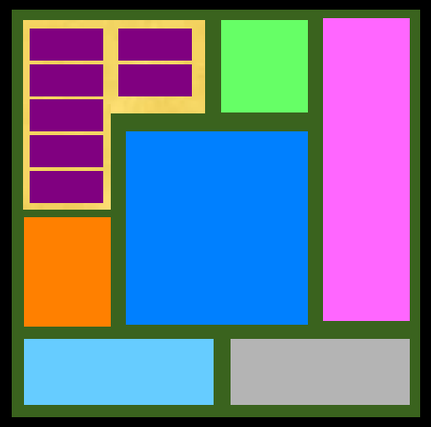
Development of Advanced Massive Heterogeneous Sensor Networks

THE Ames Laboratory

Creating Materials & Energy Solutions



Research Team

Ames Laboratory

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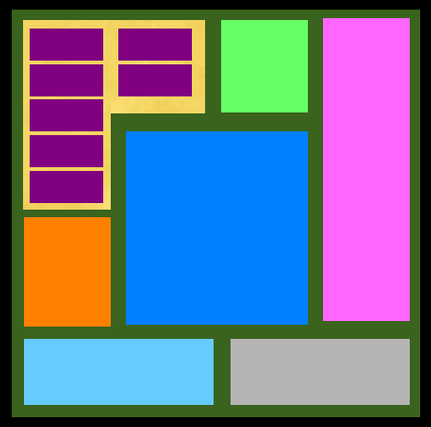
- Mark Bryden

U of Maryland

- Ashwani Gupta
- Miao Yu

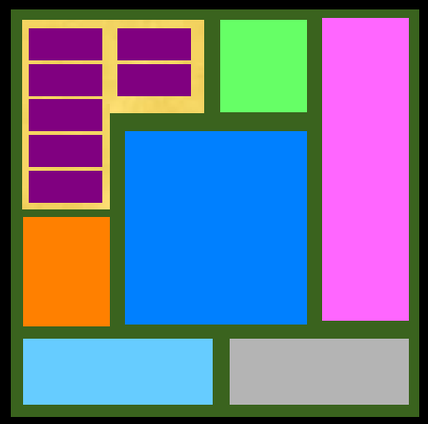
Power Plant Challenges

- Conflicting goals of reliable low cost energy and climate change mitigation
- Large investment in current infrastructure
- Little implementation of information technologies

