

## Electric Flight – Potential and Limitations

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### ABSTRACT

*During the last years, the development of electric propulsion systems is pushed strongly, most notably for automotive applications. For ground based transportation, the system mass is relevant, but of relatively low importance. This paper addresses the application of electric propulsion systems in aeronautics, where all systems are much more constrained by their mass. After comparing different propulsion system architectures the focus is cast on the energy storage problem and here especially on battery storage systems. Using first order principles the limitations and required technology developments are demonstrated by introducing battery powered electric propulsion systems to small and medium sized aircraft.*

### Abbreviations and Symbols

$b$  = wing span [m]

$C$  = capacity [Wh]

$D$  = drag force [N]

$E'$  = mass specific energy content [Wh/kg]

$f_e$  = empty mass fraction  $m_e / m$

$g$  = gravity acceleration [ $m/s^2$ ]

$L$  = lift force [N]

$m$  = mass [kg]

$m_{initial}$  = initial mass at takeoff [kg]

$m_e$  = empty mass without fuel and payload [kg]

$m_{final}$  = final mass at landing [kg]

$m_{battery}$  = battery mass [kg]

$m_{payload}$  = payload mass [kg]

$m_{pass}$  = mass per passenger [kg]

PAX = number of passengers

$P$  = power [W]

$P_{battery}$  = electric power provided by battery [W]

$R$  = range [m]

$t$  = time [s]

$T$  = thrust [N]

$V'$  = volume specific energy content [Wh/ $m^3$ ]

$v_\infty$  = flight speed [m/s]

$\eta$  = efficiency

$\rho_\infty$  = density of air [ $kg/m^3$ ]

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web aug 24 2023 1 votre cerveau fonctionne mieux vous obtiendrez bien plus qu un corps de nageur en nageant régulièrement en effet la natation augmenterait le flux sanguin en direction du cerveau conduisant ainsi à une meilleure oxygénation vous augmenterez ainsi vos fonctions cognitives serez plus alerte et votre mémoire s en verra elle aussi

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web 1 relaxation les bienfaits sur le mental la natation a un grand pouvoir de relaxation l effort physique dans l eau permet d évacuer les tensions accumulées durant une longue journée afin de libérer les raideurs cou dos bras jambes etc mais aussi calmer votre hamster qui s active 24 7 dans votre tête

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web vous l aurez compris la natation est une super alliée à partir du moment où vous aimez vous retrouver dans l eau c est

un sport polyvalent et non traumatisant pour votre corps tout pour vous séduire perte de poids tonification musculation amélioration des

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web affiner sa silhouette complète la natation est idéale pour la perte de poids la résistance de l eau permet de brûler plus de calories et l effet drainant de l eau permet de lisser la peau les mouvements amples de la natation permettent de se muscler en allongeant le muscle plutôt que par une prise de masse

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web mar 7 2017 des études récentes ont montré que la natation peut donner un coup de pouce exceptionnel à la santé du cerveau ce n est un secret pour personne que les exercices d aérobic peuvent aider à

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web de plus sachez que la natation est un sport très énergivore comptez environ une dépense énergétique de 600 kcal pour une séance d une heure pour perdre efficacement et durablement du poids nagez au minimum 2 3 fois par semaine à raison de 45 minutes minimum par séance au bout de quelques semaines vous verrez des résultats et

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web mar 22 2022 nager est une activité idéale car elle présente à la fois de nombreux avantages pour le corps et l esprit la natation est dans le haut de la liste des entraînements les plus complets elle permet ainsi de travailler tous les aspects physiques avec un risque minimum de blessure tout en prenant soin de sa santé

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web les différents bienfaits de la natation sur la santé générale la natation apporte de nombreux bienfaits sur la santé la natation est le sport complet idéal à pratiquer pour prévenir le surpoids mis à part le fait de cibler l ensemble du corps la résistance de l eau lors de la nage permet de brûler plus de calories

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web une pratique régulière de la natation permet de tonifier les muscles des bras des jambes et du tronc les formes de nage

sont multiples et permettent de travailler différents