Nuclear Aircraft??
An Idea Whose Time Never Came

presented by:
Paul Sicard
formerly of the Naval Nuclear Propulsion Directorate
Genesis

- Think late 1940’s (Cold War):
  - Air Force considered dominant branch of DoD
  - Reliance on nuclear weapons
  - Drawdown of conventional weapons
  - Reduction in conventional forces
- Fascination with novel Nuclear Power
- Nuclear bombers:
  - Could stay aloft “for years” or “for weeks at a time” (...what would crew think of this?)
  - ICBM’s not yet developed; needed bombers for nuclear deterrence
- First discussed by Fermi 1942
NEPA (ANP)

- 1946: study by Johns Hopkins Applied Physics Laboratory on potential and problems of using atomic power for aircraft --led to authorization of USAF-AEC project NEPA (Nuclear Energy for Propulsion of Aircraft)
- 1948 study by MIT concluded nuclear aircraft could be developed in 15 years for $1B
- Renamed ANP (Aircraft Nuclear Propulsion) project in 1951
Nuclear Design Issues

• Shielding (weight)
• Materials (high temperature & radiation)
• Compact design (to fit on airplane): high power density
• Radiation levels/release for normal operations
• Plane crashes?
• Continuity of power?
• Approval to fly through foreign airspace?
• Did we mention Shielding??
• More complex than Nuclear submarine
• Shorter required core design life (100 hrs?)
Nuclear Design Requirements

• High U-235 enrichment
• Thermal neutrons: higher power density -- require moderation (slowing neutrons) and reflectors
• Very high temperature
Aircraft Design Issues

- Weight
- Landing gear & runways
  -- plane would weigh the same to land as to take off, unlike conventional plane
  -- needed extra large runways
  -- would need exclusion areas on runways due to radiation levels
- Sufficient distance between crew and reactor
- Settled on “Shadow Shielding” – some shielding at reactor (equipment protection), some for cockpit/crew
- Required Shield Design (and weight!) highly dependent on reactor design.
- Specifications never really finalized for Aircraft platform. Up to 350 MW considered. Subsonic or supersonic?
One Modular Plane Concept

Crew craft, part of A-plane tail assembly, can detach and fly away in emergency.

Reactor has motorized landing gear that detaches on the airstrip and moves remotely to refueling plant, while fresh reactor unit replaces it on the a-plane.

April 1957
Reactor Design Concepts: Direct vs. Indirect Cycle

- Direct cycle: air that cools reactor also provides thrust from jet
  --simpler design
  --shorter development time

- Indirect cycle: allows intermediate cooling loop (e.g., Liquid Metal) for reactor, intermediate loop then cooled by air
  --better heat transfer, thus potentially smaller reactor even with secondary heat exchanger
  --less radioactive release
  --much more complex design
Indirect Cycle Aircraft Nuclear Engine Concept
Diagrams compare the closed-cycle and open-cycle reactor systems. Open-cycle system has radioactive exhaust.
P-1 Reactor Design

Fig. 2.2 – P-1 reactor structural arrangement
NB-36H

• Convair B-36 Peacekeeper bomber used for aircraft reactor shielding experiments
• Conventional power for engines
• Hung a 20 ton 3MW air-cooled indirect cycle reactor from a hook in bomb bay to study effects of different shielding configurations
  -- water as primary coolant
  -- had capability to drop reactor in case of emergency
• 47 flights, Sept.’55 – March ’57
• 215 hours aloft (89 critical)
• Cockpit enclosed with 11 tons lead for shielding
• Adjusted reactor shielding configuration to try to optimize weight and effectiveness
NB-36H Shielded Cockpit
NB-36H

- Followed on flights by a C-97 transport with Marines --If NB-36H crashed, Marines would parachute and quarantine the crash site
- Also had direct hotline to President’s Office in case of nuclear accident
Bomber comparisons

• Comparison of B-36, B-52, and hangar USAF built for a never-built or never-final-design nuclear aircraft:

<table>
<thead>
<tr>
<th></th>
<th>B-36</th>
<th>B-52</th>
<th>Hangar</th>
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<tbody>
<tr>
<td>Wingspan (ft)</td>
<td>230</td>
<td>185</td>
<td>205</td>
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<td>Length (ft)</td>
<td>162</td>
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<td>Weight (lb)</td>
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<td>185,000</td>
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<td>(max takeoff)</td>
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<td>488,000</td>
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HTRE
(Heat Transfer Reactor Experiment)

- Test platform for Direct Cycle Aircraft Nuclear Propulsion (at Idaho Nuclear Reservation)
GE J-87

• nuclear powered turbojet for proposed WS-125 long-range nuclear bomber
• 2 J-87’s per aircraft, powered by single reactor
• had bypass for conventional fuel (for startup, landing, decay heat removal)
HTRE-1
Reactor
Core
HTRE-3

- Reactor design similar to earlier P-1
- Tubular air passages, Nb-Cr fuel matrix and clad.
- 1350F outlet air temperature
End of ANP

- USAF decided 1956 WS-125 bomber not feasible as a operating aircraft
- However, research on ANP continued until 1961; X-6 prototype of converted B-36 was planned --similar core to HTRE-3 with Be fuel matrix
- JFK killed program March 1961 (recommendation left by Eisenhower administration)
- Epilog: a mismanaged program: spent $1B, no results, inconsistent direction, while more modest Navy programs had 14 nuclear subs already commissioned, took only 7 years to launch Nautilus.
XNJ140E Reactor for X-6 Prototype
“Nearly 15 years and about one billion dollars have been devoted to the attempted development of a nuclear powered aircraft, but the possibility of achieving a militarily useful aircraft in the foreseeable future is still very remote”