



What is a “sufficient” noise metric?

Andrew Christian

Structural Acoustics Branch
NASA Langley Research Center

Aerial Mobility: Noise Issues and Technology
A Technology for a Quieter America Workshop
December 3rd, 2020

The question

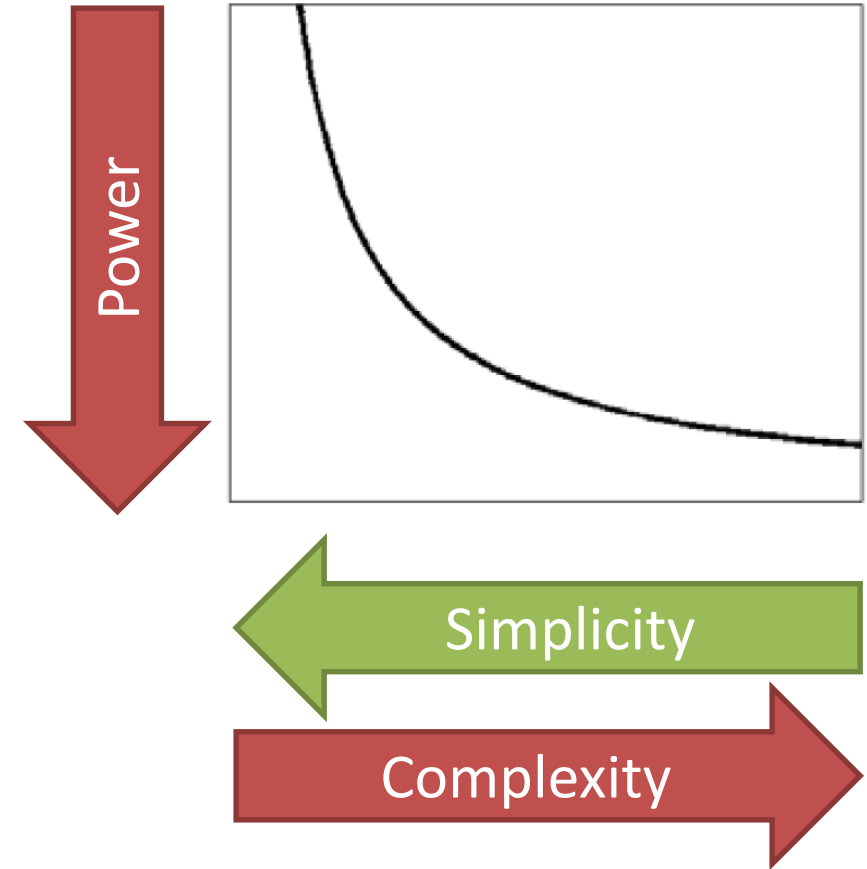


- During the recent Quiet Drones conference I was misparaphrased:
“Andy says that a metric based on A-weighted level will be sufficient for regulation”
- What I was trying to get across was a relative notion, not an absolute one.
 - Metrics of various levels of detail will find use in different situations based on the cost/benefit of their use.
- But what is a *sufficient* metric? I’d never thought about it in those terms...



