

California Leadership to End Wildfire Disasters

A proposal to channel new technology against the
challenge of mitigating wildfires



Source: Getty Images/NYTimes

Table of Contents

3 The Challenge

5 Call to Action

8 Proposal: How California Can Lead

17 Context and Current Situation

24 Appendix



Source: USA Today

The Challenge

Our firefighters put their lives on the line to fight wildfires and protect our state. They deserve the best technology and tools to do their job. However, we are falling short in this obligation and inadequate technology leaves us too slow to respond to wildfires, particularly in hard-to-access areas.

The first minutes and hours of a new wildfire are critical. Fires grow **geometrically**, meaning that after the first hours, extinguishing the fire becomes impractical and containment of the fire is a **long, costly and dangerous undertaking**.

Increasing recent wildfire activity in California and the western U.S. has exposed and exacerbated this deficiency, with disastrous consequences.

With 4.0M+ acres burned, more than twice the previous annual record, 8,500+ structures have been destroyed along with 30+ deaths. Along with the direct costs of the fire, which are expected to be \$20 billion, the weeks of economic disruption, lost tax revenues, and health impacts could increase total costs by a few-fold. Moreover, it is estimated that deaths from smoke related health complications is far more than the dozens who have directly died from the fires and could reach several thousand long after the fires have been extinguished.

Moreover, the public sees that government firefighting resources are overwhelmed and this presents a serious threat to their trust in the government's ability to keep them safe.

Technology presents opportunities for us to change this across the full spectrum of forest management, fire detection, firefighting, and logistical support. As one of many examples, already-proven technology can make our aerial response to wildfires far more prompt and effective. However, without purposeful leadership to apply this, federal frameworks in aviation regulation hold back technology and work at odds with California's greater interests.

The engine of innovation is strong in California. It is prepared to amplify small success into huge profitable world-changing success. Supplying a real test bed to generate small but real successes is needed to get from 0% to 1%.

The Call to Action

Governments must continually earn the trust of the people and inspire confidence that they are proactively out in front and leading with solutions.

The current climate emergency with wildfires in California and the western U.S. requires that governments take immediate action to re-think the full spectrum of ways we prepare for and manage wildfires and to equip our firefighters with better tools and technology.

This involves assessing the threat from a first-principles basis and exploring a full range of new systems and operational processes that leverage multiple categories of newly-available technologies.

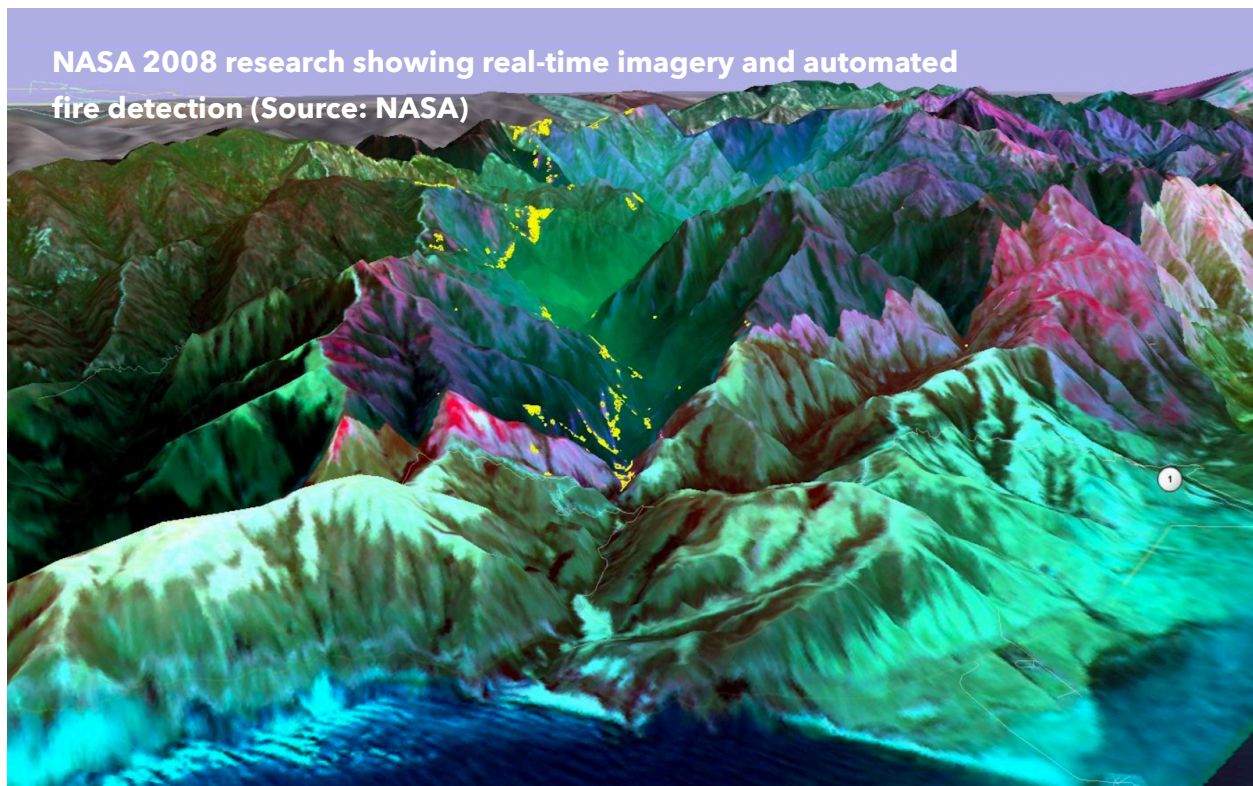
Insights

Recent advances in aerial mobility, sensing and automation, and other technologies provide the foundation for a systems-of-systems approach for reducing wildfire risk ahead of fire season, for firefighters to detect and respond to wildfires much faster, and for them to suppress fires while they are still small and more easily contained or extinguished.

