

01:03:04 Kirk Woolford: Morning from sunny Surrey!

01:03:13 Ilsa Kuiper: Evening from chilly Melbourne, Australia

01:03:16 Helena (NDTp Admin): Good morning from a chilly air conditioned office!

01:03:17 Jordan@melioro.co: Hello from Happy Hertfordshire!

01:03:19 Holger Kessler: just checking that this event has not started for anyone else yet either?

01:03:22 Andrew Smith: Good morning from overcast but warm Edinburgh

01:03:24 Inaki Esnaola: Good morning from tropical Sheffield!

01:03:30 Oleg Missikoff: Greetings from the Eternal City!

01:03:33 julian klein: Morning all

01:03:39 Pinning, Robin (STFC,DL,HC): Hello from sunny Calderdale

01:03:45 Ruth Mallors-Ray: Morning from my air conditioned pod in Kent. Looking forward to an intro into cyber physical

01:03:53 James Humphreys: Morning from Hertfordshire

01:03:54 Prathapa Ravindra: Good evening from Sydney 13 C here , we are in the middle of winter!

01:03:56 Holger Kessler: yes

01:04:12 Neil Tatman: Good Morning from 'balmy Belper' in Derbyshire

01:05:15 Chris Dent: (Now to attendees also) Morning from an overcast Renfrewshire - much better than the highs of 24C over the weekend which was far too hot for me.

01:05:25 Gailina Liew: Good morning - I've just lost audio - anyone else?

01:05:38 James Law: Audio fine here

01:05:43 Iain Wallace: Audio ok here still (zoom client, not web browser)

01:05:55 john Curzon Price: no audio for me...

01:05:59 Neil Tatman: No audio for me also...I've redialed back in, but the same

01:06:03 Andrew Smith: Audio ok for me

01:06:18 James Humphreys: Audio ok for me on web browser

01:06:18 Jacob Coker: working for me on zoom browser version

01:06:28 John Beard: audio ok for me on zoom app on pc

01:06:28 Gordon Masterton: Audio ok here

01:06:33 Jeremy Watson: OK for me - but logging in was a problem

01:06:43 jeffrey lake: all working fine for me

01:06:50 Prof. Samer Bagaeeen (Cllr.): Looking forward to the day

01:07:03 Gailina Liew: Exited and logged in again - all fine now, thanks!

01:07:04 Caroline Robinson: Audio is crackly.

01:07:13 Navein Madhavan: Audio ok on the zoom client

01:07:22 Tim Danson: Audio is fine - the problem will be on your end

01:07:38 Luke O'Rafferty: All fine here. For those without sound check you have clicked on "join computer audio"

01:10:54 John Davies: So right about harnessing data - is there a need for a discussion around a national Data Exchange of some sort, which seems to me to be perhaps be critical infrastructure going forward

01:11:02 peter w: I think that in times when we need global international collaboration, all this talk about 'global superpower' etc is unhelpful as it builds a spirit of competition and not one of collaboration.

01:12:55 Ges Rosenberg (UoB): Key issue is to know who our allies are for collaboration - this is a soft power issue as well as security and defence.

01:13:40 Caroline Robinson: Asking private companies to surrender their datasets is going to be the biggest challenge.

01:14:45 Caroline Robinson: A central system of national datasets is also a threat as well as advantage to corruption and missuse.

01:14:58 Andrew Bush: How do we control the security and use of the information and not let it turn into big brother

01:15:18 Sophie Peachey: This has to be about sharing and not surrendering. No data lakes. No lake could be big enough!

01:15:59 John Beard: @Andrew - in brief through Trust - and the concepts in Data Trusts are key

01:15:59 Mark Wharton: I'm very wary of a centralised approach. Self-sovereign and decentralised is the way forward IMO

01:16:22 Cambridge CDBB: Cyber-Physical Fabric article mentioned by Paul just now:
<https://www.linkedin.com/pulse/cyber-physical-fabric-paul-clarke/?trackingId=WBEBcUp8tIOHvhp9K%2FPKsA%3D%3D>

01:16:31 Caroline Robinson: Is it a bit like BIM? A great idea, but actually super hard to implement and will take longer to do than anticipated?

01:17:10 Ges Rosenberg (UoB): Be useful to hear thoughts on the democratisation of the technologies, models and tools & how this will be inclusive, not the 'cherry picking' of affluent-only areas for implementation.

01:17:23 Caitlin McDonald: What is BIM please @Caroline?

01:17:58 Holger Kessler: Building Information Modelling (or Management)

01:18:00 Caroline Robinson: Building information modeling (BIM) used for complex

01:18:04 John Davies: @Mark - yes but federation will be required (in a controlled way of course), otherwise data will end up in silos and its full value will not be realised....

01:18:14 Caroline Robinson: Built Environment rather than CYber.

01:18:55 Caroline Robinson: Was told it would take at least 200 years to implement BIM across the UK... at that is for existing building not future builds.

01:19:08 John Beard: Yes we have to design and architect for federation - nobody will ever have a copy of all the data

01:19:24 Martin Paver: 6 major construction companies are collaborating on a Construction Data Trust. They have agreed to securely pool data to address productivity challenges. So the obstacles can be navigated... if the appropriate controls are in place.

01:19:42 Simon Hart: BIM was a UK success story in modernising a previously unproductive sector. Some of the story of how it worked: <https://www.pbctoday.co.uk/news/bim-news/bim-level-2/84482/>

01:19:43 Mark Wharton: @john I don't disagree. A federated, decentralised infrastructure is *exactly* what I would recommend

01:21:29 Caroline Robinson: On the positive side data collection has never been easier to do.

01:22:28 Robbie Allen: @Martin Paver can you give more details on the Construction Data Trust. I'm at the sharp end of this process and finding it really difficult to get data - even if it's 'valueless' in most contexts - from construction subcontractors.

01:22:33 Caroline Robinson: Migrating and updating legacy systems is going to be interesting work to do.

01:22:38 Jeremy Watson: 'Federation' requires a meta-layer for interoperability above existing design and visualisation tools. These are incumbent and will not easily be displaced in current practice.

01:22:39 John Beard: @Mark - yes, and this will arrive better with some facilitation which ought to be inspired from somewhere central - like today!

01:23:55 Chris Dent: One point that I think will already be in everyone's minds - when developing a DT strategy it is necessary to be clear what is meant by "DT". @tom and others do you have please any documents from GO Science that indicate what is meant by "DT" in your context?

01:23:59 sue chadwick: How do we create a system of governance when, in planning law, land is described as a "coporeal hereditament" - ie an exclusively physical entity.

01:24:04 peter w: https://www.amazon.co.uk/What-Got-Here-Wont-There/dp/B07QW9LKTX/ref=sr_1_1

01:24:40 jeffrey lake: Why isn't there a way to learn expensively gained from manufacturing? I have been trying to do this but hit 'concrete' walls

01:24:55 Martin Paver: @Robbie - that is one of the reasons for setting it up. It is a not for profit. See datatrust.construction for more details. We are in the process of updating the website. Early days, but things are moving.

01:25:06 Holger Kessler: @Martin Paver I am also very interested in the Construction Data Trust (am part of the Geospatial Commission at the Cabinet Office building the National Underground Asset Register)

01:25:19 Ian Bailey: We've been working on the federation aspects of the NDT architecture recently - testing different technologies and approaches. There is definitely a core set of data that needs to be managed centrally - standards, access policy, contracts, data models, etc. However, the broader federation can be truly distributed and in some cases asynchronous

01:25:32 Mark Wharton: @john. centralise the principles, funding and facilitation, allow innovation in the implementation. The go-fair people have good ideas

01:25:41 jeffrey lake: #expensively gained knowledge.

01:25:43 Caroline Robinson: Yes, I haven't heard of the Construction Data Trust before.

01:25:56 Mark Bass: I don't know who to trust anymore

01:25:56 frank: could the statutory records of compliance with building standards/regulations form a basis for a publicly held foundation of a digital twin?

01:25:57 John Davies: @Mark/Jeremy/John - yes, there are certainly technical challenges and a 'meta-layer' will be required I think. In addition, there will be data that is made available at a national level

01:26:05 Martin Paver: If anyone would like to discuss the construction data trust then please contact me via LinkedIn. Or Grant Findlay, who is the Chair of the Trust. Happy to help.

01:26:07 Mark Enzer:
<https://www.cdbb.cam.ac.uk/system/files/documents/TheGeminiPrinciples.pdf>

01:26:08 ucfsdcde: Information overload is a challenge too - even assuming that all the information is opened up, how do we ensure that people get the information they need in the format they need, when they need etc - and can trust it once they receive it ...

01:26:22 Mark Wharton: @john - Metalayer - YES!

01:26:26 ucfsdcde: I'm also interested in how location can be used to start to integrate some of these very disparate datasets ..

01:26:57 Caroline Robinson: @Frank Estonia has already made sure that all planning applications have to be sent in digitally and then this becomes the basis for data for DT.

01:26:58 Neil Tatman: An ecosystems needs to be designed and launched. Roles and accountabilities need to be accurately understood (from Government to private sector). Commercial realities of available platforms/ tools, and the real need for credible capabilities here for scalable and accessible tools for industry to have confidence in..... IT 'giants' have a role to play here for the safe sharing/ storage of commercially sensitive datasets....

01:27:09 Robert: The definition of DT here is as good as it gets for now:
<https://www.digitaltwinconsortium.org/glossary/index.htm>

- 01:27:35 Chris Courtney - UKRI INNOVATEUK: @Neil agree, we need to navigate this carefully to really create national value
- 01:27:38 Jeremy Watson: What about cyber elements embedded in the physical fabric? i.e. the evolution of IoT and machine learning at the 'edge'?
- 01:28:06 Mark Wharton: @jeremy virtualise them as digital twins
- 01:28:28 Ged Cunliffe: There are lots of parallels with other government funded programmes which will want to take advantage of these types of capabilities - HS2 - Defence programmes - is there an opportunity for the UK to adopt a similar approach to the approach being adopted in Europe (Gaia-X)
- 01:28:30 Jeremy Watson: Avatars for machines/
- 01:28:37 Miranda Sharp: there's a lovely formula in Ash Fontana's book; value of data = uncertainty removed from decision making. (Quality is in the eye of the beholder)
- 01:28:39 Ruth Mallors-Ray: Please forgive the long post: for cyber physical I feel a key challenge for industry policy makers is being able to understand it against existing, well understood business value chains. Aerospace is a hierarchy, those at the top respond to the demands of airlines, airlines respond to travel trends. Space, whilst more complex in terms of its long term nature AND its diverse customers of multiple government departments, multiple sectors and us, the general public. But even it has a recognisable value chain ... make, launch, operate, commercialise data.
- 01:28:53 frank: @caroline yeah, estonia are leaps and bounds ahead, planning and in my view, building control data, and not just golden thread data, should form a basis, similar to estonia
- 01:29:01 Navein Madhavan: Digital Twin will have specialised definition for each sector but fundamentally the same idea. AMRC has produced a good paper on this - https://www.amrc.co.uk/files/document/404/1604658922_AMRC_Digital_Twin_AW.pdf We at the Institute of Digital Engineering are working on a bespoke definition for the sector, aligning with CDBB, AMRC, etc
- 01:29:12 Mark Wharton: @jeremy +1
- 01:29:21 Ruth Mallors-Ray: What therefore is the value chain of a cyber physical infrastructure and how clear is this to policy makers, decision makers and those that will use it?
- 01:29:22 Pinning, Robin (STFC,DL,HC): I think we should consider that there's a lot out there already that could be consider pilots (due to budget levels) - lessons should be learned from them. Not least that there's a very good reason this is hard and that isn't just technical - the legal barriers around IP and contracting are significant.
- 01:29:25 Caroline Robinson: Definition of DT is available at <https://digitaltwinhub.co.uk/>
- 01:30:10 Ilsa Kuiper: Challenges will extend to those fundamental institutions and structures that have not traditionally had to address issues raised by data and data concepts...assigning accounting standards to and about data, taxation, professional capabilities, law etc. For policy makers is about considering the performance of data and empowering communities.....beyond just data, beyond just data volumes
- 01:30:13 Will Stewart: Global context seems crucial

01:30:14 ucfsdcde: @ruth - good point re: value chains .. !

