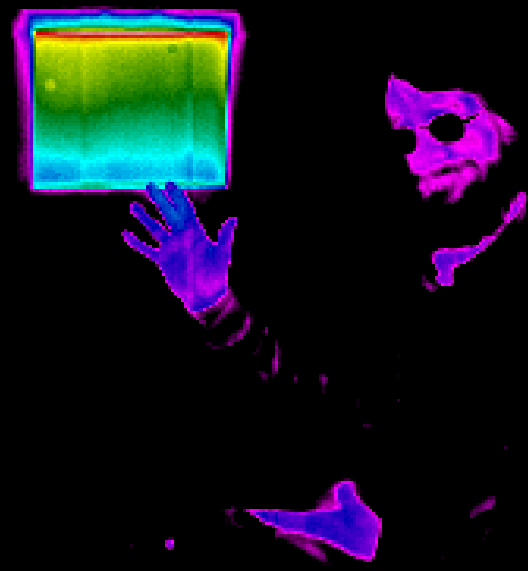
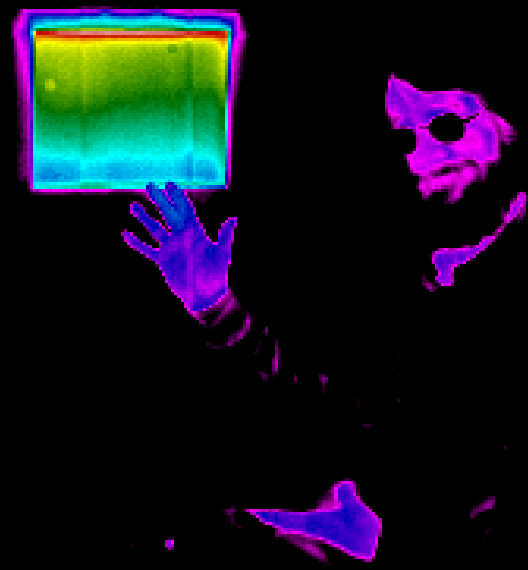


Greg Barker, MEP
Paul Norton, NERD
C.E. Hancock, MEP

# ANALYSIS DRIVEN FIELD TESTING

Building America Residential Energy Efficiency Stakeholder Meeting
Austin, TX March 2, 2012



Greg Barker, MEP
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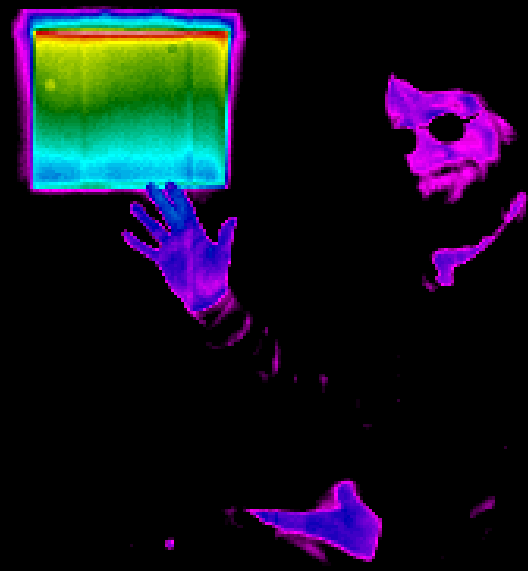
# MODELING DRIVEN FIELD TESTING

Building America Residential Energy Efficiency Stakeholder Meeting
Austin, TX March 2, 2012



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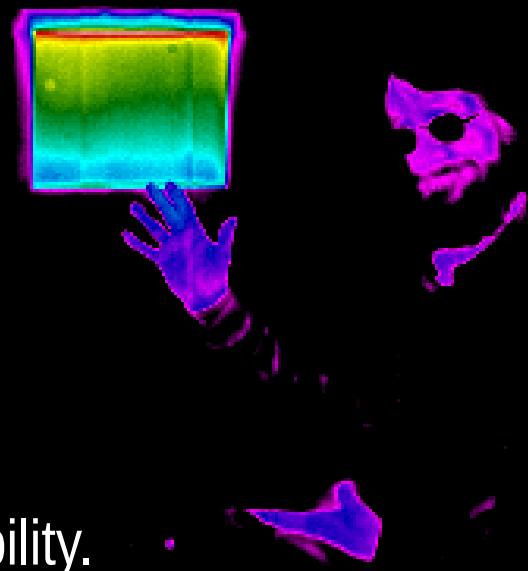
# MODELING DRIVEN MEASUREMENTS

Building America Residential Energy Efficiency Stakeholder Meeting
Austin, TX March 2, 2012

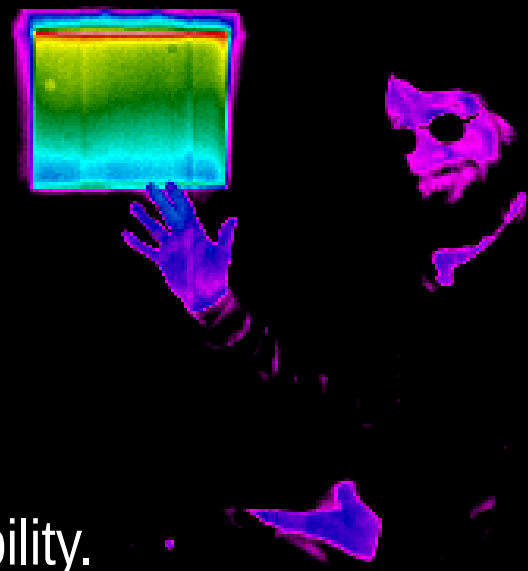


"Modeling without measuring lacks credibility.
Measuring without modeling lacks generality."

Ed Hancock

# MODELING DRIVEN MEASUREMENTS

Building America Residential Energy Efficiency Stakeholder Meeting
Austin, TX March 2, 2012



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# ANALYSIS DRIVEN FIELD TESTING

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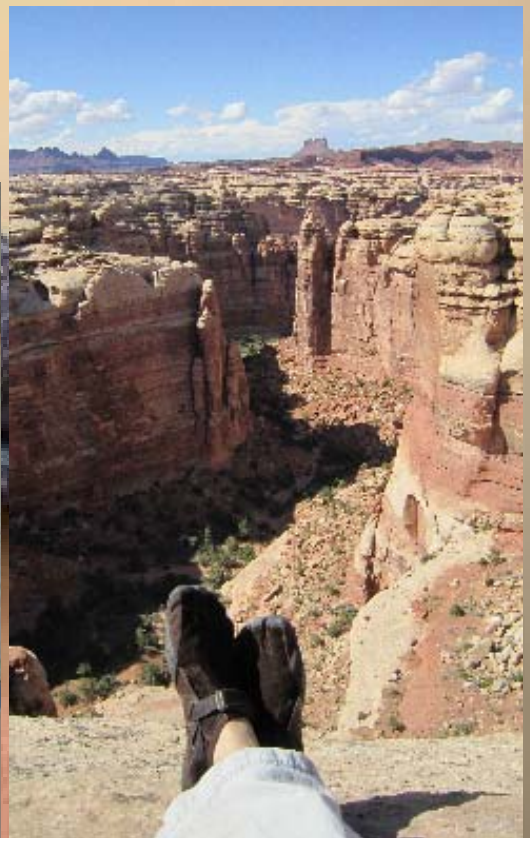
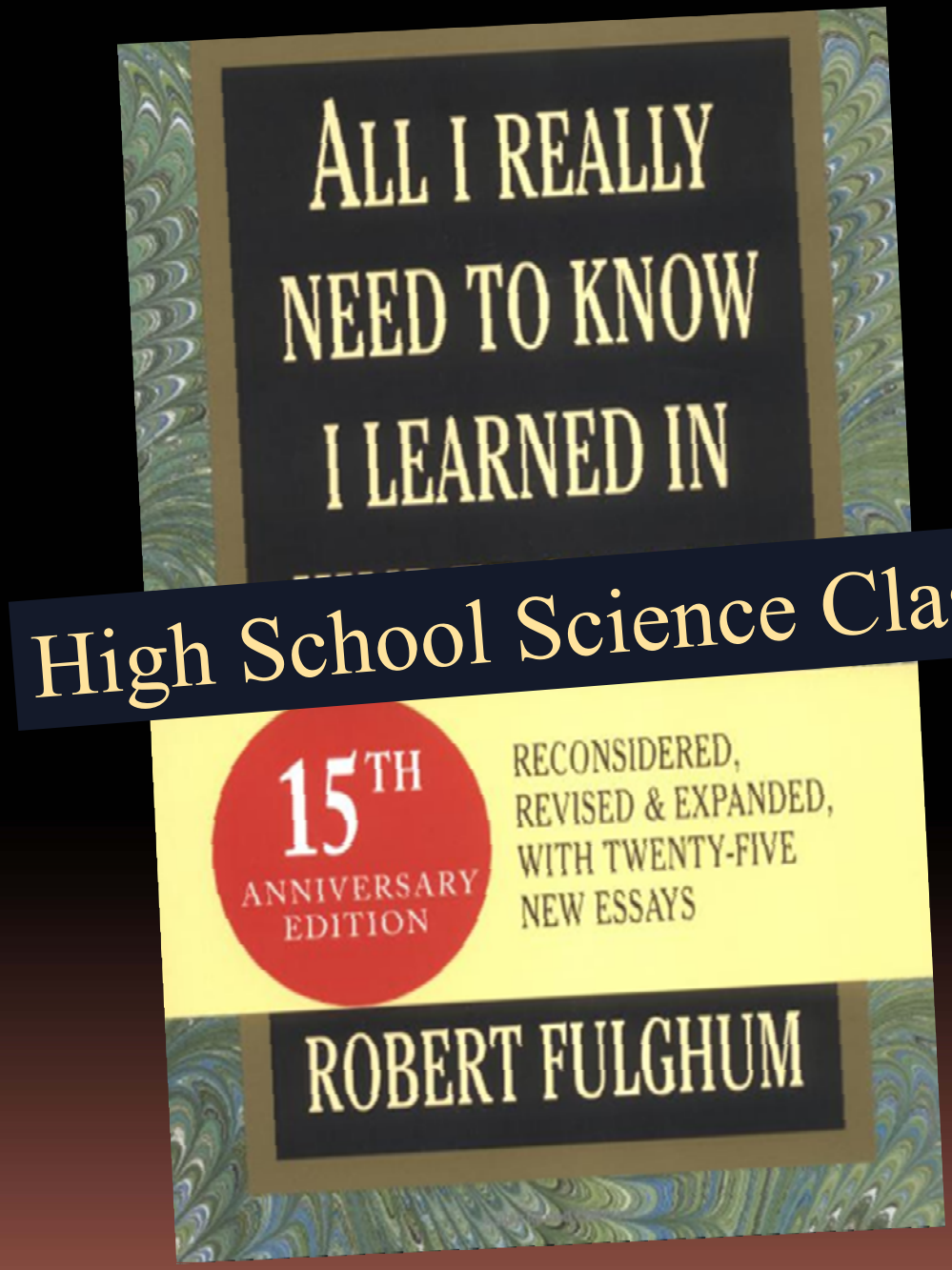
Inspiration
NEXT EXIT






