Breakthroughs, the Product of Innovators

By Burt Rutan

Breakthroughs: Why

- Technical accomplishment
  - Defines our species - separates us from other animals
  - Satisfies desire for continuous improvement
  - Provides for ‘well being’
- Without breakthroughs
  - Boredom and mediocrity
  - Low expectation of future
  - Degradation of national security

Breakthroughs: When

- When do breakthroughs occur?
  - During or shortly after:
    - Crisis, chaos, “bad” times
  - Not:
    - During tranquil, stable, “good” times
    - When highest priority is equal status of populous
- We are creative when scared

Breakthroughs: How

- Breakthroughs cannot be specified by massive funding
  - Example: Low cost space access was the **goal** of the Space Shuttle Program
- Breakthroughs occur due to the working environment
  - Kelly Johnson ‘Skunk Works’

Breakthrough Observations

R & D experience has **inverse** relationships

- Value of product….Self-perceived sophistication of customer
- Content of new technologies….Program timeline
- Product's worth….Risk averse role of managers

The management of innovators

Manager's only tasks: Set goal and get funding

- Set goal high (50% should say impossible)
- Reward achievement of goal (power of a prize)
- Let the innovator decide what risks to take
- Leave them alone and keep others out
- Applaud courage and expect multiple failures
- Allow *fun*

Focus for the management of innovators

"If you want to build a ship, don't drum up people to collect wood and don't assign them tasks and work, but rather teach them to long for the endless immensity of the sea."

*-**Antoine de Saint-Exupery***

Exposure During Childhood Leads to Adult Technical Innovation

- Inspiration begins early – Kids ages 3 to 14

Our Responsibility Now - Create Progress to Inspire our Kids

- Our Technology leaders had their inspiration in exciting times
- Periods of extreme technical progress: I will discuss three.
  - Aviation's Renaissance, 1908 to 1912
  - My inspiration, 1946 to 1957, post WWII
  - Gagarin to Skylab, 1961 to 1973

Aviation's Renaissance 1908 to 1912

- Early 1908, < 12 pilots
  - Then "I can do it"
- By 1912
  - Hundreds of aircraft types in 39 countries
  - Aircraft invented by 'Natural Selection'
  - Airshows with 400,000 attendance

Kids Were Inspired by Aviation's Renaissance

Which Kids Were Inspired by Aviation's Renaissance?

- **Every one** of those that inspired me.
  - Wernher von Braun
  - Kelly Johnson
  - Charles Lindbergh
  - Jack Northrop
  - Ed Heinemann
  - Howard Hughes
  - Sergei Korolev
  - Alexander Lippisch
  - Bill Lear





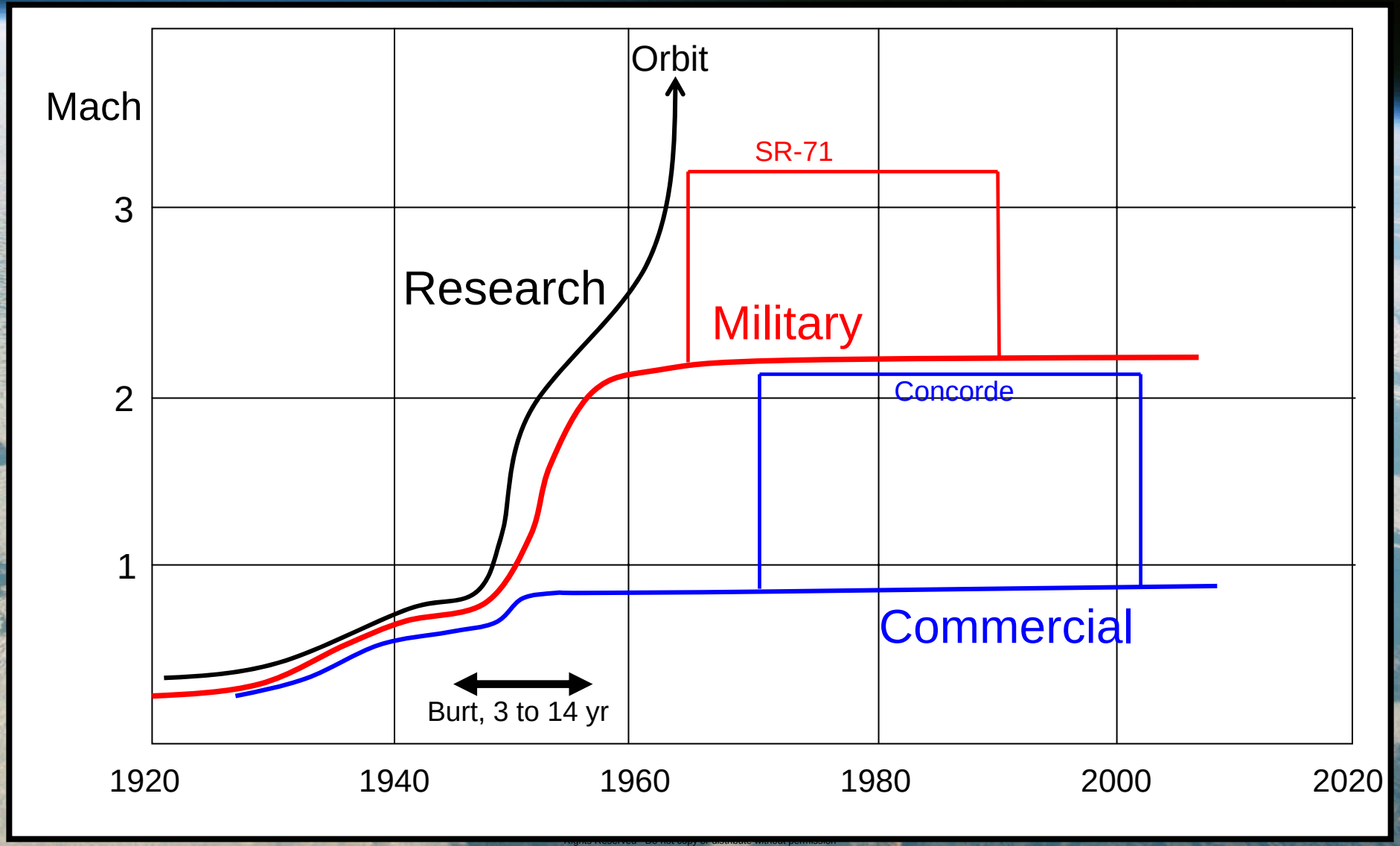


Aerospace Activity 1946 to 1957
During my Childhood (age 3 to 14)

The Jet Age starts. The Missile Age starts.

Childhood Activities Were Driven by Aviation Progress

A Jump in Performance
Inspired me during childhood



My Post-College Career Choice: Aviation (unusual for space-crazed 1965)

- Airplanes, not the moon
  - Realist?
  - Burt the conservative?
- General Aviation was the passion, but Air Force Flight Test, was the Compromise.

