Review of Distributed Propulsion

VTOL Aircraft Technology for Sustainable Transportation

Robert Vergnes CEO Neva Aerospace Ltd. (UK)

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NEVA IS NEWS:

Eole-C4, the world's first turbo-drone caught the attention of French Prime Minister Edouard Philippe during le Bourget Paris Air Show 2017. (Neva CEO Robert Vergnes far left).

WIRED

Can't Decide What Kind of Flying Car to Get? Try These 10

02

Never Say Neva!

Neva Aerospace, a UK-based consortium made up of five aviation-focused companies, wants to build the AirQuadOne. Electric turbofans for propulsion at each of its four corners make it essentially a bigger version of a hand-held quadcopter drone. Neva's range estimate of 25 miles may not sound like much, but it is refreshingly realistic—and plenty to get across most cities.

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Neva's technology ranked #2 by Wired as "Refreshingly Realistic".

Distributed Propulsion - Evolution:

Distributed Propulsion – early 1960s thinking from NASA for linear flight (horizontal):

“**Distributed propulsion** (DP) is a type of powered flight propulsion system for fixed-wing aircraft in which engines are distributed about a vessel. Its goal is to increase performance in fuel efficiency, emissions, noise, landing field length and handling performance.

“DP is typically accomplished by spanwise distribution of partially or fully embedded multiple small engines or fans along the wing.

Alternatively, it may involve ducting exhaust gases along the wing's entire trailing edge.” *

https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20100036222.pdf

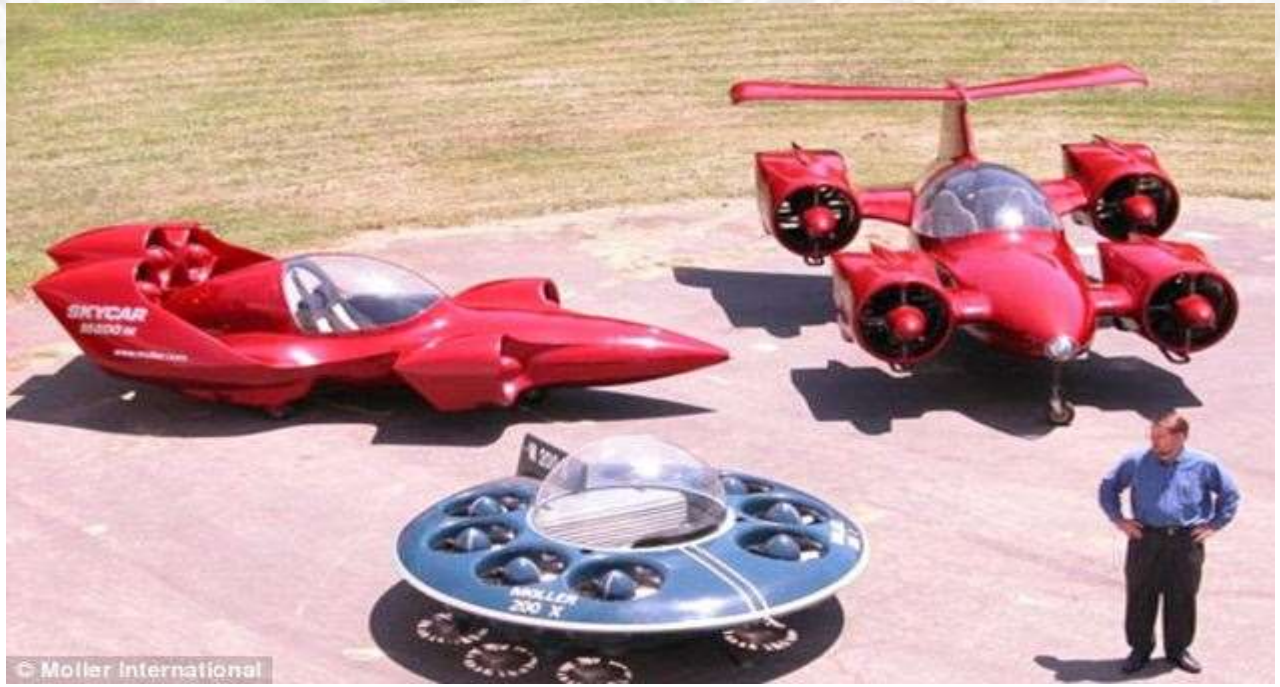
https://aero.larc.nasa.gov/files/2012/11/Distributed-Electric-Propulsion-Aircraft.pdf

.. . A long period of unsuccessful trials…

The persistent Moller flying car team has been trying for more than 20 years – without success

"The **Moller Skycar** is a prototype personal VTOL (vertical take-off and landing) aircraft – a "flying car" – invented by Paul Moller who has been attempting to develop such a vehicle type for more than fifty years.[2] As of 2016, no Moller air vehicle has successfully flown in free, non-tethered flight."

