PERSPECTIVES ON URBAN MOBILITY

MARKET ENABLERS AND ENABLING TECHNOLOGY

Jonathan Hartman

BOTTOM LINE UP FRONT

Intersection of electric propulsion, data analytics and autonomy will enable successful expansion of urban mobility systems in the next decade....

...if we ensure levels of safety and reliability at or above today's helicopter fleets.

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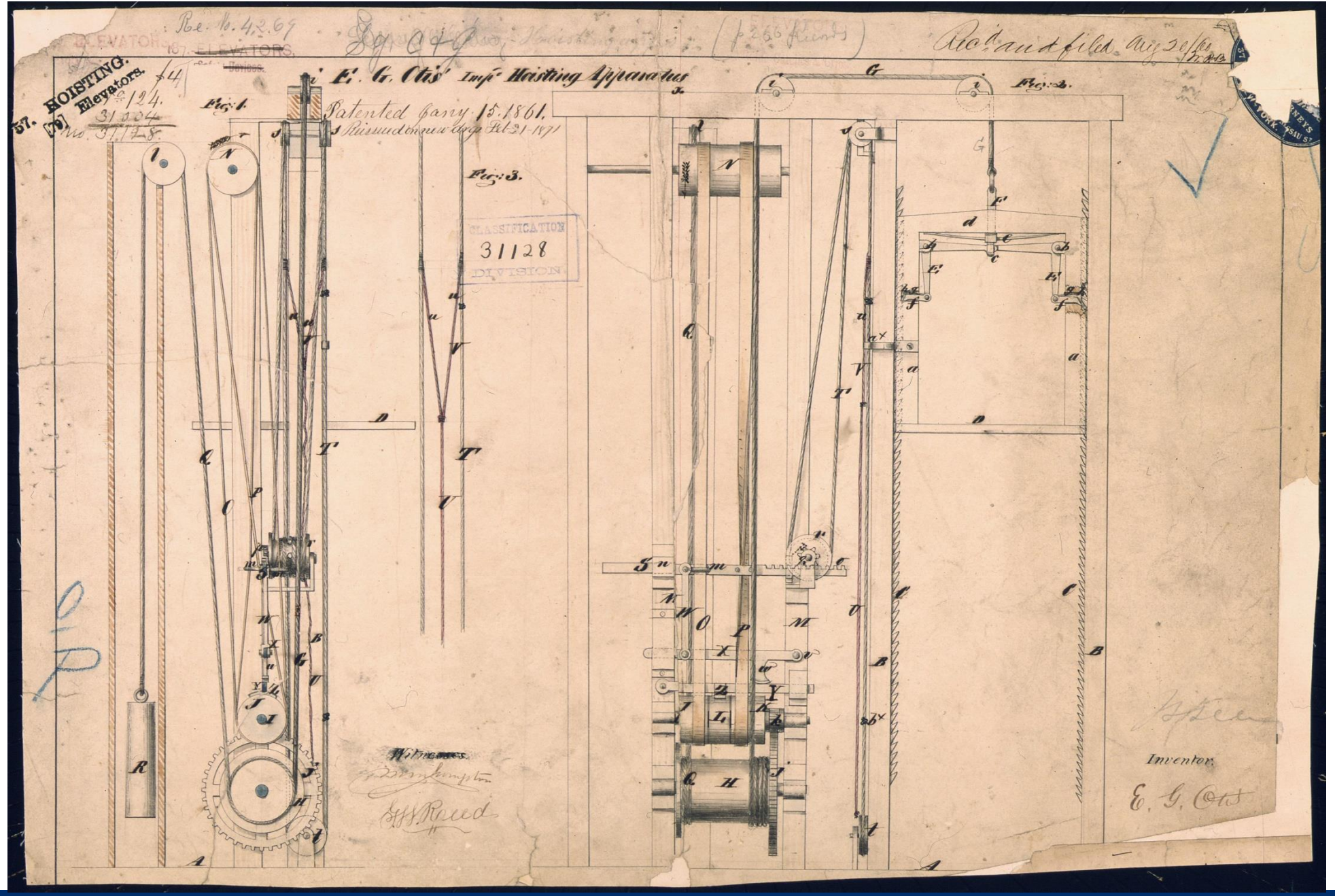

