A very common structure in various products is the I, T, or box beam. These are of course used as lightweight – high stiffness members to resist bending. They are used throughout the body of automobiles, the fuselage and wings of airplanes and the hulls of ships and submarines.

There are many ways to manufacture these beam – stiffeners, and that is the subject of this question. Given that we need to produce structural beams for

- Automobiles
- Airframes
- Ships

it is most common to find that the following processes are used in each case:

- **Automobiles**
  - Sheet metal stamping
- **Airframes**
  - Machining from extrusions or solid stock
- **Ships**
  - Weldments comprising simple components

Please answer the following questions

1. Why are the above processes the most common?

2. For each of the three processes, sketch a typical beam cross section that would be produced. Please provide enough detail to distinguish the process geometry limitations and discuss these limitations as well.

3. Please compare the market for these products to determine why one process would be preferred over another and address how the process matches the volume – cost - performance needs of the product.

4. Discuss the quality aspects of the processes, concentrating on
   - Precision needs of the product
   - Inherent precision of the process
   - Means of achieving the required “process capability”
   - Means of achieving overall product (assembly) quality

In your answer be as specific and quantitative as possible.
5. Now consider the integration of these processes into a production system. What are the relative rates of the three processes and what are there inherent limits to these rates? Again please be as specific as possible and consider the basic physical limits on these rates.

6. Discuss the reliability of each process and how this might affect the systems within which they operate.

7. Considering the processes, products, and the market, what are the requirements on flexibility for these processes? Be sure to consider not only the need for product variations, but also the matching of production volume to equipment.

8. Finally, consider the following alternatives and discuss how they compare to the standard ones with respect to: cost, quality, flexibility and rate.

- Automobiles
- Airframes
- Bending of aluminum extrusions
- Roll bending of sheet aluminum