Remote sensing, geospatial data systems, and machine learning networks allow us to combine factors including terrain, vegetation, micro-weather records, and vulnerable infrastructure to identify wildfire risks and target mitigation actions and incentives appropriately.

A full range of technologies from sensors to information and communication systems now allow us to detect and prioritize fire ignition events in near real-time.

Additionally, advanced chemical sensing technologies on drones can quickly identify the flow of toxic plumage and help prioritize vulnerable populations that need to be evacuated and to determine their escape routes.



An array of new guidance and control technologies can enable the precise delivery of fire retardants to ignition sites on very short notice and under all weather conditions and times of day to augment human operators, including in situations too dangerous for air operations today.

The scalability and economics of these technologies offers the potential for governments to field this airborne detection and mitigation solution at scale and over wide regions during times of high wildfire risk.

The opportunity ahead is not in developing the technologies, but to **tie them together** into systems that work in the real world.

This Requires Political Leadership

California has expressed interest in technology solutions with its Wildfire Innovation Sprint, awarding small contracts based on published RFIs. This proposal amplifies that, broadening scope and bringing new capabilities to increase success. Our insight builds off of analogous programs such as the USAF's Agility Prime program, to create a resourced and capable interface for rapid innovation with startups and innovators. Agility Prime brings advanced aerial mobility technology to the Air Force to support several areas of interest in cargo and personnel logistics. The program has worked to employ existing small business support programs and government contract mechanisms to make it easy to contract with small companies that are working with the government for the first time.

Finally, we must ensure that solutions make it into the field. Past efforts, such as NASA's 2008 research on wildfire detection lacked sponsorship after successful demonstrations. This proposal addresses the required mandate and capabilities to catalyze buy-in for new technologies early and to give them the pathway to real-world operations.

We propose to bring the **best minds** from across disciplines together, as well as similar programs that are working elsewhere, to *tackle and develop a solution to this challenge for California.*

Proposal: How California Can Lead

Proposal #1: Mandate a task force to have the authority to welcome testing of novel technologies in active fire zones.

Proposal #2: Establish a privately funded organization to realize a 21st century wild fire response vision.

Proposal #1: Mandate a task force

The task force, which includes public and private sector experts spanning forestry and firefighting, as well as from the technology world, will be designated by appropriate state agencies to have the authority to welcome testing of novel technologies in active fire zones. The mandate to protect firefighters, property and state resources will be appropriately balanced against other state and federal regulatory concerns. The goal is for technological solutions identified to be fully scaled and integrated by 2024.

Our proposal answers the question of, "How can we **foster and enable** private sector innovation to deliver **new solutions** to mitigating wildfires?"

In addressing this question, we consider several fundamental aspects of the challenge. First, the solutions we need are inherently systems-oriented, with a great deal of hard-to-access domain knowledge that goes into them.

Today, Cal Fire lacks an advanced engineering department to continually survey and develop integrations of new technologies. Absent deep engagement and two-way exchange to explore and develop novel solutions, it is difficult to establish conviction around what to ask for. Likewise, many potentially impactful contributors in the private sector lack understanding of wildfire detection, response, and mitigation operations. They have technologies, but not yet in a form to be immediately applied.

This compounds the difficulty for both parties, as it is both hard for Cal Fire to ask for things that don't exist, and for the private sector to anticipate and independently create them. In

fact, Cal Fire has difficulty funding most projects beyond those that respond to their immediate needs.

The traditional RFP process can work only after a wide variety of new solutions have been responsibly tested in the field. We know that we don't yet know what is possible using today's technology.

This is not unique to wildfires. It is an unavoidable truth that innovation in spaces dominated by government requires active facilitation by and incentives from government. Without this, the private sector lacks clarity on what is needed and will not justify the risk of development. Further, the tens or hundreds of billions avoided in lost economic productivity and tax revenue through wildfire prevention represents a much higher return on investment to the government than the millions in product or service revenues that preventing wildfires represents to the private sector.

As with defense and other common goods, the responsibility to fund wildfire mitigation lies with the government. What has become clear is that the threat to society that today's wildfires pose, combined with the potential for new technology to eliminate this threat, has elevated wildfires to a similar level of focus as national defense. We should thus likewise take leadership to actively facilitate and incentivize technological innovation.

Innovation happens when the government demands a solution to a pressing problem, and provides a safe sandbox innovators can use to demonstrate affordable solutions, and sends a signal to the market that risk will be rewarded. California's innovators have goodwill and well-honed skills ready to be brought to bear in California's time of need.

Let us take advantage of capitalism's secret advantage - that necessity forces invention, and that competition breeds innovation. Budgets and realistically short deadlines breed cost-effective timely solutions. There is no time to wait to get started.