FUTURE CITY MOBILITY: Traveling in Three Dimensions

An Opportunity to Add a Rapid Mobility Option to Combat Growing Congestion

INFRASTRUCTURE COSTS

HELIPADS
$0.5M - $2M
per landing spot

1 Pad Built = Connectivity to All Other Landing Sites

SURFACE ROADS
$3M - $10M
per mile in U.S. urban areas

1 Mile Built = 1 Mile of Connectivity

UNDERGROUND
$100M - $1B
per mile

1 Mile Built = 1 Mile of Connectivity

THE NEED FOR RAPID MOBILITY

- **97hrs** Lost annually per driver in the U.S. due to congestion
- **$87B** Lost annually in productive time in the U.S. due to delays
- **180km** Traffic jams in San Paulo, Brazil
- **100M** New cars per year sold by the early 2020's
- **6hrs** Viability of a heart transplant
- **$22K** per/min Lost by auto industry for unplanned downtime

BY THE NUMBERS

- **2013** First Flight of SARA Autonomous Flying Lab
- **300+** Hours of Autonomous Flight with MATRIX™ Technology
- **100+** Optionally Piloted Takeoffs and Landings
- **2012** FAA Approval for Part Life Extensions Based on HUMS Data
- **2016** 24/7 Customer Care Center Launched
- **2017** Sikorsky Demonstrates Real Time HUMS on S-92®
- **2008** Firefly™ All-Electric Helicopter Program Launched
- **190hp** High-Efficiency & Power Density Electric Motor
- **30%** Direct Operating Cost Reduction Potential with Electric Propulsion

SAFETY MATTERS

The Requirements Chosen Today Will Determine the Safety of Future Systems

SIMPLE SAFETY MATH

If successful...
50,000 Aircraft
X
3,000 Flight Hrs/Year
= 150M Flight Hrs/Year

At that rate...
Statistical Days Between Significant Failures

- 10^{-3} 3.5 Minutes — 1 Failure/1,000 Flight Hrs
- BEST IN CLASS TODAY
- 10^{-6} 2.5 Days — 1 Failure/1,000,000 Flight Hrs
- 10^{-9} 6.7 Years — 1 Failure/1,000,000,000 Flight Hrs

REFERENCES:
Lost Congestion Time: http://inrix.com/scorecard/
Traffic Jams: https://www.bbc.com/news/magazine-19660765
Cars on Road: https://imc-auto.com/global-car-sales-2018/
Viability of Organs: http://www.transweb.org/faq/q24.shtml
Downtime Cost: https://news.thomasnet.com/companystory/downtime-costs-auto-industry-22k-minute-survey-481017
Highway Cost Per Mile: https://www.artba.org/about/faq/; https://capitolfax.com/summary.pdf
Subway Per Mile Cost: https://www.citylab.com/transportation/2018/01/why-its-so-expensive-to-build-urban-rail-in-the-us/551408/

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WHY THIS IS IMPORTANT – SIMPLE SAFETY MATH

The level of safety you pick for your requirements today will determine the upper bounds of your market size

Developer's Decision

Best in Class Today

Market's Response	Statistical Days Between Significant Failures	1 Failure Per 1,000 Flight Hours (10^{-3})	1 Failure Per 1,000,000 Flight Hours (10^{-6})	1 Failure Per 1,000,000,000 Flight Hours (10^{-9})
Niche Market At Best	100 Aircraft 500 Flight Hours/Year	7.5 days	20 years	20,000 years
Evolutionary	1,000 Aircraft 1,000 Flight Hours/Year	9 hours	365 days	1,000 years
Revolutionary	50,000 Aircraft 3,000 Flight Hours/Year	3.5 minutes	2.5 days	6.7 years

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ATTACKING SAFETY DRIVERS TO DEFINE A NEW NORMAL

Start with Today's Best Practices for Component, System Safety

+

Reduce Complexity and Sudden Failure Modes (potential for minimum 10X safety improvement)

+

Eliminate Operator Error with Optimally Piloted Technologies

= Opportunity for 10^{-9} system safety level

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MATRIX TECHNOLOGY CONTINUES TO RAPIDLY ADVANCE

No prior helicopter experience plus 40 minutes in a simulator…

….enabled a safe, one hour flight in a 12K helicopter

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