BBC-Future AMA: I'm Professor Michael Smart, chair of hypersonic propulsion at the University of Queensland, Australia. I'm here to answer questions about hypersonic travel. AMA!

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Abstract

I spent 10 years at NASA's Langley Research Center designing hypersonic engines called scramjets. Scramjets are airbreathing engines (similar to a jet) and enable aircraft-like flight at speeds above Mach 5. At UQ, we flew our own scramjets as part of HyShot, and we are now involved in Hypersonic flights with DST and the US Air Force as part of the HIFiRE Program. From a young age I have always been interested in space travel. The Apollo program and the Space Shuttle really inspired me. However, these launch systems were very wasteful, with over 95% of the take-off mass of Apollo being thrown away on each flight. Almost all current rocket-based space launch systems are the same. Scramjets could help make space launch re-usable. Since 2006, I have been trying to find the best way to do this. What my research group has come up with is called SPARTAN. It uses a scramjet-powered plane as the second stage of a space launch system for small satellites. I received the 2012 International Congress for Aeronatics (ICAS) Von Karman Award for International Co-operation in Aeronautics. I'll be talking about hypersonic travel at BBC Future's World Changing Ideas Summit on 15 November in Sydney. I am happy to answer any questions on hypersonic flight and scramjets from 16:00pm EST, 21:00pm GMT. Ask me anything! Signing out now - great comments and conversation. I will check back in later to answer more questions. Cheers!

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PROF_MICHAEL_SMART R/SCIENCE

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Hello Professor Smart, thank you for doing this AMA. I wanted to know about the usability of scramjet technology on other planets where the atmospheric density is vastly different. I was particularly interested in knowing how the crafts will slow down in rarer atmospheres.

RipperNash

Scramjets fly through the atmosphere and take oxidiser from the atmosphere to burn fuel that is carried on-board. On earth we have an oxygen/nitrogen atmosphere. Scientists have looked at flying a scramjet on Mars where the atmosphere is CO2. You would need a fuel that could react with CO2 for this to work. The other issue on Mars is that the atmosphere is very thin, so the scramjet would have to fly very low to the ground.

Hi Mr. Smart! What do you think will be the next big leap in propulsion technology? Technologies that could take us to to orbit and beyond with efficiency not seen today? Thanks for the AMA!

Coccelo

Propulsion methods are separated into those that work in the atmophere (jets, ramjets, scramjets) and those that do not need an atmosphere and carry everything they need on-board (rockets, electric

propulsion, nuclear propulsion). When you fly in the atmosphere you need to overcome drag, so you need a propulsion system with a high thrust. Rockets have very high thrust, but use propellant very quickly. Jet engines can have high thrust, but do so by only carrying fuel and using oxygen from the air. Thats why jets can be used for flying for long periods (up to Mach 3). Ramjets and scramjets are similar to jets, but can operate at much higher speed. Electric and nuclear propulsion have low thrust, so can only be used in space where there is no atmospheric drag to overcome. The next big leap in propulsion technology will be to enable high speed flight in the atmosphere. Scramjets (https://en.wikipedia.org/wiki/Scramjet) can do that. There are also combined rocket/airbreathing engines like the sabre (https://en.wikipedia.org/wiki/SABRE_(rocket_engine)).

What technology or material currently limits scam jets?

Davidjhyatt

Scramjets get very hot due to friction from the atmosphere. Current metals are not a good solution. There has recently been great developments in materials called Ceramic Matrix Composites (CMC's). These can operate at 1600 deg. C, are lighter than many metals and have low expansion as they heat up. The DLR in Germany are one of the world leaders in these materials (http://www.dlr.de/bt/en/desktopdefault.aspx/tabid-2499/6930_read-10079/). This technology is key to developing scramjets.

Do you worry that your research will be used for ballistic missile systems? It seems to me that anything usable in this group of hypersonic travel research is just prime for sticking a warhead onto it.

TheMCM80

All technology can be used for good or for ill. Its about what we choose to do with it.
The alternative is to stop developing new ideas. I don't think we want that do we?

Hi Professor Smart. Thanks for doing the AMA. Outside of space travel and military use (e.g. missiles), can you see a big future for civilian use? Do you think something like a hypersonic Concorde is ever going to be feasible?

