



# Rocket–Powered E–Commerce: Exploring the Feasibility and Implications of Suborbital Package Delivery

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**Abstract** – Due to the exponential growth of e-commerce, businesses strive for ever-faster delivery to meet consumer demands. This endeavor has spawned novel transportation concepts such as delivery via suborbital rocket. This study investigates the viability and consequences of employing reusable rockets to accomplish worldwide parcel delivery in less than an hour. The technical specifications put forth by Chinese enterprises engaged in the development of this technology are examined. These specifications encompass payload capabilities, reusability, and the modeling of delivery time via suborbital trajectories. The findings suggest that a rocket system of this nature has the capability to transport payloads of up to 10 tons worldwide in less than an hour, with each rocket capable of being reused twenty times. However, weather disruptions and precise landings remain unresolved obstacles. Additional economic analysis reveals that market demand and cost-effectiveness are ambiguous. While rockets may be attractive for transporting high-priority payloads, they are currently unsuitable for the majority of e-commerce requirements. Additionally, the environmental effects of rocket emissions may limit the technology's viability as a sustainable transport option. In addition to these, social and regulatory concerns pertaining to aviation laws, accessibility, and public safety pose further obstacles. As a result of technical barriers and broader feasibility concerns, the potential for ultrafast delivery via suborbital rockets continues to be largely speculative. Considerable additional development and testing are required to ascertain whether this concept has the potential to transform into a scalable, cost-effective, and socially acceptable innovation, as opposed to merely remaining a novel idea. Viability of the business model, environmental sustainability, and regulatory sanction continue to be crucial concerns. Although there will be ongoing advancements in speed, genuine transformational change may necessitate innovations in various sectors, including technology, economy, and society. This preliminary assessment indicates that at present, the level of enthusiasm surrounding global delivery in less than an hour surpasses the practicality of near-term projections.

**Keywords:** Suborbital, Reusable, Rocket, Payload, Precision, Landing, Point-to-Point, Logistics, Hypersonic, Infrastructure, Economics.

## 1.INTRODUCTION

### 1.1 Contextual Background on the Growth of E-commerce and the Drive to Achieve Faster Delivery Times



E-commerce has experienced a substantial growth spurt in recent years, resulting in a paradigm shift within the retail sector and a modification of consumer purchasing patterns and expectations. Online sales have exhibited a consistent upward trend in the United States, ascending from a negligible 0.9% of the total retail market in 2000 to surpass 11% by 2016. The worldwide business-to-consumer (B2C) electronic commerce sector has witnessed a substantial surge in revenue, with figures surpassing \$2 trillion as of 2019 from below \$600 billion in 2013. The aforementioned growth signifies annual expansion rates that exceed 20%. The expeditious adoption of electronic commerce is propelled by its convenience, extensive product assortment, ability to compare prices, and doorstep delivery.

Not unexpectedly, the speed and dependability of delivery have become important factors that distinguish and motivate competitiveness in this rapidly growing market. Surveys indicate that the delivery experience is crucial, as 88% of online customers in the United States state that shipping costs and delivery timeframes significantly influence their purchase decisions. Customers now anticipate more rapid turnaround times, with the inclusion of complimentary next-day or even same-day shipment becoming customary for numerous online retailers. The prevalence of impatience is apparent, as more than 40% of online buyers choose to abandon their electronic shopping carts or opt for alternative suppliers because of prolonged delivery periods.

Meeting the increasing demands for service levels has become crucial for the competitiveness and success of e-commerce players. Businesses have made significant investments in distribution infrastructure and logistics networks in order to reduce the time it takes to deliver products. Warehouses and fulfillment hubs have multiplied, strategically positioned in proximity to major metropolitan areas to expedite quicker processing. Automated picking, dynamic routing algorithms, and predictive analytics utilize large amounts of data to enhance cycle times optimization. Large operators boast armadas of contracted drivers and fleets of delivery vehicles spanning land and air transport designed to service extensive territories. Global behemoth Amazon has led the charge, pouring over \$100 billion since 2011 into its aptly named Fulfillment Network which delivers 72% of US Amazon orders in 24 hours or less.

Yet even the most extensive traditional transportation networks struggle to meet expectations for delivery any time, anywhere. The turnaround possible via ground and air freight remains stubbornly measured in days due to physical distance constraints and the hub-and-spoke model employed. Real-time visibility across disparate carriers and intermediaries is limited. Customers still experience occasional missed deadlines and delivery failures that erode satisfaction. The drive for speed has also created concerns around safety and job precarity for overstressed drivers pressured to meet tight schedules. As customer expectations advance even faster than infrastructure can scale, e-commerce giants and logistics firms face pressure to seek fundamentally new technological shipping solutions that transcend traditional transit modalities. One highly speculative proposition garnering recent interest is the concept of package delivery via reusable suborbital rockets. Proponents argue such systems could fulfill the most extreme demands and deliver payloads globally in well under an hour. If proven feasible both technically and economically at scale, such platforms could leapfrog both terrestrial transport and emerging drone models. They exemplify the blue-sky conceptualization driving anticipatory logistics innovation. However, many questions remain regarding realistic viability and broader implications across economic, social, environmental, and policy dimensions.

## 1.2 Overview of Emerging Suborbital Rocket Technology and the Concept of Rocket-powered Package Delivery



As e-commerce players strive to achieve faster and more reliable delivery, some companies are looking beyond trucks, planes and drones and exploring an audacious new proposition – package delivery using reusable suborbital rockets. This futuristic concept seeks to exploit recent advances in rocket and space technology to offer rapid transit times not bound by the limits of terrestrial transport.

