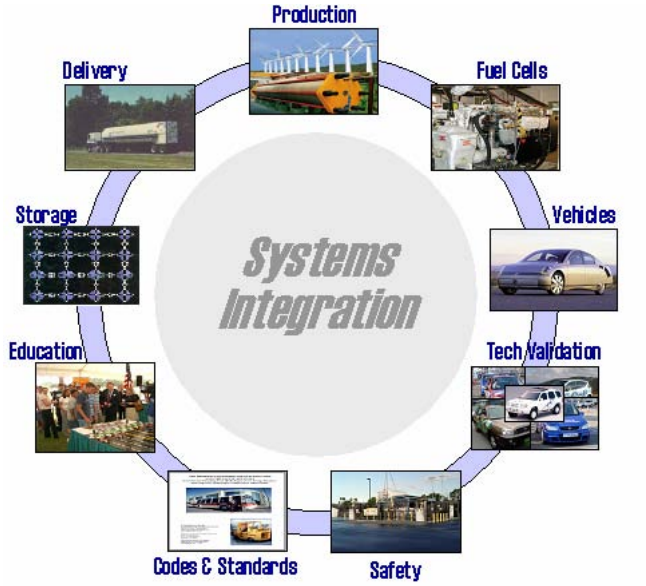
DOE Hydrogen Program

Macro-System Model



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May 26, 2005

This presentation does not contain any proprietary or confidential information

Project ID # ANP6

Overview

Timeline

- Start date: Feb 8, 2005
- End date: Continuing
- Percent complete: 1% (New Start)

Budget

- Total funding:
  - 100% DOE funded
- FY04 funding: $0
- FY05 funding: $250K

Barriers

- Lack of a Macro-System Model (C)
- Lack of understanding of the transition of a hydrocarbon-based economy to a hydrogen-based economy (E)

Partners

- Will be identified

Objectives

Develop a transition macro-system model (MSM) to support decisions regarding programmatic investments

- Investment levels
- Focus of funding
- Potential effects of funding changes

Why a transition model?

- Due to transitioning infrastructure, technology timing is critical for decision-making
- Necessary for conduct overarching and trade-off comparisons

Need for a MSM

Current Situation:

- Numerous element models
- Funding spread around
- PBA beginning to put H2 in NEMS
- Transition modeling emerging
- Feb 04 NRC recommendation

Feb 04 NRC Report

The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs:
"Systems modeling for the hydrogen supply evolution should be started immediately, with the objective of helping guide research investments and priorities for the transportation, distribution, and storage of molecular hydrogen."

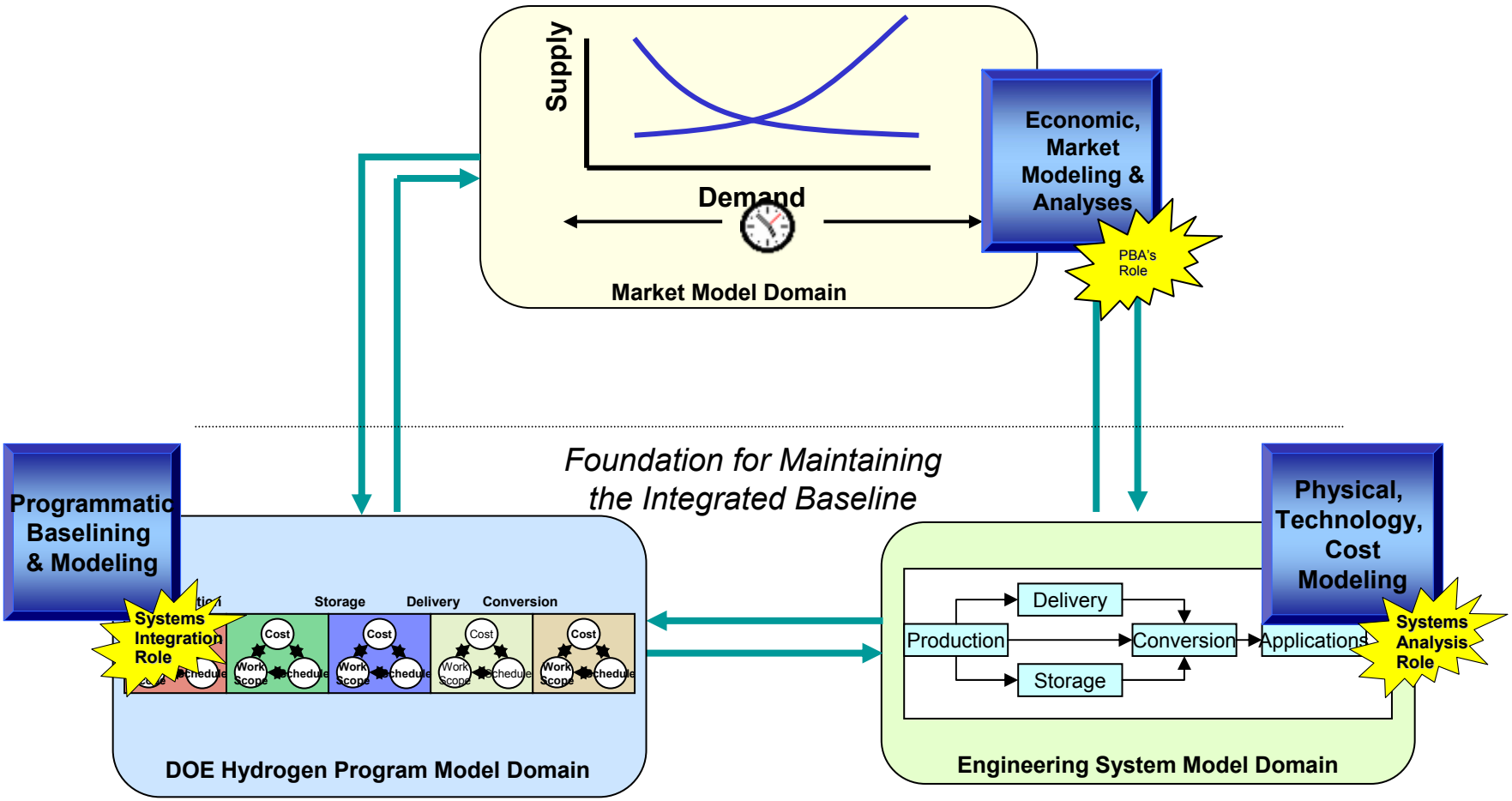
Need for a Modeling Effort:

- Support Systems Analysis, to help guide R&D
- Focused investment of DOE funding
- Standardization of element models
- Address the overall H2 infrastructure, particularly Transition
- Complementary to PBA models and to Integrated Baseline

2005 EERE Multi-Year RD&D Plan

Lack of a Macro-System Model. Although numerous models exist to analyze components and subsystems of an eventual hydrogen economy, a modeling architecture does not exist that addresses the overarching hydrogen fuel infrastructure as a "system." Such a macro-system model is critical to assessing the transition from the existing energy infrastructure to one including hydrogen. Individual models spanning a wide range of modeling platforms (operating systems, software, inputs, outputs, boundary conditions, etc.) must be integrated into a common macro-system model.

