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Celebrating National Aviation Day
… and commenting on how Sustainable Aviation Fuel (SAF) is tied to future sustainability, and success, of the enterprise

Washington, D.C., AUGUST 19, 2020 – Today is National Aviation Day in the U.S., a recognition instituted by FDR in 1939, honoring the birthday of Orville Wright, but also creating awareness of, and celebrating the progress and vision associated with, the aviation industry. Today, that industry has become so much more than most envisioned 81 years ago, while having the potential to be even more impactful for future generations. Civil aviation in the U.S. drives more than $1.85 trillion in annual economic activity, and creates livelihoods for more than 11 million workers; an industry that "punches well above its weight" in measures like balance-of-trade and value-per-environmental-impact when compared with other industrial sectors. Worldwide, the impact of aviation is huge, and likely touches all of us in some very meaningful ways. So, aviation is truly something to celebrate today, and to anticipate for tomorrow. I encourage you to do so with your family, or at least to reach out to someone you know who works in the industry, and let them know you appreciate what they're doing for the benefit of society.

As they have done regularly, in 2016, our colleagues at NASA created this poster to mark National Aviation Day. It is a nearly perfect representation of the pull that aviation had on me and so many of my peers in our formative years. Yes, the inspiring vehicle designs depicted have changed since my youth in the 60's, but the visceral draw is no less – escaping the "surly bonds of earth" … higher, faster, farther. At that age, I had no idea that that also meant mastering mechanics, materials, aerodynamics, controls and physics – forging an assemblage of extremely advanced technologies suitable to serve mankind's reach for flight – all superfluous to a 9-year-old, but still creating wonder for me today as I am able to now fully appreciate the genius-at-work inside the shiny vehicle. I hope to pass some of that wonder on to my unborn granddaughter, or the school children I might mentor, as the poster elicits… and hope you do, too.

Today, additional motivations for the future of aviation include cleaner, quieter, safer, more efficient, more affordable, and more sustainable … the specific focus of the unique plane designs shown in the poster which NASA continues to develop with industry. Such progress will enable continued sectoral growth and access to this wonderful technology for our progeny, as well as other developing markets and economies around the world who have actually yet to benefit directly from our progress.

Several things have happened in the past couple weeks that bring things full circle for me, and in more than just a colloquial sense. The NASA poster also depicts soaring birds, and

when you consider their capabilities, it reminds us that what we still have perhaps much in nature to attempt to emulate for human aviation. I clearly recall the barn swallows that used to circle my tractor as I mowed fallow fields on the farm of my youth, stealthily hunting the insects attempting to escape the approaching demise of the brush-hog. Swallows are magnificent fliers, wheeling around in tight arcs with incredible dexterity in changing direction to catch their fleeing insect prize. They often whirled within arm's reach of my perch on the tractor, and created a desired distraction to the drudgery of row-pass upon row-pass. This past weekend, after not experiencing such a spectacle for the past 42 years, I found myself being visited by three chittering, wheeling swallows while mowing the field adjacent to my current home. For the duration of their 45 minutes feeding frenzy (and the remainder of my morning chore), the tedium vanished, and I was transported back to my youth as so effectively depicted by NASA's poster. It was quite the pleasant diversion from mind-numbingly current issues associated with politics, COVID, and my concerns about the current survival challenges pressing the aviation industry, and partially prompted me to pen this piece.

Anyway, long story short, that earlier barn-swallow wonderment led to wonder-of-flight exploration, to pursuit of a private pilot's license, to short-lived aircraft ownership, to two aerospace degrees, and to 35 years of work in the aviation industry focused on the nexus of advanced technology, societal macro-economic drivers, and policy. I believe in the value of the sector. For the last eight years at CAAFI I have been focused on assisting the aviation enterprise with the development and commercialization of Sustainable Aviation Fuel (SAF) to address one of those current challenges I previously mentioned, the future sustainability of aviation as driven by public sentiment to continue lowering the carbon footprint of flight.