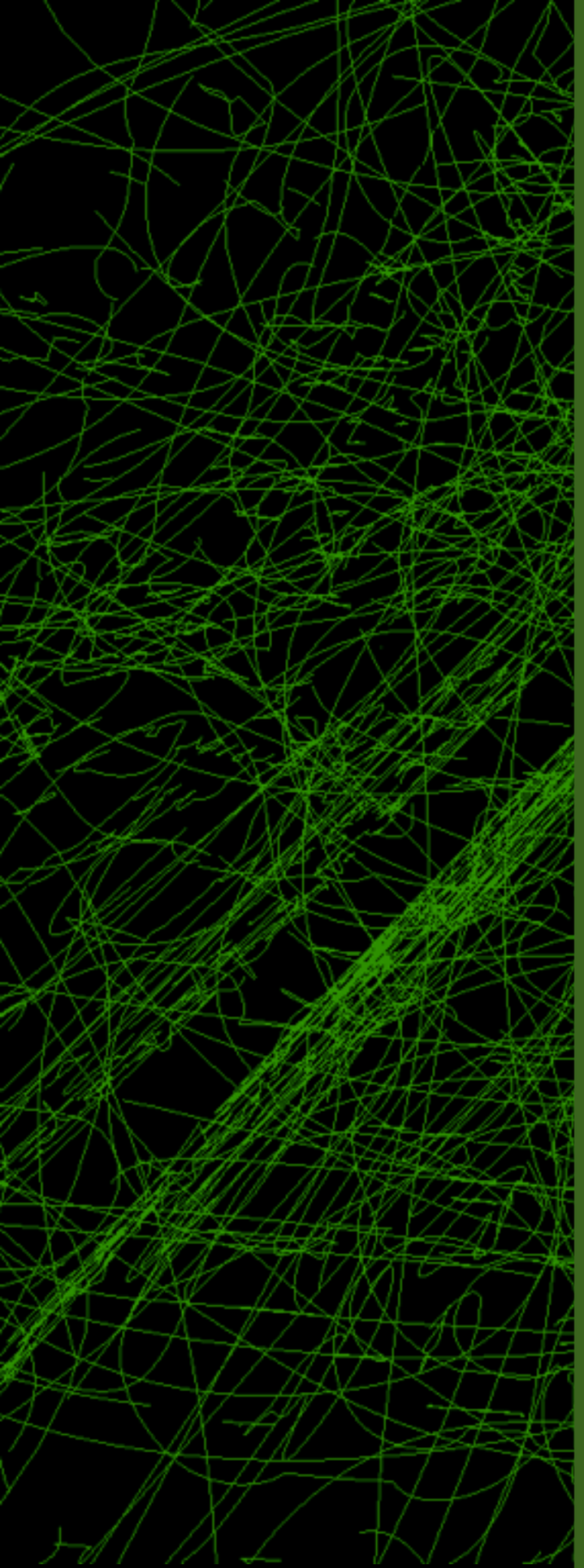


Sensors ...

- will be “free”
- will be small (lick ‘n stick)
- will be smart
- will be ubiquitous

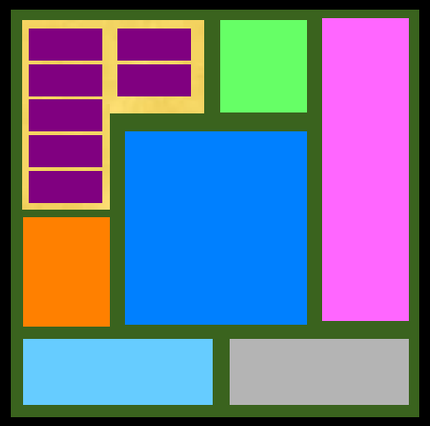


Low cost improvements in sensing for control and condition monitoring can result in big improvements in cost and carbon emissions



- “… develop the understandings, algorithms, and control strategies needed to utilize large-scale, high-density sensor networks in advanced power plants.”

- Develop techniques for the “… synchronization of heterogeneous sensors with widely varying capabilities using strategies based on self-organization.”



Efforts

1. Develop smart fiber-based sensors
2. Demonstrate and understand how multiple sensors can improve combustion measurements
3. Develop stigmeric controls for process systems
4. Large scale demonstration of stigmeric controls

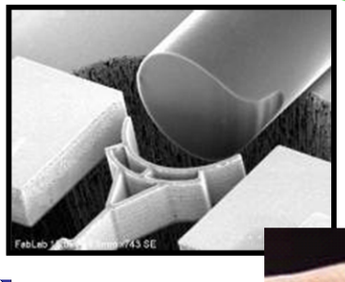
Smart Fiber-based Sensors

1. Optical Wireless Sensor Network (WSN) node developed

2. Smart system-on-a-chip multifunctional sensor platform demonstrated for pressure, temperature, chemical, and acoustic measurements

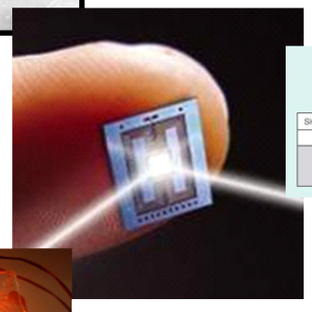
3. Smart system-on-a-chip multifunctional sensor demonstrated for multiplexed fiber Bragg grating sensors

Sensing element **Processing element** **Communication module**



Tunable
Fabry-Perot
-

Low coherence interferometer



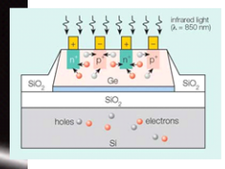
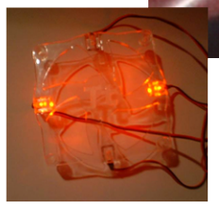


