This is space, no rocket
required and association with

Lancaster University Management
School.

So I I don't come from a quantum
background and for me a lot of

the initial, I guess few months
was trying to understand where

this technology could be
applied. I have two cofounders,

Marco and Rami, who were
actually doing physics PhDs at

the time and they could very
quickly grasp the the funder

lying scientific principles
behind the quantum random number

generator.

In this episode, I'm joined by
Alan Cross, Northwest Space

cluster manager and women know
you, cofounder and director of

Business Development at Quantum
Dice. Hi, guys. Hello. Hello.

How are we doing today? Good,
thanks.

Yeah, really good. Thank you.
Ohh, perfect. Well, thank you

very much Vimeo for joining Alan
and I today on the podcast. So

the reason that we've invited
you is that you are a co-founder

and business Development
director of an exciting quantum

dice business. So could you tell
us a little bit about the

business please? Yeah, for sure.
Happy to. Umm, so I'm one now,

one of the cofounders of quantum

dice and we are a spin out from

the University of Oxford and we
are enabling cyber security

through a device that's.

Would a quantum random number
generator and a bit about

myself. I quite founded his
company in my last term at

university, so originally I was
studying chemistry and how

quantum days came about was
through a student entrepreneur

programme without the university
right over here a fantastic so

can you take us a little bit
back to the student programme,

the entrepreneurship programme
at Oxford and how you got

involved in in this project?

It was really the first time
that the university ran such a

programme. So the programme was
first run in July 2019 and it

was led by Oxford University
Innovation, which is V

Technology Transfer department
here in Oxford and was also

sponsored by one of our local
venture capital firms called

Oxford Science Enterprises. And
the programme took place over 4

weeks in July. And so I think we
all gave up a bit of our summer

of that year and it brought
together students who were kind

of doing their undergraduate for
masters of a PHD's or.

University um from various
different disciplines, so from

the sciences to humanities and
we all had four weeks to form a

team and to choose a piece of
technology that the university

had a pageant for to develop an
initial business plan around. So

I met all of my cofounders and
we actually decided to work

together to commercialise this
patent for a self certifying

quantum random number generator.
But the University of Oxford had

and we all met on the second day
and over that initial four weeks

Oxford University.

Run courses in the mornings
where they taught students how

to do initial market
development, how to do initial

market research, as far as how
to create a pitch deck for some

initial funding. And at the end
of the full Weeks, Micro

founders and I pitched 2
directors from Oxford University

Innovation as well as investors
from Oxford Science Enterprises.

And we want that student
programme, which meant that we

won some prize funding which
allowed us to put into

production our first batch of
prototype quantum random number

generators. And interestingly,
it was also during that.

Four weeks that we met with some

of the managers of the quantum

Technology Enterprise Centre,
which is an early stage quantum

tech incubator based at the
University of Bristol that was

specifically designed to give
funding, both in terms of

salaries as well as business
development funding to very

early stage quantum
entrepreneurs. So my one of my

other cofounders, George and I
both applied for this programme

and we were awarded places on
it. And so after the Oxford

programme ended we moved to
Bristol where we spent the next

I think.

12 to 18 months working
alongside a cohort of other

quantum entrepreneurs as well as
of course working very closely

with with our other cofounders
Marco Ramya Jeanette in

developing quantum devices value
proposition and doing our

initial precede fundraise.
Fantastic. Obviously you know

that my expertise is in
entrepreneurship as well and

working with students in
universities. So your whole

journey started from a spin out
from the university. Can I ask

when you you first were put in
the group project away back in I

think it was.

2019, is that right, 2019, yes, that's right. Yeah. Did did you

see the potential initially or like straight away in in the IP

that was being pitched to? Yeah, yeah. So. So I think how the

teams formed was actually really interesting and I think this was

quite a big part to to why our team has been able to stay

together because I think when we take Parliament programme, there

was about 30 students and they wanted to form I think between 5

to 7 teams and there was a whole list of patents and IP.

About the University of Oxford had so from the medical

department from from the Physics department from the Chemistry

Department and have a teams formed was that each student

actually design was was given you know access to information

about the patterns and we could also speak to the licencing in

that you're managers at Oxford University innovation to learn a

bit more about for that particular technology and the

patent and what the potential application areas are and how

the teams formed was was actually first by each of their

participants ranking the patterns in order of how much.