# High School Science Class

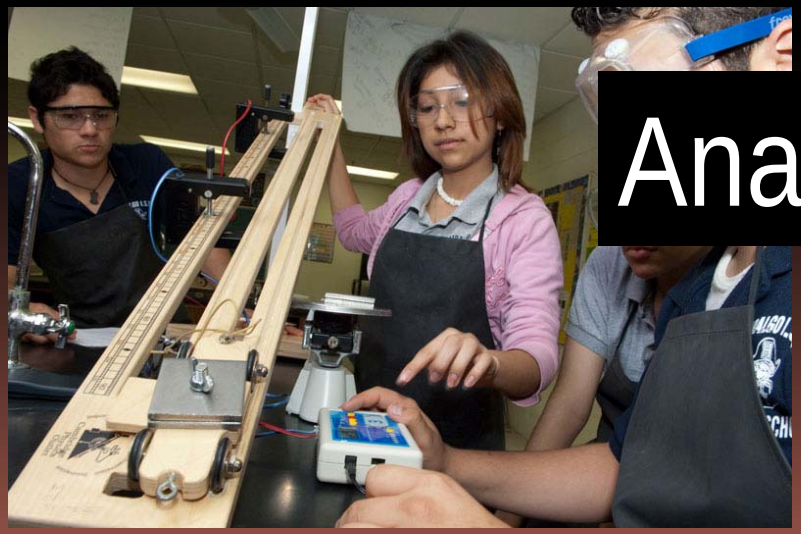
Question

Research

Hypothesis

Analysis

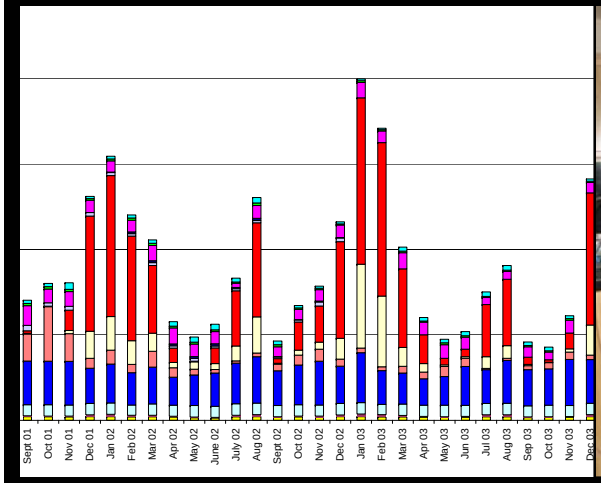
Experiment



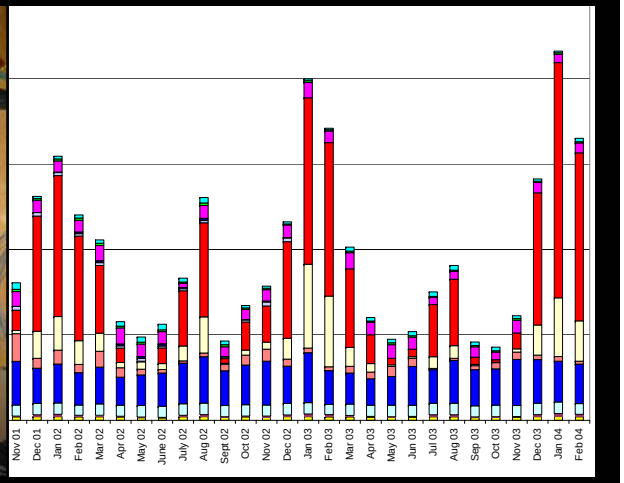
Analyze Results

Conclusion

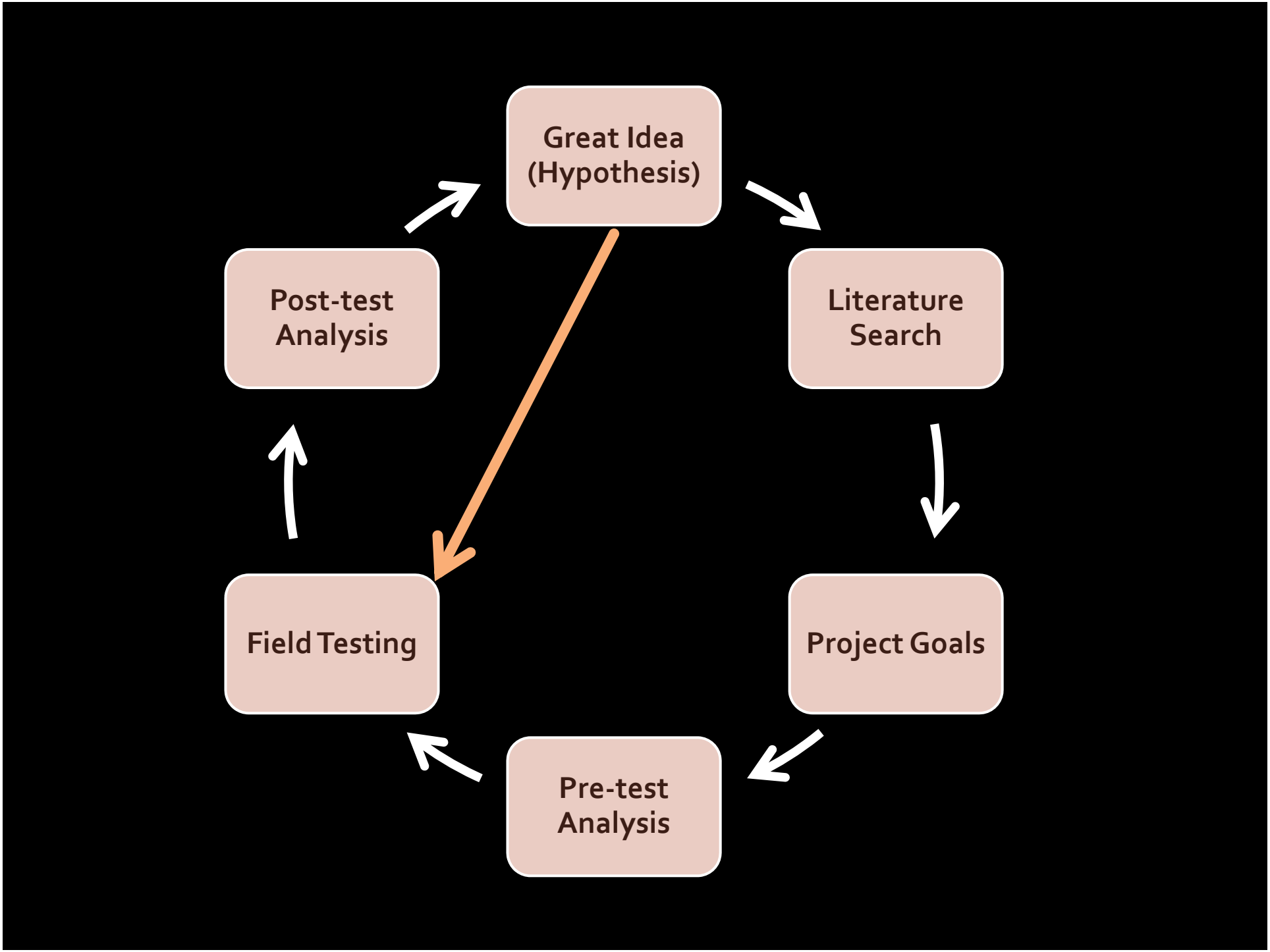
# Analtestysis

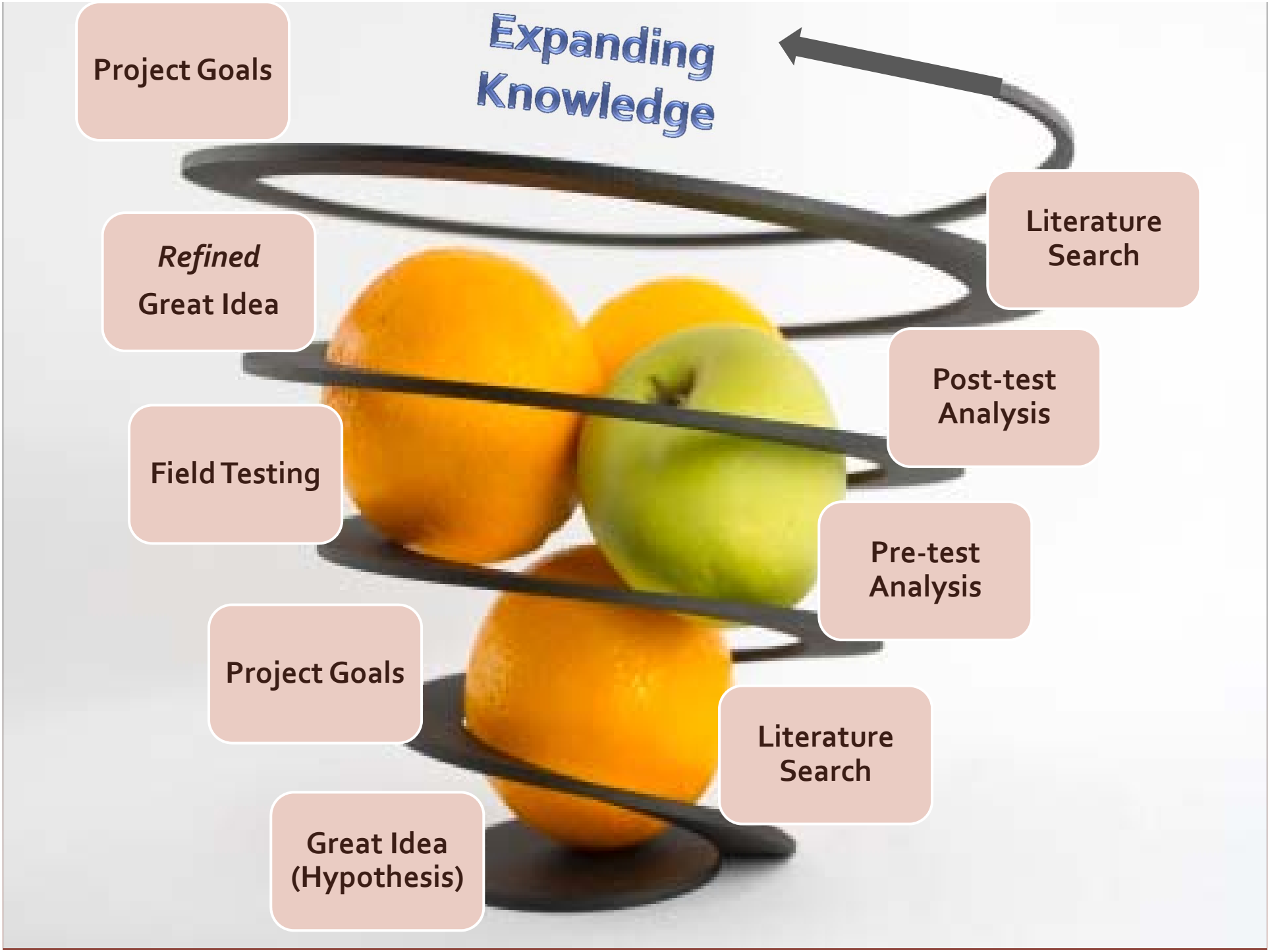







# Analtestysis


Great Idea (Hypothesis)
Literature Search
Project Goals
Pre-test Analysis
Field Testing
Post-test Analysis


Expanding Knowledge
Project Goals
Literature Search
*Refined* Great Idea
Post-test Analysis
Field Testing
Pre-test Analysis
Project Goals
Literature Search
Great Idea (Hypothesis)

Great Idea
(Hypothesis)

Literature Search

Current level of knowledge

Best models or analysis approaches available

The BIG PICTURE

What are we trying to achieve?

Detailed research questions *flow from* the project goals

## Develop a Mathematical Representation

Determine feasibility of the idea

Determine what needs to be measured and controlled to compare to model

What time scale is required for the tests and measurements?

Is the performance sensitive to occupant behavior?

Pre-test Analysis

How will the data be analyzed? “Begin with the end in mind”

“Normal operation” may not be appropriate

Full subsystem characterization or spot check against published performance data?