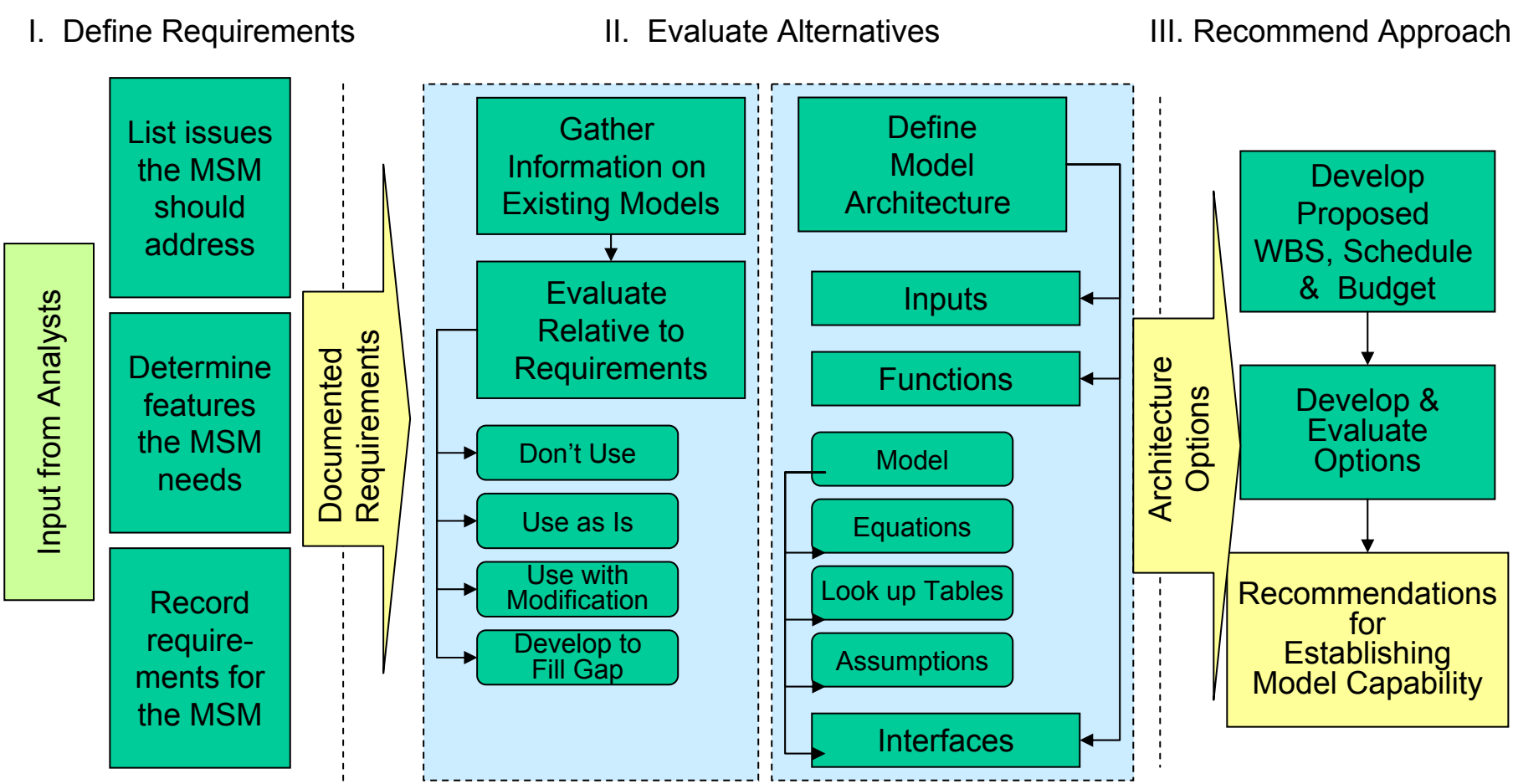
Role in EERE Modeling Domain



- **Macro-system model will simulate system performance and enable evaluation of components/interfaces from system level perspective**