Would actually want to work with that piece of technology. OK, so

how my cofounders and I came
together was because we all

wanted to work with this
technology called a self

certifying quantum random random
number generator. OK, and I

think the technology was really
the first thing that brought

myself and my cofounders
together. And I know that we

don't all come from physics or
engineering backgrounds, but I

think from my chemistry degree
at Oxford we had quite a lengthy

part of our physical chemistry
lectures dedicated to quantum

mechanics and I even did an
optional course and optional

exam on it in my second year.
Don't ask me.

Ohh, but I think that was really
interesting because I think at

university, you know, quantum
technology and and and and

quantum sciences, that's still a
relatively new field even in

academia. And I think back in
2019 quantum technologies, it

was just starting to make its
way from academia into industry.

So it just felt like a really
exciting time to join this

particular industry and to have
seen how much has developed

outside of quantum random number
generators, so in quantum

computing and quantum sensing
over the past few years.

And tell me something, I'm
sorry, I'm very curious and I

am. But how soon was it that you
started thinking about actual

space as a sector for for your
technology? Hmm. So we started

thinking about space as a sector
I say a year after we first met

through that student programme.
OK and how it came about was

that one of the quantum leaps
from a partner organisation

called Craft Prospect. But we
did an inmate UK project with

last year she reached out and
craft.

Aspect is another UK based SME
based in Glasgow and they are

leading the development of of
site based quantum key

distribution systems and the
quantum need reached out to us

to ask about our Qiang and it
was in that cool where my team

and I were first kind of well we
first had our eyes open to the

potential applications of our
quantum random number generator

in space applications and it
just already kind of snowballed

from there. Can I just take a
couple of steps back?

Quantum and physics sounds
really complex. So when you were

getting the IP from the
university, how easy was it to

understand what the researchers
had found and be able to apply

that? Ohh, that's a really good question. So I I don't come from

a quantum background and for me a lot of the initial, I guess

few months was trying to understand where this technology

could be applied. But of course we've been our funding team. I

have two cofounders, Marco and Rami, who were actually doing

physics PhD.

At the time and they could very quickly grasp the beef

underlying scientific principles behind the quantum random number

generator. And of course, we also had access to the Oxford

professors who actually led the development and actually filed

for your original patent for this quantum random number

generator. So I think on the technology development front,

there was experience in quantum within our own crowdfunding team

and we also supported a lot by the Oxford network. And how

quickly have you been able to get to grips with that?

Probably spent the first year really trying to understand only

to a level that I need to of how quantum random number generators

worked and also specifically what distinguished our product

from other quantum random number generators out there. And I

think by the end of the second

year I was invited by the

European Space Agency to give a talk to the technical team on

how self certifying quantum random number generators could

be used in space communication settings. So can I ask for the

listeners out there like me?

What is the difference? So OK, I think of a number generator and

I think of a really very simple device that can be, you know, on

my watch on the computer. So what is the? What is the

difference between the kind of random number generator people

might be aware of and A and a self certified quantum random

number generator?

So currently there are I say 3 broad types of random number

generators. What is used most commonly is actually a pseudo

random number generator, and this is based on computer

algorithms, which means of course when it's used in cyber

security settings. Because it's only pseudo random, it means

that we the numbers repeat after a certain amount of time, which

means they could be vulnerable to bias and brute force attacks.

And the other type of random number generators that has

historically been used in high security applications are.

Old classical hardware based
random number generators. These

are physical devices and they
could be based on different

physical processes. So if for
example radioactive decay of

certain components. Or it could
also be based for example on

lava lamps. I'm not sure if any
of you have seen the demos that

Cloudflare had. Yeah, so that's
the type of physical random

number generator. The two main
limitations of these classical

hardware based random number
generators is that they are

quite slow in terms of the
generation rate. So I think when

we did.

