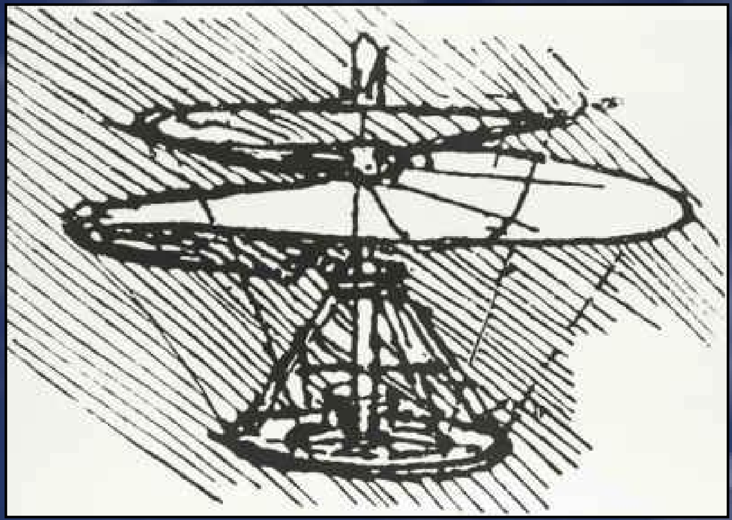
Main Rotor Blade Analysis in Helicopter Accident Investigation

by Sam Webb



Purposes and Goals

- ➔ *Establish the last flight path, heading, and attitude and of the helicopter*
- ➔ *Establish the RPM of the main rotor and engine power levels*
- ➔ *Establish drive train continuity*
- ➔ *Establish sequence of events of the accident*

Design of Main Rotor Blades

→ Investigator must have a limited knowledge of the design of the rotor system and blade

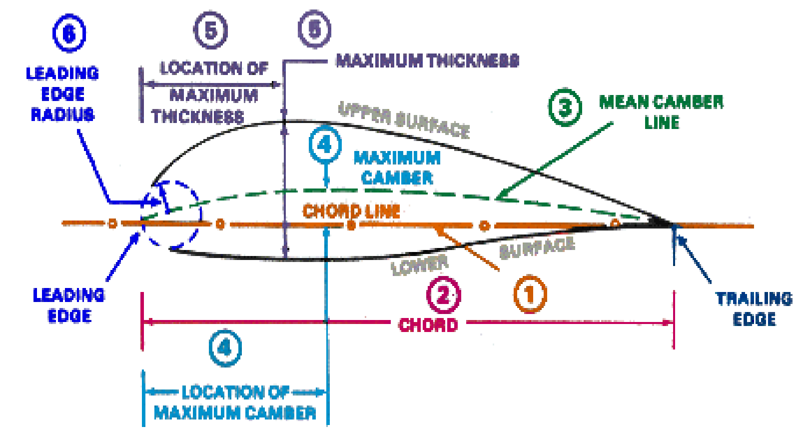
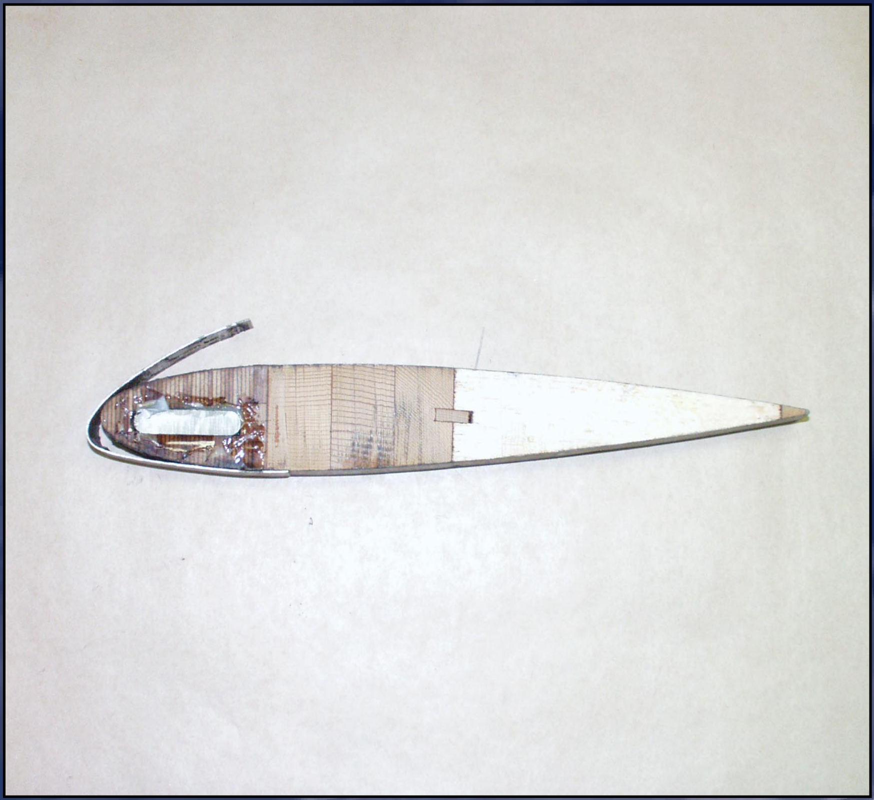


