NASA Aero-Space Technology Enterprise

Smart Air Transport System

Presented to

FAA R-E&D Advisory Committee (REDAC)

FAA Headquarters
March 14, 2000

Outline

The Golden Rule of the information age is "Time is the Scarce Commodity."

Early in the 21st century, the demand for personal transportation will soar beyond supply.

The Millennial Opportunity: SATS creates more time for more people.

- **SATS Concept**
- **SATS Program Mandate**
- **FAA-NASA Partnership Challenges and Opportunities**

REDAC SATS Review
Terms of Reference

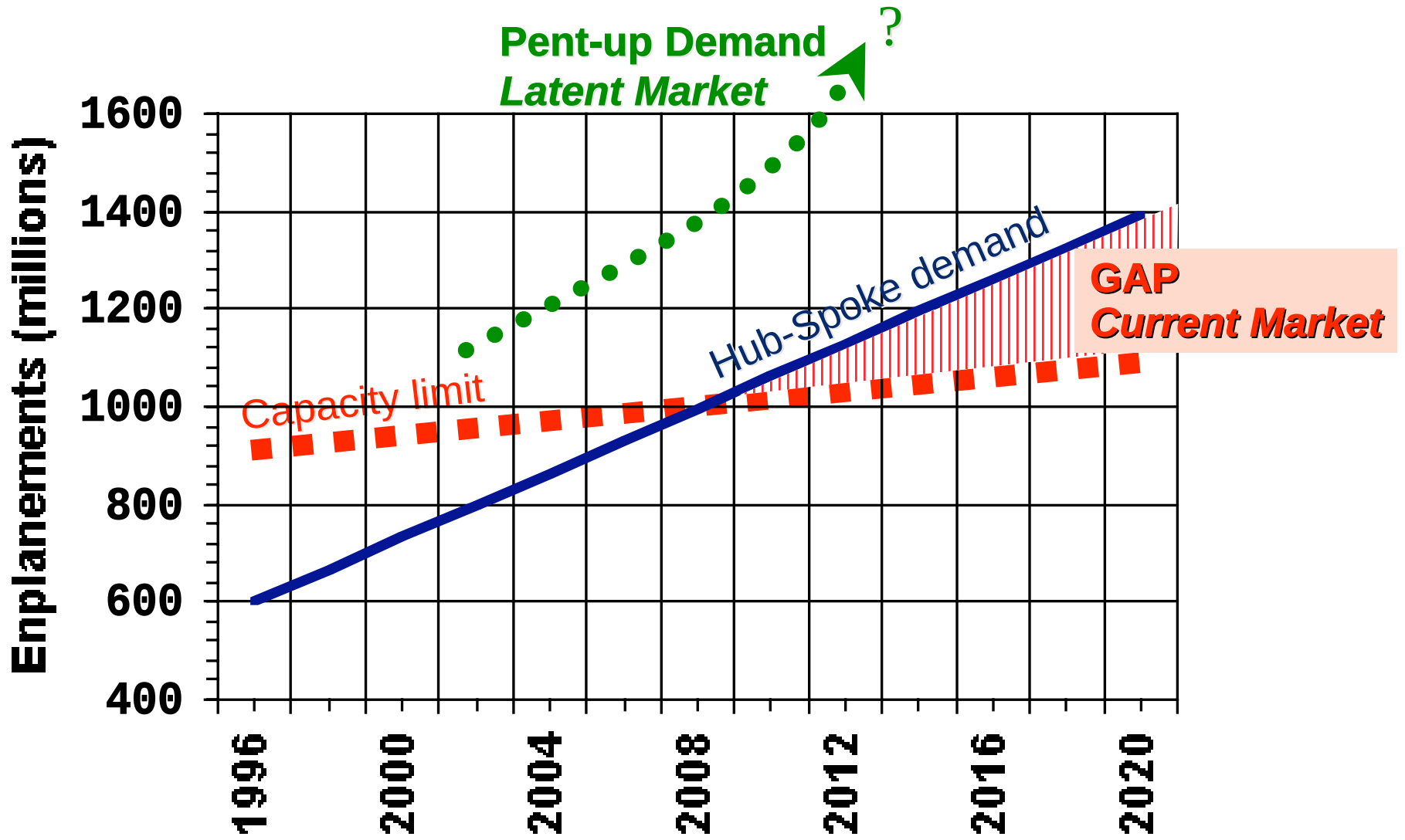
1. SATS OpsCon relationship to RTCA Free Flight and NAS 4.0
   - Executive Summary
   - SATS-NAS4.0 “Gap” Analysis
2. NAS Plan/Architecture SATS requirements
   - FAA Mission Need Statement
   - FAA Rough Order Magnitude SATS “gap” cost estimate
3. Program advocacy action planning
   - NASA-FAA Executive Committee: SATS Tasking
   - NRC SATS Study
4. FAA RE&D requirements and actions for SATS
   - FAA Lines of Business Roles in SATS Program
   - NASA-FAA partnership options
5. Regulatory Issues for SATS
   - Aircraft, Airports, Procedures, and Pilots
   - AIR AGATE model for SATS
6. FAA support for NRC Study
   - ARX Analyses
   - Policy Review

Program Strategies

- **Position SATS as a "down-market" (*vs.* up-market)latent transportation consumer innovation**
- **Govern SATS Alliance research program to develop technologies for latent transportation services market stimulation**
- **Structure the alliance for relevance to organizational charters:**
  - **NASA-industry-FAA partners define technologies for TRL ≤6**
  - **States-industry-FAA partners define technologies for 7≤TRL≤9**
  - **All partners collaborate to produce the Demonstration**
- **Organize alliance to affect State Aviation System Planning, Regional Transportation System Planning, and influence NAS Architecture**

Demand Will Soon Exceed Supply

...not even considering pent-up travel demand...



Pent-up Demand (http://apats.org)

"How many more trips would you take annually if you could save time?"

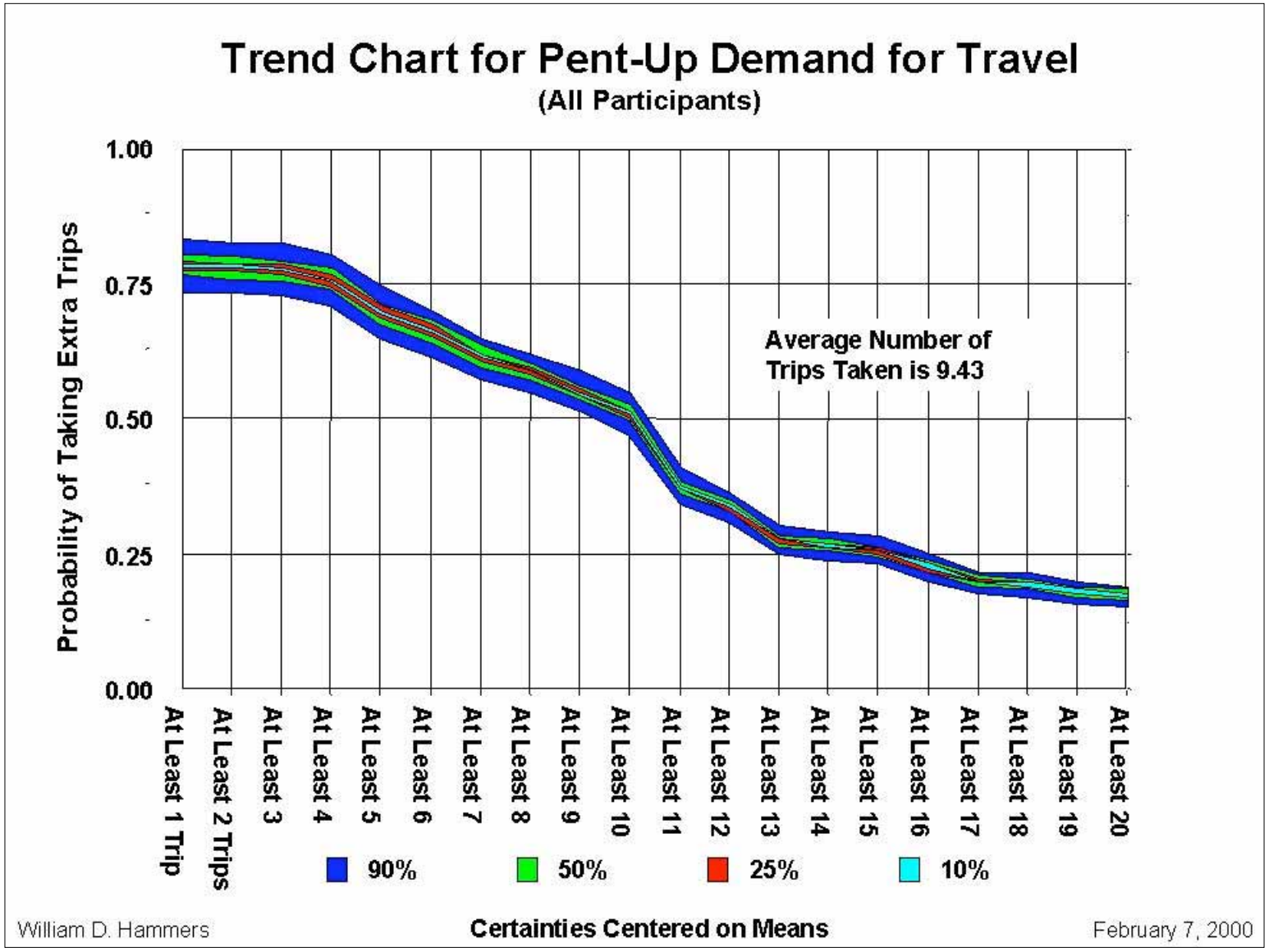
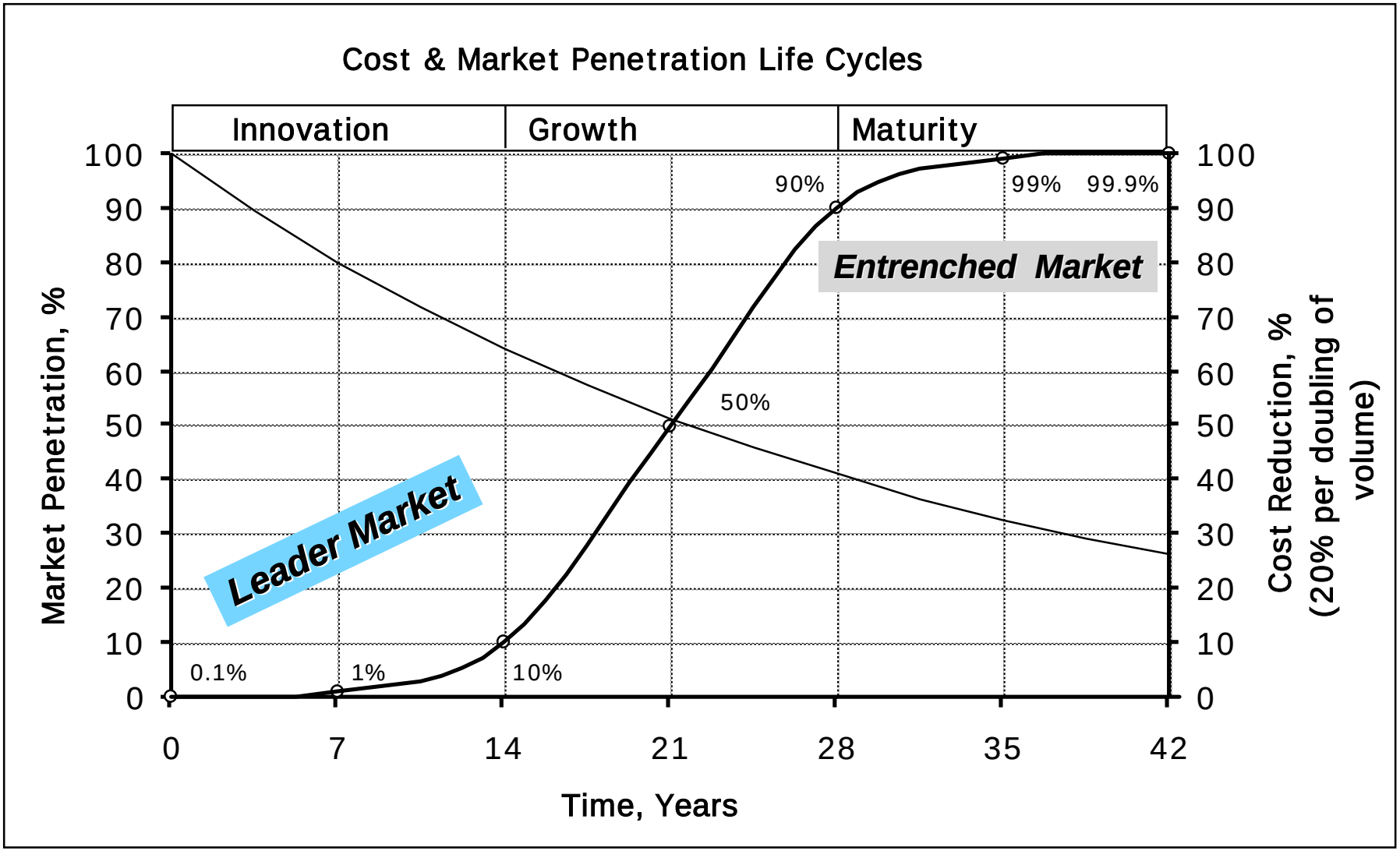