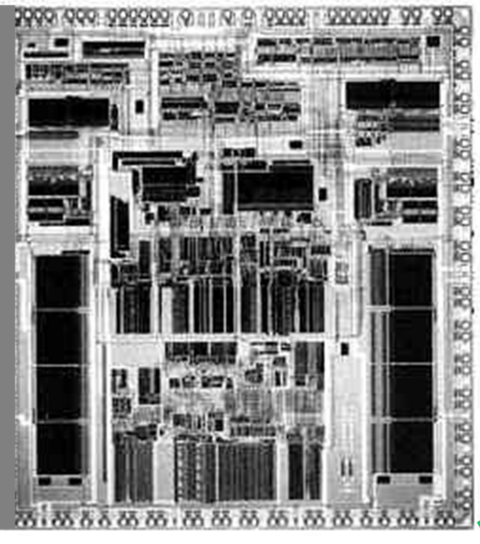
Photo
detector



Superluminescent light
emitting diode

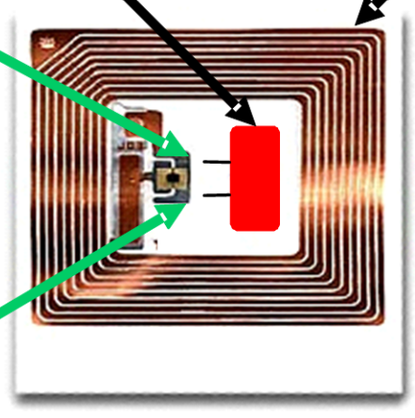
Optoelectronics

Microprocessor



- Memory
- Built-in model
- Signal processing
- Decision making

Battery Antenna



- RF communication

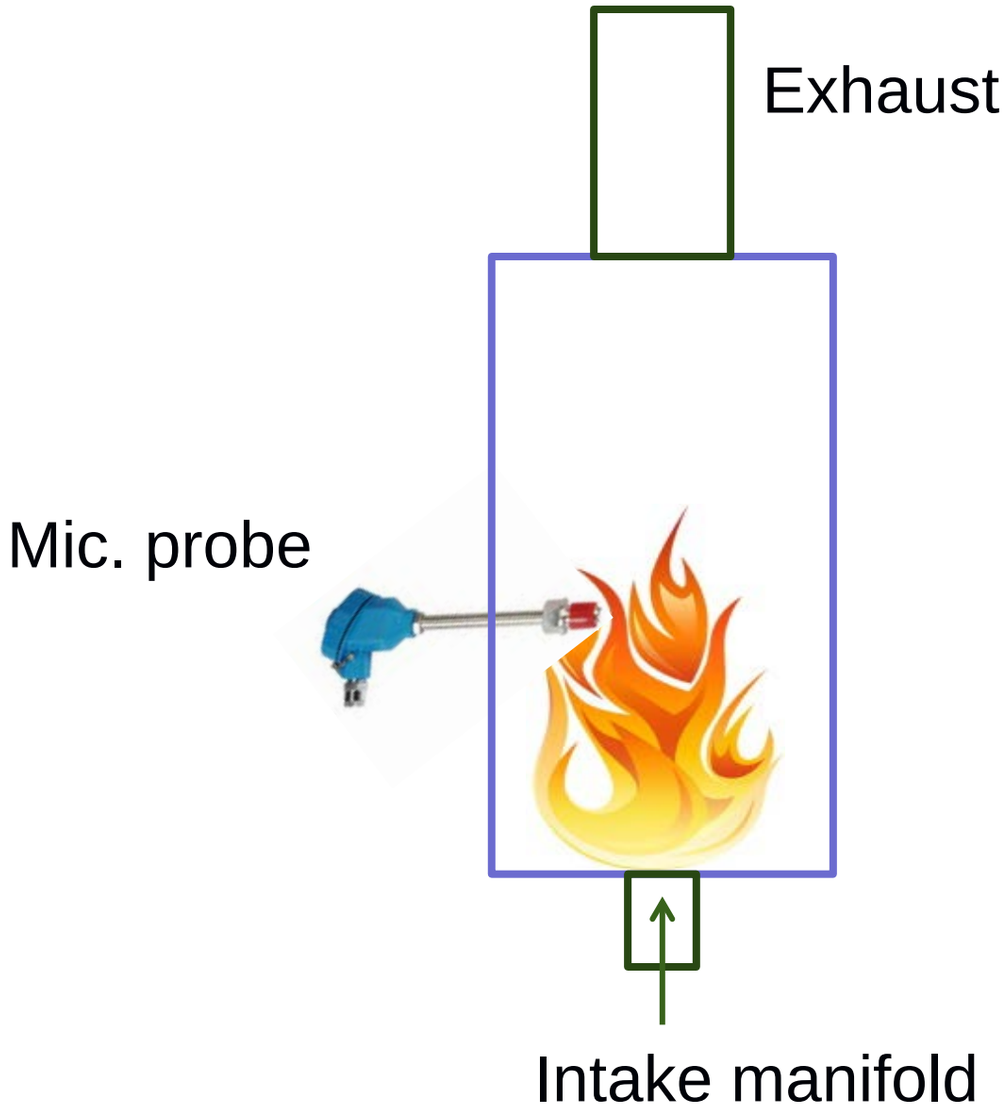
Multiple Sensor Demonstration

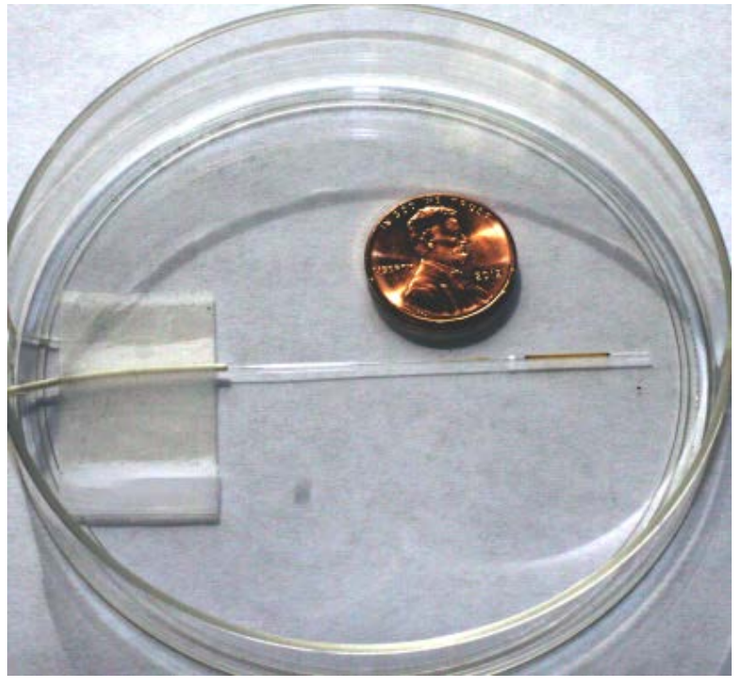
1. Studied multiple homogeneous sensors for source identification