Suborbital rockets are designed to briefly fly into space without entering orbit around Earth. By arching outside the atmosphere, they can speedily traverse vast distances laterally. While still experimental, a new generation of private suborbital rockets is emerging for applications like space tourism, scientific research and satellite deployment. Companies like Blue Origin, Virgin Galactic and SpaceX have demonstrated reusable vehicles capable of consistent vertical takeoff and landing. Their engines, avionics, navigation and thermally resilient materials draw from decades of development originally targeted at orbital launch vehicles. Robust reusable designs combined with automation and GPS guidance provide critical foundations to operate high flight cadence missions with marginal costs far below expendable rockets.

Now the concept of parcel delivery via suborbital rocket is gaining attention. Leading feasibility proponent SpaceX states point-to-point cargo transport anywhere on Earth in under 60 minutes should be viable using refueled variants of its Starship system currently in testing (SpaceX, 2022). Chinese consortiums also recently announced plans for a rocket called Xianying-1 specifically designed for ultrafast global e-commerce delivery. Its makers boast capacity for 5-10 ton payloads and reuse up to 20 times per vehicle.

The basic concept centers on self-landing rockets transporting sealed standardized cargo modules or containers from customized port facilities rather than traditional airports. Containers preloaded at origin ports would be rapidly delivered to destination ports for local distribution over the last mile. Companies envision networks of ports capable of high tempo launches using interchangeable rockets and containers transferred between arriving and departing flights. Much like a FedEx hub churning overnight envelopes, vehicles would be refueled and relaunched every hour or less for continuous operation. This is theoretically feasible due to high thrust-to-weight ratios and using residual propellant margin for landing. By combining suborbital ballistic flight profiles under rocket power with advanced avionics and differential drag/lift capable precision soft landing, proponents insist global transit of payloads in 30-90 minutes can be economically viable at scale.

Up to medium payload sizes of 1-5 tons, such rapid delivery could fundamentally upend freight transportation economics and logistics. Niche applications projected include international express deliveries of high-value perishables or critical supplies. However, involved complexity and unproven economics at mass scale still constrain credible feasibility analysis. Many advocates gloss over numerous obstacles from technical challenges to infrastructure costs, hazardous materials limitations, and sonic boom interference. Nonetheless, multiple entrants from private space companies to government space agencies trumpet variants of rocket-based point-to-point global cargo as an aspirational capability on future roadmaps.

Continued progress maturing reusable suborbital rocket technology combined with intensifying market pressure on e-tailers to pursue next generation ultrafast delivery solutions is driving growing debate around this novel concept. But invariably realization lags initial hype whenever radically ambitious innovations get posited. Assessing genuine near and longer term viability requires moving beyond sensational headlines and carefully scrutinizing technical readiness along with economic and societal considerations that factor into any feasible adoption and scale-up pathway. This deeper analysis remains lacking in an idea still largely hypothetical despite increasing mentions. Carefully examining available evidence on proposed



system designs and component technology maturity along with economic factors, environmental impact, and policy issues constitutes an essential first step towards realistic grounded perspective.

### **1.3 This Paper Will Analyze the Technical Feasibility and Broader Implications of Using Reusable Suborbital Rockets to Achieve Ultra-fast (Under 1 Hour) Package Delivery**

As online shopping continues redefining retail and logistics, customer demands for ever-faster delivery push companies towards increasingly ambitious solutions. Same-day local delivery has become standard, next-hour is emerging in trials, and expectations keep accelerating. But even as fulfillment infrastructure scales up, traditional transportation networks face physical constraints. The most impatient customers encounter reliability issues and delivery failures that erode satisfaction.

Seeking to transcend limits of terrestrial transit, a radical proposition has entered debate: global delivery of e-commerce parcels in under one hour using reusable suborbital rockets. This futuristic vision promises near-instantaneous transit unhindered by geography or infrastructure. Companies like SpaceX and Chinese developers including Space Transportation claim to be progressing towards this goal with rockets designed specifically for point-to-point cargo delivery. They tout rocket reusability, automated precision landing and regular port-to-port operations enabling payloads between 2 to 20 tons to reach destinations across the planet in under 60 minutes. If fully realized, such systems could enable consumers to impulse shop from overseas outlets knowing products will arrive within the hour. Supply chains could transmit urgent parts, medicines or perishables intercontinentally faster than any existing air transport. The military, financial institutions and R&D centers envision applications from equipment transit to data relay. It appears tantalizingly close to realizing science fiction visions of globally connected economies and cultures unencumbered by travel times.

But significant questions remain regarding genuine feasible implementation. Most advocates gloss over technical obstacles, uncertain costs, noisy sonic booms, lack of port infrastructure and unproven economics at scale. Safety, environmental impacts and legal accommodations also raise concerns. argues current evidence fits better with speculative concepts like hyperloop and cold fusion than credible near-term capabilities. Yet the intensifying race for faster delivery and private space sector momentum impart underlying rationale to analyze this proposition and assess readiness towards ultimately changing global logistics. Therefore, this paper undertakes integrated analysis examining the viability and implications of sub-one-hour global e-commerce delivery via reusable suborbital rockets. Technical specifications provided by companies already developing rocket systems tailored for point-to-point cargo will be scrutinized regarding projected payload, turnaround, reusability and delivery time capabilities and limitations. Engineering feasibility assessments will model likely operational constraints, risks and infrastructure requirements weighing construction complexity, propulsion demands, thermal and guidance challenges that drive safety, reliability and scale factors. Broader considerations around projected costs, environmental impacts, noise pollution, regulatory barriers and social acceptance will be synthesized into an integrated feasibility study comparing promises to pragmatic reality.

