National Aeronautics and Space Administration

Environmentally Responsible Aviation
N+2 Advanced Vehicle Concepts NRA Status

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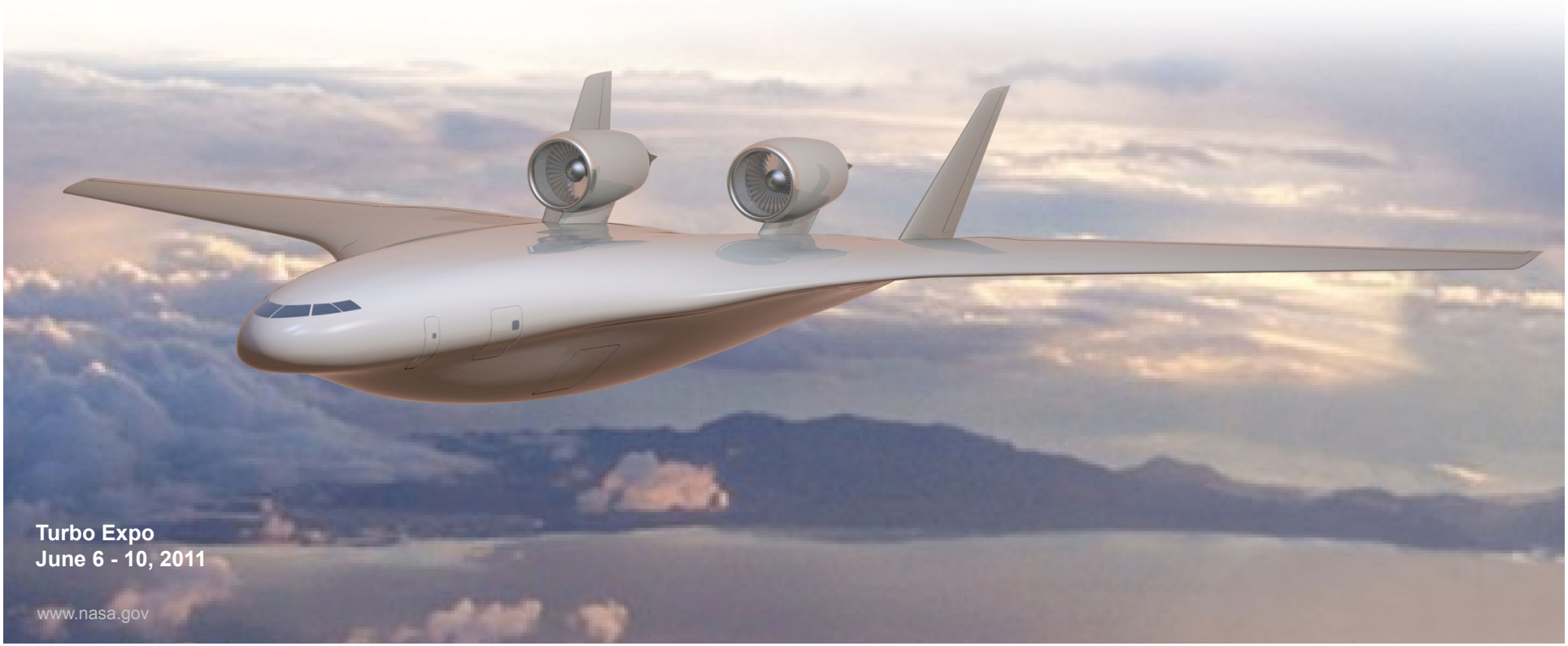
Integrated Systems Research Program