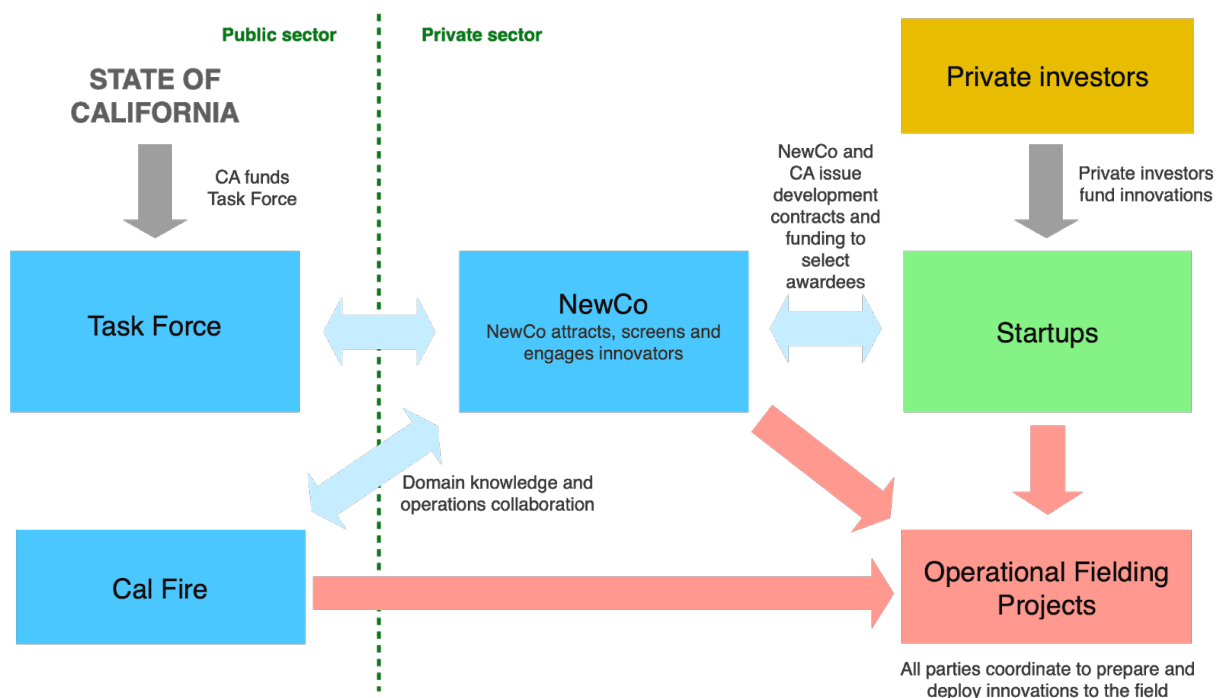
Cal Fire needs partners, steeped in new technology and who are listening to their needs and building solutions that have never been seen before. These partners must bring experience scouting and engaging with private sector technology pioneers, both startups and large companies. They should work alongside Cal Fire to serve them, to transfer their domain knowledge and ensure follow-through.

We need an institution that can define, steer, and manage innovation and implementation in the context of Cal Fire's needs.

#2 Establishing a privately-funded organization

In parallel, we support the establishment of a privately-funded organization with the mandate to plan and execute, along with private and public partners, the development and realization of a game-changing 21st century wildfire response vision.

We propose to establish a privately-funded organization, NewCo, focused on private sector innovation in wildfire mitigation leveraging new technology. NewCo will enable California and Cal Fire to effectively partner with the private sector and other government agencies, including NASA, the U.S. Forest Service and the FAA, to develop, test and deploy new solutions for detection and mitigation of wildfires.



Radius Capital and the Anthropocene Institute will use their industry connections, working relationship with NASA and the USAF's Agility Prime program, and their technology domain expertise to establish NewCo with the capability and resources it needs.

NewCo will bring NASA's research capabilities, Agility Prime's processes for engaging startups and fostering technology integration, and Cal Fire's domain and operating expertise

to bring immediate impacts to wildfire mitigation. To engage the startup community, NewCo will scout, identify, prioritize and coordinate private sector companies for partnership to catalyze private investment and new markets through innovation.

To be worth pursuing, this organization must be equipped with the mandate and resources to follow through on its objectives and deliver results for firefighters and the public, even after headlines from the latest fires have subsided.

This organization will:

1. **Take immediate steps** to facilitate bidirectional information exchange between Cal Fire and the innovation community
2. **Emphasize learning and refinement** through operating experience, putting in place frameworks for operating in a wildfire environment, including mandating operation of drones beyond line of sight, with rules in place to guarantee no interference with firefighting operations
3. **Coordinate ways that technology providers** can safely support firefighters to gather data, improve situational awareness, or support them in other ways that are immediately available for operational integration.
4. **Create a plan for California and Cal Fire**, to be delivered within 100 days, incorporating immediate learnings, to deliver near-term wins for firefighters through immediately adoptable technologies as well as to enable fire response technology development, systems integration and concepts of operations.

This plan will:

- Assess the current state of the art and the realities of firefighting operations today
- Define a vision and specific objectives
- Identify gaps and obstacles to achieving the vision
- Identify areas and technologies for exploration and corresponding new concepts of operations
- Identify immediate opportunities to leverage resources across California state agencies, NASA, FAA, DoD and other government organizations that deliver results today.

O Lay out specific milestones, around the following areas:

Crosscutting Disruptions

- Audacious Moon-Shots. Things we can't promise but might deliver. Potentially game-changing concepts that have been demonstrated or could work, but won't happen without leadership ready to embrace them if further development yields real-world results
- An overarching strategy incorporating rapid wildfire response into a comprehensive approach to fire prevention, forest management, and carbon emissions reduction efforts.

Reducing Wildfire Risk

- Geospatial data systems for identifying and mitigating wildfire risk factors
- Economic models to understand and justify investment in new approaches based on rapid response to incipient wildfires
- Novel approaches to reducing wildland fire ignition risk, including measuring deadwood fuel, installation of lightning rods on the tallest trees and other measures

Detection and Decision

- Rapid detection and classification of wildfire ignition events
- Information systems supporting rapid decisions classifying and responding to detected fires
- Command and control systems for coordinated directing of firefighting assets, including highly automated and unmanned systems
- Ability to field rapid response capability continuously during times of high fire risk

Response

- Demonstrate a fast coordinated response, preventing fire growth
- Airborne asset systems to rapidly respond to wildfire ignition events, especially during times of high fire risk
- Fire retardant delivery systems incorporating radar, laser, and GPS able to deliver retardant with high precision in all weather conditions, day or night
- Enable and improve both ground and air operations in night and zero visibility conditions
- Technology to support tele-operated bulldozers to work adjacent to fire.

