Battery Challenges and Opportunities for e-Powered Prop Flight

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Battery Propulsion System CONOPS

Sub-regional Commuter/Cargo Business Case Examples

A Sub-regional Commuter/Cargo Business Case Example

A comparison of 2 different business and operational strategies – a measurable variable cost difference between **Part 135 operating Part 23 a/c and Part 121 operating Part 25 a/c**.

Kamakair a Hawaii's **Part 135 Inter Island Cargo Operator** provides **Same Day On Demand Inter-island Service**. Affiliated with **FedEx Express** and **Fedex Ground Shipping Services** to Provide **Same Day Last Mile Delivery Services** in the **Hawaiian Islands** as well as a **Feeder Service** for the larger **FedEx cargo system.**

Using a fleet of six Cessna 208 Grand Caravans

Air Cargio Carrier	Kamaka Air	Aloha Cargo
	Honolulu to Maui (Kahuli)	
Distance	104 Miles (167 Km) ~ 40 minutes	
Package Weight	194 Lbs (68 Kgm)	
Direct Shipping Cost	US$83.42	US$172.66
Fuel Surcharge	US$25.03	US$36.86
Tax	US$5.21	US$13.35
Total Shipping Cost	US$113.66	US$226.74
Fleet	6 Cessna Grand Caravans	3 B737-300F, 1 B737-400F, 1 B767-300F
Type Operations	Part 135	Part 121
	Commuter and Utility Cargo	Scheduled Air Carrier
Note:	Important Distinction; Part Operations, Aircraft used, Number Pilots and OperatingCosts: $113.66/$226.74 = 0.50	

Typical FedEx/Amazon Stage Lengths, miles

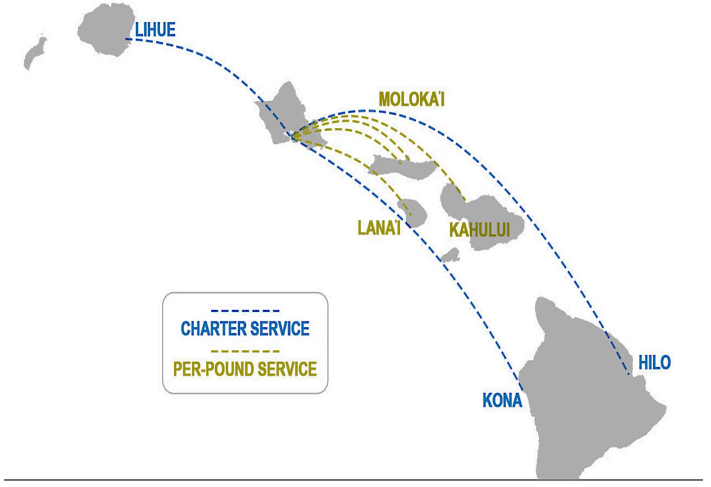
FedEx Express fleet	
Aircraft	In Service
Airbus A300-600RF	65
Boeing 757-200SF	115
Boeing 767-300F	112
Boeing 777F	51
McDonnell Douglas MD-10-30F	11
McDonnell Douglas MD-11F	57
Total	411
FedEx Feeder Contracted Fleet	
ATR 42-300F	19
ATR 72-200F	20
ATR 72-600F	4
Cessna 208B Super Cargomaster	235
Cessna 408 SkyCourier	–
Total	278
Grand Total	689

1,600 miles

550 miles

147 miles Stage Length

Amazon Air fleet Aircraft			
Aircraft	In Service		Operator
ATR 72-200AF	3	3	Silver Airways
Boeing 737-800(BCF)	26	8	Atlas Air
		12	Sun Country Airlines
		6	ASL Airlines Ireland
Boeing 767-200	12	6	Air Transport International
		6	ABX Air
Boeing 767-300ER(BDSF/BCF)	54	33	Air Transport International
		19	Atlas Air
		2	Cargojet Airways
Total	95	8	

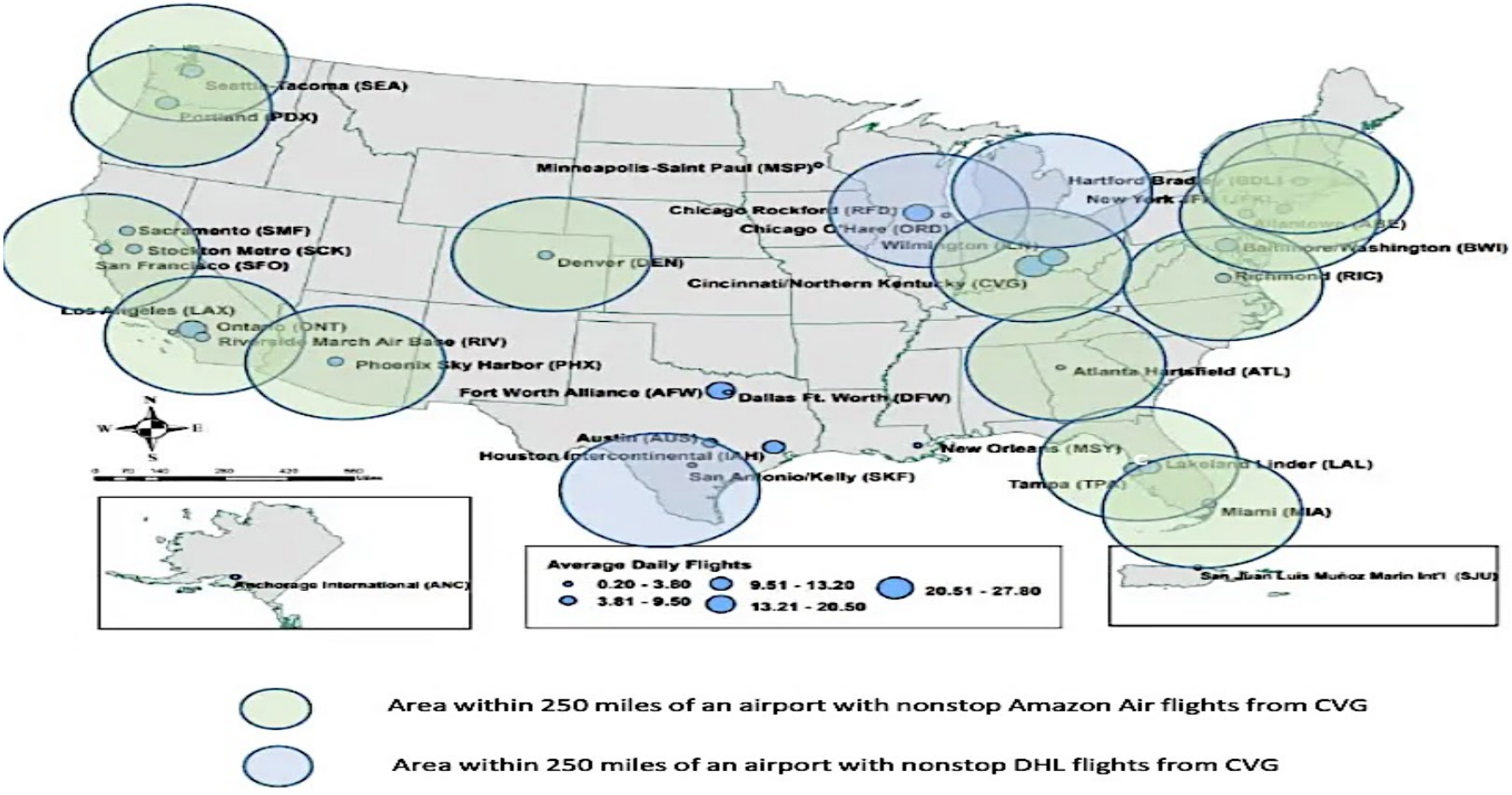


Example of a Cargo Logistics Operation Based on an Operating Feeder and Delivery Range of 250 miles by Truck or e-STOL Vehicles.

(FedEx, DHL, Amazon, ---)

FIGURE 5: Points within 250 miles of an airport with nonstop Amazon Air service from CVG and Wilmington, OH

Amazon Air destinations in green; additional DHL destinations in blue



Amazon Air's flight network at CVG and nearby Wilmington, Ohio already allows for the rapid shipment of inventory and packages to points within a four- or five-hour truck drive of the vast majority of the U.S. population, with additional routes operated by DHL. Some of the notable gaps will likely be filled during Amazon's anticipated CVG expansion later this year. UPS's Worldport in Louisville, KY is just 90 minutes away by truck.

FedEx Feeder Aircraft Modernization Experience

In **1984,** Federal Express Corporation ordered a Specially Equipped, Windowless Version, the **208A Cargomaster** to expand its overnight small-package pickup and 10:30 a.m. Delivery Service Commitment to the Medium, Smaller Cities and Communities.

SkyCourier, FAA Certified 14 March 2022 2022.

Shipping/Deliver location	to	Regional Sorting Center
Regional Sorting center	to	Hub Sorting Center
Hub/Regional Sorting Center	to	Delivery Location
Delivery Center	to	Customer (Last Mile van/truck)

Energy and **Power**

Difference Propulsion Systems Performance
for a Common CONOPS.

- **Energy usage** can be characterized by Gallons or Pounds of Fuel or the “Energy Content” of the fuel.
- **Power** is the rate at which energy is delivered, the rate of doing work. Power cannot be stored.
- **Power** is an **Instantaneous Quantity** characterizing the **Demand for Energy**.
- **Available Energy** is the stored resource (watt-hours or kilowatt-hours) that accumulates or declines predictably with usage.
- Different **Phases of Flight for CTOL, STOL or VTOL** have different instantaneous demand for energy, Power, per unit of time, occurs.
- The rate at which energy is delivered determines the “Power” capability of a battery system. For a Fixed Energy Density, different performance results for **CTOL, STOL or VTOL** designs.