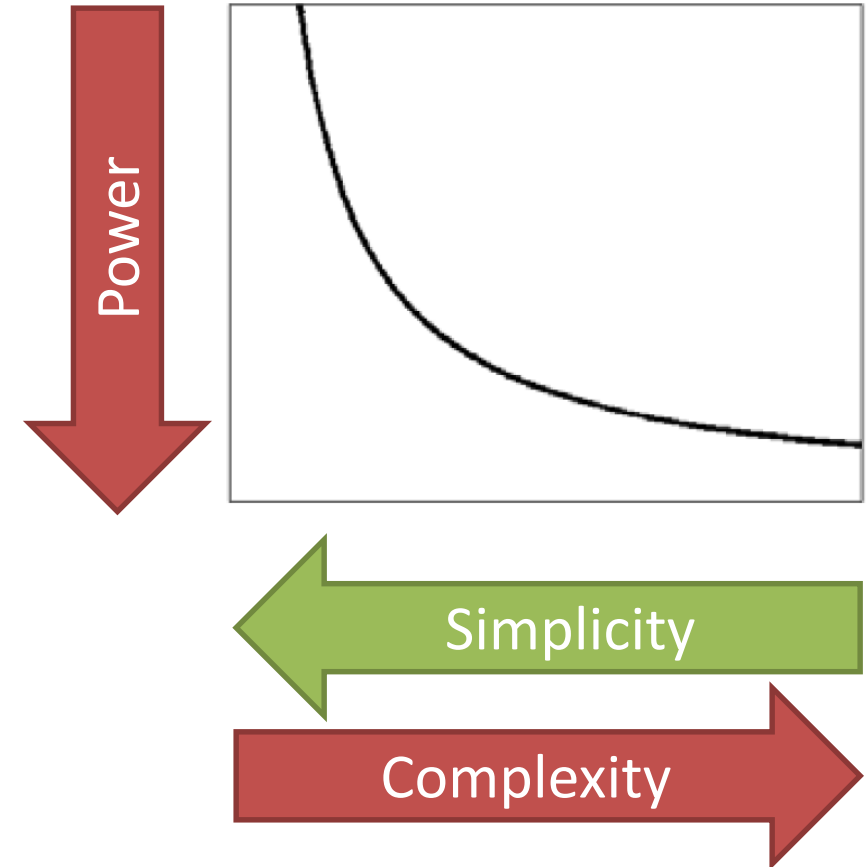
The answer

- The answer is simple: Parsimony.
“It is foolish to do with more, that which can be done with less”
- The sufficient metric needs to balance the following needs (if they exist) for a given application:
 - The power of the metric to resolve noise features *germane to annoyance*.
 - The resources necessary to evaluate that metric.



The power to do what?

- To discriminate (wrt. annoyance):
 - Within classes of vehicles
 - Between classes of vehicles
 - Between types of operations
- To be more general:
 - Extensible/applicable to new types of vehicles
- This power comes at a price:
 - Data/computational requirements
 - Regulatory fragility, loopholes, etc.



The more interesting question



- One could easily construe noise and annoyance to be infinitely complex...
 - How do we arrive at the tradeoff?
 - This leads to the *much* more interesting question:
 - What are the necessary conditions to have an increase in the complexity of regulations over time?