Air Force Flight Test 1965 to 1972

The “whole-package” experience

Best training for an aircraft designer

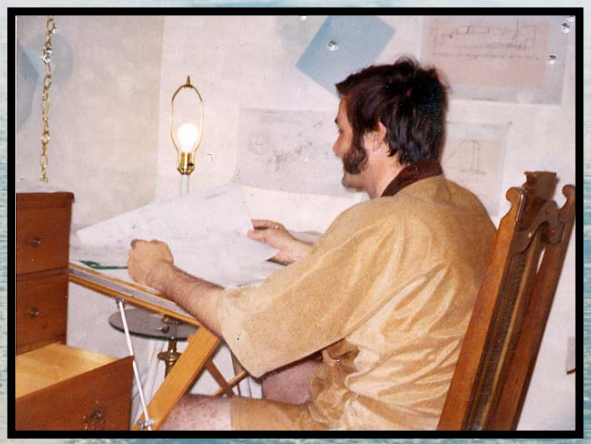
Military Flight Test Not Fulfilling

- Great experience, but not creative
- Light aircraft – target rich for innovation
- Light aircraft were the ‘fun hobby’
- The dream of a job as fun as the hobby

A Big Jump ‘Down’ 1972

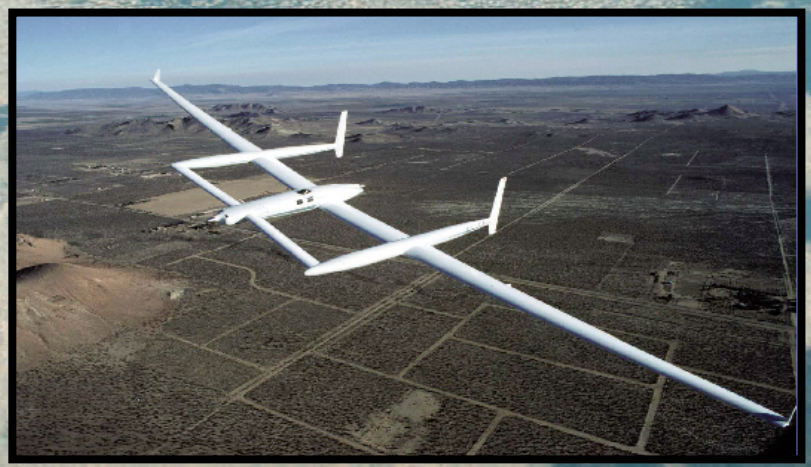
Rutan Aircraft Factory

The entrepreneur can control his destiny



The Projects of RAF 1972 to 1985

The Public Interface
The Thrill of the Milestone



Scaled Composites Company
1982 - Present

- Composites Structural Technology
- Aggressive projects, big customers
- World-Class Staff – shop and engineering
  - More folk to have fun

Scaled's Aircraft

DC-X
1995

Roton
1999

SpaceShipOne
2003

Predator
1984

Pegasus
1990

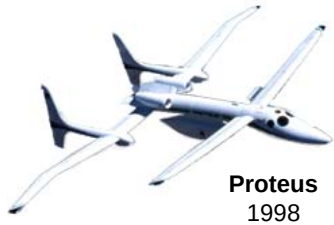
Raptor D-2
1994

X-38
1997

ARES
1990

Scarab
1986

Vantage
1993



Proteus
1998

White Knight
2002

Starship 1
1983

Triumph
1988

Raptor D-1
1993

X-47
2001

VisionAire
Vantage
1996

ATTT
1987

Lima II
1991

Freewing
1994

Adam Model 309
2000

Global Flyer
2004

Microlight
1983

CM-44
1987

Pond Racer
1991

V-Jet II
1997

TAA-1 POC
2002

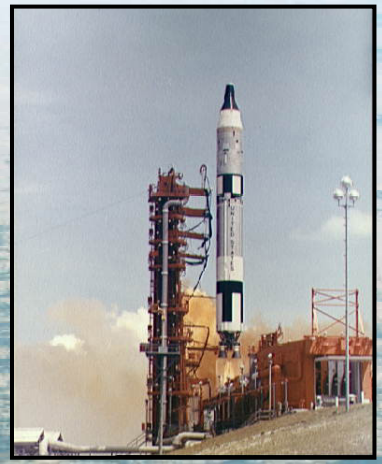
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

Why The Perfect Accident Record?

The U.S. Manned Space Renaissance 1961 to 1973

- Progress accelerated by Sputnik/Gagarin ‘losses’ – The need to regain National prestige
- A wild ride to recover prestige
  - Mercury, Gemini, Apollo lunar, Skylab and planetary exploration
- Enormous courage applied to huge risks
  - Five launch systems in seven years
  - Apollo 8/Saturn 5 risk
  - Lunar-orbit-rendezvous decision

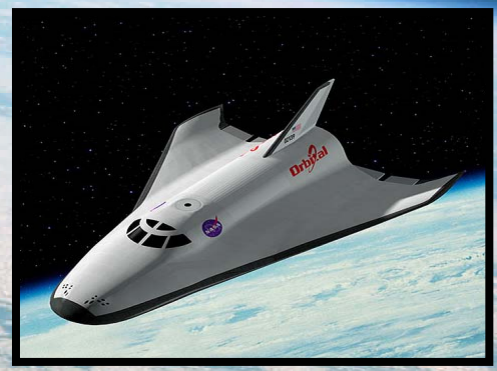
American Manned Launch Systems

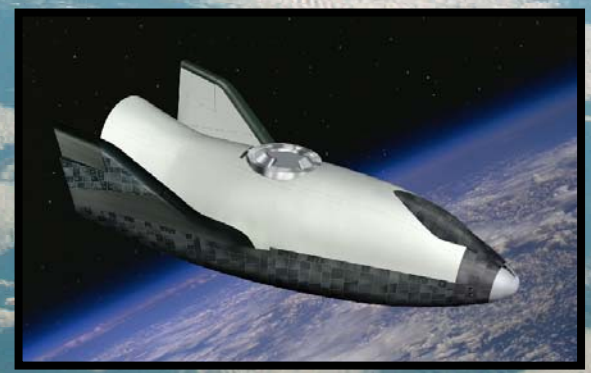
Redstone	Atlas	Titan	Saturn	Shuttle
				
Flights: 2	4	10	15	114

Each was abandoned when more expensive one became available - not matured for affordability

The Collapse that Followed 1973 to Present

- Abandoned genuine search for safe, efficient orbital manned capability.
- Abandoned lunar capability
- Risk-averse attitude: study it, do not try to fly.
- Lacked the courage to fly new research programs





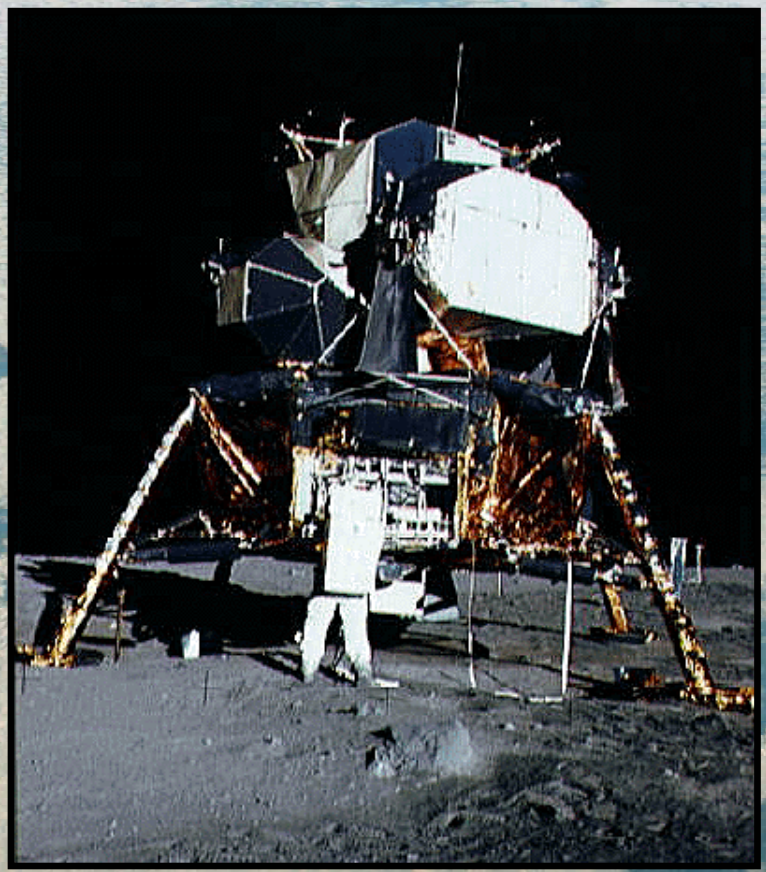
The Most Impressive Aircraft?
Lockheed SR-71