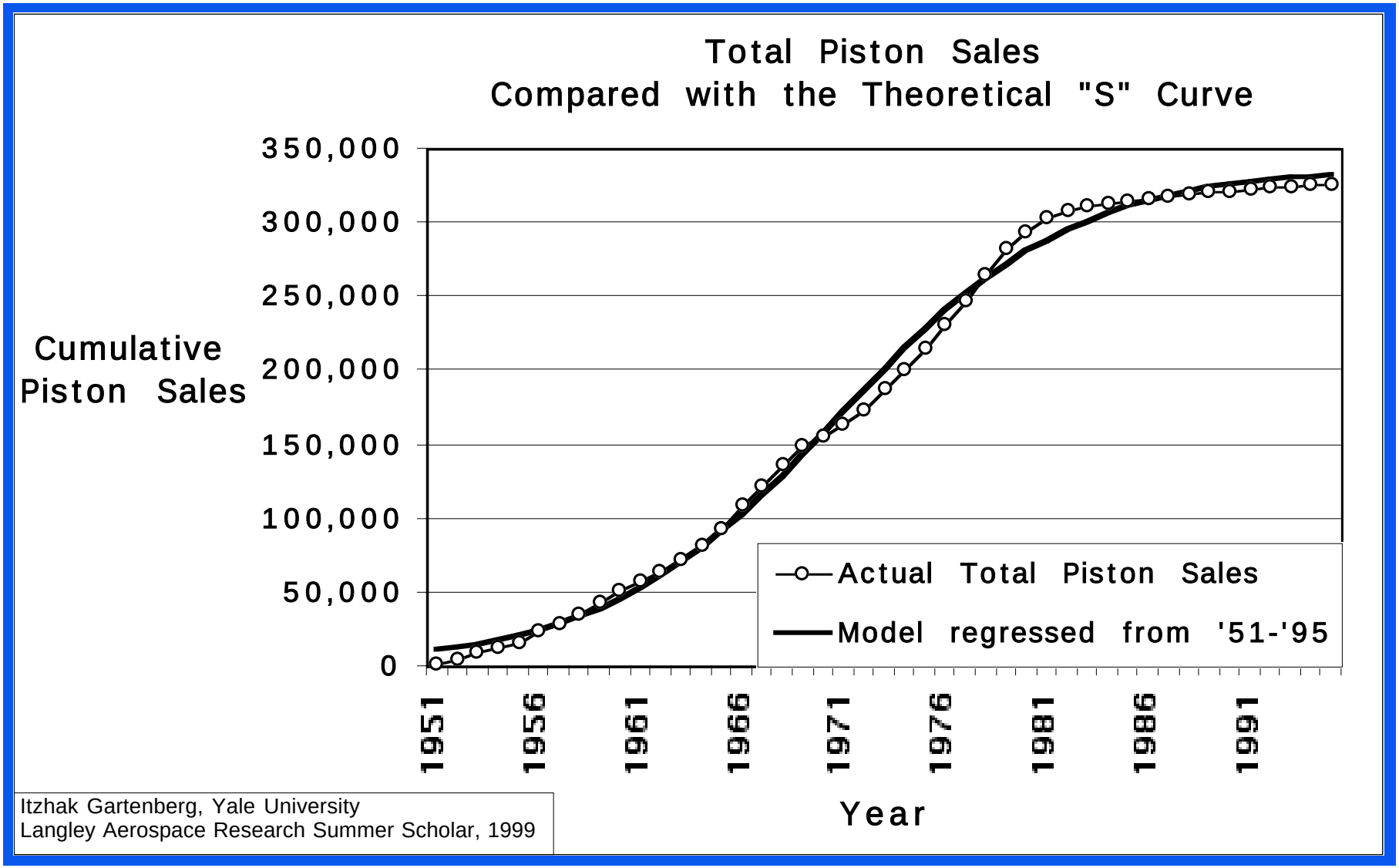
Figure 6

Innovation and Cost Life Cycles



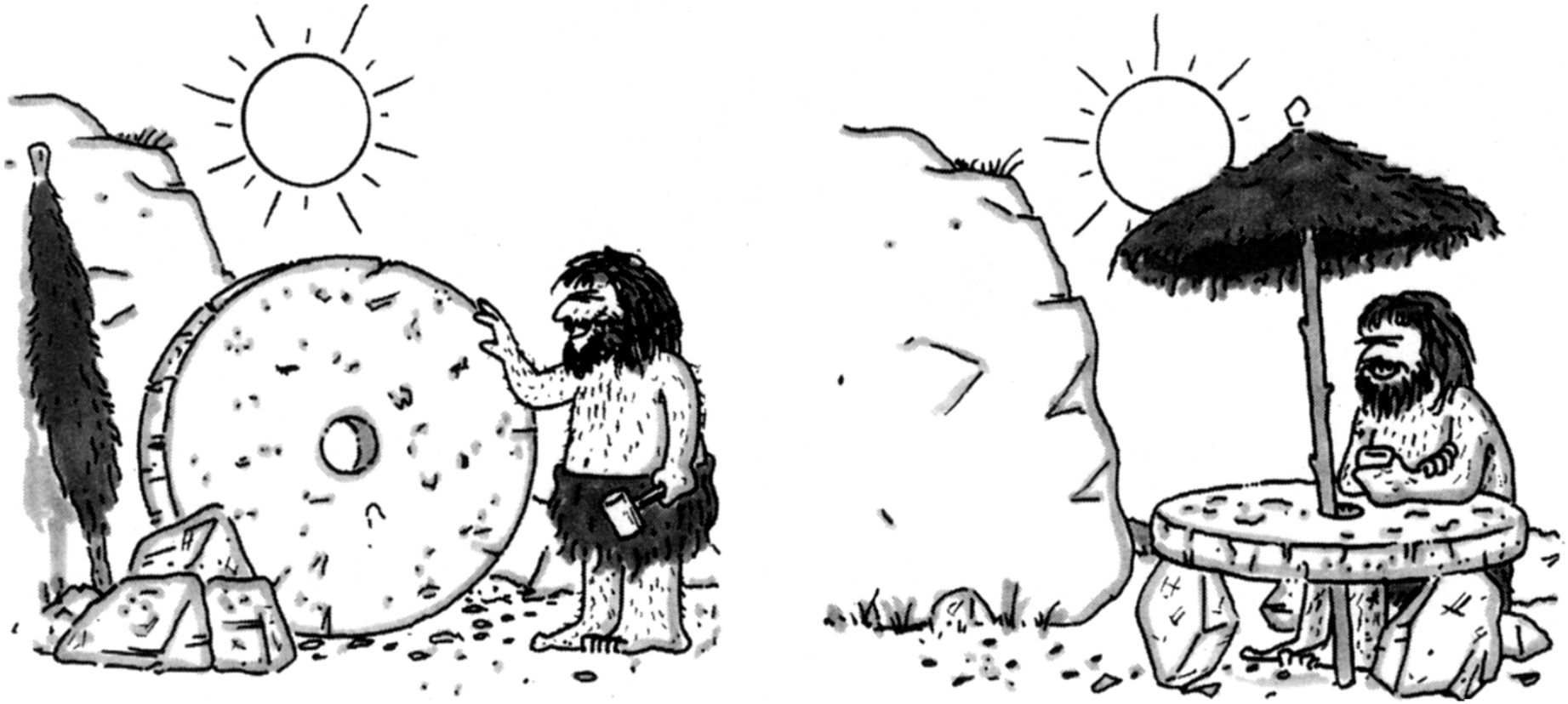
Life Cycle of the Piston Aircraft Market

...or is it really?...



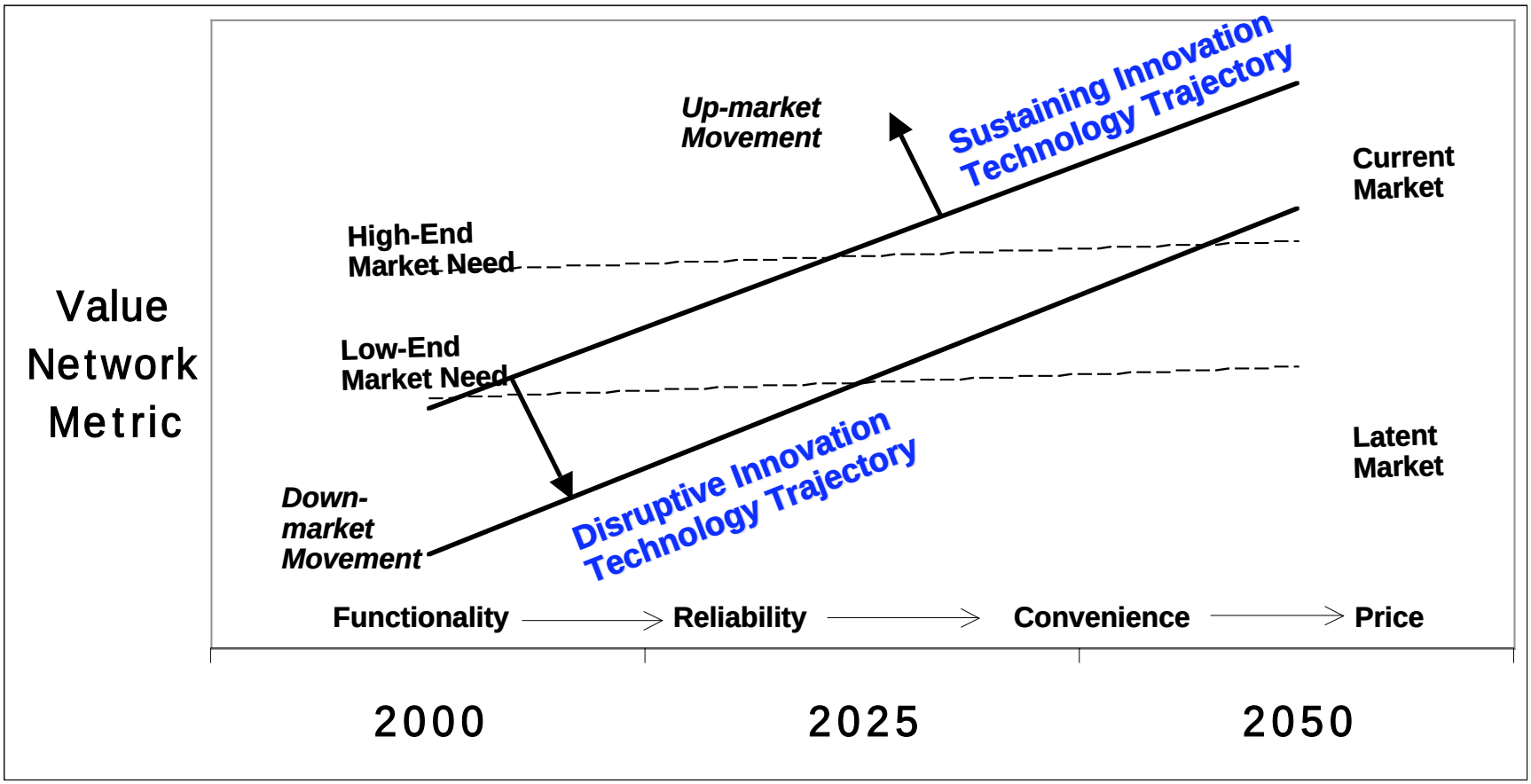
Itzhak Gartenberg, Yale University
Langley Aerospace Research Summer Scholar, 1999

What Is a Disruptive Innovation?



Innovation Categories

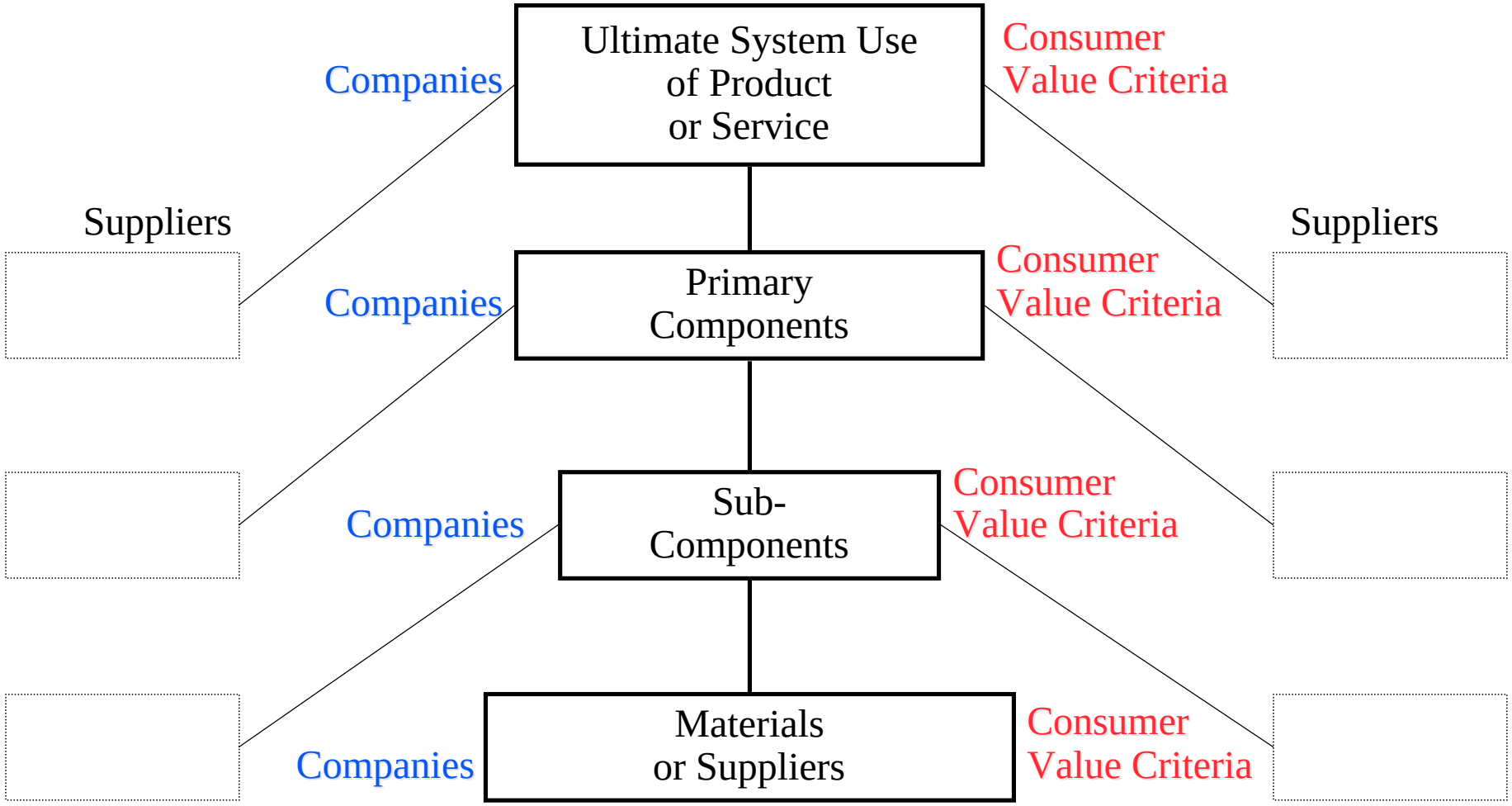
Clayton Christensen: The Innovators Dilemma, Harvard Business School Press, 1997



Value Networks

(Clayton Christensen, The Innovators Dilemma, Harvard Business School Press, 1997)

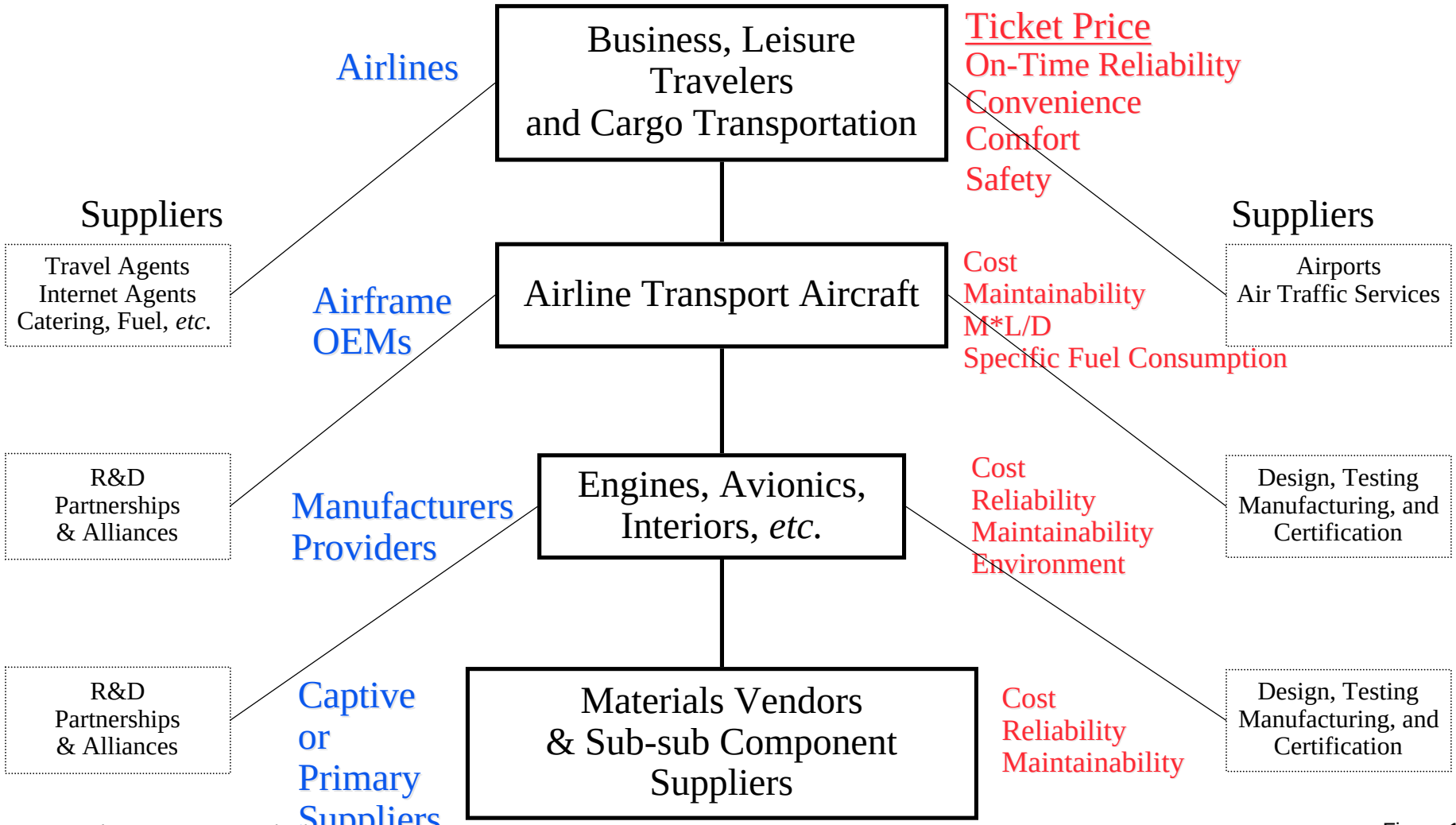
Value Networks create a nested system of expected rewards
for an incumbent or entrant enterprise
serving an existing or latent consumer base



Hub-and-Spoke/Mass Transportation Value Network

Consumer Value Criteria

Expected rewards from existing consumers for an incumbent enterprise (including investors)
drive resource allocations toward innovations for growth of the current market.