01:30:49 Neil Pennell: The Construction Industry Data Trust is being supported by the Construction Productivity Taskforce a group formed from construction industry clients Landsec, British Land and GPE and some of the UK's leading contractors including SRM, Mace, Lend Lease, Skanska and a number of leading figures from the industry who were brought together by Be the Business. grant Findlay is leading the Data Trust initiative.

01:30:58 David Lane : Market failure is not the way to think about this - market ENABLER is key. If we are looking at market failure, its too late, we have lost the strategic advantage, and we are simply applying patches to fix

01:31:01 Will Stewart: So whys this summit only UK? Lots of fine RAEng Fellows abroad

01:31:04 jeffrey lake: There is a fundamental issue in this discuss in that you are starting from the point of the technology application. Industry also made that mistake and squandered huge sums before they realised that the starting point was the fundamental questions. 'What are the problems I am trying to solve , What are the objectives that I wish to achieve'

01:31:05 Steven Carter: Standards are key if available citing ISO/IEC groups

01:31:09 Navein Madhavan: @Ruth, fully agree - well said

01:31:15 Neil Pennell: Grant Findlay of SRM.

01:31:22 peter w: w.r.t. technology - that will change; the key structures to put effort into collaboratively are information structures and models

01:31:25 Emmanuel Kahembwe: Blockchain technologies are integral to the CPF objectives. Digital Twins and being able to share and track data while maintaining trust, privacy and verifiability requires governments to fully engage in the global standards process. There is going to be a need for a global blockchain standards and protocol.. that allows for individual countries flexibility in implementation but ensures interoperability.

01:33:41 Oleg Missikoff: About fintech, CBDC is the next big issue, maybe eclipsing cryptos

01:33:42 John Beard: @David - yes think of all this as and ENABLER - of a vision for how organisations across the UK (and wider) can work together better and increase productivity

01:33:43 Holger Kessler: I think @Oleg makes a very very good point here!! I am struggling to listen and read at the same time - and I am sure the panelists must be very stressed by this also

01:35:01 Caroline Robinson: How will this be implemented when we haven't been able to make OS MasterMap data as OpenData over the past three years? And this is a Gov Com, not a private utility company?

01:35:16 bmurray25@dxc.com: If the CPF is built fast enough, at least its critical components, it can help avoid market failures of other components.

01:35:27 Oleg Missikoff: What is the position/role of humans in this scenario?

01:35:32 Ilamaram Gunaratnam: What is digital twin?

01:35:33 Caroline Robinson: Financial incentive will be key to unlock private companies datasets.

01:36:13 Will Stewart: We cannot ignore the actual physical fabric. The growing capability of the physical and the demands placed upon it are the key drivers. So 5-6G & full fibre are what really enables this

01:36:14 Caroline Robinson: @Oleg Missikoff - What is the role of the electorate?

01:36:34 Caroline Robinson: @Will Stewart Agreed.

01:36:46 Paul Clarke: We will be talking a lot more about what a digital twin is in the forthcoming discussions

01:36:50 Ilsa Kuiper: Mainstream/economic institutionalisation has selectivity reasoning for a justification for government intervention. There is more beyond market failure (e.g. evolutionary economics?).

01:36:56 Oleg Missikoff: @Caroline - In the UK or internationally?

01:37:02 Ilamaran Gunaratnam: Thanks

01:37:07 jeffrey lake: People are absolutely central to making a digital transformation successful. Many industrial projects have failed as they had forgotten a key element - to bring along their workforce.

01:37:23 bmurray25@dxc.com: Great message Will Stewart, lets not ignore the physical elements of the fabric!

01:37:35 Oleg Missikoff: @Jeffrey - Totally agree

01:37:38 Jeremy Watson: @Ilamaran - DTs are a popularised generic term for modeling and simulation, with emphasis on fusing and federating models into more general frameworks

01:38:30 Pinning, Robin (STFC,DL,HC): @jeffrey agree about people. Across organisation collaboration is critical (and yes, I got your name wrong before, apologies)

01:38:33 Christopher Ross: https://en.wikipedia.org/wiki/Digital_twin Glad someone asked

01:38:36 peter w: ... but although things might have been built different ways (as David Lane describes) the information user across these different approaches will in many cases be the same. So, we perhaps need to focus on getting interoperable information models

01:38:56 Shmuel Yerushalmi: I have two questions to panelists of present session. First question, how cyber physical fabric approach can to support resolution of hard and difficult social problems and secondly, i want to ask if this approach can in practice to improve facing disasters as COVID-19? Thanks! Shmuel

01:39:03 Caroline Robinson: @Oleg Missikoff Well, everywhere. What is the advantage to the person in the street? There is a clear advantage for better for governance.

01:39:25 jeffrey lake: Jeremy Watson - I know through the many discussions within the CDBB that your definition of what DT is would be widely challenged. It is much more fundamental than that.

01:39:38 Ilamaran Gunaratnam: Thanks Jeremy, I assume concepts like Building Information Management falls under this category?

01:39:38 Oleg Missikoff: @Caroline . And healthcare too

01:39:50 ucfscde: @peter w - can we also learn from previous work on data (and other) interoperability and standardisation - do we have existing examples of best practice?

01:39:51 Paul Clarke: @Peter. Absolutely and that has been a key focus for the Information Management Framework that CDBB have been working on but hopefully also the National Data Strategy will deliver some of this infrastructure Lego

01:40:06 Mark Enzer: @Jeffrey and @Oleg - I totally agree too. Human factors are key to the success of the CPF. We need to see it as a socio-technical change programme...

01:40:16 Oleg Missikoff: DT is a holistic paradigm

01:40:35 Caroline Robinson: @Oleg Missikoff Only if combined with personal health data. With all of these things the benefits have to outweigh the risks.

01:40:36 Sophie Peachey: What is a Digital Twin: A live digital coupling of the state of a physical asset or process to a virtual representation with a functional output. (Is one definition - by AMRC.)

01:40:50 frank: @caroline if we had a digital twin of grenfell tower, the ability to investigate information and responsibility lines would have been easier, and maybe if responsibility lines and data on compliance was within a digital twin of the tower, the disaster may not have happened.

01:40:53 Caroline Robinson: I think the biggest example of federated data is Social Media.

01:40:54 Oleg Missikoff: @Mark - Let's connect on this later

01:41:08 Jeremy Watson: @Ilamaran Yes; some of the early thinking about DTs sprang from the challenges of generalising BIM

01:41:24 Mark Wharton: @oleg yes. Agree that DT is not just about emulation

01:41:33 Ilsa Kuiper: Data standards/interoperability are a first step....next step will be heightened interpretative capability (people or tech/systems) and diminishing the need for comprehensive standardisation (and overcoming issue of what standard applies)

01:41:46 Robert: BIM is not a digital twin

01:41:52 Ilamaran Gunaratnam: Great one of my favourite topics along with Intelligent Building Management

01:41:55 Mark Wharton: @ilsa - semantic web?

01:41:59 Will Stewart: I am not sympathetic to discussions on definitions (eg DT & AI) and I think they put off the wider public. Definitions tend to expand beyond what purists would like but this is a normal part of the process and to be welcomed. Pure=niche

01:42:01 frank: @caroline sorry, so in terms of value to the man on the street, its right there

01:42:04 ucfscde: @caroline - but perhaps social media is not so integrated across the different platforms, which is something we would be needing here?

01:42:07 Caroline Robinson: @frank Raw datasets don't do that, unfortunately. Need to translate data to information and then knowledge. And then action on knowledge or insight into future modelling.

01:42:38 Pinning, Robin (STFC,DL,HC): @mark, we have a very current example of a socio-technical challenge that could be used as an example!

01:42:55 Anthony Dennis: @paul Clarke as well as a National Data Strategy, do we also need a National 'Cloud' or 'Data Centre' strategy (infrastructure) to under pin CPF from a sovereign data perspective?

01:42:57 Mark Wharton: @robin - bring it on!

01:42:59 Liam McGee: @oleg try https://www.cdbb.cam.ac.uk/files/flourishing-systems_revised_200908.pdf for centring this on human flourishing

01:43:01 frank: @caroline datasets on compliance would

01:43:02 Jeremy Watson: @Robert If you blend real-time (sensor) information with static CAD data, I suggest it is a kind of DT

01:43:03 Simon Hart: A Digital Twin is a digital replica of a physical thing, person or process that shows the past, present and future.

01:43:05 Will Stewart: blockchain has energy/sustainability issues

01:43:07 Caroline Robinson: @frank Consider the built in bias of your statement... :)

01:43:15 John Beard: @ilsa - agree - good points for the 11:40 session

01:43:21 Oleg Missikoff: Central Bank Digital Currencies (CDBC) are exploding

01:44:00 julian klein: Wont be any natural resources in 50k years!

01:44:04 Robert: Definitions are part of standardization and the basis for ISO and ANSI and more.

01:44:10 frank: @caroline person then.

01:44:31 Caroline Robinson: @frank :)

01:44:40 Melissa Zanocco, ICG: Our Vision for the built environment:
www.visionforbuiltenvironment.com

01:45:11 Ilsa Kuiper: @Mark Not sure....have come across theory that points to this as a possibility....could be simple interpretation (binary, on/off) but Ai is another

01:46:20 Liam McGee: @will crypto does have environmental issues but not all aspects of blockchain do... tokenisation may be key to keep rights over data clean at point of use, and trackable... also transparency and clarity of accountability for automated decision-making.

01:46:35 Mark Wharton: @ilsa - I'm a bit wary of NLP in this arena

01:46:41 Oleg Missikoff: A thesaurus is needed to help newbies

01:47:04 Paul Clarke: Powering circular economies and optimising for reuse and extensibilities are important outcomes. The idea of shared pre-competitive building blocks built upon common standards, interfaces and middleware will be important in underpinning those outcomes

01:47:04 Will Stewart: @liam - not crypto - just blockchain

01:47:24 Caroline Robinson: @Paul Clarke Yes.