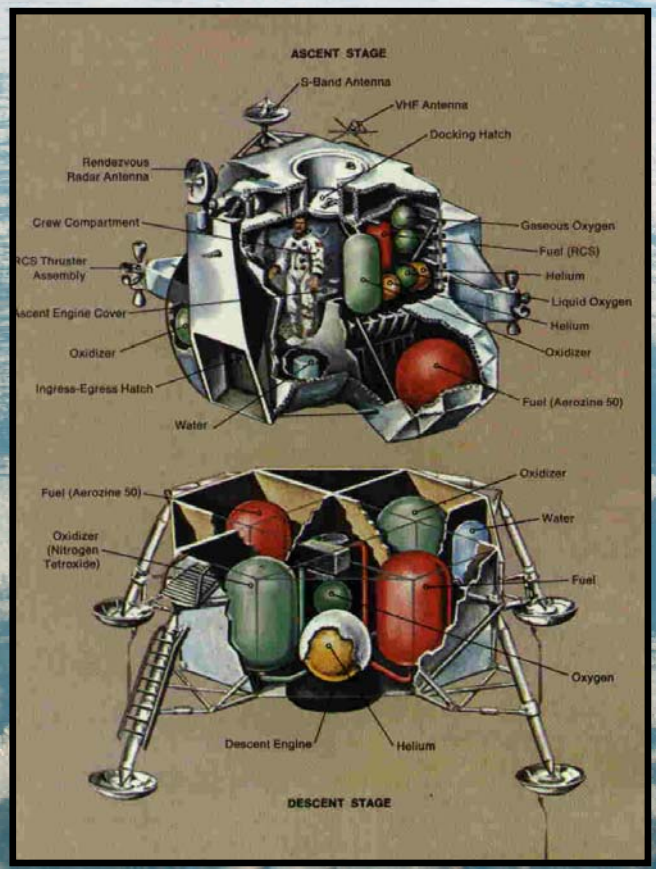
Designed in 1959, only 14 years after first operational jet.
First flown in 1963.
Abandoned in 1998, retreated to 1956 U-2.

P-80
1945

The Most Impressive Spaceship?

Grumman Lunar Module
Designed in 1964, three years after Gagarin
First flight 1968
Abandoned capability in 1972





What is wrong with this picture?

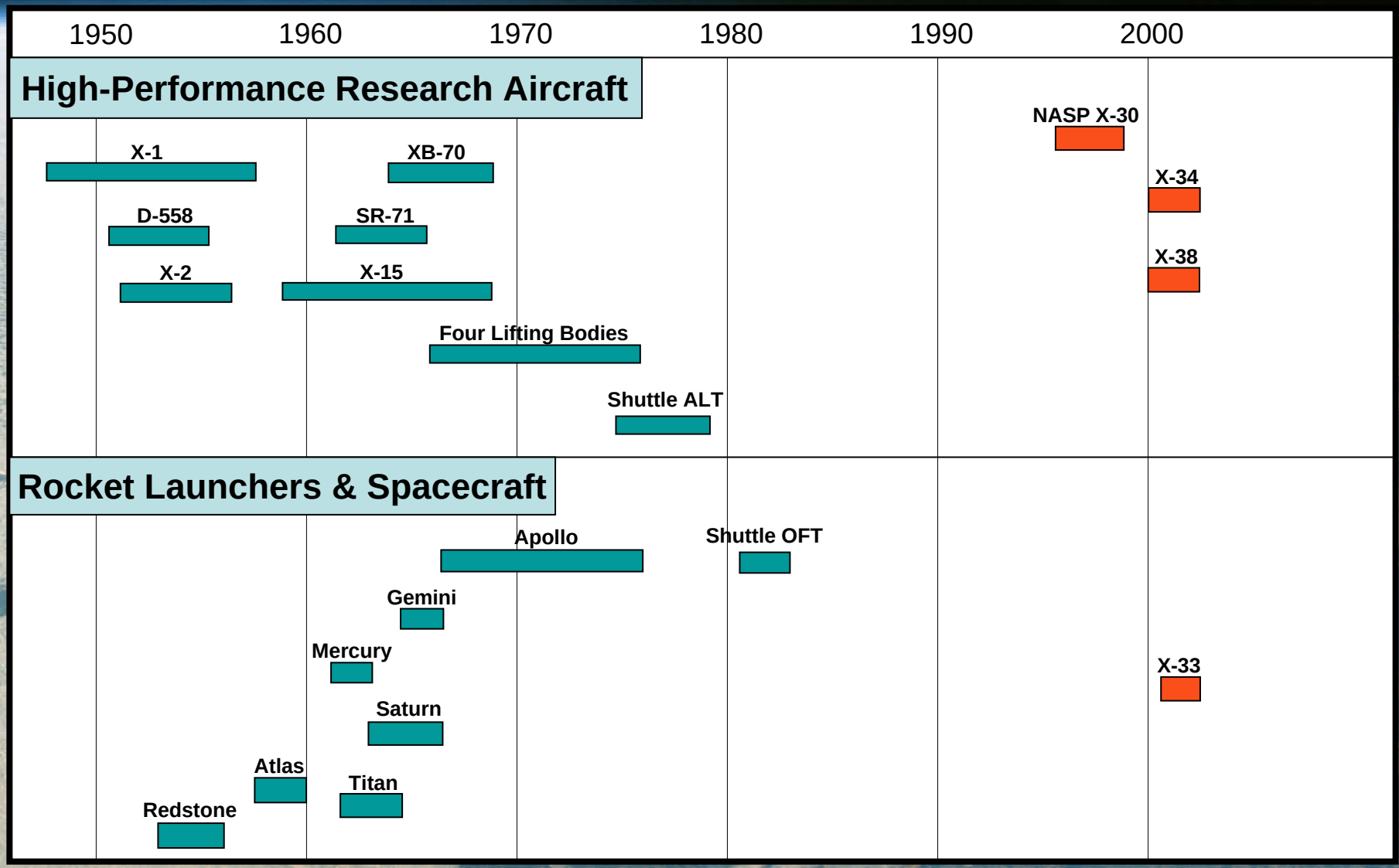
1925 1965 2005

F-22 Raptor & F-35 JSF
The only new USAF fighters for the next 40 years?

