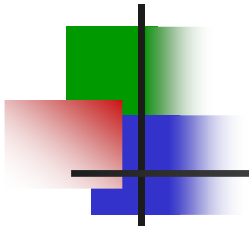
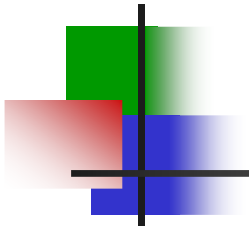
The Future of Aviation

Craig Duncan
craig.duncan@c3daero.com



Executive Summary

- Aviation today
  - Commercial aviation's hub-and-spoke system is overloaded
- Small Aircraft Transportation System (SATS)
  - A transportation network that uses small aircraft and small airports is being built
- Highway In The Sky (HITS)
  - A graphical flight path system that will make flying as easy as – and safer than – driving a car
- The Moller Skycar
  - Will usher in a new era of personal airborne transportation
- C3D Aero
  - Builds Aviation Web Services that will help make the future a reality



Problems with aviation today

- Hub-and-spoke system
  - Relies on a few large airports which do not have enough runways
- 100 major commercial airports
  - 20 are critical (O'Hare, LaGuardia, etc.)
- Average flight delay of 30 minutes
- Air travel will double or triple by 2020
- Fear of terrorism slows passenger processing

The solution: Small Aircraft Transportation System (SATS)

- National Aeronautics and Space Administration's (NASA) goal:

  "Reduce door-to-door travel time by half in 10 years and two-thirds in 25 years."

- 98% of Americans live within a 30 minute drive of a small airport
- SATS will be an airborne transportation network that will use small aircraft and the nation's 5,000+ small airports

Comparison of travel time from West Chester, PA to Langley Research Center, VA

Car (300 mi*)	**Airline (200 mi*)**	**SATS (200 mi*)**
6 hour drive	1 hour drive to PHL 1 hour check in 30 min wait on runway 1 hour flight to ORF† ? min holding pattern ? min baggage claim 30 min drive to LARC	10 min drive to N99† 5 min check in 1 hour flight to PHF† 5 min check out 20 min drive to LARC
Time: 6 hours Speed: 50 mph Cost: $35	4 hours 50 mph!* $400	1 hour 40 minutes 120 mph $150?

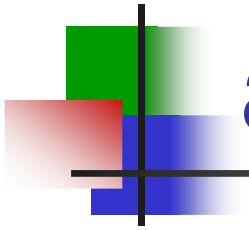
* The driving distance is 300 miles, the distance by air (as the crow flies) is 200 miles

† ORF = Norfolk International, N99 = Brandywine Airport, PHF = Newport News/Williamsburg International

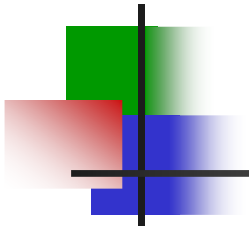
Conceptual SATS aircraft

Source: NASA

SATS: Evolution of aviation technology



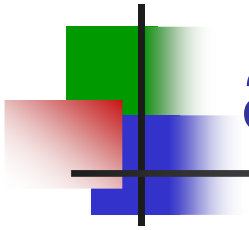
- Stronger and lighter weight materials
  - Composites
- Smaller, more efficient, and more reliable engines
  - Williams EJ22 Turbojet
- Better safety
  - Ballistic (rocket-fired) airframe parachutes
- Improved avionics:
  - Global Positioning System (GPS)
  - Collision avoidance systems
  - Highway in the Sky (HITS)



Problems with current avionics

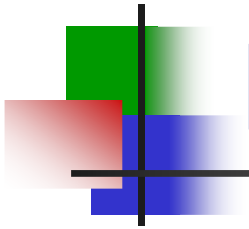
- World War I era technology
- "Steam gauge" instruments:
  - Some rely on failure-prone vacuum pumps
  - Icing can clog air pressure vents
  - Each instrument was designed individually
- Lack of integration requires a pilot to do a lot of interpretation, mental visualization, and math in their head
- Making existing instruments electronic adds another layer of complexity

