

Paths for EM/IM to Provide Strategic Differentiation

How many lines can I cross in one talk?

or

Can we create a path to technical superiority?

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Please, don't say IM is not relevant today



- It's a threat as a system question
 - Perhaps more than IM on an individual munition?
- Do we need to ask if we are doing the right analysis for meeting the IM policy?
 - Avoiding unwanted ignition.....

The case for technical superiority

- WWI
 - Technical parity across fronts (can cite more examples)
- WWII
 - Technically behind (allies) but got better – aircraft, armor
- Cold War
 - Strategy of superior technology rather than match numbers
- Gulf Wars I and II
 - Show what happens with a technical overmatch (not a commentary on other aspects of either war)
- Global War on Terror
 - Precision, low collateral damage, stealthy delivery
 - Adaptations that were successful may have made us vulnerable to another kind of warfare
 - For example, had air dominance – not attacked in depth
- Our technical superiority has been focused on the world situation of the last 30 years – that status quo has been upset

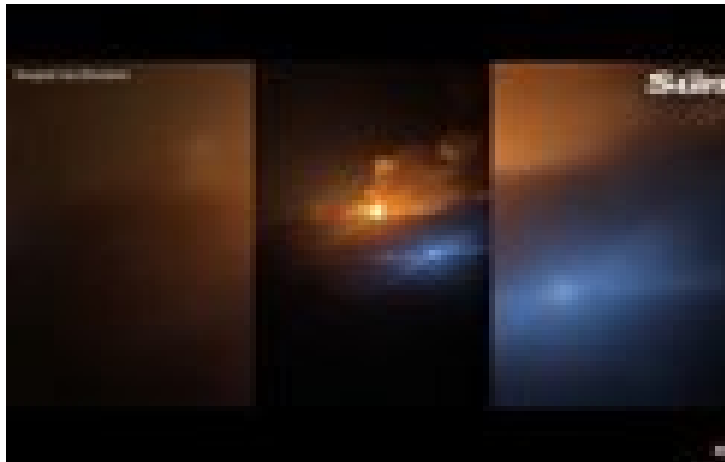
Aggressive Russia

- Willing to use weapons
 - Have used hypersonic weapons in Ukraine....and others
- Overall military of Russia has not impressed
 - Is this a technical fault? Certainly not exclusively
- Playing on foreign soil against a determined enemy is hard – did we not learn that a number of places against much less well armed foes?
- What are we learning (early) about weapons?

Case for Performance and IM



<https://youtu.be/hoo-mTsSD4Y>



- Battlefield scenario shows vulnerability of munitions that are not IM and value of range and inherent “IM” in increased performance (e.g. range)
- Takata air bag recall: need to get it “right” not default to conservatism

China military capability expanding rapidly

- Clear goals
- Focused and driven from the top
- Designed to neutralize capability of western powers to exert influence/dominance in Asia/Pacific, initially
- Numbers are scary – doubt we can count on weaknesses seen elsewhere
- Taiwan support presents key challenges and a good scenario to study

China technical numbers are amazing

- Publication examples:
 - CL-20 (since 1987 via Sci-Finder)
 - >18,000 Technical Journal publications
 - 5,873 patents
 - 1806 reviews
 - 157 books
 - Top 5 publishing organizations are in China (7 of top ten)
 - Carbon -Carbon
 - A quick search via SciFinder shows the following open-source literature statistics on Carbon Fiber Composites:
 - 162+K total publications
 - Top ten authors are Chinese
 - 34K publications in Chinese language
 - Of the top ten literature producing organizations, 8 are Chinese

From Energetics Technology Center

Let's not forget.....