Turbo Expo
June 6 - 10, 2011

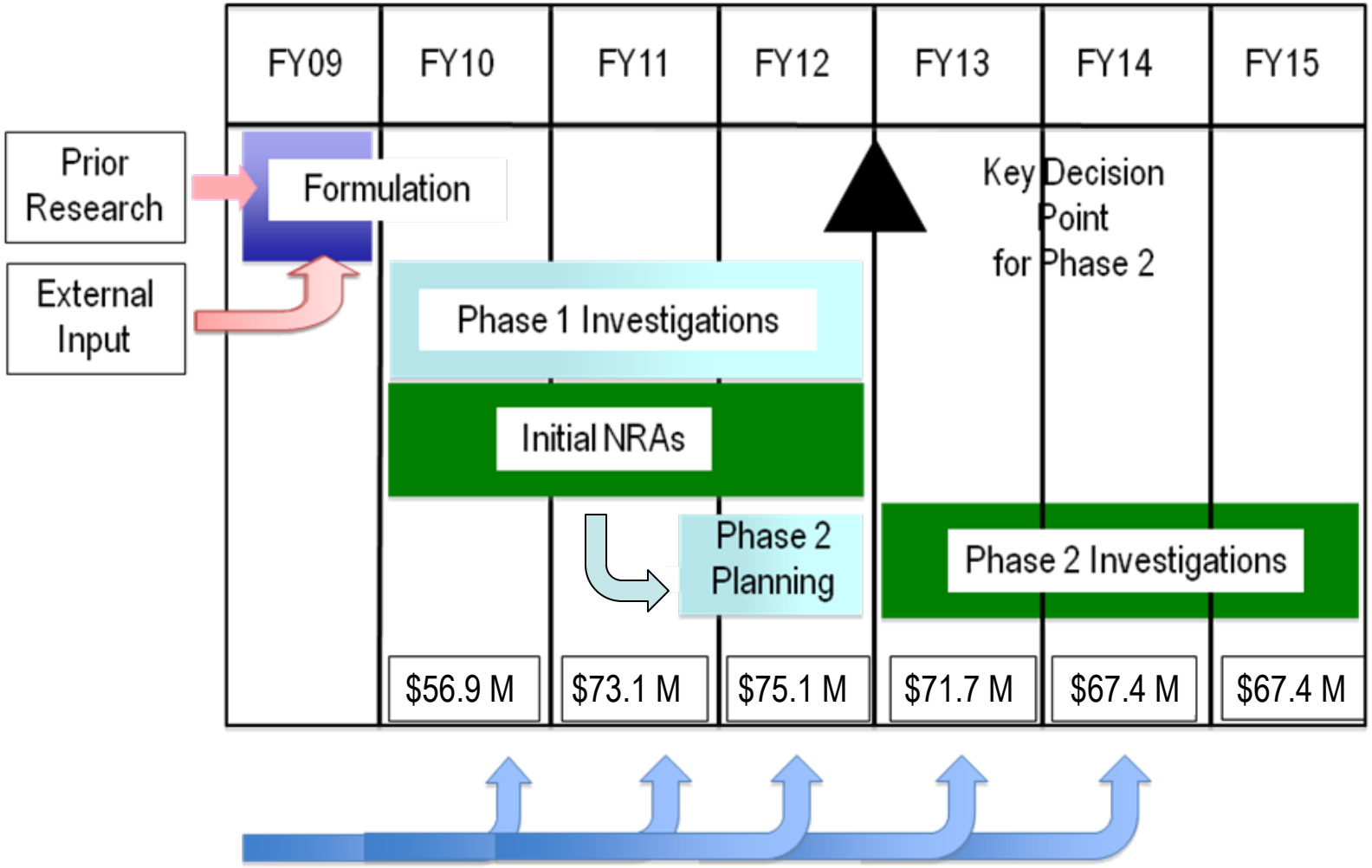
NASA's Subsonic Transport System Level Metrics

…. Innovative technology for dramatically reducing noise, emissions and fuel burn

CORNERS OF THE TRADE SPACE	N+1 = 2015*** Technology Benefits Relative To a Single Aisle Reference Configuration	N+2 = 2020*** Technology Benefits Relative To a Large Twin Aisle Reference Configuration	N+3 = 2025*** Technology Benefits
Noise (cum below Stage 4)	-32 dB	-42 dB	-71 dB
LTO NO_x Emissions (below CAEP 6)	-60%	-75%	better than -75%
Performance: Aircraft Fuel Burn	-33%	-50%**	better than -70%
Performance: Field Length	-33%	-50%	exploit metro-plex* concepts