Fuel and Time Required for Flight Segments

Fuel Capacity (Energy) In Gallons for all Tanks	335 Gallons (2,291 lbs - 5,816 KW)													
Gallons Per Hour (GPH) Consumption Rate	62 GPH													
Point-to-Point Distance	112 mile Cruse			145 Miles Cruse			200 miles Cruse				Average	152 miles		
Trip Time Needed In Hours	0.66	Hours	0.66	0.853	Hours	0.853	1.176	Hours	1.176		Average Hrs.	0.90		
IFR Safety Margin Time Needed In Hours	0	Hours	1	0	Hours	1	0	Hours	1		169 MPH			
Mission Leg Fuel Required, gallons	40.92	Gallons	103	53	Gallons	115	73	Gallons	115					
Quantity Of Fuel (Jet A) Weigh Consumed	280	lbs	704	362	lbs	786	499	lbs	922.8					
Total Capacity Fuel (Jet A) Weight	2,291	lbs	2291	2,291	lbs	2,291	2,291	lbs	2,291					
Estimated Fuel Required for One Fight														
Engine start, Taxi, and Takeoff	35	lbs		35	lbs		37	lbs						
Climb	60	lbs		60	lbs		60	lbs						
Cruse	280	lbs		362	lbs		499	lbs						
	65	lbs		65	lbs		65	lbs						
Landing, Taxi, and Engine shutdown	30	lbs		30	lbs		30	lbs						
Reserve	424	lbs		424	lbs		424	lbs						
Total mission Fuel Potential "Top-off"	894	lbs		976	lbs		1,115	lbs						
Fraction of Fuel Capacity Utilized	0.39			0.43			0.49							
Hours per Operational Day														
	Ground Time per flight													
Taxi out and waiting	15	minutes												
Taxi in and docking	5	minutes												
Unloading and reloading cargo	90	minutes												
Total	110	minutes												
Ground time plus cruse														
Total Mission (one leg)	150	minutes		161	minutes		181	minutes						
1 Round trip	300	minutes		322	minutes		362	minutes						
2 Round trips	500-600 minutes		8 to 10 hours	644 minutes	10 to 11 hours		724	12 hours			Average Operating Hrs. per Day	10.3 Hrs.	Average Hours per Operational Yr (310 days)	3,193
Circuit FOB depart, 112m, 145m, 200m, 112m, FOB ------ Average leg 142 miles											Average route	142 miles		
Time (minutes) each Leg in Sequence	150 minutes from FOB			161 minutes			181 minutes							
	150 minutes return to FOB													
Total Circuit Time	642 minutes (11 hours)										Average Operating Hrs. per Day	11 Hrs.	Average Hours per Yr. (310 days)	3,410

Cessna Caravan widely-used **Middle-mile Aircraft.**

Typical **C(208B)** Operational Routs.

Data derived from **Pilot Operating Handbook**, POH.

The **145-mile Range** is the **Fleet Average Utility Cargo usage Segment legs**.

Fuel "**Topped=off**" at Forward Airport and **refueled** at **FOB hub**, (**Fixed Operating Base**).

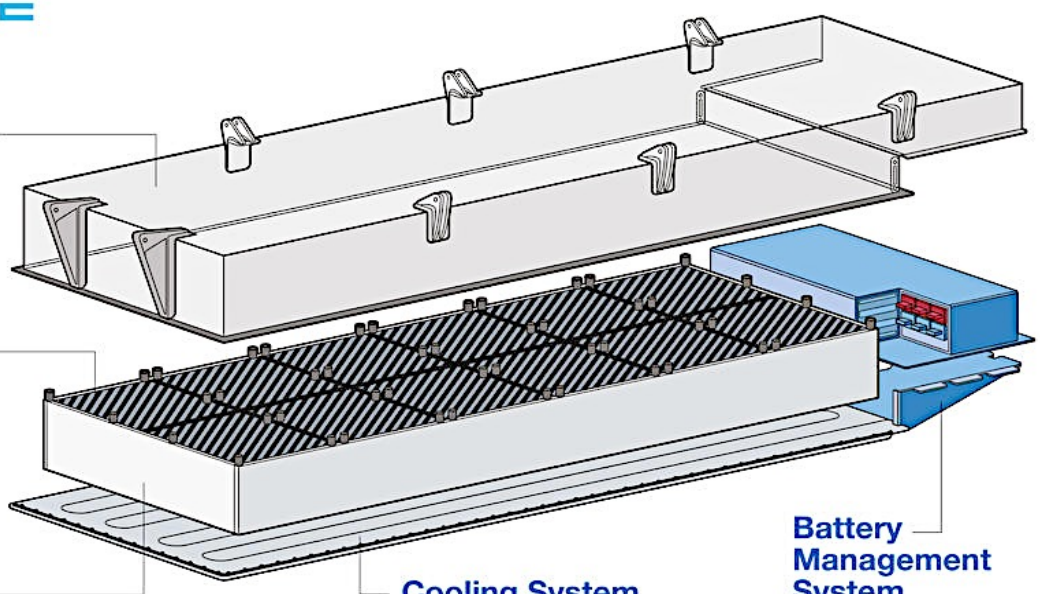
https://caravannation.com/208BG1000POH.pdf

Battery Packs consist of individual battery **Cells and Modules. Modules** built-up from **Cells**. **Battle Pack** is then assembled by **Connecting Modules Together.** Combined Series or Parallel interconnections Optimize **Voltage** and **Power.** An **Active Cooling System** ensures the **Optimum Temperature** for **Normal Operation**. A *tailored* **Battery Management System** monitors **Charge Status** for **Rebalancing**, **NO-GO Flight Planning** and other **Maintenance or Safety Conditions**.

EcoPulse™ High Voltage Battery

Developed to supply the distributed electric propulsion system, compatible with aeronautical requirements.

ECO PULSE
DAHER - SAFRAN - AIRBUS



Structural Casing
To house and protect the battery module, and enable integration on the aircraft

Cells
Lithium-ion cells selected to deliver the best energy/power ratio

Module
Interconnected cells enabled by a wire bonding process

Cooling System
To ensure an optimal temperature for operations

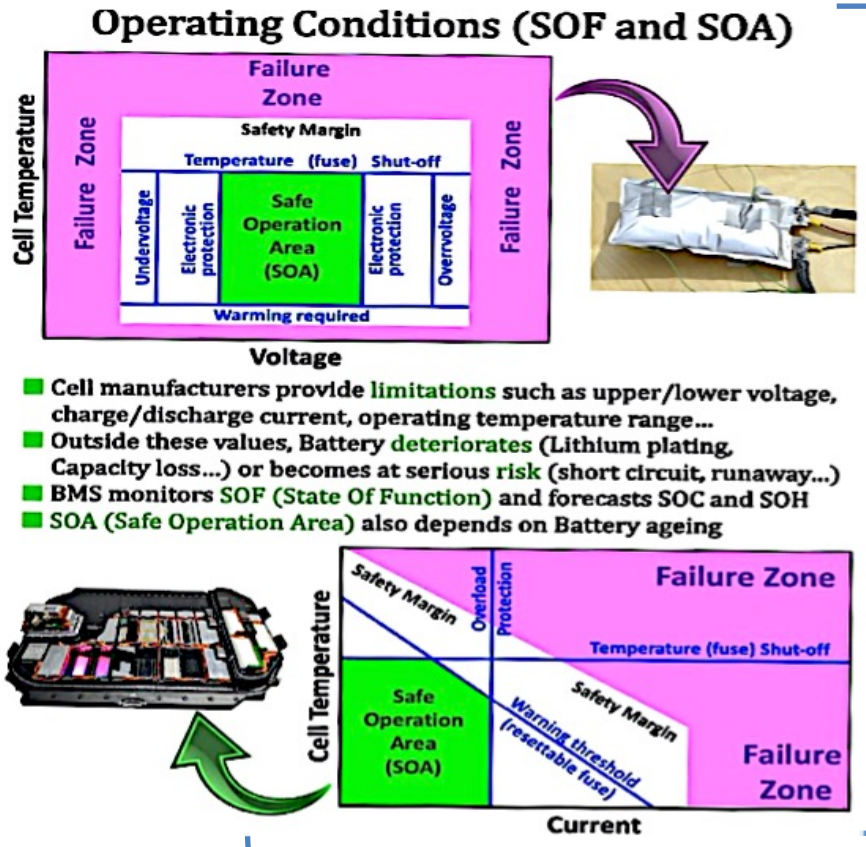
Battery Management System
To monitor, protect and optimise battery usage

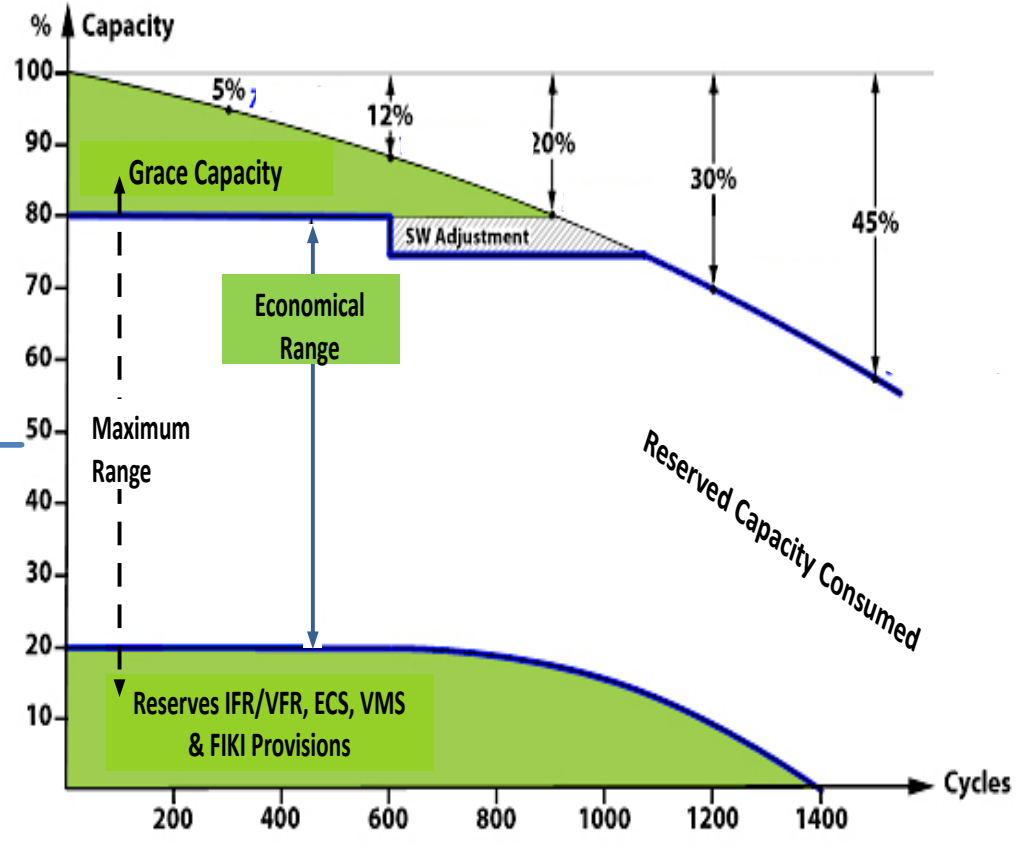
Battery Characteristics

- Li-ion (lithium-ion) technology
- 800 Vdc
- 350 kg
- 350 kW
- 750 mm x 2300 mm x 200 mm
- REACH compliant

AIRBUS

Technical and Regulatory Inputs
into
Management Of On-board Battery Energy Systems.





Battery Management System (BMS) -- Safety, Function
Flight Operations (incl. No-Go Conditions) and Durability (Life)

Cessna 208B Grand Caravan
Recessed Gravity Feed about 40 to 50 GPM

Most aircraft arrive with reserve fuel remaining in the aircraft from their previous flight

(Typically, around 15% of its capacity - Topping-off for NEXT MISSION LEG.)

Simulation approach, Convert lbs. of Fuel into Equivariant Kw Energy to Estimate E-propulsion Turn-time.