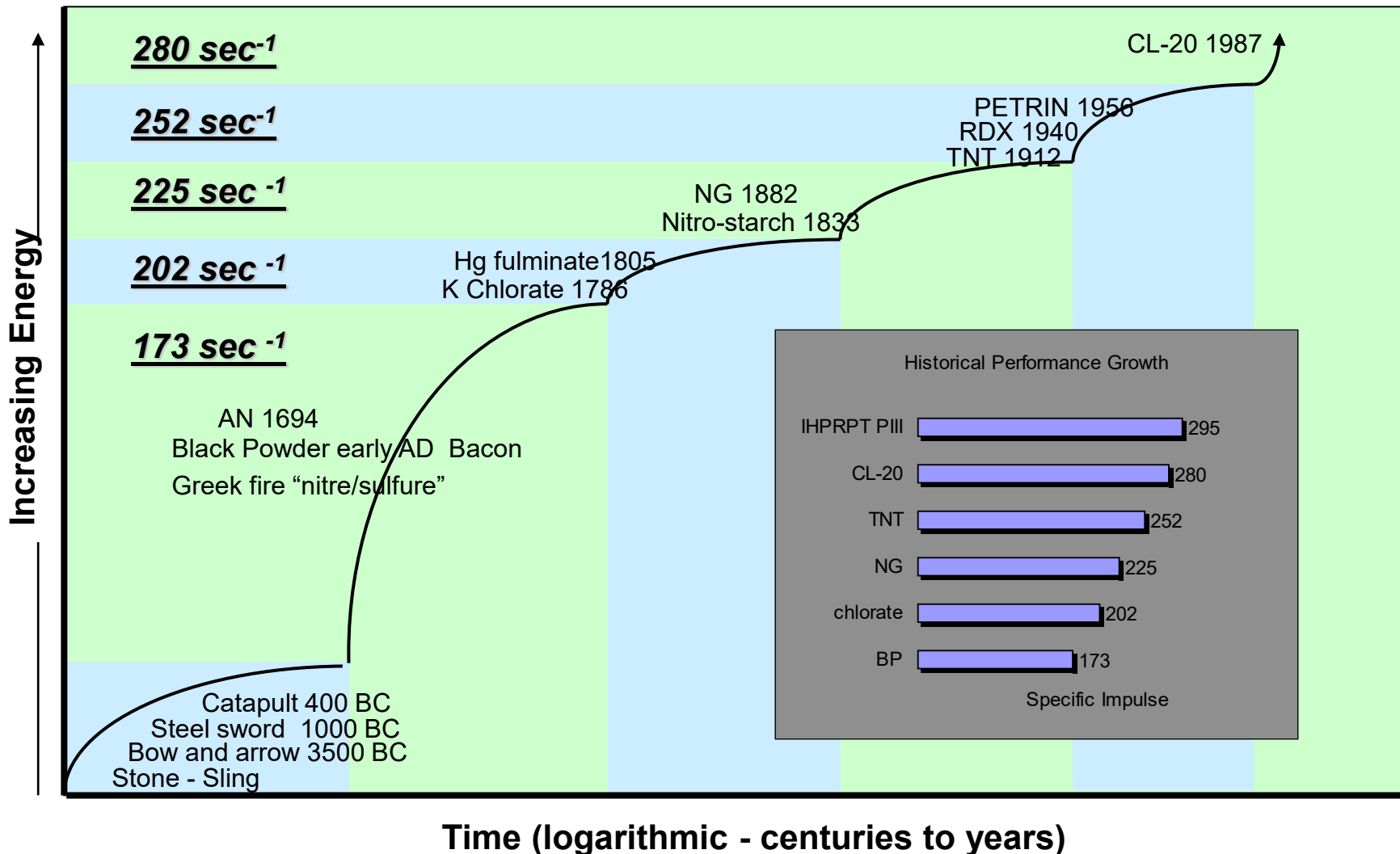
- North Korea
- Iran
- Non-state terrorist organizations
- More.....

Here's the problem

- We aren't particularly efficient right now (development, acquisition, sustainment). Does anyone want to argue that?
 - All through our system – not one part – all are contributing
 - Examples
- We off-shored too much of our industry
 - Economics drove much of change.....and is a barrier to bringing back
 - Sad reality of shipping pollution off-shore
- Just plain getting buried by R&D and production in China – we appear to be losing both quantitative and, maybe, qualitative advantages.
 - Does not bode well for our future.....
 -and change is really hard

Historical Performance Growth

Energy asymptotically approaches a physical limit for a given technology followed by a dramatic technology change and a period of rapid increase
 – today we are again on the cusp of such a change



Changing the Pallet

Weapons in the US have been built with a stationary pallet for over 70 years

- The primary energetic materials in all US military (and civilian) propellants, explosives and pyrotechnics (PEP) were developed in the 19th or first half of the 20th Century
- The weapons systems we have today are designed based on the capabilities of this limited pallet of materials – any improvements are incremental, at best

How could even a few new energetic materials impact PEP and munitions?