- 01:48:02 Melissa Zanocco, ICG: Our Vision is for a built environment whose explicit purpose is to enable people and nature to flourish together for generations... Just as we live with the choices that our predecessors have made for the built environment, the decisions we make now will impact the generations to come. We therefore need to focus on outcomes for future generations as well as for the people using the built environment today.
www.visionforbuiltenvironment.com
- 01:49:35 Miranda Sharp: @Paul Clarke, how are you addressing the market failure / market enablement question?
- 01:49:56 Oleg Missikoff: Industry 4.0 is another field for DTs
- 01:51:38 jeffrey lake: Ind4.0 is the european banner for digital transformation (particularly in manufacturing) . A DT can be one element in that , but it is only 1 element.
- 01:52:22 David Lane : @Miranda - trying to persuade Govt to think differently in their policy thinking and where intervention is needed - like ARPA for the internet
- 01:52:34 Paul Clarke: We absolutely cannot wait for a market failure to happen! The market will not build the secure core underpinning infrastructure built with common standards and pre-competitive building blocks. Traditional funding models are not setup to fund this either. So we need to create new delivery and funding models to build that core which academia, industry and public sector can then build upon
- 01:52:39 Oleg Missikoff: @Jeffrey - A powerful one though
- 01:52:50 Chris Courtney - UKRI INNOVATEUK: there is little doubt that cocreation is the right approach and akin to living labs. the challenges are not only human or only technology. We need investment and development which really combines these aspects, not pursue technology first technology try to persuade after the fact.
- 01:54:53 jeffrey lake: Oleg: each element is powerful , it depends upon the problem you are trying to solve. DT's are being promoted as 'The Solution' but that is in danger of being oversold. Digital transformation is a journey and the creation of a DT could be a part of that - but not necessarily.
- 01:54:56 Miranda Sharp: that's great news, thank you @Paul and @David, interesting times
- 01:55:15 Chris Courtney - UKRI INNOVATEUK: the market failure is already here in the sense that the ability to share across systems, sectors and so on is very hard to do in real world now and limits potential now. it is possible but very expensive and complex to do and the case then isn't there. For example most people accept the notion of having end to end visibility of a global supply chain and the value it can unlock, but doing it for real is very challenging and too expensive for widespread use, even before you get to trust, security, ethics etc.
- 01:55:36 Chris Courtney - UKRI INNOVATEUK: and that's before you imagine new possibilites
- 01:56:04 Liam McGee: @caroline I think that social media is more of an example of how *not* to do it... walled gardens, no interoperability, wildly skewed power relationship between data holder and data provider, no rights maintained over data at point of use. Internet much better, but that was much more of an emergent tech from a set of standards agreed by ... accident, really. I remember HTML5 standards development became just a case of

'document what people are already doing most frequently and make that the standard'. May be an interesting approach here.

- 01:56:15 Oleg Missikoff: @Jeffrey - to tackle complexity we need holistic approach
- 01:56:41 Mark Enzer: Key potential market failures:1) Federation failure = multiple, bespoke, proprietary connections between digital twins would build friction into the network/ecosystem. 2) Ethics failure = unregulated development of the market would not default to "data for public good"
- 01:56:43 Sophie Peachey: @Chris Courtney - please see the Rail Digital Twin Ecosystem IOTICS is creating with Rolls-Royce.
- 01:56:50 Oleg Missikoff: Systems thinking
- 01:56:53 Ilsa Kuiper: @Paul C Agree but are models/approaches there but remain untested, unused (eg innovation contracts, managing degrees of unknowns, accepting outcomes may not necessarily be achieved)? Goes to Sabine's point about robots
- 01:56:59 Jordan@melioro.co: Technology is the 'easy bit' (comparatively!). The difficult bit is around governance, ownership, policy, legality, ethics, assurance, etc. and the ability to get the core underpinning capabilities (including data) up and running. Co-creation (co-delivery?) has got to be key - but how do we find the right 'experiments' to drive the narrative?
- 01:57:09 Pinning, Robin (STFC,DL,HC): @chris and @liam - great related points
- 01:57:44 Caroline Robinson: Jordan@melioro.co Yes.
- 01:58:12 peter w: we didn't do well over the past 40 years with the EU in terms of collaboration - we need to learn from that lesson
- 01:58:25 Oleg Missikoff: In Italy we have already started a collaboration with Cdbb
- 01:58:33 Mark Wharton: @rob buckingham. JUST START! Yes, oh, yes. learn by doing
- 01:58:35 Miranda Sharp: @Liam, agree, though as a colleague at the ATI said. HTML had a broad spectrum use case in the ability to publicize and transact. What is the equivalent for the CPF?
- 01:58:38 Ilamaran Gunaratnam: What type of new age companies are you advocating get started to support this great initiative?
- 01:58:49 peter w: <https://digital-strategy.ec.europa.eu/en/policies/strategy-data>
- 01:58:52 Syed Ali R. Zaidi: @Rob, excellent point at some point we need to start building stuff :)
- 01:58:56 Graham Meaden: Standards on Data Quality and Data Quality Criteria and how to apply them. Without these orgs cannot establish effective data governance.
- 01:58:57 Robert: @Jeremey, agreed, doing what you say gets you closer to a DT and leads you to the understanding we need a top down ontology for AI, DT, ML, etc. An ontology will also make it clear where marketing and waffle stops, and interoperable engineering and computer

science begin. The hard part of DT needs a lot more work but currently gets subsumed by the view that it's about data science and information management.

- 01:59:10 jeffrey lake: in a Digital Transformation, the application of technology in whatever form is an Outcome and not an Objective.
- 01:59:19 Greg Demchak: create interactive prototypes by combining parts in ways!
- 01:59:24 Liam McGee: Just start but also make what you are doing shareable. Interoperable, or at least documented. Ontologies conformed with, standards more-or-less kept to..
- 01:59:34 peter w: <http://dataspaces.info/common-european-data-spaces/#page-content>
- 01:59:43 Claire Ellul, UCL: Another EU example of a federated data service (very top down standards driven) <https://inspire.ec.europa.eu/>
- 01:59:46 Alain Waha: Themes interesting part of the internet success is that is is triggered by very few "narrow waist" technologies and governances? v. Light touch; retrospective adoption of "what works";
- 01:59:47 Mark Wharton: @liam that's our approach
- 02:00:16 Greg Demchak: everything already exists, they just need to be combined and demonstrated. Check out how the laser was developed...
- 02:00:28 Navein Madhavan: Taxonomy and ontology is critical to demystify and ensure we're pulling in the same, right direction
- 02:00:29 Liam McGee: @Robert: we need a TLO by ideally it should emerge from what-is, not be imposed upon it. Otherwise adoption will be *hard*. Need to enable little bits of adoption for little bits of interoperability.
- 02:00:51 Caroline Robinson: @Claire Ellul, UCL Yes, INSPIRE programme is great! :)
- 02:00:54 Mark Wharton: @navein. I agree
- 02:01:03 John Beard: @sabine - yes, finding a coalition of the willing - forming a federation of the willing - and several of them for that matter - is a good way to start. We need to encourage and help people to do this.
- 02:01:15 Chris Courtney - UKRI INNOVATEUK: think the collaborate versus compete debate depends on which layers you are focussing on and use case, sectors etc. the approach for building a global set of standards for a platform might be different to application into nuclear, pharma etc
- 02:01:16 Liam McGee: @Mark Wharton: excellent. Whose approach?
- 02:01:39 Mark Wharton: IOTICS
- 02:01:51 Mark Wharton: (sorry for shameless self promotion)
- 02:02:04 Cambridge CDBB: Gemini Principles:
<https://www.cdbb.cam.ac.uk/DFTG/GeminiPrinciples>
- 02:02:06 Neil Tatman: We need to "get on with things" as discussed. Today, Industry carries too much risk in developing these capabilities, but has the need to do so to answer their

business challenges..... We have many Use Cases, the risk is 'analysis paralysis' and we have to allow a more organic approach to succeed. The Living Lab is a great concept, but we need to address the scale and security as-part of the commercial realities..... Bring in the organisations which can enable this to happen....

- 02:02:09 Claire Ellul, UCL: @caroline - yes, but it is top down and with a very specific (environmental) purpose - not sure that would work for the wide variety of use cases for DTs mentioned in this chat...
- 02:02:10 Mark Wharton: (not sorry)
- 02:02:16 Oleg Missikoff: How about open a permanent chat to address the topics more quietly?
- 02:02:27 Oleg Missikoff: Here is too fast
- 02:02:30 Steve Maclaren: How do we create a more innovative approach to security of data? multiple channels for sharing, disaggregation? de-centralise??
- 02:02:59 Navein Madhavan: @Neil, agreed. Building to scale and not just chasing after proof of concepts. Building to scale requires the foundational layers being discussed in this CPF
- 02:03:10 Jeremy Watson: We need dynamically settable permissioning of information associated with DTs - temporal and identity variables. Concept of 'Digital Trusts'?
- 02:03:27 Caroline Robinson: @Claire Ellul, UCL Yes, this is about governance and data and how it affects society... so more dialogue is required and we are talking about commercial data, which has its own legal issues.
- 02:03:34 Steve Maclaren: I think we need to bust some preconceptions regarding security and understand the value of the data or not as each case dictates
- 02:03:39 Pinning, Robin (STFC,DL,HC): One point I've not seen mentioned yet. I'm a veteran of the UK e-science and grid days. I'm also involved in the current UKRI Digital Research Infrastructure. The on,y way we can make something like this work, evolve and be sustainable (for people and the software/hardware infrastructure) is to ensure long term ensured funding. 5 year plan, 10 year rolling vision etc.
- 02:04:01 Oleg Missikoff: Blockchain?
- 02:04:04 Ian Bailey: We've opted for an ABAC approach in the National Digital Twin architecture as it's hard to align roles across multiple stakeholders. Crypto and auth are pretty much commoditised these days, and it's just a case of picking a suitable framework
- 02:04:35 Oleg Missikoff: Blockchain rather than crypto
- 02:04:41 Jeremy Watson: @Oleg Blockchain is about provenance assurance not security
- 02:05:18 Caroline Robinson: @Robin Yes, as I mentioned before for the built environment and digitising it would take 200 years to do.
- 02:05:23 Ian Bailey: Where there is no centralised authority for contract verification, Blockchain has application. Hard to see where else it fits in this work.

02:05:29 jeffrey lake: @Naveien, there are processes for undertaking a digital transformations which includes the creation of PoCs/MPV's and Full Scale . Manufacturing has already been through this . How do people like me share that knowledge?

02:05:33 Ilsa Kuiper: Embed privacy, trust, protections..... in code?

02:05:39 Oleg Missikoff: Right, cryptography rather than cryptocurrencies

02:05:51 Miranda Sharp: agree @Jeremy and the National data strategy round table made that point exactly and are looking for projects <https://dcmsblog.uk/2021/07/national-data-strategy-forum-themes-from-the-first-discussion/>

02:06:27 Robert: @Liam, agreed, it's the chicken and egg. But we're past the point of understanding the difference between a virtual representation (BIM) and a true DT (oilfield well models). And ontologies are not intended to be static, we can see that in the medical ontologies.

02:06:28 Sophie Peachey: @Alexandra Bolton - be as open as possible but no more so - in our language: let the Digital Twin be in control of its own destiny and choose to share what it likes with whom it likes, revoking that at any time.

02:06:33 Caroline Robinson: I think the debate is very stimulating... thank you everyone for your links! :)

02:06:56 Liam McGee: @sophie: "share what you can, nothing more, nothing less"

02:07:04 peter w: realistically, how far are we away from 'having a robot come and mend a washing machine'? Wouldn't the washing machine be picked up and taken to the place where it would be repaired?

02:07:29 Liam McGee: @robert: yes! Ontologies should be Agile.

02:07:40 Caroline Robinson: And its parts rather than expert robots that we need for washing machines! :)

02:07:46 Syed Ali R. Zaidi: @Sabine: You made good point around data sensitivity and preservation mechanism at edge. However, there is often a conflict between commercial exploitation, i.e.: 1) I want to get all the data and who knows what I will find from it ; and 2) I know what I am looking for and I only need that data with consent for a specific use case. The problem is how do we educate people so they let go of obsession of over collecting the data without understanding value proposition attached to it.

02:08:01 Liam McGee: @robert: they should be an agreement of commonality between all that is and is planned.

02:08:05 Oleg Missikoff: @Liam - and federated

02:08:34 Ian Bailey: For ontologies to be extensible over long periods of usage it requires a lot of up-front design of the basic foundational patterns. If you don't get this right, you create huge amounts of technical debt down the line.