FIGURE 2-10. AIRFOIL TERMINOLOGY.

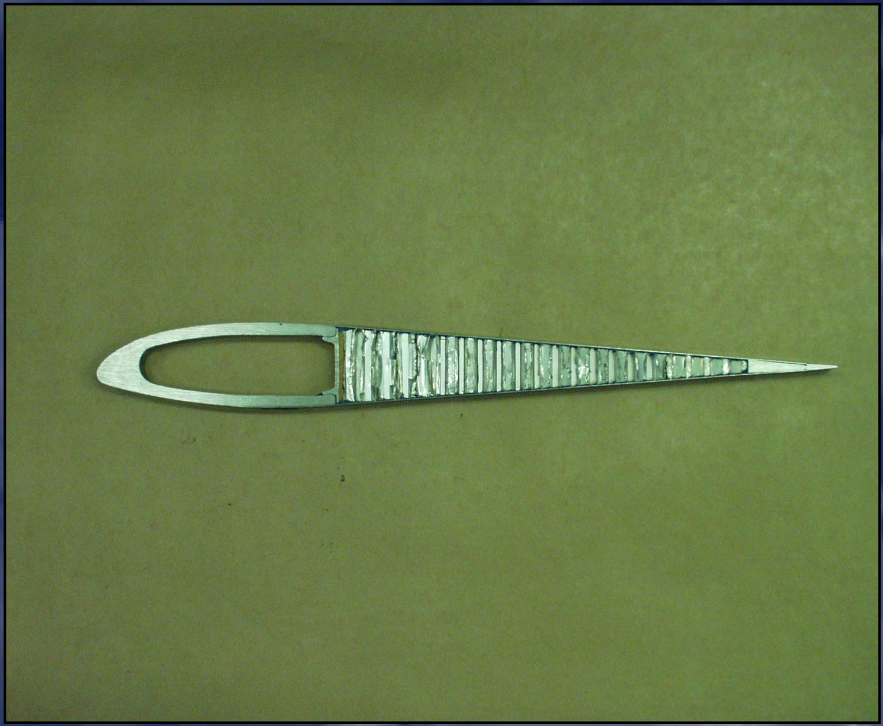
Design of Main Rotor Blades

- Wooden symmetrical airfoil
- Nickel leading edge, wooden filler, steel spar



Design of Main Rotor Blades

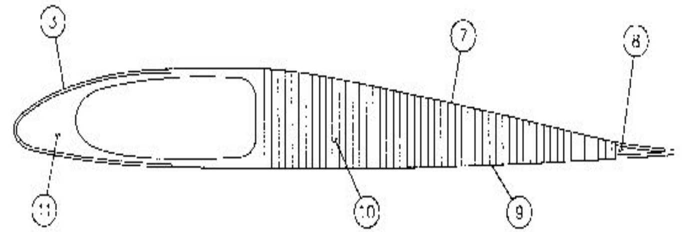
- Aluminium spar and skin, honeycomb core