Problems with current air traffic control



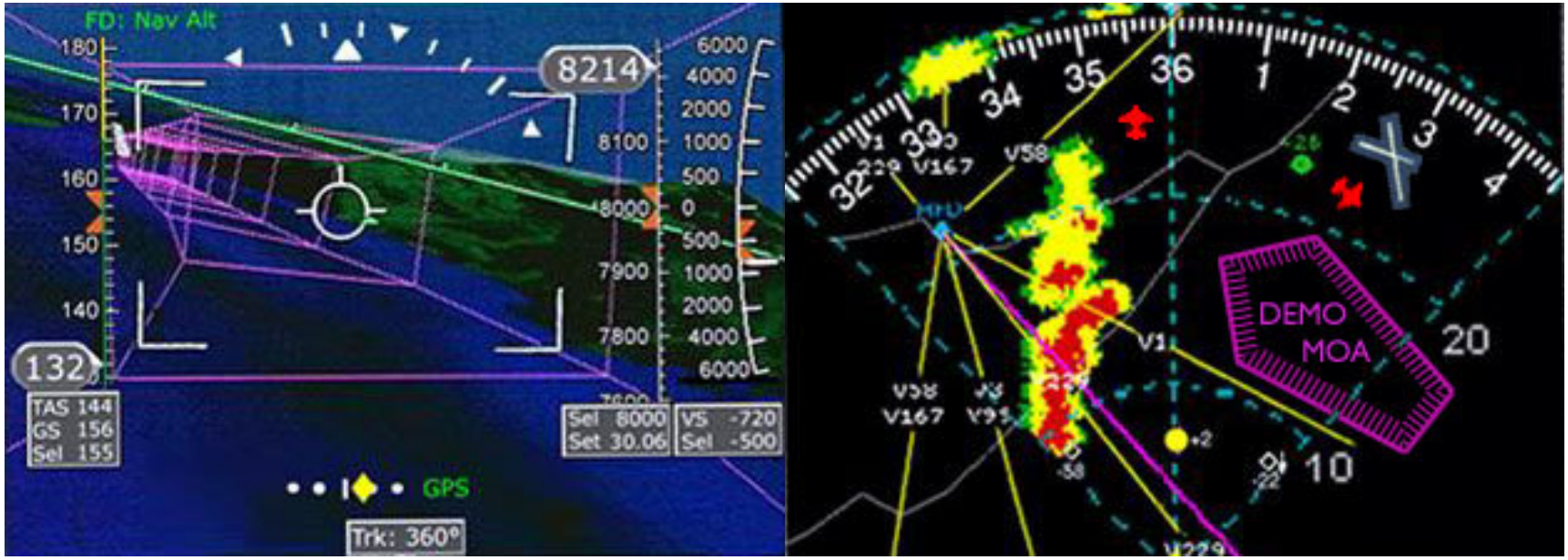
- World War II era technology
- Radar – Can be inaccurate
  - Minimum separation requirements:
    - 5 miles horizontal
    - 1,000 feet vertical
- Radio – Inefficient
  - Transmissions can be "stepped on"
  - Human controllers hand off pilots from section to section
- Airspace – Confusing
  - Becoming more segmented and complex
  - Difficult for a pilot to tell exact location

The solution: Highway In The Sky (HITS)

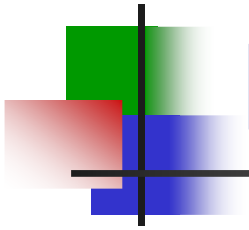


- A graphical flight path system
- Flying will be as easy as – and safer than – driving a car
- Intuitive cockpit displays show:
  - Virtual path for aircraft to follow
  - 3D representation of terrain and obstructions
  - 2D moving map of other aircraft, weather conditions, restricted airspace, and airports

