NASA ENVIRONMENTAL COMPATIBILITY WORKSHOP
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REducing the impact of rotorcraft noise and development of future noise reduction technology

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HELICOPTERS & CTRs

• NOISE IS THE CRITICAL ENVIRONMENTAL ISSUE?

• . . . IS THIS TRUE?
  - . . . NO, PUBLIC ACCEPTANCE IS THE MOST CRITICAL ISSUE!

NOTE: PUBLIC ACCEPTANCE IS OFTEN VOICED AS A DIRECT NOISE ISSUE BUT IT IS DEPENDENT ON WIDE RANGE OF FACTORS.
PUBLIC ACCEPTANCE

• WHY ARE SMALL/MEDIUM HELICOPTERS LESS ACCEPTED THAN FIXED-WING AIRCRAFT?

• WILL LARGE PASSENGER ROTORCRAFT (S92, EH101, BB609, FUTURE LARGE CTRs) BE CONSIDERED LIKE CURRENT HELICOPTERS?

• HELICOPTER OPERATIONS CAN BE ACCEPTABLE
  – HELIJET COMMUTER: VANCOUVER-VICTORIA, B.C., CANADA
  – AIRSPUR (AFTER INITIAL PROBLEMS), LOS ANGELES 1982/84
  – 1960/70 NEW YORK, CHICAGO AND LOS ANGELES OPERATIONS
  – ABERDEEN ‘NORTH SEA’ (UK)
  – PENZANCE-SCILLY ISLAND (U.K.)

GKN Westland Helicopters
Long Term Leq Value Essentially Independent of Short Term Transients (Peaks)

Leq(16hr) = 52
HEICOPTER NOISE

GENERALISED FLYOVER TIME HISTORY

Sound Pressure Level - dB (Arbitrary Datum)

-40 -30 -20 -10 0

Time - Seconds

TRI or Tail Rotor Noise

Helicopter with High Tail Rotor Noise, High TRI or High BVI

- Helicopter with no BVI, no TRI and Low Tail Rotor Noise

CTR
PUBLIC ACCEPTANCE

Public Acceptance

Virtual Noise (Non-Acoustic)

Acoustic Trigger
Visual Trigger
Noise Characteristic at Distance *

Acoustic

Maximum Noise Level (EPNL/SEL) †

* Trigger for Non-Acoustic
† Certification Value
PUBLIC ACCEPTANCE

Public Acceptance

Virtual Noise (Non-Acoustic)

Acoustic Trigger

Acoustic

Noise Characteristic at Distance *

Maximum Noise Level (EPNL/SEL) †

* Trigger for Non-Acoustic
† Certification Value
Reaction to Helicopter Noise
Acoustic and Virtual Noise†

†Virtual (Non-acoustic) Factors Equal OR more Important
Helicopters

Noise Character at Distance*
Duration
Maximum Noise Level (Certification Level)

Community

Background (Ambient) Noise Level
Variations in Level with Time

*Level of - BVI (Blade Vortex Interaction : Impulsive Main Rotor Noise)
- TRI (Tail Rotor Interaction : Main Rotor Wake/Tail Rotor Interaction)
- Tail Rotor (Tail Rotor 'Whine')
- Engine (Not a Major Issue)
VIRTUAL NOISE FACTORS

Helicopters

- Safety/Fear of Accidents
- Low Flying/Low Altitudes
- Type of Flying (Public less Tolerant to Leisure or Perceived Leisure Travel)

Community

- Heliport (or Airport) Environmental History
- Quality of Life
- Satisfaction with Area, Employment, Work Travel Distance etc.
Helicopter Noise

Ambient (Background) Noise

Zero Acoustic Annoyance

DECREASING ANNOYANCE: INCREASE PUBLIC ACCEPTANCE
PUBLIC ACCEPTANCE STUDY

CONCLUSIONS

• PUBLIC ACCEPTANCE NOT DIRECTLY RELATED TO ABSOLUTE LEVEL: i.e. NOT DIRECTLY RELATED TO CERTIFICATION LEVELS OR VALUES USED FOR RATING COMMUNITY RESPONSE.

• REDUCTION IN NOISE CERTIFICATION LIMITS AND/OR "ACCEPTABLE" COMMUNITY RATING STANDARDS (LIMITS) CANNOT BE EXPECTED TO INCREASE PUBLIC ACCEPTANCE
VIRTUAL NOISE REDUCTION

- CONTROL OF NOISE TRIGGER IE. CHARACTER AND LEVEL.
  IMPACT ON OPERATIONAL FLIGHT PROCEDURE AND FLYOVER
  HEIGHT.

- EDUCATION OF THE PUBLIC*: ISSUES
  - SAFETY
  - NEED FOR ROTORCRAFT
  - IMPACT ON NATIONAL AND LOCAL ECONOMY
  - OPERATIONAL CONTROL+

*WHO SHOULD TAKE LEAD . . NASA, FAA, OR INDUSTRY? WILL
REQUIRE MAJOR INTERNATIONAL AND DOMESTIC PROGRAM . .
HENCE ALL WILL NEED TO BE INVOLVED IN A PUBLIC/PRIVATE
PARTNERSHIP

+OPERATORS WILL HAVE TO ACCEPT FLIGHT PATH AND HELIPORT/
VertiPORT ATC CONTROL FOR NORMAL OPERATIONS IN URBAN
ENVIRONMENTS TO GAIN PUBLIC ACCEPTANCE
CURRENT RESEARCH