02:08:38 mark.emerton@innovateuk.ukri.org: @Peter - don't have washing machines at home - it's a terribly inefficient use of resources. Have a robot collect clothes from a box outside your house, deliver them back afterwards

02:08:39 Robert: @Liam. They as in ontologies?

02:08:51 jeffrey lake: ontologies aren't always required - eg , a closed system DT (a factory) .

02:09:16 Mark Wharton: @jeffrey, surely that's not what today is about, tho'?

02:09:26 Ian Bailey: @Jeffrey - I guarantee there's some kind of data structure even in a closed community

02:09:30 Pinning, Robin (STFC,DL,HC): Hear hear! On bureaucracies.

02:09:31 Chris Courtney - UKRI INNOVATEUK: @mark I refer to washing machine at home as 'washing at the edge' :-)

02:09:35 Ilsa Kuiper: @David Lane Too true...limitations to ethical frameworks. Interesting research by CAIDE at University of Melbourne on this point

02:09:42 John Grant: The New Breed review: The case for treating robots as animals
<https://www.newscientist.com/article/mg25033310-500-the-new-breed-review-the-case-for-treating-robots-as-animals/>

02:09:58 Mark Wharton: @chris courtney. Can I borrow that?

02:10:00 peter w: @mark.emerton - I agree. we need complete transformation of the system and that includes tasks like washing clothes

02:10:01 Graham Meaden: Bureacracy is a bit of a misnomer. The problem is the organisations and staff are do not share common motivation.

02:10:01 Liam McGee: @Robert: yes. @Jeffrey - even a closed system needs to be shareable, so the learnings can be shared, and so that new bits can be nailed on.

02:10:01 frank: not sure about england, wales and NI, but in Scotland we have public registers of building regulation compliance for buildings.

02:10:01 Greg Demchak: robots can be great for reality capture in dangerous environments--capture high-res LiDAR and photos so people can interact with a digital capture safely. Apply AI-ML to the images to locate high-risk defects...

02:10:24 Caroline Robinson: @Liam McGee Yes.

02:10:24 Joseph Weston: crypto could also be key to facilitating a national digital twin - ability to handle billions of micro-transactions to enable monetisation of data could encourage actors to share their data with the NDT. Thoughts?

02:10:26 Robert: @Jeffery, your point is why we need an ontology. For me a Siemens automation system would not be a DT.

02:10:30 Luc Bidaut: about size of regulatory, etc. too many la(w)yers?

02:10:46 mark.emerton@innovateuk.ukri.org: @Chris - perhaps - but autonomous logistics has many second and third order effects - what is central and what's 'edge' changes if moving 'stuff' around becomes cheap and seamless.

02:11:16 Robert: DT for me entails instantiation and aggregation.

02:11:21 Ilsa Kuiper: Time for the lawyers who are versed in computers, technology and code?

02:11:42 Caroline Robinson: DT is technically possible it is the data silos that make it difficult to achieve. Shared platforms are the answer.

02:12:04 Graham Meaden: @ilsa should we start with engineers first!

02:12:36 Holger Kessler: great point @Alexandra!! Very true

02:12:36 Mark Wharton: @caroline hear, hear!

02:12:41 Liam McGee: @ilsa and who are familiar with the problems of judicial mercy, context and nuance within automated decision systems. Always like Jonathan Zittrain on that kind of thing.

02:13:09 Steve Maclaren: @caroline, completely agree

02:13:42 Miranda Sharp: is there a question to which the answer is not "more joined up government and decision making?"

02:13:46 Oleg Missikoff: At todays speed when one finishes niversity the world has already changed

02:14:09 Caroline Robinson: @Miranda Sharp Agreed.

02:14:14 Ges Rosenberg (UoB): May engineers and Universities are working collaboratively, on living labs and well-versed in codes. Scaling up and delivering education around a systems approach looking at socio-technical, co-design and interconnectedness/interdependencies.

02:14:19 Mark Wharton: @caroline shared platforms, but don't centralise the data

02:14:34 Ges Rosenberg (UoB): *many

02:14:35 peter w: Plan Ceibal is a model to follow: <https://microbit.org/impact/case-studies/plan-ceibal/>

02:14:45 Caroline Robinson: @Mark Wharton Yes.

02:14:51 Oleg Missikoff: @Rob - with edutainment

02:14:51 Rich Walker: I'm old enough to remember the Sellafield visitors centre on a wet July afternoon as a warm and welcoming place :)

02:14:58 peter w: Uruguay has a lot of things right when it comes to getting young people to use computers

02:15:03 Mark Wharton: @oleg "All university courses are different forms of history"

02:15:26 Oleg Missikoff: @Mark - hehehe

02:15:44 jeffrey lake: I agree that you have data structures which are vitally important but when we have designed a factory DT, we understood the data well, its structure, completeness, correctness, links, etc. As it was a closed system, the need for ontologies was very limited. This reduced the cost. The reverse of that was true when we were creating a DT of a rail system. the data was so different and diverse so that we had to use a 'data lake' approach and sophisticated ontologies. Once again, you mustn't start the journey with the idea of a specific technology but asking the fundamental questions and the appropriate technologies will be the outcome.

02:16:22 Caroline Robinson: @jeffrey lake Agreed. :)

- 02:17:22 Claire Ellul, UCL: @jeffrey lake - agreed - but also need to consider how we can bring the existing siloes into the mix ..
- 02:17:53 Sophie Peachey: Hi Jeffrey - Difference and diversity shouldn't be a reason to create a data lake - isn't that just creating a new set of challenges around duplicated data, multiple sources of 'truth' and yet another data silo. Decentralised secure interoperability is the way to go!
- 02:17:54 Mark Wharton: "Don't digitally recreate what we've had before"
- 02:17:56 Caroline Robinson: Potentially a one-stop-shop for data for all utilities first, then water and waste water, then products/purchasing/shopping.
- 02:18:03 John Beard: @jeffrey - excellent description of real world experiences - we will all learn more if we can have more such examples/case studies
- 02:18:15 Caroline Robinson: Then, we can integrate all of these various systems.
- 02:18:21 Mark Wharton: @caroline I can't find you on LinkedIn, but we should talk
- 02:18:28 Pinning, Robin (STFC,DL,HC): @jeffrey, also agree. Related to David's panel comments too but we need envision a new world. One that is more sustainable and very compelling for all generations.
- 02:18:54 Liam McGee: @jeffrey fair point. I guess I'm just pushing for interoperability to be designed in even to closed systems, for the benefit of other systems and later systems. Ontology is just one way of achieving that.
- 02:18:56 Ilsa Kuiper: @Graham M @Liam Might be biased - am interested in engineering and law
- 02:19:01 Jeremy Watson: The market - particularly CAD OEMs - don't yet see the market drivers and opportunity
- 02:19:10 Graham Meaden: @jeffrey, agreed, but how do we motivate operatives on the railway to spend that extra time out on the network to collect better, high quality data which has no direct impact on their job.
- 02:19:16 Ges Rosenberg (UoB): University labs are great but tend to be reductionist. Getting graduates integrating, collaborating across disciplines, innovating with society around real-world problems. Universities teach engineers maths and physics and design, but insufficient codesign and innovation with public engagement. Many US Universities are more civic by virtue of their civic approach.
- 02:19:24 peter w: <https://www.ceibal.edu.uy/es> - the 2021 robotics and view games olimpiad is being advertised there. The UK needs to be levelled up to the state of Uruguay when it comes to using computers in education
- 02:19:44 Robert: David Lane pointed out earlier we've had cyber-physical simulation, HIL, SIL and MIL for 40 years, and Michael Grieves claims DT is an evolution of the Apollo 13 'digital twin'. But like others have said above, the Ontology should remain flexible - the more I think about the terminology DT the more I don't like it. At the end of all this we need the language to be computable and minimally ambiguous.
- 02:19:55 Pinning, Robin (STFC,DL,HC): @ges - the link to industrial challenges is also critical

02:20:00 Caroline Robinson: @Mark Wharton - You can find me here:
<https://nl.linkedin.com/in/caroline-robinson-560a1b35>

02:20:01 Jeremy Watson: @ Rob Government procurement preferences can help

02:20:26 Sophie Peachey: @Graham - Rolls-Royce and IOTICS has created a Rail Digital Twin Ecosystem which is decentralised and in which each separate data owner - different companies) has control of what they share with whom. There is no data lake.

02:20:27 Ges Rosenberg (UoB): @pinning - agreed

02:20:42 Oleg Missikoff: I don't like the fact that either i loose the chat or the conference

02:20:48 Caroline Robinson: My background is in Community Renewable Energy/Transport and grass-roots activism as well as data management! :) And I find this topic fascinating!

02:21:11 Melissa Zanocco, ICG: Agreed!

02:21:16 Oleg Missikoff: Let's do a chat later on

02:21:21 Will Stewart: Greg - get a software update - chat should be a side-panel

02:21:23 Tim Rawlins (NCC Group): the challenge with Ontologies is that they go out of date so fast - there is an ISO for telling the date and time but everyone uses a different way to say it...

02:21:27 jeffrey lake: we designed the factory (closed system) to be able to be integrated into a wider industrial digital twin (open system). the factory was a black box and we designed the 'outlinks' with future interoperability in mind

02:21:56 Wendy Hall: @Tim - we're addressing those problems in the next panel

02:21:56 Claire Ellul, UCL: @jeffrey lake - essentially, an API ...

02:22:02 Caroline Robinson: @jeffrey lake YES. :)

02:22:22 Liam McGee: @Tim if you build an ontology more on the lines of HTML5, then it self-heals as it diverges from reality. It's job becomes to document the most frequent ways of modelling the real.

02:22:40 jeffrey lake: yes a sophisticated API

02:23:12 peter w: much talk of ontology in the chat. we need to agree an upper-level ontology for all other ontology developments to reference, otherwise we just develop a number of silos

02:23:24 Mark Wharton: @claire APIs are ok, but tend to be too specific, not generic enough. I believe metadata should be more important than APIs

02:23:28 Navein Madhavan: @Tim, could you have intelligent agents or multi agent systems updating outdated ontologies....?

02:24:11 Caroline Robinson: @Mark Wharton Can combine both. :)

02:24:11 peter w: @mark wharton +1 to the primacy of data over APIs

02:24:24 Tony Fish: market failure = do we mean economic change, when we discover that the imagined value does not exist and we need to align to a new measure. Or market failure - does not do the right thing?

02:24:33 Tim Rawlins (NCC Group): <https://xkcd.com/927/>

02:24:40 Claire Ellul, UCL: @mark - interesting idea .. sometimes the 'metadata' word scares people/puts them off .. I think that with data you need both the API to serve the data and the metadata to document what is being served? (API was in relation to Jeffrey's black box concept)

02:24:43 Mark Wharton: @caroline - yes, that's my firm belief

02:24:52 Liam McGee: @peter w: or agree that the upper/top level ontology will be derived from existing frequently used ways of modelling data, and then the ontology seeks to comply with as many domain ontologies as possible, with the outlier domain ontologies then being brought in to alignment by peer pressure rather than command and control..

02:24:55 Greg Demchak: does AI require such rigid ontologies, or can it learn and make decisions by making best guesses based on historical patterns?

02:25:55 Liam McGee: @Greg depends what you mean by AI. Automated reasoning? Requires ontologies, really. ML? That'll do pattern finding in unstructured and semi structured data.

02:25:55 Wendy Hall: @Greg - that is such a good question. One for the UKRI research programme in this space

02:25:57 Pinning, Robin (STFC,DL,HC): @tim. Exactly!

02:25:59 Mark Wharton: @claire our key principles

1. Digital twin is in control of its destiny
2. Metadata describes the API
3. There's no need for a centre

02:26:03 Oleg Missikoff: Knowledge graphs are also very useful

02:26:07 Claire Ellul, UCL: @mark - exactly that!