HITS cockpit displays



Flight path and moving map displays. Adapted from NASA



HITS air traffic management

- Pilot will select destination by either:
  - Clicking on a map display
  - Speaking the name of the airport
- Aircraft will automatically access Aviation Web Services and use them to:
  - Obtain updates of weather, navigation, airport, and aircraft performance data

    Note – Most information will already be cached in a database on the aircraft
  - Plan the flight and navigate through the air
  - Receive alerts and notifications
  - Display current flight information

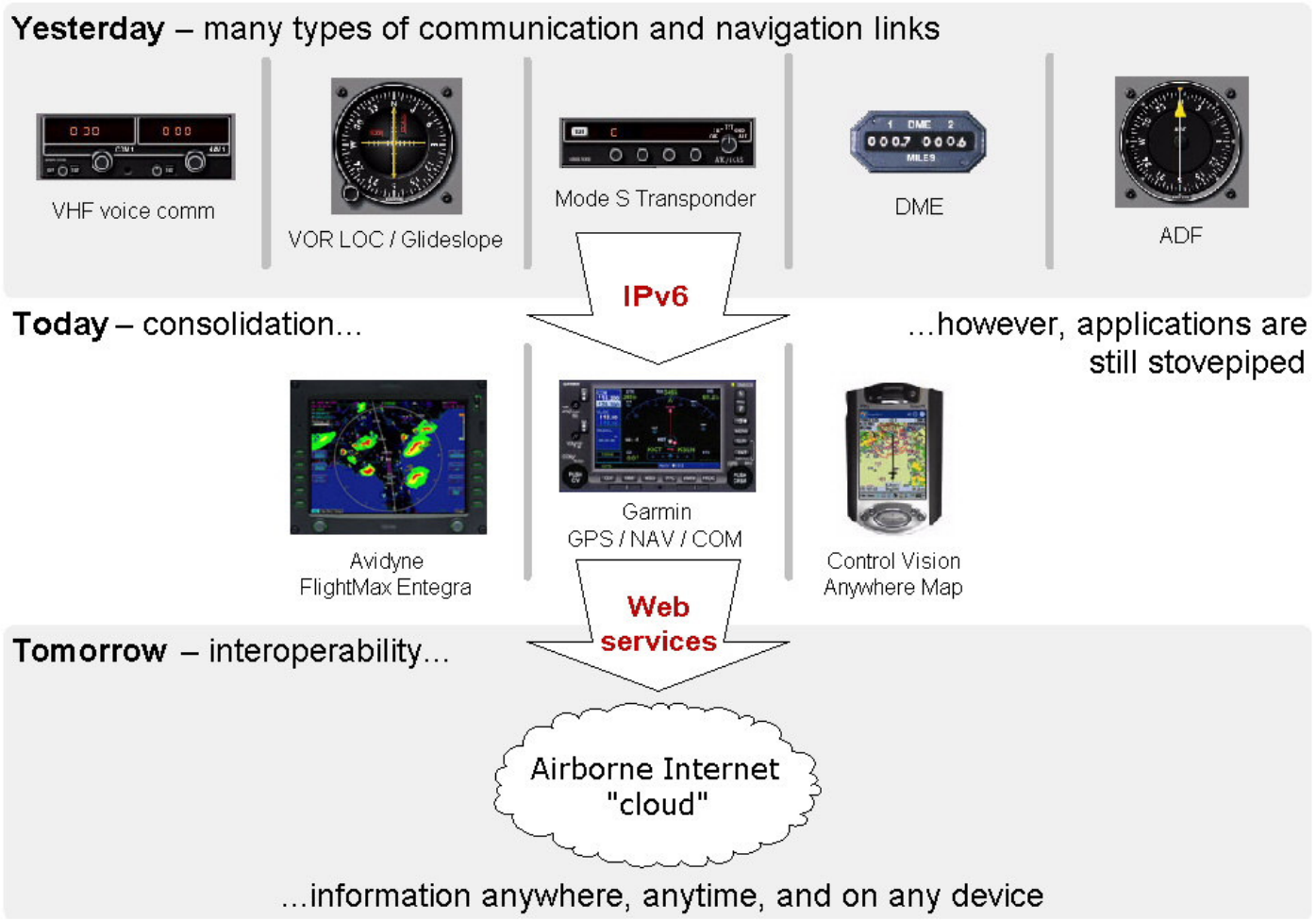
HITS air traffic management continued

- Aviation Web Services
  - Software components that can be run over the Internet and contain aviation data in an Extensible Markup Language (XML) format
- Aircraft will be able to communi-cate information to other aircraft in the area