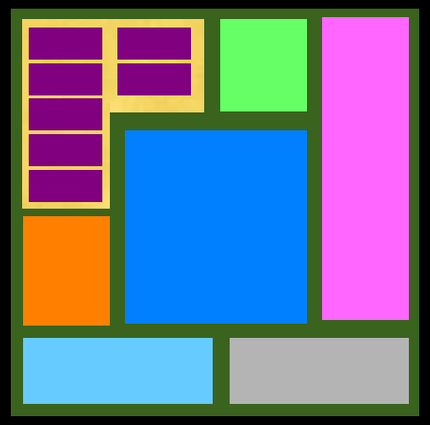
2. Simulations of geometry arrangement and source identification performed

3. Experimental studies of geometry arrangement and source identification performed

Acoustic Measurements of Combustor

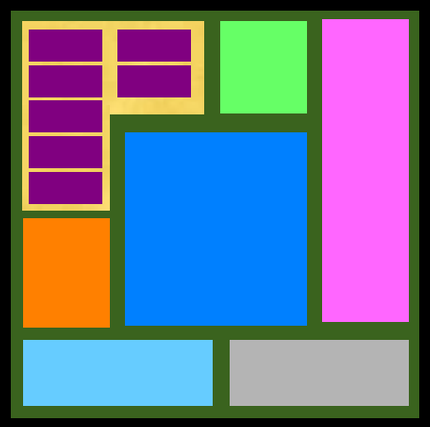






Stigmergy

Agents interact with each other through the structure under construction (modifying their local environment)