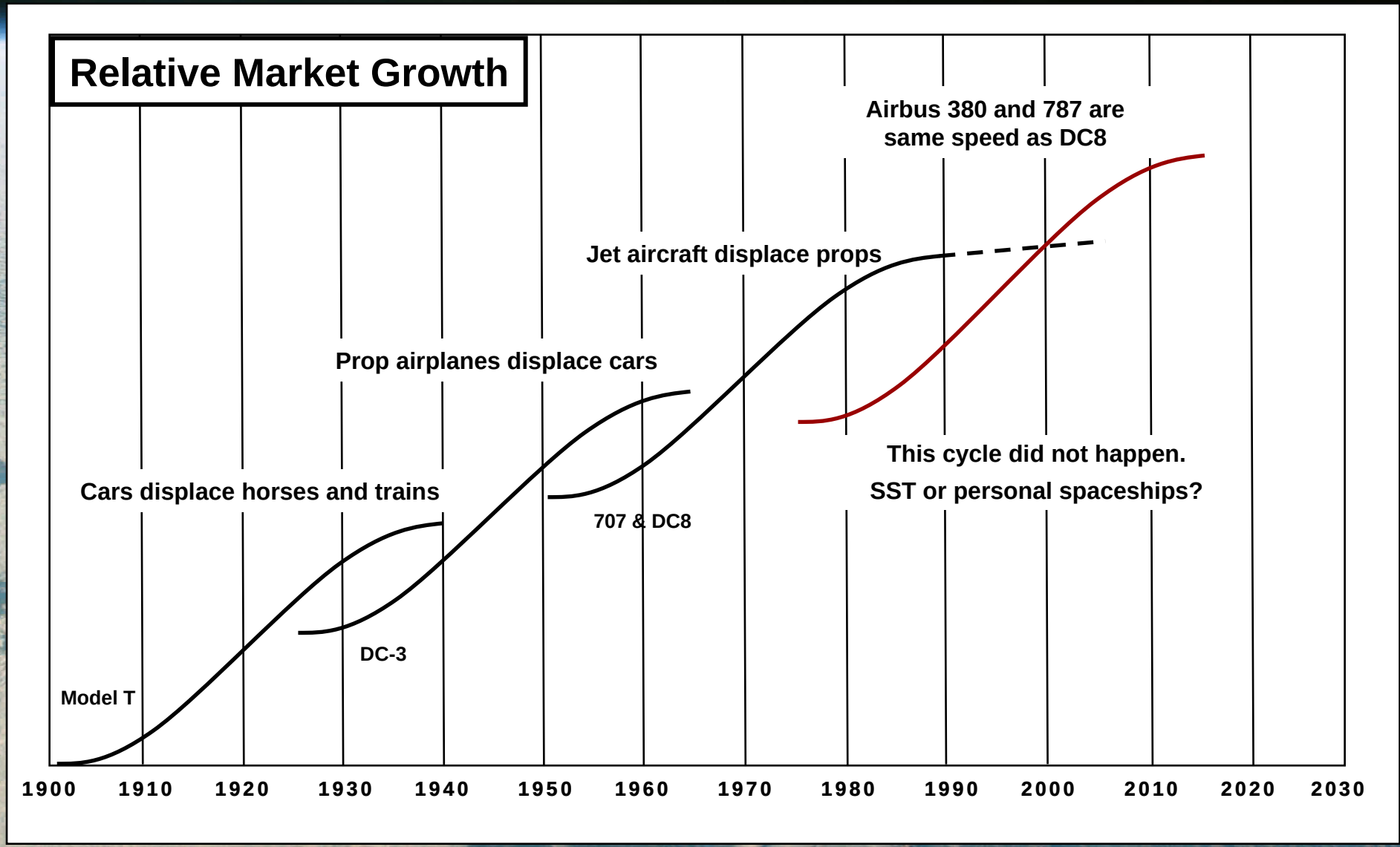
- Another 40 years with 1960's performance?
- Requirements based on perceived need, not a desire to find performance breakthroughs.
  - Air superiority in < 2 days, last two decades.
- Requirements direct Development Programs, not Research.
  - Industry employs a new generation of aerospace engineers who think development **is** research.
  - Risk averse requirements breeds risk averse technical progress.

Historical Perspective

Manned Research Programs That Expanded the Envelope



Higher Speed Travel – Forty Year Cycles
We are Overdue - Recent Cycle is Missing



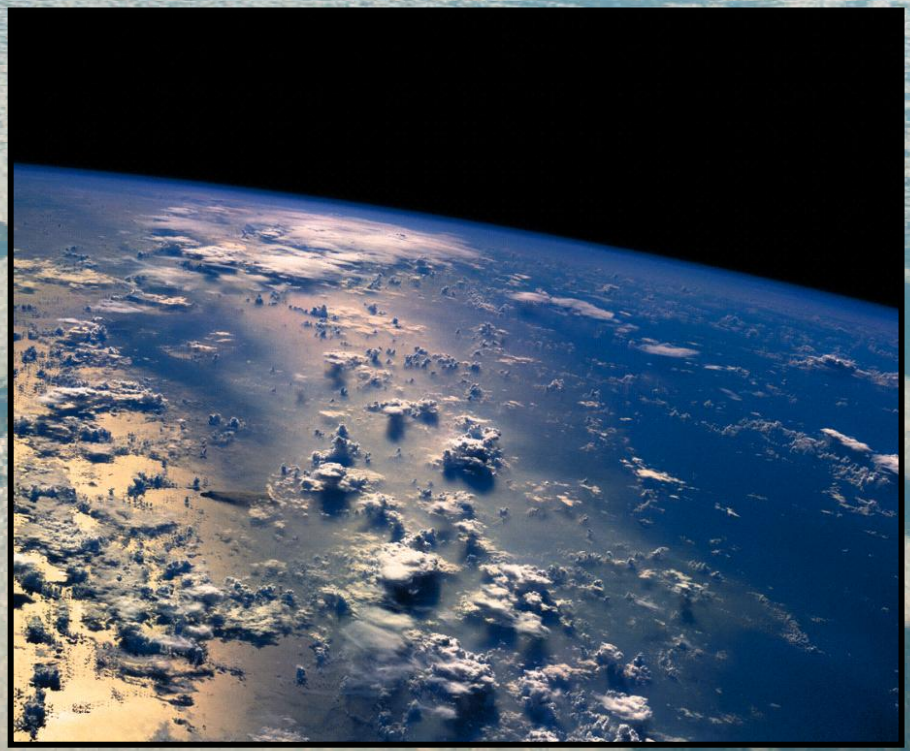
Orion/Ares, NASA's road ahead

- Retreat to Apollo/Shuttle-era hardware for manned orbital and lunar operations
- No opportunity to discover breakthroughs
- Another 13 years without progress for Personal Spaceflight
- Lack of challenge for another full generation of spacecraft designers.

Our Sub-Orbital Space Program

The Goal is Fun, To Enjoy This View

To stimulate a Private Spaceflight industry,
so others can enjoy this view



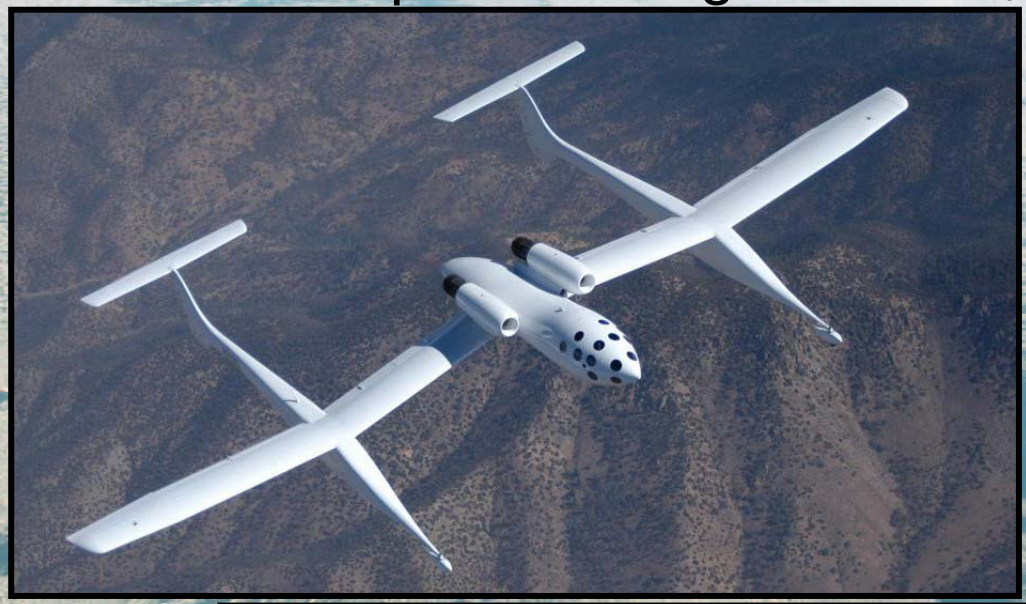
Space, for us – Why Now?

- SpaceShipOne was a personal goal, not a customer request
- Inspiration from visionaries' courage
  - Required my exposure **as a child**, not a view of current aerospace practice
- The 'New Space' investors/developers – were, **as children** inspired by Sputnik to Apollo
  - Allen, Musk, Bezos, Branson, Bigelow, Page/Brin & Carmack

Our Research Test Pilots

Launch Aircraft - White Knight

- Identical systems components to Spaceship.
- Provides pilot training for boost, entry & landing.