02:26:07 Mark Wharton: *destiny*

02:26:39 Wendy Hall: I agree - no need for a centre to control. But we need a way to exchange info etc

02:26:52 John Beard: re keeping up with chat in parallel with speakers: I'm using a desktop screen and the Zoom app, and both panels are visible at the same time, and I find this works well. But on smaller screens YMMV ...

02:27:01 jeffrey lake: @Navein; yes you can have auto updating ontologies . You have a heavy use of AI's , we did this for a client developing power systems. We used AI to investigate CAD models (early gen models) , updated them and then used AI to create ontologies to create in filed links - they wanted to use the power of analytics to predict power outages

02:27:16 Paul Clarke: Completely agree about knowledge graphs and semantic maps

- 02:27:36 Graham Meaden: In a safety critical environment it is evident that the personal fear of incurring liability stymies the sharing of data. A baseline for describing the quality of data is fundamental to enable reduction in liability.
- 02:27:46 Miranda Sharp: @paul I agree one of the key missing blocks is the means of sharing data but also the means of transacting. (We are addicted to "free" or "open|" services which has skewed our view on transacting)
- 02:27:52 Max Zadow: CGA just provided a HD map delivered through a Digital Twin funded by CCAV to help a Westfield CAV drive in real world.
- 02:28:03 Robert: Are commenters above confusing ML with AI?
- 02:28:05 Caroline Robinson: @jeffrey lakeOoooh, that sounds like an interesting project. Please keep in touch: <https://nl.linkedin.com/in/caroline-robinson-560a1b35>
- 02:28:06 Mark Enzer: @Wendy - I agree that 'central control' would not work, but we would benefit from 'connection and coordination' to join things up.
- 02:28:19 jeffrey lake: The key issue for the client was that these power systems were constantly being relocated so new links had to be constantly updated.
- 02:28:21 Paul Hunter: @greg, this is where ML comes in, Machine Learning will solve as it learns from data??
- 02:28:27 Bill Murray : What is the minimum Viable CPF to avoid most market failures? What is the extent of the ecosystem that creates the CPF? What is the size of the data sharing universe around the CPF?
- 02:28:46 Glen Robinson: I agree that technology to support a decentralised data collaborative is still a short way off, but the centralised approach, the custodian model, exists today, and I/we (Microsoft) still see very low adoption due to a fundamental struggle to understand the value in sharing data.
- 02:28:52 John Grant: What has to be built first? Collaboration and cooperation protocols and frameworks.
- 02:29:02 Oleg Missikoff: Neural networks/deep learning
- 02:29:02 Ian Bailey: @Wendy & @Mark - you'll need to centralise the core standards
- 02:29:12 Liam McGee: @Graham: and yet it's also important not to accidentally think that autonomous vehicles (or any other autonomous system) do things that no one is responsible for.
- 02:29:26 Bill Murray : DEEP SOCIO...YES!
- 02:29:27 Ilsa Kuiper: Will the CPF arguably be endless....need for build/bolt on approach, design to adapt/recognise cost of change and recognising there will be risk (and degrees thereof) associated with the path taken/embedding positions?
- 02:29:30 Navein Madhavan: @ Mark E, coordination and connection and more importantly leadership. Points to empowerment as well
- 02:29:30 Mark Wharton: @glen the "altruism problem"?

02:29:33 Neil Tatman: Made Smarter Innovation Hubs have this ambition, i.e host and demonstrate multiple solutions, and multiple vendors - bridging the software and physical environments.... Even demonstrating collaboration across geographical instances.... Chris Courtney - discuss

02:29:42 Liam McGee: #deepsocio will now trend on linkedin...

02:29:49 Chris Courtney - UKRI INNOVATEUK: the integration between current data, where it is, how its stored and used etc is really important. We need to be careful not to just create a new model that is needed for future systems as if they operate in a green field, because for many industries they don't.

02:29:57 Graham Meaden: @Liam absolutely

02:29:57 Matthias Gropp: Exactly, not collecting everything is the key. You only want to store what doesn't change and allow for interfaces for dynamic data. Nearly all data is dynamic, as the real world is. Geospatial parameters give a good starting point to relate data to the world.

02:30:05 Mark Enzer: @Ian - I completely agree - we need shared rules: "collaborate on the rules; compete in the game"

02:30:14 jeffrey lake: I have been looking for ways to share knowledge with the 'built environment' for some time but find it very difficult to break through though my last project was very successful.

02:30:15 Claire Ellul, UCL: @chris Courtney - exactly, the legacy siloes are very rich in data!

02:30:18 Caroline Robinson: @Chris Courtney Agreed.

02:30:24 Oleg Missikoff: Consensus systems

02:30:26 Mark Wharton: @matthias +1

02:31:00 Wendy Hall: @Ian - I know. But it can be a virtual centre - doesn't need a building a lots of staff

02:31:18 Chris Courtney - UKRI INNOVATEUK: @Neil - ha! one for a smaller discussion but an opportunity to create more of this approach and ambition is certainly in mind. Only a start but a start none the less

02:31:26 Glen Robinson: @mark , indeed. Although the few places we see adoption today is around sustainability data sharing as most orgs we work with feel they are clear on the value here, which is good for us all. A good use case to get data collaboratives going and proven before moving into other areas.

02:31:45 Max Zadow: We have built a Digital Twin so far used for virtual learner driving, CAV and installation of a 5G infrastructure - in real world and taking into account social data. In real world with benefits from cyber. Working on MaaS with TfGM at moment.

02:31:46 Oleg Missikoff: Isn't this wat hubs should do?

02:31:59 Will Stewart: David Lane's approach sounds much more that of engineers that make things happen

02:32:21 David Lane : @will - thanks!

02:32:43 Glen Robinson: <https://planetarycomputer.microsoft.com/> an example of a planetary computer built around data sharing.

02:32:44 Mark Enzer: @Alexandra - well said!

02:32:57 Paul Clarke: In democratising innovation, we need to enable citizens to see themselves as innovators that that innovation being something that others do and is then done to them. Maker labs and other institutions such as cyber physical campuses at a national scale could be important here

02:33:04 Caroline Robinson: @Max Zadow Awesome.

02:33:14 John Beard: @Alexandra - yes, the subject is very much systems of systems

02:33:30 Liam McGee: Valuing intangibles such as data, carbon embodiment, human capital, seems like a great place to start.

02:33:36 Anthony Dennis: ESA Earth (planet scale) Digital Twin info can be found here https://www.esa.int/ESA_Multimedia/Images/2020/09/Digital_Twin_Earth

02:33:41 Mark Wharton: @glen data "communities" or "consortia" is a good starting point. See IOTICS' work in the UK Rail industry.

The world is built on "enlightened self interest"

02:34:05 Oleg Missikoff: This is an initiative for an Earth Digital Twin <https://digital-strategy.ec.europa.eu/en/policies/destination-earth>

02:34:09 mark.emerton@innovateuk.ukri.org: On the planetary DT example - the prediction / historical review / modelling / visualisation aspects are intuitive - but what are the cyber-physical interventions - i.e. the robots / smart machines.

02:34:21 Chris Courtney - UKRI INNOVATEUK: @Paul Clarke I think the coming together in living labs across traditional disciplines or sectors is a major gap, whereas we have many (perhaps too small) attempts at narrower living labs/innovation hub approaches

02:34:29 Mark Enzer: @Liam - I agree. We need to value digital assets, then the money people will care about them.

02:34:30 Liam McGee: @Mark Wharton The world is also built on solidarity.

02:34:33 Tony Fish: +1 thank you

02:34:34 Melissa Zanocco, ICG: @alexandra and @mark enzer second that - that is a quote right there: "The planet is the ultimate system of systems and the cyber physical fabric is the only thing we can use to manage it".

02:34:35 Robert: And how do you model SOS, realtime, and in sync. That's the hard problem i mention above.

02:34:38 Laurie Reynolds: @ David Lane, your point about multi-disciplinarity is key for me. Bringing different professionals deepens and broadens and develops shared understandin, but we need more structure and tools for mapping the relationships.

02:40:26 Paul Clarke: In my view, the CPF needs to unlock and empower the inherently messy, unpredictable and non-linear nature of successful innovation. Fostering the collaboration and co-ordination but also the networking, serendipity, leaps of faith, chance encounters, chaos etc

02:40:33 Cambridge CDBB: Please do continue the conversation from the first panel on the Digital Twin Hub. A discussion thread has been created:
<https://digitaltwinhub.co.uk/forums/topic/430-cyber-physical-fabric-summit-panel-1-cyber-physical-fabric/>

02:41:28 Cambridge CDBB: Video from the day as well as the follow-up summary will be sent out but also available on the DT Hub: www.digitaltwinhub.co.uk

02:42:06 Caroline Robinson: @Cambridge CDBB Awesome.

02:42:27 Claire Ellul, UCL: @Cambridge CDBB - great, very interesting discussion, glad to continue ..

02:43:33 Cambridge CDBB: Read Dame Wendy's post on this panel discussion:
<https://www.linkedin.com/feed/update/urn:li:activity:6821735265854394368>

02:45:31 peter w: use DCAT to store data stewardship information :
<https://www.w3.org/TR/vocab-dcat-3/>

02:46:32 Mark Wharton: "The interoperability layer" - amen to that

02:47:08 Liam McGee: Building on Dame Wendy Hall's intro... and given the knowledge we have in this chat room... is there a thing that you think everyone should read to help with thinking about CPF? I'd be grateful to build out my reading list. Here's mine:
https://dash.harvard.edu/bitstream/handle/1/4455262/Zittrain_Future+of+the+Internet.pdf?sequence=1 -- thinking about how much this feels like the early days of the web, and the legal and ethical things to be bearing in mind.

02:48:25 Liam McGee: And here's <https://nic.org.uk/app/uploads/Data-for-the-Public-Good-NIC-Report.pdf>, which is indeed great.

02:48:40 Oleg Missikoff: BIMs are not connected to the context and static whereas DTs are connected and dynamic

02:49:06 Mark Enzer: @Chris and @Laurie - I agree too. I think that this means the 'Delivery Vehicle' for the UKDT/CPF needs to be both integrated and collaborative.

02:50:10 Liam McGee: Some great analogies in here too:
<https://royalsocietypublishing.org/doi/pdf/10.1098/rsta.2016.0126>

02:51:11 mark.emerton@innovateuk.ukri.org: Be great to hear more from panellists about Metaverse as a term and how we should adopt it. Sir Tim and Dame Wendy didn't call it 'the internet for the WWW' they just called it 'the WWW' - same could well be true for the Metaverse; it's another internet application. Is 'metaverse' bubbling up because ultimately it's the most memorable, intuitive term for a world-wide DT system.

02:51:19 peter w: it is not only 'value' of data, but also the scope that it has to expose you to risk

02:51:31 Tony Fish: why does value and sharing have to be co-joined ? Is this a framing of our economic model of growth?

02:51:40 Caroline Robinson: @Oleg Missikoff Yes. Agreed.

02:51:48 Will Stewart: @Mark - I agree

02:51:55 jcogman@red-scientific.co.uk: Do you see a place for shared ontologies / taxonomies to assist with interoperability? In which case who do you see leading on this?

02:52:12 Liam McGee: @tony fish this is surely thinking of value in terms of common good, not finance?