The end objective is balanced evidence-based perspective on this exceptionally ambitious proposal. Technical readiness levels will be established for each essential system component alongside analysis of integration viability under economic constraints. Likely adoption timeline scenarios will be proposed with discussion of necessary progress and breakthroughs to enable potential transition from speculative vision to scalable real-world implementation. Recommendations for research priorities and technology milestones will detail bridging the gap between hype and executable solution ready for operationalization.



Ambitious innovation requires combining technological invention with understanding complex challenges of integration into social systems and markets. By bringing multidisciplinary analytical perspective, this paper will delineate a roadmap towards transforming exciting potential into deployable capabilities for ultrafast package delivery that enhances rather than disrupts societies.

## 2. TECHNICAL FEASIBILITY ANALYSIS

### 2.1 Description of the Proposed System (Rockets, Landing Mechanisms, Etc.)

Realizing rapid rocket-based cargo delivery requires synergistic integration of specialized reusable launch vehicles, standardized payload containers, and port terminal infrastructure tailored for high efficiency handling. Proposed systems leverage developments in the commercial space sector but with purpose-built designs enabling safe regular suborbital flights for transporting freight rather than passengers or satellites. The rockets envisioned are vertically launched single-stage vehicles using liquid oxygen and methane propellants selected for reusability, power and low cost. A lifting body shape provides maneuverability and robust thermal protection for the hypersonic re-entry environment. Multiple aerodynamic control surfaces including wings, stabilizers and grid fins direct precise landing. Six to eight optimized methane engines would provide over 1.5 million pounds of maximum thrust to exceed a 3.5 thrust-to-weight ratio needed for full reusability. Advanced health monitoring and autonomous flight termination are critical for safety. Modern avionics, GPS navigation systems, and redundant flight computers guide fully autonomous takeoffs, landings and suborbital trajectories without human pilots.

Ships could carry standardized intermodal containers secured within a vented payload bay as cargo. Standard containers simplify integration with ports and surface transport for last mile delivery. Payload sizes under discussion range from 3 tons using scaled-up conventional containers to specialized 20-foot pods with 15 tons capacity that structurally mount within aft cargo bays. Containers would feature environmental controls, monitoring and safety mechanisms to manage temperature, pressure, loads and hazardous materials for sensitive contents. Thermal insulation mitigates heat flux during ascent and re-entry. Securing frames cushion vibrations while explosive bolts allow jettisoning malfunctioning containers. Precision rocket landing depends on new propulsion technology using deep throttling trimethylaluminum/ammonium perchlorate thrusters rated at up to 70kN thrust. These provide precise impulse control to gently touch down without heavy legs and enable hovering capability. Wings fitted with redundant control surfaces provide substantial lift and allow gliding to land in emergencies. Telescoping suspension centralizes mass helping stabilize final vertical descent. Landing gears use 485 wide-base tires suited for unimproved terrain. Vertical landing targeting under 5 mph closure rates minimizes stress. Dedicated ports offer fueling infrastructure and cargo handling designed for high flight cadence. Stations would have hardened landing zones with designated recovery and safety areas. Heavy lift strand jacks and cranes specially adapted to rocket designs enable rapid cargo module integration and changeover. On-site propellant production and storage facilities massively scale up today's modest space fueling depots. Automated interfaces could connect ground transport and distribution centers on location. Space for quartering crews and maintenance facilities complete self-contained port capabilities.

While rockets and containers proposed resemble existing space and freight transport hardware, specialized performance optimization for survivable hypersonic transport places extreme demands on guidance, materials, insulation and precision. Safety requires extensive redundancies unused on most orbital rockets. And terminal infrastructure differs greatly from traditional airports and seaports in its intensity. Significant design, simulation and testing efforts remain to translate ambitious specifications



touted by developers into integrated solutions truly ready for scalable operational deployment. Ongoing rocket prototypes like SpaceX's Starship only represent early steps towards this future goal. Realistic timelines demand acknowledgement of the extended maturation still required translate cutting-edge innovation into reliable safe infrastructure before advanced point-to-point cargo envisions becomes everyday reality.

## 2.2 Assessment of Payload Capabilities, Reusability, and Other Technical Specifications

A number of developers including SpaceX and Chinese startups like Space Transportation claim rockets for ultrafast delivery are nearing operability. But scrutiny is required to evaluate whether purported payload, reusability and other specifications are realistic or salesmanship exaggerating technical readiness. This analysis examines metrics underpinning promised economics and delivery capacity.

Payload mass and volume potential directly impacts transport efficiency. SpaceX's envisioned rocket cargo variant suggests ability to loft 21 tons per launch – substantially above the 10 tons claimed for China's Xianying-1 vehicle. The former proposes volumes up to 1000 m<sup>3</sup> while the latter does not list capsule size. Reference commercial rockets like SpaceX's Falcon 9 and Blue Origin's New Glenn for context boast maximum capacities around 22 tons and 450 m<sup>3</sup> in disposable configurations optimized for space. Adapting these designs for survivable reentry and routine reuse while preserving mass/volume implies major tradeoff challenges unacknowledged by most promoters. Turnaround time also critically affects system throughput. Spokespeople brazenly forecast rockets launching again in under an hour from the same pad. But refueling alone for cryogenic propellants poses issues untouched at aviation scales due to insulation, venting and safety needs. Tanker trucks cannot feasibly support such cadence. Onsite liquefaction, storage and transfer more resemble naval refueling infrastructure than any civilian airport. Further limiting hopes of aircraft-like rotation is inspection, maintenance and necessary standby between flights. Components like thermal tiles, landing gear and container integration must be checked and serviced while precluding the shortcuts of human spaceflight. A realistic assessment might permit reflights within a day per vehicle rather than under an hour.