Field Testing

Pay attention…..
pay attention….
pay attention….
to the data

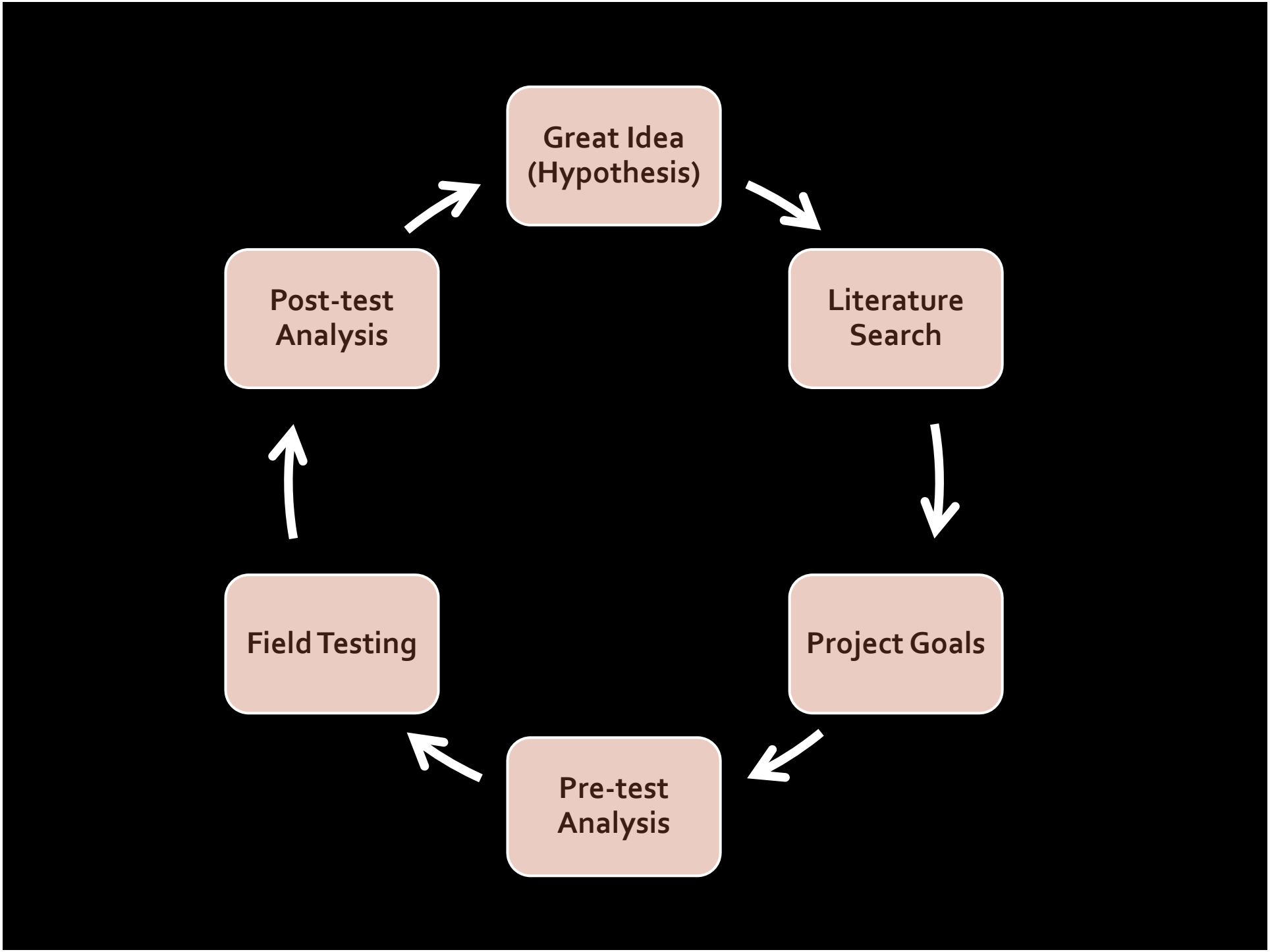

Compare model and measurements

Use measurements to improve the model

Generalize the results

What if? scenarios

Propose improvements to the idea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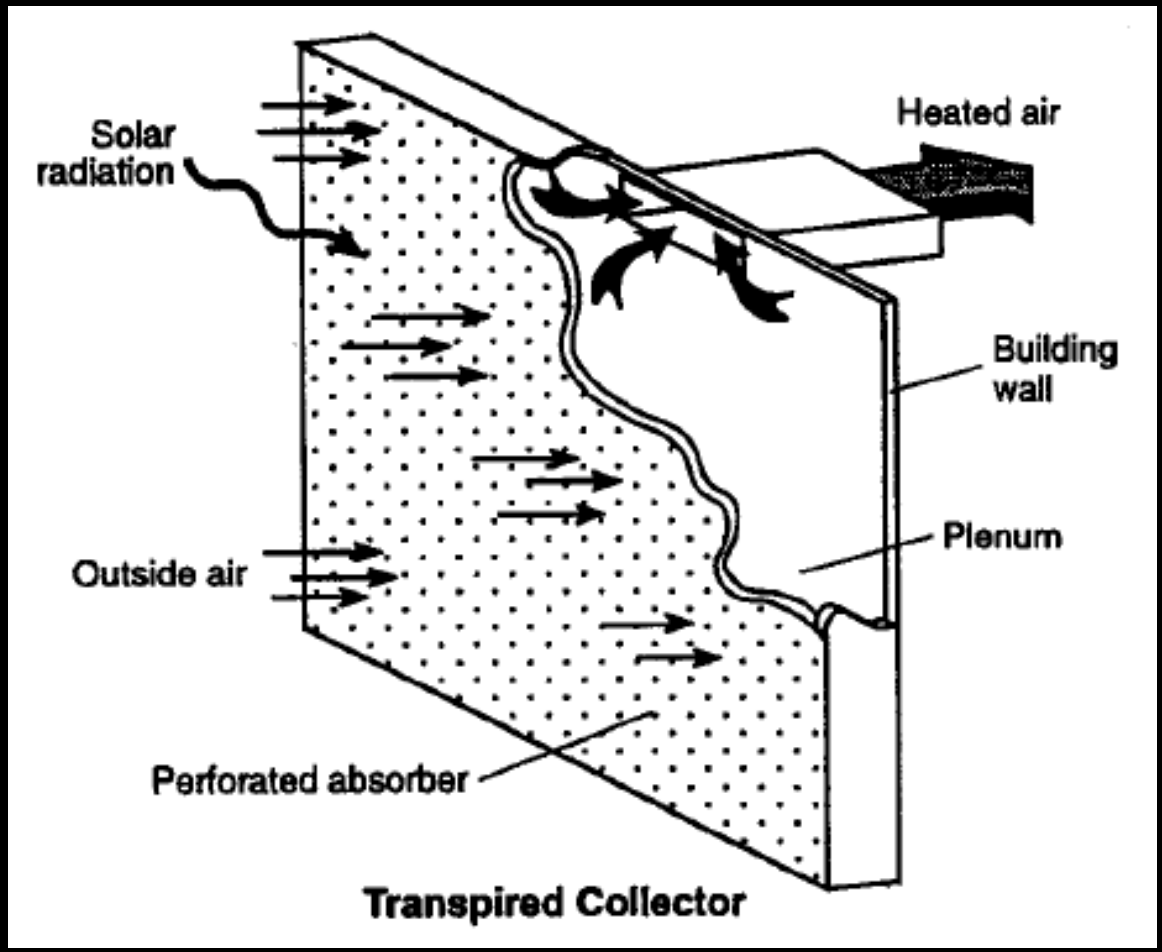
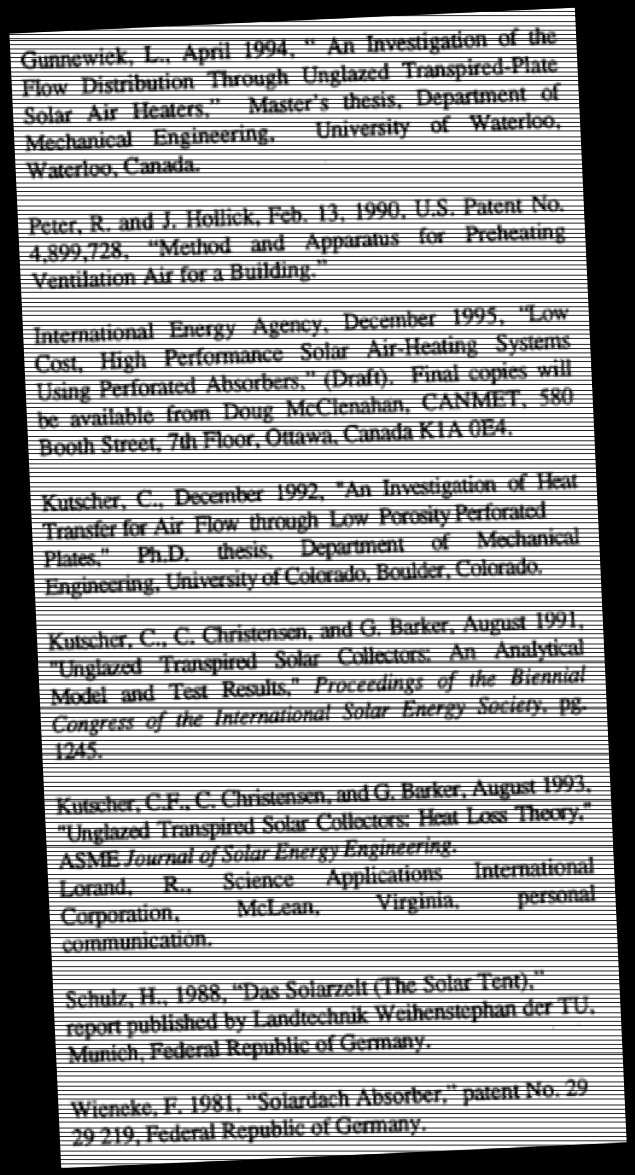
Great Idea (Hypothesis)



## Literature Search




Gunnewiek, L., April 1994, " An Investigation of the Flow Distribution Through Unglazed Transpired-Plate Solar Air Heaters," Master's thesis, Department of Mechanical Engineering, University of Waterloo, Waterloo, Canada.

Peter, R. and J. Hollick, Feb. 13, 1990, U.S. Patent No. 4,899,728, "Method and Apparatus for Preheating Ventilation Air for a Building."

International Energy Agency, December 1995, "Low Cost, High Performance Solar Air-Heating Systems Using Perforated Absorbers," (Draft). Final copies will be available from Doug McClenahan, CANMET, 580 Booth Street, 7th Floor, Ottawa, Canada K1A 0E4.

Kutscher, C., December 1992, "An Investigation of Heat Transfer for Air Flow through Low Porosity Perforated Plates," Ph.D. thesis, Department of Mechanical Engineering, University of Colorado, Boulder, Colorado.

Kutscher, C., C. Christensen, and G. Barker, August 1991, "Unglazed Transpired Solar Collectors: An Analytical Model and Test Results," *Proceedings of the Biennial Congress of the International Solar Energy Society*, pg. 1245.