02:52:24 Ian Bailey: Matthew West is leading on the NDT ontologies

02:52:45 Tony Fish: what is the market failure ? economic, value creation, growth, competition, delay or not doing the right thing to be a better ancestor

02:52:57 Liam McGee: @jcogman ODI is also a good place to start

02:53:00 Oleg Missikoff: In a EU project we have developed an interoperability Platform based on ontologies and consensus system

02:53:03 Claire Ellul, UCL: @oleg - that's a good definition, although I think within the BIM community there are efforts for both (and we also have GeoBIM which is specifically looking at geospatial + BIM + real time etc)

02:53:24 Caroline Robinson: Is the only benefactor from integrated data collection government and businesses that sell services to government?

02:53:52 Oleg Missikoff: @Claire - Any links?

02:53:52 Tony Fish: @liam "value for public good" is different from "value" which can mean anything you want to frame it as.

02:54:44 Mark Enzer: @Mark - 'Metaverse' is one of those flexible terms that can mean different things to different people, so it is great for getting people excited, but not so good for engineering. In general terms it is 'the sum of all digital worlds'

02:55:23 Tony Fish: @mark "sum" or "integration"

02:55:53 Mark Enzer: @Tony - both/and

02:56:08 Carsten Roensdorf (OS):@Oleg https://portal.ogc.org/files/?artifact_id=96354 Built environment data standards and their integration

02:56:11 Caroline Robinson: Has gaming already built cyber worlds and we are only now catching-up?

02:56:48 Oleg Missikoff: @Caroline - Thanks

02:57:07 Ilsa Kuiper: Of the data that is intended to be shared...do utilities have a handle on the meta data, particularly data sourced from third parties? Further, how do proposed developments contrast to those existing frameworks that already pay for use/license re copyright in "data" (in Australia, surveys for land title registration and for data generators i.e. surveyors)?

- 02:57:08 mark.emerton@innovateuk.ukri.org: On terminology - I recall a very stubborn early drone industry - rejecting the term 'drone' at every opportunity - leaving behind a messy range of alternatives like UAV, UAS, UA, RPA, RCA, RPAS etc - 'Drone' ultimately won that fight, and the negative connotations of the term faded away - but the time spent on terminology didn't help the community and probably pushed the public, government and other sectors out of the conversation (and the real conversations and growth went on in the organisations who just started using 'drone' and got on with it. - the fact that Metaverse is a flexible term is fine, so is Drone - it's not as if this community has exactly pinned down what we're trying to build yet anyway, so a broad but intuitive term might help gather momentum (and the technology terms underneath can also coexist but we need an intuitive term to talk to public and government and other sectors.
- 02:57:19 Navein Madhavan: @Caroline - The difference in gaming is that it doesn't need to be "accurately" linked to the physical or any physical element. As Matthew mentions, cost is a great driving power
- 02:57:55 Wendy Hall: Good point @mark emerton
- 02:58:01 Mark Enzer: @Caroline - Yes. It's just that gaming has done it for entertainment. Now we are talking about engineering-quality cyber worlds that can be used for public good.
- 02:58:34 Claire Ellul, UCL: @oleg - a couple of years old now but:
https://3d.bk.tudelft.nl/pdfs/18_georeferencing.pdf
- 02:58:39 Wendy Hall: Perhaps we should just be talking about the interoperability standards for the Metaverse. Not quite so catchy 😊
- 02:58:41 Miranda Sharp: @tony and @liam value is subjective, like data quality, which doesn't mean we shouldn't try and measure it.
- 02:58:43 Caroline Robinson: @Navein Madhavan And yet <https://www.enr.com/articles/51650-digital-tools-join-traditional-methods-for-notre-dame-rebuild>
- 02:59:10 Pinning, Robin (STFC,DL,HC): @sarah re: culture change around data. In applied (not tech) industry some see the value of that but like much of this there's a leap of faith in many organisations that gets lost in communication between the company's innovation lead and the company budget decisions
- 02:59:35 Caroline Robinson: @Pinning, Robin Agreed.
- 02:59:37 Louise Wright : I think that gaming environments tend to focus on looking realistic. When we move to the real world and a wider range of measurement modalities (different bits of the E-M spectrum, ultrasound, etc.) we have to go well beyond what is currently possible within games.
- 02:59:41 Pinning, Robin (STFC,DL,HC): As ever, this is another part of trusting other organisations
- 02:59:45 Carsten Roensdorf (OS):@Navein Depends on the game - a few years ago Realtimeworlds built a massively multiplayer online platform to run multiple games in parallel in a fairly realistic world. They had the idea that they would start with a simple 3D model that people playing the games would then enhance building up their neighbourhoods or other areas of interest in more detailed. Great concept, but apparently wasn't successful commercially.

02:59:46 Will Stewart: @Wendy - I agree!

03:00:15 Caroline Robinson: @Louise Wright Yes, we can go beyond and build on what has already been created. :)

03:00:31 Oleg Missikoff: I say it again: it's impossible to follow conference and chat!

03:01:18 Will Stewart: @Oleg - try harder! Chat should be in a side panel

03:01:33 Navein Madhavan: @Caroline, Carsten - agreed! Learning from gaming and building upon with specific needs we require.

03:01:34 mark.emerton@innovateuk.ukri.org: @Oleg - you can save the chat at the end and review, and you can re-watch the conference from the recording.

03:01:39 Caroline Robinson: Chat is super stimulating; thank you for contributing! :)

03:01:46 Oleg Missikoff: It's the density of issues not the vision

03:01:53 Mark Enzer: https://www.cdbb.cam.ac.uk/files/the_pathway_towards_an_imf.pdf

03:01:59 Paul Clarke: We will be writing up the key points in the chat and making the recording available

03:02:30 Caroline Robinson: @Paul Clarke Super.

03:02:42 Oleg Missikoff: Thank you Paul

03:02:55 Claire Ellul, UCL: @carsten - gaming is definitely something to be explored further .. and we now have integration of Cesium and unity which can help ..

03:03:04 Gailina Liew: Excellent and thank you, Paul.

03:03:13 mark.emerton@innovateuk.ukri.org: @Louise - that's been the approach in engineering circles for a while - that the game engines are only suitable for visualisation - but i'd wager that that's changing, and the game engines are highly flexible, highly scaleable platforms that could well be at the heart of a complex DT / metaverse architecture.

03:03:30 Oleg Missikoff: I won't miss Liz, so see you later

03:04:44 Caroline Robinson: @Claire Ellul, UCL Yes, we worked on Cesium :)

03:05:15 Caroline Robinson: @mark.emerton Great observation.

03:05:25 Claire Ellul, UCL: @mark - I think that's why the cesium/unity plug in is interesting - cesium has more of an 'information system' basis (location data + semantics) ..

03:06:00 Caroline Robinson: @mark.emerton I think what our cyber models don't usually factor people, but gaming does and puts the narrative first. Interesting thoughts.

03:07:21 mark.emerton@innovateuk.ukri.org: @Caroline - yup and Unreal has the RESTful API for data integration into UE

03:07:42 Ges Rosenberg (UoB): Data sharing great. Digital twins however also require the mathematical modelling, analysis and simulations to turn data into useful knowledge for the different stakeholders. Different users will need to build different modelling layers. Democratisation/interpretation/sharing/transparency for model algorithms is an issue we

need to consider. There is a public interest and we know this most recently from GCSE/A level examination algorithms.

- 03:07:43 Martin Aston: It's important to clarify what "engineered" means as this could be confusing in this context. Engineering is not a physical process per se. It is the conversion of science to a viable product definition and so is a knowledge-based function. The use of digital systems within the engineering process is key to delivering future products.
- 03:07:45 Caroline Robinson: @mark.emerton Agreed.
- 03:07:48 Robert: I forget where I saw this. Philosophers debate, scientists speculate.... and engineers get on with the job. To make the 'links' mentioned by Wendy we need more engineers involved in digital twin initiatives. MIT for example have been asked by the Super Majors to refactor their graduate programs to produce 'Digital Engineers' who are capable of effectuating oil company transition from fossil to renewable.
- 03:07:49 Navein Madhavan: @ mark Emerton - well put. Visualisation is absolutely critical as well for mere mortals to understand data and digital twins etc.
- 03:08:29 Claire Ellul, UCL: @navein - 100% agree - visualisation is a great way to get non-specialists interested in DTs and to democratize the data ..
- 03:08:35 Caroline Robinson: @Robert Oooh, I like that. Do you have a link?
- 03:08:48 Mark Enzer: @Martin +1
- 03:09:04 Will Stewart: @Mark - agreed - engineering owes less to science than scientists believe!
- 03:09:06 John Davies: Would be interesting to know the extent to which the Game developers use ontologies in their metaverses...
- 03:09:09 Caroline Robinson: @Navein Madhavan Agreed.
- 03:09:52 mark.emerton@innovateuk.ukri.org: @Claire and @Navein - the visualisation outputs also have significant engineering uses - in autonomous vehicles for example in change detection and GPS-denied visual navigation.
- 03:10:02 Caroline Robinson: @John Davies How about a Gaming vs Data Engineers Blue Sky session? We could learn so much. :)
- 03:10:04 Martin Paver: There is also an ontology for how the physical asset was delivered. Engineering challenges, risks, schedule variance etc. This extends beyond DAFNI but is critical for a joined up ecosystem.
- 03:10:22 John Davies: @Caroline +1
- 03:10:30 Robert: Good to see some support for ontologies coming out of UCL. What is their view on competing ontologies (e.g. Smith vs. West)
- 03:10:37 Oleg Missikoff: Where are we considering modelling notations?
- 03:10:40 Liam McGee: @Liz Varga that was great. Does 'precision' include levels of truth?
- 03:10:41 Paul Clarke: The digital commons required for stitching together other types of synthetic environments beyond digital twins (especially emulations) and smart machines will be an extension of the digital commons/ IMF required for UKDT programme. Issues such as real-

time coupling, impedance matching of models build at different levels of fidelity/ abstraction and the concept of shared time (that David Lane mentioned) will be particularly important

- 03:10:54 Oleg Missikoff: Modelling notations?
- 03:11:13 Ilsa Kuiper: Ontology relativity?
- 03:11:39 Rob Solly: @mark.emerton there a lot of merit in using game technology to visualise and integrate DTs. Our approach at Improbable adds the "highly flexible, highly scalable platform" to the visualisation part that you can find in many game engines
- 03:11:52 Caroline Robinson: @Ilsa Kuiper Awesome. :)
- 03:12:02 Ilyas Oren: @Liz Varga, please state again the reference you recommended for TLO.
- 03:12:07 Liz Varga: @Liam how we know what we know and indeed the whole road to computational epistemology is critical to versions of the 'truth' Listen up to Peter Rai!!
- 03:12:17 Tony Fish: loving this
- 03:12:18 mark.emerton@innovateuk.ukri.org: @Rob Solly - I was expecting you to be lurking here!
- 03:12:29 Liam McGee: :-) am a big epistemology fan.
- 03:12:45 방대한:A South korean government agency operates the wonderful digital twin platform. Let me introduce it next time.
- 03:13:00 Tony Fish: @liam you can spell it - ahead of me !
- 03:13:01 Matthew West: @Tony Curzon: Agreed. We anticipate a distributed architecture with service providers providing resources in much the same way as web service providers do.
- 03:13:20 Liz Varga: The DAFNI link is <https://dafni.ac.uk/dafni-champions-2-2/dafni-champions-infrastructure-research-ontologies-2/>
- 03:13:57 Liam McGee: @tony fish: Can recommend Peter Lipton, "Inference to the Best Explanation"
- 03:14:03 Liz Varga: At CDBB there is a survey of top level ontologies <https://www.cdbb.cam.ac.uk/news/publication-top-level-ontologies-and-industry-data-models>
- 03:14:12 Ilsa Kuiper: @Caroline R. The potential for such posited from theory...
- 03:14:38 Navein Madhavan: @Liz, brilliant, thanks
- 03:14:42 Ben Pritchard, Thales: (My Alexa just tried to answer Pete's example question) :-)
- 03:14:57 Wendy Hall: Fabulous :-)
- 03:15:02 Tony Fish: who says truth is truth
- 03:16:06 Mark Enzer: Tony 'Pontius' Fish
- 03:16:10 Oleg Missikoff: First order Logic?