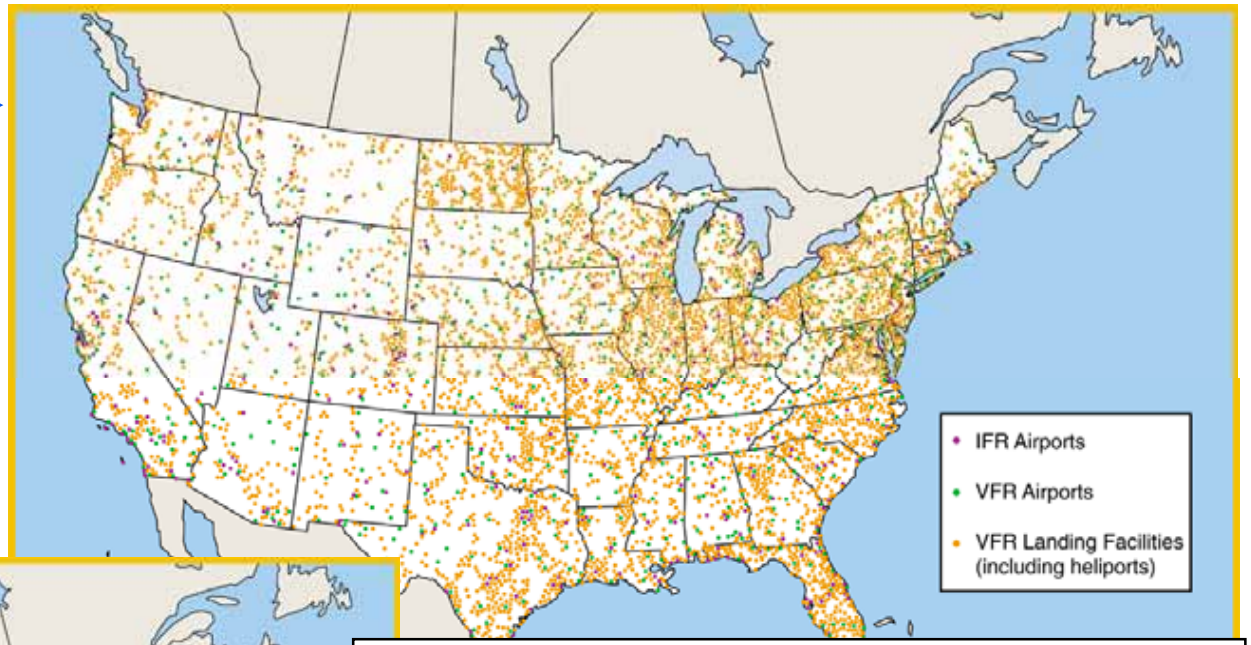
SATS Program Planning Structure

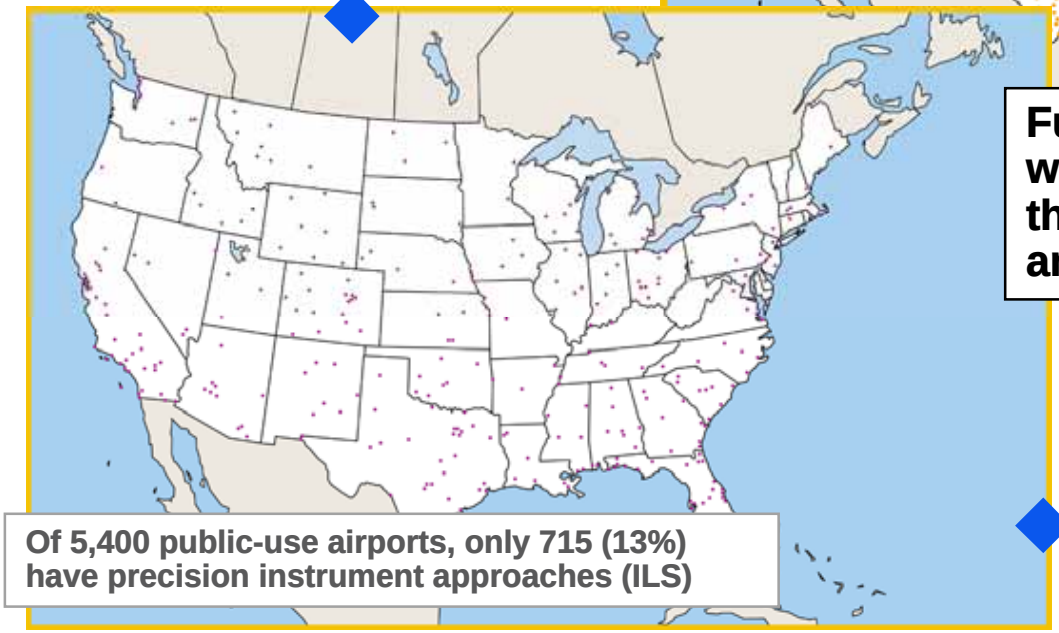
- **Vision:** ***"SATS is a safe travel alternative, freeing people, goods, and services from transportation delays, by creating access to more communities in less time."***
- **Goal:** ***"Reduce public travel times by half in 10 years and by two-thirds in 25 years."***
- **Program Objective:** ***"Prove SATS Works" Hypotheses***
- **Approach:** ***2003 Experiments leading to 2005 Showcase Demonstration***
- **Demonstration Objective:** ***Prove that SATS technologies enable near-all-weather utility of the new generation of affordable transportation aircraft throughout all of the nation's underutilized landing facilities and airspace.***
- **SATS Projects Hypotheses:**
  - ***20:1 RPZ Operations***
  - ***High-Density 4D Operations***
  - ***Automotive Cost Paradigm***

SATS Increases Accessibility and Mobility

(". . .creating access to more communities in less time. . .")

Expanded <u>Accessibility</u> to several times more destinations





Of 5,400 public-use airports, only 715 (13%) have precision instrument approaches (ILS)

Fully utilized 5,400 public-use near-all-weather landing facilities can increase theoretical NAS Throughput by more than an order of magnitude

Improved <u>Mobility</u> saving more travelers more time

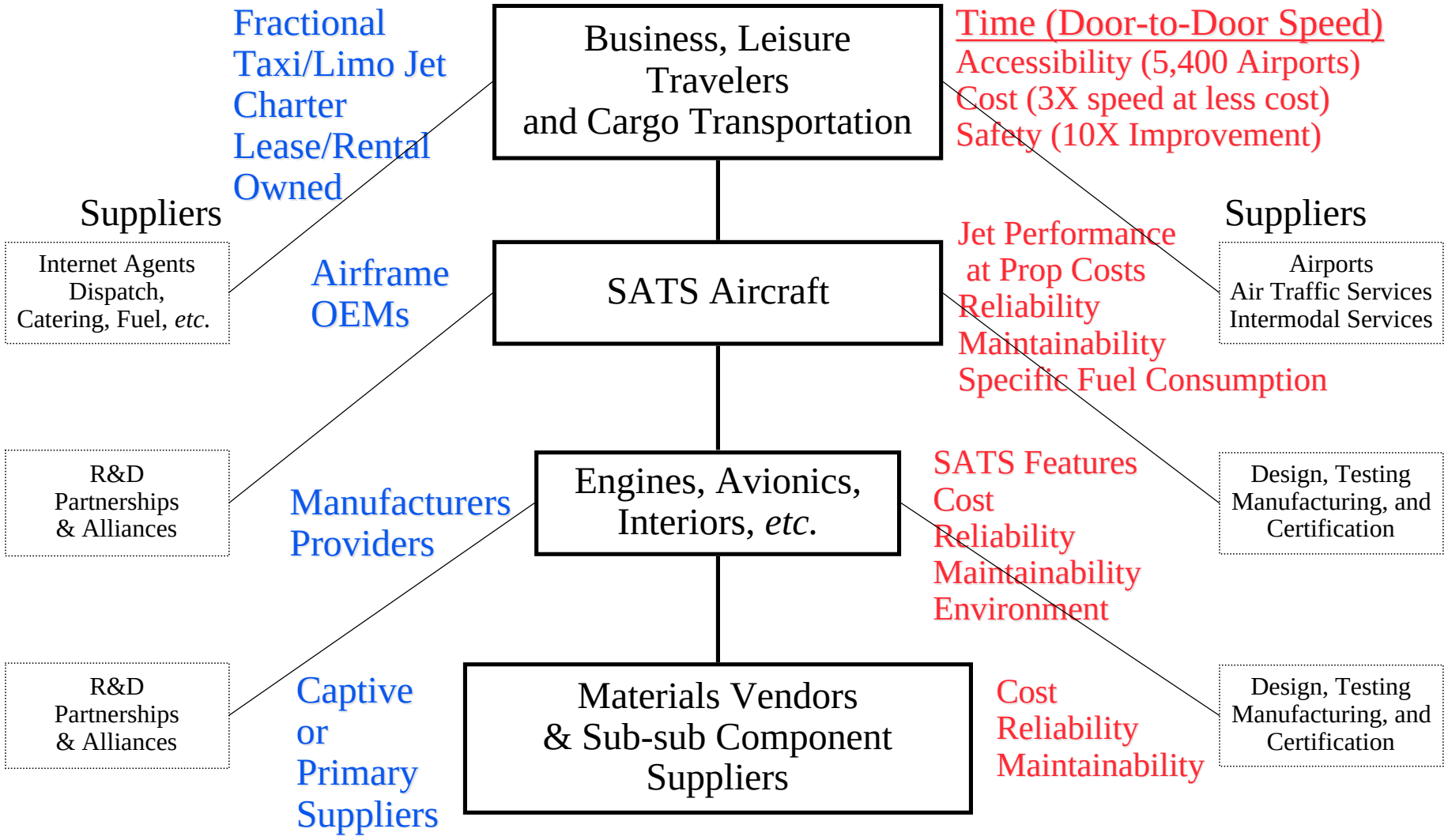
Meeting 21st Century Transportation Challenges

The Smart Air Transport System is a safe travel alternative that frees people and products from today's system delays creating access to more communities in less time.

Proposed SATS Value Network

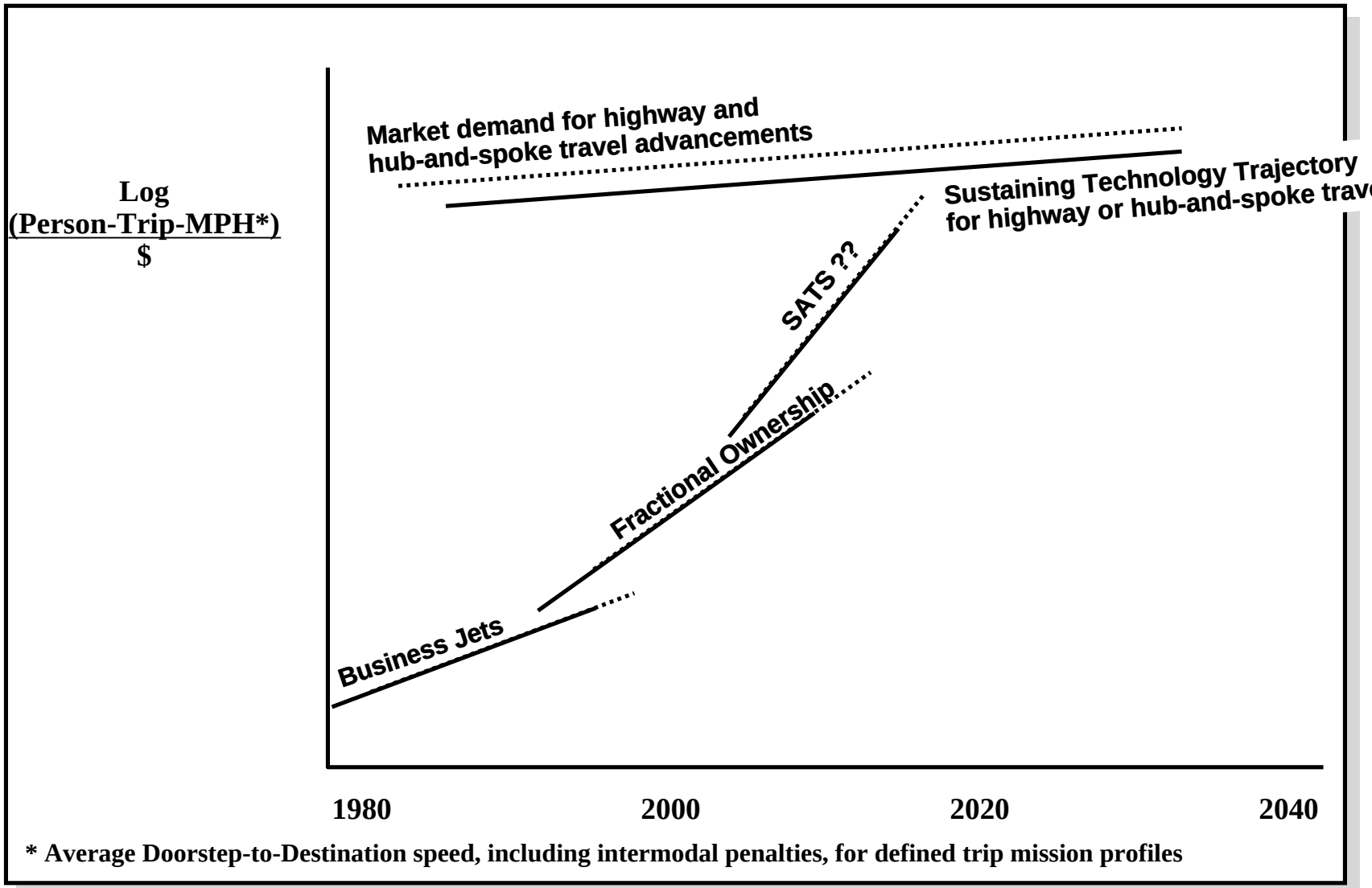
Consumer Value Criteria

Expected rewards from latent consumers for entrant enterprises drive resource allocations toward paradigm shifting innovations.