Dragannia

Scramjets are the best propulsion system for flying at hypersonic speed. However, scramjets only work at hypersonic speed. So a combined propulsion system is needed. NASA are working on a combined jet/scramjet engine called a TBCC (https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150010169.pdf). This is what will be needed for a hypersonic concorde. Using scramjets as the 2nd stage of a rocket-scramjet-rocket launch system is a nearer term use for scramjets (https://www.uq.edu.au/news/article/2015/08/launching-australia-space).

How should the Govmt/Commercial balance be optimized for innovation & longevity of hypersonic propulsion and related aerospace programs?

HxBen

Government can play an important role in fostering new technologies. This type of support allows the scientists/technologists with the ideas to maintain control of the technology for a longer period.

However, once a technology has passed a threshold, then commercial support is best for development, as the financial imperative is the most effective way to move it along quickly.
Government should be looking at technologies that are showing progress and support them; i.e. choose winners. This is how to foster a high tech economy.
Australia has invested very heavily in hypersonic research. It is now ready for application to space launch. Support from government would be a effective way to bring this technology to a commercial reality.

With all the trouble regarding noise output that supersonic craft have encountered due to the nature of faster than sound travel I was wondering how such concerns will affect hypersonic craft.

Atari_5200

Hypersonic flight occurs at relatively high altitude (30 km rather than roughly 10 km for current subsonic aircraft). This will significantly reduce noise levels on the ground.

Hi Prof. Smart, thanks for the AMA! Since test model conditioning for models in shock tubes can be hard, particularly for hypersonic conditions, have you had to design purely for rocket tests? Did you and your team design specific equipment or processes to make shock tube conditioning easier?

ThatDeznaGuy

Our T4 shock tunnel at UQ can recreate the exact conditions of hypersonic flight (http://hypersonics.mechmining.uq.edu.au/t4). It can do this up to approximately Mach 12. However the test time is of the order of milliseconds. So the main limitation is the test time.

What would be the maximum altitude that the spartan concept could reach? Would it limit what kind of satellites could be launched?

DizzyLime

Spartan is a 3-stage system: rocket-scramjet-rocket. The first stage rocket is reusable using a fly-back technique from Heliaq (http://heliaq.com/). The second stage scramjet fly's to Mach 10 and around 35 km (http://heliaq.com/project-information/spartan-description). It then releases a small third stage that takes the 100 kg satellite up to orbit. So Spartan does the same thing as a current satellite launch system, but its over 85% reusable.

Hello Prof Smart,

What are your thoughts on the SABRE) engine?And it's approach to managing the problems with scramjet engines?

Thanks.

1I111I

The Sabre engine is a combined rocket and airbreather. Its a very interesting idea. It will be great to see it come to fruition. A scramjet is a much simpler engine that is more mature than the Sabre. Scramjets have been flight tested numerous times by different groups around the world. UQ scramjets are now ready for application to a reusable satellite launch system (SPARTAN).

Hello! Sometime ago I read an article about a propulsion system that (loosely interpreted) harnesses shock waves from high voltage current passed through ram air to propel an aircraft without the need for fuel after a certain speed. Just as lightning sets off a shockwave by superheating air, this would do the same thing as ram air pressure increases with speed and sustains thrust by current-heated air and can be achieved at a much slower speeds than 'traditional' ram engines. It seemed like an excellent idea. I was wondering if this is anything but a typical 'shiny engineering idea' and if so, do you think ram engines will become common place sometime in the near future?

AmericanoWsugar

I have not heard about this. With regard to ramjets, these have a limited speed range. Once you go away from a turbine based jet engine it makes more sense to go straight to a scramjet (rather than a ramjet) as it can fly over a much wider speed range.

Have you ever worked on the SR-71 Blackbird and if so, what was your favourite part about working on it?

LimpCoffee

I have not worked on it. I have seen it in the flesh and its extremely elegant and beautiful. My favourite thing about it it that it fly's at Mach 3. The most interesting thing about it is that it leaked fuel until after it took off. These gaps were sealed as the SR-71 heated up during flight!

Hey Professor. I'm an aerospace engineering student in the states. Where should I intern to get the best chance of working in this feild? Is a master's needed? Thank you for your time in doing this AMA!

