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Joint Challenge 3: The Economics of Jointed Structures

M.R. Brake (Sandia),

D.J. Ewins &

C.W. Schwingshackl (Imperial),

H.G.D. Goyder (Cranfield),

P. Reuss (Stuttgart),

and M.S. Allen (Wisconsin)

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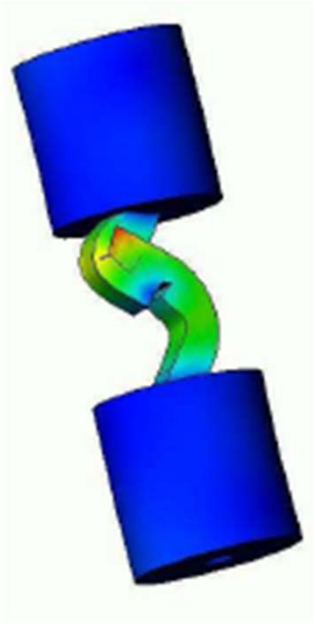

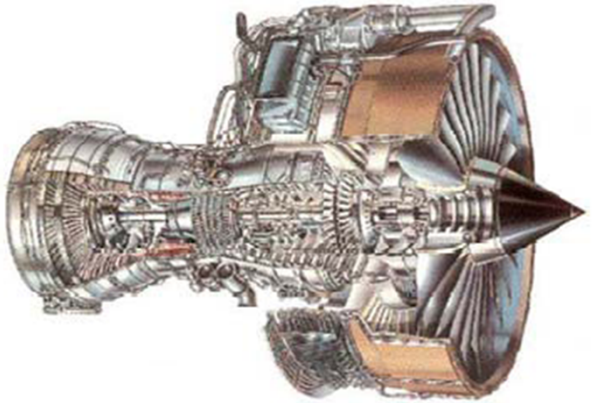

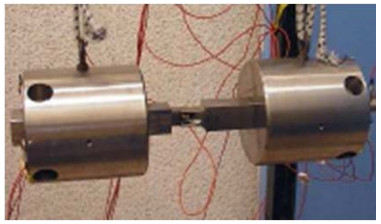

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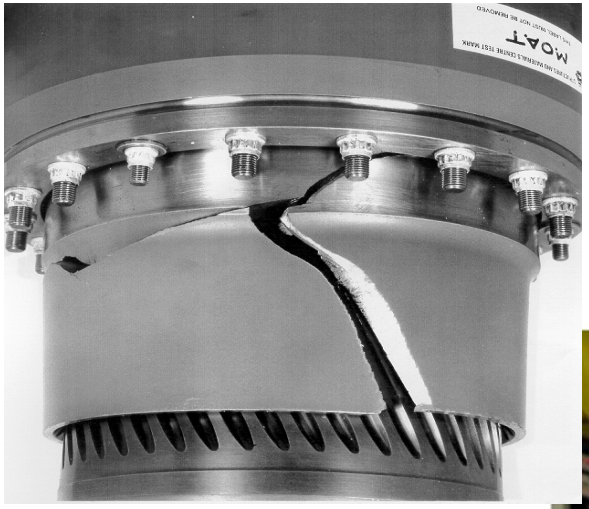
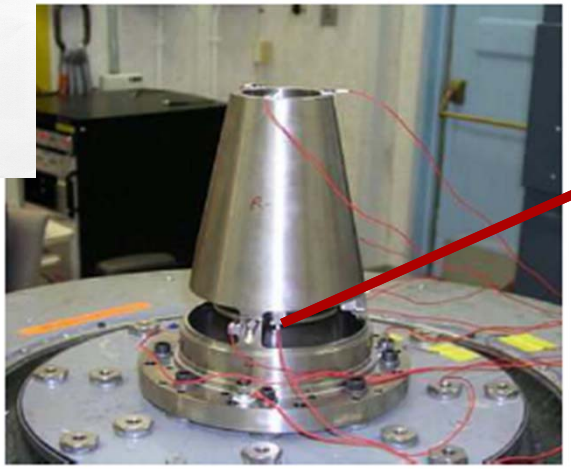
The Economics of Designing Structures With and Without Joints

- Why not design and build monolithic structures?
- Do we need jointed structures?