SATS Value Network Metrics

SATS continues the disruptive innovation path initiated by business jets



* Average Doorstep-to-Destination speed, including intermodal penalties, for defined trip mission profiles

SATS Accessibility = Economic Development

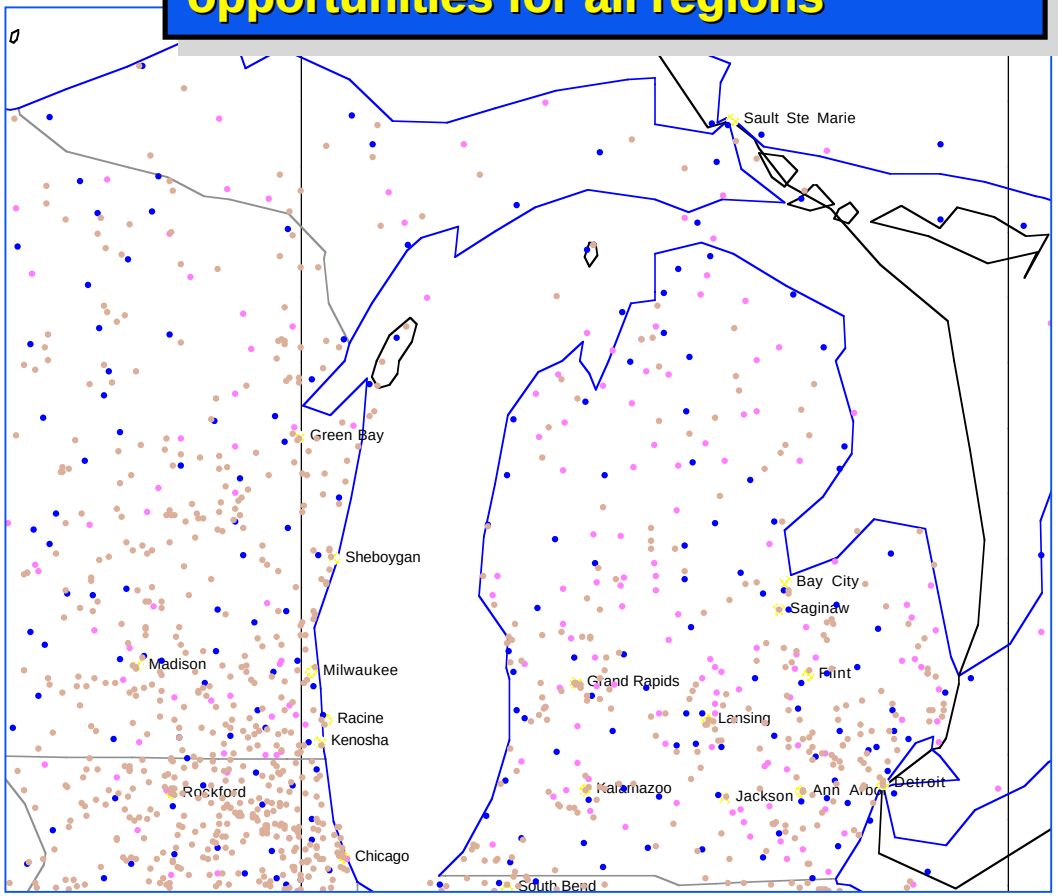
Michigan General Aviation Today

- $ 475 Million in Economic Impact
- 389 Public-Use and Private Airports
- 20 Precision Approach Airports
- 18,510 Active Pilots
- 6,570 Aircraft

~~INSTRUMENT LANDING FACILITIES~~
~~VISUAL ONLY~~

- Highway in the Sky SATS Facilities

SATS will enable ~75% more accessibility by air for all Michigan's communities, expanding economic opportunities for all regions



The New Generation Cockpits, Propulsion, and Aircraft

Lancair Columbia 300

Cirrus SR-20

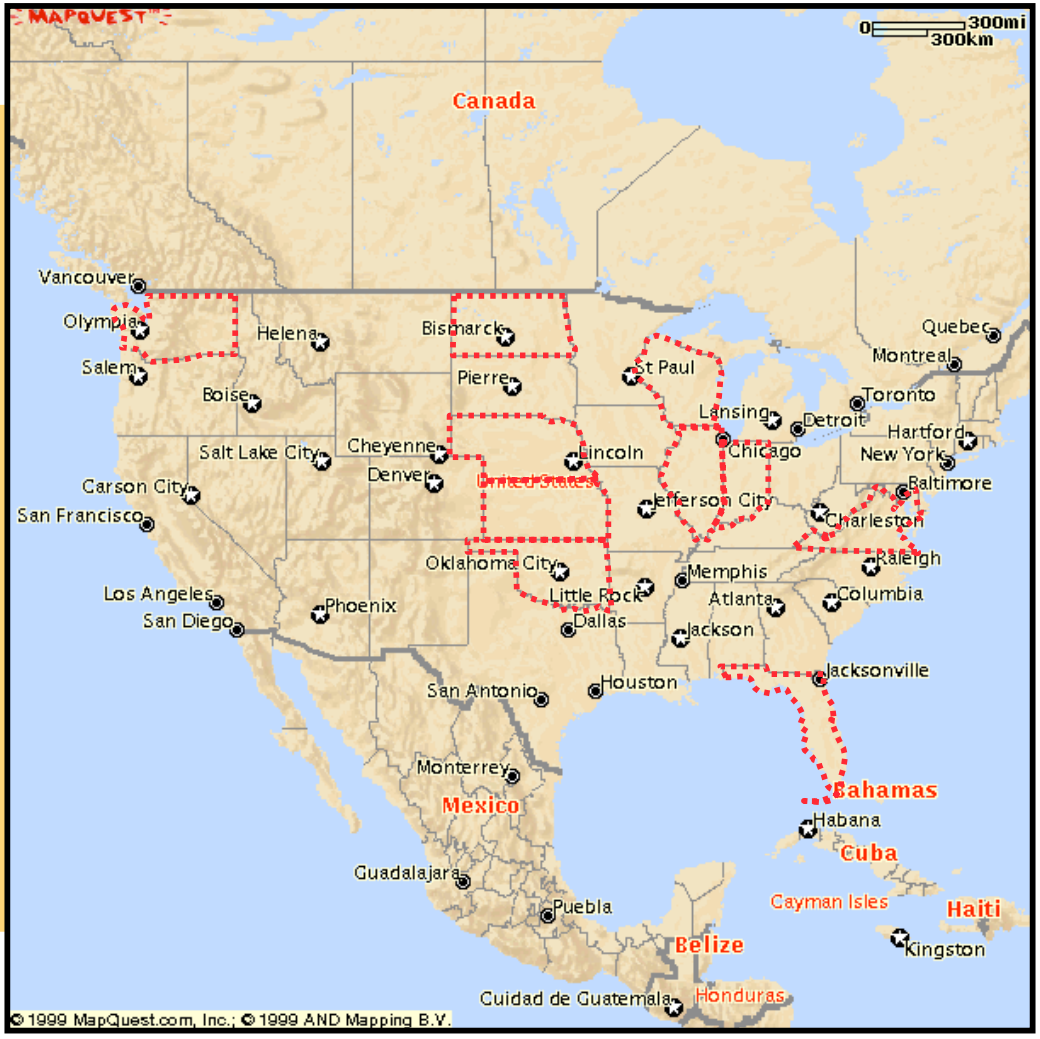
Eclipse 500

and Others….

Coming Soon
to an airport near you!

States Roles in SATS Planning

- **Aerospace States Association SATS Resolution, July, 1999 (~40 states)**
- **SATS "Leader" States Committed to Support Program Planning (~10 states)**
- **State SATSLab Partnerships (2 states to date)**
- **Showcase Demonstrations planned in 2003, 2005**



Technology Readiness Levels

9 Actual system "flight proven" on operational flight

8 Actual system completed and "flight qualified" through test and demonstration

7 System prototype demonstrated in flight

Product Refinement

Typical End of NASA Involvement

6 System/subsystem model or prototype demonstrated in a relevant environment

5 Component (or breadboard) validation in a relevant environment

4 Component and/or breadboard validation in a laboratory environment

Focused Program

Limit of R&T Base Activities

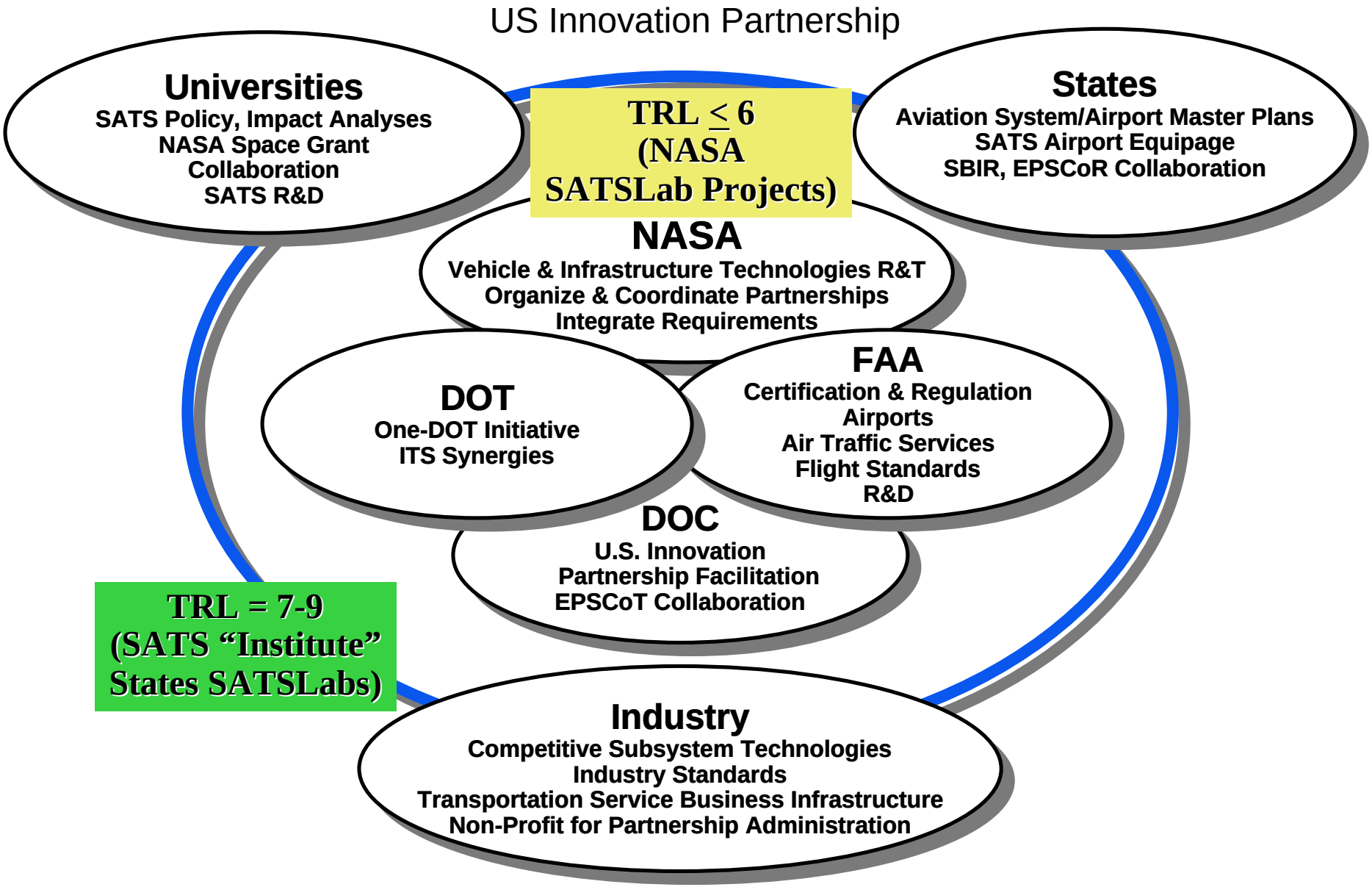
3 Analytical & experimental critical function and/or characteristic proof-of-concept

2 Technology concept and/or application formulated

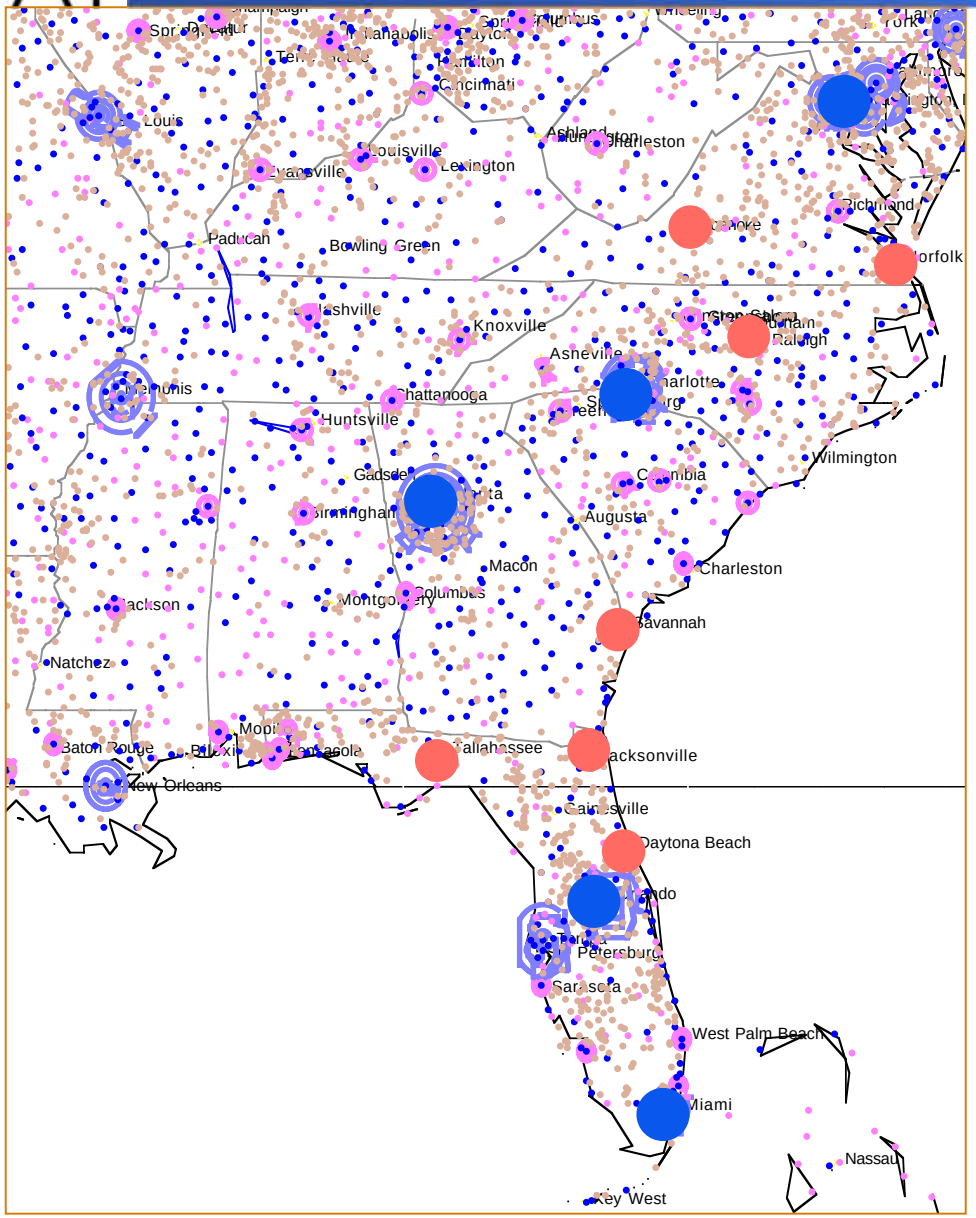
1 Basic principles observed and reported

Base R&T

Candidate Federal-States SATS Partnership Roles



SATS Creates Third Tier Market Access



- **Facilities that serve the Third Tier market are non hub-and-spoke**
- **Current Regional Jet service is driven by up-market forces, toward larger aircraft serving existing spoke network**
- **Pent-up demand measurements portray latent market opportunity for SATS**
- ***SATS creates air carrier access to Third Tier markets***

SATS Accelerates Free Flight

- **Accelerated fleet equipage is vital to NAS modernization and free flight**
- **SATS accelerates pace of small aircraft fleet equipage for free flight capabilities**
- **SATS will accelerate migration of free flight technologies and procedures into air carrier applications**
- ***SATS accelerates air carrier access to free flight***

SATS Reduces Delays

- **Runway Independent Aircraft (RIA) using Simultaneous Non-Interfering (SNI) approaches can reduce delays associated with the growing air transportation demand by more than 50% for a hub airport.**
- **The economic and environmental efficiencies of the RIA/SNI alternative provide orders of magnitude savings over building new runways.**
- ***SATS reduces delays at Class B facilities.***

