Propulsion

- Acquisition of Engine Technical and Economic Data
- Estimation of Installation Effects
Engine Company Support

*Phase I*

- Performance, weight, geometry data packs were provided for each of the selected Phase I airplane performance assessments.

- Engines selected to be representative of broad spectrum of applicable cycle and fuel types.

- Economic and technology projections.

- Emissions \((\text{NO}_x)\) estimates.

- Research recommendations provided.
Variable Cycle Engines

<table>
<thead>
<tr>
<th>Company</th>
<th>Cycle Type</th>
<th>YR CERT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerojet</td>
<td>M = 6.0 ATR (LH₂ &amp; CH₄)</td>
<td>2015</td>
</tr>
<tr>
<td>General Electric</td>
<td>M = 4.5 Turbo-ramjet (CH₄)</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td>M = 3.2 Turbofan (JP)</td>
<td>{2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2015</td>
</tr>
<tr>
<td>Pratt &amp; Whitney</td>
<td>M = 3.8 Turbojet &amp; TBE (JP)</td>
<td>{2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td>M = 10.0 Turbo-ram-scramjet (LH₂)</td>
<td>2015</td>
</tr>
</tbody>
</table>
OUT BD NACELLE INST.

$M = 4.5$

$M = 2.4$
NOZZLE EXPANSION RATIO

\[ \frac{A_q}{A_e} \]

\[ M_{\infty} \]
NACELLE DRAG COMPARISONS

\[ \Delta C_D (\text{counts}) \]

FRICITION WAVE INTERFERENCE

\[ M = 1.1 \]

\[ M = 2.4 \]

\[ M = 4.5 \]

M = 4.5 DESIGN

M = 2.4 DESIGN
NOZZLE BOATTAIL DRAG
M=4.5 DESIGN

D/D^2

2-DIMENSIONAL
AXI-SYMMETRIC
M=2.4 REF.

MACH NO.
Technology Issues

1. Improve subsonic SFC.
2. Thermal stability of fuels.
3. Inlet mutual unstart.
5. Noise suppression.