Kutscher, C.F., C. Christensen, and G. Barker, August 1993, "Unglazed Transpired Solar Collectors: Heat Loss Theory," ASME *Journal of Solar Energy Engineering*.

Lorand, R., Science Applications International Corporation, McLean, Virginia, personal communication.

Schulz, H., 1988, "Das Solarzelt (The Solar Tent)," report published by Landtechnik Weihenstephan der TU, Munich, Federal Republic of Germany.

Wieneke, F. 1981, "Solardach Absorber," patent No. 29 29 219, Federal Republic of Germany.

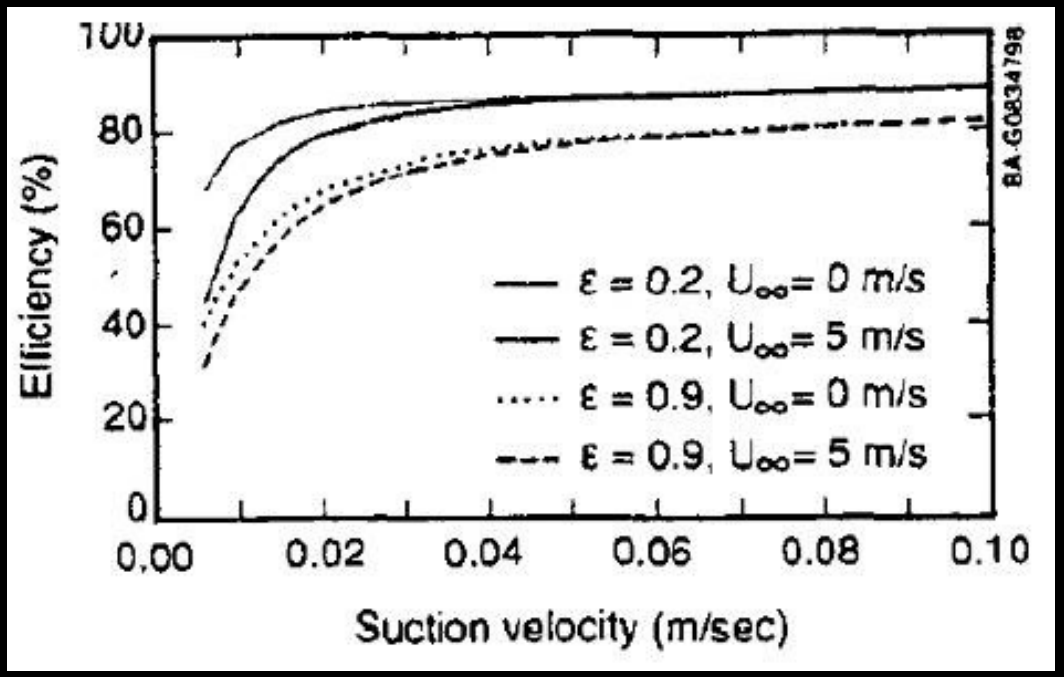

Research at NREL began with a literature search. This revealed a considerable number of articles on glazed matrix absorbers for heating recirculating air. There were also two German concepts of interest: an unglazed perforated roof absorber for heating ventilation air (Wieneke, 1981) and an unglazed fabric absorber used to heat air for crop drying (Schulz, 1988). We could find no information on the physical theory or performance of a thin, unglazed, transpired absorber for once-through air heating.

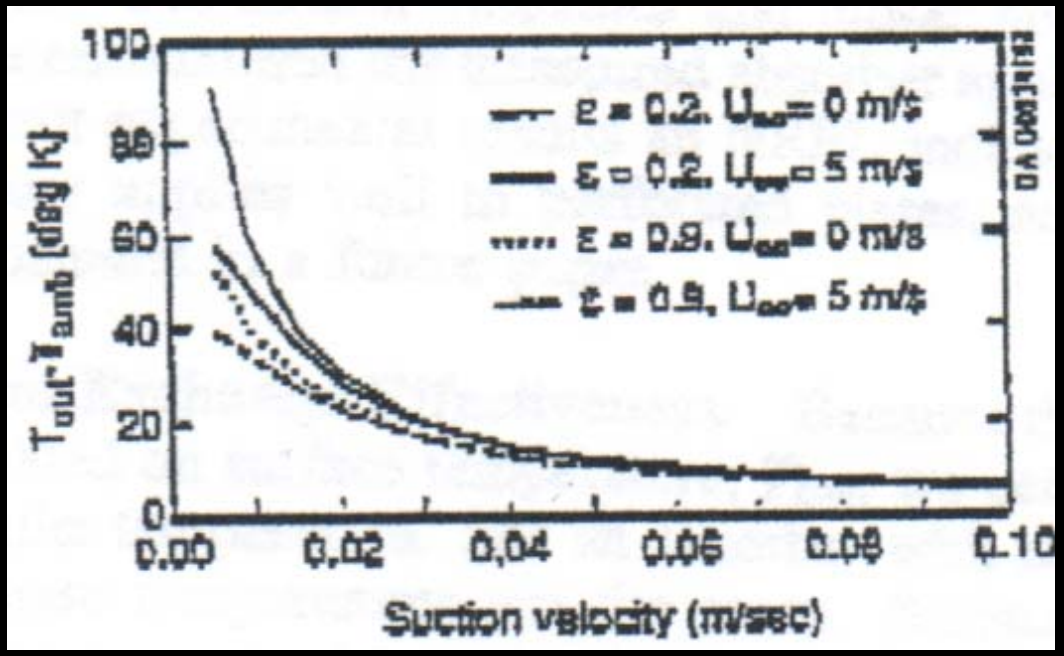
"We could find no information on the physical theory or performance of a thin, unglazed, transpired absorber for once-through air heating"

**Project Goals**

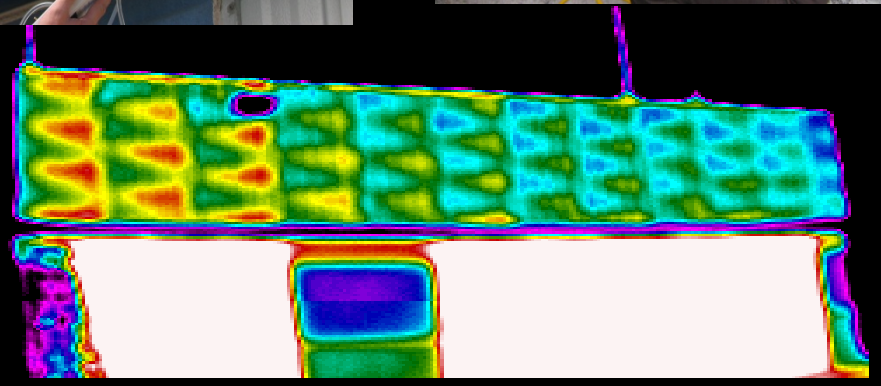
Develop a method
to predict the performance of
transpired collectors under
various weather conditions
and collector geometry