Design of Main Rotor Blades

- ➔ Composite asymmetrical airfoil
- ➔ Uni-directional S-2 glass/ epoxy fabric & E glass/ epoxy tape, fibreglass spar
- ➔ Superior fatigue tolerance, notch and corrosion resistance

1. BLADE BOLT RETENTION BUSHINGS
2. M/R BLADE BONDED ASSEMBLY
3. NICKEL PLATED 301 STAINLESS STEEL EROSION STRIP
4. TRIM TAB
5. FRETTING PAD
6. 301 STAINLESS STEEL EROSION SHIELD
7. 2-PLY UPPER SKIN [CLASS B GLASS/EPOXY FABRIC & E GLASS/EPOXY TAPE
8. UNIDIRECTIONAL S-2 GLASS/EPOXY TRAILING EDGE STRIP
9. 2-PLY LOWER SKIN [CLASS B GLASS/EPOXY FABRIC & E GLASS/EPOXY TAPE
10. 2 LB/CU. FT. NOMEX HONEYCOMB CORE
11. UNI-DIRECTIONAL S-2 GLASS/EPOXY ROVING SPAR STRUCTURE [+/- 45 DEG S-2 GLASS/EPOXY OUTER AND INNER TORSION WRAPS]



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Main Rotor Design Differences

- → Normally wider cord / longer length blades
- → Higher main rotor RPM/ higher blade inertia

Two Bladed Systems, (teetering, semi-rigid)

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Main Rotor Design Differences

- Blades usually lighter construction, less cord, less length
- Main rotor RPM values marginally lower to compensate for cord area differences

Fully articulated, multi-blade systems

Main Rotor Design Differences

- → Blades same construction as multi-bladed system
- → Main rotor RPM values same as multi-bladed system

Coaxial- counter rotating, multi-blade systems

Main Rotor Damage Differences

- Blade bending, not shattering
- Blades generally intact
- Blade bending inboard and downward
- High angle of attack= blade tearing aft of spar