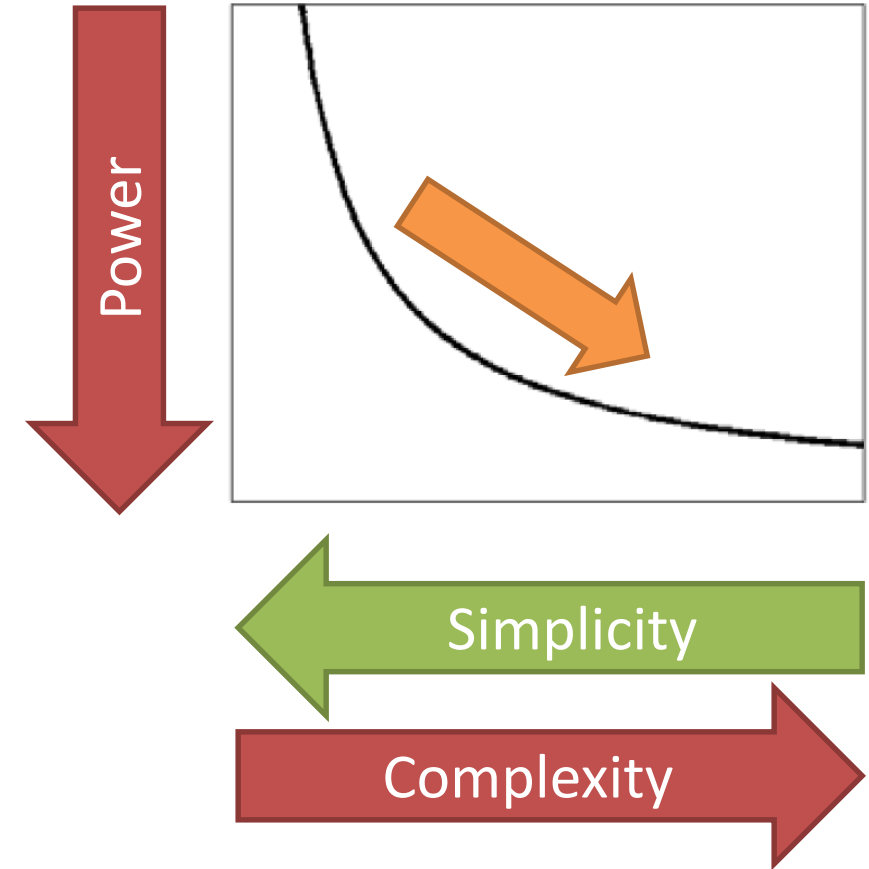


Before I answer

- This is all just my opinion, and it's not even really an opinion, just a point of view that I haven't yet heard – one that requires a step back.
 - Try to see this problem, not as a community noise researcher or regulator, but looking at the entire issue – including OEMs, operators, [annoyed people] – as a single system.
 - Then we might be able to draw parallels with other systems that have evolved complex regulatory mechanisms over time.
- The crux of my answer really has nothing to do with noise.
 - I will not wind up with an opinion on what regulations are needed, what metrics are appropriate, etc.
 - In this way, the conclusions ought not to conflict with other points of view.

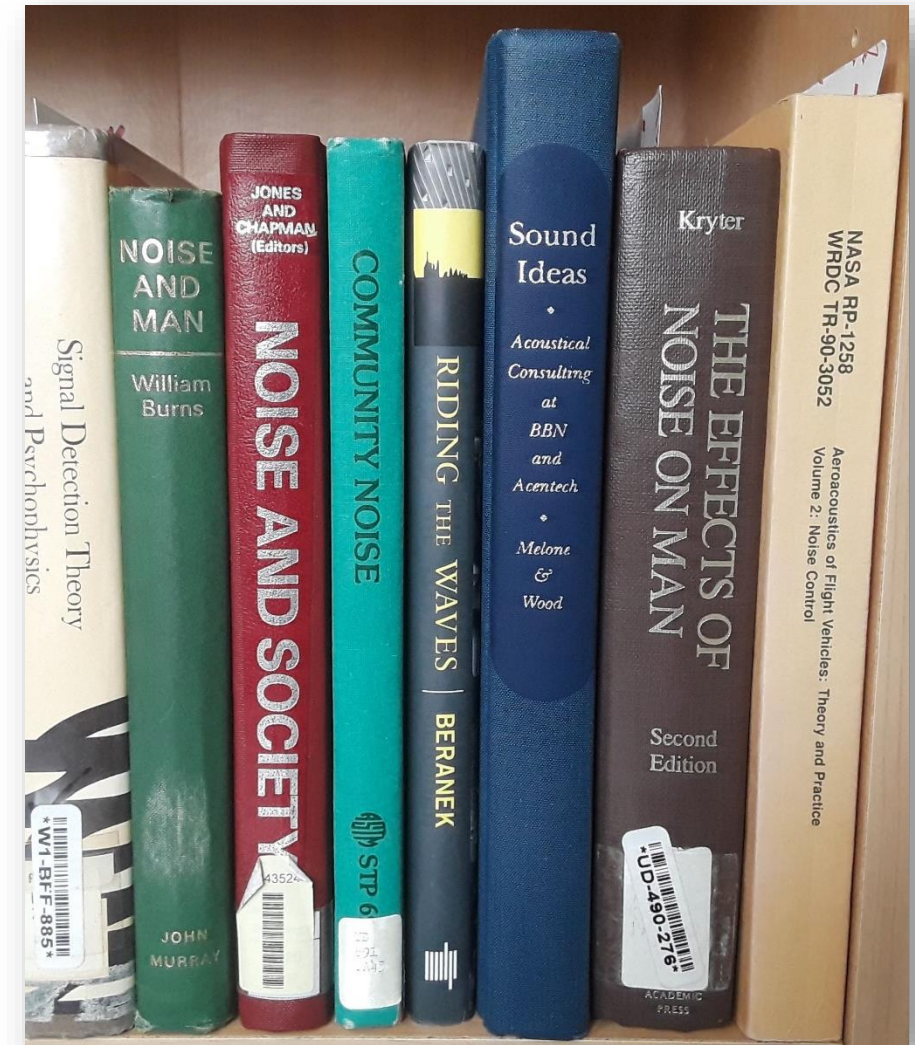
The more interesting answer

- You need opposing forces within a bounded system.
 - The issue has to be complex to begin with...
 - This is general point of view supported by other results in evolving/complex systems.
- These forces act to squeeze the system into a state of heightened complexity in order to increase the “efficiency” of the use of the finite space.