Runway Independent Aircraft (RIA) Reduce Airport Delays

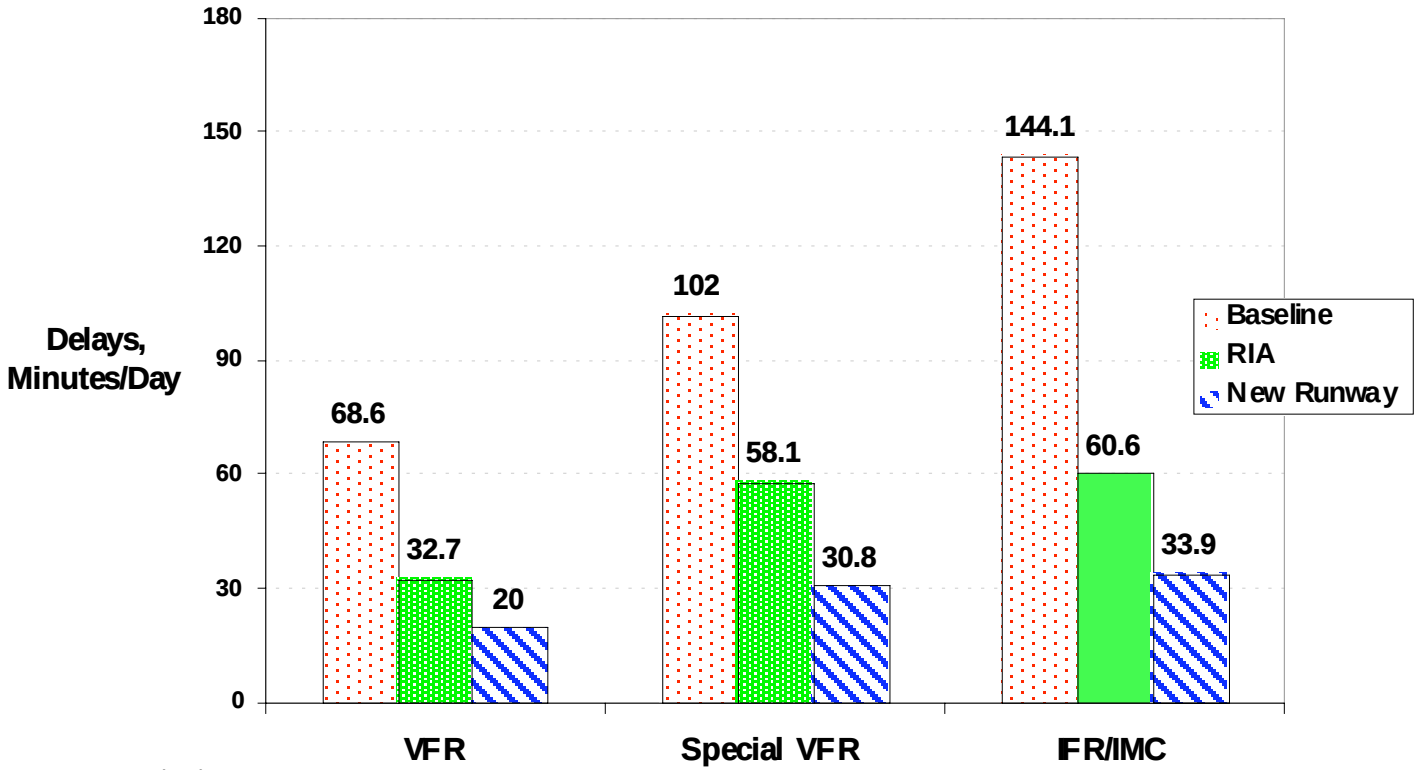
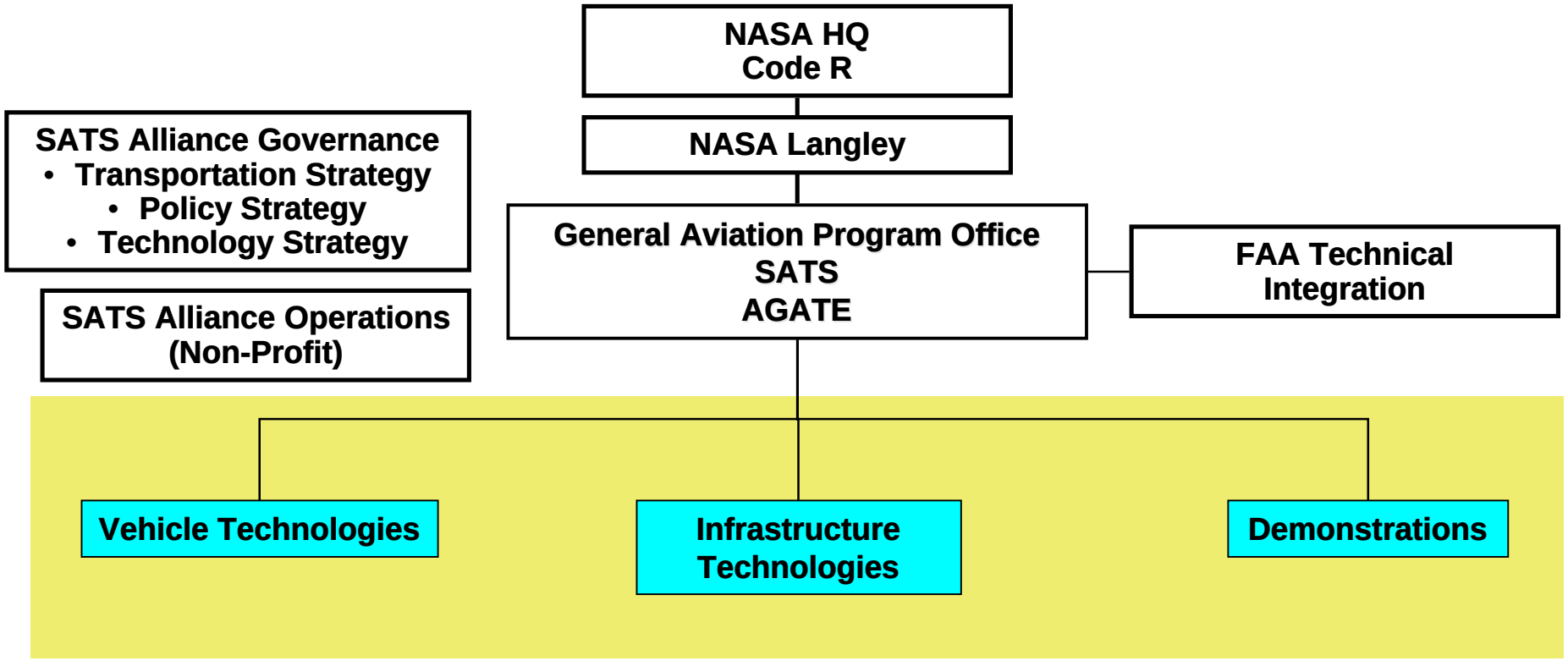


Figure 25
Results of 1999 FAA Newark Airport Task Force Study

SATS *Draft* Program Governance Elements



SATS will operate under a Joint Sponsored Research Agreement

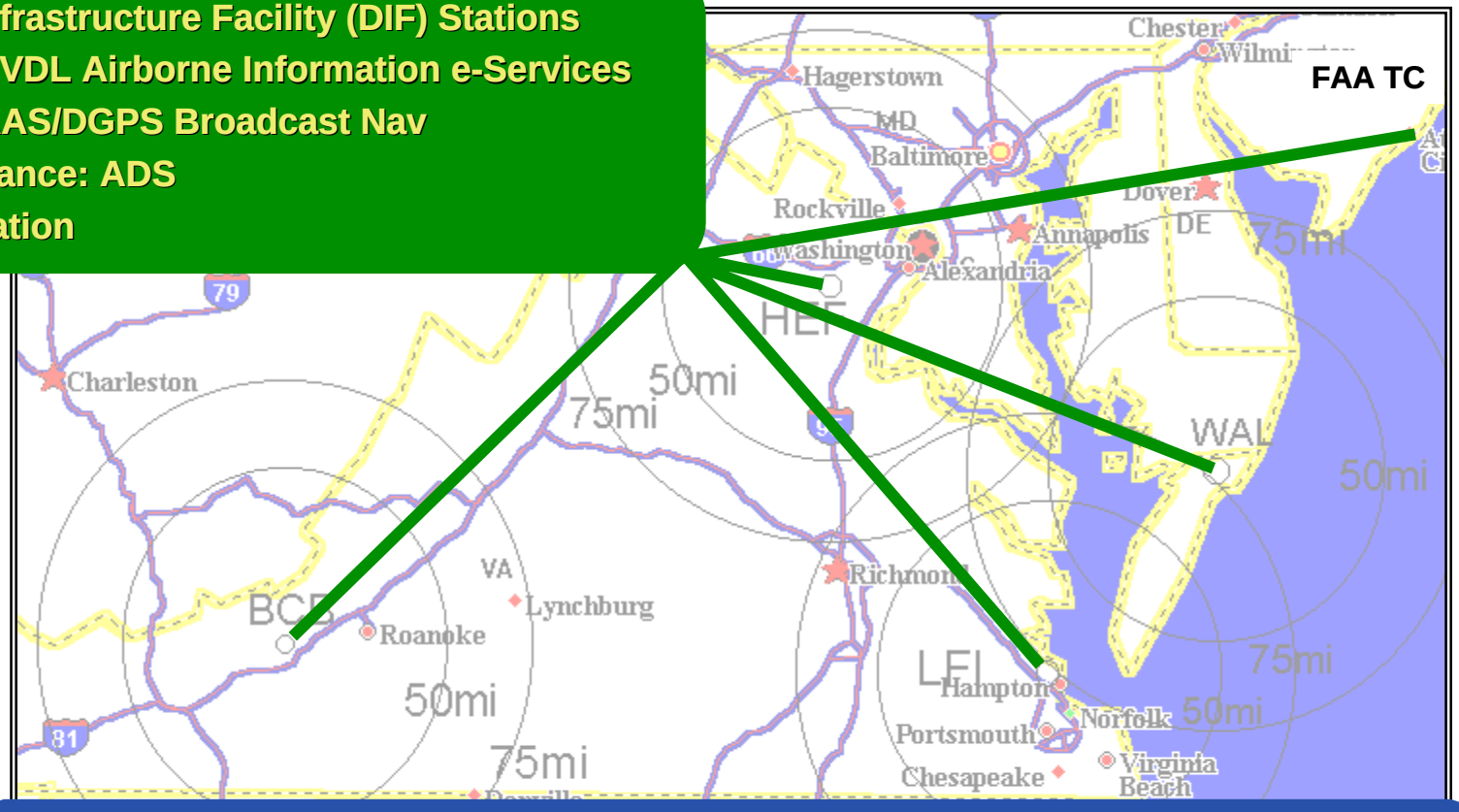
- **Cost Shared**
- **Collaboration for pre-competitive outcomes**
- **Competition for competitive technologies**

SATS Focused Program
NASA Technology Validation (TRL ≤ 6)
State/Industry Demonstration (TRL >6)

Virginia SATSLab

Datalink Infrastructure Facility (DIF) Stations

- **Comm: VDL Airborne Information e-Services**
- **Nav: LAAS/DGPS Broadcast Nav**
- **Surveillance: ADS**
- **ATM Station**



- **Highway in the Sky (HITS) Precision Guidance to All Runway Ends**
- **Airborne Internet, Client-Server architecture**
- **VFR 20:1 Approach Zones in IMC using "Virtual" TerPs**
- **Towerless, Radarless Operations with self-sequencing & separation**

SATS Hypotheses
"Prove SATS Works"

1. **The public can safely operate a SATS vehicle in 4-D, in near all-weather, including abnormal operations**
2. **The public can afford to travel by SATS**
3. **SATS infrastructure is an affordable option for national transportation system investments**
4. **SATS benefits all suburban, rural, and remote communities in terms of accessibility, mobility, economic opportunity, environment and quality of life**

Demonstration Projects
"Prove SATS Works"

SATS Approach and Departure

- **Prove that HITS integrated with Synthetic Vision and "virtual" TerPs will safely support use of VFR (20:1) Runway Protection Zones and approach and departure patterns and missed approaches in IMC, with potential application to virtually all runway ends and helipads in the nation.**

High-Density 4D Operations

- **Prove that SATS technologies enable (1) user preferred trajectories & (2) reduced separation & sequencing in non-towered, non-radar airspace in all-weather*, takeoff to touchdown, with potential for seamless interoperability at facilities in Class B airspace.**

(* Not including hazardous weather)

Automotive Cost Paradigm

- **Prove that automotive cost paradigms for design and manufacturing can be applied to easy-to-use SATS vehicles.**

Demonstration Project Hypotheses

SATS Approach and Departure

- Use of synthetic vision with Highway in the Sky operations enables near zero visibility landing minima.
- Traditional approach lighting will not be required when using synthetic vision with Highway in the Sky operations.
- The number of aircraft that can operate simultaneously in a non-towered, non-radar airspace is limited only by airport acceptance rates.
- Terminal Procedures (TerPs) can be "virtual" (*I.e.,* computed on-board in real-time) and dynamic under all conditions of weather and traffic.
- The airborne Clients can make all separation & sequencing decisions.
- Simultaneous operations on intersecting runways can be conducted.

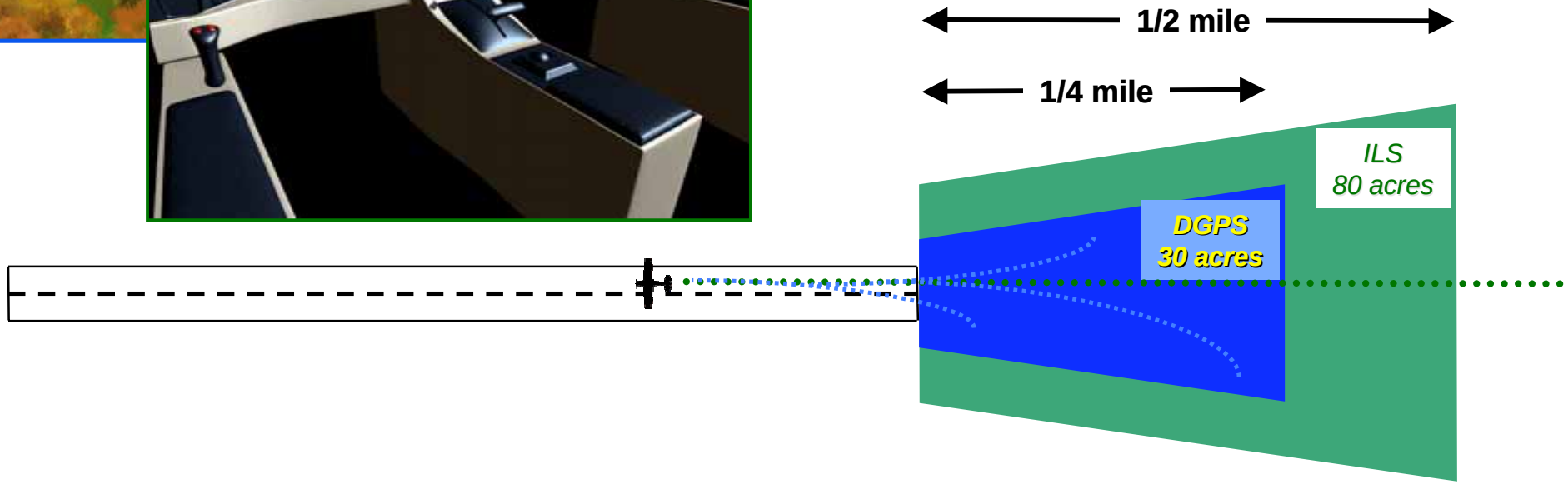
What else?

Precision Guidance to *Every* Runway End in America

Highway in the Sky / Synthetic Vision with "Virtual" Approach Procedures:

- **Saves land**
- **Limits noise**
- **Increases safety**

Runway Protection Zone (RPZ)



Demonstration Project Hypotheses

High Density 4D Operations

- **Dynamic access through Special Use Airspace can be provided without voice communication**
- **Routing and altitude segments can be pilot-controlled (user-preferred) in non-radar-airspace**
- **The airborne Client can make all separation & sequencing decisions with limited Server input**
- **Mixed equipage and procedures are enabled with SNI Ops**
- **Operations for intersecting runways, missed approaches, and Land & Hold Short are enabled by SNI Ops**
- **Non-interfering transit operations in Class B airspace are enabled by SNI Ops**
- **Near zero-visibility minimums for SATS-equipped aircraft are enabled by SNI Ops**

What else?

Demonstration Project Hypotheses

Automotive Cost Paradigm

- Aircraft can be designed and manufactured at unit costs comparable to automobiles
- Ease-of-use technologies can be common between automobiles and SATS vehicles
- Cockpit architectures can share common elements between automobiles and SATS vehicles
- Off-board architectures can share common elements between automobiles and SATS vehicles

What else?