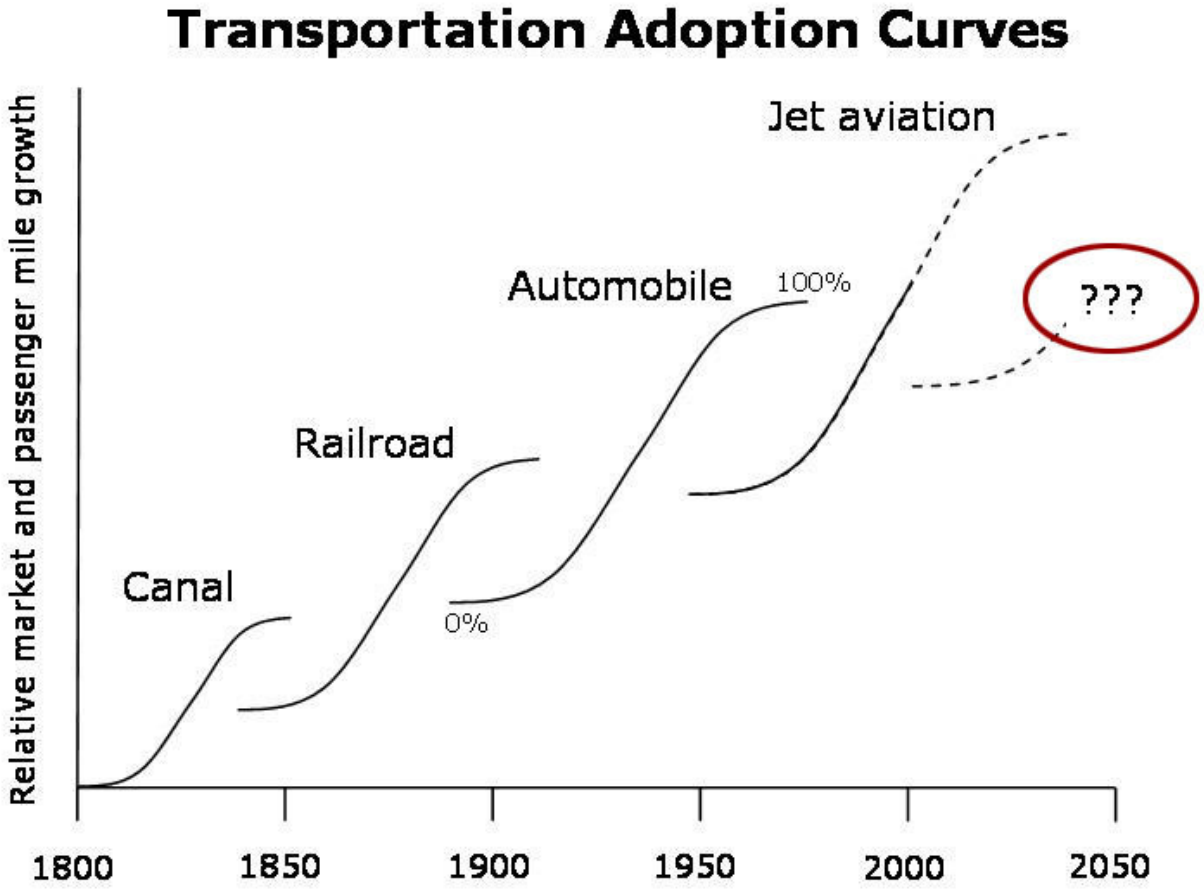
HITS air traffic management continued

- Aircraft will broadcast their own Aviation Web Services to the National Airspace System (NAS):
  - Flight tracking information
  - Local weather conditions (PIREPs)
  - Equipment performance data and failures
  - Controller Pilot Communications Markup Language (CPCML)
- Will use the Airborne Internet
  - A private, secure, and reliable peer-to-peer aircraft communications network that uses the same technologies as the commercial Internet

Airborne Internet replaces stovepiped technology



Question: What is the next mode of transportation?



Adapted from www.skyaid.org

Answer: The Moller Skycar

"Mark my word: A combination airplane and motor car is coming. You may smile. But it will come."

– Henry Ford, 1940

Skycar information

- Personal airborne transportation system (door-to-door SATS):
  - Drive to nearest vertiport (several blocks)
  - Fly to vertiport nearest destination
  - Drive to destination
- Vertical Takeoff and Landing (VTOL):
  - Needs a 35 foot diameter area vertiport
  - Cul-de-sacs, parking lots, and top of buildings
- Ducted fan powered lift aircraft
  - Deflects air vertically for takeoff and horizontally for forward flight
- Will use SATS and HITS technology

Skycar economics

- Value:
  - Door-to-door from West Chester, PA to Langley Research Center, VA (200 miles) in 40 minutes
  - No switching between vehicles
  - No airport parking, taxi, or car rental costs
  - Looks cool
- Cost:
  - Currently a million dollars
  - Mass production will lower cost between $60 K and $80 K

Skycar safety and environmental impact

- Safety:
  - Eight Wankel rotary engines
    - Reliable – three moving parts per engine
    - Redundant – two engines in each of the four intakes
    - Engines can be modified to run on many different types of fuel
  - 14.5 glide ratio
  - Two ballistic airframe parachutes
- "Green":
  - Fuel efficient – 28 mpg
  - Ultra-low emissions
  - Quiet – 76 db