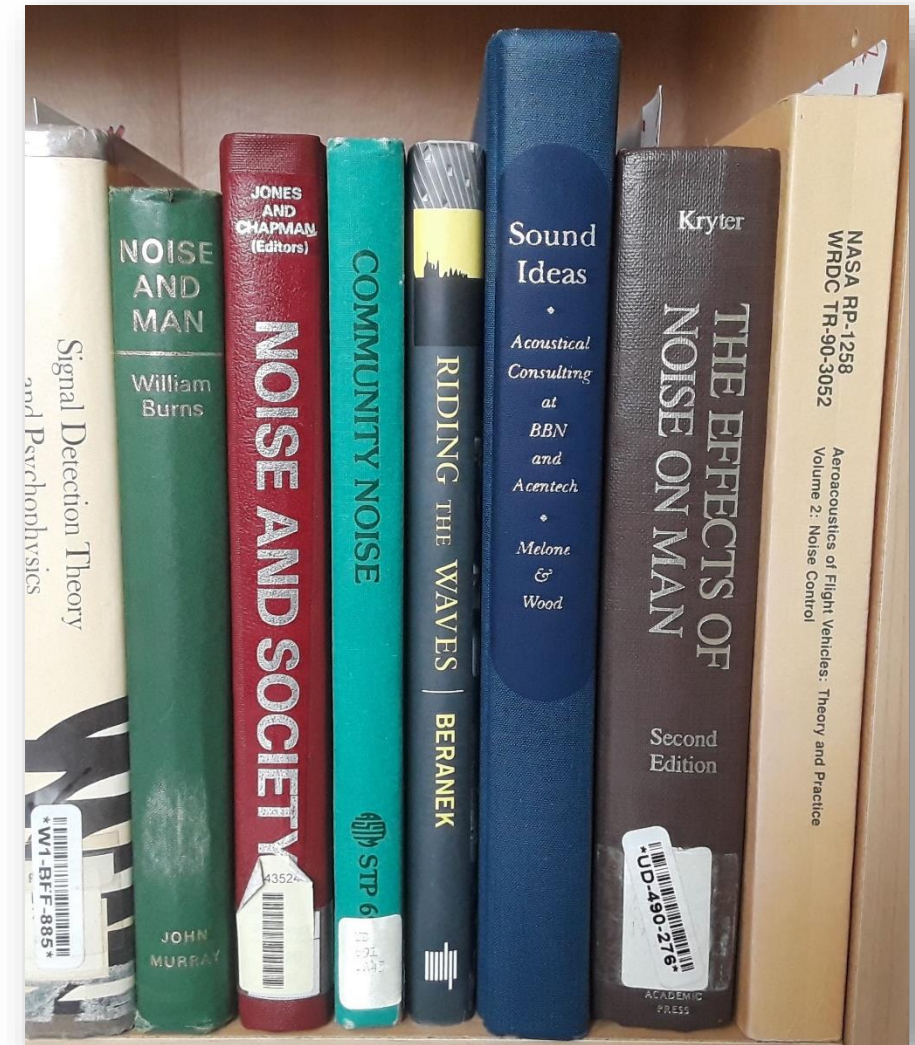
Whence PNLT?

- The *ex tempore* example I gave at the Quiet Drones conference concerned the dawn of the jet age, and the birth of PNLT.
 - The Tone-corrected Perceived Noise Level metric was a product of a particularly acrimonious time in the history of noise.
 - It is a considerably more complex metric than those based on A-weighting.
 - So why do we have it?