Supporting Firefighters

- Delivering innovations that have an immediate impact on firefighting, including enhanced safety to fire crews via improved situational awareness, communications, and logistics in support of a nimble and rapid response to fire
 - Improved lift systems for helicopter rescue/extraction and slung loads
 - Improved logistical support (supply, health, comfort, safety) for firefighters across communications and supply, in both nominal and contingency situations
5. **Attract, screen and identify** private sector technology, development, integration, and operations partners
 6. **Evaluate and prioritize** a mix of the most promising ideas
 7. **Develop and field** five to fifteen high-impact concepts, some to be delivered in the very near-term and others after further development and operational integration.
 8. **Leverage resources** across Cal Fire, the private sector, NASA, FAA, and other government agencies to support execution.
 9. **Coordinate** a rapid development capability to reduce time from development to initial operational deployment

Funding and Operation

NewCo will be a privately-funded organization. It will establish innovation pathways for identifying and prioritizing needs within Cal Fire, identifying and evaluating private sector contributors relevant to the needs, and defining and managing development pathways across multiple entities. It will provide program management to track progress against delivered results.

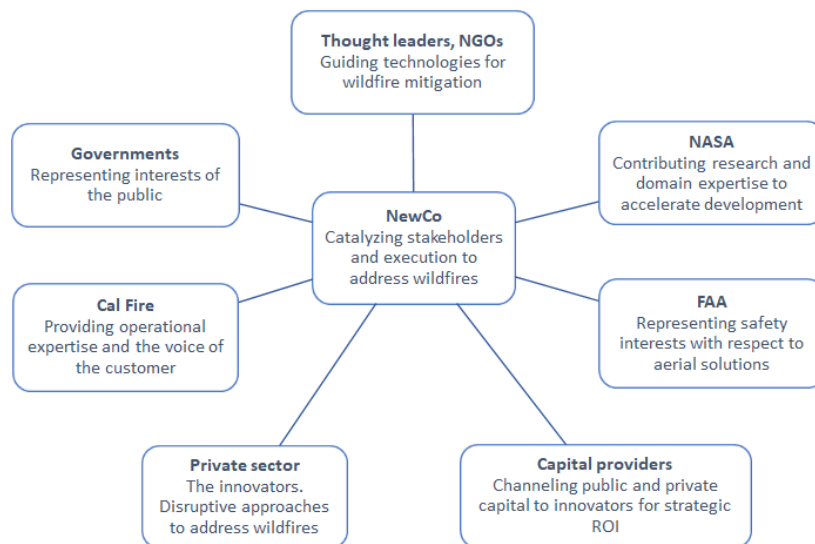
NewCo's mission is that any NewCo recommended technology acquired by the state should be expected to earn a return for taxpayers of at least ten times its cost. Unlike earthquakes, wildfires are striking us with enough regularity that we can and should be able to demonstrate savings for taxpayers by developing and utilizing appropriate technology. NewCo should be held accountable for making great investments that significantly reduce the state's total fire control expenses despite the cost of the program.

NewCo will also instantiate a solution certification team whose role is to independently assess project results, cost effectiveness, and operational adoption, integration and scalability. Through its activities, NewCo will create new markets for technology and catalyze private investment.

In sum, by creating a low resistance path for new technology to find its way into firefighting, we will address a major environmental and socio economic threat while also drawing in investment from others to accelerate learning, which in turn drives industrial leadership for California and the United States.

Team and Prospective Partners

NewCo will bring together partners that are representative of the necessary public and private sector stakeholders including capital providers, technology innovators, thought leaders, and government agencies. We have already received interest from NASA, from theUSAF's Agility Prime program, and from prominent California-based aerospace companies.



The organization will attract the following prospective partners:

- **Peter Shannon**, Radius Capital
- **Luka Tomljenovic**, Radius Capital
- **Jim Barry**, Radius Capital (advisor) - real-time operational aviation data management leader
- **Carl Page**, Anthropocene Institute
- **Frank Ling**, Anthropocene Institute
- **Richard Chan**, Anthropocene Institute
- **Dave Korsmeyer**, NASA - led 2008 aerial wildfire detection research
- **Parimal Kopardekar**, NASA - unmanned systems traffic management and aerial mobility leader
- **Davis Hackenberg**, NASA - a leader of NASA's advanced air mobility National Campaign
- **John Cavolowsky**, NASA - transformative aeronautics program leader
- **Col. Nathan Diller**, USAF Agility Prime - a leader of the USAF's program to engage startups
- **JoeBen Bevirt**, Joby Aviation - CEO of a leading CA aero startup and wildfire-fighting advocate
- **Brett L'Esperance**, Dauntless Air - CEO of the largest U.S. operator of light firefighting aircraft
- **Allan McArtor** - former FAA Administrator
- **James Hererra**, FAA - veteran and advanced aerial mobility leader within FAA
- **Chris Hadfield** - Canadian test pilot, astronaut, entrepreneur
- **Sertac Karaman**, MIT - aero/astro professor, entrepreneur, unmanned systems leader
- **Juan Alonso**, Stanford University - professor, entrepreneur
- **Craig Jimenez**, Air Tractor - independent director at firefighting aircraft manufacturer
- **Martine Rothblatt**, United Therapeutics Corporation - technologist, entrepreneur, philanthropist
- **Chris Alexander**, Airbus - chief engineer for unmanned aerial systems
- **Steve Sargeant**, Marvin Test Solutions - aerospace operations leader, USAF Maj Gen (Ret)

Achieving Rapid Development and Test

A comprehensive test environment that enables rapid and effective development of systems will accelerate timely deployment of innovations for upcoming fire seasons. A priority will be to establish a safe test environment for real-world application development of a range of tools to assist firefighters.