An initial analysis of the
random number generators out

there on the market, we realised
that the classical hardware

based random number generators
only generated in the low

hundreds of kilobits per second.
And when you compare this to

what was the fastest quantum
random number generator out

there on the market last year,
well, I mean the the fastest

quantum random number generator
up there was generating at

around 1 Gigabit per second. So
there's a significant increase

in the rate of the random number
generation and hence the rate of

the number of encryption keys.

That can be generated. And of course as we move into a more

connected world where there's an increasingly higher and higher

volumes of data that needs to be transferred at any moment in

time, this is where the rate really becomes quite important.

The second drawback of the classical hardware random number

generators is that because for physical devices they are, you

know, vulnerable to being tampered with physically. So for

example, I think there was a case a few years ago where

Intel's random number generator, which was a classical hardware

based device, I think people were able to kind of change the

physical.

Components that made-up this hardware based random number

generator and they actually reduced the quality of the true

random numbers that were being generated and all of this went

undetected. So this also leads to a silent failure problem. So

is this in response to cause I OK so I've I've been hearing

about.

Let me try and get my words right here. I'm trying to figure

out all the things you just said trying to I I haven't had a year

to think about it and process

it. So let me think about this

through. So there's a challenge
at the moment around classical

encryption isn't there because
what's happened in this entities

and actors are stealing huge
amounts of data that is very

well encrypted using classical
methods because they know that

in the future when when quantum
when you know you know mega

qubit quantum computers come on
online they'll be just be able

to all that encryption will melt
away.

Able. And lock it. Yeah. So they
could. So it's still now crack

later. Yep. Right. Uh-huh. So
this this using quantum random

number generation is, is this
getting one step ahead of that

imminent threat. I think you've
perfectly described the download

now harvest later problem. And
it's absolutely as you've just

said, although quantum computers
do not exist to the maturity

right now where they can break
classical encryption, it doesn't

really prevent, you know,
malicious third parties from

downloading really sensitive
government or or private data

right now.

Saving it and then and then kind
of breaking into it when quantum

computers do reach that level of
maturity and the part that

quantum random number generators
has to play in, this is kind of

in two folds. Um, so whether
it's post quantum cryptography.

So these are the types of
security solutions that are

being developed which should
also be able to withstand

attacks against quantum
computers. So it's whether it's

in post quantum cryptography or
even in the currently used

classical security protocols,
both of these types of security

protocols.

Need a source of random numbers
to make the encryption keys. And

what we're doing right now is
really providing that first

stepping stone to allow security
integrators to start protecting

and to start building solutions
that can ensure that they will

be able to safeguard their data
even decades into the future.

Thank you very much for that.
That's fantastic, isn't it? It's

amazing where we're getting with
the technology in terms of

encryption in the space sector.
How big a challenge do you think

that really is today? And if I
can?

Just a second part to that
question. What do you think in

terms of the future in terms of
encryption becoming a really key

issue in the space sector? Can
I, can I jump in on that and

take it back back a step because
what I want to know is, OK, in

the space sector, what are the
applications? OK, Yep. So three

questions we're putting at you
there. What are the

applications? What are the
current problems and what do you

intend? What do you think are
the future problems in terms of

encryption? Wow. Well, I I think
those are three very good and

three very timely aggressions,
so starting with the 1st.

On about what the applications
are, it's the same as in

terrestrial settings actually.
So if I look back at the

projects that we have done
previously, there are people

kind of building quantum
communication networks on the

ground. So for example, here in
the UK last summer BT launched

London's first Quantum Metro
Network, which uses Quantum

Communications Corp called
Quantum Key Distribution to

securely transfer data. And
quantum key distribution is a

type of post quantum security
solution that's currently being

developed and quantum key
distribution.

Encryption keys and they need
the encryption keys to be

generated from a quantum random number generator. So this is

where companies such as quantum dies would come in. But you

know, it's really interesting because with modern

communications we really depend on terrestrial networks as well

as satellite based networks and the same goes for quantum

communications. So if we look at where Quantum falls into the

space sector, we can look at the different projects for the UK

has invested in alongside partner countries over the past

three years and specifically into satellite based quantum

key.