Pre-test Analysis



Field Testing



## Post-test Analysis

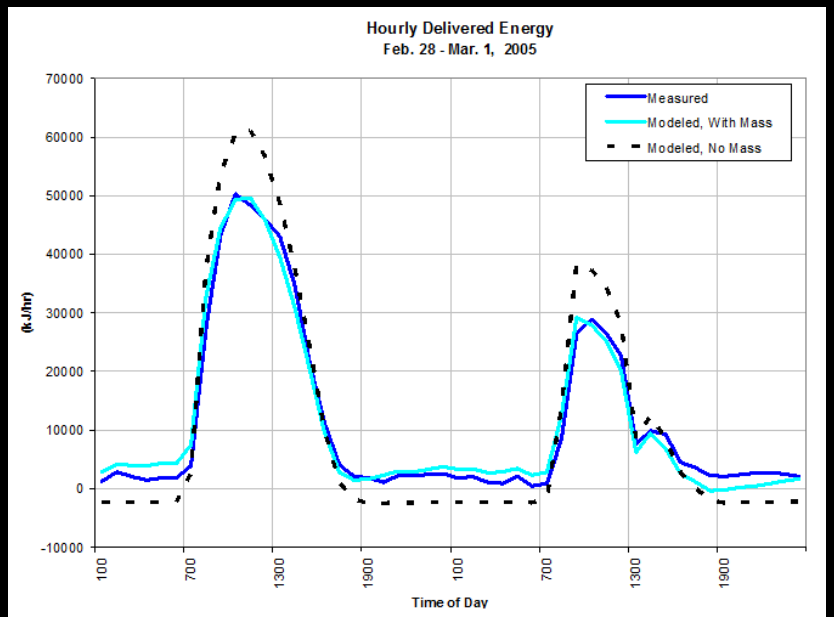
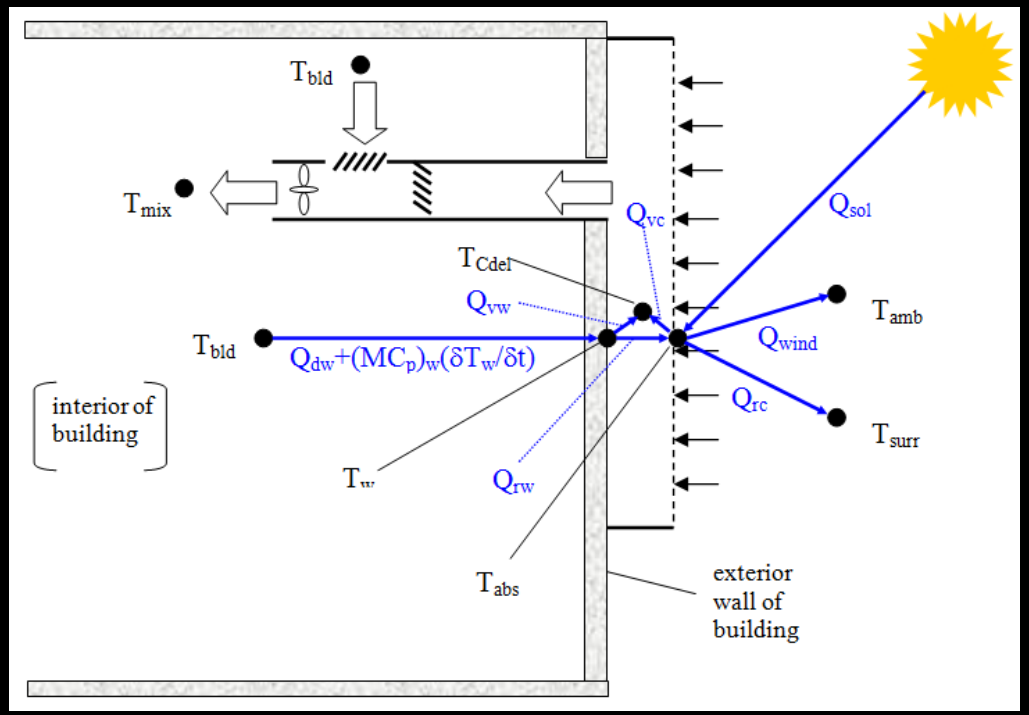
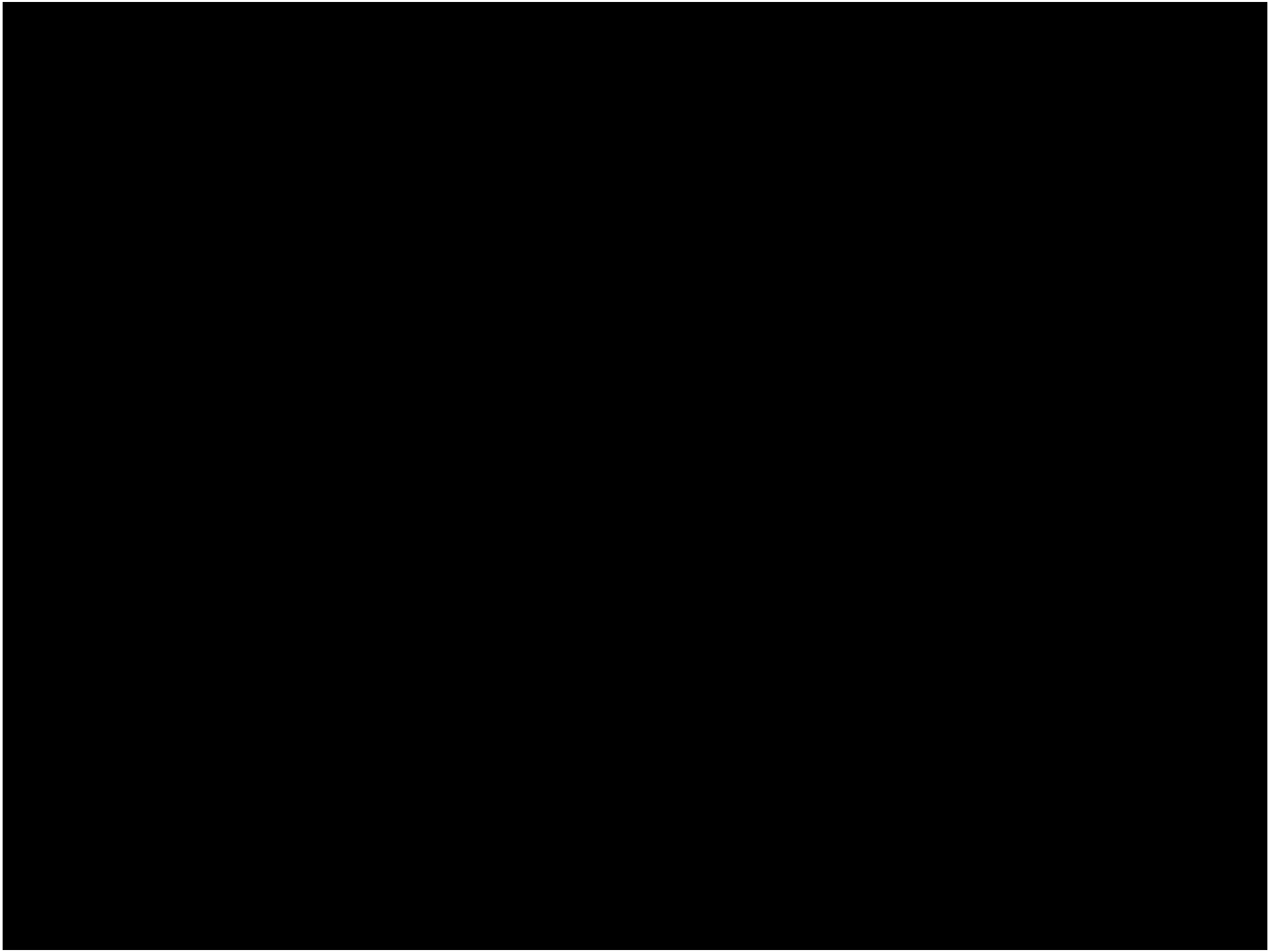
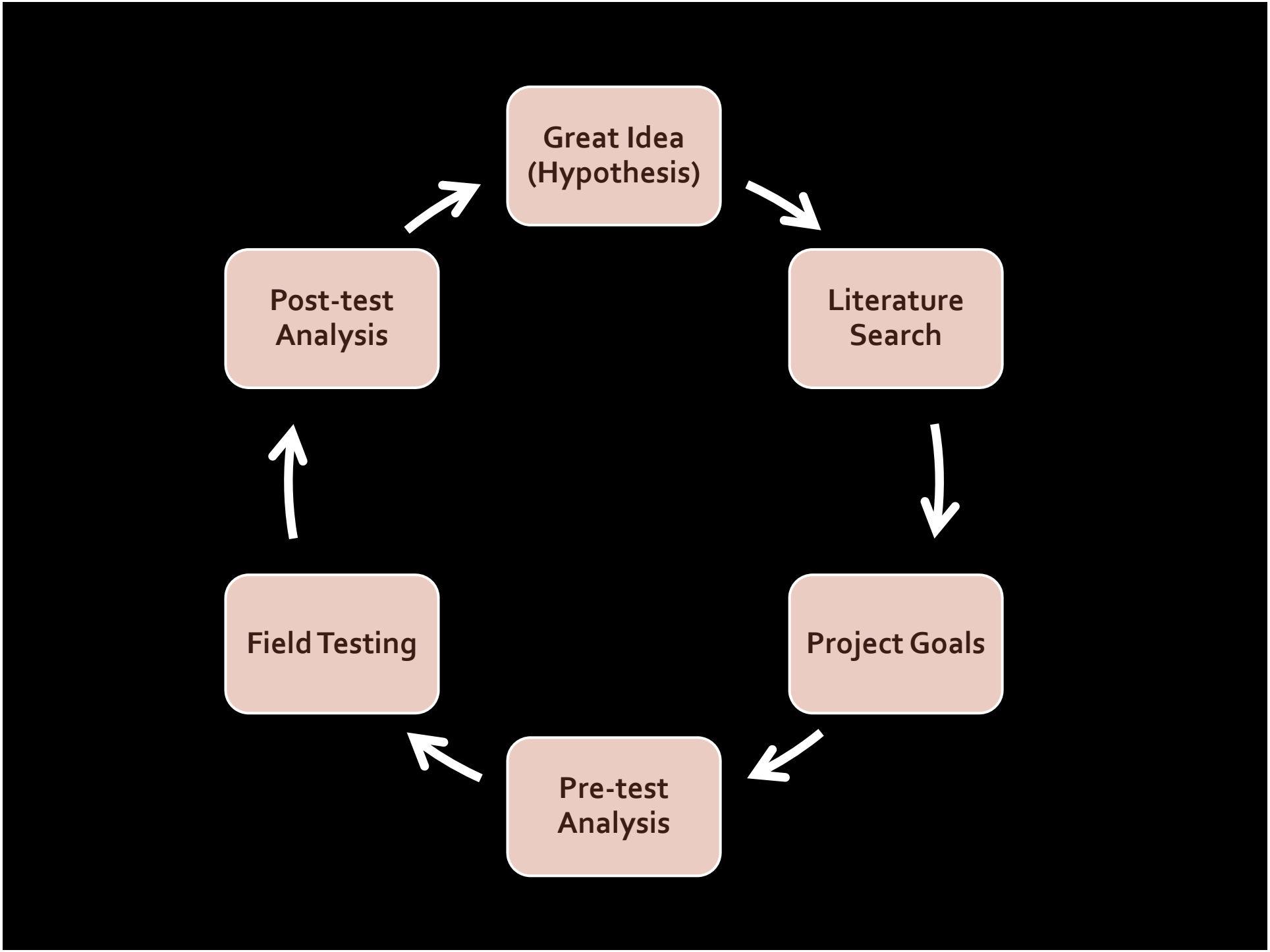