Low Main Rotor RPM

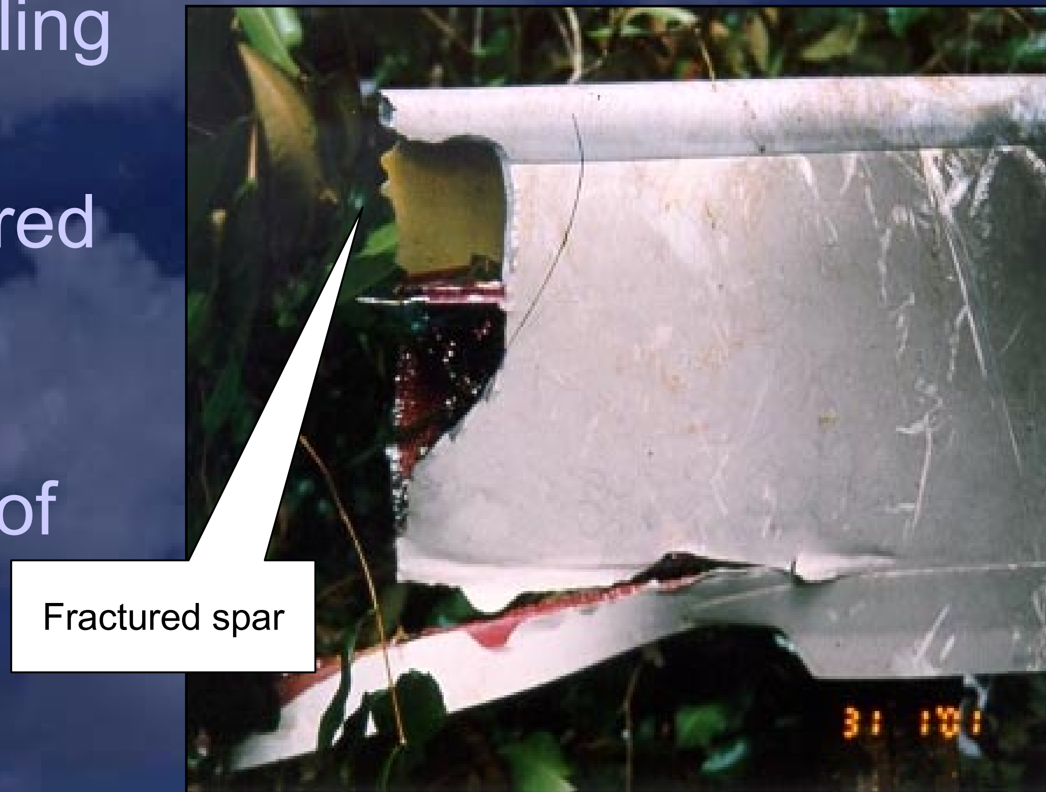
Main Rotor Damage Differences

→ Blade tip weights intact

Low Main Rotor RPM

Main Rotor Damage Differences

- → Spar fractures, trailing edge separation
- → Honeycomb fractured and separated
- → Damage mainly to outboard sections of blade



High Main Rotor RPM

Main Rotor Damage Differences

- → Tip weights "ejected"
- → May travels for kilometres from the impact site (farther distances for multi-bladed systems)

High Main Rotor RPM

Main Rotor Damage Differences

- → First blade to impact surface most damaged
- → Following blades exhibit lesser damage due to main rotor inertia bleed off

High Main Rotor RPM

Main Rotor Damage Differences

→Damage is in plane

High Main Rotor RPM

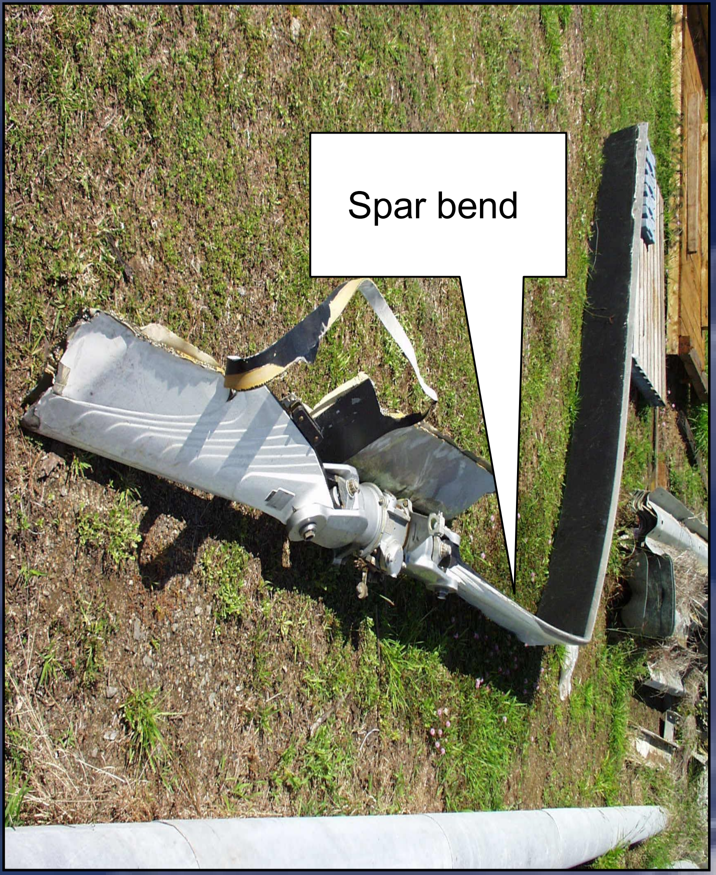
Main Rotor Damage Differences

- ➔ Massive blade distortion on multi-bladed systems
- ➔ Blades sustain more damage due to lighter construction
- ➔ Articulated systems, dynamic stops fail