Another unique, related story played out last week, one I suspect is similar to my own and hundreds of others similarly struck with the "aviophile" condition. Robert DeLaurentis, self-described "Peace Pilot" / "Zen Pilot," completed a transformational journey, "the Pole-to-Pole Peace Mission," flying in the "Citizen of the World," a highly modified Gulfstream Twin-Turbo Commander 900. This was a polar circumnavigation of the planet, encompassing 26,000 nautical miles, visits to 23 countries and 6 continents, including an 18 hour solo segment over the South Pole. Roberts's intent was simple – "to encourage and inspire." Mission accomplished, Robert! Furthermore, he was also performing science along the way. Oh, and the additional tie to this piece … he flew the mission using a SAF blend, acquired in part from Gulfstream Aerospace Corporation, via World Fuel Services and World Energy's Paramount, CA SAF production facility. Gulfstream has been using SAF in their own operations since 2016, and are now also offering that fuel to select customers at their Long Beach facility. DeLaurentis used SAF to lower the environmental impact of his flight, so as not to detract from the overall benefits of the endeavor. SAF can do the same thing for all of civil aviation, and in fact we've already started doing so.

Some observers, both inside and outside the industry, continue to push back on the need to improve aviation's sustainability. Let me simply say that we have to acknowledge the fact that the policy makers and the public have concluded the need for improvement. This has been the case since the Kyoto Protocol was signed in 1997, has been the topic of focus at every U.N. Framework Convention on Climate Change (UNFCCC) meeting since, drove the case for the European Union (EU) Emissions Trading Scheme (ETS) which monetizes carbon for our industry, formed the basis for the Paris Accords, and is now responsible for the continued outgrowth of financially impactful legislation. Most people are unaware, but there already exists the first SAF blending mandate in Norway, with pending proposals to do the same across Scandinavia and much of Western EU. Funds that were provided to the industry to weather COVID impacts in some countries have sustainability commitments attached. In the same way that the industry has had to improve its performance on noise

and criteria air pollutants (now with an increased focus on particulate matter) for the last four decades… we need to now stay in front of regulation on greenhouse gases. The aviation industry itself recognized this in 2008 with voluntary commitments that were the precipitators of the International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) agreement which enters into effect on January 1st 2021. And the lead-up to the industry commitments themselves were the basis for founding CAAFI in 2006 to work on behalf of the industry to foster the development and commercialization of SAF.

SAF are partially synthetic drop-in jet fuels made from bio-based or other circular-economy feedstock sources, using industrialized biochemical and thermochemical processes. On a gallon-per-gallon basis, today's SAF blending components typically reduce net CO_2 emissions by 50-80% versus conventional jet fuel. In several cases in development, the SAF will actually deliver negative carbon index scores, meaning that its production can remove more greenhouse gases from our environment than it will release during in-flight combustion. SAF are safe for use today, and have been used continuously at select airports (e.g. LAX) since 2016. There are greater than 350 million gallons per year in offtake commitments from multiple airlines representing a greater than $6 Billion outlay, and all of the SAF output from the first several planned production facilities has been committed. Stay tuned for further announcements along these lines later this year, as they continue to be made on a regular basis.

The challenge that we have with SAF today, and why we are only uploading SAF at less than 0.1% of total jet fuel usage, is that they are more expensive than the depressed price of petroleum-derived jet fuel. They are also disadvantaged versus renewable diesel production. So, this is the primary focus that CAAFI and others have right now; fostering the development of feedstocks, supply chains, conversion processes, and byproducts to enable lower-cost production and facilitate airline uptake. It's a challenge, but we continue to make progress, especially with assistance from DOE and USDA on the development of technologies and feedstocks, and from FAA on a wide range of activities from fuel qualification through supply chain analysis. In some cases, state and national governments are also deploying policy elements that help close the price gap. So, we're making slow progress.

However, there is a bottom line message I want to emphasize with this writing, especially about news items that detract from this fundamental concept:

SAF usage will immediately start to lower the net GHG footprint of aviation. We don't need to wait for unique technologies to work their way into the fleet. We don't have to modify fuel distribution infrastructure. We simply need to stand-up the facilities to produce the fuels, in an accelerated fashion from the build-out described above. We know how to make them, we know they can be sustainable, and their use is impactful! In fact, we know some of these fuels will be carbon negative! With the right policy approach, we can see a significant ramp-up in production from a broad range of renewable and circular-economy resources.