This will be a combination of virtual and physical test environments. Given the systems nature of the engineering work ahead, these can be useful tools to understand what at-scale operations would look like under different scenarios and where the system shows stress.

For physical test environments, we propose to leverage the established protocol of Temporary Flight Restriction zones used today over active wildfires, and to create these zones over high-risk regions on high-fire-risk days in order to test detection and rapid response in a safe manner. We will leverage the separation from other air traffic that TFRs provide to create safe environments for test and development using manned and unmanned aircraft for wildfire detection and mitigation. While these zones do present an additional burden to the aviation community, we argue that the use of this safety mechanism for test and development will accelerate technology leading to fewer large fires and thereby far less overall use of TFRs in the future once the technology is deployed.



Source: Spectrum News/AP Photo

Context and Current Situation

Wildfires are a natural part of California's landscape. Up until the 20th century, wildfire was much more prevalent in the environment. Researchers estimate that historically, prior to concerted efforts to fight wildfires, 1-2 million acres burned each year in California and tens of millions of annual acres burned across North America.

Since the mid 20th century's advent of mechanical firefighting, developed around cutting firelines with bulldozers and dropping retardant with air tankers, annual acres burned have dropped precipitously. Throughout the 1940s and 1950s, California saw a 36% decline in area burned. This decline, driven by improved firefighting operations and resources, continued until the 1980s.

However, established firefighting methods are becoming less effective in recent years as temperature and precipitation patterns change. The turn of the century saw an end to the cool, wet Pacific Decadal Oscillation climate pattern. This pattern was replaced with warmer and drier conditions that are now being amplified by global warming effects induced by fossil fuel emissions.

In recent years, between **4 and 10 million acres** burn annually across the United States, resulting in an average of **15,000 smoke-related deaths** due to follow-on health complications.

The fire season in California and across the western U.S. is starting earlier and ending later each year. Warmer spring and summer temperatures, reduced snowpack, and earlier spring snowmelt create longer and more intense dry seasons that increase moisture stress on vegetation and make forests more susceptible to severe wildfire. The length of fire season is estimated to have increased by 75 days across the Sierras and seems to correspond with an increase in the extent of wildfires across the state. Consequently, the number of wildfire induced smoke deaths will more than double by the end of the century.

Climate change is acting as a force multiplier that will increasingly exacerbate *wildland fire* issues over the coming **decades**.

The state can expect to experience longer fire seasons, increased frequency and severity of drought, greater acreage burned and related impacts such as widespread tree mortality and bark beetle infestation. While the advent of effective wildland firefighting was initially heralded as great progress, the consensus now is that decades of fire suppression have disrupted natural fire cycles and added to the problem.

Further, 21st century anthropogenic climate disruption is causing severe fire weather conditions to become more frequent and the efficacy of conventional suppression is declining. Conventional firefighting tactics of dumping retardant, cutting firelines, and lighting backfires often fail to stop wind-blown flames from jumping over firelines or firebrands lofting in the sky and landing miles from a wildfire's front. Conventional firefighting strategies and tactics are very human labor intensive, involving long hours of

exhausting work in punishing conditions over rough terrain. This model struggles to scale and can easily be overwhelmed by large simultaneous fires, as we have experienced in 2020. Many are concluding that conventional tactics are thus insufficient to prevent or suppress the large wildfires that are now being driven by climatic conditions that will be with us for the far foreseeable future, and thus require complete re-thinking.

California's overall efforts have not kept pace with these growing threats.

Wildfire Management Strategy

A comprehensive wildfire management strategy is built on four main pillars spanning different disciplines, different scope of stakeholders, and different timelines of efficacy. These are:

- **Manage forest and wildlands** with respect to fuel buildup, firebreaks, and other preventative measures
- **Better prepare the wildland-urban interface** to coexist in an ecological environment dependent on wildfires, including strengthening the resilience of houses and other elements of the built environment in these areas
- **Reduce global carbon emissions**, reducing the climate-induced driver of wildfires over the very long-term
- **Detect and respond more quickly** and effectively to wildfires when they occur

A set of wildfire mitigation recommendations published in February 2019 by Cal Fire in response to California Governor Newsom's Executive Order N-05-19 laid out a plan incorporating immediate, mid-term, and long-term priorities to protect public safety and maintain the health of forest ecosystems from wildfires, recognizing the urgency created by the Camp Fire of 2018.

These recommendations largely focus on identifying particularly vulnerable communities, prioritizing areas for vegetation management, working with other agencies and the private sector to incentivize mitigation behavior such as hardening homes to the threat of fire. They address better economic and operational support for firefighters and recommend investigating improved methods for real-time information sharing to support wildfire response operations.

However, **little attention** is focused on the *potential* for **new technology** to augment the existing capacity for firefighters to carry out their job and **change the rules of the game in firefighting**.

This is an area where we intend to focus and where we can meaningfully fill the gap and create very high impact.

A report from the Leonardo DiCaprio Foundation, also issued in February 2019, criticized Cal Fire's strategy as relying too greatly on fire suppression while observing that their suppression-based approach was proving to be progressively more expensive and less effective. Their report recommends a de-emphasis on fire suppression and reallocation of resources to protect homes at the wildland-urban interface and make them more resilient to and able to coexist alongside wildfires. They rightly observe that wildfires are an important part of the forest, chaparral, and wildland ecosystem and that a return to more natural rates of burn would restore long term balance and health.