***Technology Readiness Level for key technologies = 4-6. ERA will undertake a time phased approach, TRL 6 by 2015 for "long-pole" technologies
** RECENTLY UPDATED. Additional gains may be possible through operational improvements
* Concepts that enable optimal use of runways at multiple airports within the metropolitan area

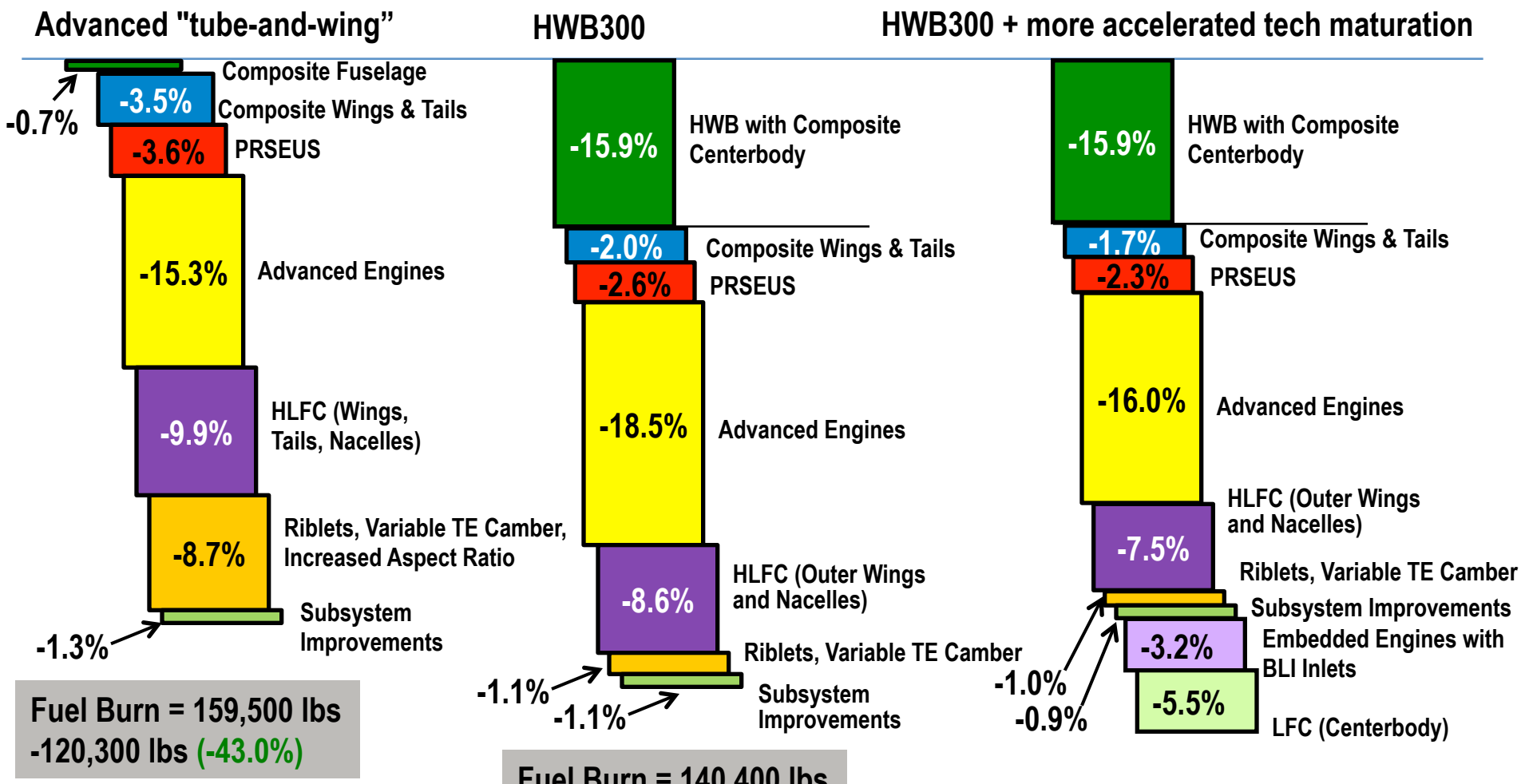
ERA Project Flow and Lifespan



Technical input from Fundamental Programs, NRAs, Industry, Academia, Other Gov't Agencies