High Main Rotor RPM

Main Rotor Damage Differences

- Blade spindling/ distortion
- Spar fractures depending on main rotor RPM
- Bending of spar depending on angle of attack



Damage From Water Impact

Factors Effecting Main Rotor RPM

- ➔Inertia of the blade- with high inertia will lose RPM slowly with increased angles of attack
- ➔Higher the helicopter gross weight and/or density altitude= more the blade wants to overspeed
- ➔Manoeuvring- tends to increase RPM due to energy enhancement of the rotor system

Supporting Evidence

- → Will collaborate other evidence
- → Distorted or broken
- → Direction of force will collaborate power on or off and autorotation

Main Rotor Controls

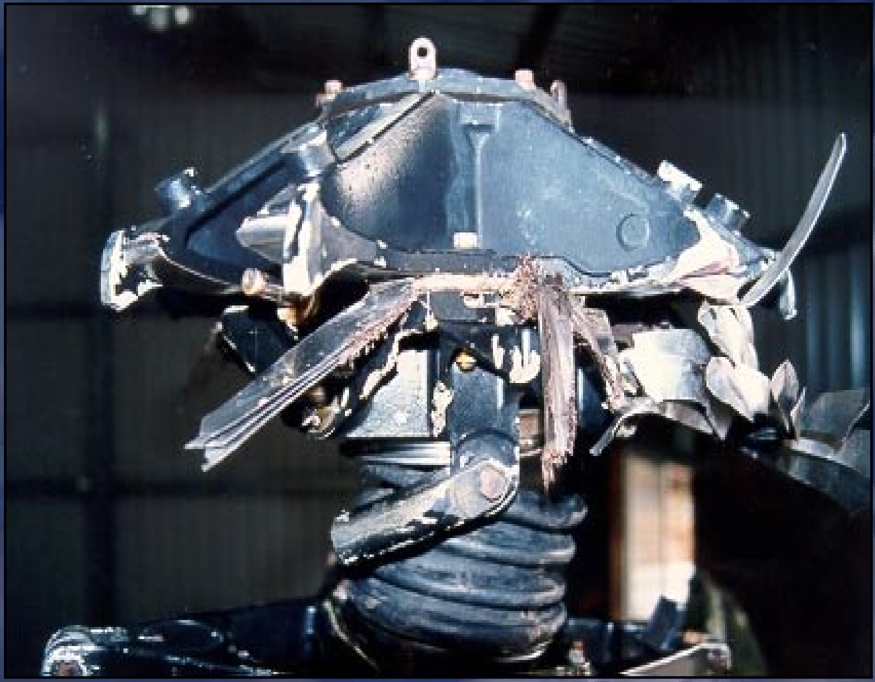
Supporting Evidence

- ➔ Damage to pitch horn, blade grip, mast assembly on semi-rigid and rigid systems= indication of high RPM