NASA Roles

- **Establish the role for automation technologies in proving the SATS operator hypotheses.**
- **Establish the architecture technologies for the cockpit, the comm/nav/surveillance systems, and the airspace that prove the SATS infrastructure hypotheses.**
- **Create the collaborative environment that establishes technology options that prove the SATS vehicle hypotheses.**

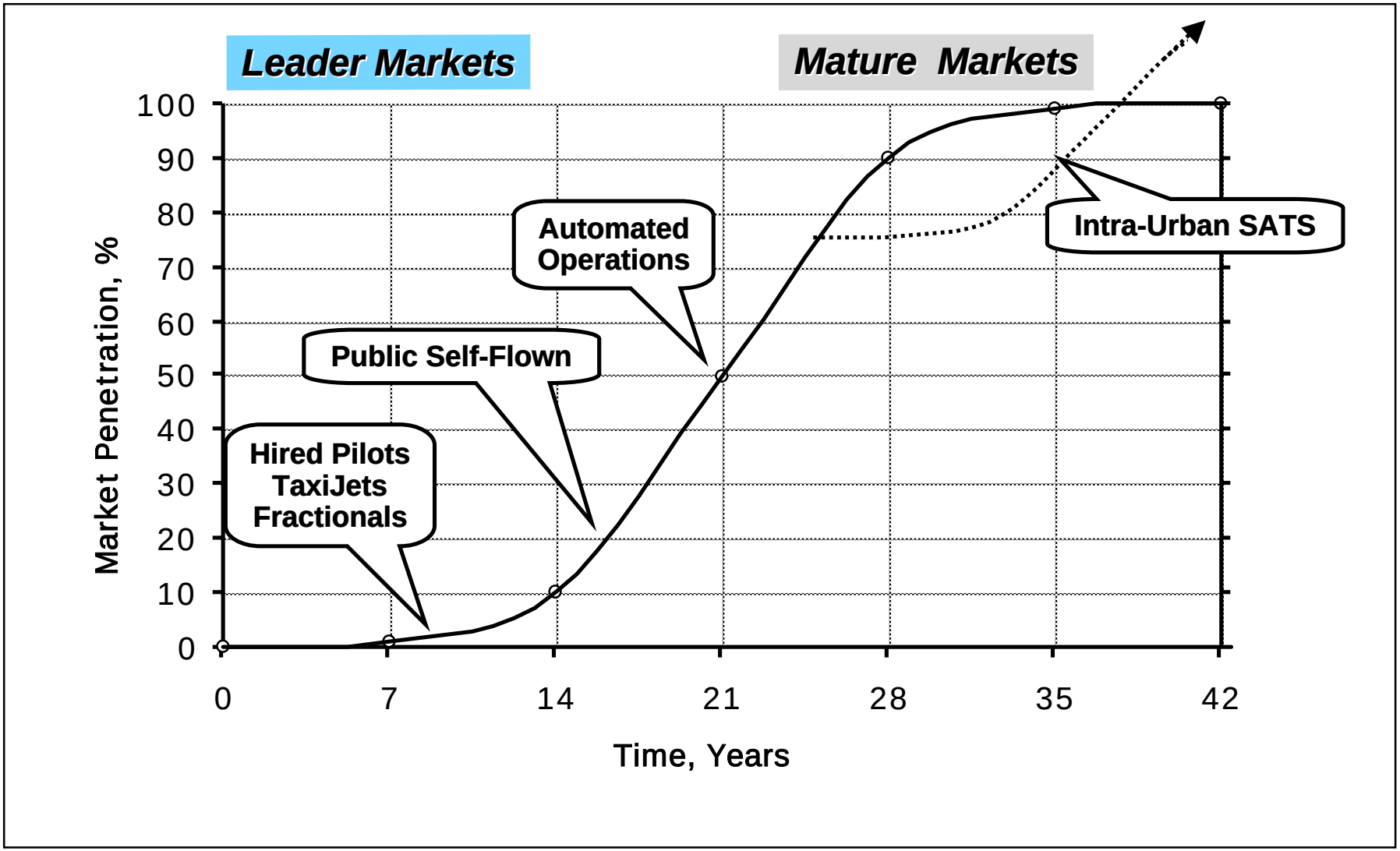
1. **The public can safely operate a SATS vehicle in 4-D, in near all-weather, including abnormal operations**
2. **The public can afford to travel by SATS**
3. **SATS infrastructure is an affordable option for national transportation system investments**
4. **SATS benefits all suburban, rural, and remote communities in terms of accessibility, mobility, economic opportunity, environment and quality of life**

Potential FAA Roles

Agree to metric requirements for acceptance of SATS "proofs"

- **Operations approvals for experiments and demonstration (AFS)**
- **Airport issues for HITS approach design, commercial activities, *etc.* (ARP)**
  - **FAR 77**
  - **AC 150-series**
- **Air Traffic Services issues for non-managed and managed airspace (ATS)**
  - **Procedures**
  - **Airspace**
  - **Regulatory**
- **Certification reform and streamlining (AIR, AFS, ATS)**
  - **Aircraft**
  - **Equipment**
  - **Airmen**
- **SATS transition and deployment plans (ARA, ATS, AFS)**
  - **Handling mixed equipage**
  - **Infrastructure transition**
- **Further FAA roles to be determined (AOA)**

A Potential SATS Innovation Life Cycle



SATS Milestones

2000

Concept & Architecture Requirements

Alliance Development

SATS Market Analyses

Initiate SATS Pre-Cursor Analyses & NRC Study

GAP Engines Flight Validated

AGATE Avionics & Airframe Technologies Complete

Initiate Federal-States SATS Partnership

Initiate "Leader States SATSLab Partnerships

SATS Technology Downselects

Identify SATS Integration Options

Integrate & Evaluate SATS Alternatives

Baseline SATS Architecture, Ops Rqmts

Demonstration Downselects
Validate 20:1 RPZ HITS Approaches

Downselect Automotive Cost Paradigm Concept Vehicle Design

States Deploy SATS Infrastructure

FIS Datalink

Communications Approaches

Document SATS Products

- Infrastructure technologies
- Aircraft technologies

Showcase Demonstration

Transportation System Assessment

Key:
- Current Investments
- Future Potential Investments

FY 1999 | FY 2000 | FY 2001 | FY 2002 | FY 2003 | FY 2004 | FY 2005

SATS Funding

Administration FY 2001 Budget Submittal to Congress*

	FY 01	02	03	04	05
SATS Focused Program*	$9M	$15M	$20M	$20M	$5M
States Matching	($TBD)	($TBD)	($TBD)	($TBD)	($TBD)
Industry Matching	($TBD)	($TBD)	($TBD)	($TBD)	($TBD)
Matching Subtotal	$5M est.	$8M est.	$10M est.	$10M est.	$10M est.
SATS Subtotal (ESTIMATE)	$14M	$23M	$30M	$30M	$10M
SATS Base Program	$3M	$5M	$8M	$8M	$8M
Industry Matching	$0 est.	$1M	$2M	$2M	$2M
SATS-Focused SBIR/STTR	$5M est.	$5M est.	$5M est.	$5M est.	$5M est.
TOTAL (Focused+Base+SBIR)	$22M est.	$34M est.	$45M est.	$45M est.	$45M est.

*** In Administration's FY 2001 Budget**

FAA/NASA Executive Committee

SATS Agreement

SATS Program Description:

"The Small Aircraft Transportation System concept is a safe travel alternative that frees people and products from transportation system delays, creating access to more communities in less time."

Joint NASA-FAA supporting statements are:

- FAA and NASA are working together to define a SATS operational concept as it relates to the transportation infrastructure of the U.S. and will begin a NASA funded research initiative to explore the feasibility and viability of implementing that concept.
- Under the charter of the NASA/FAA Executive Committee, the agencies agree to form a working group to define the FAA-NASA engagement in SATS program development and implementation planning.

SATS NRC Study

Purpose: Provide an independent assessment of the validity of SATS hypotheses

Status:

- **Committee to consist of 12-15 members**
- **18-24 month study**
- **Currently assembling list of candidates**
- **First committee meeting in May or June**

Issues:

- **Committee chairman still not identified**
- **Late start pushes completion of study well into FY02**

Desired Committee Expertise

Technology and Infrastructure

- **Avionics/Flight Deck Systems**
- **Alternative Technologies**
- **Product Manufacturing and Integration:**
- **Propulsion**
- **Air Space/Air Traffic Control and Management**
- **Airports/Landing Facilities**
- **Automation Systems/Com-Nav Capabilities**

Market Demand and Use

- **Human Factors Integration**
- **Aviation Safety**
- **User Training**
- **Aircraft Certification**
- **Future Travel Demand**
- **Transportation Economics**
- **Airport and Airway Capacity/Logistics**
- **Private Finance**

Airline markets/Aviation Operations

Public Sector Role and Policy Issues

- **Public Policy**
- **Environment**
- **Technology Policy/History**
- **Innovation Process/Role of Government**
- **Local Economic Development**
- **Public Finance**

REDAC Communications Strategies for SATS

- **SATS concept has sufficient potential value to the nation to warrant NASA-FAA investment.**
- **The SATS technologies have sufficient potential benefits to the future NAS to warrant specific FAA-NASA collaboration on:**
  - **Regulation & Certification**
  - **Flight Standards**
  - **Airports**
  - **Air Traffic Services**
  - **R&D**
- **"Airline friendly" SATS message: *The airline community benefits in three ways from SATS:***
  1. ***Third tier connectivity to smaller markets***
  2. ***Class B capacity relief***
  3. ***Accelerate path to free flight***

Suggested REDAC-ASTAC Actions

- **Encourage the Administrators to:**
  - **accelerate the FAA engagement and resource commitments for SATS planning and demonstration (*I.e., take next steps on SATS Mission Need Statement*)**
  - **position SATS activities within the agencies as a "disruptive innovation" (*I.e., apart from "mainstream" customer- and resource allocation-driven organizations*)**


The Smart Air Transport System is a safe travel alternative
freeing people and products from transportation delays,
by creating access to more communities in less time.
"Reduce public travel times by half in 10 years and two-thirds in 25 years"

Backup Charts

Showcase Demonstrations

"Showcase Demonstrations", implemented with State and Local Government partners, integrate SATS Features and validate key technologies. Experiment in FY 03 and Demonstrations in FY 05 are planned for a constrained spectrum of variables (vehicle, terrain, meteorological, geographic, demographic, and airspace). Demonstrations serve as basis for (1) technology application strategies by industry (regulation and certification) and (2) influence of public policy decisions on deploying SATS infrastructure based on consumer and community response to technologies. Demonstrations to be limited to 2 states at most.

•FY03- Validate subset of SATS Operational Capabilities in Terminal Airspace

- **Validate 20:1 runway protection zone for near all weather operations using Highway-In-The-Sky (HITS) operating system**
- **Basic Datalink system philosophy (only demonstrate essential communication link with Flight Information (FIS) and Traffic Information (TIS) Services)**
- **Intuitive vehicle controls (integration of AGATE Features, e.g., decoupled controls, single power lever)**
- **Training systems concepts for reducing cost and time for all-weather operations (extension of AGATE activities)**

•FY05- Airport-to-airport validation of integrated technologies for safe, near all-weather accessibility including:

- **Automation-enabled separation and self-sequencing in non-towered, non-radar airspace (multiple aircraft demonstration)**
- **Simultaneous non-interfering operations (limited demonstration)**
- **Datalink system, including full suite of information services (Flight Information Services, Commercial Information Services, Traffic Information Services)**
- **Integrated avionics standards and systems**

SATS Features and Capabilities

SATS Features (Strawman)

- **"Smart" Airports (Highway in the Sky Approaches; Airport databus; "Virtual" Terminal Procedures (TerPs); Synthetic tower/towerless-radarless operations)**
- **Ultra- Propulsion (non-hydrocarbon and heat engine options; low-noise/emissions)**
- **AutoFlight (Integrated Vehicle and Air Traffic Services automation; Control de-coupling; Ride Smoothing)**
- **Airborne Internet (Satellite-based communications-navigation-surveillance for Ground-to-Sky Air Traffic Management functions in all airspace)**
- **Simultaneous Non-Interfering (SNI) Approaches at Class B airports for Runway-Independent Aircraft**
- **Affordable Manufacturing (Thermoplastics, aluminum, composites automation for integrated airframe systems design & manufacturing)**
- **Wireless Cockpit (open standards for on-board systems and architecture; databus; through-the-window displays)**
- **Cyber-tutor and InterNet-based training systems (embedded and on-board training and expert systems)**
- **Extremely Slow Takeoff & Landing (Configuration Aerodynamics for slow & vertical flight; roadability)**

SATS Distinctions

- **The SATS concept establishes a new priority ranking for intercity transportation consumer value-criteria, minimizing door-to-door time.**
- **SATS fills a vacuum not currently populated by transportation services (vacuum left by up-market movements of the rest of the industry).**
- **SATS serves a latent market that cannot be quantified *a priori*; a business case cannot be based on *a priori* known behavior of this latent market.**
- **SATS also serves a current market for enthusiast, romance and elitist aviation products and services that can be quantified.**
- **Upmarket forces in the established G A industry may make it easier for entrant firms to introduce SATS vehicles, or for organizations embedded in established firms with insulation from mainstream resource constraints.**
- **Upmarket forces at well-developed General Aviation and Regional landing facilities may make it easier for SATS infrastructure to be introduced by entrant communities.**
- **NAS Architecture, regulation and certification for SATS will require innovation (SATS serves a personal *versus* a mass transportation need).**

States' SATSLab Products

Products

- Community, economic & environmental education & advocacy
- Airport management & patrons education & advocacy
- Design of SATSLab experimental infrastructure, patron services, training & FAA coordination
- Analysis of *current* & *latent* SATS consumer markets
- Deployment of Virginia SATSLab Demonstration
- Design of other local experiments
- Implementation of other local experiments?
- Implementation of other SATS Demonstrations?

Funded*

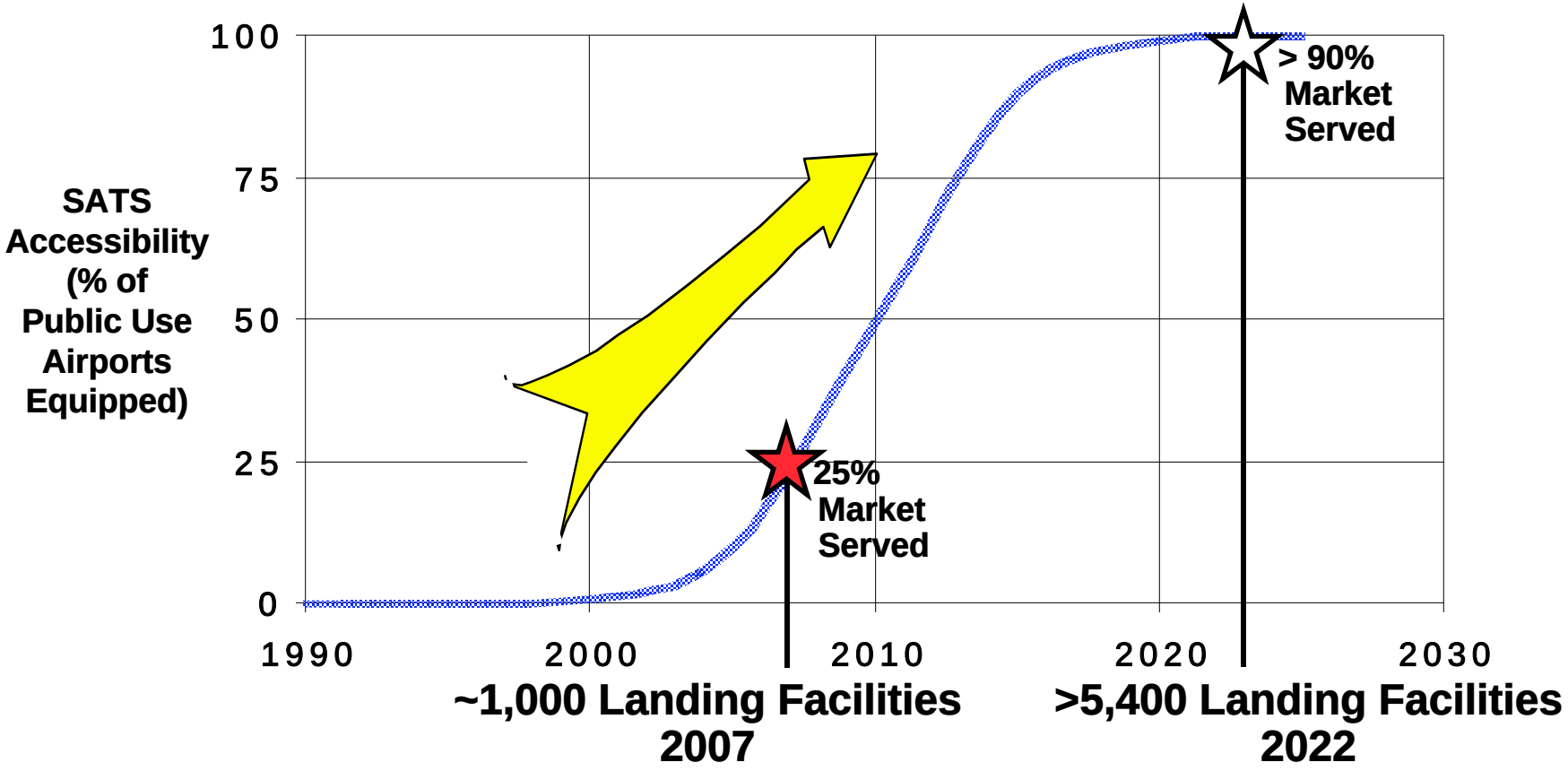
Unfunded

- Implementation of other local experiments?
- Implementation of other SATS Demonstrations?