Source: https://en.wikipedia.org/wiki/Moller_M400_Skycar



The limiting factors were control systems, thrust modulation speed, controller power (calculators), turbine efficiencies, and power to weight ratios (batteries & engines).

There was no viable proposal to combine VTOL and distributed propulsion for heavy-duty use…until Neva.

2009: start of a new era to design safer aircraft. "3D Distributed Propulsion (3DDP)"

Neva Chief Science Officer Prf. Brotherton-Ratcliffe defined axioms of "3D Distributed Thrust for Aeronautic Levitation and Propulsion":

- The reactivity of turbine thrust systems depends on the inner mechanical momentum of the turbine and consequently an efficient Levitation system requires:
  (a) a plurality of high-average-power high-static-thrust low-modulation-frequency thrust systems to compensate for most of the gravity, and
  (b) a plurality of low-average-power high-modulation-frequency thrust systems to compensate for force transients.

- Thrust systems should be dispersed around the vehicle on a surface whose normal is the gravity axis in order to create a levitating support thrust which is more-or-less evenly distributed over said surface, thus reducing thrust density and conferring a fundamental redundancy of operation among the plurality of thrust systems.

- In order to confer 3D flight stability, a subset of the thrust systems described above should be replaced with intrinsically 3D thrust systems, said systems being capable of thrust in additionally two mutually orthogonal directions to the gravity axis.

- For high-speed efficient linear flight, an aerofoil should be incorporated in the design and high dynamic thrust turbines used for linear propulsion.

First original Neva Patent: Electric VTOL Aircraft using Electric Ducted Fans .

2013: First 3DDP VTOL Electric Flight

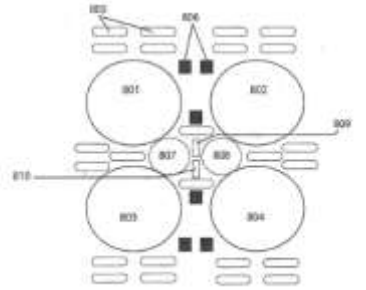
Neva Mission: To be a world leader in sustainable aero-technologies, helping to meet the challenges of changing climate and social demographics.

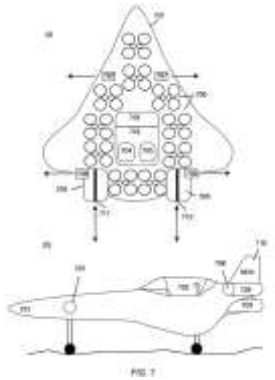
Neva Vision: The future of transportation is *sustainable*, *aeronautical*, *electrical* and *distributed*.

The early Neva R&D Project to develop new types of Manned and Unmanned Air Vehicles (MAV/UAVs) was led by **Prf. Brotherton-Ratcliffe** (Brighton University UK) and **Robert Vergnes** (PPL/MBA).

Following a successful first flight in 2013, Neva Aerospace Ltd was incorporated in the UK to pursue the work of Neva's venture as it attracted key talent across Europe.


United States
Patent Application Publication





Patented Portfolio Technologies:

- Manned & Unmanned Air Vehicles (MAVs / UAVs)
- Electric TurboFan (ETFs)

Distributed propulsion | Distributed control | Distributed sensors | Distributed energy sources
More safety | higher efficiency | New fixed-wing and rotorcraft aircraft design options

Following Neva's lead…

Why are they struggling?

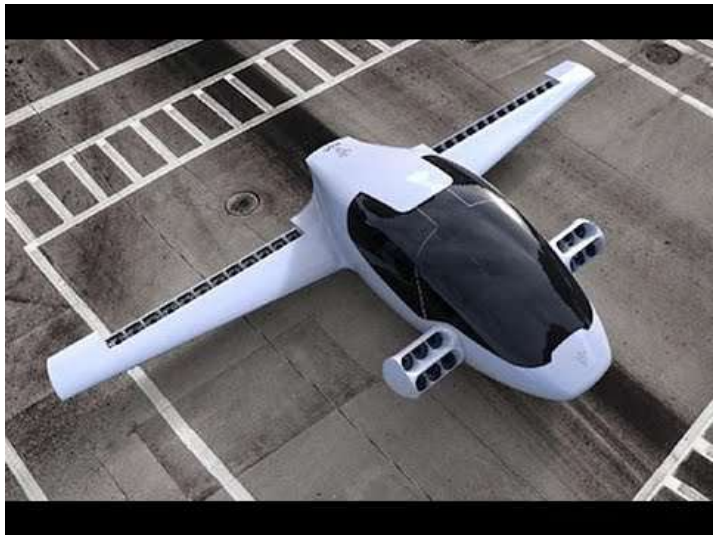
Conventional propulsion, 2D linear distributed propulsion and VTOL distributed propulsion are only sub-sets of a general, true 3D Distributed Propulsion.