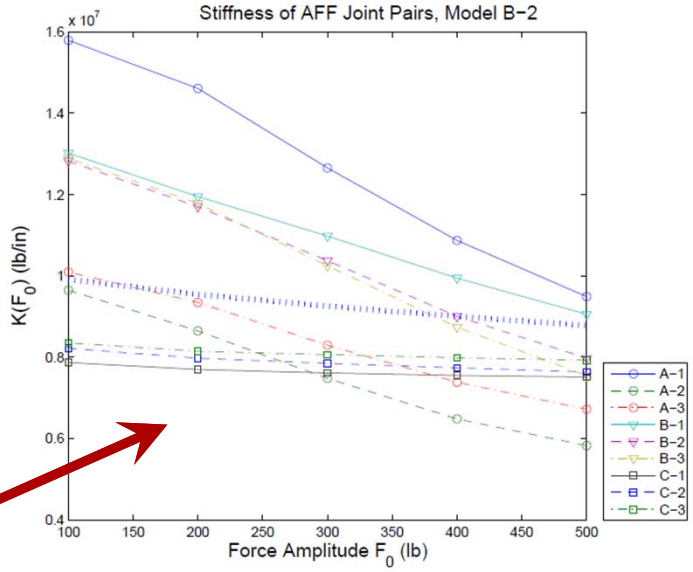


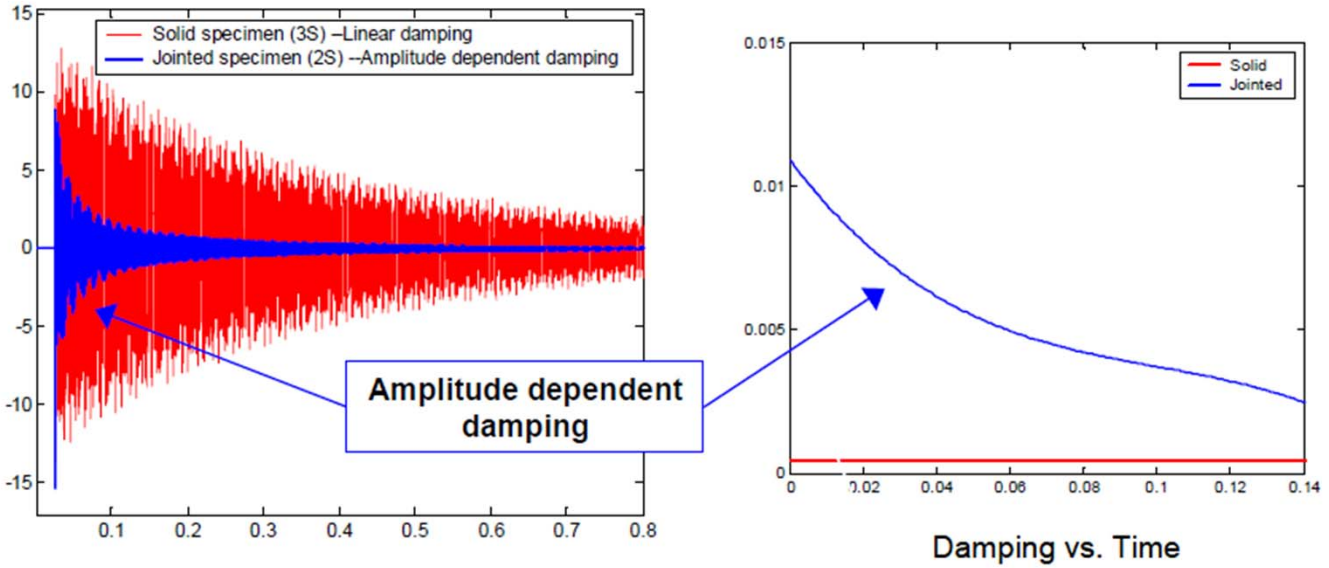
Figure 12.15. Stiffness of AOS Joint Pairs.

The thick dotted line is the stiffness of the four-parameter Iwan model, calibrated to reproduce the dissipation curve with fidelity and to match the stiffness of a load of 400 lb.