Skycar performance comparison

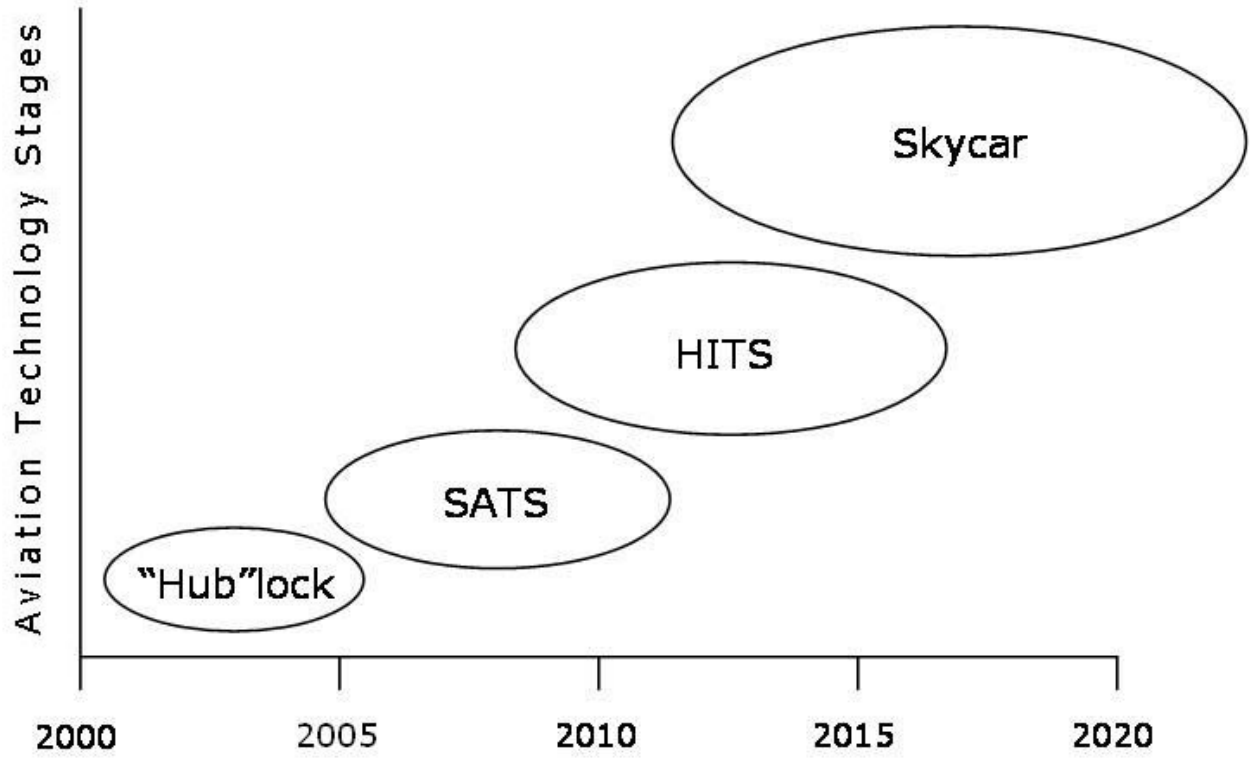
	Moller M400 Skycar*	**Lancair 300 aircraft**	**JetRanger helicopter**
Passengers	4 (M600 seats 6)	4	5
Cruise / top	325 / 370 mph	220 / 270 mph	135 / 140 mph
Max range	920 miles	1,520 miles	430 miles
Useful load	950 lbs	1,350 lbs	1,500 lbs
Max weight	2,400 lbs	3,400 lbs	3,350 lbs
Fuel econ.	28 mpg	13 mpg	4.5 mpg
Climb rate	7,050 fpm	1,340 fpm	1,280 fpm
Ceiling	30,000 feet	18,000 feet	13,500 feet
Power / boost	640 hp / 1,400 hp	310 hp / NA	420 hp / NA
Runway	35’ diameter area	1,550’ x 50’	75’ diameter