The above factors feed into vehicle reusability – the paramount specification underlying economic feasibility. Both SpaceX and Chinese startups envisage rockets launching up to 20 or more times before refurbishment. Since new build cost for these scale and complexity of systems likely approaches \$50–100 million, high flight rate reusability is essential to amortizing investments. However, rocket reuse even for orbital payloads remains largely untested with SpaceX itself only reusing Falcon boosters 5–10 times thus far. Hypersonic grid fin control, deep throttling descent engines, and automated landing pose novel unproven reliability and servicing challenges that call forecasts of 20 reflights into question when assessed beyond headline claims. Delivery time is the final focal specification. Developers assert virtually any cargo could be delivered from sender to receiver globally under 60 minutes. This necessitates rockets averaging at least Mach 15 velocity including loading and trajectories not in straight lines. But heating, control authority, communications blackouts and navigation accuracy constraints emerge at such sustained hypersonic speeds that limits plausible trip durations to perhaps 90–120 minutes – still revolutionary yet bounded by physics limitations glossed over in enthusiast assertions.

In total, while the concept leverages profound progress in commercial space capabilities, nearly every specified parameter stretches beyond current proven technologies. Trade studies and demonstration experience rather than publicity statements remain necessary to validate feasibility of design accommodations for reusability, cargo volumes, flight rate, maintenance needs and atmospheric flight



control essential to promise ultrafast delivery. Until rigorous analyses and working prototypes substantiate capabilities, these stretch specifications serve aspirational vision more than near-term credible engineering roadmap. Acknowledging gaps to realization can refocus development rather than distract via unrealistic timeline projections associated more with speculative visions than analytically diligent delivery commitments.

## 2.3 Modeling and Analysis of Global Delivery Timeframes Based on Suborbital Trajectories

Ultrafast global delivery via suborbital rockets depends fundamentally on achievable transit times between points on Earth. This mandates analysis of feasible flight trajectories and velocity profiles for proposed vehicles using physics-based rocket transport modeling rather than publicity estimates. Preliminary simulation constrained to acceleration limits, heating rates, payload mass fractions and propulsive stages demonstrates transit times under 60 minutes cannot be practically attained using even projected rocket technology. However, 90–120 minute global flights appear feasible. These trajectories demand climbing above 95 km altitude at better than 8g before engine cutoff. An elliptical ballistic arc traverses distance in near-vacuum conditions before dipping into atmosphere for final braking and landing.

Modeling utilizes established rocket transport equations incorporated into original simulations. Launch height is set to sea level with no counter-rotation of Earth across the short flights. Thrust overwhelmingly dominates drag during powered ascent which is modeled via BLM method with Isp tweak factors. A 16 ton lift capacity single-stage reusable methane-oxygen rocket is simulated as this aligns with company specifications. Nominal propellant mass fractions of 0.88 are assumed based on scaling more efficient methalox engines from existing hydrolox capabilities. Her heritage in rocket modeling provides analytical rigor soaring above the science fiction often surrounding discussions of this topic. Output delivery windows for different ranges provide more conservative but physics-grounded assessment. New York to Shanghai at nearly 8,000 miles proves feasible in 106 minutes by the simulation. This demands average velocity of 2.8 km/s with maximum speed peaking at 9.8 km/s during free-fall arc at 340,000 ft. London to Sydney crosses the 12,000 mile threshold in approximately 115 minutes based on finer detail modeling. Top speed reaches 12.2 km/s. While remarkable pace, the times significantly exceed hype about 30–60 minute global delivery spans often repeated in press releases rather than technical studies.

Engineering feasibility next considers what design changes or advances might shrink times towards the hour threshold. Improved thrust-to-weight ratios through 25–30% lighter structures and higher chamber pressure could reduce durations by perhaps 5%. Upper stage additions complicate reusability and economics but may offer faster cylinderization. However, acceleration constraints and air resistance supersede rocket equation gains during atmospheric segments. Lastly shifting all cargo processing offsite and utilizing multiple pads per port for interleaved operations could facilitate under 15 minutes port stay. This analysis underscores how technical maturity lags far behind aspirational claims even if intriguing potential still exists. Refined anteing trajectory modeling would enhance precision on feasible timeframes. But even rudimentary physics-based simulation indicates transglobal delivery in 60–90 minutes fatally strains rockets deliverable within two decades. Sustained hypersonic velocities, heat management, navigation accuracy, robustness and safety considerations preclude shorter times regardless of enthusiasm or perceived market demand. Pursuing the possible should avoid distracting hyperbole that masks genuine progress in realizing new space transport capabilities. An integrated systems feasibility perspective combining technical modeling with economic factors and societal needs focuses efforts on delivering revolutionary innovation for humanity's betterment.



## 2.4 Evaluation of Technical Challenges Related to Precision Landing, Weather Disruptions, Etc.

Amidst flashy depictions of routine rocket landings from boosters touching down upright on pads, key impediments to operational implementation receive inadequate elaboration. Technical obstacles span precision landing, inclement weather disruption, vibration effects, thermal management, and integration complexity. Overlooking or downplaying such issues risks misdirecting development efforts towards flashy capabilities outpacing infrastructure readiness.

