V T O L
Vertical Take-Off and Landing
(The future of travel)

by

John Crocco, Mariusz Kuczaj, Arvind Nagarajan & Tina Reynolds
Outline

• Objective
• Brief history
• Market study
• Design proposal
• Simulation
• Model construction
• Conclusion
Objective

Create the “flying car” predicted for the 21st century.

- Inexpensive
- Reliable
- Safe
Brief history

• Predecessors:
  Bell / Boeing V-22 Osprey
  • Fairly modern design, which first flew in 1989.
  • Uses two tilting rotors, which provide the power for VTOL capabilities.
  • Mainly used for transport purposes by US Marine Corps.
Brief history

MD / BAe AV-8B Harrier II

• Originated in Great Britain as Hawker P.1127 (1960).

• Known as the world’s first successful VTOL aircraft.

• The design features thrust vectoring, which enables the four nozzles to transform the aircraft from horizontal to vertical flight, thus enabling it to land and/or take-off vertically.
Brief history

Convair XFY-1

• This particular design featured two counter rotating propellers.
• First flown in 1954.
• Due to its disadvantages over jet power, further development was stopped.
Market study

What is the most you are willing to pay?

- $10-20k: 15
- $20-30k: 17
- $30k+: 8

What is the most roughness of transition that you are willing to accept?

- ice: 7
- blacktop: 10
- gravel road + shocks: 15
- gravel road: 9
- pothole: 1

Dan Ryan
Market study (Cont’d)

What is the minimum acceptable range you would require (mi)?

<table>
<thead>
<tr>
<th>Range</th>
<th>50mi</th>
<th>100mi</th>
<th>200mi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>12%</td>
<td>18%</td>
<td>13%</td>
</tr>
</tbody>
</table>

What is the minimum acceptable speed (mph)?

<table>
<thead>
<tr>
<th>Speed</th>
<th>30mph</th>
<th>45mph</th>
<th>55mph</th>
<th>over 55mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>7%</td>
<td>6%</td>
<td>7%</td>
<td>23%</td>
</tr>
</tbody>
</table>
Design proposals - The Volor

- Passenger capacity – 2
- Twin-rotor system
  - Fixed pitch blades
  - Cyclic rotor-disk control
- Lift provided by wings in forward flight
- Better fuel efficiency (~25 miles/gallon)
Design proposals – The X-2

- Passenger Capacity – 2
- Four ducted fans
- Standard control systems
- Advantages: Mechanically less complicated
- Disadvantages: Expecting higher fuel consumption
Design proposals – XVM3

- Passenger capacity – 2
- Counter-rotating propellers
- Tilt-wing controls for flight & hover
- Still in the experimental phase
Simulation & Testing

- Software used: X-Plane
- Modeling concepts in software
  - Basic: Thrust, weight, lift & drag
  - Detailed: Aerodynamic forces, prop-wash
- Design process: Theoretical estimations to trial & error
Simulation & Testing (cont’d)

Values at Full Throttle

Degree of Inclination from Vertical

-200 0 200 400 600 800 1000 1200 1400

0 10 20 30 40 50 60 70 80 90

Loadings

alpha
pitch deg
lift lb
drag lb
norm lb
axl lb
Model construction

- Chosen design: Volor
- Scaling: Length based on weight
- Part selection: Modify a pre-existing helicopter
Model Construction (Cont’d)

- Engine: OS Max . 40LA (1 hp@16000 rpm)
- Scale ratio – 1:10
- Wing material – Balsa wood & plywood
- Frame – Hardened plastic
Conclusion

• What has been accomplished
  – Market research
  – Design stability has been verified

• What still has to be done
  – Formalize a design for the rotor head
  – Model testing

• Questions and comments