• MAINLY AIMED AT REDUCTION OF ABSOLUTE (OVERALL) NOISE

• FOCUSED ON MAIN ROTOR AND BVI

• BVI (BLADE VORTEX INTERACTION) NOISE REDUCTION WILL LOWER ABSOLUTE (OVERALL) NOISE AND DECREASE IMPULSIVE CONTENT (IE. IMPROVE CHARACTER)

... .BVI UNFORTUNATELY FOCUSED MOSTLY ON REDUCTIONS AT NOISE CERTIFICATION APPROACH TEST CONDITION OF 6°/Vy AND NOT NECESSARILY APPLICABLE TO NORMAL OPERATIONS

... .LITTLE EMPHASIS ON COMPLETE HELICOPTER NOISE REDUCTION (CONFIGURATION, DESIGN, INTERACTION EFFECTS): PERFORMANCE (OPERATING COST) IMPLICATIONS OFTEN NOT CONSIDERED

... .TAIL ROTOR AND TRI NOISE IS MAIN SOURCE AFTER BVI: IMPACTS BOTH ABSOLUTE LEVEL AND CHARACTER
RESEARCH AIMS

- **MINIMUM ANNOYANCE/MAXIMUM PUBLIC ACCEPTANCE Rotorcraft: Not necessarily a "QUIET HELICOPTER" in terms of absolute level**

- **MINIMUM ANNOYANCE AT MINIMUM COST IMPACT (LOWER COST CRITICAL TO GROWTH OF ROTORCRAFT INDUSTRY)**

- **BOTH DESIGN AND OPERATION PROCEDURES MUST BE CONSIDERED: MINIMUM NOISE FLIGHT PROCEDURES CAN BE PRE-PROGRAMMED INTO AUTOMATIC FLIGHT CONTROL SYSTEMS**
RESEARCH - COMMUNITY RESPONSE

- CONFIRM IMPORTANCE OF ‘NOISE CHARACTER’

- CONFIRM / ESTABLISH FACTORS WHICH CONTROL ‘VIRTUAL NOISE’ FOR CURRENT HELICOPTERS

- STUDY COMMUNITY RESPONSE TO LARGE PASSENGER HELICOPTERS AND CTRS OPERATING FROM LARGE HELIPORTS / VERTIPORTS

- … ESTABLISH DESIGN FEATURES AND PUBLIC EDUCATION TO MINIMISE COMMUNITY IMPACT
RESEARCH REQUIRED

- UNDERSTANDING/RATING IMPACT OF NOISE CHARACTER ON APPROACH AT LEVEL WELL BELOW THE MAXIMUM NOISE LEVEL

- FURTHER UNDERSTANDING OF TRI AND TAIL ROTOR NOISE GENERATION

- STUDYOF OVERALL DESIGN IMPLICATIONS: CONTROL OF NOISE WHILE RETAINING PERFORMANCE AND LOW COSTS

- DEVELOPMENT OF MINIMUM NOISE LANDING PROCEDURES...FUTURE AUTOMATIC FLIGHT CONTROL.
RESEARCH AREAS

• NOISE LEVEL/CHARACTER IS DEPENDENT ON TIP SPEED: ADVANCED BLADE PROFILES WHICH PROVIDE "HIGH LIFE" AT LOWER SPEEDS REQUIRED

• BVI: HIGHER HARMONIC CONTROL (HHC) AND INDIVIDUAL BLADE CONTROL (IBC) OFFER POTENTIAL TO CONTROL BVI - MAJOR CERTIFICATION AND SAFETY ISSUES STILL NEED TO BE RESOLVED. TIP SHAPES (VANE/"STUB WING") ALSO APPEAR TO OFFER POTENTIAL WITH NO REAL CERTIFICATION ISSUES

• ENGINE NOISE SIGNIFICANT FACTOR ON MANY HELICOPTERS - WILL BECOME MORE OF A PROBLEM AS OVERALL NOISE LEVELS ARE REDUCED. LITTLE OR NO SMALL ROTORCRAFT ENGINE NOISE CONTROL RESEARCH. SPACE AND WEIGHT ARE CRITICAL FACTORS FOR HELICOPTER
RESEARCH/DESIGN

- OVERALL ROTORCRAFT DESIGN: CONFIGURATION AND DETAILED DESIGN ISSUES - NOISE/PERFORMANCE/COST MUST BE CONSIDERED IN CONCERT

- NOISE ABATEMENT APPROACH PROCEDURES*

- INCREASED ROUTE HEIGHTS: ATC IMPLICATIONS: RE-EVALUATION OF “AIRPORT AIRSPACE” REQUIREMENTS

*6°/Vy APPROACH PROCEDURES GENERATE MAXIMUM NOISE LEVELS YET IFR PROCEDURES BASED ON 6° ARE BEING PROPOSED/DEVELOPED - IS THIS LOGICAL??
CONCLUSIONS

- **IF...**
  - VIRTUAL NOISE MINIMIZED (CRITICAL FACTOR)
  - BVI, TR, TRI REDUCED/NOISE CHARACTER IMPROVED
  - MINIMUM "ENVIRONMENTAL IMPACT" (NOT JUST LOW NOISE) DESIGNS DEVELOPED
    - ...THEN ROTORCRAFT INDUSTRY CAN GROW AS MAJOR AVIATION SEGMENT

- **AND IF...**
  - ENGINE NOISE CONTROLLED
  - IMPROVED BLADE DESIGN (IMPROVED PERFORMANCE AT LOW TIP SPEEDS)
  - LOWER COST ROTORCRAFT DEVELOPED
    - ...THEN INDUSTRY POTENTIAL WILL BE FURTHER ENHANCED