Distribution systems. So for example currently the UK has an

ongoing project with Singapore. So in the UK is led by rail

space and in Singapore it's with a startup called Spectral and

they are really building satellite based quantum key

distribution networks and justice for ground quantum key

distribution networks need quantum random number generators

with encryption keys. So do the satellite based quantum key

distribution solutions and this is where we came in last year,

we completed a piece of work to build a space suitable quantum

random number.

Generator that can be integrated into a Cubesat and then launch

into low Earth orbit in order to generate the encryption keys as

needed for quantum communications via satellites.

So if I am I am I right in saying that the difference

between the reason why satellites are useful with

quantum key distribution is because in terrestrial networks,

let's say fibre optics, after a few 100 kilometres your your

your entangled photons will be absorbed by the materials in the

in the fibre optics in the in the glass. Whereas with a

satellite it using an optical optical system, you know laser

essentially to communicate to to to send that quantum

distribution key to where it needs to be and it's not going

to get absorbed by.

The actual infrastructure that's transporting it, is that right

or am I making things up? You could be.

I don't think you're making things up, and I think, you

know, we.

The limitations is exactly as you said, if we use kind of

fibre networks on the ground versus always kind of distance

limitations. And of course

there's a lot of, Oh yes,

capital expenditure that needs
to go in, in order to install

these type of networks. Of
course, there's still a lot of

capital expenditure needed in
space settings, but at least

with satellites, there is less
of a restriction on the distance

or the geography of the network.
So can I ask another question? I

noticed and again happy to be
wrong and I noticed that you're

kind of.

Vision, or your ambition really
for the business at the moment

is for your, your, YOUR
technology to be in 75.4 billion

devices by 2025. Yeah, that's
right.

Highest number, I think I
shocked myself when I had that.

Yeah, me too. I was wondering
how, how's that? How does that

work?

Hmm. Yeah. So I think we're kind
of looking quite a few years

into the future now. I think up
to now in in in our talk, we've

really talked a lot about, you
know, some of the really

specific applications of quantum
random number generators and a

lot of these are in critical
national infrastructure, which

is great. And it's something
that we have really enjoyed

working for because it really
demonstrates that quantum random

number generators have a place
where ultra high security is

needed. But looking a few years
into the future, we really want

to develop a smaller and more.

Available and a relatively low
cost version of our quantum

random number generator that's
still has with self

certification feature and with
that we want to embed it into

even consumer level Internet of
Things devices. So for example

we would want every laptop or or
or or every mobile phone to have

one of our quantum random number
generators. And this is because

we believe that every individual
really deserves the best that is

really in terms of security,
especially as we move into a

more digitised age, so in terms
of the space sector.

What is that really thinking
about secure by design from the

outset and really looking at
this tech being embedded in some

of the components to build the
satellites? So that or or is it

something or am I talking
rubbish this time?

Sharon, I, I, I really love how
you used the phrase secure by

design because that's one of the
key points that we are able to

address with the self

certification brutal that we

have for our quantum random number generator. So I think the

beauty behind the South Certification protocol that we

have is that we are able to protect against any external

attacks on the device. So how this works is we have this

protocol that continuously monitors what's happening in the

in the physical environment around our device.

And is able to detect for any changes. So for example, if a

malicious hacker decides to heat it up or shoot microwaves at it,

this protocol can can detect these changes are also at the

same time a just unos adapt to these physical changes so that

whatever leaves our random number generators actually

guaranteed and verified. Truly random numbers. That's only

coming from a quantum process. Wow, fantastic. You should see

Alan's face here. All right Alan Alan's process all well, that's

something else. Allenby eyes are going back and forth.

With these brains got 100 mile an hour.

So can I? OK, so I'm going to.

I'm going to come back to a kind of space side of things.

Five years ago there was about 1500 active satellites.

Today there's several thousands active satellites. By the end of

the decade there's going to be 10s of thousands of active

satellites. That's just an earth orbit. 250 missions planned to

the Moon robotic and human. And traditionally these these, these

systems certainly in in in Earth orbit have been a bent pipe. So

signal goes up, signal comes down the majority of the of the

process and in fact all the processing takes place on Earth.

All the satellites are is is generating imagery or or a link

for communications.

Or generating data in some way. But what's happening now with

all these big satellites, these mega constellations is that they

are mesh networks in the way that we're used to terrestrial.