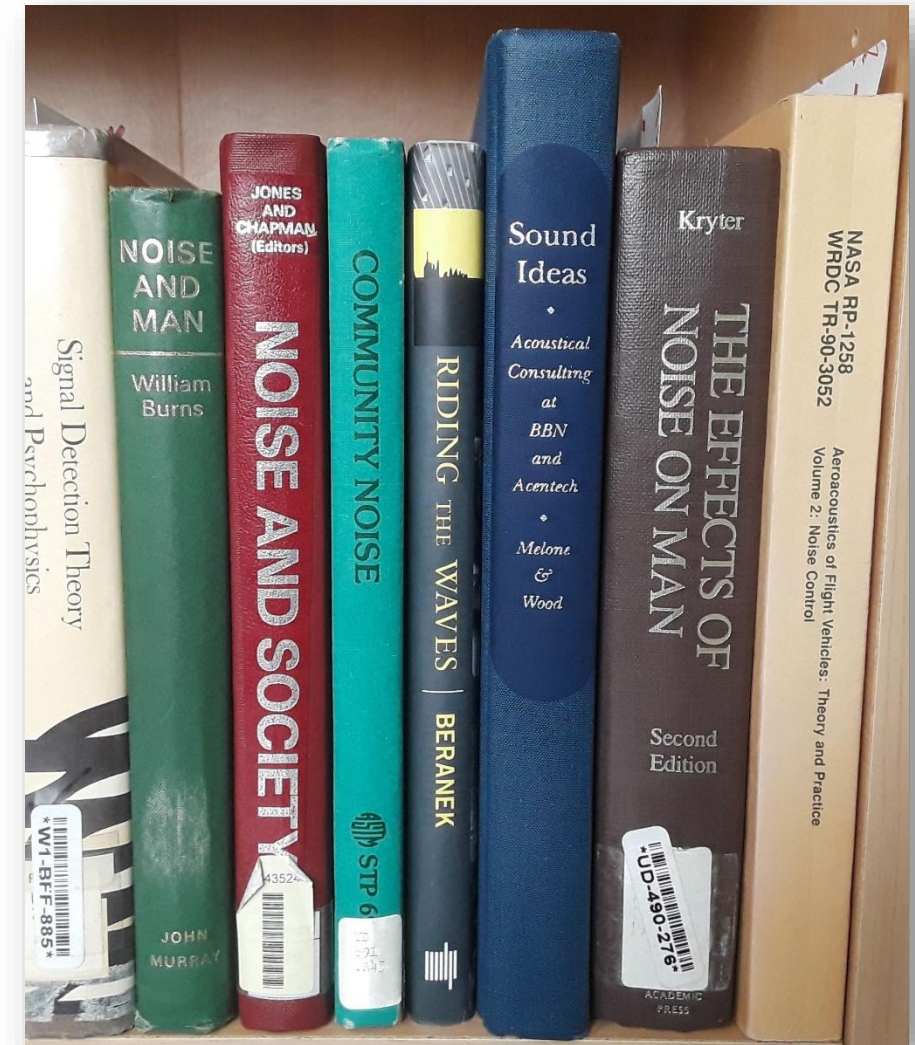
Whence PNLT?

- In the mid-1950s, Boeing wanted to start using a modified military jet aircraft for commercial passenger service.
 - The Boeing 707
 - The plane *already existed*
- At the same time, there as an inchoate, but growing, antinoise movement taking root near large US airports.
 - The airports *already existed* (and were expanding)
 - The annoyed people (and their houses) *already existed*
 - Some litigation had already started...



Whence PNLT?

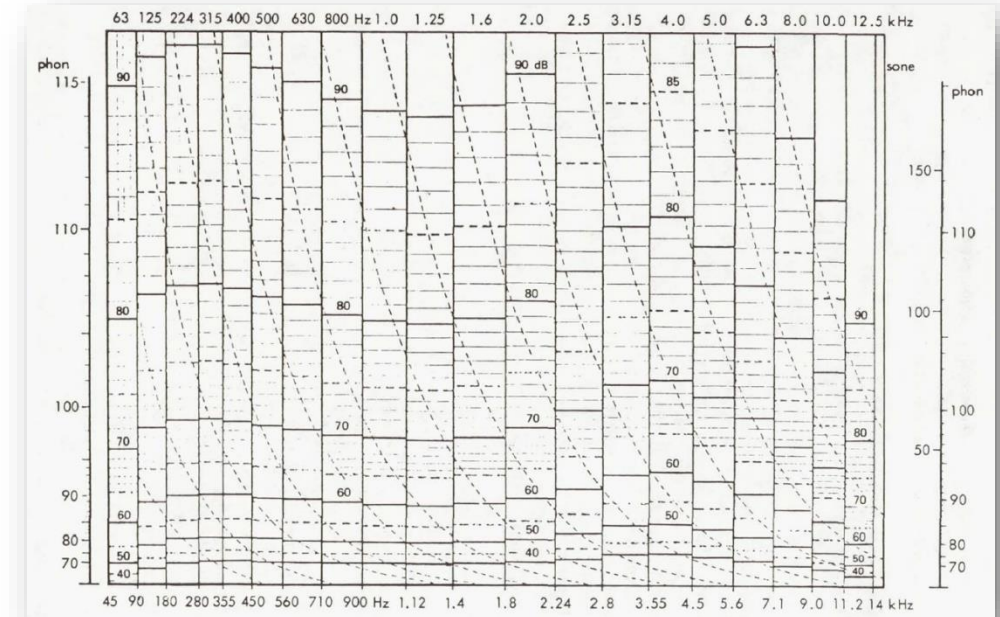
- The Port Authority of NY/NJ saw a problem coming with the noise of the 707 and contracted BBN to investigate:
 - Due to qualitative differences between the sound of existing commercial prop planes and the proposed jet airliners, it was determined that there was a 15 dB perceptual offset between the two classes of vehicles when measured by the A-weighted methods of the time.