Planning Approach

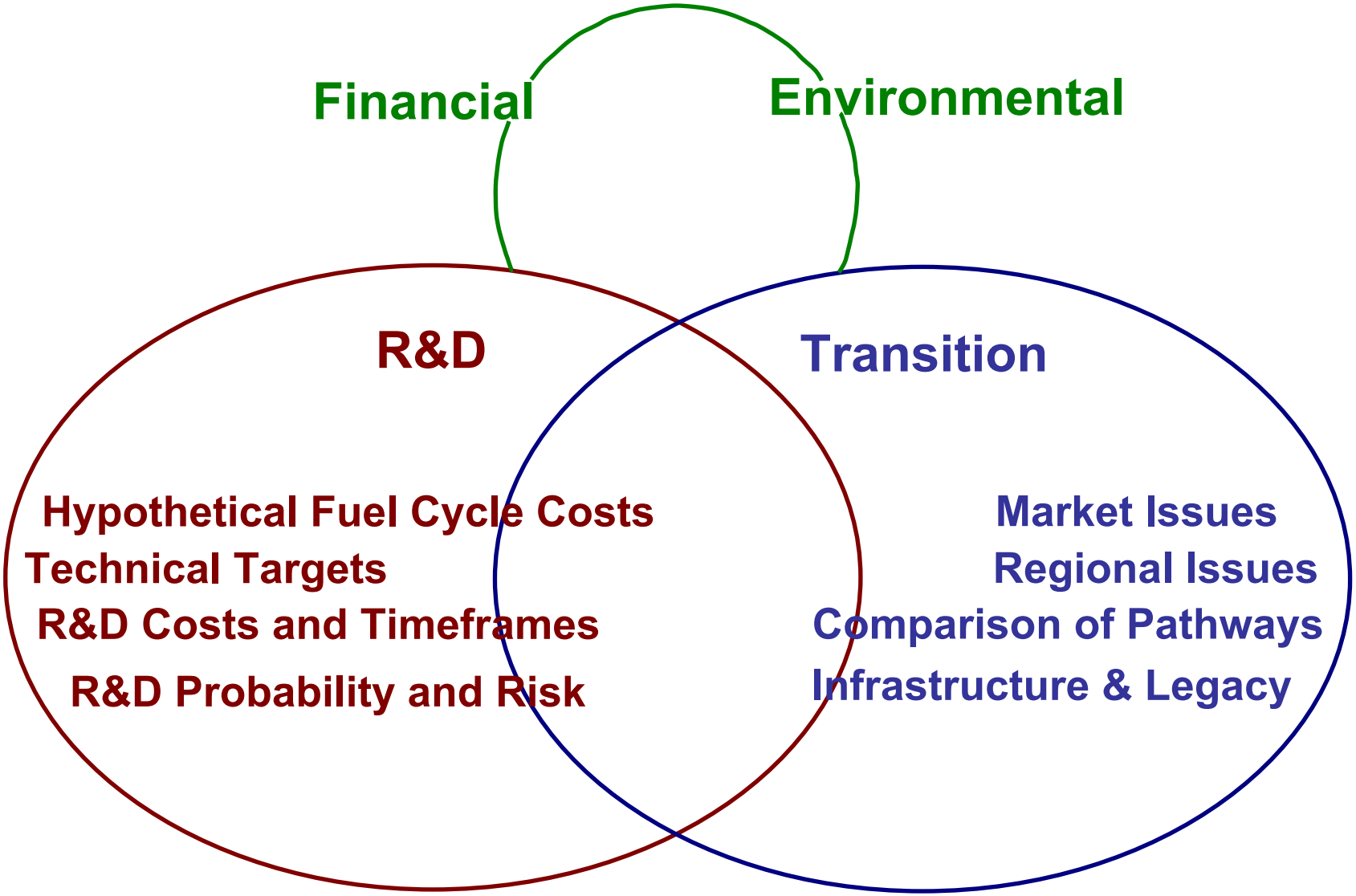
Planning according to systems engineering principles



Progress

- **Step I (defining requirements)**
  - **Developed straw-man list of issues the MSM must address**
    - **Analysts within the community will review and add to it**
  - **Developed list of features the MSM must have**
  - **Starting to list requirements**
    - **Output**
    - **Input / Integration**
    - **Functional (timeframes, data management system, etc.)**
    - **Non-functional (user interface, reports, etc.)**
- **Step II (evaluating alternatives)**
  - **Started gathering information on existing element models**
  - **Completed a Request for Information (RFI) for macro-system model architecture tools**
  - **Reviewed some additional potential tools that integrate distributed element models**

Issues the MSM Will Address



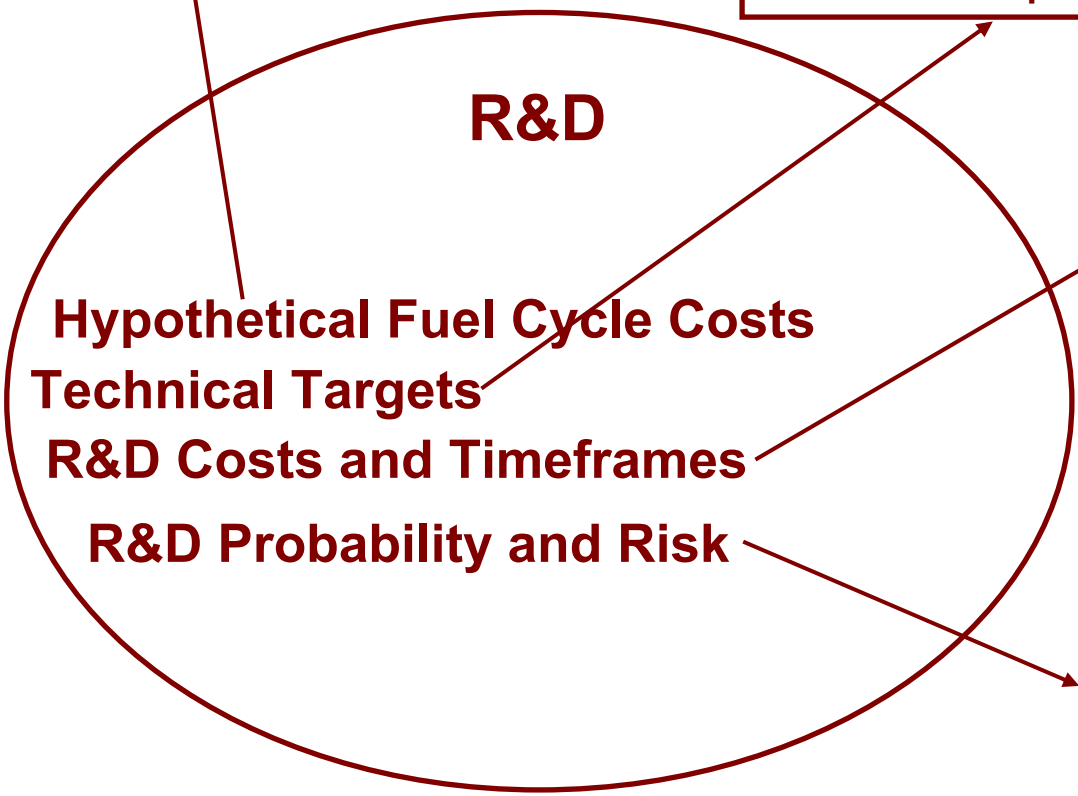
R&D Issues

Are the current technical targets the best ones?

What relationships and inter-dependencies do they have?

How should components and interfaces be optimized?

What is the full cost per mile driven and how will it evolve over time?