SpaceShipOne

Air-launched
Feathered entry
Runway landing

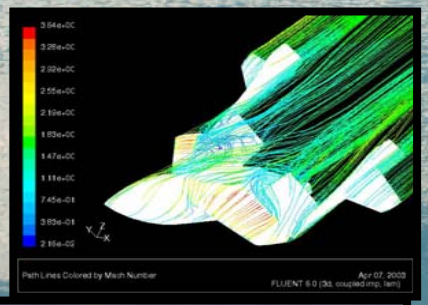
The Re-entry Feather

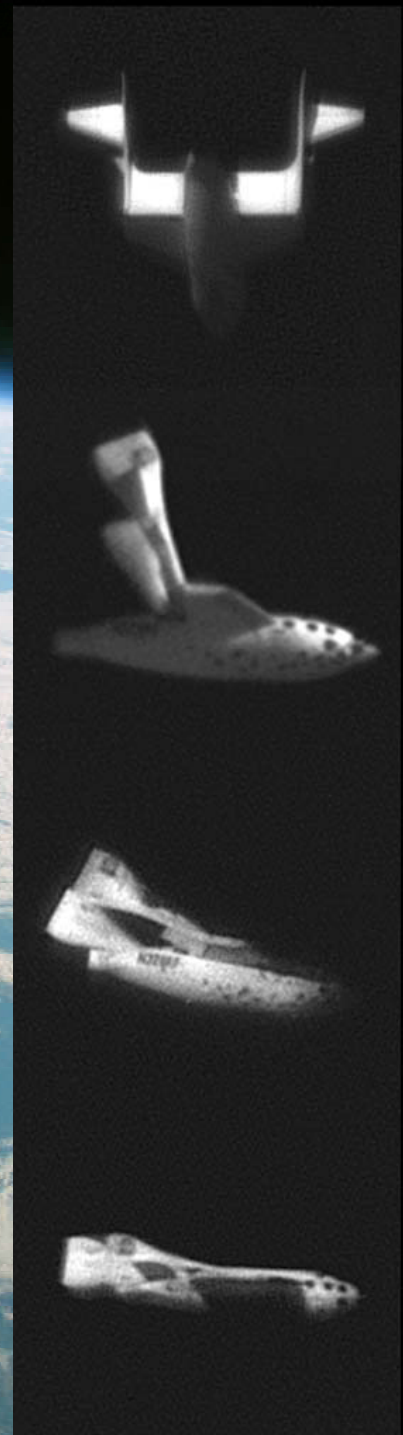
Immune to accidents caused by entry flight controls

Forces Ship to a Stable High Alpha Condition

Active controls not needed

- High Drag = Lower loads & Lower Heat
- Result: ‘Care-Free’ atmospheric entry





An Aggressive Flight Test Program

- White Knight , Pre-Spaceship
  - Performance, Stability & Space Systems Development
  - 56 flights, 10 Months
- Rocket Hot-Fire Ground Tests
  - R & D - nine months, eleven firings
  - Flight qualification - Three Firings

- SpaceShipOne Flight Tests
  - Two captive carry (one manned)
  - Glide tests - 7 glides, 4 months
  - Rocket Powered Envelope Expansion – 4 flights, last one >100km
  - X-Prize – 2 full-performance flights in 5 days

Space flight really **is** too dangerous
Airline experience as a model

Risk statistics, fatal risk per flight

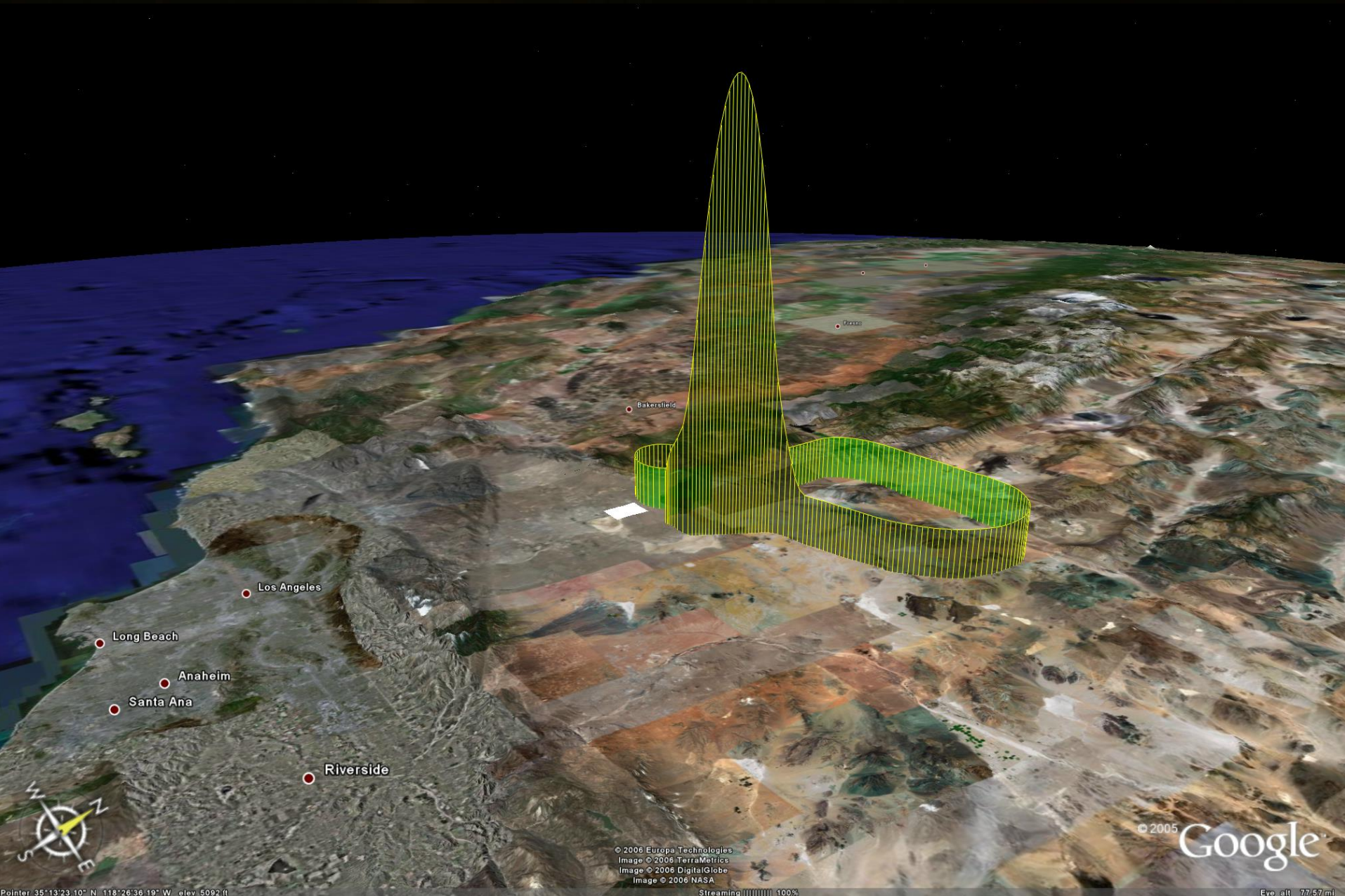
- All manned space flight = 1 per 66 flights
- First airliners (1927 & 1928) = 1 per 5500. Same aircraft, but add some maturity (1933 to 1935) = 1 per 31,000
- Modern airlines = 1 per several million

- Logical Public Spaceflight goal:
  - Better than the first airliners
  - < 1% of the historic government space risk
  - Achievable only for sub-orbital