Battery Charger Technology

The Ground Time Available for **"Topping-off" Battery Energy** is **Driven** by **Operational Needs,** the specific **Battery Pack Chemistry** and **Capacity,** and **Available Charging Power**. Charging Time Estimate;

$$Charging\ time\ = \frac{Battery\ Capacity}{(Charger\ Power)x\mathbf{0.9}}$$

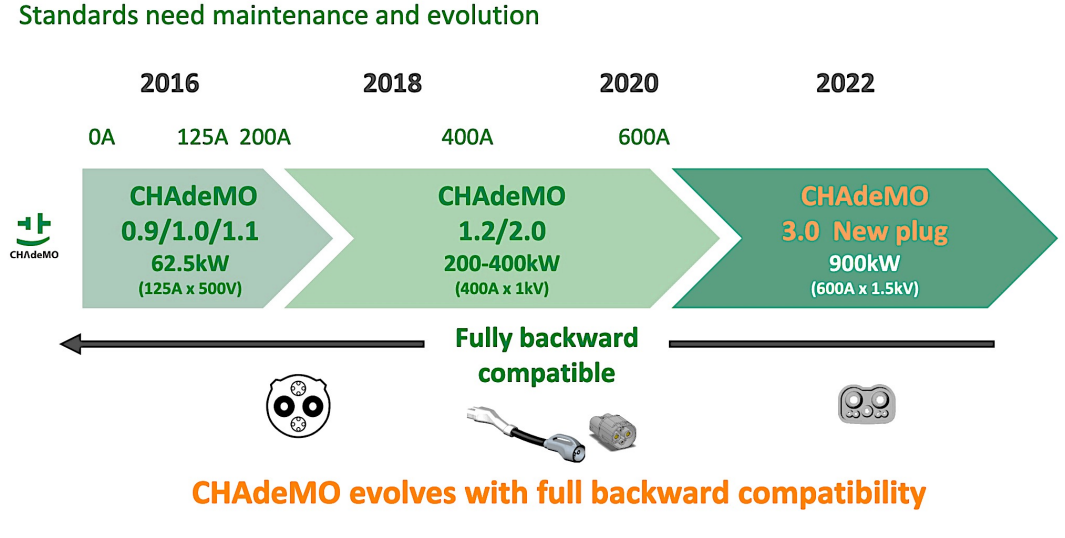
Turn-time needs from **System CONOPS** suggests the desirable **Charger Power**;

$$(Charger\ Power)\ = \frac{Recharg\ Capacity}{(Charging\ time)x0.9} \cong \frac{2{,}478\ kw}{(Charging\ time)x0.9}$$

The **0.9 factor** Accommodates Energy Dissipation. Resistance Increases with Cyclic Usage. One Mission Leg; **145 miles, 976 lbs. fuel is 2,478 Kw** to "top-off" the battery **State of Charge** available leaving the FOB. The simulation used the **Emerging DC Fast Chargers (DCFCs)** technology.

1.5 hr. Turn-time Goal not available, 2 hrs. for "top-off," with "Slower Night" Charging is Practical.

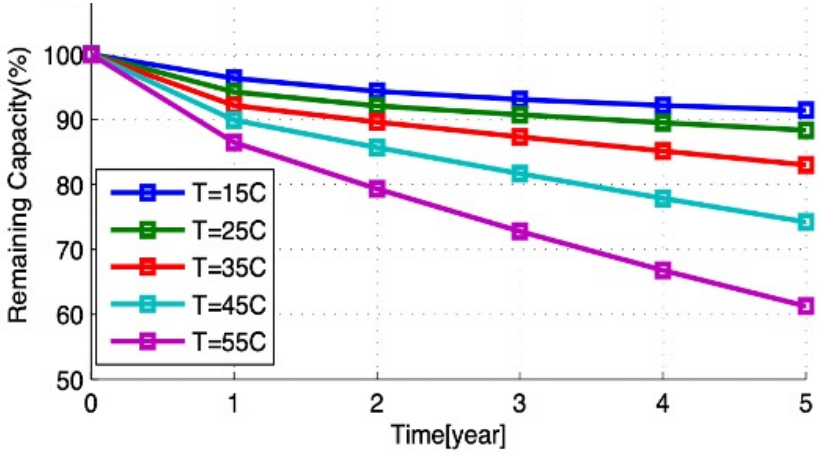
Battery Chemistry and Charger must be Compatible and Managed by the **Battery Management System, BMS**.



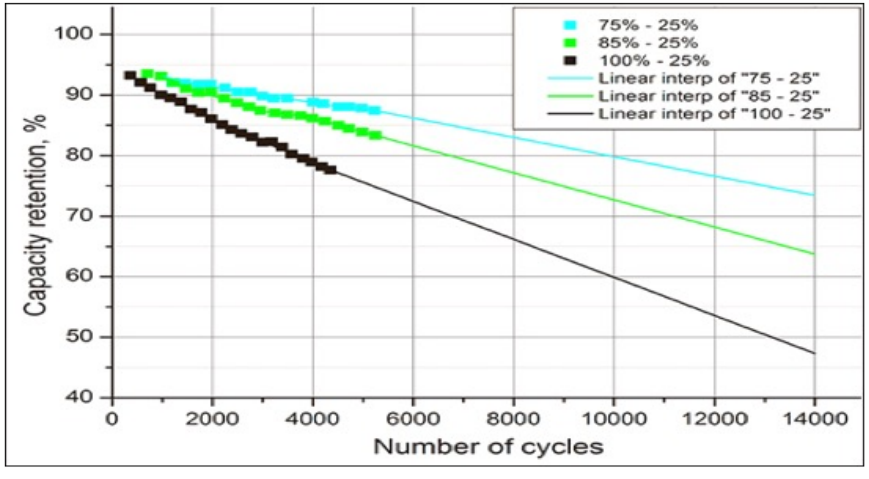
Eviation, a Cargo Express Service Provider **DHL Express**, which ordered 12 fully electric **Alice eCargo** planes, and **Piëch-Desten** have **Baselined 900-kW Ultra-fast Chargers**.

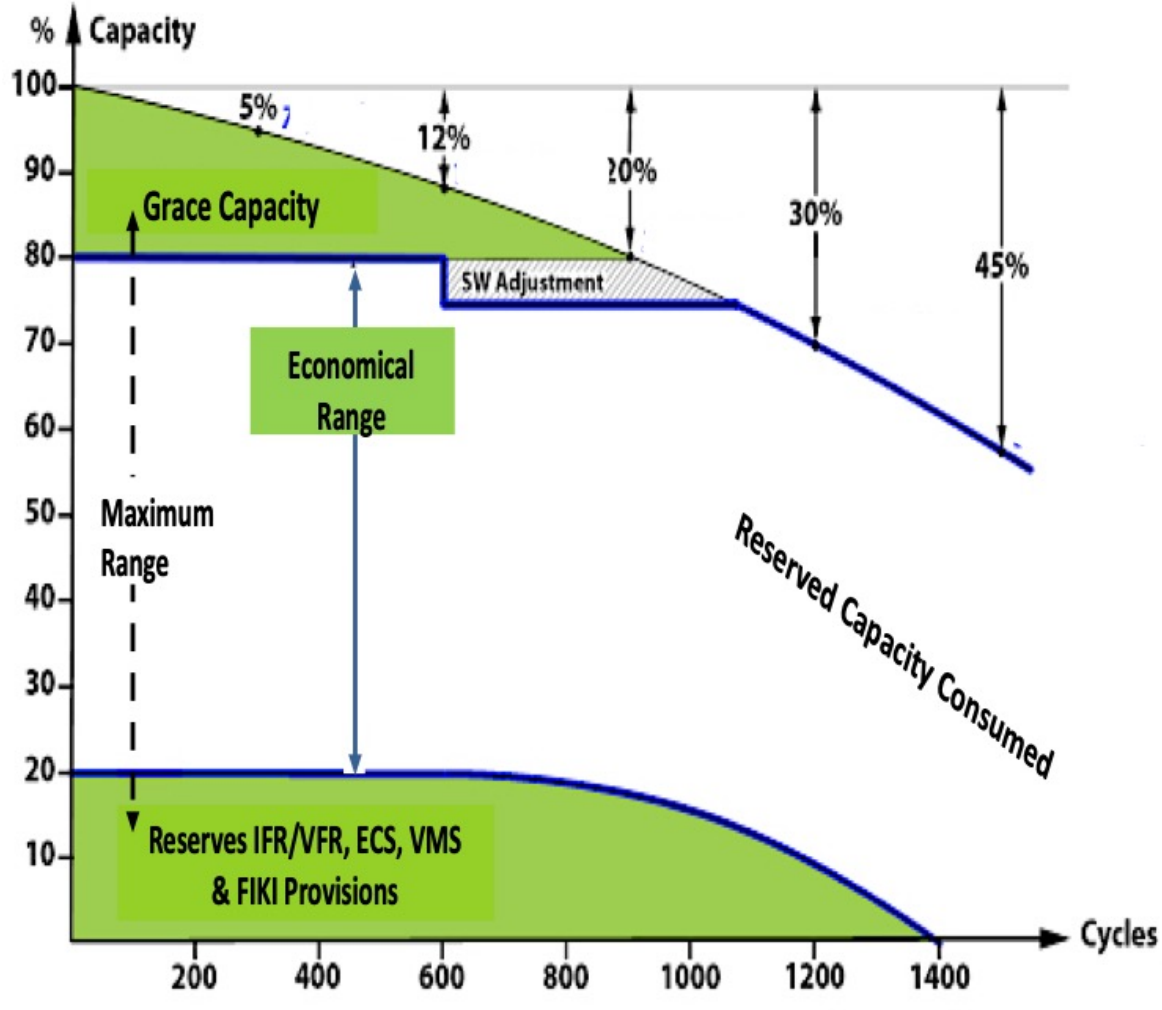
Calendar and **Cyclic Aging** Results in a **Steadily Decreasing Battery Capacity** due to **Time-at-Temperature** and **Number and Magnitude of Operational Cycles.**

When a Battery Pack Capacity has Fallen to 80%, it will be Scheduled for Replacement.