*** In Administration's FY 2001 Budget**

National General Aviation Roadmap Goal
(Revised December 1999)

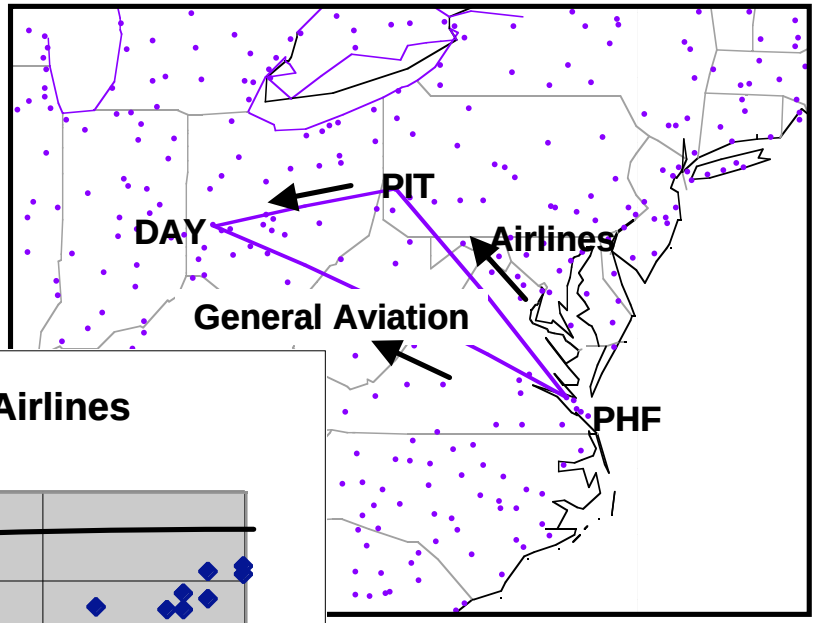
" Reduce public travel times by half in ten years and two-thirds in 25 years,"
(at equivalent highway system costs,
increasing mobility for all of the nation's communities
through advanced small aircraft transportation).

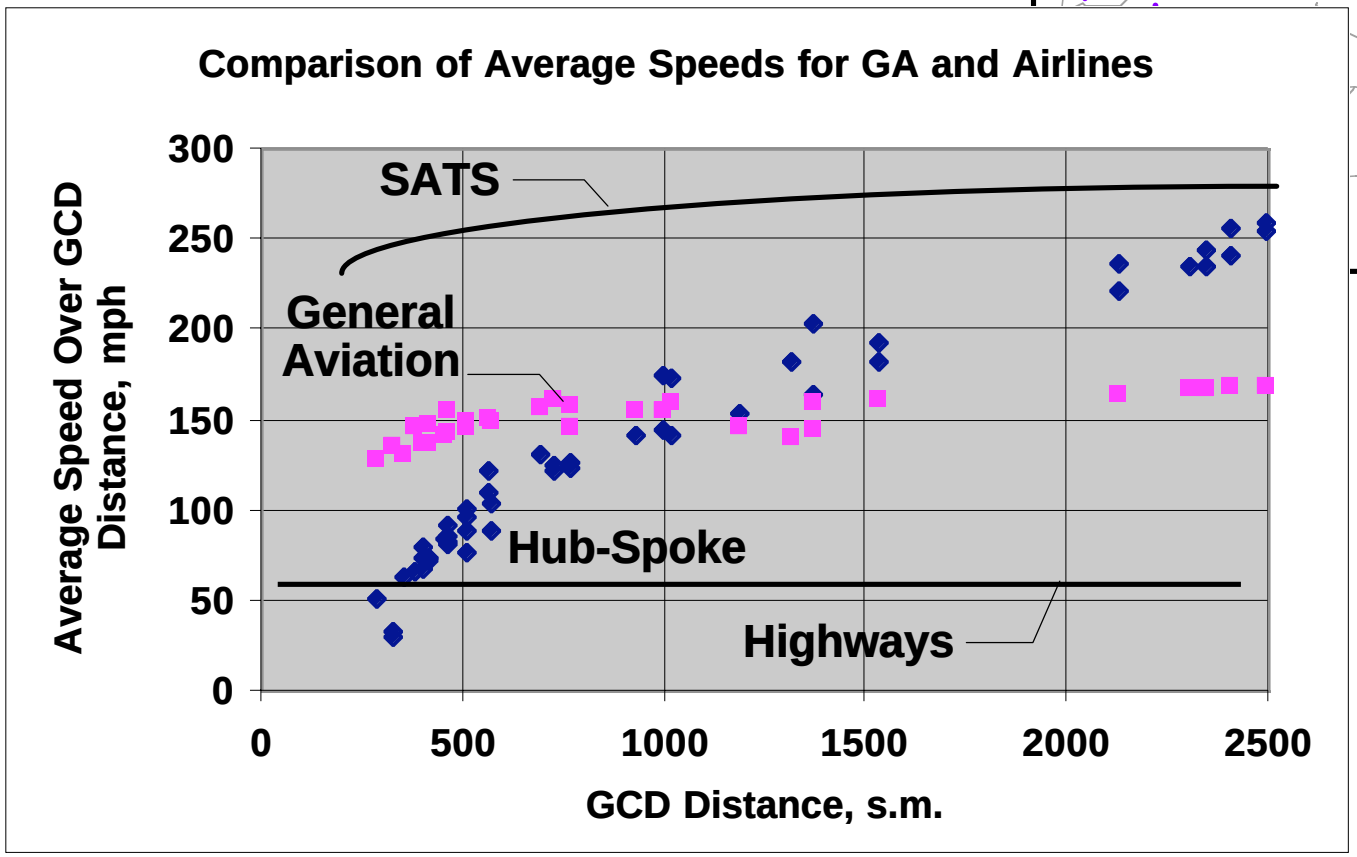


Smart Air Transport System Speed

"Reduce public travel times by half in 10 years. . ."

**SATS reduces travel times,
while highways and Hub-and-spoke travel times
will continue to increase.**



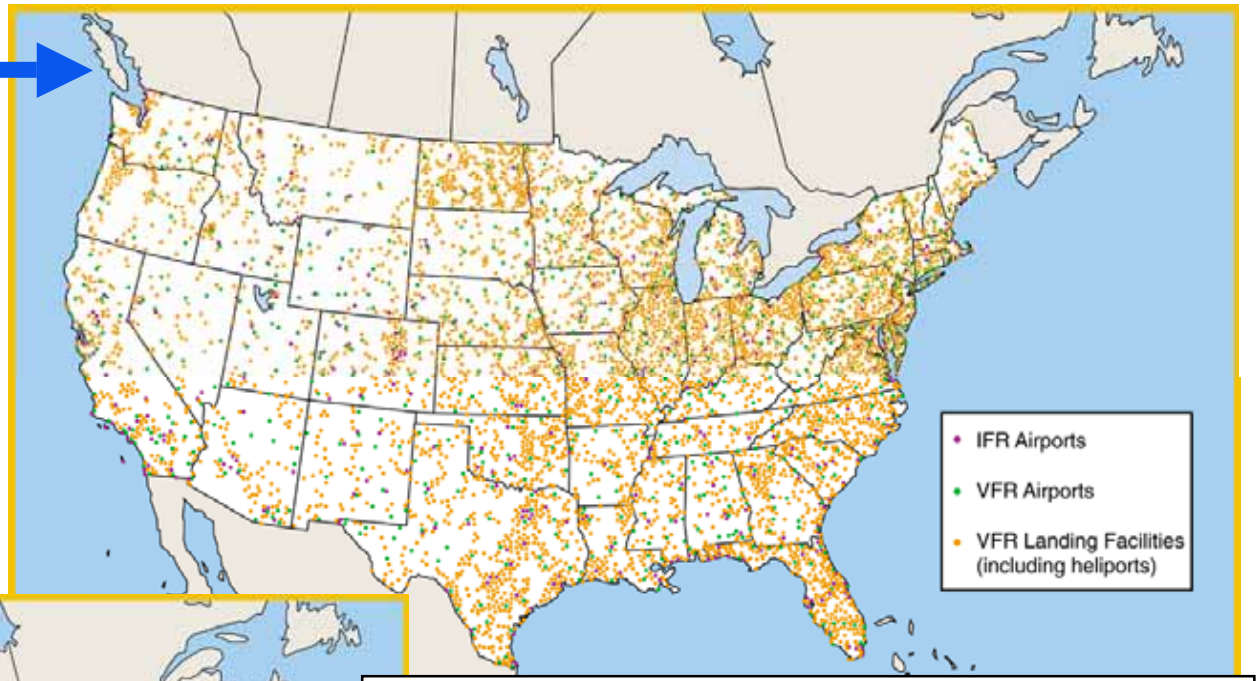


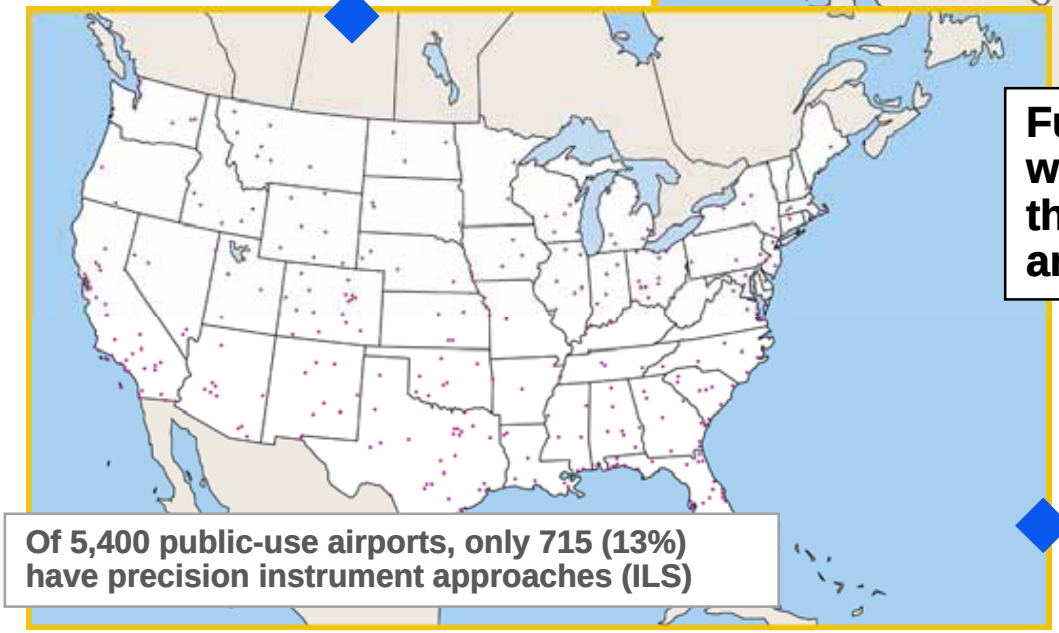
- Hub-Spoke: OAG times for 28 destinations
- General Aviation: time-optimized flight plans
- Including intermodal penalties (:45 +:45 for airline & :30+:30 for GA departure & arrivals)
- No GA destination benefit (for proximity of airports)
- SATS with new GAP engines: costs equal current General Aviation at 2 times the speed.

SATS Increases Accessibility and Mobility

(". . .creating access to more communities in less time. . .")

Expanded <u>Accessibility</u> to several times more destinations



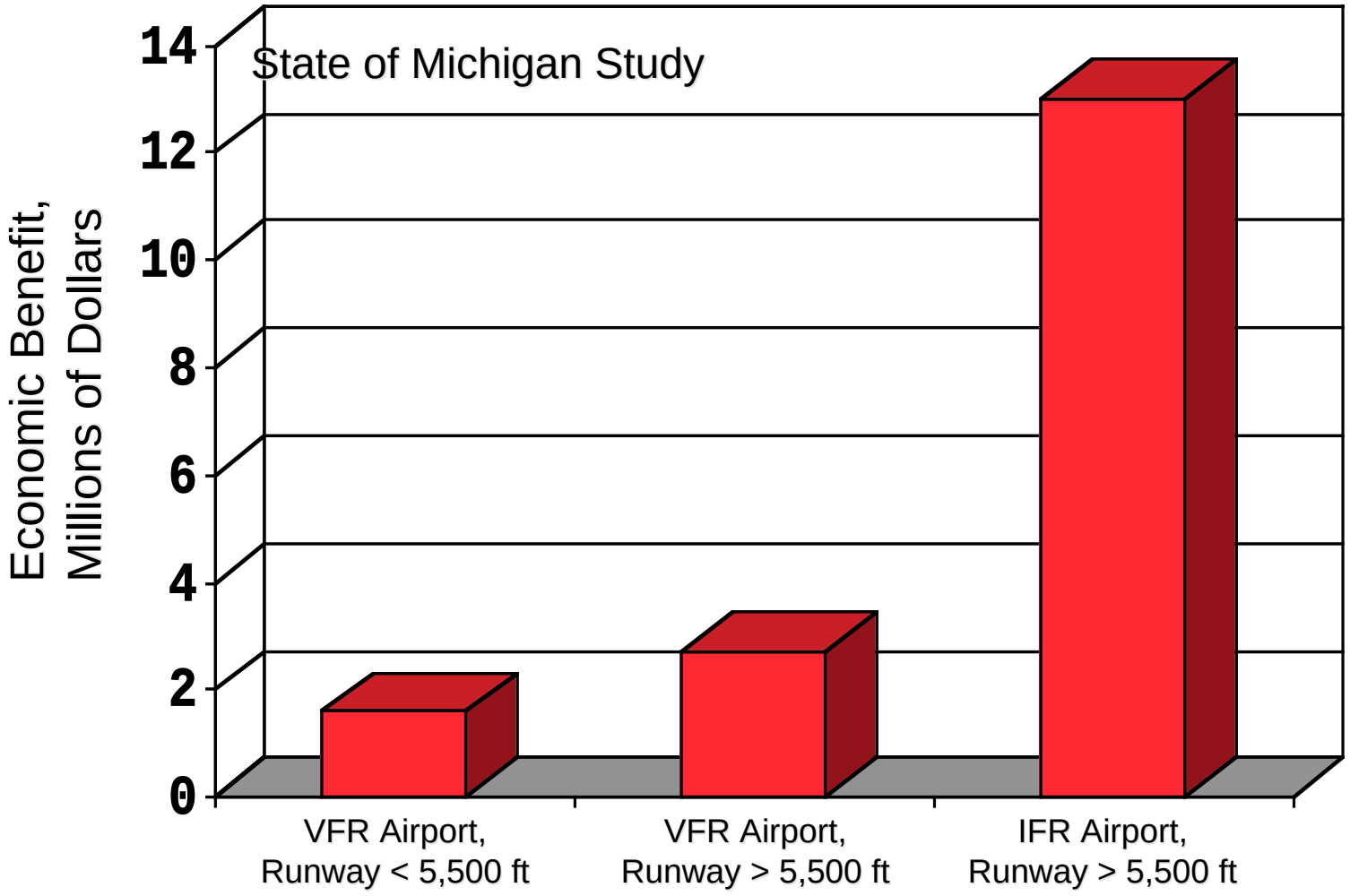


Of 5,400 public-use airports, only 715 (13%) have precision instrument approaches (ILS)