- Much emphasis is placed on simple energy increase – it is relevant and significant
- However, the larger benefit is that the trade spaces will be opened with new combinations of density, energy, oxidation index, molecular weight available to the creative formulator and designer of munitions
- Trade space can include lethality mechanism, lethality at target, range of munitions, time to target, signature/plume, size of component
- **Effects at the weapon system are more than additive – they multiply each other**
 - *Example: lower weight warhead with higher performance propellant increases range, speed, lethality by more than either of the individual numbers suggest*

We don't have to invent a magic powder to provide the latitude for revolutionary increases in weapon capability and a strategic advantage

Example of winning at performance and sensitivity

- Castable CL-20 formulation provides energy of pressed composition with reduced sensitivity
- Pressed CL-20 formulation shows both improved performance and reduced shock sensitivity compared to baseline formulations

Win-win scenarios are possible

Formulation	Density (g/cc)	Gurney Constant @ $V/V_0=7$ (m/s)	Gurney Energy @ $V/V_0=7$ (kJ/g)
DLE-C038	1.805	3005	4.515
PBXN-110	1.680	2780	3.864
LX-14	1.835	2948	4.345



Bullet Impact in generic hardware
No damage to end closure or copper liner
Mild response to 0.50 cal round



Slow Cook-off
No damage to main body, end closure, or copper liner
Heating rate was 3.3°C/hr

Historical example of using the existing pallet

- Start with single base: Nitrocellulose
- Add a little more energy: Nitroglycerin
- Want improved dimensional integrity, add: PEG
- Add a curative for the polymer: diisocyanate
- Improve freezing point of the NG, add: BTTN
- Same to amend Tg of PEG, add: PCP
- Maybe a bit more energy, add: nitramine monopropellant
- Need to better control the burning rate, add: lead catalyst

Result:

- Move from relatively low performance single base gun propellant to a high energy, minimum smoke tactical rocket motor propellant

Conclusion:

- Effects are more than additive when applied creatively to create a differentiated technology for weapons

The Case for Change

- What would it take?
- “...must believe that change is the lesser evil, and that a failure to change will realistically produce catastrophic, near-term consequences, such as the loss of a major war.”
 - Christian Brose in “The Kill Chain”, 2020

Are we there, yet?

Western Democracies have advantages

- Vibrant, creative economies
 - Not top driven with fake data
 - Much better able to respond to signals than we give them credit
 - People are willing to take some major risks (examples)
- Alliances of the willing
 - If we can stay together – causes make a difference
- Remarkable militaries
 - Professional, committed, remarkable people
 - Equipped with effective systems that overwhelmingly work
- Political systems that I believe are an enduring advantage
 - Personal freedoms that are worth protecting
 - Less fear of overthrow as in autocracies (don't waste energy oppressing)
 - Not as fast making decisions, but many voices should result in better outcomes and fewer massive blunders
 - Messy, slow, ponderous, confusing, frustrating – it can be a good thing

Here's a couple of ideas

- Unleash the creativity that is possible only in a free, democratic society
 - Let errors and inefficiencies of autocracy accumulate.....they always do
 - Cost of maintaining domestic control
 - Cost of bad decisions because of top-down decisions
 - We need to open the flood gates in energetics
 - Provide environment with challenging goals
- Look hard at where we can reduce the inefficiencies in our system
 - Support the best – wherever it may come from
 - Parts of our system drives towards “novel” rather than “optimal”
 - Advocate for technology creativity – not our home base
 - Structure hurts – everyone needs to pay bills
 - IM based on hazards analysis – let's create advantages that count on the battlefield – and not hold back technology unnecessarily
 - How do you get many kbar into a large rocket motor being shipped by truck/train or stored versus improving stimulus expected on the battlefield for tactical munitions
 - Micro-bureaucracy, we can each break down in our own home
 - Building barriers to others competing with us is a natural.....it's hard
- Help expand what is on the pallet
 - Improve acceptance of new materials even if not yours
 - A little bit does go a long way