Now the concerns:

1. **Advanced aircraft technology**: I'm a fan of advanced technologies being incorporated into future aircraft, and the industry needs them, but we can't force their usage before they are technically viable and demonstrated at commercial utilization readiness levels. We have seen examples from each of the major manufacturers of the intolerable impact on multi-billion dollar investment activities, due to redesign or backtracking, remanufacture, rework, retest … in cases where technology implementation went forward prematurely. Although things like fully electric aircraft might work now for

personal aircraft, and perhaps in another 15 years for a small regional commuter, fully electric large aircraft are not realistically viable for another 30 years. About 80% of world-wide aviation fuel burn is associated with aircraft larger than the commuter or regional level. For these larger aircraft, fully electric technology levels associated with energy or power production and utilization per unit weight or volume is off by a factor of 50. And the associated enabling systems are in their infancy. What's more, the certification basis does not exist. So, let's all be pragmatic - look in detail at 12 of the most discussed "next generation" commercial aircraft designs - 11 of them are hybrid-power aircraft, meaning, if successful, they will still burn jet fuel with a turbine to create primary power aboard the aircraft for subsequent conversion to electric propulsion. SAF enables this first use of the next generation of hybrid propulsion technology to deliver net GHG reductions. Let's not forego spending on SAF R&D, demonstration and deployment right now in the pursuit of future sustainability improvements that will not see entry into service for another 30 years. Let the advanced technologies come to the market when they are ready and justified, but pursue SAF now.

2. **Hydrogen**: The best use of renewable hydrogen in our industry is for the creation of SAF, and this will likely be the case for at least the next 30 years. Hydrogen is critical to synthetically create SAF from renewable and circular-economy resources - the C_7 to C_{17} family of pure hydrocarbons we know and love as jet fuel. SAF production requires a fair amount of hydrogen depending on the production process (say between 1-4%+ of the mass of the feedstock used). Let's produce sustainable hydrogen and use it in that fashion, rather than as a fuel itself. The case for using something other than a turbine and hydrocarbon fuel, won't be made until we see fully-fledged new aircraft designs that demonstrate double digit operating cost reductions versus the models pending and in-production now. We would also need someone to determine how to pay for the more costly refineries and infrastructure switches required by hydrogen. Let's be pragmatic and stay focused on SAF, produced with renewable hydrogen, as the near-term solution.

3. **Power to Liquids**: Finally, there's been a lot of discussion about power-to-liquid fuels (P-t-L). These are SAF that are synthetically produced from hydrogen and carbon monoxide using renewable power, to deliver fuel with very low carbon indices. The hydrogen is proposed to be stripped from water or biogas, and the carbon monoxide is ripped from carbon dioxide, in some cases sourced from the atmosphere via Direct Air Capture. Again, I'm a technologist, and I appreciate the technical elegance, but I don't appreciate the even higher price point of such fuels. Some estimates predict these fuels will only perhaps equal today's (already high) production price of bio-derived SAF by **2035**. Again, let's not forego spending on nearer-term SAF at the expense of pushing out progress. For those countries who believe they have no biomass resources to spare, then fine, spend away, but don't expect near term reductions in GHGs from your airlines' fleets. For the remaining majority of us, let's use those agricultural residues, forestry residues, municipal solid waste, animal waste, sanitary waste-water treatment, industrial effluents, purpose grown lipids, etc. to produce the first few tens of billions of gallons of SAF. Then, when the time and technology are right, let's look to P-t-L to form the basis of a second round of production expansion.

Finally, if you haven't spent much time thinking about SAF, the Business Aviation community, through the SAF Coalition (which includes CAAFI), today released a second SAF Guide, entitled *Fueling the Future*, intended to serve as an educational and informational resource about the practicalities of SAF development, industry adoption, and pending expansion of supply and use, primarily from the perspectives of the business aviation community. It also reinforces the industry's global commitment to sustainable aviation

fuels as a key component to enabling the global industry meet its long-term goal to address climate change by halving carbon emissions by 2050 relative to 2005 levels.

Take a look at the Guide, and with consideration of the above, move SAF into your consciousness and lexicon with respect to your vision of the future of aviation. And, perhaps, fold up a few paper airplanes with the kids after dinner tonight, let them know about the significance of National Aviation Day. Tell them about people with vision like Robert DeLaurentis, and that aviation has a sustainable future in its flight plan, and potentially in theirs, and that SAF will likely play a key role.

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