Fig. 7 Comparison of measured to modeled Qdel for the last 2 days of February, 2005.



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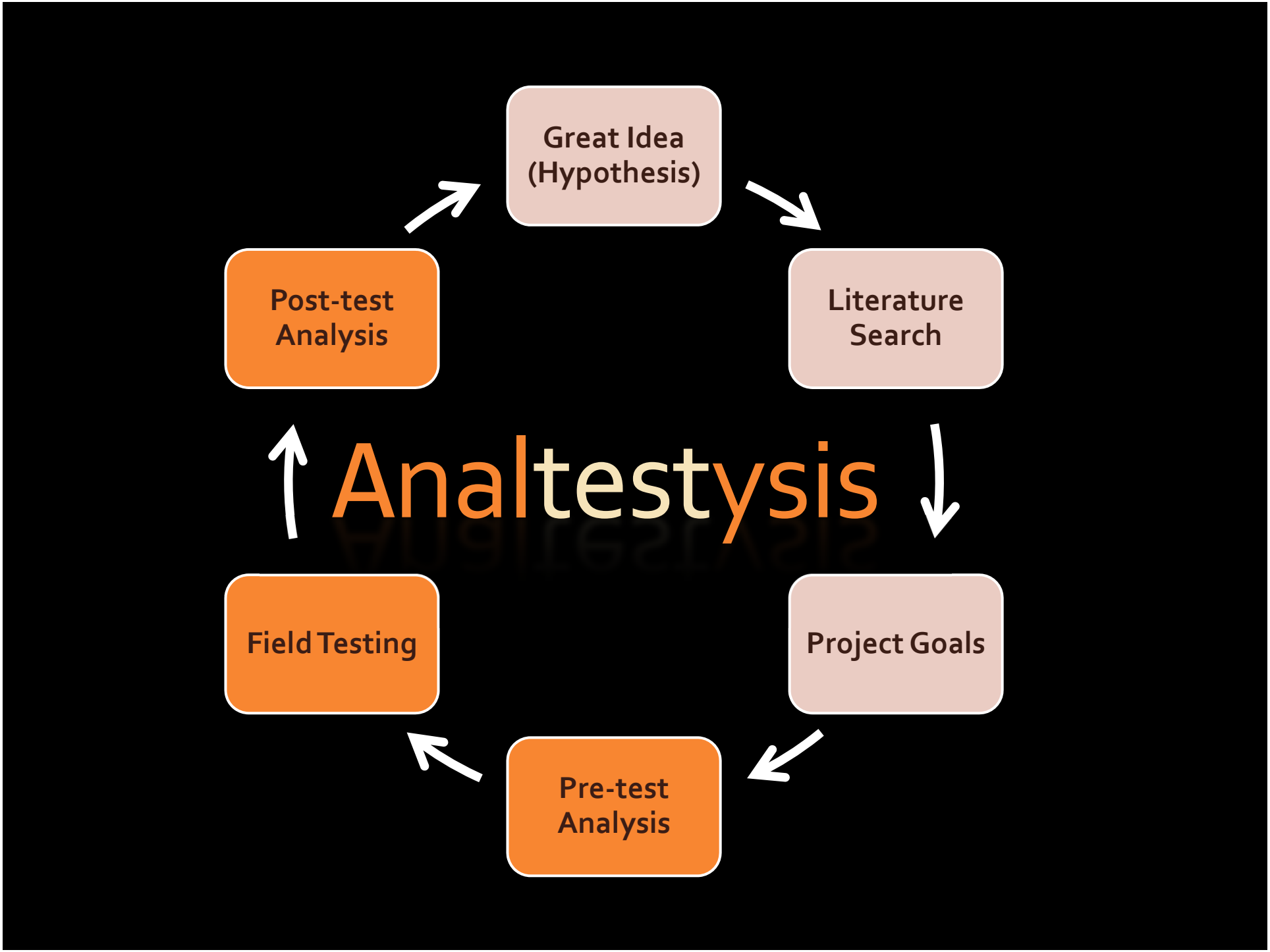
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Post-test Analysis
Analtestysis

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Modeling


Measuring

Modeling early provides insight into the measurements needed

*Abnormal* operation during testing may be the best way to compare measured and modeled results

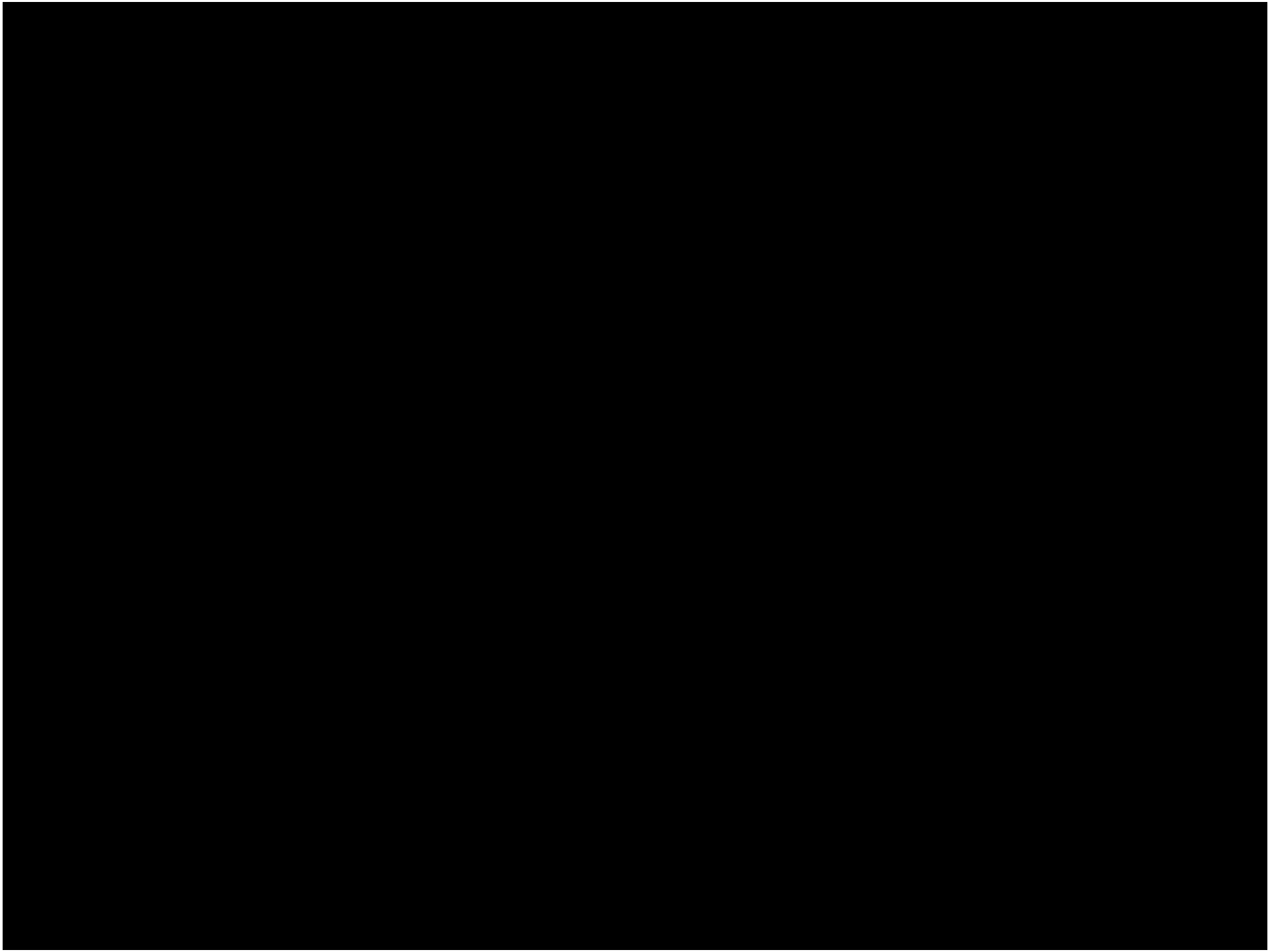
*Pay Attention*!...
…to the data – *especially* at the beginning

