Advanced Fire Detection Concepts
Satellite and Non-Satellite Techniques

Scope of Task

- **Technical Scope: Identify alternative methods for detecting and monitoring wildfires**
- **Deliverable: 1st draft report describing alternative detection and monitoring methodologies**
- **Period of Performance: now until September 30**
- **Team:**
  - **Tony Vodacek**
  - **John Schott**
  - **Bob Kremens**
  - **Scott Brown**
  - **Rolando Raqueno**
  - **Lee Sanders (ERIM)**
  - **Graduate student gang: Stef, Dom , Andy**

We will investigate the physical effects of fire and discuss feasibility with the forest fire community

Characterize physical parameters (T, EM and gaseous emissions) of forest fires

Conduct literature search of alternative methodologies

Discuss feasibility and utility of techniques with fire community (USFS, NIFC, etc.)

Identify alternative concepts and develop evaluation plan for each concept

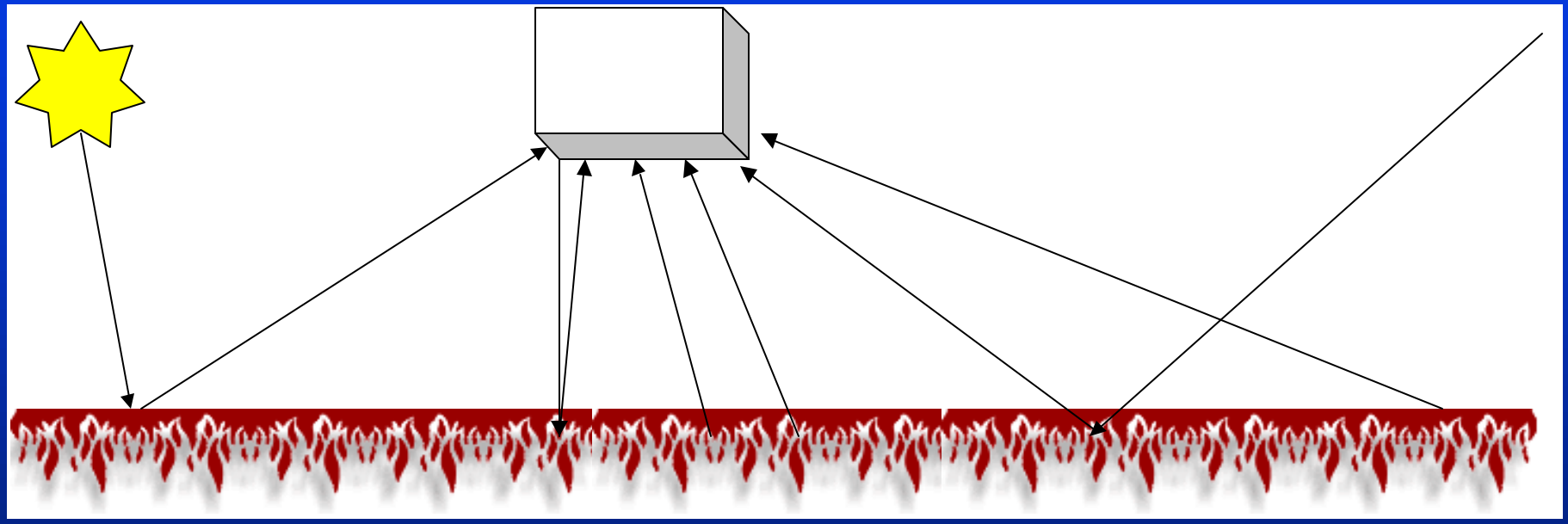
Model, simulate, and develop proof-of-principle prototypes to test effectiveness and feasibility

Year 1, Phase II → **Year 2** →

Phenomenology of Fires

- The physical characteristics of fires will be identified
  - Electromagnetic energy spectra
    - » Thermal
    - » Narrow emission lines (high spectral energy density)
    - » radio waves (microwave, and lower frequencies, passive and active)
  - Gaseous and particulate emissions
    - » Combustion products
      - Smoke (particulates)
      - CO_2
      - Water vapor
    - » Products of pyrolitic reactions
    - » Post-fire residues
  - Probe techniques
    - » Optical probes (laser induced fluorescence, lidar, reflectometry, IR, visible)
    - » RADAR
    - » Chemical probes

Wildland fire produces a wealth of detectable phenomena



- EM emissions from UV to Radio, gaseous and particulate products, and modification to the local environment

Specific questions….

•Optical (UV to LWIR) :

Are we missing anything? Combinations of wavelengths? Change algorithms?

•Passive microwave:

With current noise figures, can the thermal signature at some wavelength be detected? Is the atmosphere transparent to this frequency?

•Gaseous emissions:

What are the primary gaseous decomposition products prior to a fire? Can these be detected by LIF or other methods? Does the high concentration of CO_2, CO and H_2O near a fire change the scene at any wavelength in a useful way? Can gaseous absorption features be used in concert with other detection methods?

Specific questions….(2)

- **Smoke and particulates:**

Can smoke be detected more easily that fires? Is woodland smoke peculiar to the woodland, or is all smoke about the same?

- **Radioactivity?**

Plants sequester many elements in concentrations up to 10^9 times that found in their environment (e.g. tobacco and Am^{241}) Is there a detectable radioactive release of these sequestered materials upon combustion?

We are investigating previous detection techniques from many fields

- An extensive literature search is being performed in the following disciplines:
  - Optical methods
    - » Smoke detectors
    - » Optical emissions
      - Previous satellite efforts in the IR and visible
      - Line emissions
      - Unique combinations of optical signatures
  - Materials evolved from combustion
    - » Gas detectors (hydrocarbon detectors - CO to complex HC)
    - » Particulates (smoke detectors, non-optical)
  - Radio frequency techniques
    - » RADAR reflection cross sections for low temperature (~1000K) fires (Veridian)
    - » Passive microwave (weapons fusing)

Detector concepts will be developed for the most promising fire phenomena

- Likely detection methods and combinations of methods will be developed
- Interaction with fire fighting community essential to provide user with desired tools
- System engineering - The needs of the community should be met by an understanding of integrated communication, deployment, field use models, etc.

Mathematical sensor models will be constructed and several prototypes built

- Known stimuli (from measurements) will be applied (in simulation) to promising sensors (plume models applied later)
- Continue physical characterization of burning biomass
  - Local controlled burns (Ft. Drum, Finger Lakes National Forest)
  - At USFS Firelab in Missoula, MT
- Low cost proof-of-principle prototype will be constructed (as student project) and tested at controlled burn

Our deliverable (report) will have the following format:

- A section covering the basic physics of fires
- Analysis sections with the following form:
  - Emission/phenomena physical background (~few paragraphs)
  - Literature search results
    - » Cited references
    - » Copies of relevant seminal papers
  - Back-of-the-envelope calculations for the phenomena,
    - » e.g., there is a plume of CO at a 10 ha fire of XX ppm. Present cheap detectors detect CO at the 0.0YY ppm level. What is the range of a CO detector on a fire of this size?
  - Feasibility projection

Example: radio-linked aircraft-deployed smoke detector

- Conventional ionization chamber smoke detector
- False alarm prevention (CO monitor?)
- Low data rate radio link
- Reports to field deployed central transmitter
- Inexpensive (< $75)
- CE Student senior project (A. Seema), maybe with LACOMS