So they're talking to each other or they will be talking not to

all of them, but you know, within their own constellations

on all the processing so that they're not just transmitting

raw data so that it's processed data. So the space environment

is on the cusp of something brand new. It's on the cusp of

becoming much more complex in terms of data management and

data processing.

So can you, can you tell us a

little bit more about how your

system with your with your with
your this for randomization and

quantum key distribution so on
how does that fit into this much

broader in imminently more
complex space environment. Well

you know I I I think what you
described there is really

exciting and it's definitely
something that I saw when

quantum days took part in the
accelerator programme that the

UK space agency ran on a really
got to see you know.

What a lot of the other space
startups or new space companies

are doing and of course in
Oxford there's a lot of work in

the Harbour Centre and so a lot
of work within the MPs division

here in Oxford to do with kind
of satellite based

communications or satellite
based simulations et cetera. I

think work Quantum dies plays in
this is really in the role of an

enabling component. So due to
the self certifying encryption

keys that we I would to
generate, we can enable space

security companies or satellite
based communications.

Please and two ways have access
to truly secure encryption keys

in order to secure the data
that's transmitted either from a

satellite to ground or in

between satellites. But another

really interesting area is
actually in the area of

simulations. I think earlier you
mentioned that there's a lot of

kind of onboard simulations
being done etcetera, with the

data then being sent back down
to Earth. And one of the

interesting areas of where
quantum random number generators

fit in is actually looking at is
there a benefit that the higher

quality random numbers?

From a quantum source, is there
a tangible benefit that we can

bring to the researchers who
need a source of random numbers

to do simulations? So for
example, in Monte Carlo

simulations and this is an area
that still still relatively new,

but it's definitely an area that
we're really excited to be part

of pursuing. It just sounds like
the world is your oyster. I can

really see this working and see
the growth plans. I think it's

fascinating that there's that
there's a physical component to

this that that if, if, if, if a
hostile actor.

Tries to physically interfere.

With the with the technology, an
example of this. I think the

reason why I think this is
interesting is because we're

starting to see in the space environment, you know it's not

just about hackers on Earth trying to hack in. We're

starting to see quite regularly interference in satellites from

other satellites. Not so long ago a launch went up from a

particular country who shall remain nameless and when they

launch they have to pre register all the major bits that will

come off the rocket so that the nose cone and these kind of

things.

Yep, got predesignated and it was. A bunch of amateur

astronomers were cataloguing it and watching it as they do, but

like trainspotters.

Interested in these in these details and what happened was

suddenly what was designated as a nose cone suddenly changed to

orbit.

Yeah right and that can only happen when it's got rockets on

it so it wasn't a nose cone fair it was something else that had

been launched nefariously and they that come country tried to

keep secret. So it's I'm it's not really a question it's just

a statement that it's it's really interesting that the the

protocol that you've developed is actually tackles the its

cyber physical it's not simply cybersecurity there's physical

security embedded in as you say this and you know designs to to

succeed.

I have a question, and this is a bit more speculative. OK? My

question is what frightens you with this development of this

technology with the with the world becoming increasingly

competitive and fractured in many ways?

And what in this realm frightens you? What should we be keeping

an eye out for, and why?

Are we doing enough?

In this sector, in this space, to ensure that humanity itself

is resilient. Whoa, that's a big question. Wow. So many big

questions this morning.

Umm, I think what frightens me if I speak from the point of

view of a quantum technology entrepreneur, is that I know

just how nascent this industry currently still is and how much

technology and is a product development. And our scientific

research needs to happen to turn the current proof of concepts

into a commercializable or product that really adds value

to society. And what really frightens me is actually the

breakdown of collaboration, of a

breakdown of international

collaboration.

I think in quantum technologies
and also in the space sector,

these are two very critical
sectors for all countries. So I

think for me you know a lot of
the work so far has been done

through international, very,
very large multi year

collaborative projects and I
really hope that this is able to

continue over the next few
years. I think what is really

encouraging for the UK is
actually the UK, Australia space

bridge that was really launched
last year and I think one of the

first projects.