- 03:16:17 Miles Elsdén: I like the idea of ontologies - but in my experience they are extremely difficult to develop, particularly the top-level (real-world) ontologies. Cyc has been at this for a long time...
- 03:16:25 Robert: Epistemology, Ontology, Methodology and method. All well understood by the medical and science communities, however, engineers can go through their whole career without being exposed to it. Which is a huge failing of the UK's Universities.
- 03:17:44 Wendy Hall: They should come to Southampton then
- 03:17:46 Caroline Robinson: Am learning so much... fascinating, how we interpret language and nuance.
- 03:18:22 Navein Madhavan: Device attestation +1
- 03:18:53 Liz Varga: In the DAFNI report we say: First order logic deals with predicates (or objectives) and uses quantified variables to create expressions of logic or axioms. A theory may be expressed in first order logic. Only one semantics is studied.
- Second and higher order logics allow predicates and higher level relations to be quantified introducing the capability to have several possible semantics or full semantics (D. Miller, 1991). This makes it more expressive, but with higher order logics, there is no effective deduction system
- 03:19:01 Matthew West: @Robert: This is our evaluation of the different TLOs we could find (more than just WEST vs SMITH) and our rationale for choosing and the choice we made.
<https://digitaltwinhub.co.uk/files/file/91-the-approach-to-develop-the-foundation-data-model-for-the-information-management-framework/>
- 03:19:06 Liam McGee: @pete: Also when was it true and do two data sources disagree and how important it is to be true to a given level of accuracy for a particular use context.
- 03:19:19 Ivo Willems: Impressed with Pete's explanation !
- 03:19:50 Jordan@melioro.co: @Miles Elden - I was wondering if you were here!
- 03:19:56 Robert: Hi Wendy Are you saying engineering undergrads are taught EOMM at Southampton?
- 03:20:08 Miles Elsdén: @Jordan
- 03:20:13 Martin Sadler (UK): In addition to epistemology might be worth paying attention to narratology (how we tell stories) as the basis for citizen involvement and democratising
- 03:20:21 Robert: Thanks Mathew. Will check it out
- 03:20:26 Miles Elsdén: Didn't realise I was only posting in the Panelists channel!
- 03:20:46 Liam McGee: @Robert MK:U's integrated data science degree apprenticeship will also be covering these areas (if I have anything to do with it :-)
- 03:20:53 Caroline Robinson: @Martin Sadler (UK) Yes. :)

03:20:58 claudia gibbard: Will this summit be recorded ie will we be able to watch another time. I haven't been able to commit as much time to today as I would have like to

03:21:20 Matthew West: @Andrew J: Agreed classification systems are important. We refer to them as Reference Data in the Information Management Framework.

03:21:21 Navein Madhavan: @Martin S, absolutely! Critical to ensure widespread adoption and democratisation and not be put off by pure "technical"

03:21:31 Paul Clarke: Yes, recording will be shared

03:22:07 Ana Basiri: I wish chat was also recorded, there is a really good conversation to go back and watch/read

03:22:15 Oleg Missikoff: What's the meaning of SI in this context?

03:22:16 Wendy Hall: I think we can share the chat as well?

03:22:27 Paul Clarke: We are capturing chat and will attempt to write up the key points, questions etc

03:22:35 Ges Rosenberg (UoB): Sharing the chat would be excellent

03:22:41 Ana Basiri: @Paul Thanks, that would be fab!

03:22:59 Rich Walker: SI is Systeme Internationale I think - the common reference for physics

03:23:14 John Beard: metre kilogram second etc

03:23:14 Oleg Missikoff: Metrics? Pk

03:23:16 Holger Kessler: doing some AI on the chat might just give us the solution :-)

03:23:22 Liam McGee: Re epistemology: also interesting to understand it in terms of inductive reasoning and explainability. Explanation needs only to be sufficient to the use.

03:23:32 Holger Kessler: I would massively appreciate a copy of the chat also.

03:23:39 Caroline Robinson: @Holger Kessler Ha! :)

03:23:50 mark.emerton@innovateuk.ukri.org: @Holger - might save the chat and stick it into GPT3 and see what comments I can auto-generate!

03:23:57 Robert: Liam, I am jealous of them ;-) Push for it, there are some interesting conversations going on in the USA between the top-tier schools and the major corporations who fear for their relevance post I4,0. Undergraduate programs need to change.

03:24:37 Rich Walker: @mark - have the Office for AI got a way to detect "government briefs" that were generated from GPT-3? seems like an important tool...

03:24:49 Geoff McCormick: I am also keen to see a copy of the chat !

03:25:35 Pete Rai : A presentation on Towards Computable Epistemology can be found on my YouTube channel: https://www.youtube.com/watch?v=f_7te9o9Oic

03:25:42 Pedro: @Robert, how so, the change of the programs, in that perspective?

03:26:05 Andrew Scullion: A domain agnostic ontology for metrology. Is that not what the Semantic Sensor Network Ontology is? Why do we need another one?

03:26:16 Miguel Xochicale: Not sure what are the policies regarding the chat for GPT-3 but also keen to have access to it. Lots of good questions, references and conversations.

03:26:17 Liam McGee: My favourite metric from the national rail ontology: BTU Foot per Square Foot Hour Degree Fahrenheit

03:28:01 Mark Enzer: "we already have a market failure, otherwise we would have interoperability already" - I totally agree

03:28:16 Matthias Gropp: Louise, very good, very crucial points, we call this Geospatial Certainty in our industry. To keep track of this quality status of data is crucial.

03:28:28 Cambridge CDBB: The video for the day, chat and follow-up summary will all be available on the DT Hub www.digitaltwinhub.co.uk

03:28:31 Robert: Pedro, that needs a long answer! Feel free to ping me on LinkedIn: <https://www.linkedin.com/in/dr-robert-prince-wright/>

03:28:32 John Davies: "Pete Rai

To
Everyone

12:26:43 "A domain agnostic ontology for metrology. Is that not what the Semantic Sensor Network Ontology is? Why do we need another one?" There will always tend to be overlapping ontologies describing similar domains. Ontology mediation can be used to mitigate the issue (to some extent)

03:28:36 Oleg Missikoff: What about enterprises other than industry? Tourism, Trade, etc

03:28:41 John Beard: re chat - we could be brave and share the raw chat, as an annex to the distilled version that the hosts are kindly providing

03:28:44 Ilsa Kuiper: Legitimation (across macro-meso-micro levels)? Data institutionalisation?

03:28:55 Emmanuel Kahembwe: Cambridge CDBB shared a link for a thread related to the summit..

If anybody has been in the zoom call from the start, please share the whole chat there:

<https://digitaltwinhub.co.uk/forums/topic/430-cyber-physical-fabric-summit-panel-1-cyber-physical-fabric/>

03:29:17 Cambridge CDBB: DT Hub links to continue the conversations:
Panel 1 – Cyber-Physical Fabric
<https://digitaltwinhub.co.uk/forums/topic/430-cyber-physical-fabric-summit-panel-1-cyber-physical-fabric/>
Panel 2 – Tech/Data Interoperability
<https://digitaltwinhub.co.uk/forums/topic/431-cyber-physical-fabric-summit-panel-2-techdata-interoperability/>
Panel 3 – Research

<https://digitaltwinhub.co.uk/forums/topic/432-cyber-physical-fabric-summit-panel-3-research/>

Panel 4 – Adoption

<https://digitaltwinhub.co.uk/forums/topic/433-cyber-physical-fabric-summit-panel-4-adoption/>

Panel 5 – Lessons learnt

<https://digitaltwinhub.co.uk/forums/topic/434-cyber-physical-fabric-summit-panel-5-lessons-learnt/>

- 03:30:06 Tony Fish: what is the (this) market failure? do we all agree? When was the market asked to optimise for this thing that we are saying the market has failed at?
- 03:30:39 Matthew West: @John: "A domain agnostic ontology for metrology. Is that not what the Semantic Sensor Network Ontology is? Why do we need another one?"
It is rather the case the SSNO is a domain ontology, which needs to fit with other ontologies in other domains, and in that sense it is not domain neutral.
- 03:30:39 Mark Enzer: @Andy P-H - maybe 'within' proprietary commercial applications, but not between...
- 03:31:04 Miles Elsdén: Referring back to Rob Buckingham's earlier point we can use the existing network of Living Labs (Federated). There is plenty of infrastructure already there across multiple technology areas that are relevant, we need to link them up and then identify (and fill) the gaps.
- 03:31:18 Holger Kessler: Very very interesting!!
- 03:31:45 Caroline Robinson: @Miles Elsdén Yes.
- 03:31:46 Matthew West: @Tony Fish: One market failure is just the failure to recognise the value of data and its use.
- 03:31:53 Emmanuel Kahembwe: @Tony one of the market failures is that there is limited data interoperability.. no standards, data silos
- 03:31:57 sue chadwick: there is an existing register of information sharing agreements Register of Information sharing agreements under chapters 1, 2, 3 and 4 of part 5 of the Digital Economy Act 2017 - GOV.UK (www.gov.uk)
- 03:32:56 Graham Meaden: @MarkEnzer, it's not a market failure, it's a societal failure. A society that has chosen capitalism.
- 03:33:05 Mark Enzer: @Andy P-H - HTML?
- 03:33:50 Andy Parnell-Hopkinson: My bad, posting only to panellists: Yes, @Mark Enzer between. If there's a need and a budget, there's a way
- 03:33:54 Caroline Robinson: @Graham Meaden Open and transparent data from public funds would make life easier... US has this advantage.
- 03:33:54 Will Stewart: Standards need indeed to be simple to be widely adopted

03:33:55 mark.emerton@innovateuk.ukri.org: Are the technology components and architectures really ready for standardisation, or is this too much a moving target?

03:34:08 Laurie Reynolds: Someone should develop an ontology from the chat.

03:34:08 Andy Parnell-Hopkinson: You don't need standards for interoperability

03:34:19 Will Stewart: perhaps not just simple but minimal

03:34:28 Caroline Robinson: @Andy Parnell-Hopkins Bombshell. :)

03:34:42 Ges Rosenberg (UoB): Naturally the agenda comprises a lot of cyber/digital/data, but to establish value from practicable use cases, we need discussion of digital-physical system integration, sensors (observability) and actuation (controllability) would help steer towards the cyber-physical fabric - where physical should cover social, natural and anthropogenic physical systems. Lots of knowledge from control systems community, natural and behavioural sciences will be beneficial in this conversation.

03:34:43 Andy Parnell-Hopkinson: @Caroline reality

03:34:52 Oleg Missikoff: Human centred approach

03:35:16 David Lane : Thanks @Wendy! Will try and pick this up in the next panel session on research

03:35:26 Miranda Sharp: @tony excellent discourse here on market failures in tech and the need for a new way if defining anti-trust legislation
<https://www.tortoisemedia.com/2021/06/23/microsoft-censorship-and-china/>

03:35:36 Paul Clarke: It's a long term vision failure which is a recurring challenge. We have to fix this for climate change and come up with new democratic structures to own and tackle 20+ year challenges at a national and planetary scale across multiple governments

03:35:58 Will Stewart: UKRI should fund standards for government info

03:35:59 Emmanuel Kahembwe: UKRI should be funding national data provenance technologies (e.g. blockchain) which are critical to talking about the truth of any digital data..