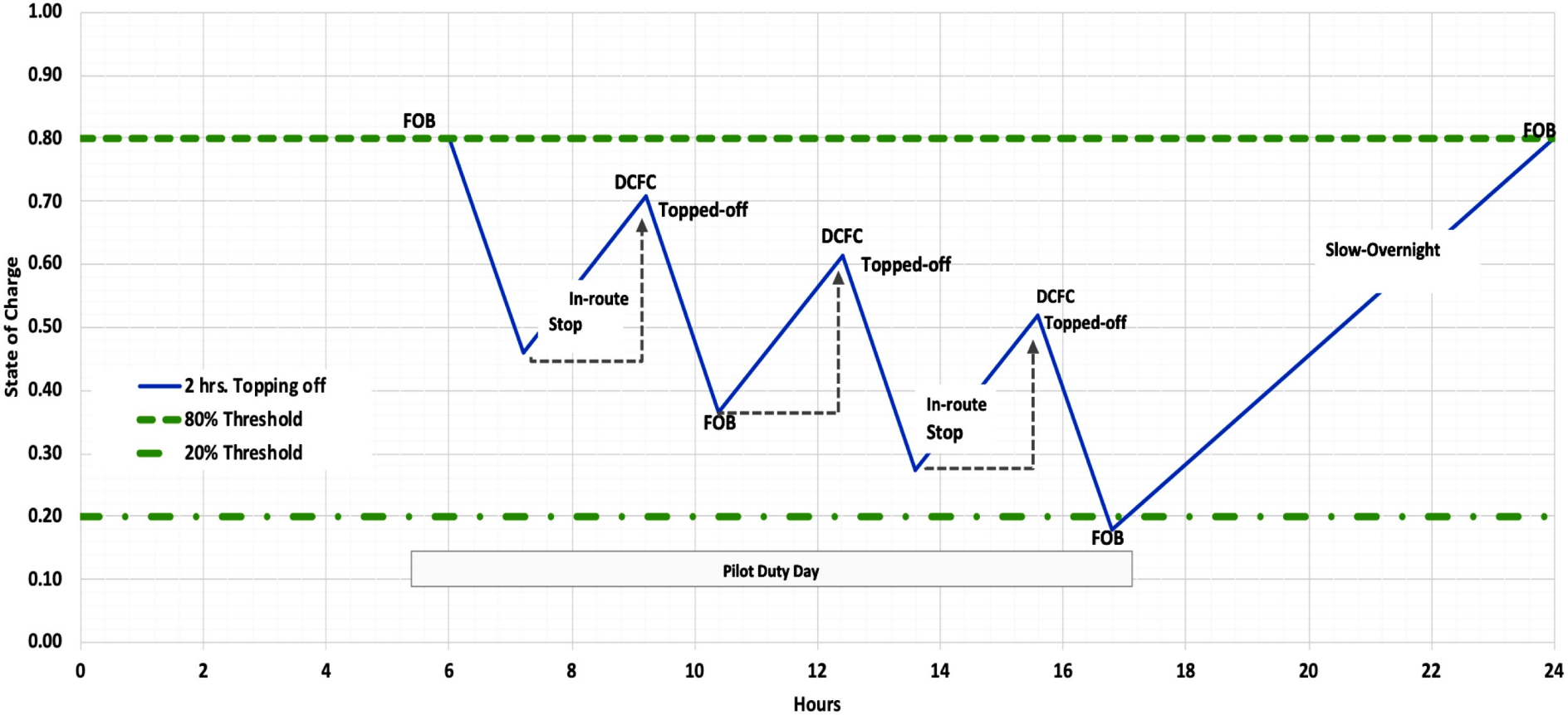
(a) Calendar aging with varying temperature at 50% SoC.



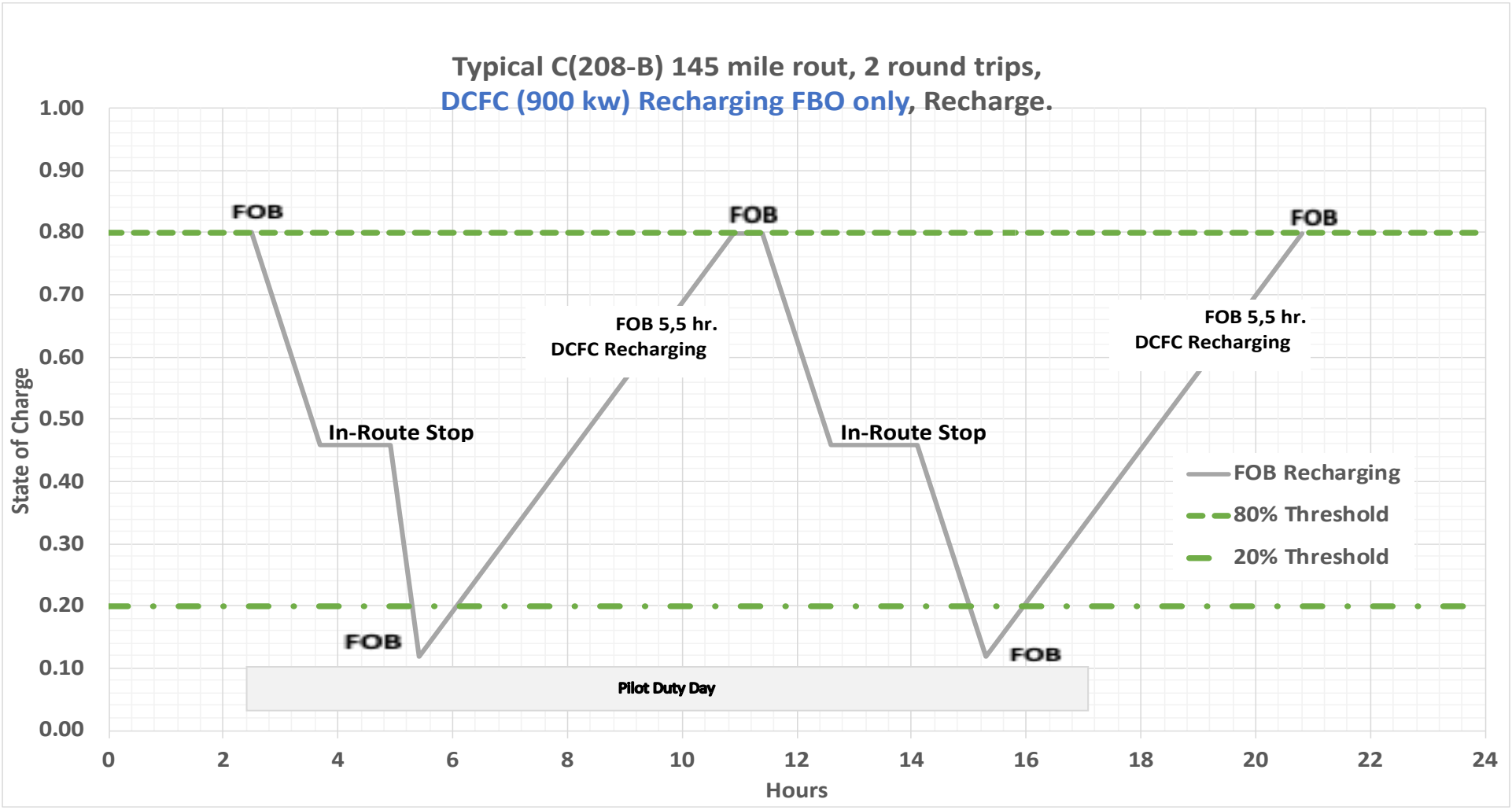


B. Xu, A. Oudalov, A. Ulbig, G. Andersson and D. S. Kirschen, "Modeling of Lithium-Ion Battery Degradation for Cell Life Assessment," in *IEEE Transactions on Smart Grid*, vol. 9, no. 2, pp. 1131-1140, March 2018, doi: 10.1109/TSG.2016.2578950.

Typical C(208-B) 145 mile rout, 2 Round Trips, DC Fast Charge, DCFC (900 kw) Topping-Off In-Rout, with Slow-Overnighht Recharge.



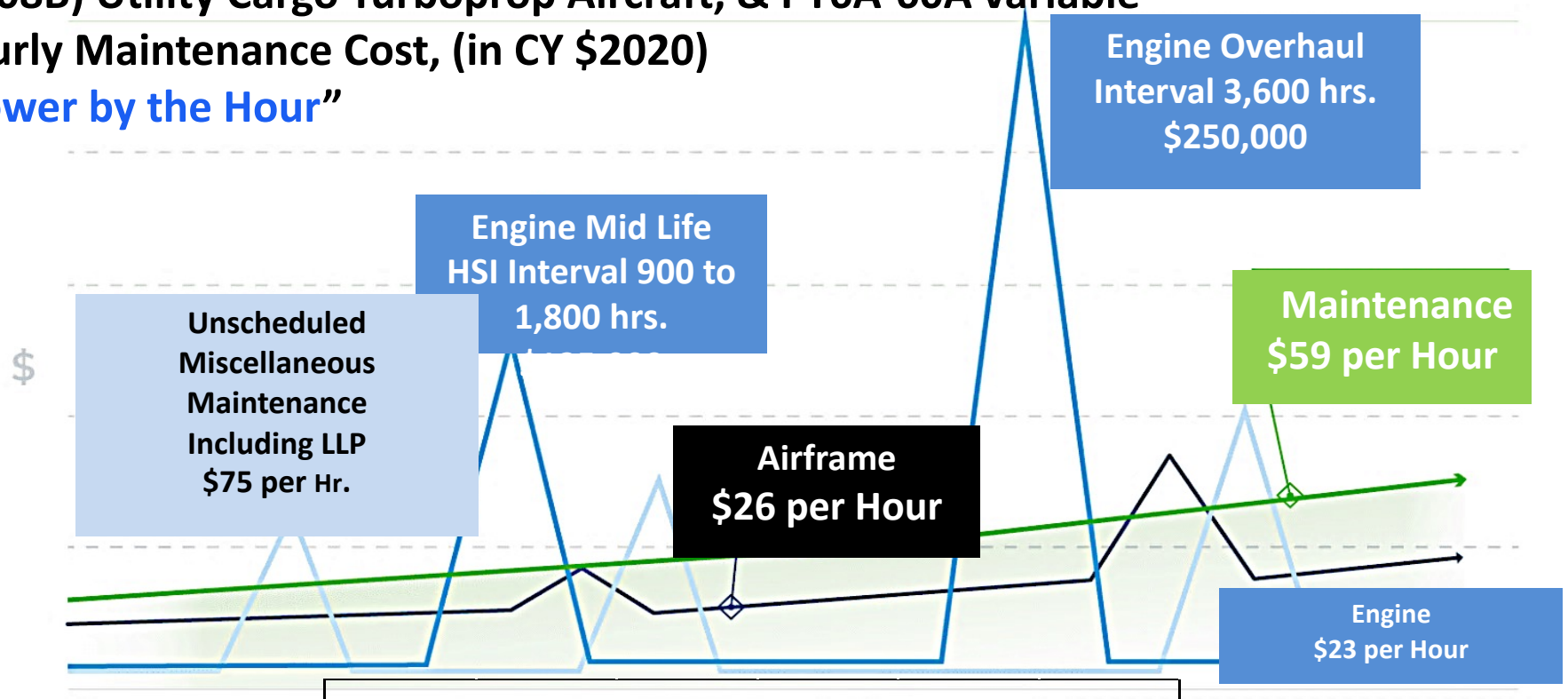
Average Cycle	Occurance per Day	Cycles per 310 days per year	Average "cycle life"	Specific cycle Life fraction Consumed per year	Consumed Life Fraction per Year	Calander Aiging Capacity Retention	Expacted Life Capacity (Years) for this Specific Usage	Propulsion Operating hrs. per Day	Hours to Battery Replace for specific usage
29%	3 cycles	930	10,000	0.093	0.116	0.9	7.7	2.36	5,670
62%	0.5 - 1 cycle per day	155	6,700	0.023			Years		Hours



Average Cycle	Occurance per Day	Cycles Per 310 Days per Year	Average "cycle life"	Specific cycle Life Fraction Consumed per year	Calander Aging Capacity Reduction	Expected Life Capacity (Years) for this Specific Usage	Propulsion Operating hrs. per Day	Hours to Battery Replace for specific usage
0.68	2	620	3,600	0.172	0.9	5.2 Years	2.36	3,823 Hours