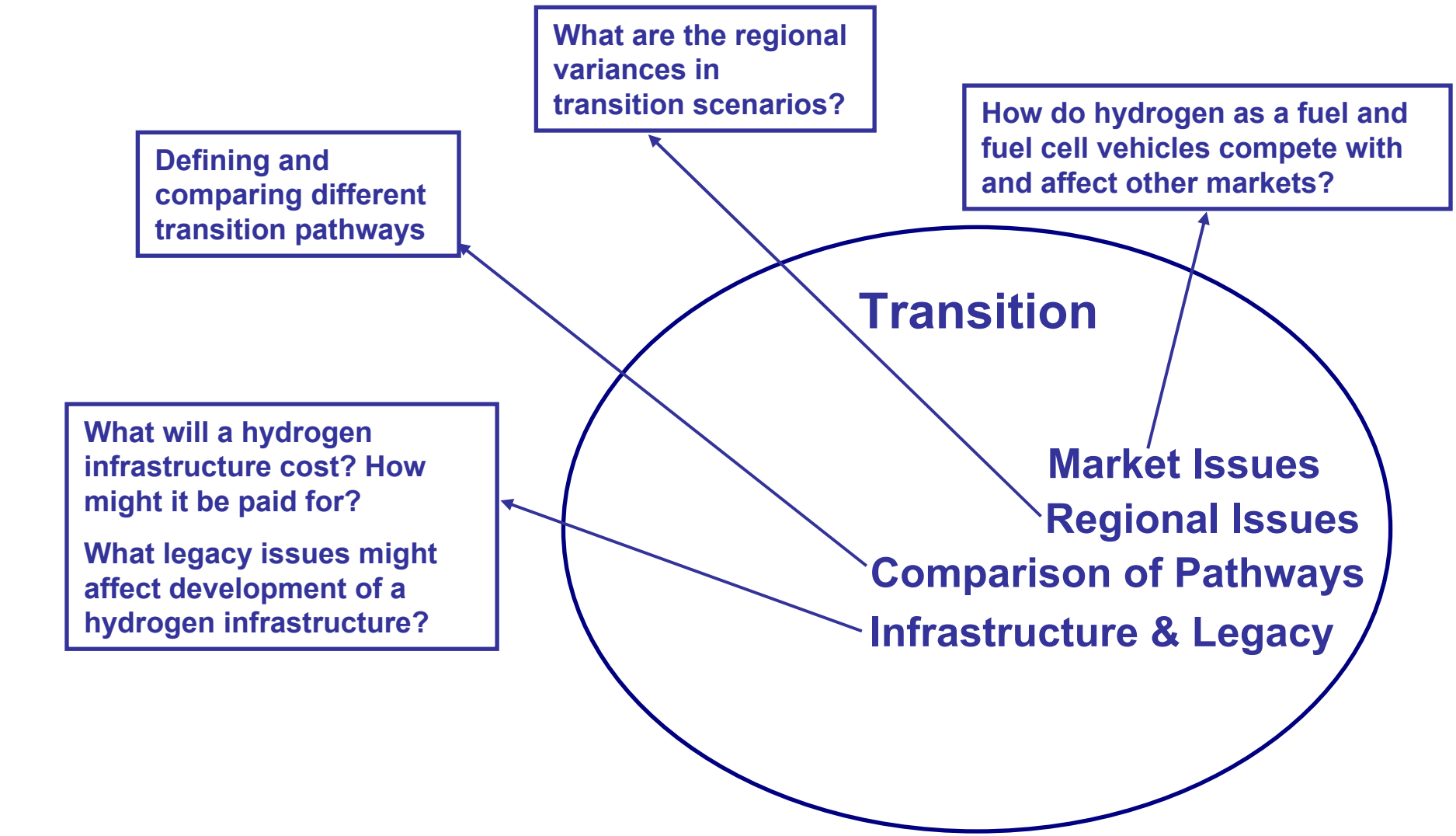


Given funding and resource limitations, which components/ technologies/processes should be funded? When?

What are the critical paths/ components/technology hurdles?

How can risks be mitigated by funding competing technologies?

Transition Issues



Financial and Environmental Issues

Financial

What requirements do corporations have before they will invest in hydrogen technologies?

How should the government best invest to bring about the hydrogen economy?

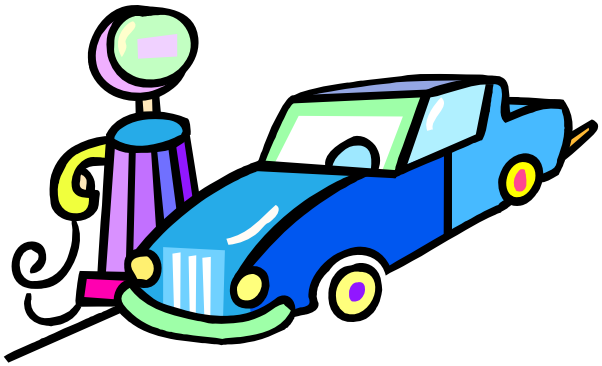
Environmental

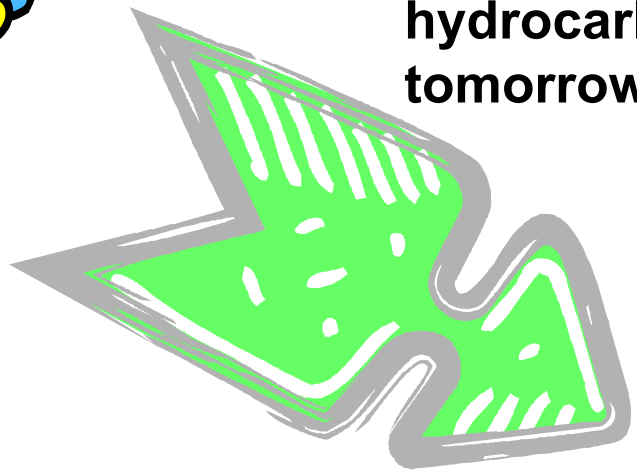
What resource requirements and emissions profiles do transition scenarios have? How do they compare?