Psychoacoustic research ensues...



- The PNLT metric was powerful enough that it was able to predict the response to noise from both classes without the need for a jet-mode “switch.”
- Its complexities:
 - Based on nonlinear “perceived noisiness”
 - Contains a correction for “tones”
 - Requires one-third octave band data vs. time to compute (difficult in the ‘50s!)



Graphical Loudness Worksheet
After Kryter (NASA RP-1115)

The PNLT legacy



- Back then, the complexity of the PNLT was [sufficient] in order to bridge the gaps between the vested interests of the OEMs, operators, and the desires of the ensonified populace.
- Over time, PNLT became a worldwide standard, and has continued to operate well, even as many of the acoustical features of early jet aircraft have melted away.
- This was a complex issue, there were competing forces.
 - The solution was to increase the complexity of the metric.

The Wing Experiment



- In 2018, a trial of drone-based package delivery to suburban Canberra in Australia.
 - This included non-LOS operations over residences.
 - Operated on a trial basis wrt. noise.
- Noise was determined to be a major issue to the serviced community.



Images used with permission: https://wing.com/en_au/press/australia/

and: Burgess, M., "Drone delivery and noise regulation in the Australian context," in Proc. o/t Quiet Drones e-Symposium, Oct. 2020

Wing: Redesigning the vehicle

- I can tell this is a noise-intelligent design just by looking at it:
 - “Lift+cruise” configuration
 - Large props in front of lifting surfaces
 - The blade-passage rate was tuned down
- On top of that, they operationally:
 - Disperse flight tracks near hubs
 - Fly it fast and low, so doesn’t appear to loiter (~150 ft AGL @ ~70 mph)



Images used with permission: https://wing.com/en_au/how-it-works/

and: Burgess, M., “Drone delivery and noise regulation in the Australian context,” in Proc. o/t Quiet Drones e-Symposium, Oct. 2020



Wing: What happened next?

- Wing was allowed to continue as a fully commercial operation in Canberra, with expansion to parts of Brisbane.
 - In 2020, as of October, there have been multiple thousands of deliveries, and only 25 complaints regarding noise.
- The Australian government recently released a position paper on “Emerging Aviation Technologies”
<https://www.infrastructure.gov.au/aviation/drones/files/drone-discussion-paper.pdf>
 - In terms of noise regulation, while there is a proposed construction for how noise issues can be handled *as they emerge*, there are no concrete limits imposed at this time.



Wing: What happened next?

- Does this square with our expectation?
 - Wing only operates one vehicle
 - It only performs one service
 - It does this over a very limited geographical/demographic area
 - The company has been judicious and proactive wrt. noise
 - The resulting regulation is very parsimonious: no additional regulation

→ This seems to make sense!

There are no elements in this situation that would lead us to expect increasing regulatory complexity over time.

Where does this leave us?



Some may see this outcome as unfortunate, as it points to a looming paradox:

- The capital investment necessary to enable some of these advanced air mobility concepts is hindered by uncertainty regarding noise regulation.
- But the regulations sought to decrease that uncertainty may not appear until there is a vested interest to increase noise commensurate to the community reaction.





In summation

- (I suspect) that the necessary conditions for regulations to emerge and increase in complexity are understandable and foreseeable.
 - This doesn't produce an opinion on particular regulations or metrics.
 - I still have no idea what a "sufficient" noise metric will be in an absolute sense, *a priori*, for a novel vehicle type, commercial service, etc.
- The historical record provides examples of times when these forces were in play and when they were not.