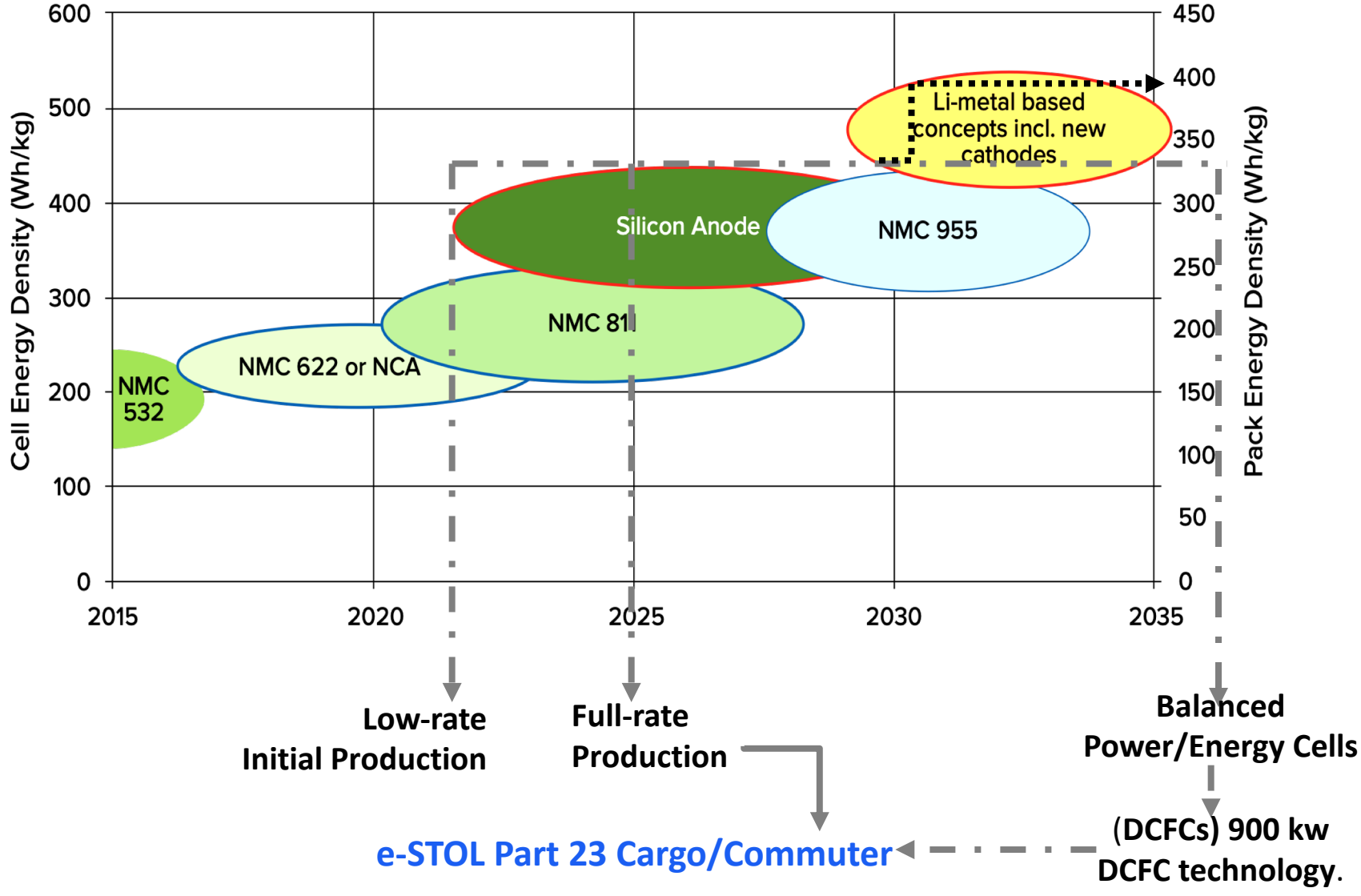
C(208B) Utility Cargo Turboprop Aircraft, & PT6A-60A variable Hourly Maintenance Cost, (in CY $2020)

"Power by the Hour"



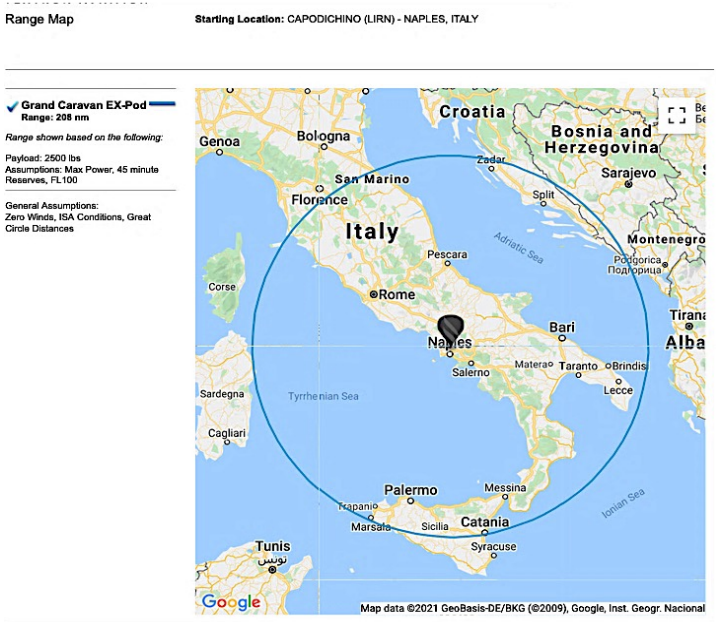
Time Between Battery Pack Replacement Comparison with TBO		
	Years	Hours
Topping-off Inrout	7.7	5,670
Recharge FBO Only	5.2	3,823

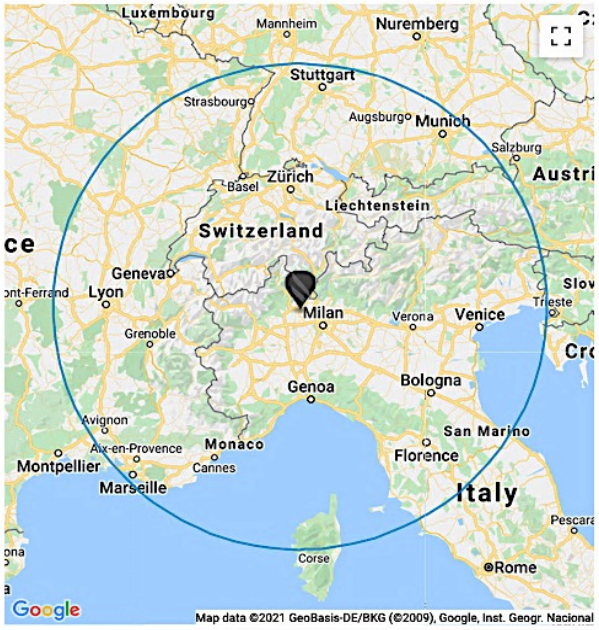
Projected Improvement in Specific Energy at the Cell and Pack Level (Originally Developed by DOE-VTO).



208 nm (239 miles), *Middle-mile Delivery*
Similar Range used by Amazon, FedEx, DHL & Others
for
Logistics Feeder System.

2,200 Lbs. Payload-Range
MTOW ≅ MLW





Compatible with 300 -350 Wh/Kg Battery Pack Energy Densities

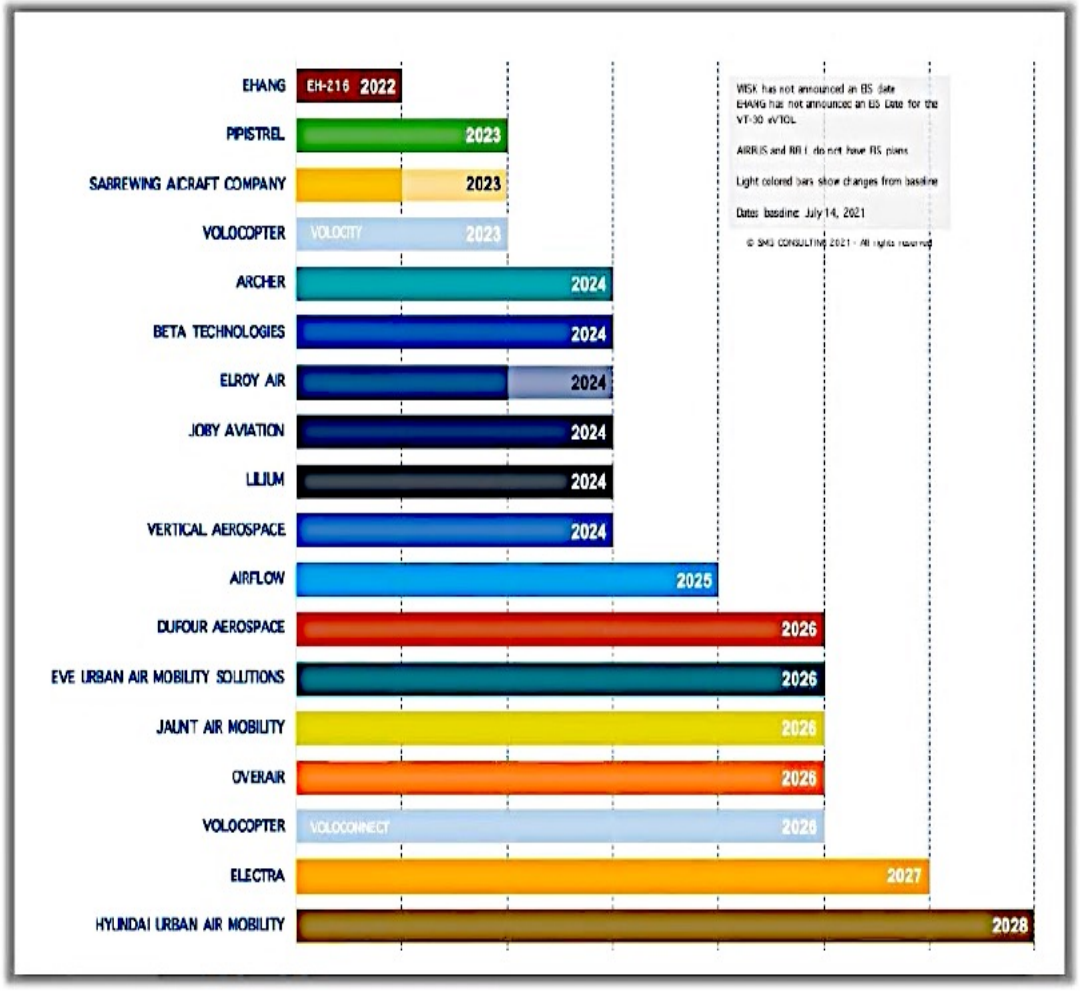
Weight/Mass Reductions Accommodating Battery Weights:

- Fuel and fuel subsystem's weights
- Elimination of turbine engine for turboprops,
- Seats as appropriate
- Subsystems converted from legacy mechanical/hydraulic into a "More Electric" configuration.
- Retain MTOW & MLW

Entry Into Service Projections -- Dependent upon Funding

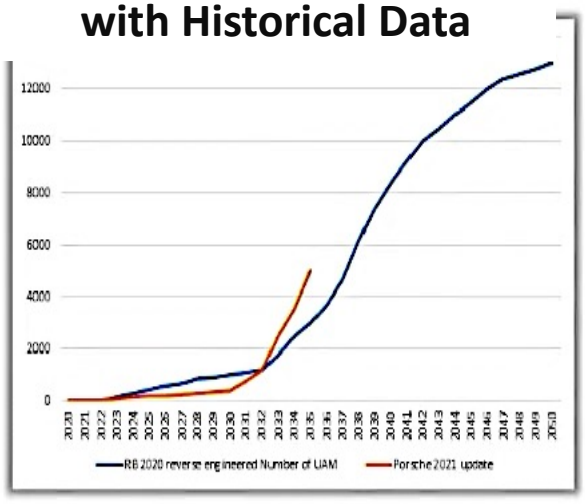
8,987 Provisional Orders, **486 (~5%) are Firm Orders**.