From the joint handbook (SAND2009-4164)

Layers of Questions

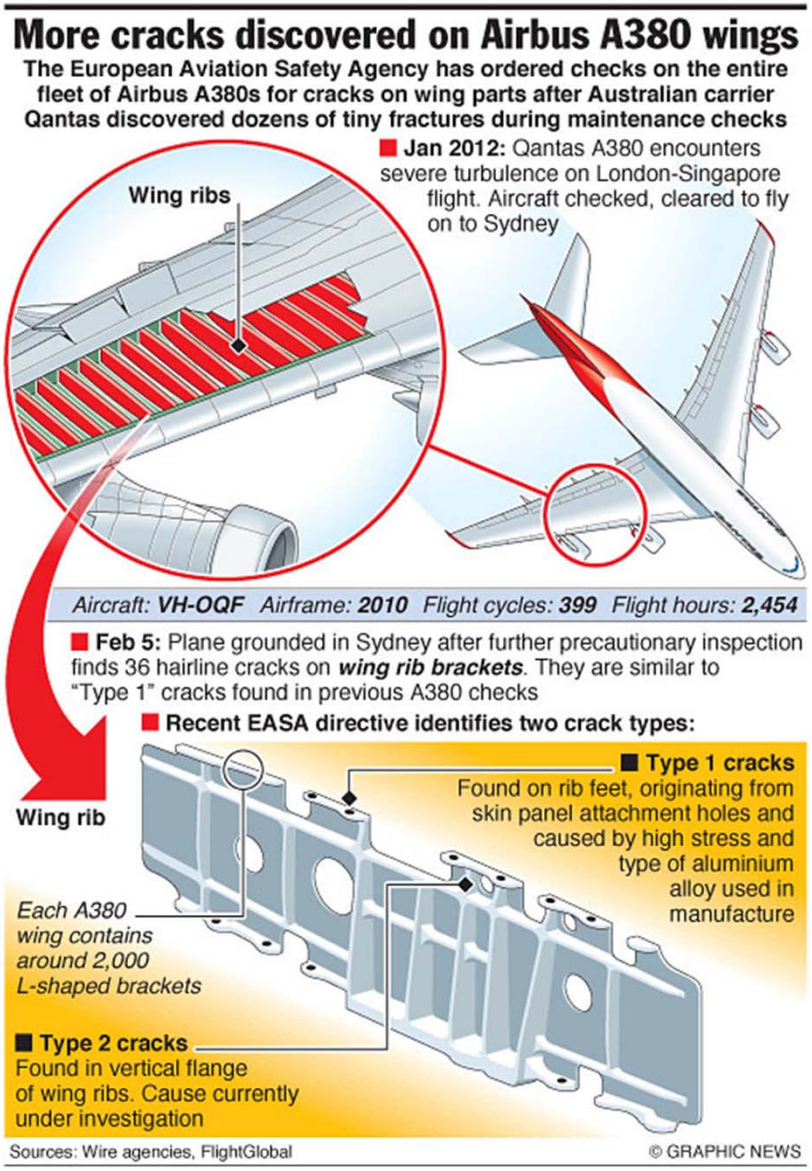
- What are the economics of designing structures with and without joints?
  - Is it better to have a monolithic or a jointed structure?
    - How do joints affect the dynamic performance of a structure?
    - Ex: Is it better to manufacture one casing or three smaller components that are jointed together?
      - Is there/what is the cost benefit of joints?