Beli_Mawrr

Its great to have a masters or a PhD, as this is a complicated field. This give you the chance to understand the theory ans its application at a deeper level.

Will these engines replace jet engines?

Cypronis

No scramjets don't work below Mach 5. See my answer about the TBCC that NASA are working on which combines a jet and a scramjet.

Hello professor,

I'm working in active debris removal. I am quite intrigued, and wish to gain a better understanding on some matters. Any comments would be most appreciated.

On the SPARTAN page, the quoted text mentions changing the paradigm of tossing spacecraft away after their use. In addition, there is mention of allowing spacecraft to be internationally monitored.

As concerns the changing paradigm, I wonder if you could explain if and how this applies beyond the obvious reusability of the launch system itself. For instance, does this envision more easily (inter)changeable spacecraft in a new orbital ecosystem, such as near-space or very LEO?

As concerns international monitoring, what exactly is meant with this capacity. Is this meant in the context of monitoring LEO, e.g. for a system of space traffic management, or perhaps, rather, in terms of international security? Which idiosyncratic or simply novel aspects of SPARTAN will make this ostensible monitoring capability a reality?

Thank you

Moongrazer

Yes, Spartan is about changing the the paradigm of throwing spacecraft away. This is about making satellite launch cheaper and less wasteful. I am not sure where you read about allowing international monitoring. Can you point this out?

Do you expect civilian supersonic air travel to ever make a comeback?

Urgullibl

Yes. There are some very advanced concepts that have solved the sonic boom problem (http://fortune.com/2015/11/24/supersonic-private-jet/). A key aspect was putting the engines on the top of the plane.

Do you think Countries like China, Brazil or Turkey which are trying to invest into aviation should mainly invest into Ramjet? Or Ramjets are still not economical other than military applications?

I mean do you see Boing/Airbus planes that utilize 2 turbofan + 2 Ramjet (or anything similar) in the foreseeable future ?

neosinan

See my answers on NASA's TBCC; a combined jet and scramjet. This is the best method for commercial hypersonic travel.

At what point does the atmospheric pressure diminish to the point that a scramjet cannot operate?
Is there a relationship between altitude and and minimum speed require to provide sufficient oxygen to maintain combustion? At higher altitudes, does the composition / ratio of atmospheric gases change as compared to sea level percentages?
Are scramjet engines being designed for sustained cruising at subspace altitudes; or alternatively, are they simply designed to delivery a discrete specific impulse without having to carry oxidizer?

shiningPate

We typically fly a scramjet at a constant "dynamic pressure". This is a measure of the aerodynamic effect. If you fly too high (low dynamic pressure), then there is not enough air for combustion. If you fly too low (high dynamic pressure) then the vehicle gets too hot. A dynamic pressure of 50 kpa is typical. Dynamic pressure depends on the Mach number squared. So we fly at higher altitude when travelling at higher Mach number.

Which challenges are left (in materials science, and otherwise) that are currently hindering commercial implementation? How long do you foresee until they are solved?

aerospacemonkey

Scramjets get very hot due to friction from the atmosphere. Current metals are not a good solution. There has recently been great developments in materials called Ceramic Matrix Composites (CMC's). These can operate at 1600 deg. C, are lighter than many metals and have low expansion as they heat up. The DLR in Germany are one of the world leaders in these materials (http://www.dlr.de/bt/en/desktopdefault.aspx/tabid-2499/6930_read-10079/). This technology is key to developing scramjets, and is ready for use.

Do you play Kerbal Space Program? If so, what configuration of engines and intakes is closest to a scramjet?

shakefu

No I don't, but some of my students do.

What is the difference between supersonic and hypersonic? Do you believe we will ever develop ultrasonic or reallysonic technology?

Umpskit

Supersonic travel is above Mach 1 (~1000 km/hr). Hypersonic travel is above Mach 5.

Do you know anything about the SR-72 that is planned to use scramjets?

Efajigaloop

Just what I see in the media

How likely are we to see Scramjet engines in civilian applications? It seems like these would be perfect for trans-atlantic or trans-pacific flights, but is noise and complexity going to keep companies like Boeing from developing civilian versions?

RandomUser1914

See my comment on NASA's TBCC. Its a combined jet and scramjet (https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150010169.pdf)