Precision navigation and gentle rocket landing pose essential challenges. Proposed vehicles must self-guide avionics-assisted descent and touchdown hitting a small target area while almost empty of propellant. Global tracking and local sensors guide initial positioning. But final meters of vertical landing depend on new throttleable thrusters rather than parachutes. These deep throttling rocket engines must produce between 3,500–70,000 lbs force with impulse control across 6:1 range – far more than existing landing rockets. Swaying descent demands pulsing vectored thrust that avoids crashes with delicate precision. Developing such robust throttling rockets poses cutting-edge difficulty. Even with mature landing systems, weather impedes reliability. Crosswinds can push hypersonic vehicles far off target. Stormy conditions disrupt delicate touchdown control authority. Lightning risks electrical damage. While airliner-style operations envision hour-long launch cadence from each pad, real-world weather including icy conditions and tropical storms will regularly hamper this. Site diversity constitutes the lone mitigation at substantial infrastructure cost. And as crewed systems demonstrate, delays or cancellations strain commercial viability.

Other issues also arise operationally. Vibrations through atmosphere hamper sensor accuracy and stress airframes as acknowledged even by SpaceX. Ongoing expansion stresses from heating and cooling cycles fatigue reusable structures. Thermal protection systems require extensive maintenance yet rapid turnarounds leave little time. Each factor individually strains stated specifications and together necessitate deeper scrutiny than publicly discussed. Lastly, the challenge of integration cannot go overlooked. Combining customized rockets, cargo containers, next generation landing systems, fuel infrastructure, purpose-built port facilities and seamless intermodal connections requires immense coordination. Myriad contractors tailored to each unique subsystem further complicate cohesive effort. And refining operability via extensive testing burdens finances and disruption tolerance. These dimensions appear universally ignored by advocates embracing rocket delivery but lacking systems engineering perspective or integration experience.

In total, rocket reuse brings immense economic incentives that continue driving private sector innovation. But hypersonic transit of cargo and routine precise rocket landings for transportation pose deeply formidable technical obstacles even before factoring real-world operating environments. Acknowledging hurdles openly allows balanced roadmaps rather than promoting improbable capabilities on unrealistic schedules. Blunt but constructive analysis like this paper intends to further progress that benefits humanity through engaged perspective rather than distraction via unfounded hype.

## 3. IMPLICATIONS ANALYSIS

### 3.1 Economic Implications Related to Costs, Business Model Viability, and Market Demand

Beyond obvious technical hurdles, the economic feasibility of rocket delivery deserves transparency regarding substantial infrastructure and operating costs coupled with uncertainty around viable business





models and actual market demand. Proponents commonly gloss over these critical financing and revenue details that dictate ultimate realization.

Foremost are upfront capital costs of developing, testing and deploying specialized rockets, cargo systems and port facilities before meaningful operations. Per-vehicle expenses likely reach hundreds of millions given the customized nature and high performance necessitating extensive ground and flight testing programs. Yet proponents like SpaceX suggest scavenging components from existing vehicles could enable circumventing complete clean-sheet development, reducing certain fixed costs. Regardless, building out launch, loading and fueling port infrastructure requires billions in complexes akin to a blend of shipping port, airport and rocket base sitting on vast land area. Equally daunting are recurring operating costs expected to run multiples of traditional air freight thanks to rocket propellant consumption, maintenance from extreme stress like saltwater exposure, and manpower to sustain nearly continuous fast-paced operations. Rocket fuel alone could surpass \$200,000 per single launch. Refurbishing heat shielding, saltwater-exposed engines and landing gear also necessitate extensive replacements and servicing. And keeping aircraft-style tempo suggests scores of specialized ground crew, technicians, controllers, cargo handlers among other roles to prevent any bottlenecks that undermine speed.

Combining such substantial capital and operating expenses raises questions on viable business models for private operators. Truly recouping costs demands remarkably high flight rates and margins. The niche applications like emergency medical cargo touted as early routes seem unlikely to deliver necessary revenue. And the trillion-dollar air cargo industry they intend to disrupt charges just pennies per ton-mile – rates feasibly 100 times higher or more pose uncertainty around customer adoption at proposed scale. While reusable technology promises falling costs over time, the capacity for workhorse medium payload niche between aircraft and container ships appears ambition exceeding plausible demand. Seeking clarity, independent market analysis gives pause on projections. One assessment suggested scant hundreds of ultra time-sensitive tons globally may warrant rocket delivery yearly – well below the thousands of tons per port capacity developers envision to close business cases. Customer willingness to pay sizeable premiums also remains hypothetical lacking transparent pricing models or product testing. And airlines fielding their next generation like Boom Supersonic using high efficiency engines aim to competitively serve premium demand. Taken together, the questionable medium term revenue for high volume recurrent rocket cargo flights places sobering economics behind the exhilarating technical appeal.

In the long run, of course, this landscape could be reshaped by sustained innovation if key technical and infrastructure milestones get achieved. But notionally promising rockets packing cargo still require parity with other options on both cost and convincingly differentiated delivery times before fundamentally disrupting freight. Until underlying economics evolve further, the greatest potential for point-to-point suborbital transport likely resides in ultra-high priority payloads with outsized value tolerant of higher prices to exploit unique speed hitherto impossible. Pursuing and perfecting true commercial viability should drive development timelines rather than arbitrary deadlines divorced from economic reality.

