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Assessment of Technologies for the Silent Aircraft Initiative

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The Silent Aircraft Initiative produced an aircraft design that combined many new and novel technologies to give a solution that was predicted to be fuel-efficient as well as extremely quiet. The study presented in this paper seeks to assess the benefits and penalties of each of the proposed technologies. A method has been developed that estimates the overall change in fuel consumption and engine noise caused by modifications to an aircraft design. The method sizes a propulsion system for a specified design and determines adjustments to the cruise performance based on changes in the engine components, the installation system, and system weight. The offdesign performance is also calculated so that the noise can be estimated. The method has been applied to show what contribution each silent aircraft technology made to the overall goal of the project. It also shows the tradeoffs between noise and fuel consumption for various technologies and indicates that there are configurations that can achieve both lower fuel burn and lower engine noise. The method has been used to identify a low-risk configuration of the silent aircraft, for which a new design is presented.

Nomenclature

A	=	area, m^2
D	=	drag, kN
d	=	diameter, m
H, H^*, H^{**}	=	boundary-layer shape, kinetic energy, and density factors
L	=	lift, kN
LCV	=	lower calorific value of fuel, kJ/kg
l	=	length, m
M	=	Mach number
MTOW	=	maximum takeoff weight, kg or lb
$\dot{m}$	=	engine mass flow rate, kg/s
n	=	number
OEW	=	operating empty weight, kg or lb
PR	=	pressure recovery
p	=	pressure, kPa
S	=	wetted area, m^2
s	=	range, km
s	=	entropy, kJ/kg K
T	=	temperature, K
U	=	blade speed, m/s
V	=	flow velocity, m/s
W	=	aircraft weight parameter, kg
X_N	=	net thrust, kN
α	=	aircraft climb angle
η	=	efficiency
θ	=	boundary-layer momentum thickness
ω	=	variable density factor (a function of jet velocity)

Subscripts

cr	=	cruise
emb	=	embedded
ex	=	exhaust
f	=	fan
in	=	inlet
j	=	jet
nac	=	nacelle
noz	=	nozzle
p	=	polytropic
pay	=	payload
pr	=	propulsive
ref	=	reference
TOC	=	top of climb
TO	=	takeoff
0	=	stagnation condition
∞, a	=	freestream, atmospheric

I. Introduction

THE demand for aircraft to be both quieter and more fuel-efficient is greater than ever. The expected increase in air traffic means that the number of aircraft operations are rising continuously, leading to both greater noise and greater emissions of pollutants. Industry and government have developed the Advisory Council for Aeronautics Research in Europe 2020 vision for air transport [1]. This has the ambitious target of cutting both noise emission and fuel consumption of aircraft to one-half of the levels from aircraft built in 2000 by the year 2020. Such levels of reduction are expected to require major technological breakthroughs in both engine and airframe design.

The goal of the Silent Aircraft Initiative was to design a viable concept aircraft that is no louder than background noise in a typical urban environment. For this project, aircraft noise emission was the primary design variable. However, it was realized early in the project that to produce a credible aircraft design for the future, the fuel consumption of the design would be critical. The project has thus generated many ideas for possible new technologies that in combination have the potential to significantly reduce both noise and fuel consumption. Many of these technologies were incorporated into the final design of the aircraft, which is shown in Fig. 1.

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