automated)	1,000,000's (Automated)
TA2: Symbiotic Exchange	Quantitative (reduction in human effort)		N/A	0.6x	0.2x	0.1x
	Qualitative (cognitive load)	NASA-TLX (Task Load Index)	N/A	Protocol and baseline development	Comparative assessment through design challenges	Comparative assessment through design challenges



Schedule and Milestones





- DARPA BAA: HR001119S0083
 - FedBizOpps website (<http://www.fedbizopps.gov>)
 - Posting Date: August 13, 2019
 - Abstract Due Date: August 29, 2019 at Noon ET
 - Proposal Due Date: October 14, 2019 at Noon ET
- Government Response to Questions Session
 - Questions can be submitted until 11:00am to SymbioticDesign@darpa.mil
 - Questions will be answered during Q&A session (12:00-1:00pm)
- Online Material
 - DARPA Program Page
 - Copy of Proposers' Day Presentations
 - Frequently Asked Questions (FAQs)



www.darpa.mil