As demonstrated consistently by Neva's Prf. Brotherton-Ratcliffe and his team since 2009 and in Neva's patents, 3D Distributed propulsion and a modular approach for turbofans thrusters are a new and viable way of mastering atmospheric flights.

As noted by "Wired" in their review: *"Lilium's claims of 190 miles of range at 190 mph may take some yet-to-be invented battery tech though."*

Lilium's & Aurora PR demo flights, were measured in minutes. Our calculations estimate around 4 to 6 Minutes. We have been there few years back already with our Micron Prototype ourselves ! And decided that 5 minutes flight is of no use and that the key issue was to ensure proper **and efficient electric turbofan technology first as this is the key to distributed propulsion aircraft.** This is why we focused on Electric Turbofans (ETFs) and released our first ETFs Athena which is 3 times more efficient than the airbus e-fan.

- ***NASA-Aurora (US):*** *for defense transportation*
  http://www.aurora.aero/lightningstrike/
- ***Lilium-Aviation (GE):*** *2 seater VTOL-business jet*
  http://lilium-aviation.com/



Our vision for sustainable transportation

The boundaries between wheeled & airborne transportation will blur.

A bright future and a large addressable market.

This represents the view of Neva Aerospace on the future of aircraft and other brands are mentioned for respecting copyrights. They may not share our views.

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Neva Technologies ranked #2 by Wired over all competition: [Read here.]

Volocopter (DE)

- EASA certification. Standard multi-propelers for electric helicopter. (Investor: Daimler)

Ehang (CN)

- No demonstration on record. Design inherently dangerous. Probably cannot fly more than 10min in its current configuration. (Investor :GP Capital)

XTI-Trifan (USA)

- Does not use Distributed propulsion. Very early stage (no POC).

Lilium (DE)

- Uses distributed propulsion. Test flight duration 4 minutes (estd). May infringe patents in some regions. (Investors: Atomico)

Air-Mule(CityHawk)

- Uses only 1 or 2 usual helicopter turbines. Very high Capex and Opex similar safety issues as with helicopter designs.

Aeromobil (SK)

- Unsafe as it does not use distributed propulsion – probably high Capex and Opex. (Investor: IPM Asia)

Tesla / Terrafuguia (USA) Flying Car Concept

- Only at concept level. Such aircraft design has never been tested and is far from the safety of distributed propulsion. It is unclear if the design is really endorsed by Tesla.

Workhorse (USA)

- *Similar to heang. It had never flown at the time of this report.*

KittyHawk (USA)

- Use distributed propulsion. Large Multicopter. Low safety. Highly dangerous due to multiple free rotating blades. Aimed at extreme sports fans. (Investor: Google).

AeroFex(USA)

- Low safety. Similar to Airmule (Urban Aero CityHawk) using 2 fans with vents. Smaller version for one or two persons.

Other developers of related technology

Contenders:

- **NASA-Aurora (US):** for defense transportation **http://www.aurora.aero/lightningstrike/**
- **Olaeris/Aeva (US):** multi-ducted-copter: **http://www.olaeris.com/**

Outsider :

- **A certified turbine Jetpack from New-Zealand : http://www.martinjetpack.com/**

Pure Public Relations – or "wish-techs":

- **Airbus(EU):** stopped quadcruiser vtol wing project. We believe they also failed on the e-Fan. They are now re-starting e-turbofan with their partnership with Siemens in 2016**:** (VTOL or linear?)and issuing nicely designed concepts which seem far from any engineering realism.
  http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2016/corporate/pr2016040246coen.htm&content[]=Corp
- **Google(US):** Google-X-Wing project stopped and restarted with a Hybrid-Jouav type plane.
- **Amazon(US):** https://www.amazon.com/b?node=8037720011
- **Back to The Future (US)**– DeLorean (?): https://www.wired.com/story/delorean-aerospace-flying-car/