Features of a Macro-System Model

- Dynamic engineering transition model
- Simulate performance and evolution of infrastructure
- Use distributed architecture to link existing and emerging models that analyze individual elements
- Include both fuel and vehicle supply and demand estimates to capture competition
- Include both hydrogen and gasoline supply chains
- Capture regionality of hydrogen infrastructure
- Capture influence of early-adopters on transition

Infrastructure Transition Model





The MSM will simulate possible transitions between today's hydrocarbon economy and tomorrow's hydrogen economy

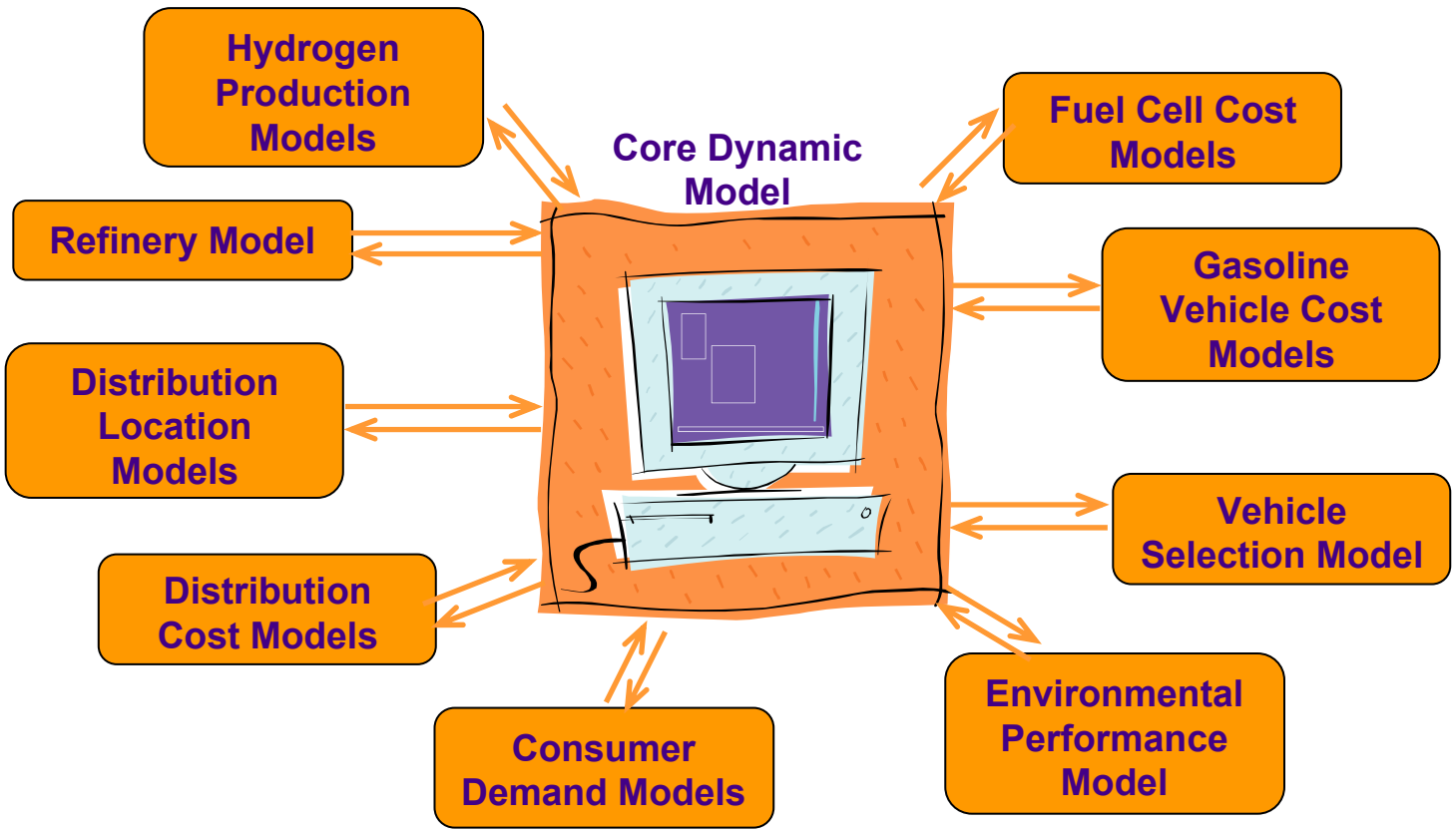
The MSM will be designed to adapt and grow as the program advances

It will be continuously updated and maintained to reflect the current status of technologies, technical milestones, thoughts on transition, and other programmatic factors