Our view is that a return to natural burn rates of 1-2 million acres per year in California and tens of millions of annual acres across North America is economically unacceptable to society and politically unacceptable to our leaders. As such, active suppression of wildfires and active management of forests going forward must be done in a smarter way.

California must adopt an ***“all of the above”*** approach to mitigating wildfires.

While carbon emissions reductions are important, their effects will not be realized for decades. Likewise, even aggressive reform of forest management practices, replacing and burying thousands of miles of utility transmission lines, and heavily incentivized retrofitting of millions of homes will not happen fast enough to protect us from wildfire disasters in the near-term. Each of these efforts will also be tremendously expensive.

In spite of the staggering challenge, California's vulnerability to wildfires presents a unique opportunity for the state to lead in implementing advanced technologies, including aerial technologies, for mitigating wildfire disasters. It is technology that is our solution for the

near-term. These solutions can be deployed faster, and even cheaper, than with changes in the infrastructure. Technology can move faster in driving wildfire disaster mitigation than any of the above efforts.

To the extent we choose to suppress wildfires, we should develop technology and techniques to do a better job of it. Rapid response to wildfire ignition can be a multiplier to measures being taken to reduce wildfire risk, and when taken in comparison to contemplated costs of wide-scale retrofitting or burying of utility transmission lines, can be implemented at much lower cost.

Wildfire suppression spending is soaring. In response to increasing wildfire activity, both federal and state agencies have been dramatically escalating their suppression spending over the last 30 years. For example, in 1986, Cal Fire spent \$15 million on suppression, but in 2017 the agency spent \$947 million, and is set to far exceed this number, and its budget, this year.

Cal Fire is seen to have the world's premier firefighting aviation program. In 2017, its aviation budget was \$55.6 million, equal to about 3% of the organization's overall budget of \$2.1 billion.

Critics, however, cite Cal Fire's use of air tankers as “costly and increasingly ineffective”.

Highlighting the limitations of today's air tanker technology and operations is fair. Dropping water or retardant precisely requires pilot skill to maneuver close to fire and rough terrain. This can entail great risk as pilot and plane are vulnerable to the blinding smoke and high winds of extreme fire conditions. These risks limit operations and make air tankers unusable at night or close in to turbulent areas around intense fires. The demands of the job mean Cal Fire pilots generally can fly no more than seven or eight hours on a fourteen hour shift and they typically fly no earlier than 10 a.m., or in certain cases 8 a.m. Critics, however, miss the fact that new technologies can transform the response, reach and impact of our aerial firefighting assets and put powerful new capabilities in the hands of firefighters.

The limitations of today's air tankers were illustrated in the early hours of the Camp Fire in 2018. The fire started at 6:29 a.m. on November 8th, 2018 near the foothill town of Pulga,

on a high canyon wall inaccessible to ground-based firefighters. At 6:45 a.m. a nearby Cal Fire firefighter made a request for air support. It was not until 7:44 a.m. that a single tanker aircraft was able to take off to head to the scene. After circling the area from three different angles seeking smooth air and an accessible approach for a retardant drop, at 8:29 a.m. the plane finally gave up and returned to base, unable to drop retardant due to wind and conditions at the fire scene. Cal Fire regulations require air tankers to be grounded when there is even moderate turbulence or windspeeds exceeding 35 mph. As such, throughout that day, while the Camp Fire raged through Paradise, a fleet of air tankers located nearby in Chico, CA was grounded by high winds and dense smoke.

California Companies and Culture Relevant to the Effort

With its startup culture and investors, California is unparalleled at bringing new thinking and solutions to global challenges. Relevant startups, many based in California, include:

Volansi Concord, CA	Falkonry Sunnyvale, CA	Tecton San Francisco, CA	Zipline Half Moon Bay, CA
Simple Machines San Jose, CA	SafeGraph San Francisco, CA	Matternet Mountain View, CA	Fiddler Labs San Francisco, CA
Flightwave Aero Santa Monica, CA	Cape Redwood City, CA	Fantasma Los Angeles, CA	Airspace Systems San Leandro, CA
Vantage Robotics San Leandro, CA	Wing Palo Alto, CA	White Fox Defense Technology San Luis Obispo, CA	Toofon San Diego, CA
Aerones San Jose, CA	Unmanned Life San Francisco, CA	Planck Aerosystems San Diego, CA	Dreamhammer San Diego, CA
Apollo Robotics Systems Ventura, CA	MotionDSP Burlingame, CA	Paladin Drones Mountain View, CA	DroneInch Fremont, CA

Pterodynamics
Los Angeles, CA

XWing
San Francisco, CA

Overwatch Imaging
Santa Barbara, CA

Technosylva
Spain and CA

Pyka
Oakland, CA

Mapbox
Washington, D.C.

Airspace Link
Detroit, MI

ATRIUS
Austin, TX

Autonodyne
Boston, MA

Applied Navigation
Bothell, WA

AML
UK

Climacell
Boston, MA

MAGicALL
Camarillo, CA

NodeIn
Burlington, CT

OneSky
Exton, PA

Resilienx
Syracuse, NY

Squawk
Layton, UT

Vita Inclinata
Broomfield, CO

Teoco
Fairfax, VA

Uavionix
Bigfork, MT

Faradair Aerospace
Coates, England

Aerospace technology providers

The state already works with a wide array of mature aerospace technologies that can be rapidly adapted and deployed for wildfire mitigation.