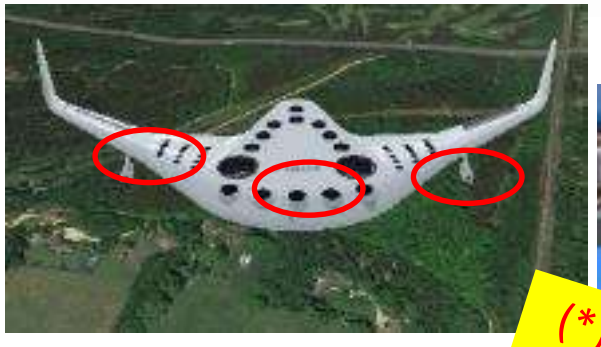
The key to the Neva difference:

Neva technologies are based on a disciplined scientific approach.

The “Axioms of Ratcliffe” are patented for winged craft and rotorcrafts.*

They provide for understandable design, necessary safety, proper control mechanisms & efficient thrust.

This has also led us to develop new types of turbines.



(*) 2009 Priority Date Patents Granted in the UK and in the USA.

3DDP for wing-craft and rotorcraft in a nutshell:

Multiple turbofans (mostly electrical) of different sizes and orientated in three dimensions to ensure sustentation and stability.

Neva in the small drone market 25Kg and less (LT25)

Usual small Drone Competition:




- From 100g to 25kg
- Public domain technology (Open Source)
- Commodity prodicts for B2C gadgetry market
- Not allowed to fly in regulated airspace
- Poor redundancy & no industrial systems
- Dangerous rotors and blades
- No industrial connectors

Neva small applications (LT25):



- From 5kg to 2 tonnes – economically viable
- Protected by more than 10 patents
- OEM Patented Turbines
- Industrial machines with ROI
- Can embark all regulatory equipment
- Intrinsic safety for field work and EHS
- Integration with IS & ERP – data warehouse management and ATC (Air Traffic Control)
- Use of inherently-safe turbines can transform the small-medium weight market.

New doors are opening. Solid, patient scientific work and engineering design means Neva can be first through.

Beyond our axioms for 3D Distributed Propulsion and standard helicopter and airplane designs, we believe there is no real scalability. It comes down to physics and aerodynamics

Small multi-copters are toys and low-tech. it is highly improbable that any real advances technology will come out of this market now. Flying becomes far more complicated as the weight increases. **Currently propellers for multi-copters have no pitch-adjusting-blades and no rotor-plane adjustment**. These two features make a helicopter fly efficiently – but implementing them is costly and difficult for small drones makers.

In our view, for flying, hovering and transition from VTOL to linear flight, with useful payloads, our patented "3D Distributed Propulsion" technology is still the only viable available solution.

After all, if it was so simple to have a VTOL airplane or super-large multi-copter, then Boeing or Airbus would have done it long time ago! Instead, Boeing and the US Airforce have stuck with the Osprey V22 design. VTOL-wing planes with small fans or propellers, such as Amazon is attempting, in our view, cannot be properly and efficiently scaled up as they, too, fail to follow the axioms of 3D Distributed Propulsion, which are patented by Neva.

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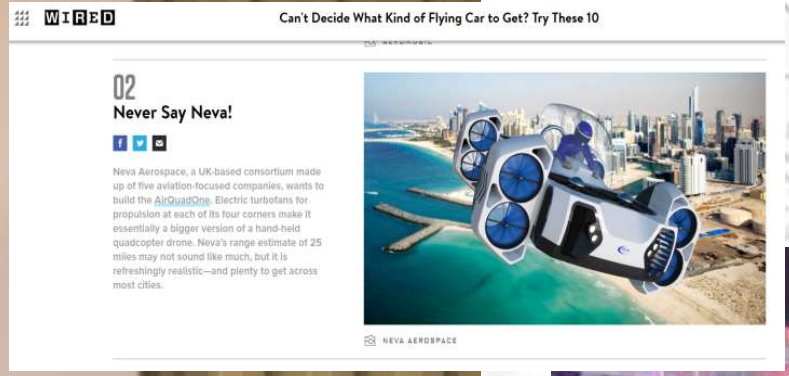

52nd INTERNATIONAL PARIS AIR SHOW LE BOURGET JUNE 19 - 25, 2017 | 52e SALON INTERNATIONAL DE L'AÉRONAUTIQUE ET DE L'ESPACE PARIS LE BOURGET 19 - 25 JUIN 2017

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