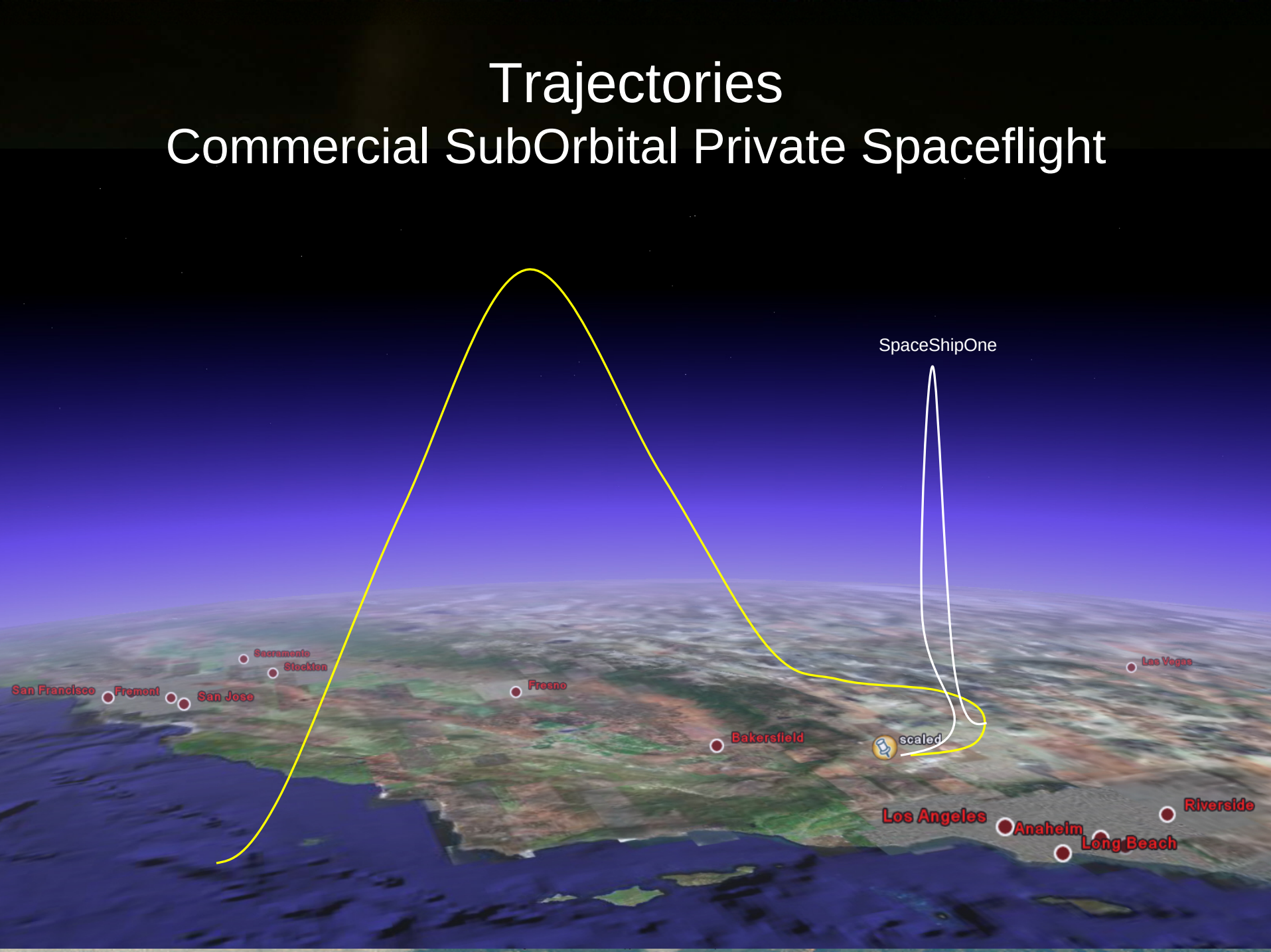
Is a New Space Renaissance Possible?
What Is Needed?

- **Environment that existed for aircraft in 1909**
  - Entrepreneurs in competition for market share
  - Belief that “I can do that”
- **Courage to try risky concepts**
  - Breakthroughs needed for safety
  - Robust solutions needed
- **Research justified by exploration and fun**
  - Not just politics and ‘science’

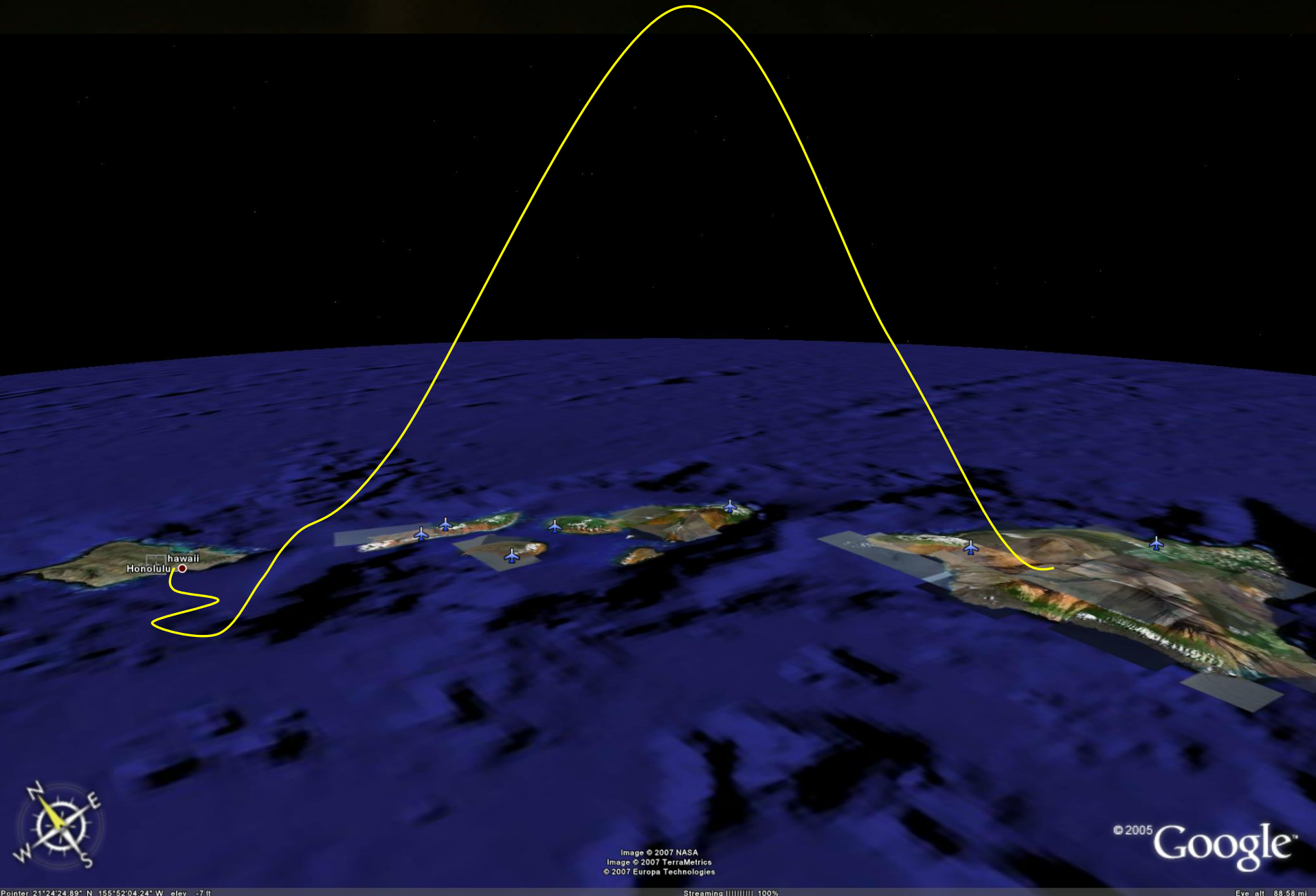
Your View from 130 Km altitude – Mojave Desert



Trajectories
Commercial SubOrbital Private Spaceflight



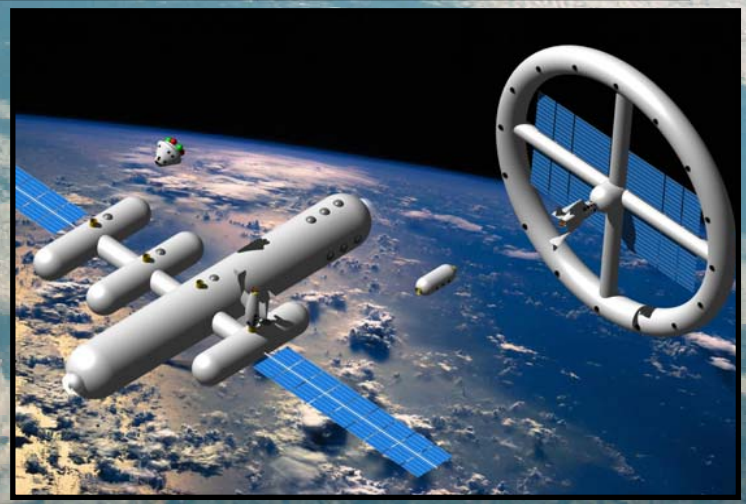
See the Islands from a different perspective….