Scaled Composites
Mojave, CA

General Atomics
San Diego, CA

L3/Harris
Torrance, CA

Lockheed Martin
Palmdale, CA

Northrop Grumman
Sunnyvale, CA

Raytheon
Chula Vista, CA

ES Aero
San Luis Obispo, CA

Flighthouse Engineering
Portland, OR

Bell
Fort Worth, TX

Appendix



Peter Shannon

Founder, Managing Director, Radius Capital

Peter is an investor focused on advanced aerial mobility and its application toward positive impact for transportation across the economy and is founder of Radius Capital.

Advanced Aerial Mobility Community

Peter is active in the aviation community around regulatory and technology issues critical to enabling high-scale adoption of aerial mobility systems and has high exposure to emerging technologies and business models. His domain experience includes manufacturing, electric vehicles, drones, autonomous systems, materials and chemicals processes, power electronics, electric motors and batteries.

Peter is an appointee to NASA's Aeronautics Research and Technology Roundtable, a part of the National Academies of Sciences, Engineering, and Medicine, the mission of which is to advise NASA on how they can uniquely contribute to U.S. leadership in eVTOL technology and advanced aerial mobility.

Peter co-authored *Advanced Aerial Mobility - A National Blueprint*, as a member of the Committee on Air Mobility Research and Technology through the Aeronautics and Space Engineering Board of the National Academies of Science, Engineering, and Medicine. This report was commissioned at the request of NASA and published in February 2020. It lays out a roadmap of recommendations to NASA and other government agencies to support advanced aerial mobility private sector innovation and U.S. leadership in aerospace.

Peter is a standing member of the Transportation Research Board's New Users of Shared Airspace Committee, through the National Academies of Science, Engineering, and Medicine.

Peter advises the Choctaw Nation of Oklahoma, a participant in the FAA's UAS Integration Pilot Program and NASA's UAM Grand Challenge program, on a strategy to establish a national test center for advanced aerial mobility.

Peter conceived of and patented algorithms and a system for efficient utilization of vertiport resources in a high-scale mobility network, receiving the U.S. Patent, *Vertiport Management Platform*, in 2020. He speaks regularly on advanced aerial mobility at meetings and events:

- World Knowledge Forum- Seoul, Korea
- Vertical Flight Society annual eVTOL Symposium
- CAFÉ Foundation annual electric flight conference
- Revolution.Aero Urban Air Mobility conference
- NASA Ames Unmanned Traffic Management events
- NASA Urban Air Mobility Grand Challenge events
- Small UAS Coalition
- Commercial UAV Expo
- U.S. Helicopter Safety Team Infrastructure Summit

Prior Venture Capital Experience

Prior to Radius, Peter was at Firelake Capital and Atlas Venture. As an investor, Peter built valuable experience investing in hard technologies (materials science, sensing, robotics, chemical processes, manufacturing) being commercialized into complex value chains and with regulatory risk factors.

Peter's entrepreneurial experience began while an undergraduate, when he co-founded Eye Response, Inc., a company that pioneered computer eye-tracking systems and was acquired by Dynavox, a company in the medical devices industry.

Education

MBA, with High Honors, from the University of Chicago Booth School of Business, 2005
BS, with Distinction, in Systems Engineering from the University of Virginia, 1997.

Pilot and Other

Peter started flying when he was 19 and actively maintains a Private Pilot Certificate with Instrument Rating. His flight time includes the Citabria, Cirrus SR-22T, Cessna 172, Bonanza A36, Aviat A-1B Husky, Diamond DA-20, and Cessna 152. Peter is an Eagle Scout, avid skier, kite surfer, and mountain biker.



Luka Tomljenovic

Partner, Radius Capital

Luka is a graduate of the United States Air Force Academy where he earned a Bachelor of Science degree in aeronautical engineering. While at the Academy, Luka was a soaring instructor pilot, captain of the glider aerobatic team, and a squadron commander leading a unit of 120 cadets. His other achievements include being recognized as the outstanding student in flight test engineering, runner-up in the U.S. national glider aerobatics championship, as well as the recipient of the “Best of the Best” award as the outstanding cadet in his class. Luka is a Distinguished Graduate from the Academy, placing second in the overall class merit out of 937 graduating cadets.

Following the Academy, Luka served in the Croatian Air Force as an officer and fighter pilot. During his 9-year military career, Luka served in numerous leadership capacities, including as a Weapons and Tactics Officer of his fighter squadron, a role given to experts in tactical deployment and innovation. Luka was the youngest pilot to be selected for MiG-21 conversion training, where he was recognized as the top graduate.

Transitioning out of the military, Luka earned an MBA degree from the University of Notre Dame, where he focused on finance, leadership and investment, and graduated Magna Cum Laude (GPA 3.90/4.00). As an MBA student, Luka was part of a 25-member team of equity analysts responsible for managing a \$7m fund, allocated out of the university endowment fund. In addition to developing generalist investment theses, this experience included developing fundamental, EPS forecast, and technical analyses, as well as introductory exposures to taking long/short positions based on industry and economic analyses.

Subsequent to graduate school, Luka joined a \$17b automotive Tier-1 supplier (Delphi Automotive, now Aptiv) and worked in corporate finance, corporate development, and M&A roles. His experience included leading budget and planning processes, developing long-term financial projections, scenario / sensitivity planning and analysis, supporting acquisitions and divestitures, strategic business modeling for the CFO, as well as leading initiatives generating \$80-100m of annual improvements in working capital cash flow. Luka was also the finance lead for a ~\$50m product line where he led a 10% manufacturing performance improvement, doubling budget targets.