Fully utilized 5,400 public-use near-all-weather landing facilities can increase theoretical NAS Throughput by more than an order of magnitude

Improved <u>Mobility</u> saving more travelers more time

All-Weather Accessibility Means Economic Development



VFR - Visual Flight Rules
IFR - Instrument Flight Rules

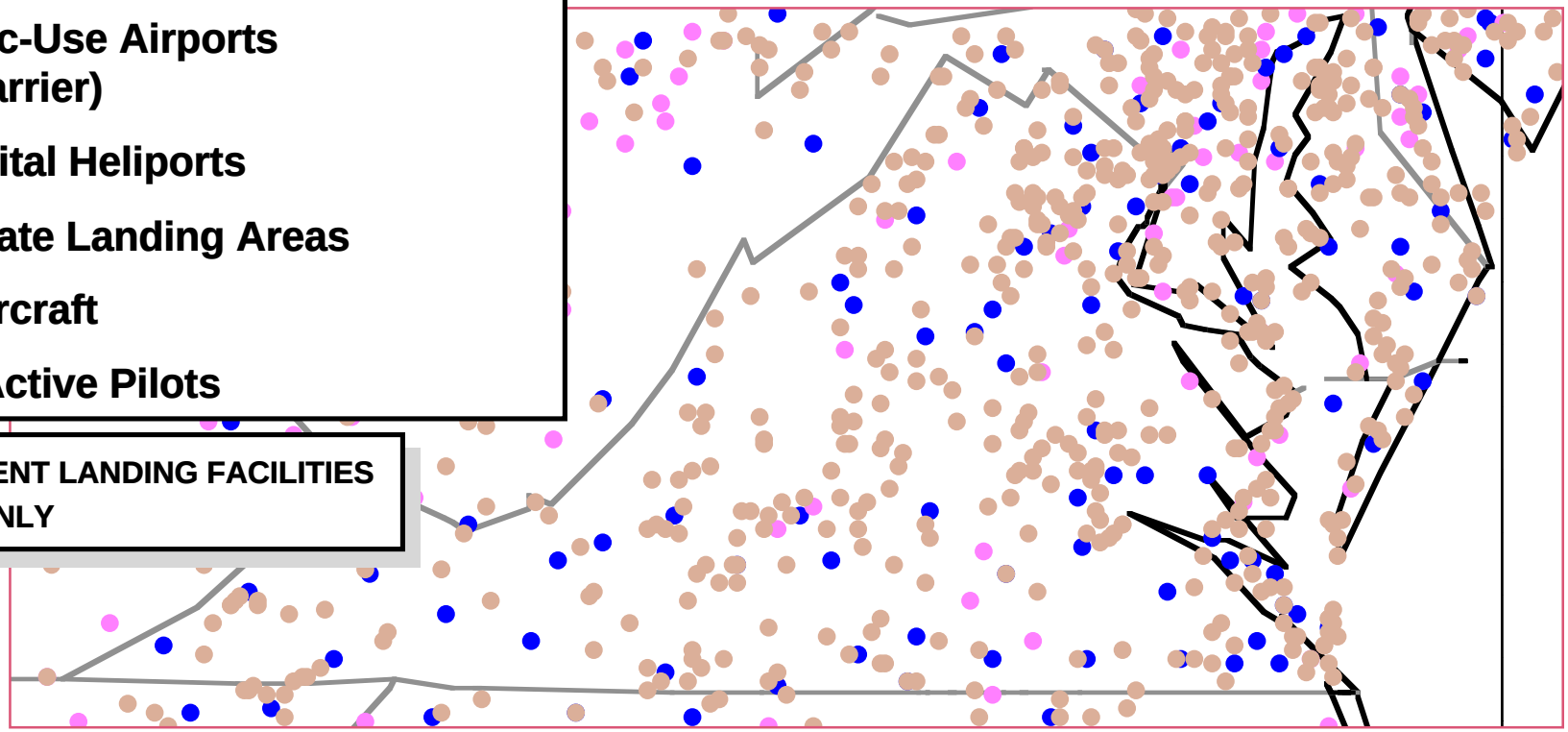
SATS Accessibility = Economic Development

Example for one state

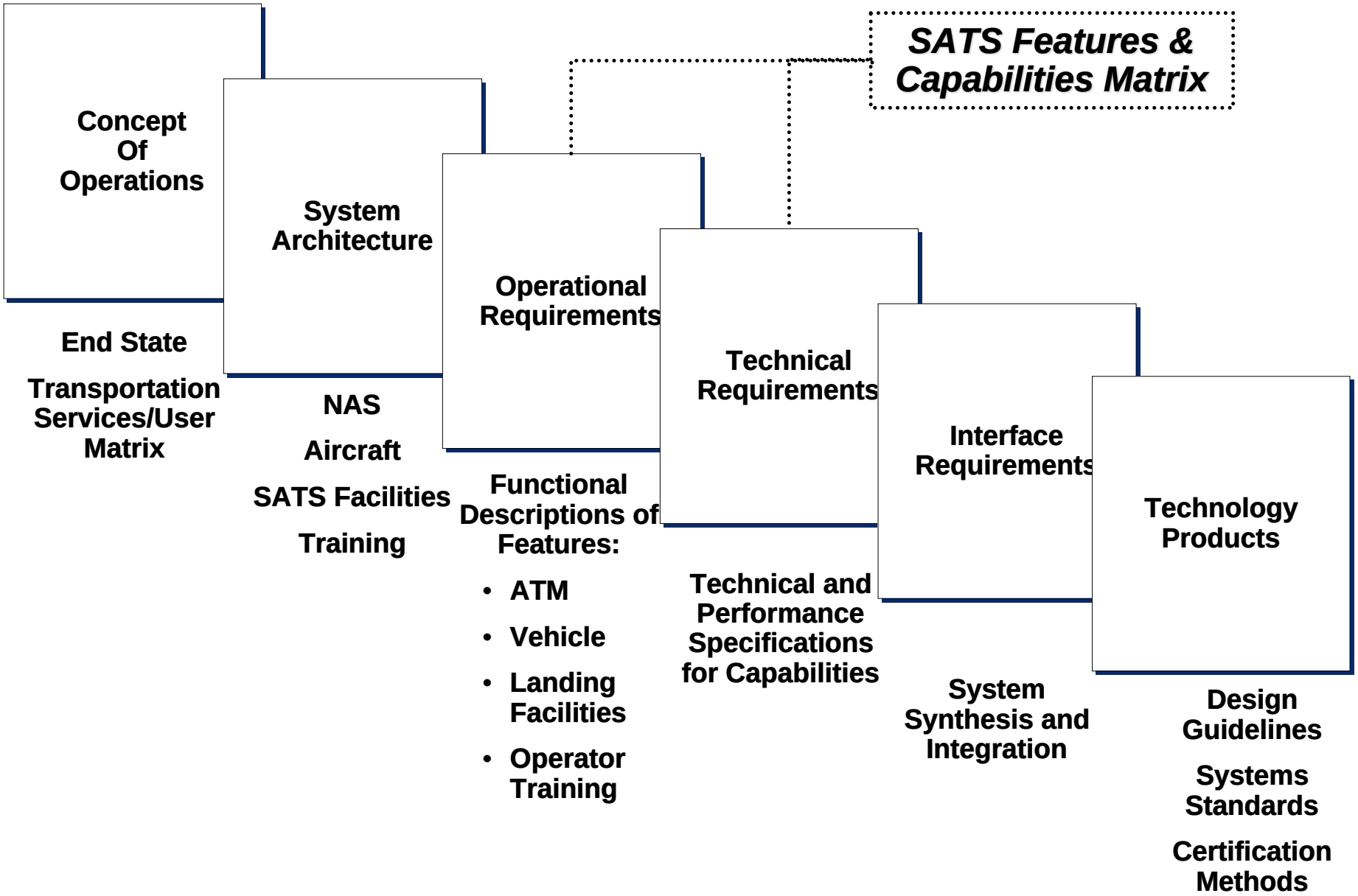
Virginia General Aviation Today

- **~$175 Million in Economic Impact** (Primary & Secondary)
- **2,400 jobs from General Aviation** (Primary & Secondary)
- **68 Public-Use Airports (9 Air Carrier)**
- **54 Hospital Heliports**
- **227 Private Landing Areas**
- **4,104 Aircraft**
- **15,525 Active Pilots**

SATS will enable ~90% more accessibility by air for all Virginia's communities, expanding economic opportunities for all regions



Systems Engineering Products

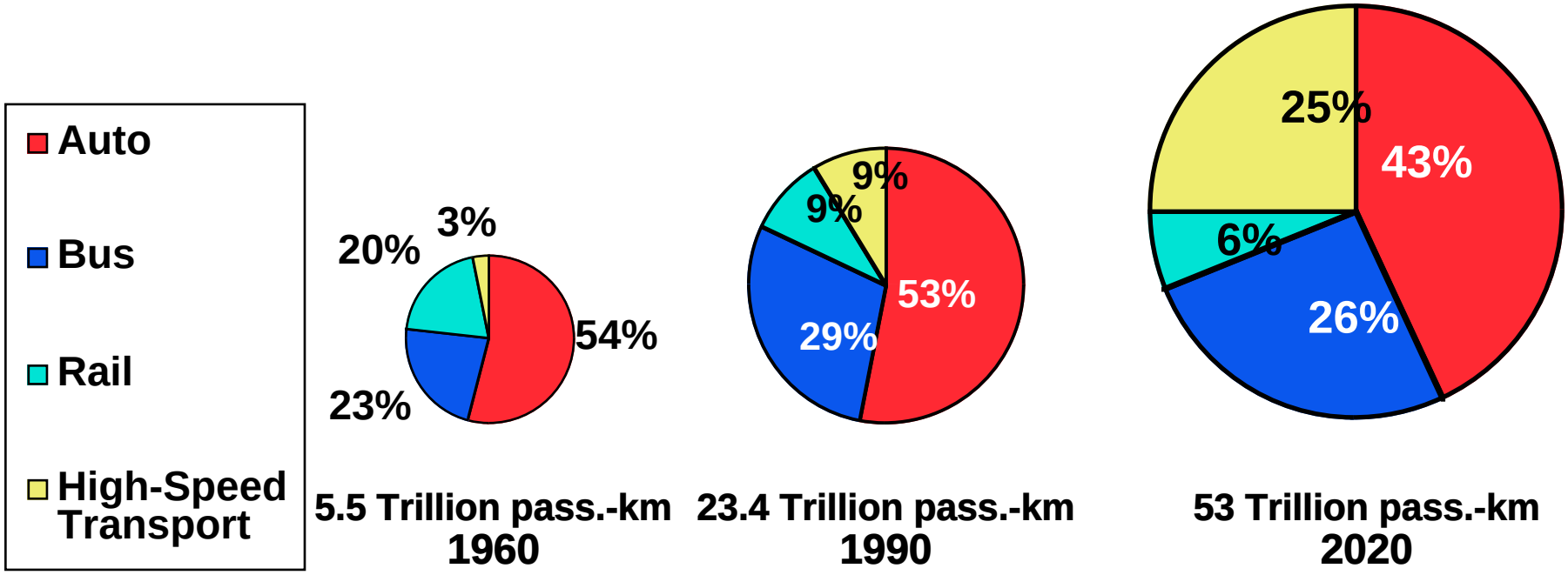


Strategic Planning Tenets

- The innate human desire for personal command of time and space creates demand for distributed (personal) transportation systems.
- The Information Age will usher in a new magnitude for the value of time.
- The Baby Boom generation's peak spending (traveling) period coincides with saturation of the hub-spoke airway and interstate highway systems.
- The Third Migration Wave (beyond the suburbs), coupled with tele-commuting, creates new transportation demand and challenges.
- The revolution in digital bandwidth redistributes intelligence from centralized to distributed system nodes, enabling the aviation transition from centralized to distributed air traffic management (free flight).

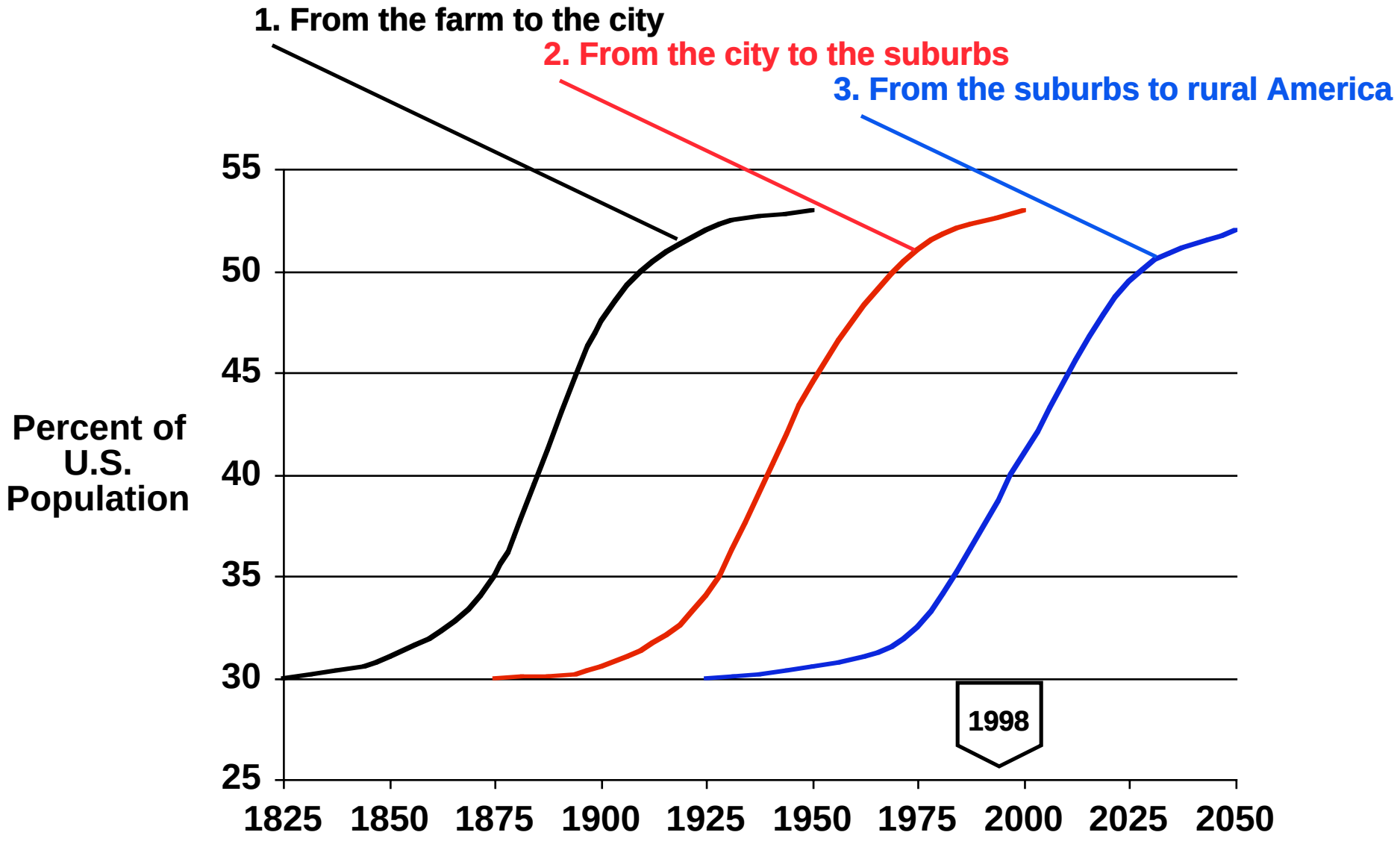
The Pig in the Python

As *per capita* income rises,
per capita annual travel rises,
personal daily travel time budgets remain constant,
and
high-speed modes gain market share
(Schafer and Victor, Sci. Amer., Oct. 1997)



Global Travel Mode Shares will be driven by
the largest population and spending wave in history:
The Baby Boom

The Third Migration Wave



(R)evolutions in Higher Speed Travel

What is Next? More Speed to More Destinations

The "Atomic Structure" of Business Innovation Cycles