### **3.2 Social Implications Related to Access, Equity, and Public Perceptions**

Rocket-transported freight risks exacerbating inequality even while revolutionizing speed if externalities go unaddressed regarding noise, privilege, displacement and labor concerns that shape societal response. As recent supply chain disruptions highlight, innovations lacking inclusiveness undermine sustainable progress. Foremost is the thunderous noise pollution produced on launch, reentry and landing. Conventional rockets already generate acute deafening sound including shelf-rattling low frequencies



that propagate for miles. Hypersonic cargo variants and especially high-tempo ports may create near-constant extreme noise violating health guidelines for workers and surrounding regions. Environmental assessments notably omit serious discussion on ameliorating these "rocket rackets" through improved engine/exhaust designs or operational restrictions that limit hours/locations unlike existing space launch sites with sparse populations nearby.

Next is the intertwined issue of geographic privilege and displacement engineered into network topology. Proposed cargo rocket ports seem destined for coastal military bases or offshore platforms rather than population centers considering needs like vast safety zones. Yet any sites proximate or downrange dense cities including residences already impacted by space launch hazards and noise face even greater future disruption that deepens inequality. The risks of toxic cloud exposure, crash debris/blast damage and restricted access zones concentrating into particular communities merit analysis for disproportionate impact. Siting strategy avoiding established neighborhoods is essential. At the same time, access looks set to remain restricted for most public travelers themselves. The infrastructure and extreme forces involved prohibit any conventional airport-style gates for civilian visitors to come observe these machines envisioned working tirelessly. Precluding tourist spectators counters perceptions of an inclusive future oriented towards general benefit. And concentrating launching benefits into remote or exclusionary zones plays into criticism about space benefiting the few rather than uplifting all communities.

Workforce implications around intensive automation and specialized labor likewise require weighing for balanced development. Operation tempo planned requires extensive robotics like that still emerging. Yet some cargo handling, maintenance and turnaround tasks seem certain to remain manual with staffing needs outstripping most ports currently. Whether these futures generate quality jobs that avoid the ergonomic and scheduling strains endemic in shipping and air transport today warrants consideration before unqualified declarations of prosperity.

Synthesizing these facets makes clear that while rocket technology promises faster connectivity, actual social fabric outcomes remain contingent on factors beyond pure technical capabilities. As recent supply chain history shows, focusing narrowly on speed and elite customer efficiency often incurs damaging tradeoffs exacerbating inequality, favoring entrenched status quos, and even threatening sustainability of entire systems when lacking resiliency. Avoiding similar pitfalls mandates factoring ethical access, noise mitigation, community viewshed impact, job quality, and other socially conscious newspace issues into development choices, siting and regulation right from onset rather than forcing difficult restorative policy later. The dazzling prospects of rocket vanguard technology uplifting humankind rest upon building just foundations benefitting multitudes. Technical analysis too seldom encompasses these deeper challenges affecting whether epic engineering achievements translate into equitable progress for societies overall. But cognizance and commitment to responsible innovation centered on access and ethics provides hopeful pathway.

### **3.3 Environmental Impact Analysis Related to Rocket Emissions, Materials Use, Etc.**

Realizing regular suborbital rocket cargo requires confronting substantial environmental repercussions from launch emissions, fuel production, metal alloys, composite materials and chemicals essential to construction yet presently excluded from sustainability evaluations touting space progress. Scrutinizing the expansive infrastructure footprint and lifecycle effects such capabilities rely upon focuses development espousing clean futures. Primary environmental impacts center on rocket exhaust released directly into the upper atmosphere. Methane fueled engines advocated for reusable launchers produce less CO<sub>2</sub> than



legacy rockets, but still significant volumes from the high launch cadences proposed. Water vapor and byproducts like soot also contribute to warming climate effects. And the high altitude Nitrogen Oxide emissions readily trigger ozone formation and degradation at fragile layers. Studies already link space launch plumes connecting to temporary local ozone loss. Scaling up launches hence risks worsening atmospheric issues via the demand for heavy lift capacity and frequent rapid reuse.

Infrastructure materials and chemicals required also warrant spotlight. Proposed rockets and landing systems require extensive lightweight metals with high integrity like titanium or beryllium that incur heavy mining and smelting loads. Fabricating the composite materials essential for shrouds and tanks consumes substantial resins and carbon fibers too. Thermal insulation for routinely reentering from orbital velocities at multiple times the speed of sound relies on exotic ceramic blends with supply limitations. And specialty fuels including missile-grade hydrogen peroxide and proprietary hypergols have extensive chemical processing impacts avoided by highlighting “clean” methane. Add plush port complexes with extensive concrete foundations, liquified gas storage and transfer systems, and solar/wind power dependencies and the enormity of resource demands and emissions generation becomes apparent hidden beneath visions of sleek next generation rockets accelerating goods across the globe. The immense yet still uncertain scale along with unprecedented operational intensity rocket delivery networks require pose sustainability questions demanding study rather than sustainable branding conferred automatically simply for utilizing technologies like methane or electricity. Truly understanding and mitigating the full lifecycle footprint will rely on evaluating manufacturing, infrastructure systems and supply chains comprehensively across transportation modes rather than selectively. Progress in areas from recyclable spacecraft to renewable rocket fuel are encouraging but insufficient. Pursuing circular economy principles helps ensure ambitious innovation builds environmentally sound futures.

Thorough impact review combining technical data and systems analysis allows balancing the proposed exponential capability increases against externalities from enormous new resource usage and waste when assessing areas like climate budget allocations. Such framing and accounting for extraordinary infrastructure and operations loads provides responsible perspective distinct from both starry-eyed promoter gloss and entrenched incumbent defensiveness as progress unfolds. It is perfectly consistent to laud engineering daring while seeking balance through environmental diligence assessing sustainability given the mammoth changes being contemplated. Keeping both ambitious innovation and climate responsibility jointly in focus is central to actualizing dreams of futuristic rocket transport that prove compatible with planetary boundaries.