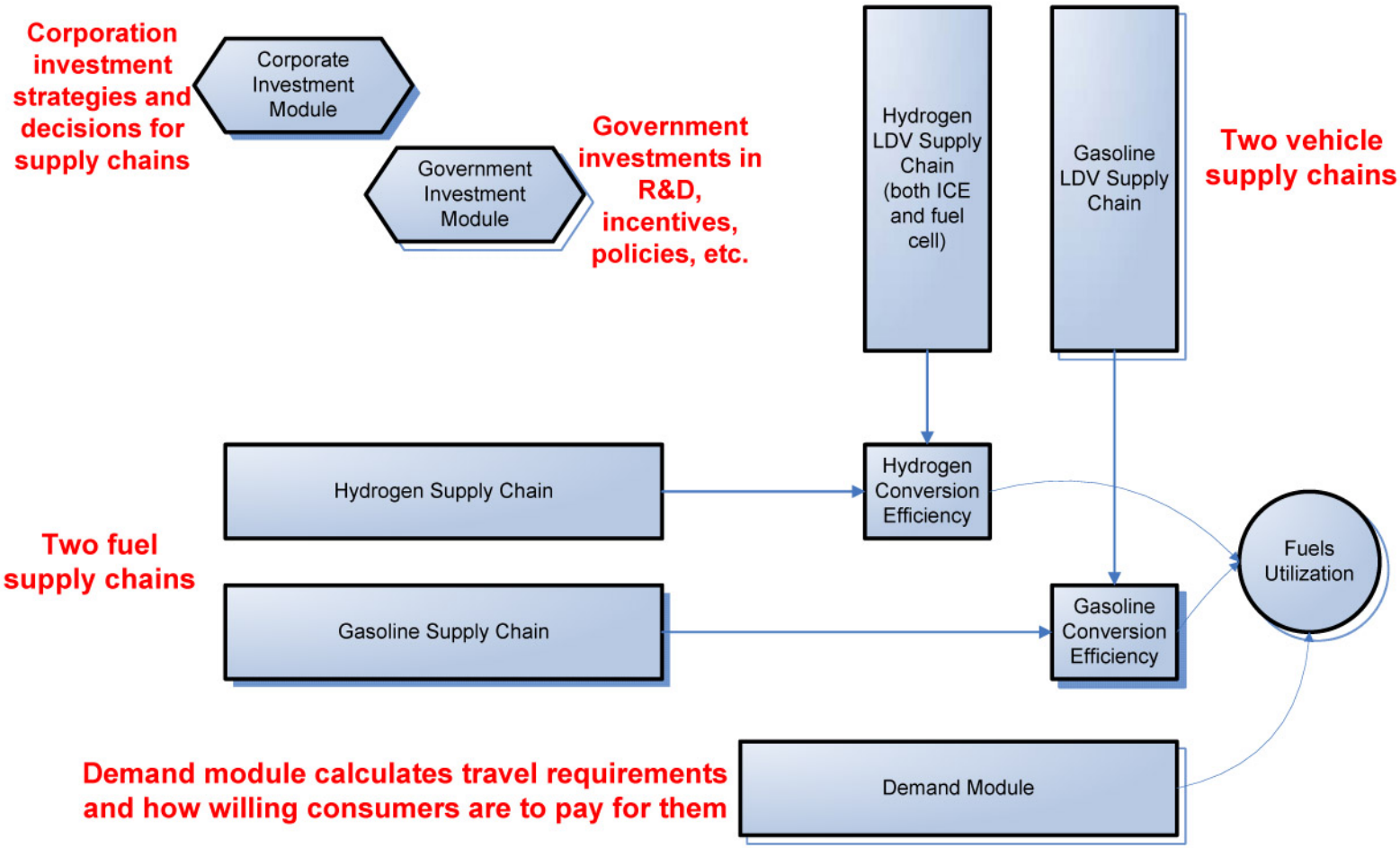
Distributed Architecture

Core dynamic model will integrate and utilize existing and emerging component and element models to the extent possible

Share standard inputs, credible/documented data, and outputs that can be used by the economic/market model and program model domains