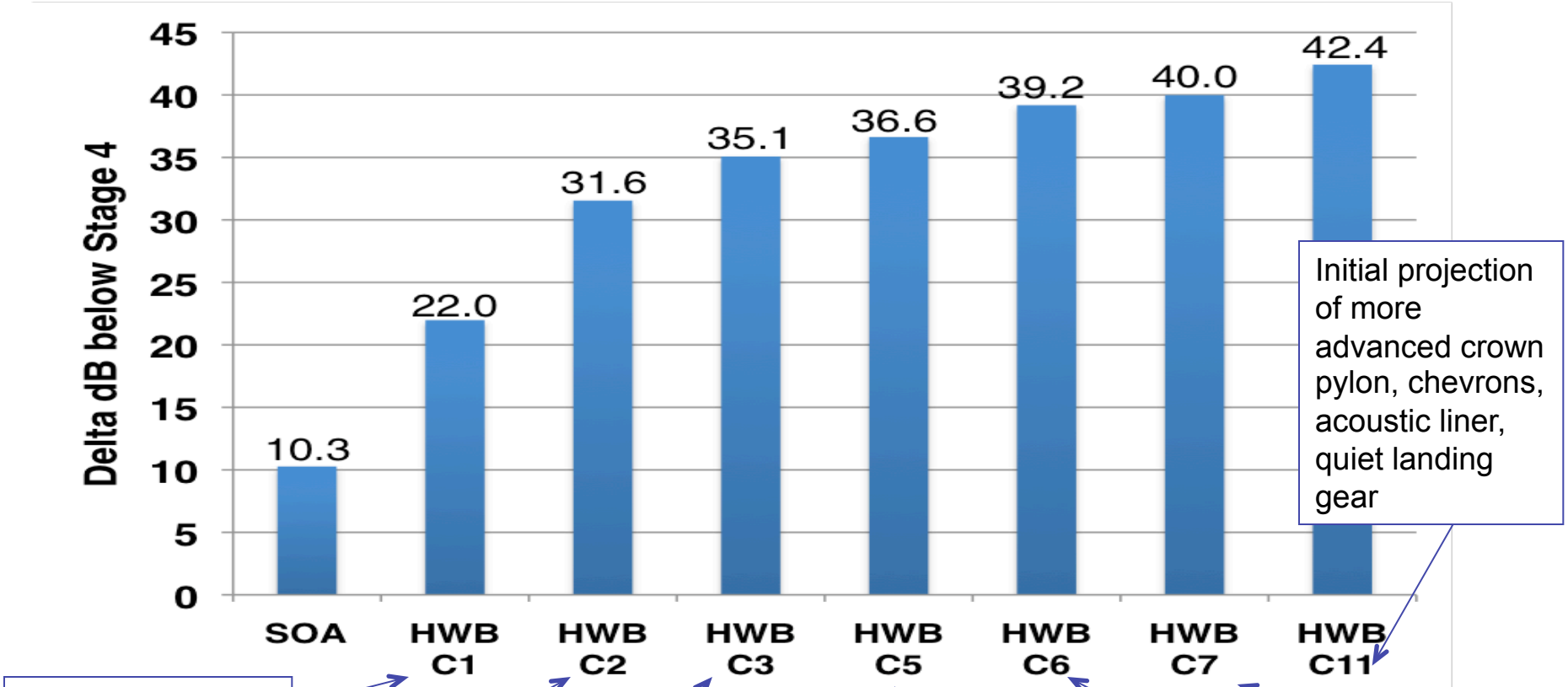
Where did the numbers come from?
Fuel Burn - Technology Readiness 2020

Technology Benefits Relative to Large Twin Aisle (Reference: 777-200LR "like" Vehicle)



Reference Fuel Burn = 279,800 lbs

Progress – Propulsion Airframe Aeroacoustics
Tube and Wing/Hybrid Wing Body/SOA Engine (2009/10)



Initial projection of more advanced crown pylon, chevrons, acoustic liner, quiet landing gear

Baseline engines 1D downstream of trailing edge

Simple shielding, engines move 2D upstream

Chevrons reduce source & increase shielding effectiveness (same area, more noise reduction)