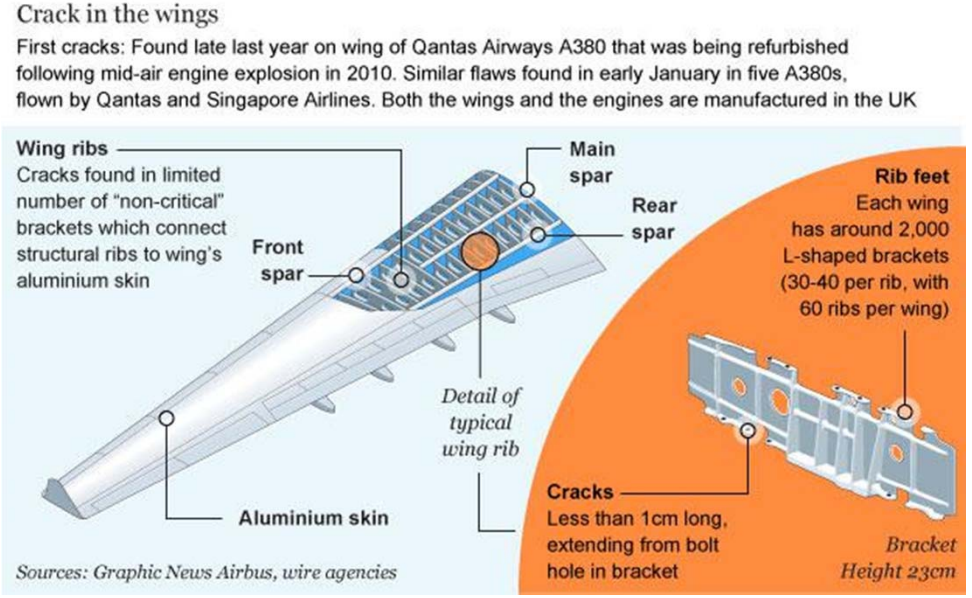
Framework for a Cost Benefit Analysis

- Cost of Failure
- Cost Benefit of Saving Weight
- Cost Benefit of Using Joints as Design Tools
- Cost Benefit of Using Joints to Monitor Structures

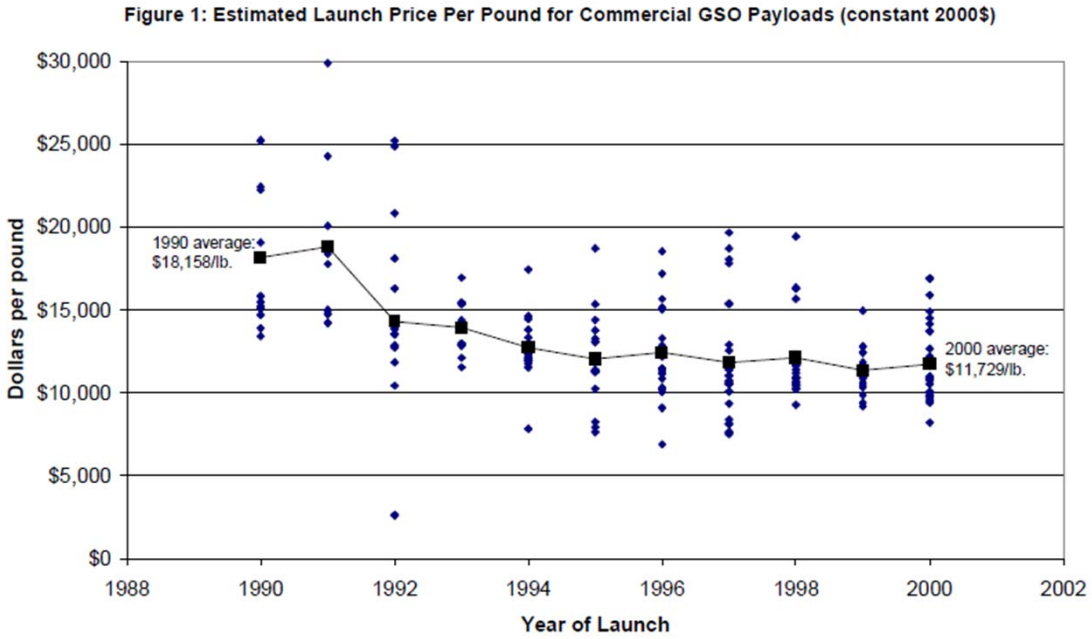
Cost of Failure



- An example: the Airbus 380
  - Cracks found adjacent to joints
  - Fleet grounded for several months
  - $330 million cost to repair
  - $30 million cost to airlines for not being able to use the planes
  - Additional costs for redesigning



Cost Benefit of Saving Weight

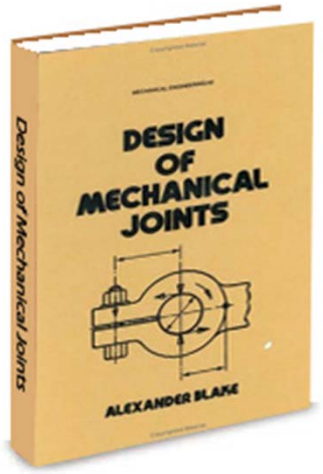


- Most prominently the savings is in fuel efficiency (automotive, aerospace, turbines, etc.)
- Example: in order to launch something into a low orbit, it costs $4,000/pound, and for a geosynchronous orbit, it costs $16,000/pound. (Approximately $12,000/pound on average)
- Reducing weight of joints by X pounds in a satellite directly saves $12,000*X per launch.