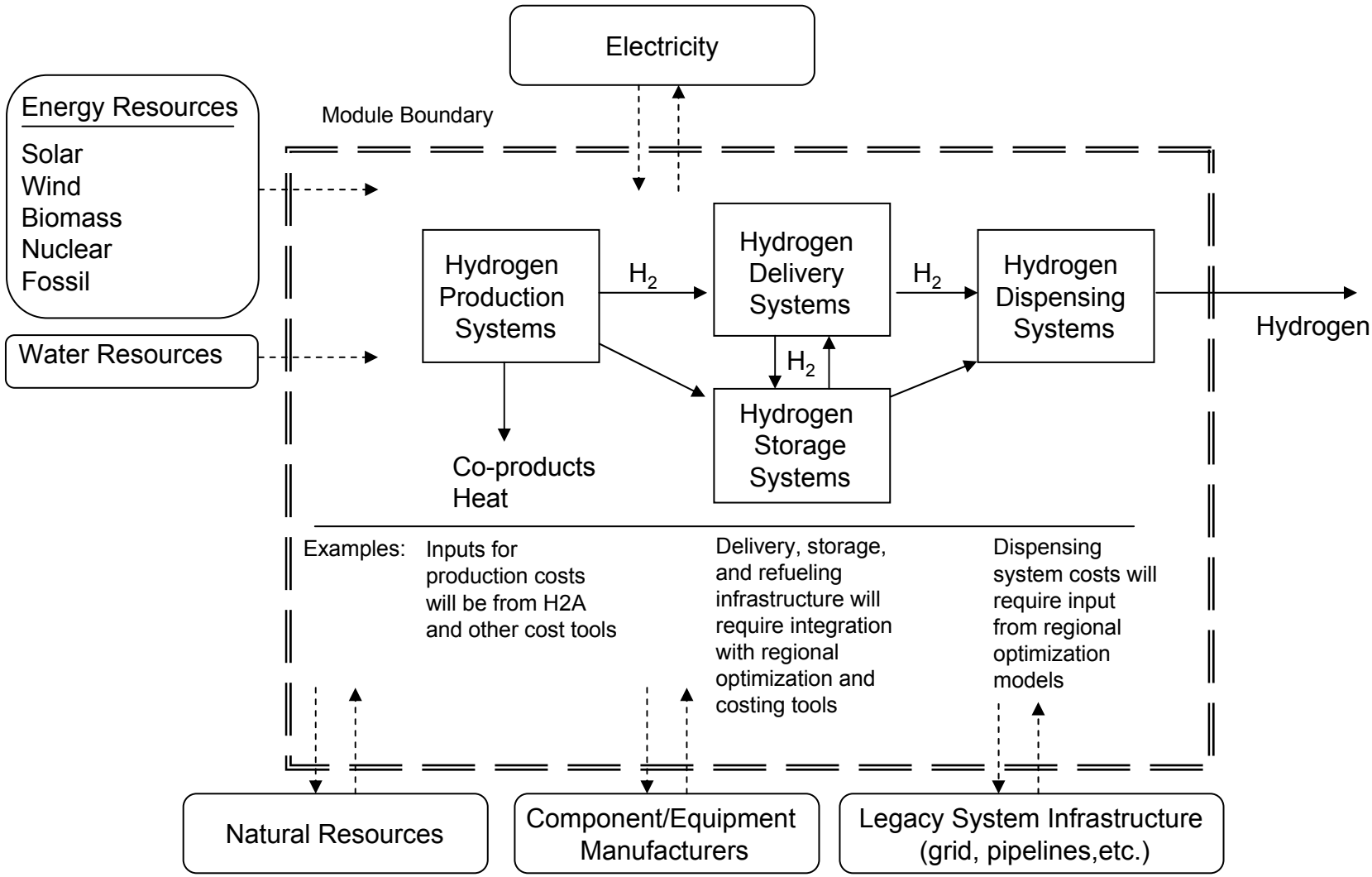


High Level Structure for Core Dynamic Model



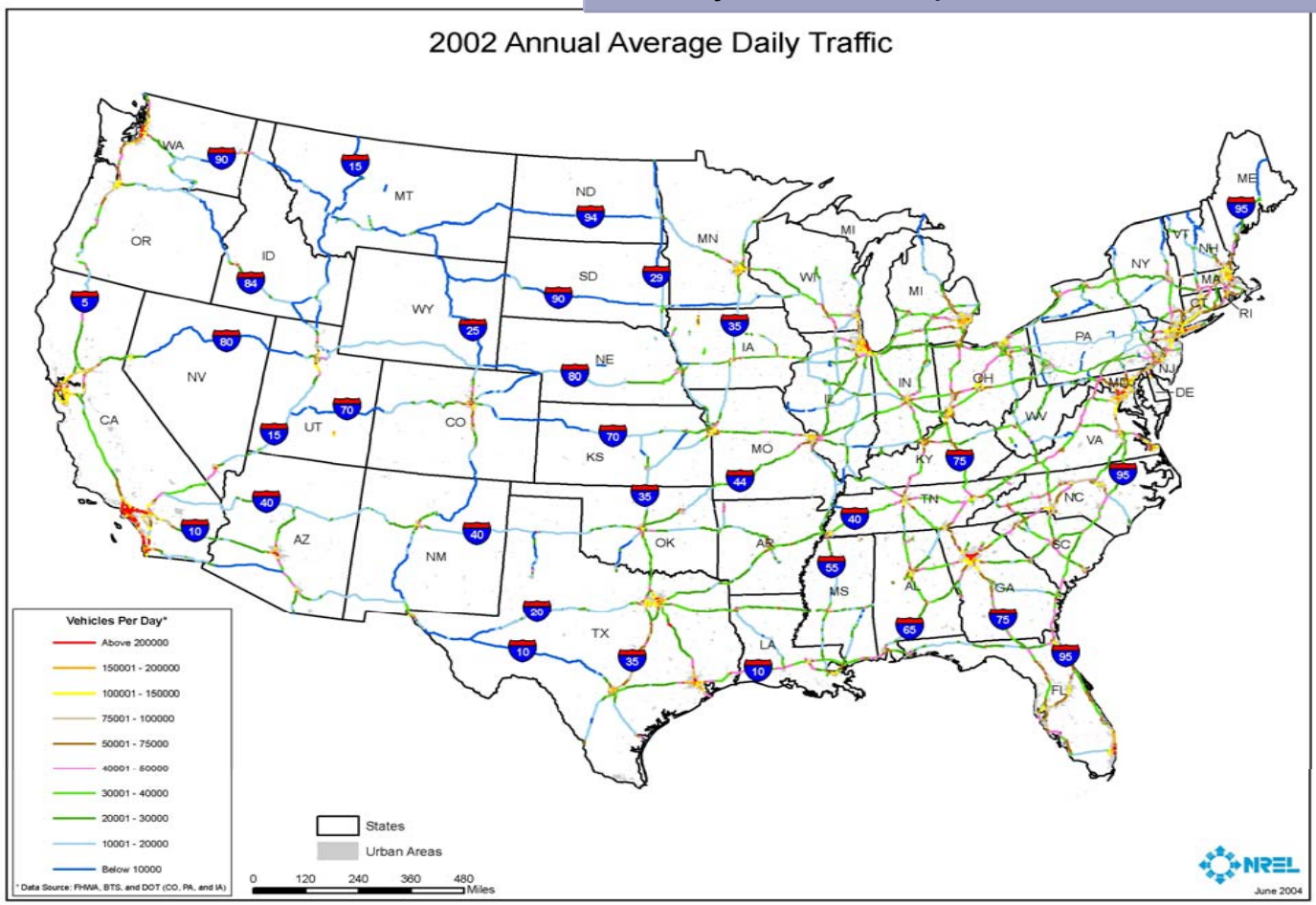
- Competition captured endogenously
- Addition of electricity module and other transportation modules at a later date