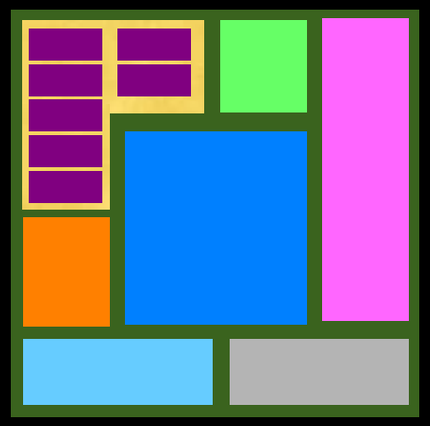


Previous Work

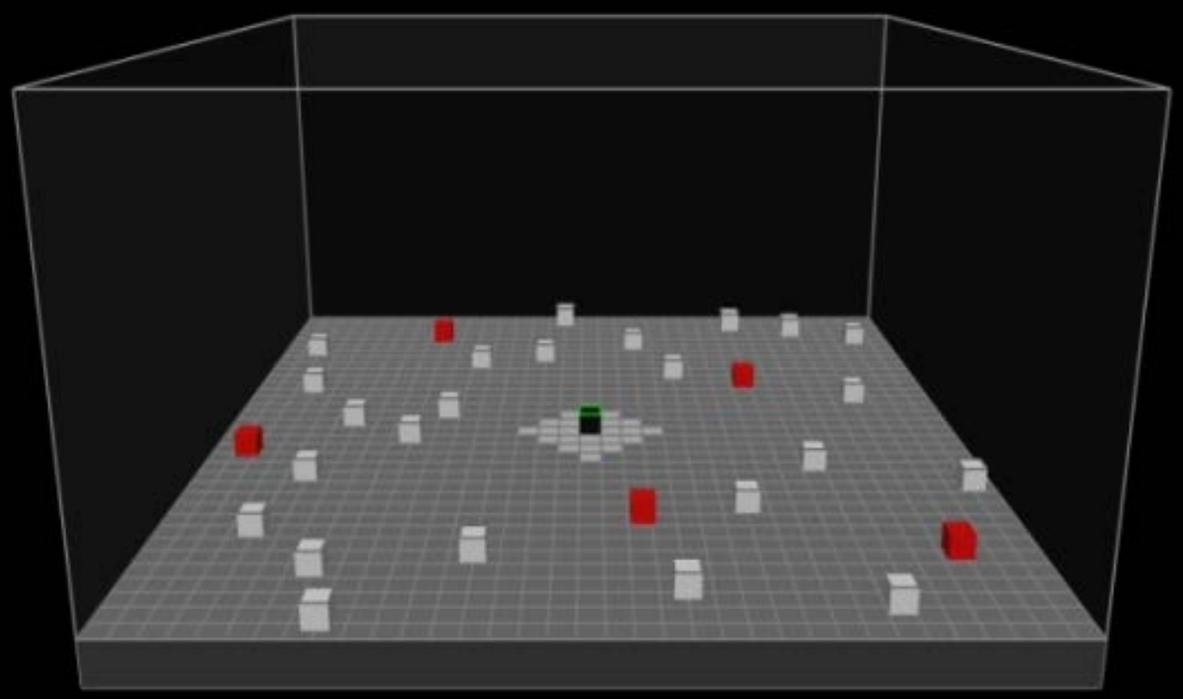
Most efforts have focused on sign-based stigmeric methods such as the ant colony optimization algorithm

