16.070
Final Projects

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A moving map display is a situational awareness tool used by pilots in both the civil as well as the military aviation world. The display shows a two-dimensional view of different navigation charts.

Figure 1. SM-4000 COLOR Skymap IIIC by Bendix/King*  
* Source: http://www.avionix.com/movmap.html
# Navigation Charts

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Scale</th>
<th>Range (nmi)</th>
<th>Full Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNC</td>
<td>1:5M</td>
<td>160</td>
<td>Global Navigation Chart</td>
</tr>
<tr>
<td>JNC</td>
<td>1:2M</td>
<td>80</td>
<td>Jet Navigation Chart</td>
</tr>
<tr>
<td>ONC</td>
<td>1:1M</td>
<td>40</td>
<td>Operational Navigation Chart</td>
</tr>
<tr>
<td>TPC</td>
<td>1:500k</td>
<td>20</td>
<td>Tactical Pilotage Chart</td>
</tr>
</tbody>
</table>
Image Formats

- JPEG - Joint Photographic Experts Group
- GIF - Graphics Interchange Format
- BMP - Windows Bitmap
- Links

http://www.askscott.com/scott/scholastic/GIFJPG.htm
http://www.jpeg.org/
http://www.dcs.ed.ac.uk/home/mxr/gfx/2d/BMP.txt
http://www.w3.org/Graphics/GIF/spec-gif89a.txt
Value Addition

- Explain the advantages/limitations of each of the image formats

- Manipulate images

- Apply the knowledge of the image formats to the moving map display design problem
The Attitude Direction Indicator shows the roll and pitch of the A/C

Figure 1. Attitude and Direction Indicator*
* Source: http://xflight.powerweb.de/original/parts/center_console/adi/adi_01.jpg
OpenGL

- Introduced in 1992
- Industry's most widely used and supported 2D and 3D graphics application programming interface (API)
- Stable, Reliable, Portable
- Has an Ada95 API called AdaOpenGL
Value Addition

- Explain the rationale behind multi-function displays
- Use an industry accepted standard for building a simulation
- Understanding the coupling between aircraft and display
Data Links

- Data links allow aircraft to transmit information in real- or near real-time

- Act as a force-multiplier

- Connects information providers with information consumers
  - Fire-Control-Computer – Weapon
  - Aircraft – Air Traffic Controller
RS-232C

- RS-232 is a standard electrical interface for serial communications defined by the Electronic Industries Association ("EIA").

- Defines a mark (on) bit as a voltage between -3V and -12V and a space (off) bit as a voltage between +3V and +12V.

- The RS-232C specification says these signals can go about 25 feet (8m) before they become unusable.
TCP and IP were developed by a Department of Defense (DOD) research project to connect a number different networks designed by different vendors into a network of networks (the "Internet").

Lockheed Martin developed a Maritime Surveillance architecture scaled for P-3C AIP and S-3B Ada P3I systems, and initially demonstrated the capability to link an Ada tactical graphics API to S-3B code.
The MIL-STD-1553 is a military standard that defines the electrical and protocol characteristics for a data bus.

- Commonly used across all military aircraft
- The civil equivalent is ARINC 429, ARINC 629
1553 Architecture

- **Bus Controller**: Controls bus Access
- **Bus Monitor**: Records all information flowing on the bus
- **Remote Terminal**: Talks when instructed by the bus monitor
Value Addition

- Explain how data-links work
- Understand industry standard protocols applicable both in the commercial as well as military world
- Understanding the mapping between application and data link
Fuel Management

- Full Authority Digital Engine Control (FADEC) is an engine manage that monitors fuel consumption and optimizes engine performance.

- The FADEC has to take into consideration the flight envelope of the aircraft, the mode of operation and inform the pilot when bingo fuel is reached.
**Value Addition**

- Understanding how fuel management works
- Explain the coupling between aircraft mode of operation and fuel management
- Understand complex system modeling.
The Kalman filter is a set of mathematical equations that provides an efficient computational (recursive) solution of the least-squares method.

Supports estimations of past, present, and even future states, and it can do so even when the precise nature of the modeled system is unknown.
• Explain how Inertial Navigation Systems and Global Positioning System work

• Understand how GPS and INS information can be integrated using a Kalman Filter

• Explain the advantages and disadvantages of using Kalman filters
A method of homing navigation in which the missile turn rate is directly proportional to the turn rate in space of the line of sight.

Foundational algorithm from which all missile guidance algorithms are derived
Missile Guidance Modeling

- Numerical solution of differential equations
  - Runge-Kutta integration methods

- Adjoint technique for tactical missile guidance system design

- Proportional navigation and miss distance
Value Addition

- Explain how guidance algorithms work

- Understand how missile engagement simulation can be carried out

- Explain the advantages and disadvantages of using proportional navigation guidance
The task of the conflict detection is to predict an intrusion of the protected zone. This protected zone was chosen to reflect RVSM separation standards: 5 nautical mile radius and a height of 2000 feet (altitude -1000ft to altitude +1000 ft)
Aircraft Modeling

- The aircraft can be modeled using differential equations

\[\begin{align*}
x'(t) & = v \cos(\theta(t)) \\
y'(t) & = v \sin(\theta(t)) \\
\theta'(t) & = \frac{g}{v} \tan(\phi(t))
\end{align*}\]
Value Addition

- Explain how Conflict detection is carried out for air traffic control

- Understand how separation rules influence the conflict detections process

- Explain the advantages and disadvantages of using different conflict detection algorithms