Source:

www.futron.com/upload/wysiwyg/Resources/Whitepapers/Space_Transportation_Costs_Trends_0902.pdf

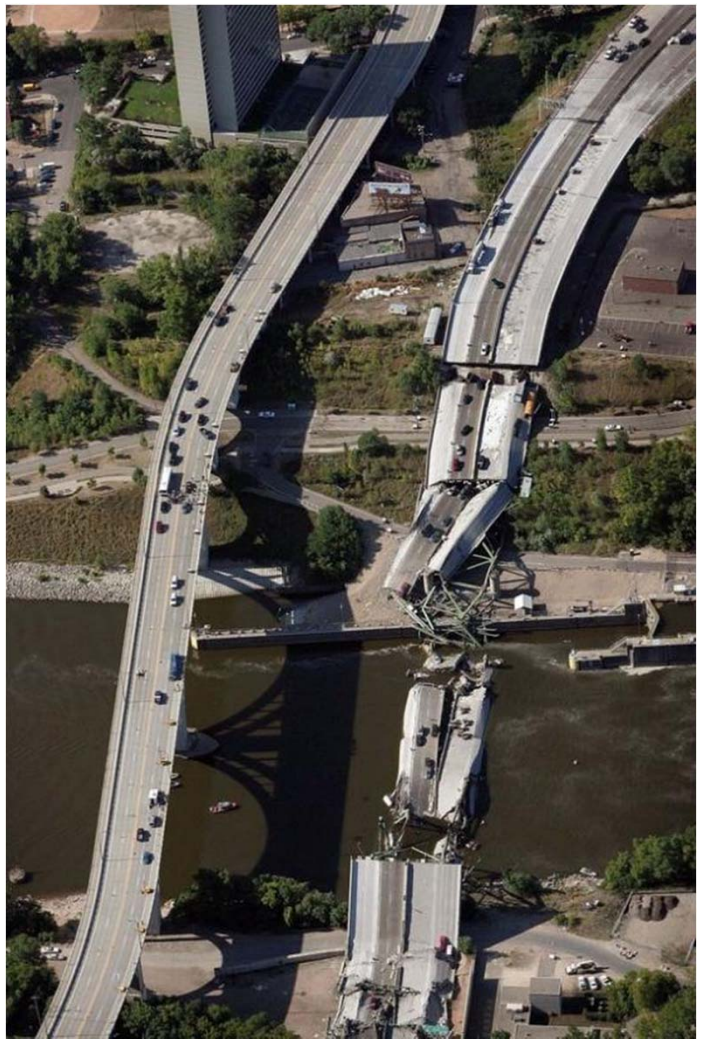
Cost Benefit of Joints as a Design Tool



- Ultimate goal: predictive model of joints
  - Pre-built model of joints with known performance
  - Handbook with easily understood metrics for how a specific joint performed
  - Ability to condition structural response by design of joints
- Impact on direct cost of design time, development cycle, product testing, and production
- If we had X capability from a better knowledge of joints, could we cut out a step in the design cycle?

Cost Benefit of Using Joints for Structural Health Monitoring

- Key idea: structural health monitoring built into joints
- Opportunity to optimally plan a repair cycle for a structure
- Early warning sign to avoid structural failures
- Many potential applications have catastrophic consequences associated with failures
- Cost benefit expected to be deduced from insurance company estimates



I-35 in Minnesota, August 1st, 2007

Concluding Thoughts

- High level question: What is the economics of designing a structure with and without joints?
- If joints are needed, what effect do they have on a system's performance?
- To answer some of these questions, a cost benefit is needed
- Several themes identified:
  - Cost of failure
  - Cost benefit of saving weight
  - Cost benefit of designing structures with joints
  - Cost benefit of using joints to monitor structures
- All of this is predicate on developing a predictive model of joint behavior

Some Points for Discussion

- What are the unknown economics of designing structures with joints?
- Are there any themes missing from the cost benefit framework?
- What are the appropriate next steps for developing a cost benefit analysis?
- What work in other fields can we leverage?