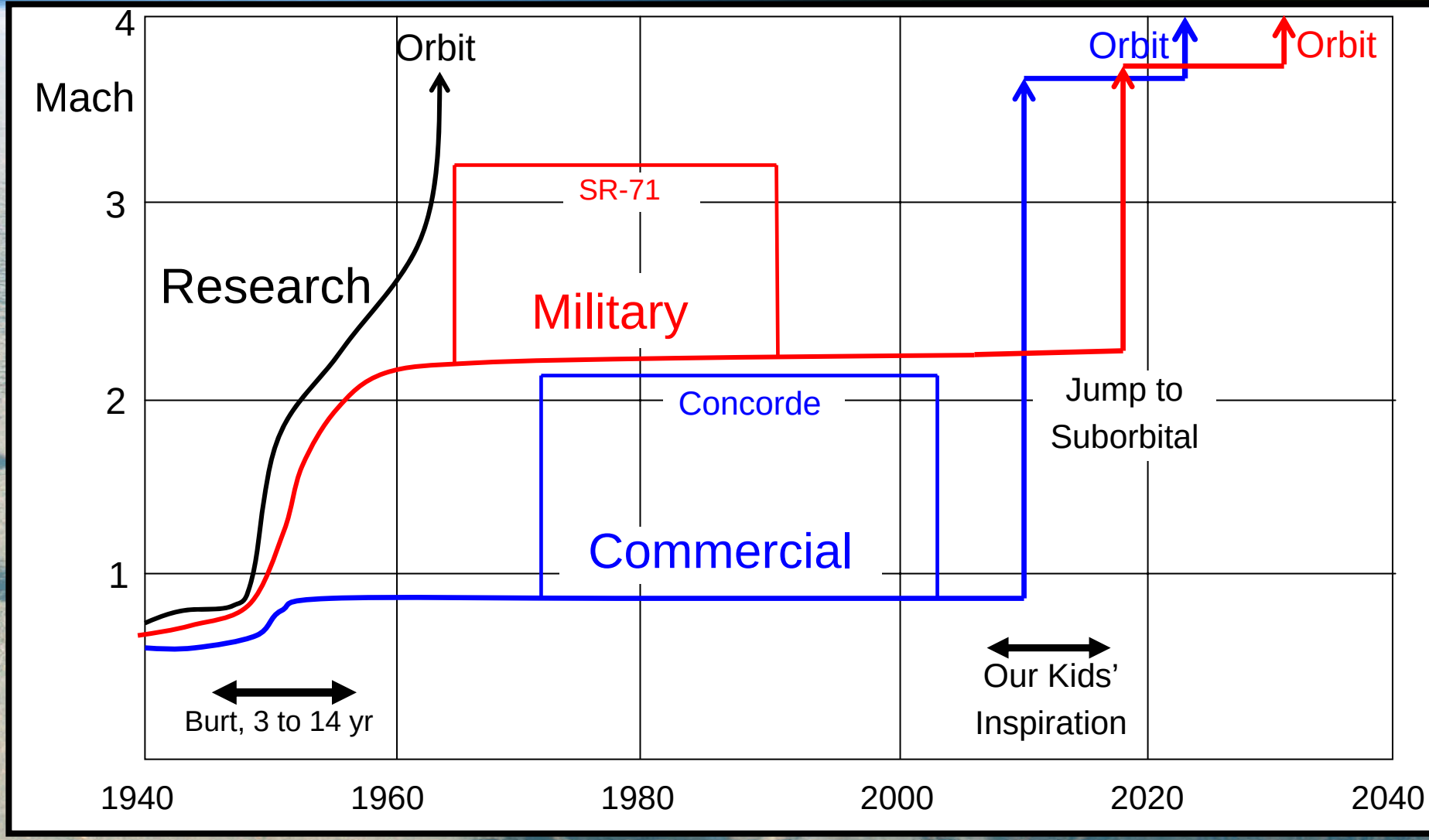
The Next Steps for Private Spaceflight

- First industry - sub-orbital flights
  - Experience – optimized
    - Large cabins, large windows and body weightless float.
- First industry - high-volume
  - Competing spacelines, flights priced to fly 100,000+ people (first 12 years of operations)

Success will accelerate solutions for safe, affordable flights to orbital resort hotels



A Prediction
Commercial Jumps Ahead of Military



What Good is a Private Sub-orbital Space Industry? Just for Fun?

- The home computer – Internet example
  - ‘Fun’ really **is** defendable
- Inspiration for kids
  - Today’s technology products are enablers, not goals
  - Kids need to be inspired by a far-out dream/goal

Why we stopped flying SpaceShipOne

Your request to a non-expert….
Rutan's Comments on S & T Focus for Defense?

- U. S. competitive position in Science and Engineering.
- True responsive space presence.
- Heavy transport.
- The "all UAV Air Force".
- Human contribution to global warming.
- Humanity's future in a connected world.

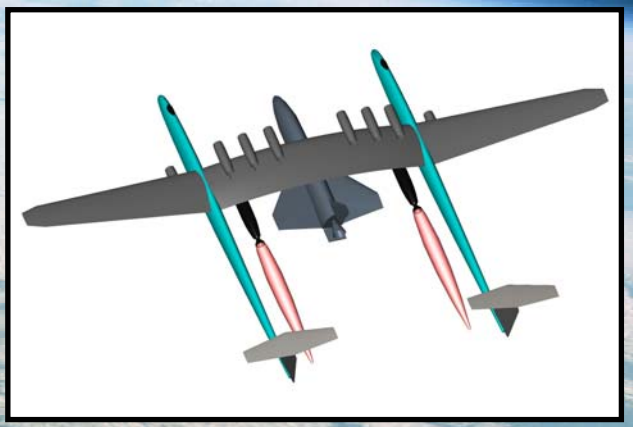
U. S. competitive position in Science and Engineering

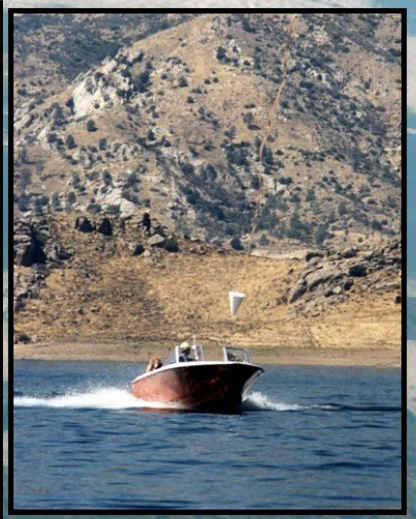
- The education statistics are bleak
  - Science vs. lawyers/media/politicians/actors*

  * And other criminals
- The real reason – we are boring our youth
  - Development vs. research
- The solution – take real risks
  - Exploration
  - Adventure
  - Breakthroughs
- Strive to be great, not to be ‘equal’