* Projected

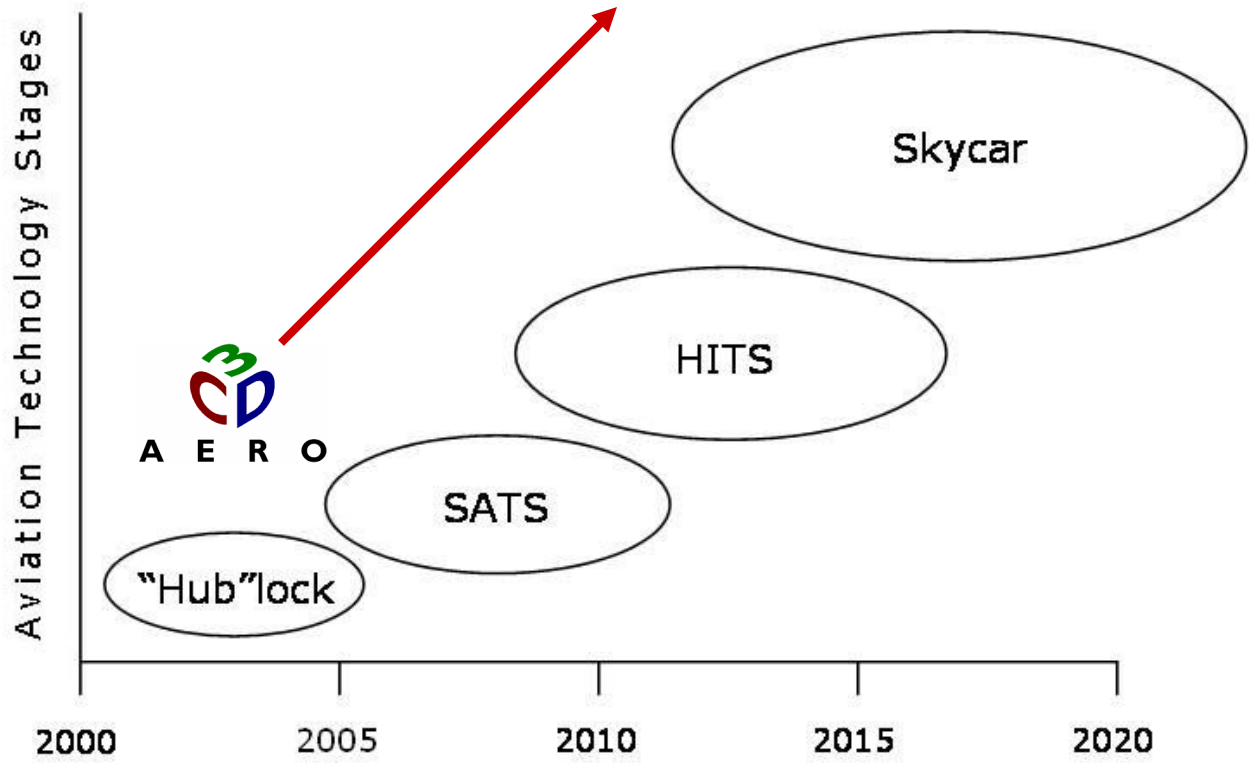
Skycar stages

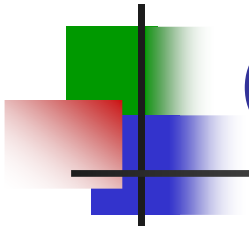
- 10 years
  - Military – Light Aerial Multipurpose Vehicle (LAMV)
- 20 years
  - Air taxi with pilot
- 30 years
  - Automated air taxi (electronically piloted)
- 40 years
  - Private ownership (electronically piloted)

Aviation technology stages



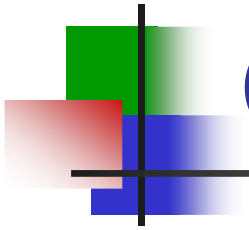
C3D Aero writes software that will help make the future a reality





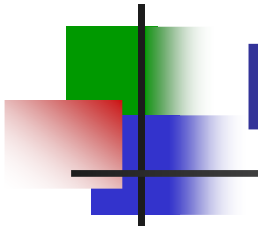
C3D Aero Vision and Mission

- Vision
  - Enable pilots to access aviation data on the Internet from the cockpit
- Mission
  - Create Web services for the aviation industry



Conclusion

- Aviation today
  - Commercial aviation's hub-and-spoke system is overloaded
- Small Aircraft Transportation System (SATS)
  - A transportation network that uses small aircraft and small airports is being built
- Highway In The Sky (HITS)
  - A graphical flight path system that will make flying as easy as – and safer than – driving a car
- The Moller Skycar
  - Will usher in a new era of personal airborne transportation
- C3D Aero
  - Builds Aviation Web Services that will help make the future a reality



Links

SATS and HITS

http://sats.nasa.gov
http://www.defensedaily.com/cgi/av/show_mag.cgi?pub=av&mon=0301&file=0301sats.htm
http://www.aero-space.nasa.gov/library/nasao/highway.htm
http://www.aerospace.nasa.gov/aero_blueprint/index.html
http://www.airborneinternet.com

Skycar

http://www.moller.com
http://www.skyaid.org/Skycar/overview2001.htm
http://www.skyaid.org/Skycar/flying_driving_car.htm
http://travel.howstuffworks.com/rotary-engine4.htm

Web services

http://www.c3daero.com/aviation/aviationwebservices.aspx
http://www.pcmag.com/article2/0,4149,103013,00.asp
http://msdn.microsoft.com/webservices
http://www.capeclear.com/products/webservices