Remainder are **Letters of Intent, LOI's or MOU's**



Fleet Projections

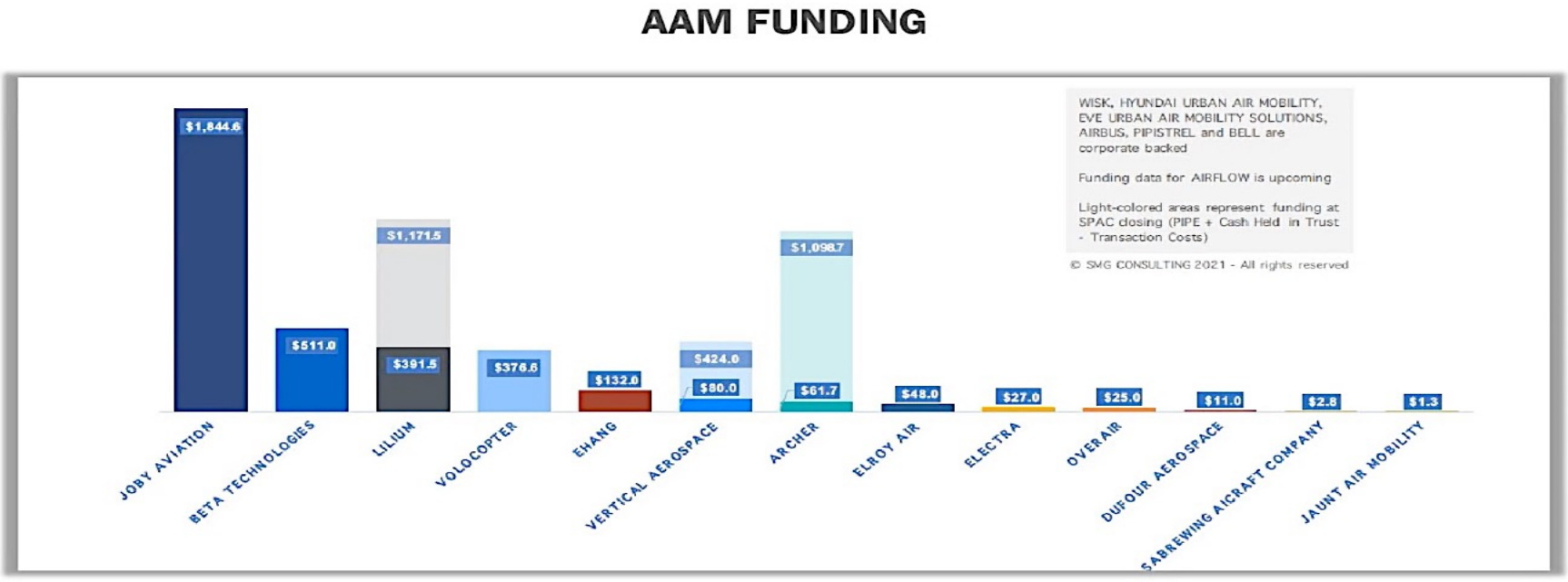
Projections Inconsistent with Historical Data



SOURCE: SMG CONSULTING/AVIATION WEEK NETWORK

AVIATION WEEK NETWORK

Funding Status
Mix of Urban and SubRegional e-Vehicle Orders & Business Concepts
(OEM Development Focus versus Combined OEM, Facilities and Operator Roles)
Current OEM Expectation $400 -$500M (2021 US$)
to reach Type Certification for EIS? (Conforming Prototype?)



Richard Aboulafia: **Wisk Funding,** a couple of Boeing people have said, "Well, it's Not $450 Million in a Lump Sum, a Small Deposit -- with a Commitment to More In the Future" - a Forward Bet in the Technology.

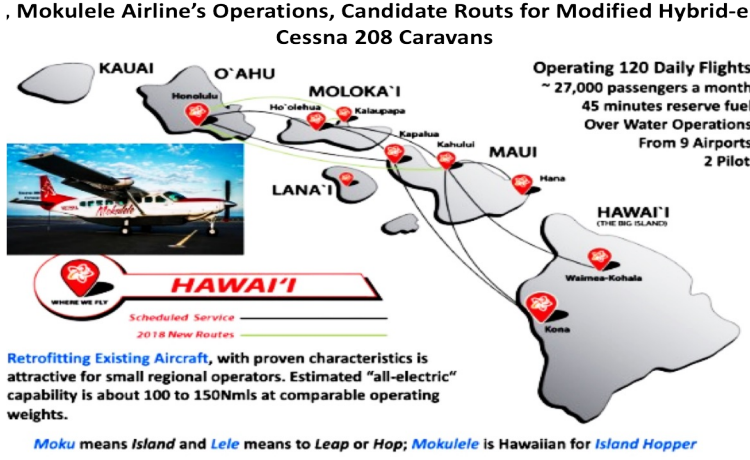
Vertical Aerospace has **CONDITIONAL PRE-ORDER options totaling**
1,350 VX4 eVTOL aircraft, Leonardo Grottaglie Airframe Subsystem
Subsystem partners work on conditional basis.

Operational Utility Evaluation Testing; Typical in LOI/MOU Requirements

Operational Test and Evaluation is conducted on **Production**, or **Production Representative Articles**, to determine whether, **Battery Packs, Chargers, BMS, Vehicle-Propulsion Integration and Infrastructure Systems** are **Operationally Effective** and **Suitable** for **Launch Customer(s)** to **Support** their **Decision** to **Buy a**nd **Operate** the **Airplane**.

Examples:

- **Ampaire modified Cessna 337 & 208EX Caravans**



Commuter Circuit – 2 to 3 stops.

Mokulele Airlines Hawaii November & December 2019; 22 sorties over 17 flying days for a total time in the air of 23.6 hours. **Point-to-Point 28-mi**. route between Kahului and isolated Hana, Maui over land in visual conditions under an **FAA 'Market Survey' Experimental Aircraft Certificate.**

*-- Operational flights between **Scottish mainland and Orkney Islands**, Over Water, Point-to-point and **Typical***

- **Heart Aerospace, new ES-19 Regional Airliner**; Sweden and Norway, **Cold Weather Testing-** Cold Climate Impacts Batteries with Potential Range Limitations**.**

Understand what infrastructure is Required for the Airports because you Can't Expand Faster than the Available Infrastructure that Supports these Planes.

E-STOL Commuter (Air Taxi-Buss) "Island Hopper" Business Example

Typical Day's Operation/Operation Perspective

7 – 30 minute Turn-Times -- UAM Air Taxi Concepts?

~ 21 mission cycle legs/day

Amphibious Light-sport Aircraft Option?

Compatible with Hybrid or e-Propulsion?

Loganair
Scotland's Airline

		Monday						
Notes								
Flight Number	LM	700	702	703	704	705	706	707
KIRKWALL	**dep**	**07:35**	**08:40**	**09:40**	**10:50**	**15:30**	**16:30**	**17:30**
Eday	arr							
	dep							
Stronsay	arr			09:49				
	dep			09:56				
Sanday	arr			10:01			16:43	
	dep			10:08			16:50	
Westray	arr		08:55					
	dep		09:02					
Papa Westray	arr		09:04			15:45		
	dep		09:11			15:52		
Westray	arr					15:54		
	dep					16:01		
North Ronaldsay	arr	07:52			11:07			17:47
	dep	07:59			11:14			17:54
Papa Westray	arr				11:24			
	dep				11:31			
Eday	arr	08:09						
	dep	08:16						
Stronsay	arr						16:55	
	dep						17:02	
KIRKWALL	**arr**	**08:26**	**09:26**	**10:21**	**11:46**	**16:16**	**17:11**	**18:11**

2 Britten-Norman Islander, 8 PAX
1 Each DHC-6-310 & -400, 19 PAX
Others

Morning Circuit
07.00 to 11.8 = 4.8 hrs.
249 mils/400 km

Rest Break/Topping-off
11.8 – 15.50 hrs.
(Pilot Rotation?)
3.8 hrs.

Afternoon Circuit
15.50 to 18.50 = 3 hrs.
171 miles/275 km

Overnight Recharge
~6 hrs.

Operating Day
~12 hrs.

Pilots
1 Pilot In Command (PIC)
1 Standby?

Textron to Acquire Pipistrel:

Pipistrel Velis Electro Technology

Energy Capacity: 24.8 kWh in two liquid-cooled Pipistrel batteries.

Batteries: take ***1 hour to recharge from 30% to 100% capacity*** allowing an endurance of up to 50 minutes plus 10 minutes of VFR reserves when flying in proximity of the aerodrome.

Battery Management System (BMS): built-in continuous Health-monitoring System displaying the estimated 'age' of the battery.

Take-off Limitation: (**Not Allowed**) when **State of Charge** (**SoC**) is **below 50%.**

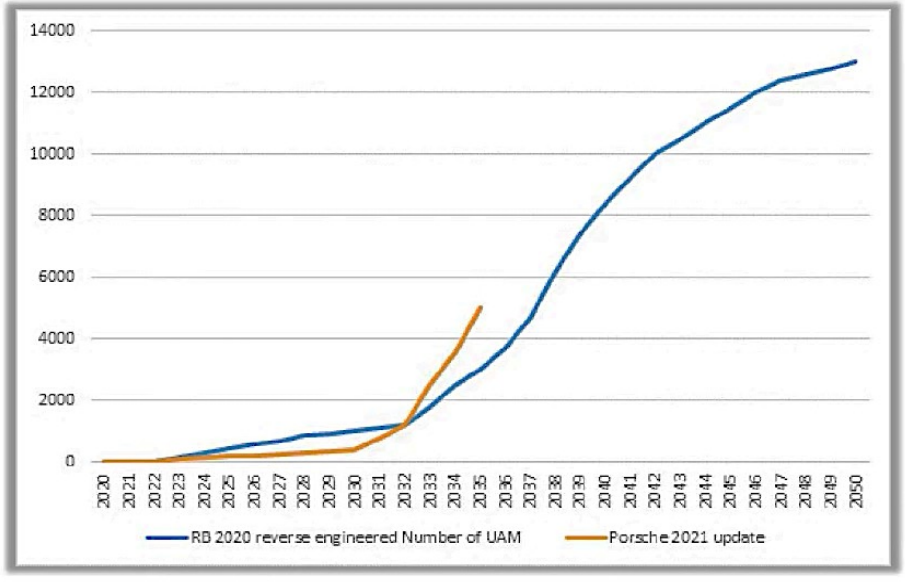
SKYCHARGE: Green Motion and Pipistrel DC charging technology - fixed stand or with wheels for mobility. CCS or CHAdeMO technology and plug?)