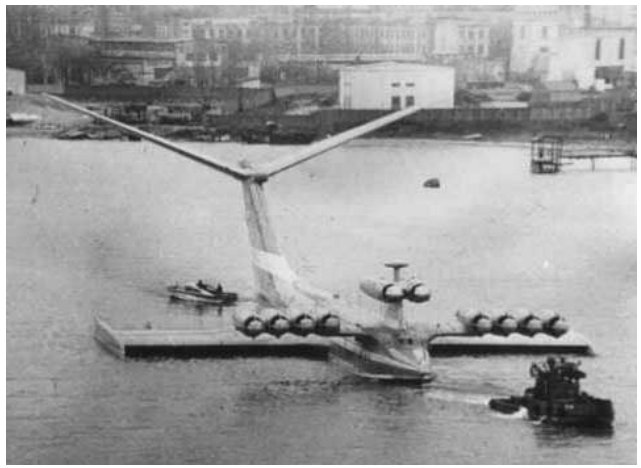
True Responsive Space Access

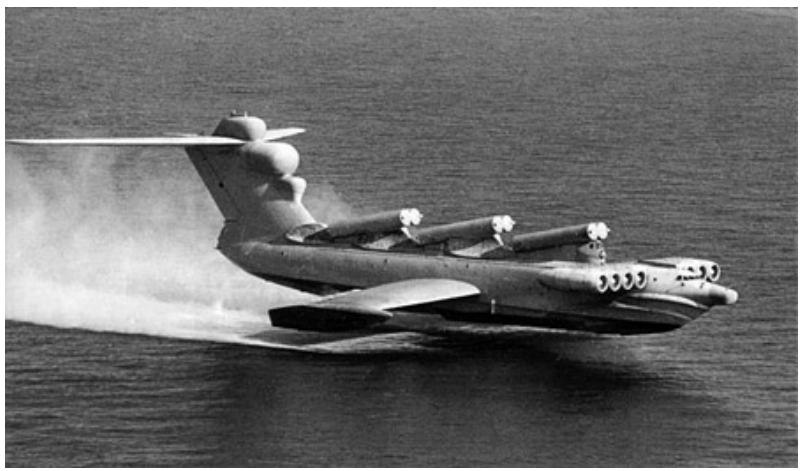
- Air launch
- Routine, high-volume operations
- Sea recovery





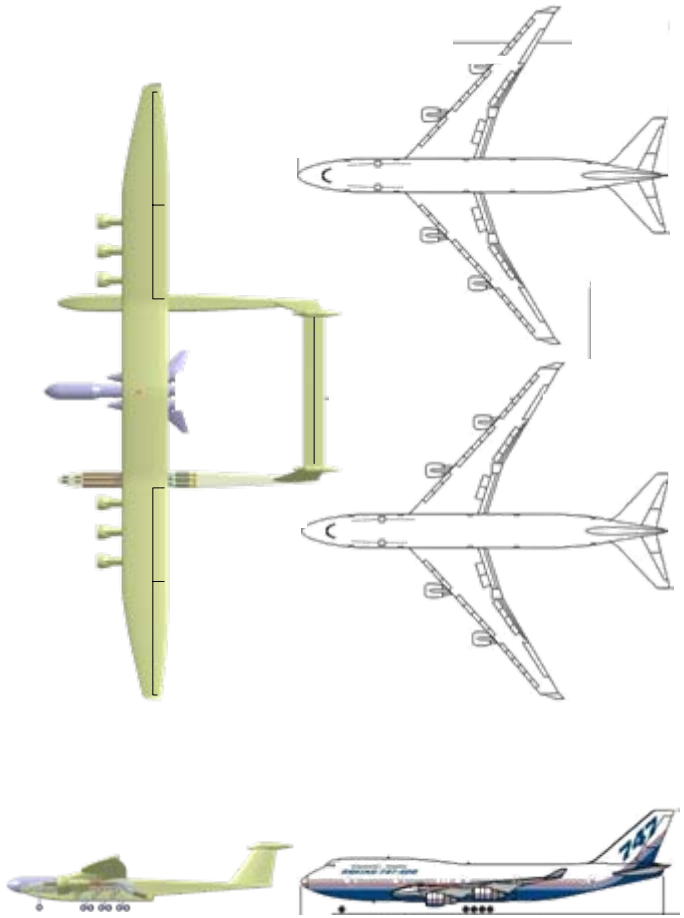
Russian Ekranoplans (wing-ships)





Heavy lift via use of a large space launcher

Payloads up to 450klb



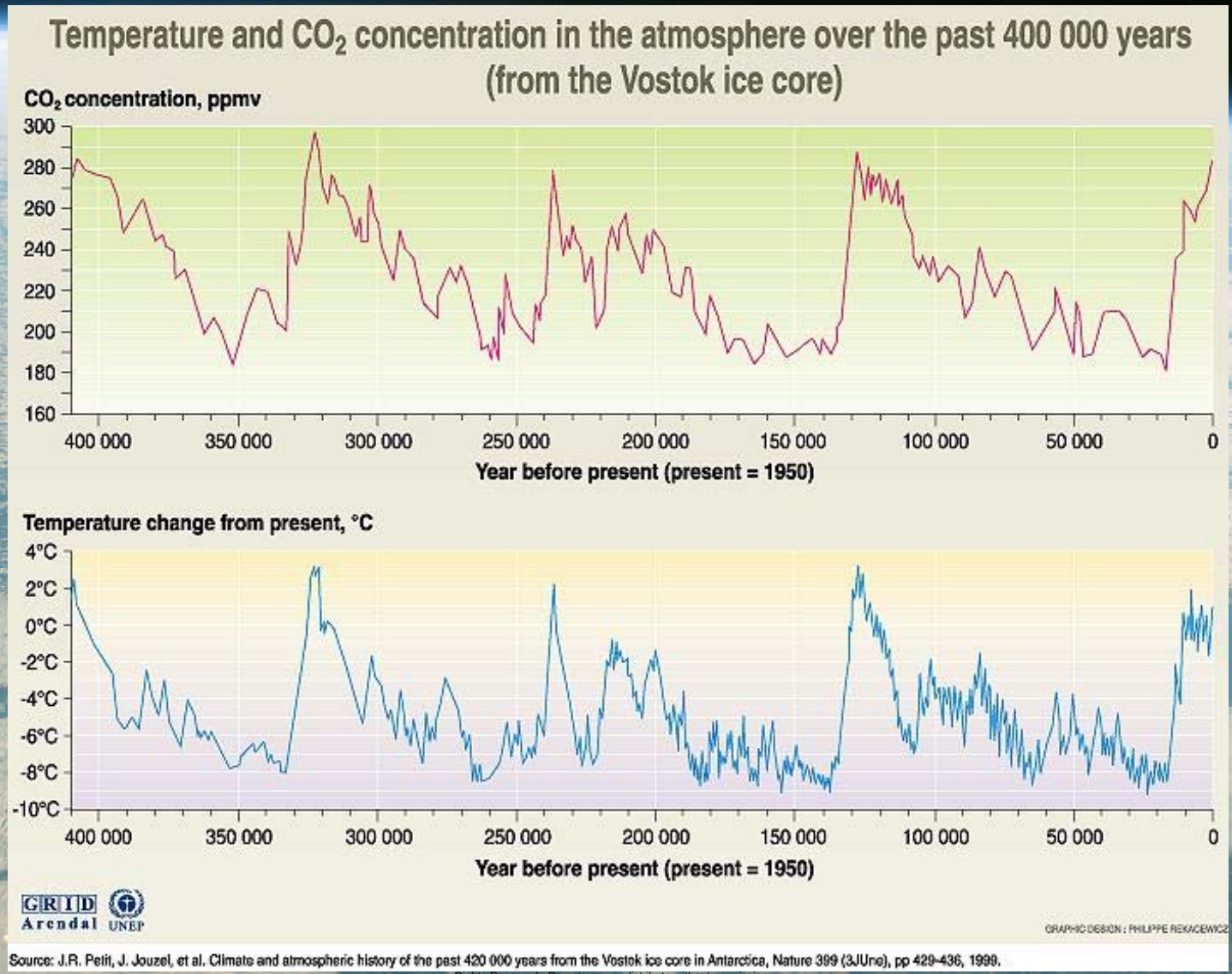
UAV vs. Manned Aircraft Systems

- The fighter pilot's proficiency
  - Our leadership maintained?
  - Proliferation
- The fighter pilot's courage
  - Eliminate Capt Scott O'Grady?
- Cost savings?
  - Development and Ops

Are we destroying the planet?

Consensus vs. Science

Technical solutions follow technical measurement



Humanity's future in a connected world

- Internet….the tip of a huge iceberg
  - Our need to travel, if a virtual mode is available
  - Countries – defined by belief, not by geography
- Humanity – we are just getting started