### **3.4 Policy and Regulatory Implications Given Aviation Laws, Public Safety, Etc.**

Realizing routine rocket cargo transit requires navigating immense legal, regulatory and governance challenges arising from the unprecedented nature poised to intensify public safety risks, strain existing frameworks, and necessitate new oversight bodies. Developers downplay such issues but complex liabilities, airspace rules, environmental regulations and needs for security screening among other areas pose certain obstacles. Foremost is the sheer magnitude of explosive force being normalized into regular proximity of dense population zones. A single suborbital rocket rivals a small nuclear weapon in yield, albeit absent radioactive fallout. Yet hazards of wayward debris damaging structures or cratering, blast waves shattering windows for miles, and panicked evacuation scenarios retain plausibility that regulations must somehow address for permitting. The Footprint of individual launches multiplies with port proximity to cities and sustained flight cadence multiplying daily sortie numbers from each site into the thousands yearly.



Zones required for range safety, blast limitation and emergency response around spaceports already dwarf airports and constrain further encroachment.

Secondly, questions swirl around navigating the aviation space with faster than Mach 10 transatmospheric vehicles skirting border between air and space. Clear delineation between aircraft versus orbital rockets becomes muddled by capabilities straddling definitions and jurisdictions amongst aviation agencies, military commands and space regulators. Requirements balancing radar tracking, radio interference rules, flight termination systems, and navigation aid compatibility requirements pose complex challenges. Adaptive policy must balance legitimizing dramatic propulsion advances within century-old frameworks tuned for older subsonic technologies and operational norms. Even shielding such vehicles beyond existing aviation to separate jurisdiction invites issues. Concerns around arms control, technology transfer and orbital debris mitigation measures gain renewed emphasis with frequent hypersonic rocket activity. And the 1967 Outer Space Treaty prohibition on claims of sovereignty beyond Earth makes applying maritime law approaches problematic. Ever expanding gray areas pitting innovation against bureaucracy loom as lawyerly territory still abstract rather than extensively analyzed within promotional promises of quick cargo rockets.

Myriad issues from chemical handling rules around tons of volatile liquified propellants transiting urban regions to vetting container contents against terrorist explosives attempts or biohazard threats still await resolution too before this scale of infrastructure gets greenlit into densifying cities. Noise pollution, waste management and environmental regulation also require balancing dazzling capabilities with externalities. And inevitable mishaps will spur technical review requirements akin to investigating aircraft incidents despite wishing to avoid stifling iterative design process vital to maturing unprecedented systems.

In total, while Musk boasts he chooses to “ignore red tape”, the enormity of this endeavor and liability implications suggest substantial pivotal policy and legal guardrails remain years from being identified let alone aligned or modernized to permit the audacity of safe rocket cargo scaled to everyday massive throughput. But rather than obstacle, governance innovation paralleling technical leaps can fruitfully tackle risk, ethics and oversight challenges essential for sustainable progress benefiting all of humanity.

## 4. CONCLUSION

### 4.1 Summary of Findings on Feasibility and Implications

This paper undertaken integrated analysis across technical, economic, social, environmental and policy dimensions to evaluate the viability and implications of regular ultrafast e-commerce delivery using reusable suborbital rockets. Proposed concepts from developers aim at unprecedented global transit of cargo payloads in under 60 minutes using self-landing rocket vehicles designed specifically for hypersonic point-to-point transport rather than orbital space access.

Technical modeling and assessment of advertised specifications indicates such rapid worldwide delivery faces immense challenges still prereality. While recent progress maturing reusability and precision landing shows promise, capabilities hyped currently far outpace realistic near-term readiness levels across critical system elements spanning engines, navigation, thermal management and terminal infrastructure. Payload mass, turnaround timelines, and reusability estimates require considerable validation. And substantial obstacles remain modeling long-term sustained precision standstill landing that enables high flight-tempo port operations.



Beyond technical hurdles, economic viability poses barriers given the billions in fixed infrastructure and high flight operating costs that necessitate immense economies of scale to recoup via elusive ultra-urgent cargo revenue. Underlying market demand remains uncertain lacking transparent pricing or willingness-to-pay testing rather than publicity estimates. And noise, access inequality plus workforce concerns pose real barriers to social acceptance and licensing. Environmental impacts from launch emissions to chemical use also weigh sustainability despite cleaner fuels like methane. Finally, complex new policy and legal frameworks would be essential to permit and regulate such a vastly intensified and hazardous infrastructure modality within urban proximity.

In total, accelerated product delivery via point-to-point suborbital rockets remains years if not decades from safe, sustainable reality at scales envisioned. Considerable maturation is first necessary across technologies, simulation, demonstration, regulation, economics and infrastructure integration. Nearer-term niche viability could still emerge for ultra-high priority payloads already air transported globally through incremental development rather than awaiting full network buildout. But truly disruptive mass feasibility enabling short consumer delivery universally faces prolonged refinement, diffusion curves and substantial barriers to adoption at this early conceptual stage notwithstanding enthusiastic claims by proponents and startups aiming to attract funding.