Main Rotor System

Supporting Evidence

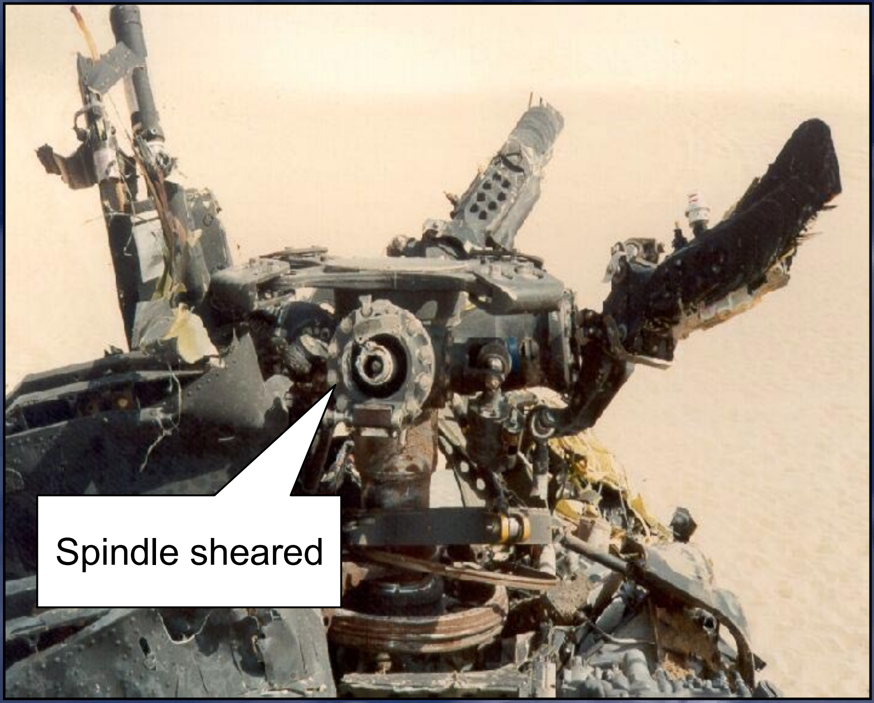
- Torque-tension strap damage



Main Rotor System

Supporting Evidence

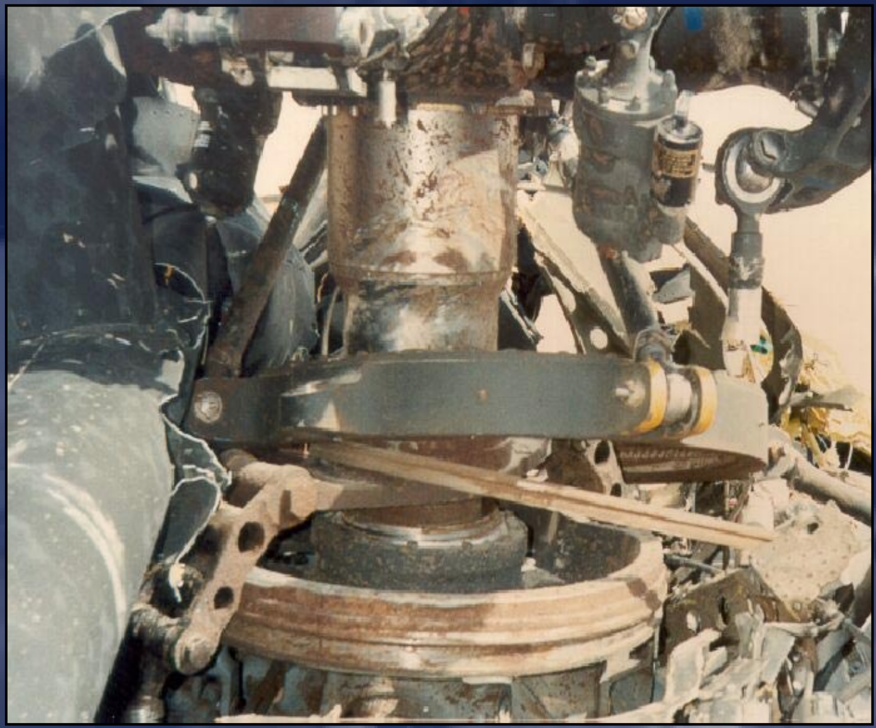
→ MR Spindle shear damage



Main Rotor System

Supporting Evidence

- ➔Swashplate duplex bearing damage= indication of high RPM



Main Rotor Swashplate

Supporting Evidence

- → Pitch change rod end attachment damage
- → Static overload indications= high RPM
- → "Necking" indications= low RPM

Main Rotor Controls

Summary

Sometimes you just
have a bad day!

Summary

Sometimes you never understand!?!?!?!?!

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Thank you for your attention!