Questions

Comments

Advice

Stories



# Integrated Analysis, Testing, and Monitoring Approach

**Design**

- Analyze proposed design options
- Select targeted systems
- Establish expected performance

**Test**

- Write test plan
- Conduct field/lab tests
- Measure system performance
- Collect data to improve analysis results

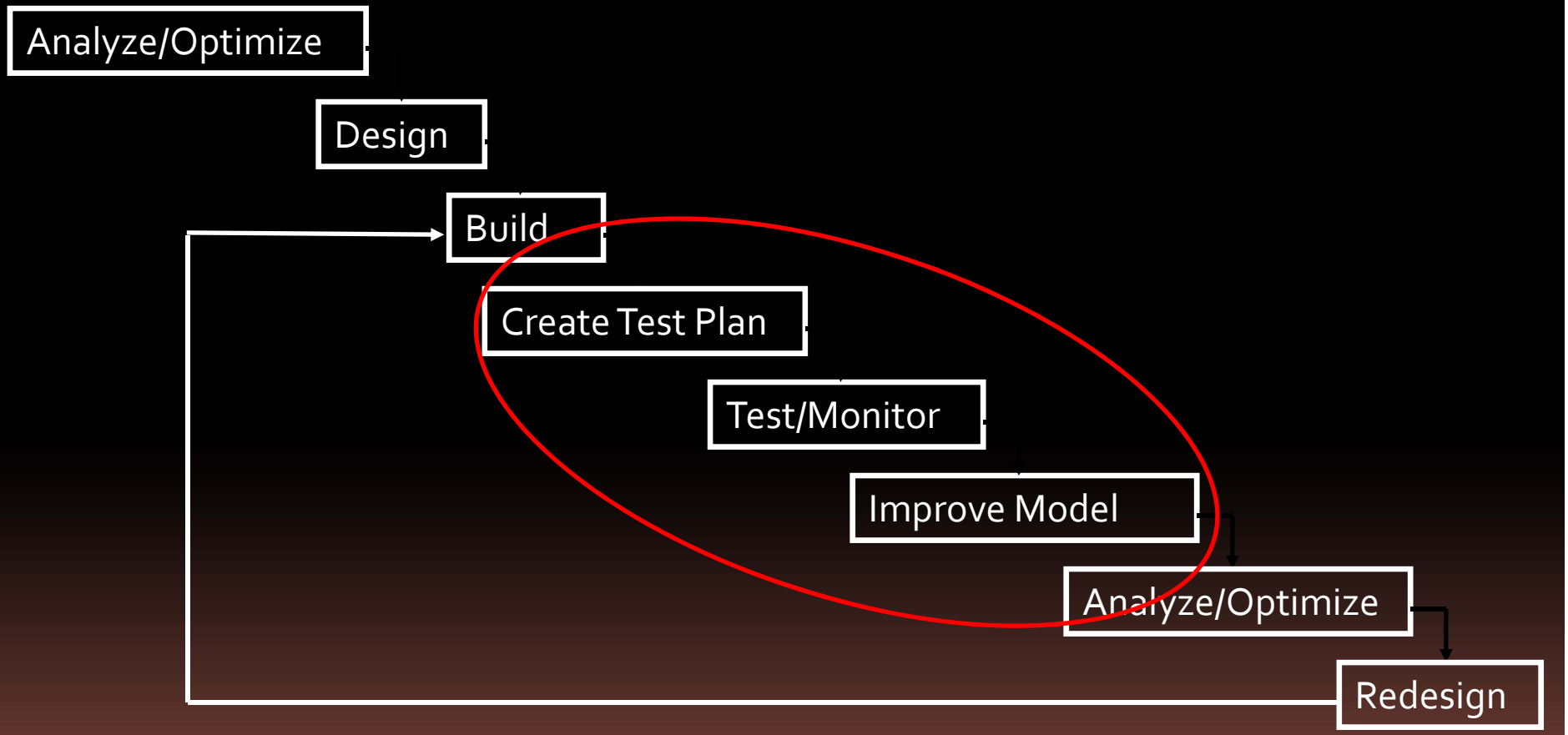
**Redesign**

- Develop “tuned” models
- Redesign systems to improve performance

**Retest**

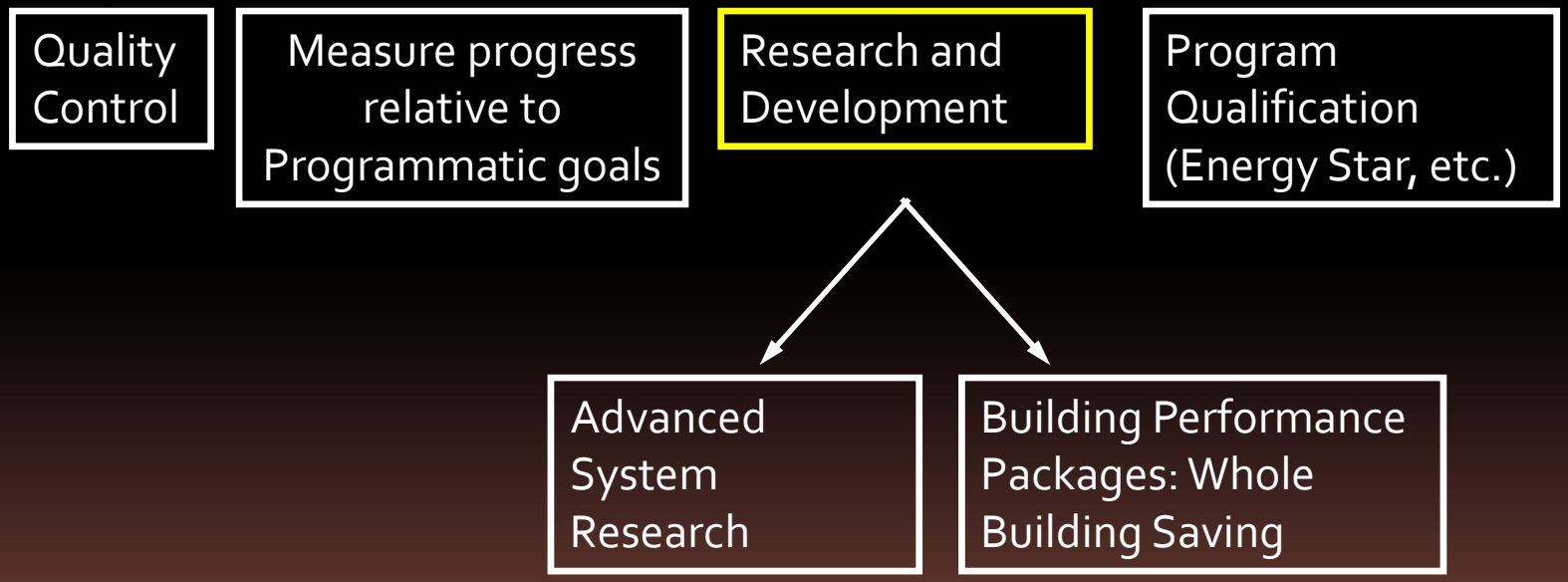
- Confirm performance improvements
- Reject system options that cannot meet performance requirements

# Integrated Analysis, Testing, and Monitoring Approach



# Monitoring and Testing Approaches are united to support multiple goals

## *Why test and monitor buildings?*



# Short-term Tests

Specific tests of components, systems or whole buildings:

- Can test performance to evaluate issues that have higher uncertainty for simulations
- Many performance issues can be characterized in a relatively short test
- Can provide Quick feedback on system performance.
- Short tests can specifically characterize the performance of unoccupied building and systems under our controlled protocol, not under the idiosyncratic control of random occupants.
- Short term tests may be repeated seasonally.

# Long-term monitoring

- Characterize occupant behavior and influence on performance
- Characterize seasonal performance changes
- Observe interaction of occupant with system controls
- Get actual energy use data
- Catch equipment operational problems or malfunctions
- Characterize realistic inputs for simulations