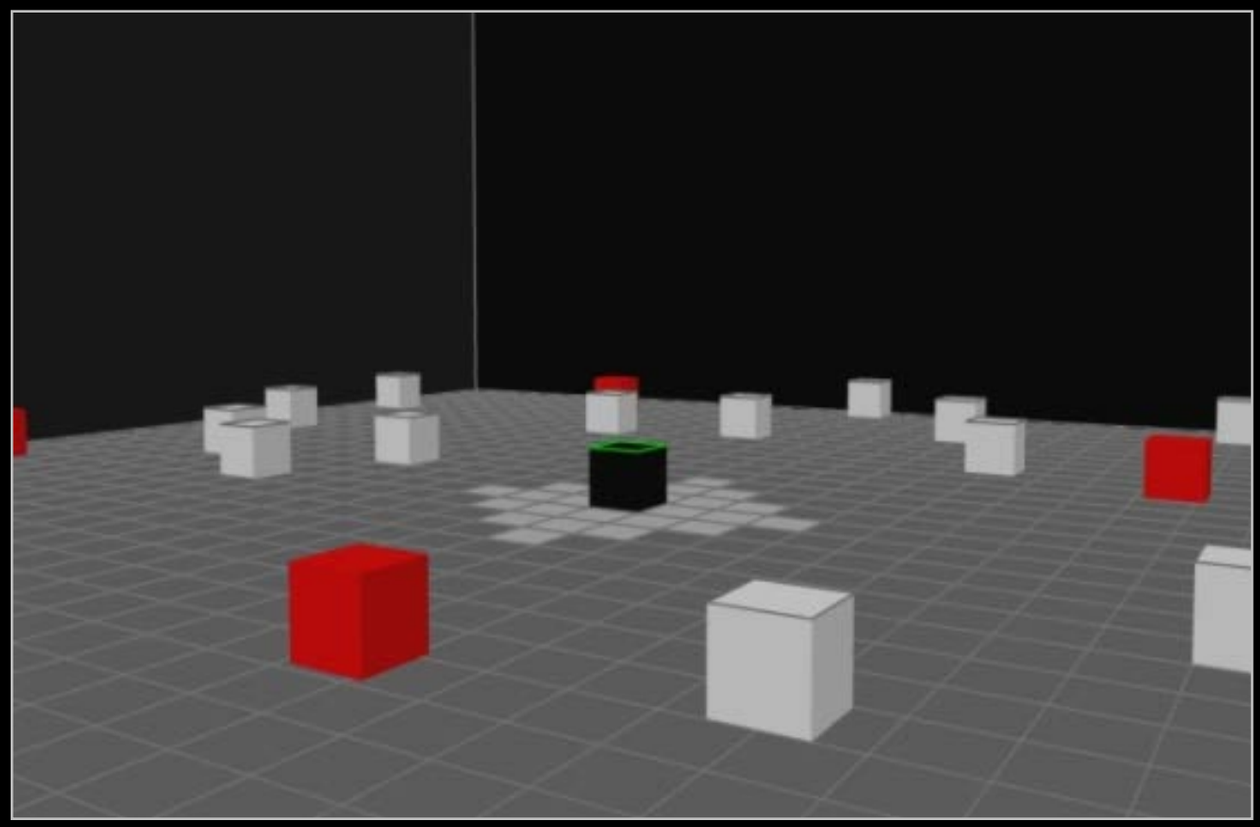
- network optimization
- scheduling problems

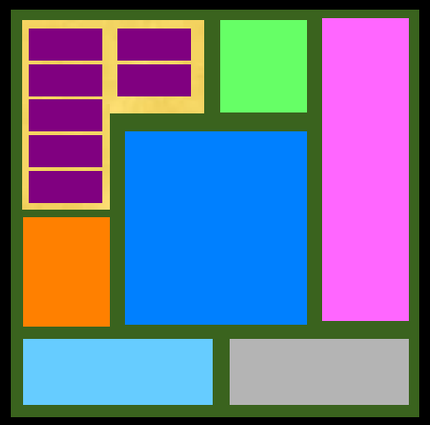
	Sign-based	Sematectonic
Quantitative	Ant colony	Worn down trails
Qualitative		Collective construction