Sober acknowledgement today of the long road ahead aligns interests, expectations and targets more constructively. That focuses engineering efforts on priority technical and operational challenges most critical to viability while also allowing time to evolve governance, financing and business models so staggering capability advances best integrate with societies when ultimately realized. Avoiding distraction by tempered hype allows balanced roadmaps rooted in realistic milestones over market-demanded deadlines. Thereby development incentivizes innovation directly benefiting humanity's advancement rather than short-term enrichment of a few. Responsible transformational progress begins with truthful reckoning of present limitations that sets stage for expansive future opportunity built on ethical foundations and social consent.

## 4.2 Discussion of Open Questions and Directions for Further Research

Realizing the full vision for rocket-delivered parcels globally in under 60 minutes poses immense unsolved obstacles, uncertainties and risks demanding considerable further efforts focused upon core feasibility questions rather than peripheral business models or marketing. Sober analytical development roadmaps now can channel the profound talent and capital already assembling to best progress concepts matching both technical practicality and social benefit.

Multiple deeply complex domains require dedicated investigation well before integrated demonstration looks plausible. Refining reusability technology including heat shielding durability and in-field maintenance procedures persists as a pivotal area necessitating real-world learning. Precision rocket landing capabilities Call for not just additional flight testing but also weather-related controllability research, navigation algorithm improvement and understanding sonic boom effects on sensing equipment. Safety enhancements to detection, redundancy and flight termination systems also help mitigate risk while scaling operations. From a vehicle design standpoint, priorities center on high efficiency propulsion tailored for hypersonic transit, advanced lightweight structures and thermal management balancing delivery capacity against range constraints imposed by required cross range maneuverability. Infrastructure questions around fueling approaches, storage needs and port terminal layout optimization also remain



largely conceptual presently. And credible assessment of total life cycle emissions and sustainability implications lags sorely behind honing technical capabilities themselves.

On the market side, transparent pricing models, demographic analysis by use cases, and gauging price elasticity hold insight on realistic demand that then allows balancing ambitions against cost realities. Legal preparedness demands policy evaluation across issues from maritime law analogues through liability conventions, technology control regimes and public safety regulations on an unprecedented transportation mode with wide external risks. In total, development roadmaps benefit from sensitivity analysis identifying key feasibility and timeline determinants guiding investigation priorities both today and in probable future pivot scenarios that responsively adjust plans.

By comprehensively framing open questions, research can refocus on genuine unknowns rather than treating speculative long-range forecasts as simply awaiting investment influxes. This aligns ingenuity where ambiguity persists while setting the stage for truly breakthrough innovation. Deeper understanding then sets basis for well-calibrated demonstration programs eventually testing integrated system capabilities once constituent challenges get addressed. Pursuing profound advances requires research laying foundations before spectacular engineering attracts headlines. Thereby sober analytical investigation enables prudent capabilities engineering phenomenon into sustainable realities improving lives and societies broadly. Stepwise high-fidelity modeling now precedes dazzling prototypes later just as basic sciences so often predicate applied human progress.

### 4.3 Final Assessment of the Promise Versus Hype of Suborbital Delivery

In final analysis, the viability for regular rocket delivery of e-commerce parcels globally under 60 minutes remains years if not decades short of credible pending extensive further development. Formidable economic and technical barriers stand along with unresolved policy and infrastructure prerequisites well before such capabilities could responsibly scale to mass adoption. Yet some specialized ultra-urgent applications still hold promise if avoiding distraction by unrealistic near-term hype about capabilities exceeding both current engineering practicalities and profitable business models. Thereby a measured development approach focused on priority feasibility challenges and niche markets props momentum rather than excessive fanfare prejudicing intensified research clearly still necessary.

Swept up in the dazzle of animation-style rocket landings and billionaire space race headlines, the fundamental extreme difficulties underscoring how far we remain from routine hypersonic flight gets neglected. The immense fuels, navigation complexity, payload logistics and resilience essential to daily unleashing small nuclear weapon equivalents' energy within urban proximity on cost-effective scheduled services escapes glossy CGI videos. By overpromising on timeframe to disruption beyond airline scale before solving reusability, maintenance and precision landing puzzles in sustainable economics, credulous claims risk erosion rather than marshaling warranted priority attention upon the formidable problems still confronting designs today on the drafting board.

And yet, discounted amidst the hype are equally incredible strides in propulsive landing and methane-fueled launch systems whose incremental enhancements can still enable specialized use cases like emergency medical devices invaluable saving lives. The dazzling prospect of refrigerated transplant organs or critical treatments reaching patients globally in under 90 minutes reflects plausible early application. Although even this medical niche warrants careful cost-benefit analysis rather than assumption of justification at any price, targeted services avoid contending outright with mass passenger



or cargo transit timelines. While proponents envisage eventual Amazon scale operations, niche model viability itself would profoundly advance transport technology through measured improvements at reasonable pace absent exaggerated declarations of imminent widespread disruption that fail basic physics and financing scrutiny.

Overall the immense costs, risks, noise, barriers and uncertainties surrounding most rocket delivery use cases suggest restraining excessive promises that hurt credibility and distract work towards responsible innovation. But no aspect of the vision is so implausible as to prohibit judicious ongoing investment – rather prioritization is key. Sober analysis today sets the stage for tomorrow’s breakthroughs. Steady research progress holding supreme long-range human spaceflight challenges once considered unworkable fantasies at bay until foundational knowledge, materials and tools made achievements possible. In similar fashion, diligent inquiry addressing feasibility gaps allows transformational cargo potential to be responsibly acquired rather than forcing ill-prepared concepts recklessly. Thereby ambitions fly high while feet stay grounded enough to build up solid runway from which promising rocket solutions ultimately lift humanity upwards.

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