New Technologies Create New and Expands Established Markets.

Marketing Projections are Complex
due to the Interaction
Between the Different Modes of Transportation & Associated Infrastructure.

Current Projections are for a Slow, Steady, Initiation Phase
(~ 500+ Deliveries next 10 years),
Followed by Accelerating Deliveries
Typical Historical Experience.

REAL FLEET NUMBERS



Source: Aviation Week

AVIATION WEEK NETWORK

nation Classification: General

1965-2021 4,965 C(208), BN-2, and DHC Twin otters STOL Utility A/C Delivers

In Conclusion

- **Change is in the Air**
  - **E-commerce Expansion**
  - Restructuring of the Just-in-Time Supply Chain from a **Global to a Regional Focus**
  - **Escalating Fuel Prices**
  - **Government** (**Improved Energy Independence**) **Mandate.**
- **Passenger-to-Freighter (PTF) Conversions Accelerating.**
- **Short Range 200-250 subregional Mile mile Air Feeder Cargo Transportation**
  - **eVTOL** Last-mile Package moving Shipments between Sortation Locations.

    FedEx to Test Autonomous eVTOL Drone Cargo Delivery with Elroy Air
  - **eSTOL (Middle-mile Feeder Cargo Air Logistics)**
    - **2030 Feasible (Technology & Mature Business Operational Structure)**
    - **Demonstrated Operational (Profitable) Utility** for **Part 135 Operating Airlines**

    Textron e-Aviation
  - Amphibious Light-sport Aircraft (Water Air Taxi?)

New/Modified Aeronautical Ecosystem will **Evolve** by **2030**

How will Italy Respond to this Change?

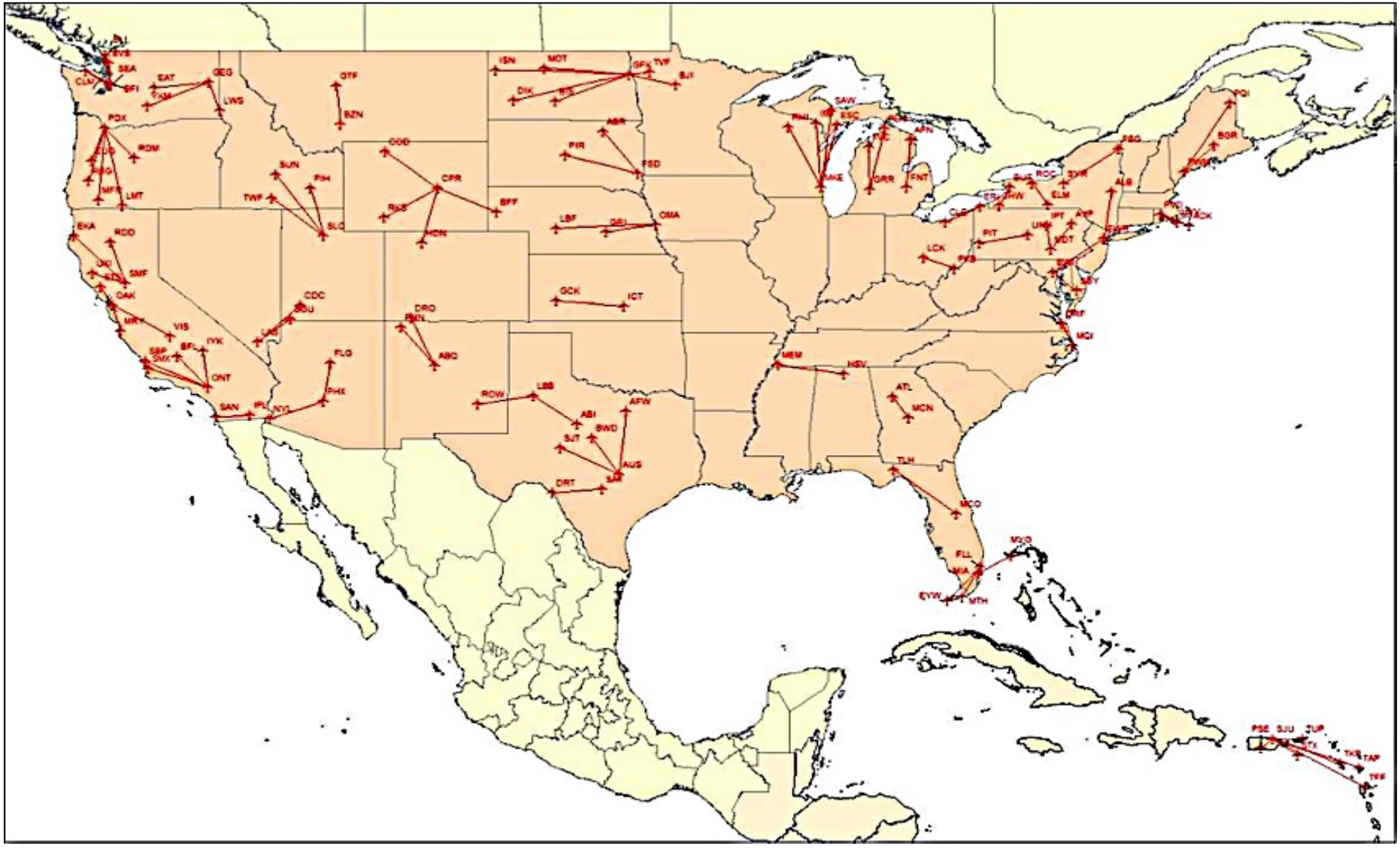
Ho Finito

Forza Ukraine

Briefing Available; **jchalpin.blogspot.com**

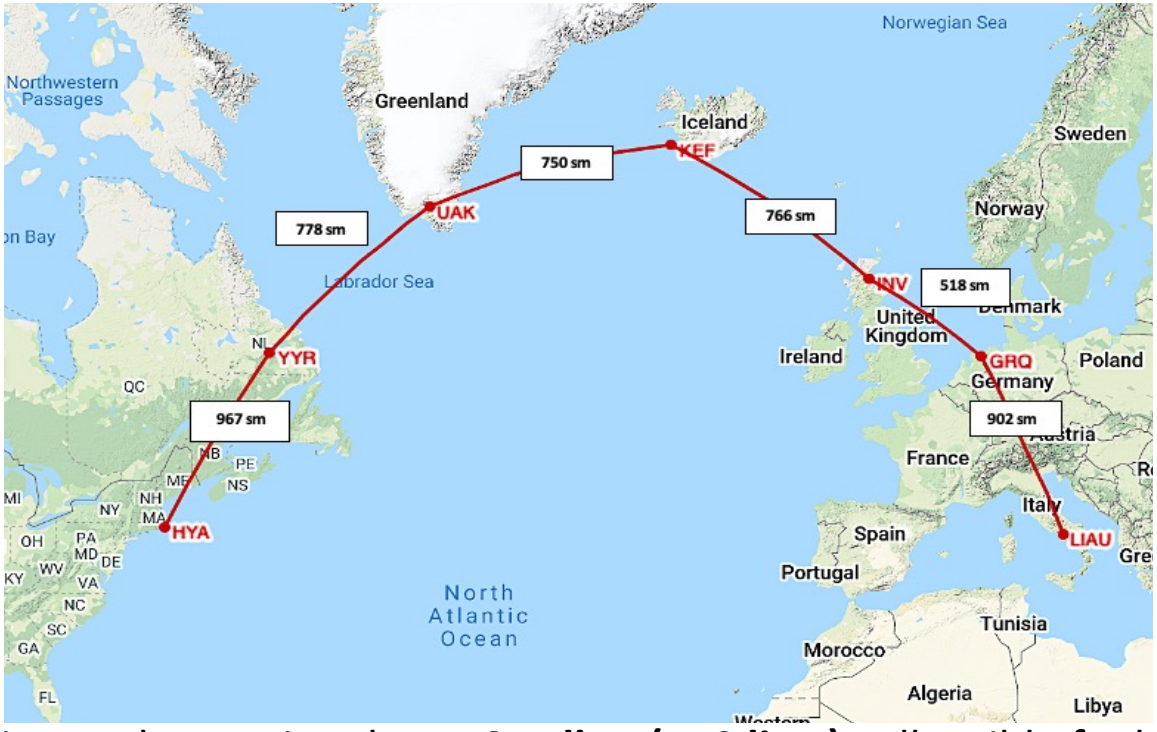
FedEx Cessna 208B Regional Service Routs in US

(Example of Point-to-Point and Multiple Stop Circuit Operations)



“Range Extension -- Topping-off/Refueling”

Tecnam flew the first two P2012 Travellers on a five-stop, 4,641 sm, Three-day Trek from Capua Italy to Cape Cod, MAS. (Image by Great Circle Mapper)



- **200-gallon** wing-tank capacity plus **119 gallon (450 liter)** collapsible fuel tanks in the rear of the passenger cabin
  - Flight **In-weather** 8,000 to 12,000 feet (Laps rate)
- **Typical usage;**
  - **Norway's Wideroe**. operates an extensive network of regional flights with 75% of its routes being shorter than 275 km. (171 miles)
  - **Cape Air’s** average usage about 3.7 hours - six cycles per day.