Active Pylon adds more jet shielding effectiveness, elevons add more aft fan shielding

Favorable directivity of jet from crown pylon

Acoustic liner added to crown pylon for aft fan attenuation

AIAA Papers - AIAA 2010-3912, and 3913

N+2 Advanced Vehicle Concepts NRA

- The Study
  - Twelve months in duration
  - Five tasks
    - Tasks 1-4 relate to a full sized concept
    - Task 5 relates to a subscale testbed vehicle
  - $10.9M total awarded to three teams
- 2 Options
  - 50/50 cost share required, up to two awards, 17 months duration
  - Option 1
    - Preliminary design of subscale testbed
    - NASA share: up to $12.5M per team
  - Option 2
    - Testing to reduce risk / increase confidence of preliminary design
    - NASA share: up to $10M total

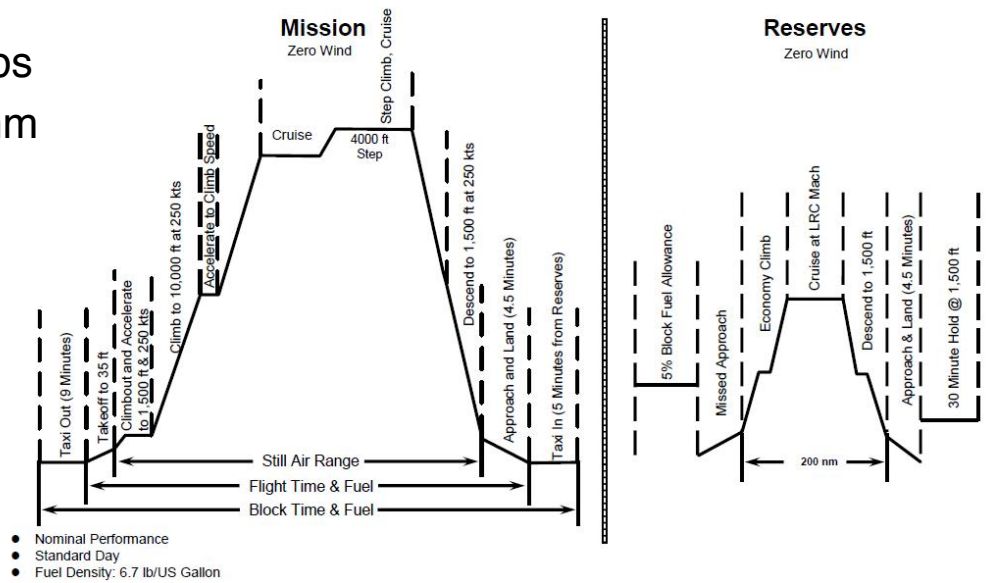
Task 1

- Future Scenario
  - What does the world that you are designing to look like?
    - Formation flight?
    - What are your assumptions that are driving your design?
  - What is the NextGen scenario in 2025 that you are designing to?
    - What level of completion is NextGen at?
  - What is the interplay between your concept and NextGen?
    - How would you like NextGen to be tweaked to accommodate your PSC?

Task 2

- Develop a M = 0.7 – 0.85 conceptual design of a 2025 EIS subsonic transport that simultaneously meets the Noise, Emissions and Fuel Burn goals
- Design Mission

Cargo		PAX
100,000 lbs	Payload	50,000 lbs
6,500 nm	Range	8,000 nm



- Repeat for:
  - 1998 tube and wing
    - Baseline toolset
  - 2025 EIS tube and wing
    - Separate configuration from technology
- Provide concept data packages for all designs

Tasks 3 & 4

- Technology Maturation Plans (TMP's)
  - 15 year Roadmap for each of the critical technologies
    - Key research, analyses, tool and method development
    - Necessary ground and flight tests
  - Starting and ending TRL & SRL
  - Cost, schedule and technical outcome
  - Useful for advocacy beyond ERA Project timeframe
  - "Is the problem physics, or is it money?"