Prior to joining Radius Capital, Luka was a Partner at Airbus Ventures, an early-stage venture capital fund backed by Airbus, where he was responsible for global capital deployment and deal making. While at Airbus Ventures, Luka led a wide range of deep-tech investments in technologies strategically aligned with Airbus' vision of the future of aerospace, including autonomous systems, electric aviation, battery technology, factories of the future, robotics, drones, space systems and technologies, materials, quantum computing, AI hardware etc. Luka gained substantial exposure to the top engineering and business leadership at Airbus, benefitting from discussions shaping aerospace innovation at Airbus, including drones, airliners, helicopters, urban air mobility vehicles, military aircraft, satellites, and rocket launchers. Luka was responsible for developing standards for deal review processes, including diligence and investment memos. He is an active speaker and thought leader and serves as a mentor to startups and accelerators.



Carl Page

President, Anthropocene Institute

Carl Page is President of the Anthropocene Institute. He is a co-founder of eGroups, Inc., where he helped build a network of 14 million users who relied on eGroups to support Web-based collaborative work efforts. eGroups was eventually acquired by Yahoo! and is today known as Yahoo! Groups. A serial entrepreneur and investor based in the Bay Area, Mr.

Page's experience ranges from hardware to Internet companies, and from startups to large multinationals. He has previously held positions at Microsoft and Mentor Graphics. He sits on various boards, including the Michigan State University Computer Science and Engineering Advisory Board, the National Advisory Committee to Electrical Engineering and Computer Science and the Michigan Memorial Phoenix Energy Institute at University of Michigan, and the Board of EcoAmerica.

Carl is a graduate of the University of Michigan, with a BSE in computer engineering (1986) and an MSE (1988).



Frank Hiroshi Ling, PhD

Chief Scientist, Anthropocene Institute

Frank Hiroshi Ling is chief scientist with the Anthropocene Institute. He has previously consulted for various US and Asian organizations, including the Asian Development Bank (ADB) and Jane Capital Partners. Dr. Ling was also a research fellow at the Institute for Global Environmental Strategies (IGES) and at Ibaraki University. He is editor of the book

Climate Smart Development in Asia: Transition to Low Carbon, Climate Resilient Economies and is a contributing author to the publication The Energy Revolution Will Save Japan. Dr. Ling has been an expert reviewer for the Fifth Assessment Report for Working Group III of the Intergovernmental Panel for Climate Change (IPCC).

Dr. Ling received his PhD from the Department of Chemistry at the University of California at Berkeley and was a post-doctoral fellow at Lawrence Berkeley National Laboratory and the Energy and Resources Group at UC Berkeley. Frank received his BS in Chemical Engineering from Caltech and his MS degree from the University of California at Santa Barbara.



Richard Chan

Executive Program Manager,
Anthropocene Institute

Richard is focused on the development of climate impact programs and its application toward positive economic and health outcomes for at risk communities, and is the director of Outreach at the Anthropocene Institute.

Sporting a portfolio that spans from a 13-year career in the US Federal government as a patent prosecutor appearing before the federal appeals court, to a career as an entrepreneur building out mobile recording studios for Grammy award-winning producers and talent, Richard Chan has always been drawn to experiences that require him to challenge himself and learn new skills. His service in the government included working as an intellectual property attache and trade advisor for the State Department under President Obama to spear-heading an agency-wide action plan for restructuring a 1200+ member USPTO Technology Center into flexible art units that could organize and distribute varied patent cases with great efficiency.

His passion for building effective teams, articulating strategy and identifying talent has earned him business deals around the world. As managing director of Decix Technologies, Richard leverages his years as a Federal prosecutor for intellectual property cases to offer intellectual property strategy and consulting to a number of different companies and organizations. His entrepreneurial and invention experience also translated into joining the AAAS-Lemelson Invention Committee member and invitation to speak multiple times as an intellectual property specialist at SBIR.

As Executive Director of Outreach at Anthropocene Institute, Richard oversees the inception of two online games to increase numeracy among young people. His efforts include due diligence on investment projects in COVID-19 treatment, desalinization, commercial scaled drones, AI communication protocols for air travel, and mechanical technology for magnetic coil wheel applications. Richard also organized the company's debut at SXSW, until the 2020 pandemic closed the event but inspired him to help create a partnership between Anthropocene Institute and Stanford SPARK in *Wear to Care*: a promotional campaign encouraging mask-wearing through innovative personalization.

About Radius Capital

Radius Capital is an early stage investor and leader in the software, data systems and enabling technologies driving advanced aerial mobility. We are investors in the scalable technologies binding digital and physical world systems to drive productivity and transform industrial and transportation/mobility paradigms. Our investments encompass enabling technologies broadly applicable to industries impacted by automation, big data, and connectivity, yet our strategy is informed by deep domain expertise and national leadership in advanced aerial mobility, one of the most viable near-term fields of application with broad industry impact across the economy.

Advances in electric propulsion and automation are redefining flight, with implications for transportation, logistics and new applications. The ability to safely and simply access vertical space to move people or goods, independent of roads or terrain, leads to a long-term transformation for society.

Beyond seeking investable opportunities, we actively contribute on the front line of the conversation across public and private sector stakeholders and continually connect entrepreneurs, companies and government entities to push the frontier of the new airspace system. We have converted our early entry into this space into a position of insight, thought leadership and influence. This unique and privileged position translates to relationships and insights extending across private sector startups, large industrials, and the public sector, each of which play a role in the commercialization of advanced aerial mobility across numerous applications.

About Anthropocene Institute

The Anthropocene Institute is an incubator for technologies, policies, and market mechanisms that address global environmental challenges: climate change, biological diversity, and sustainability. We provide due diligence to an investor pool, in areas of scalable change that abate global warming, support ocean conservation, clean water and air through our projects.

Our position in the heart of Silicon Valley, combined with our unique understanding of entrepreneurship, policymaking, and global development priorities provides context in guiding technological, institutional, and financial innovations needed to enable a sustainable planet and prosperous future.

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