Example: Hydrogen Supply Chain

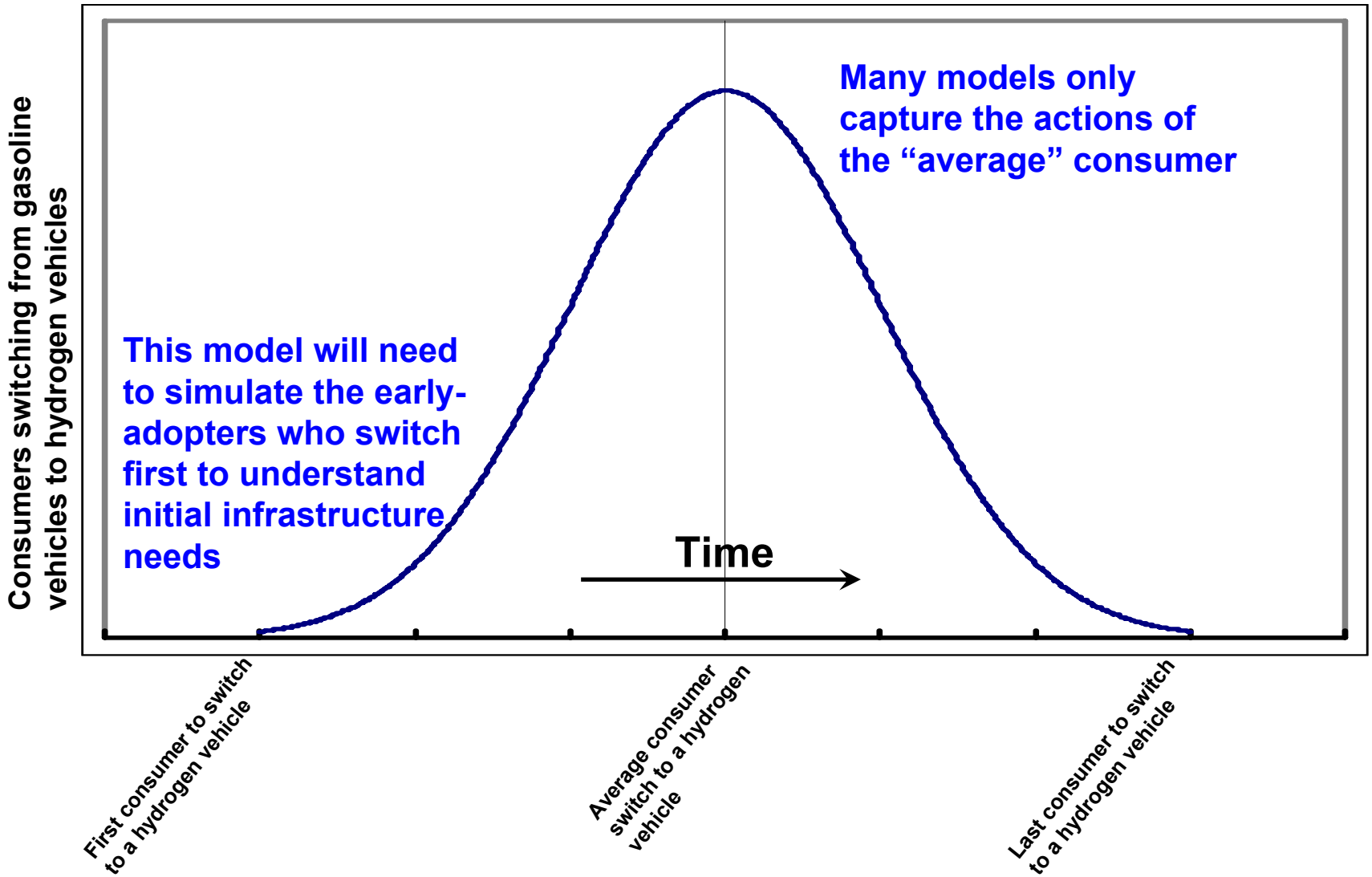


Regionality

Energy source, delivery, and demand are all regional issues; therefore, the macro-system model must have a regional structure that captures those issues and helps identify the mix of production and delivery schemes.



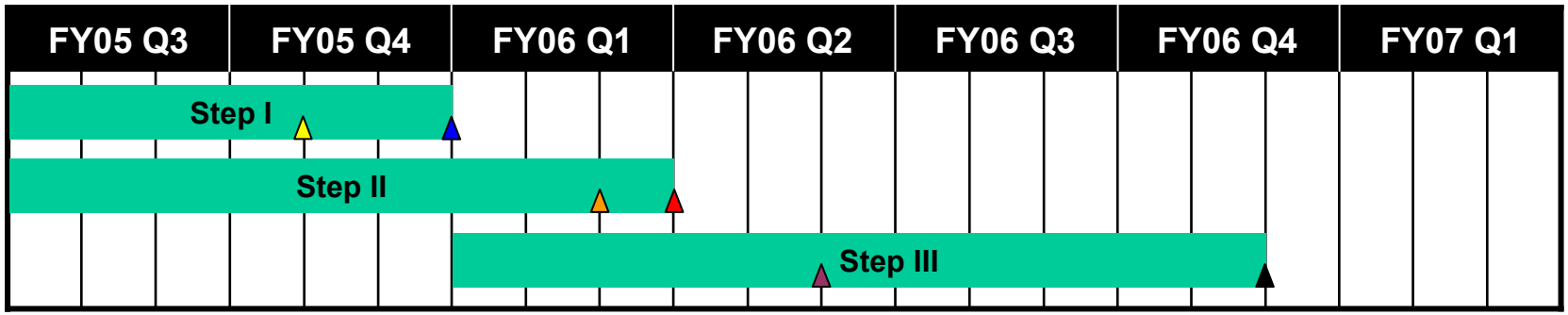
Early-Adopters



Response to Previous Year Reviewers' Comments

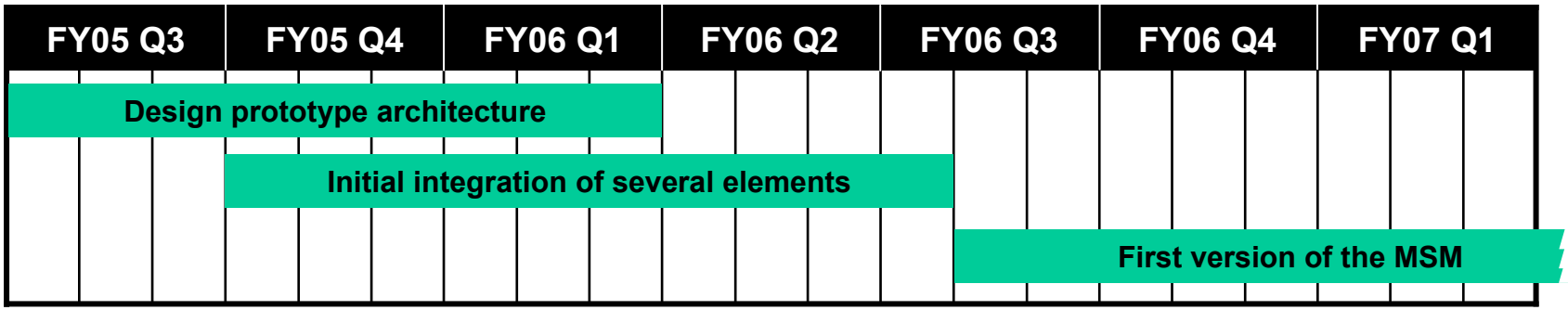
- **This is a new project so no comments have been made**

Future Work (Planning)



- **Step I (defining requirements)**
  - Complete list of issues the MSM must address and report on them (July 31, 2005)
  - Complete list of requirements (September 30, 2005)
- **Step II (evaluating alternatives)**
  - Continue gathering information on existing element models
  - Review existing transition models for usability as core dynamic models (November 30, 2005)
  - Complete review of potential tools that integrate distributed element models (November 30, 2005)
  - Select transition model for use as core dynamic model (December 31, 2005)
  - Select model-integration tool (December 31, 2005)
- **Step III (recommend approach)**
  - Capture MSM requirements, description, and usage in a requirements document (February 28, 2006)
  - Peer review of MSM plan by the hydrogen modeling community (August 31, 2006)

Future Work (Model Development)



- Design prototype model architecture (December 31, 2005)
- Initial integration of several element models (April 30, 2006)
- Complete first version of the macro system model (January 31, 2007)

Supplemental Slides

- **Hydrogen Safety**
  - **This is a modeling effort. There are no hydrogen hazards directly associated with it.**
- **Publications and presentations**
  - **There have been no publications on this work.**
  - **Presentations**
    - **Dale Gardner presented this work to the "National Academy of Sciences Committee to Review the FreedomCar & Fuel Partnership" on January 24, 2005.**