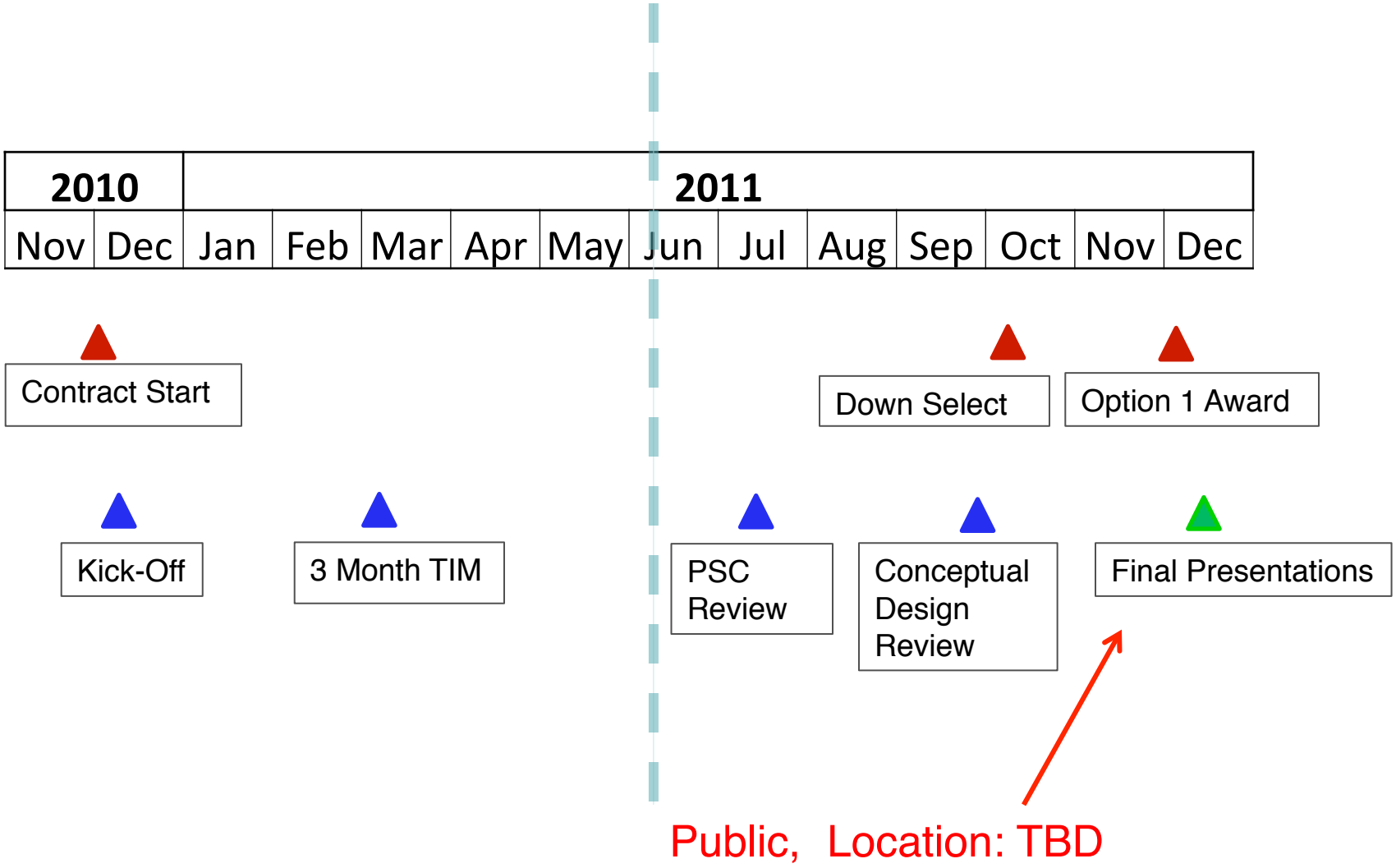
- FY 2013 – 2015 Critical Technology Demonstrations
  - Long poles, enabling technologies, or first victories
  - Scalability beyond PSC
  - Sorted by:
    - Airframe
    - Propulsion
    - Integrated Propulsion/Airframe
    - Subscale Testbed
  - How to de-scope from deluxe to bare bones (cost, complexity, schedule, risk)
  - Provides guidance to Phase II of ERA Project