Was funded through the UK,
Australia Space Bridge was

actually for quantum space
communications. So that's a

really good vote of confidence
into the collaborative

capabilities between these two
countries and is that breakdown

in collaboration because the
actual security or you know

defensive or offensive
capabilities of quantum are are

so?

Clear that actually what
countries want is to do their

own thing to get that advantage
over each other rather than

working collaboratively. Hmm.

Yes, I think you definitely have

a point there. I think space was
kind of brought into one of the

new domains of warfare. And of
course for quantum technology, I

I can only speak about quantum
random number generators, but I

think from our conversations
with the government we know

about quantum random number
generators is classified as a

dual use technology. There are
no export restrictions on it as

of yet, however.

This is a developing arianas and
area that we're keeping quite a

close eye on.

Perfect. Thank you. So we have a
we like to end our podcast by

reading out a quote to our
guests and asking them what they

think about it. So today I've
picked a quote from Carl Sagan

and it says somewhere something
incredible is waiting to be

known. What would that quote
mean to you? So there's quite

actually reminds me of a quote
from a company that I've been

doing some work with called
Ambassador through Space

Scotland. So Space Scotland has
a working group called New

Voices and Space.

And it's a group of volunteers
that works to develop

initiatives to show that the UK

space sector is open and

accessible to all. And one of
the initiatives, first that I'm

doing there is actually raising
funding to bring Amber sets,

build your own satellite courses
to students, and so to kind of

600 students in underprivileged
areas across Scotland and also

the UK. And the reason is to
give them the chance to have

ownership over their own space
engineering project in the hopes

that it sparks an interest in
STEM subjects later on as they

apply to universities or go for.

On the apprenticeships and the
quote that Members had had in

their material was actually
there are X number of Amber

search builder and satellite
kits out there being used in

schools. One of them could be
used by a student who in 10

years time will be a future
astronaut and could be making

incredible discoveries out in
space that can better humanity.

So I think that's a really
lovely way to tie and both of

those quotes together. I
couldn't have asked for a better

answer to that question as a mum
and someone that loves space.

Who's got children that are the
space enthusiasts at that age

group? I couldn't have thought
of a better answer. Thank you so

much. You've made my day. I was waiting for a joke cause I've

been no jokes about. There's been no quantum jokes. You know,

there's something out there wonderful waiting to be

discovered as well. There isn't. There isn't. You know, that's

funny.

Low level quantum jump or is it?

Oh, I guess I should ask you. Ohh. I always did a story. But

if you could go to space, would you go to space? This is where

we fall out.

Right, that's all the time. But if you could go to space, would

you go to space? And why? Ohh I would go to space because I

would love to look at what Earth looks like from space, but there

must be something more than that. But that's a great answer.

Yeah, but there's more to that answer than that.

Just because I can't go. Yeah, because I want to. Well, I

think, you know, in a in a rocket with Alan and Chris and

Greg and me. So I think we're gonna have to have a party

rocket at some point.

Ohh exactly. I think I've got to also be remiss of me. Not to say

a huge congratulations and doing my usual over exciting here, but

congratulations for being in the 30 under 30.

Ah, thank you. Thank you very much. How's it going?

Yeah, it was a really wonderful surprise actually. But you know,

it, it wouldn't have happened without all the work of of the

crowdfunders for the past 3 1/2 years, as well as all the

growing team that we've managed to bring into quantum days over

the past year and a half. Ohh. Well, it was absolutely

wonderful to see all the, the news articles about your journey

and huge success and I look forward to seeing how you and

the team move forward. Thank you so much for your time today.

I've had a great time, Alan, that was really, really.

What they've been really interesting for me on this is

that most of the other interviews we've had, I've had

contact with in the past. Yeah. And I've been supporting them in

various guises over the years. It's been really interesting to

to to be faced with something so fresh and so, so cutting edge

really, it really impacting the boundaries of what reality, what

we know about reality and how we apply that. So thank you so much

for your time and for your insight. It's been really

interesting. Well, thank you
very much for having me on the

podcast, both of you. I know
it's really, really nice to have

had the chance to.

You know, talk about about the
space sector and how that merges

with quantum tech this morning.
Ohh, fantastic. Will you take

care and we'll catch up soon.
Bye now. Bye.