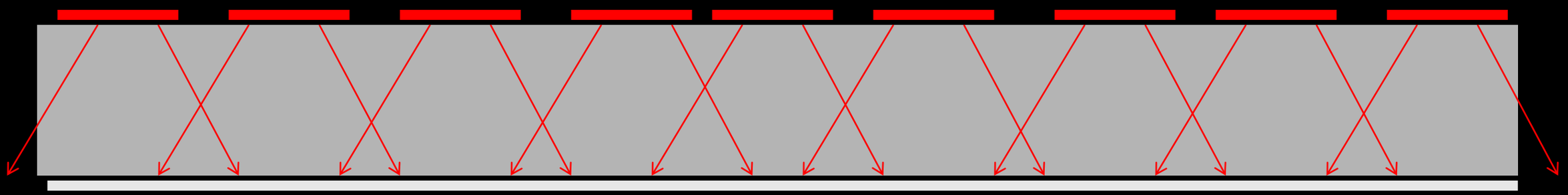
Collective construction problem



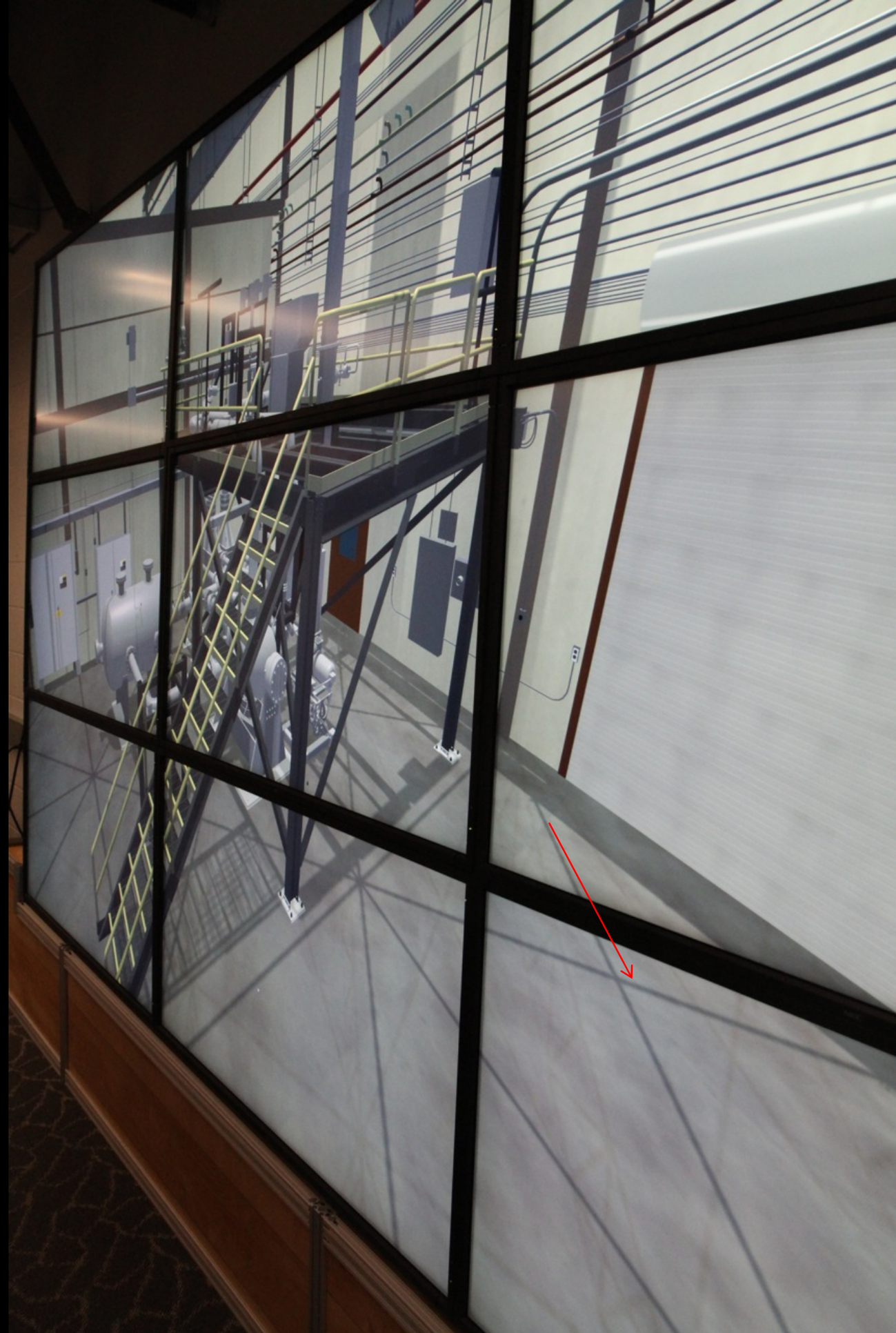


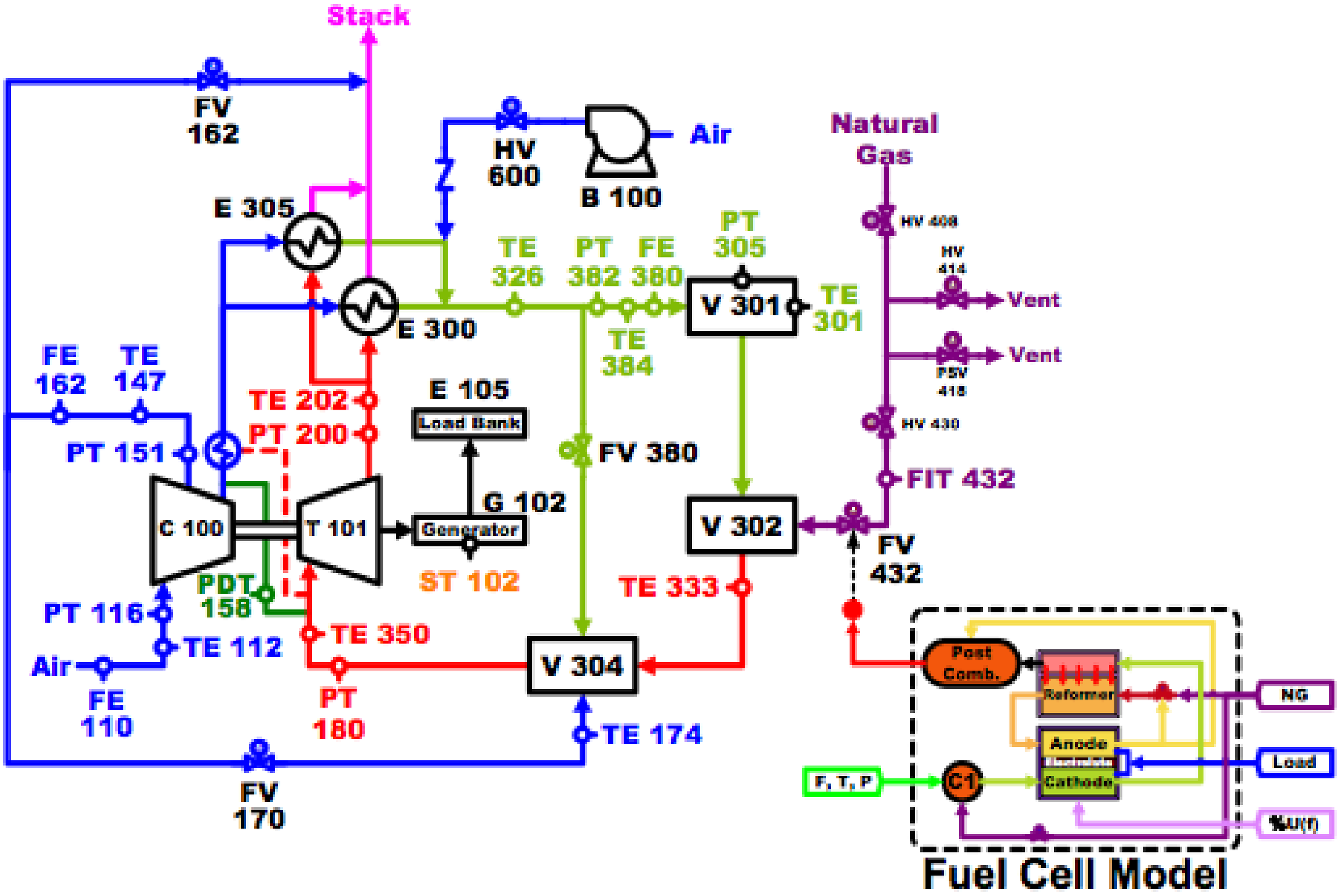


Collective construction problem



High Performance Project




Stack
FV
162
HV
600
Air
B 100
Natural
Gas
E 305
PT
305
TE
326
PT
382
FE
380
HV 408
HV
414
Vent
E 300
V 301
TE
301
TE
384
FE
162
TE
147
TE 202
PT 200
E 105
Load Bank
Vent
PSV
418
HV 430
PT 151
FV 380
FIT 432
G 102
C 100
T 101
Generator
V 302
FV
432
ST 102
PDT
158
TE 333
PT 116
TE 112
TE 350
Air
FE
110
PT
180
V 304
TE 174
FV
170
Post
Comb.
Reformer
NG
Anode
Load
F, T, P
C1
Cathode
%U(t)
Fuel Cell Model

Three Steps

FY 2012 ICE can mimic and follow MESA

FY 2013 ICE controls MESA Sensor and Control Strategies tested on ICE

FY 2014 Testing of new sensor and control strategies in the MESA-ICE facility