Task 5

- Conceptual Design of a Subscale Testbed Vehicle (STV)
- Proposal for completing Preliminary Design of the STV
- ROM cost and schedule for completing design, construction and initial flight testing of the STV

- STV requirements
  - Same configuration as the PSC
  - Same Mach and cruise speed as PSC
  - Retractable Landing Gear
  - Sufficient scale to demonstrate noise, emissions & fuel burn goals
    - Notionally ~ 50% or larger
  - Adaptable for future modifications
    - Engines
    - To demonstrate UAS in the NAS technologies
  - Projected 20 year research life

Schedule


2010
2011
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Contract Start
Down Select
Option 1 Award
Kick-Off
3 Month TIM
PSC Review
Conceptual Design Review
Final Presentations
Public, Location: TBD

The Awardees…

Lockheed Martin

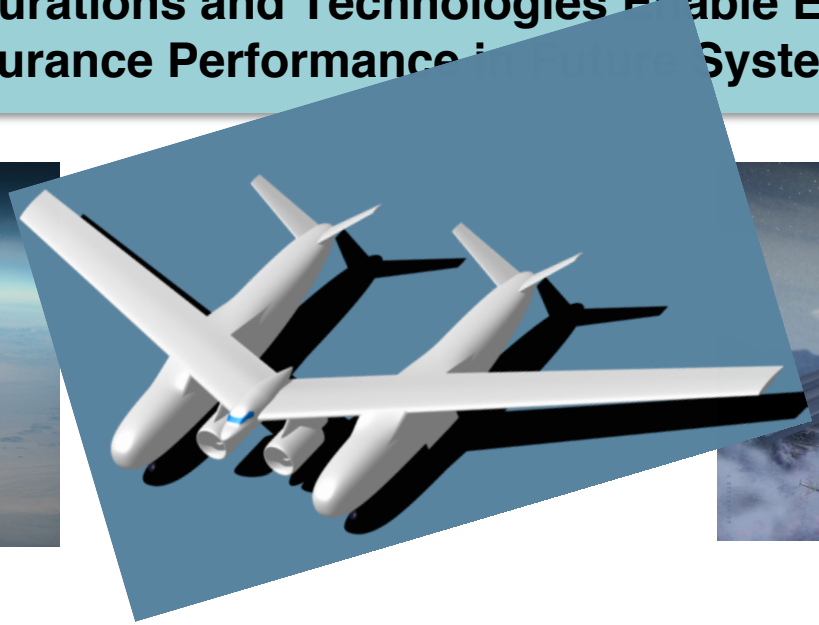
Lockheed Martin

Lockheed Martin

- The Lockheed Martin ERA design is a non-traditional “Box Wing” concept for improved structural and aerodynamic efficiency.
- It incorporates advanced technologies in the areas of:
  - advanced propulsion for significant fuel burn and noise reduction
  - new light weight materials
  - laminar wing aerodynamics
  - other efficiency technologies
- The concept is envisioned to integrate into existing airport infrastructure without significant changes and to provide a passenger experience consistent with the best of today’s airliners.

Northrop Grumman

Innovative Configurations and Technologies Enable Efficient Long-Endurance Performance in Future Systems



Northrop Grumman

- Technologies and configurations that improve energy efficiency are beneficial to both military and civil aircraft
  - Civil or military applications only become important in the integration of the technologies
  - Application can affect the degree of benefit the system sees from a particular technology
- Technologies and configurations that improve energy efficiency generally work in one of three ways
  - Reducing drag
  - Reducing weight
  - Increasing efficiency of propulsion systems
- Reductions in drag and weight, and increases in efficiency of propulsion systems are just as applicable to civil aircraft as military aircraft

Boeing

Boeing

- Boeing's Blended Wing Body (BWB) proposal takes advantage of the improved L/D of the BWB platform, and will use many of the technologies that have previously been identified with the BWB:
  - PRSEUS lightweight, damage arresting composite structure
  - Laminar flow
  - Acoustic shielding inherent in the configuration
  - Proven low speed flight controls
  - High efficiency, new technology engines
- Boeing's study will investigate both geared turbo fans and open rotors