Loganair
Scotland's Airline

Orkney Inter-Isles Air Service
Summer 2022 Timetable

20 February 2022 to 29 October 2022

Monday

Notes								
Flight Number	LM	700	702	703	704	705	706	707
KIRKWALL	**dep**	**07:35**	**08:40**	**09:40**	**10:50**	**15:30**	**16:30**	**17:30**
Eday	arr							
	dep							
Stronsay	arr			09:49				
	dep			09:56				
Sanday	arr			10:01			16:43	
	dep			10:08			16:50	
Westray	arr		08:55					
	dep		09:02					
Papa Westray	arr		09:04			15:45		
	dep		09:11			15:52		
Westray	arr					15:54		
	dep					16:01		
North Ronaldsay	arr	07:52			11:07			17:47
	dep	07:59			11:14			17:54
Papa Westray	arr				11:24			
	dep				11:31			
Eday	arr	08:09						
	dep	08:16						
Stronsay	arr						16:55	
	dep						17:02	
KIRKWALL	**arr**	**08:26**	**09:26**	**10:21**	**11:46**	**16:16**	**17:11**	**18:11**

Tuesday

Flight Number	LM	701	708	709	719	710	711	707
KIRKWALL	**dep**	**07:35**	**08:30**	**09:30**	**10:30**	**15:30**	**16:30**	**17:30**
Eday	arr							
	dep							
Stronsay	arr		08:39					
	dep		08:46					
Sanday	arr		08:51			15:43		
	dep		08:58			15:50		
Westray	arr			09:45				
	dep			09:52				
Papa Westray	arr			09:54	10:45		16:45	
	dep			10:01	10:52		16:52	
Westray	arr						16:54	
	dep						17:01	
North Ronaldsay	arr	07:52			11:02			17:47
	dep	07:59			11:09			17:54
Papa Westray	arr							
	dep							
Eday	arr							
	dep							
Stronsay	arr					15:55		
	dep					16:02		
KIRKWALL	**arr**	**08:16**	**09:11**	**10:16**	**11:26**	**16:11**	**17:16**	**18:11**

Wednesday

						A			A	B
Flight Number	LM	700	713	714	715	716	710	711	707	707
KIRKWALL	**dep**	**07:35**	**08:40**	**09:40**	**13:35**	**14:45**	**15:30**	**16:30**	**17:30**	**17:30**
Eday	arr					14:55				17:40
	dep					15:02				17:47
Stronsay	arr		08:49							
	dep		08:56							
Sanday	arr		09:01				15:43			
	dep		09:08				15:50			
Westray	arr			09:55						
	dep			10:00						
Papa Westray	arr			10:02				16:45		
	dep			10:09				16:52		
Westray	arr							16:54		
	dep							17:01		
North Ronaldsay	arr	07:52			13:52				17:47	17:57
	dep	07:59			13:59				17:54	18:04
Papa Westray	arr				14:09					
	dep				14:16					
Eday	arr	08:09								
	dep	08:16								
Stronsay	arr						15:55			
	dep						16:02			
KIRKWALL	**arr**	**08:26**	**09:21**	**10:24**	**14:31**	**15:12**	**16:11**	**17:16**	**18:11**	**18:21**

Thursday

Flight Number	LM	701	708	709	717	710	711	707
KIRKWALL	**dep**	**07:35**	**08:30**	**09:30**	**14:20**	**15:30**	**16:30**	**17:30**
Eday	arr							
	dep							
Stronsay	arr		08:39					
	dep		08:46					
Sanday	arr		08:51			15:43		
	dep		08:58			15:50		
Westray	arr			09:45				
	dep			09:52				
Papa Westray	arr			09:54			16:45	
	dep			10:01			16:52	
Westray	arr						16:54	
	dep						17:01	
North Ronaldsay	arr	07:52			14:37			17:47
	dep	07:59			14:44			17:54
Papa Westray	arr				14:54			
	dep				15:01			
Eday	arr							
	dep							
Stronsay	arr						15:55	
	dep						16:02	
KIRKWALL	**arr**	**08:16**	**09:11**	**10:16**	**15:16**	**16:11**	**17:16**	**18:11**

Friday

Flight Number	LM	701	708	709	719	710	711	707
KIRKWALL	**dep**	**07:35**	**08:30**	**09:30**	**14:20**	**15:30**	**16:30**	**17:30**
North Ronaldsay	arr	07:52						17:47
	dep	07:59						17:54
Stronsay	arr		08:39					
	dep		08:46					
Sanday	arr		08:51			15:43		
	dep		08:58			15:50		
Westray	arr			09:45				
	dep			09:52				
Papa Westray	arr			09:54	14:35		16:45	
	dep			10:01	14:42		16:52	
Westray	arr						16:54	
	dep						17:01	
Eday	arr							
	dep							
Stronsay	arr					15:55		
	dep					16:02		
North Ronaldsay	arr				14:52			
	dep				14:59			
KIRKWALL	**arr**	**08:16**	**09:11**	**10:16**	**15:16**	**16:11**	**17:16**	**18:11**

Saturday

Flight Number	LM	720	721	722	723	724
KIRKWALL	**dep**	**08:30**	**09:30**	**10:30**	**15:00**	**16:00**
North Ronaldsay	arr			10:47	15:17	16:17
	dep			10:54	15:24	16:24
Stronsay	arr		09:38			
	dep		09:46			
Sanday	arr		09:51			
	dep		09:59			
Westray	arr	08:45				
	dep	08:52				
Papa Westray	arr	08:54				16:34
	dep	09:01				16:41
Westray	arr					
	dep					
Eday	arr					
	dep					
Stronsay	arr					
	dep					
North Ronaldsay	arr					
	dep					
KIRKWALL	**arr**	**09:16**	**10:11**	**11:11**	**15:41**	**16:56**

Saturday Refit (26th Feb & 5th Mar)

Flight Number	LM	722	723	724	725	726	727
KIRKWALL	**dep**	**08:00**	**09:10**	**10:20**	**14:00**	**15:00**	**16:05**
North Ronaldsay	arr	08:17					
	dep	08:24					
Stronsay	arr				15:09		
	dep				15:16		
Sanday	arr			10:33	15:21		
	dep			10:40	15:28		
Westray	arr		09:25				
	dep		09:32				
Papa Westray	arr		09:34		14:15		
	dep		09:41		14:22		
Westray	arr				14:24		
	dep				14:31		
Eday	arr	08:34					16:15
	dep	08:41					16:22
Stronsay	arr			10:45			
	dep			10:52			
North Ronaldsay	arr						16:32
	dep						16:39
KIRKWALL	**arr**	**08:51**	**09:56**	**11:01**	**14:46**	**15:41**	**16:56**

Sunday

Flight Number	LM	725	726	727
KIRKWALL	**dep**	**10:30**	**16:00**	**17:30**
North Ronaldsay	arr			17:47
	dep			17:54
Stronsay	arr			
	dep			
Sanday	arr			18:00
	dep			18:07
Westray	arr			
	dep			
Papa Westray	arr	10:45	16:15	
	dep	10:52	16:22	
Westray	arr		16:24	
	dep		16:31	
Eday	arr			
	dep			
Stronsay	arr			18:12
	dep			18:19
North Ronaldsay	arr	11:02		
	dep	11:09		
KIRKWALL	**arr**	**11:26**	**16:46**	**18:28**

NOTES

Monday am drop to Eday during school term only - bookings can be made on the Eday Monday morning flight, shared with North Ronaldsay, however this is subject to availabilty from 12:30 - 18:00 the day before departure.

Sunday - Sanday/Stronsay flight drop off / pick up on request. Bookings can be made on the Sanday or Stronsay flight, shared with North Ronaldsay, from 12:00 on Friday until 12:00 on Sunday.

A - School term only (5 Jan - 01 April and 19 April - 30 June and 16 August - 05 October 2022)

B - School holidays only (04 - 18 April and 01 July - 15 August and 06 - 21 October 2022)

CONTACT

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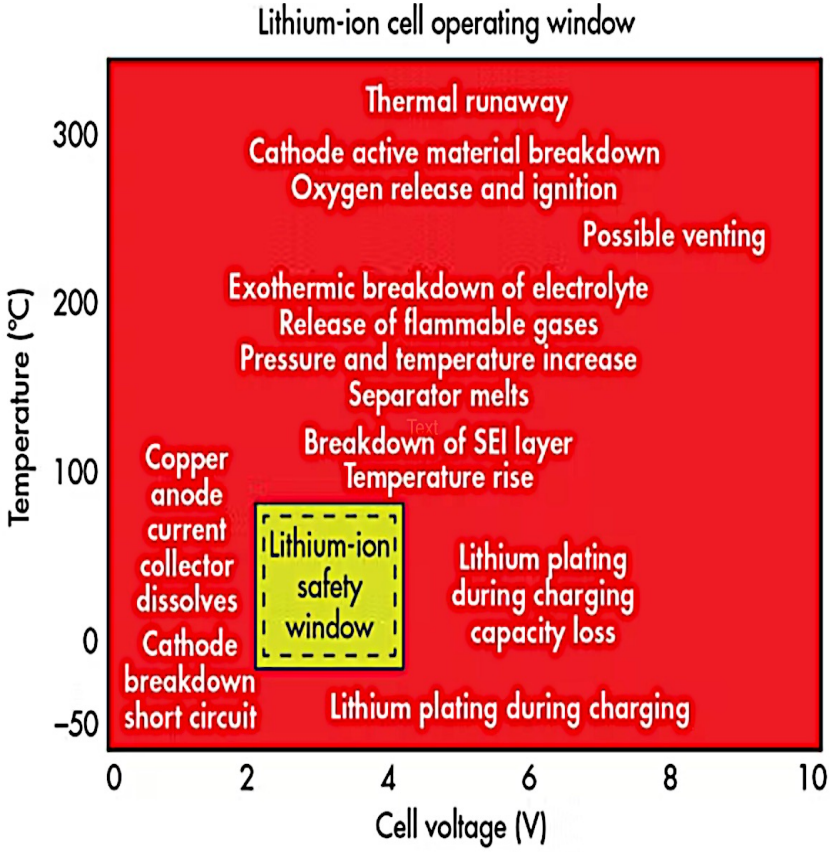
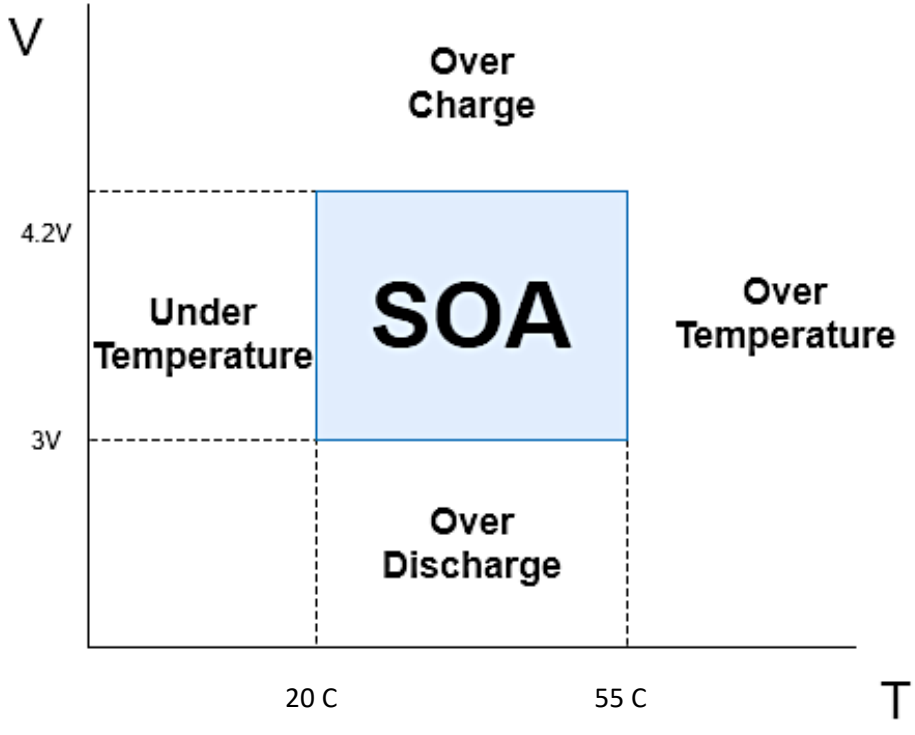
Booking Online - www.loganair.co.uk

Technical and Regulatory Inputs
into
Management Of On-board Battery Energy Systems "Safe Operating Area" (SOA)





Battery Management System (BMS) -- Safety, Function
Flight Operations (incl. No-Go Conditions) and Durability (Life)