03:36:04 Holger Kessler: Breaking down the structures that reward competition and prevent collaboration

03:36:10 Oleg Missikoff: Stakeholders' Engagement

03:36:26 James Humphreys: Creating hand-crafted ontologies are clearly a major challenge.

Could machine learning to learn its own form of ontology (which might not look the same as how we think of the world)?

It would open it up to vastly more data and lower the bar to sharing data.

03:36:28 Ilsa Kuiper: Scope for government/public sector to enhance data capability (I.e. deeper realisation of transparency, new public services). ...but also to realise scope in managing risk where data will be used in new and unexpected....and possibly negative ways?

03:36:38 Oleg Missikoff: We need to widen the comprehension and adoption of the paradigm

03:36:42 Liam McGee: @Matthew West is would be good to open up those problems more widely for discussion

03:36:52 Laurie Reynolds: UKRI wish A graph-based tool for organising knowledge and context which could be used for capturing content and understanding from sessions like today.

03:36:55 Miles Elsdon: The need for public engagement has run through all the discussions. As was mentioned earlier, we need a wide systems approach looking a techno-social-economic perspectives. All supported by work on trust, ethics, regulation and assurance...

03:37:20 Caroline Robinson: Can we have the speaker on the main screen?

03:37:35 Miranda Sharp: pluralistic views and pluralistic creation of value @liz

03:37:37 Oleg Missikoff: Truth is a religious concept. I'd rather talk about reality

03:37:40 Ilyas Oren: Research area idea: Construction industry-specific data science to develop AI and machine learning to inform decision making.

03:38:00 Paul Hunter: while standards are agreed, we also need to look at the review and change timeline that also happens, OS is reviewed and can change the position of any data already logged for example.

03:38:02 Liam McGee: @Laurie Reynolds... graph based tool for making KG's and ontologies human-friendly and explorable: I think we may be able to offer you one of those.

03:38:03 Chris Dent: Like in many intrinsically collaborative areas, funders should minimise barriers to entry for relevant teams who do not already have track records in this area - for instance there are many people who would not call themselves "digital twin" but who have much to bring to the table (e.g. people who work on applied methodology for decision analysis)

03:38:05 Caroline Robinson: @Oleg Missikoff Yes, a faith system.

03:38:20 Matthew West: @Andy Parnell-Hopkinson "You don't need standards for interoperability". No, but standards reduce the cost of interoperability by orders of magnitude. Consider the history of nuts and bolts, before standards a nut and bolt had to be made as a matched pair, afterwards any nut compliant to the standard would fit any bolt to the same standard. Applied to rifles this has won wars.

03:38:25 Graham Meaden: Support for pluralism in standards are key for liberty

03:38:32 Oleg Missikoff: @Caroline - agree

03:38:33 Liam McGee: @Oleg: no, truth is a transcendental quality. And science uses it as it's anchor.

03:38:46 John Grant: Technological evolution and appropriate standards is one key aspect, but I'd argue more needs to be done to support lifelong learning and learning in the open.

03:38:46 Liam McGee: @Oleg but it's not a binary measure.

03:39:03 Martin Paver: The US have an AI construction institute. Worth looking at what they are up to.

- 03:39:08 Stephen Ashley: UKRI should be funding work around using technical and governance frameworks such as data trusts, to enable industry to share data to go after use cases that prove the value of the cyber physical framework
- 03:39:21 Matthew West: The thing about standards is that you need to develop the standards that give you freedom to do things rather than ones that prevent it. You don't have mobile phones without the standards that enable them.
- 03:39:34 Mark Enzer: @all - UKRI should put money into the overall 'socio-technical change' - ie work with the humans as well as the tech
- 03:39:53 Oleg Missikoff: We're modelling the reality not the truth
- 03:39:55 Kirk Woolford: Desperately trying to follow both panel and chat... In response to discussions about games, Epic has been investing heavily to support Digital Twins through Unreal. There is a good overview here: <https://www.unrealengine.com/en-US/blog/what-are-digital-twins>
- 03:39:55 Caroline Robinson: @Stephen Ashley Data Trusts - yes.
- 03:39:56 Robert: Funding needs to focus on CPS simulation. We got so far in the 90s and 2010s and then funding bodies decided the knowledge had been transferred to industry. That was a false assumption. How for example do we simulate a multi-physics SOS realtime and in synch with the 'real' twin. This is the hard part being ignored both in the USA, EU, and UK. We also need to move beyond ODE/DAE systems to include PDEs.
- 03:40:05 Liam McGee: @louise: yes, we're doing a lot of work on visualising truth vs value in intuitive way.
- 03:40:15 Emmanuel Kahembwe: @Mathew West +1
- " standards reduce the cost of interoperability by orders of magnitude. "
- 03:40:15 Will Stewart: RSS does provide courses for MPs - not sure they are listening!
- 04:11:30 Cambridge CDBB: Professor David Lane's post on this Research panel session <https://www.linkedin.com/in/lanedavid/detail/recent-activity/>
- 04:11:43 Holger Kessler: @David Lane - I cannot wait any longer: when will those little ?dogs start moving :-)
- 04:13:41 s.c. stuart: good morning from Los Angeles, CA - really enjoying the panels so far - fascinating... [<https://scstuart.digital/>]
- 04:13:42 Paul Clarke: @Holger. They are powered by crowdsourced funding. Credit card contributions accepted :-)
- 04:15:52 David Lane : @Holger - they're switched off! Too distracting :)
- 04:17:02 Paul Clarke: @Mark G. Love that analogy. One of the other characteristics of power is that you can trust that you will get 240V AC @ 50Hz when you flip the switch. CPF needs to be a similar utility that people can trust and take for granted

04:19:41 mark.emerton@innovateuk.ukri.org: <off to order a microphone>

04:19:56 Holger Kessler: love that insight @Caitlin (off he goes to source a microphone)

04:20:01 Caroline Robinson: mark.emerton :)

04:22:26 Mark Wharton: impact of speaker directly proportional to broadband speed

04:24:11 Mark Wharton: what about comparing the models to the sensor data from the real world?

04:25:31 Chris Dent: cf James's comment - I often say that a good day in academia is when the PhD student can use their own code!

04:25:59 Miranda Sharp: @james what was the data or data tools that you would have liked to be have that was inaccessible last year?

04:26:17 Mark Wharton: @david.lane it was meant as a joke

04:27:02 David Lane : @mark - I know! Good one - because its partially true alas

04:27:19 Caroline Robinson: This is the most important part!

04:27:24 Caitlin McDonald : As David says—very relevant for issues of digital access & inclusion which are inherently part of existing technological barriers, and which will have to be considered for CPF's future too

04:28:56 Emmanuel Kahembwe: Maybe we should try to co-locate cyber-physical research hubs with innovation and governance hubs to facilitate collaboration and exchange of ideas.. and even open up opportunities for researchers to commercialise their work.. maybe a cyber-physical innovation village?

often i find that research is far removed from commercial interests and has a hard time getting to relevant policy makers..

04:29:33 Caroline Robinson: Open and transparent datasets is important for government and business. See <https://data.nasa.gov/>

04:29:39 Miranda Sharp: precisely @emmanuel. We omit to include the lawyers, insurers and financiers at our peril

04:30:54 Caroline Robinson: Which enabled FREE, open, and transparent geospatial data from: <https://scihub.copernicus.eu/>

04:31:02 Mark Enzer: @Miranda +1

04:31:19 James Hetherington : Miranda ++

04:31:24 Caroline Robinson: Which also calculates or tries to the impact of open geospatial data.

04:33:04 Mark Wharton: @emmanuel co-located in a virtual sense, I guess. But I agree with your thrust

04:33:16 Robert P-W: I've learned hard way there is a difference between business case (strategic) and value proposition (economic). The former is what c-suite management look for.

04:33:40 mark.emerton@innovateuk.ukri.org: @Caroline - feels like a session where all these existing tools and datasets could just be showcased for everyone's awareness would be

hugely useful. I appreciate there's probably good lists squirreled away somewhere, but would be brilliant to have speakers visually walk us through these existing available tools, datasets or twins.

- 04:33:51 Pinning, Robin (STFC,DL,HC): @Emmanuel like STFC Daresbury and RAL?
- 04:33:52 Paul Clarke: @Miranda. And regulators who need models and living labs to understand and prepare for what is coming down the pike, collect data to inform regulation etc
- 04:34:06 Mark Wharton: @robertPW doesn't that mean that Governments *have* to be involved?
- 04:34:17 Navein Madhavan: What about IP generation through increased digitalisation and democratisation/protection of that?
- 04:34:19 Mark Enzer: @Emmanuel and Mark - maybe virtually co-located via something like a cross-sector DT Hub?
- 04:34:26 Robert P-W: And how is Blockchain scalable when transaction fees are determined by the cost mining?
- 04:35:03 Ilsa Kuiper: Should the test or measure of data investment/business case also include consideration of what can't be achieved in the future if the investment is not enacted now?
- 04:35:04 Miranda Sharp: @Paul +1
- 04:35:08 Alexander Tessier: ++
- 04:35:24 mark.emerton@innovateuk.ukri.org: VERTICAL INTEGRATION.
- 04:35:36 Caroline Robinson: @mark.emerton I think Data Trusts would be the answer. Sector-based open, transparent and free datasets. ESA also do lots of training webinars as you describe showcasing how to use the variable datasets.
- 04:36:58 Paul Clarke: I would suggest we need more agile and granular mechanisms for controlled and secure sharing of data than data trusts. More research required
- 04:37:01 Navein Madhavan: same goes for Tesla @Bill - innovation through first principles amongst all the other characteristics you've mentioned!
- 04:37:15 jeffrey lake: a key reason that so many companies have issues validating the business case is that they started from the position of the technology, ie, the 'solution' to try and work backward and find a problem to solve and validate with a business case is very tough. better to go : Problem to be solved- define strategy - assess corporate capability- engage the business - come up with some projects - decide on PoC's - then FSD
- 04:37:20 peter w: Berners-Lee was in his mid 30s when he made the W3 proposal. What fraction of this 'coalition of the willing' are around that age? many speakers are reminiscing about PDP11s and other industrial archeology. We need more, younger people taking the lead, otherwise there will not be the momentum through the next 20-30 years that this project needs
- 04:37:40 Claire MacDonald: they also have the benefit of all the discovery and research in the field done by NASA and others before them. So they do not need to cost recover any of that

04:38:19 mark.emerton@innovateuk.ukri.org: @Peter W - mid 30's talent with the right tech knowledge probably working in gaming right now! :-P

04:38:27 David Lane : @PeterW -spot on. We set the conditions for this to happen

04:38:33 Paul Clarke: @Bill. Please don't forget smart machines :-)

04:38:50 Laurie Reynolds: One reason Space-X can launch spacecraft for 1/10th the NASA cost is reuse of vehicles. Not building one-off bespoke designs

04:39:08 Alexander Tessier: Kaizen.

04:39:09 John Grant: Bill Murray, the path to industrialisation is through lifelong learning and learning in the open. Higher education is expensive and failing.

04:39:27 Pinning, Robin (STFC,DL,HC): @peterw absolutely! The younger generation are digital, cloud and virtual collaboration natives. For technology the gap between academia/research council pay and the tech sector is diverging rapidly. Driving them away

04:39:32 Alexander Tessier: How many revisions of Apollo were there? With Space-X, they keep revising and improving. It's not a one-off -- it's a long term program.

04:39:57 Neil Tatman: SpaceX & Tesla have also been successful by not considering any legacy (business or product)..... This is where the UK typically constrains itself; we have a rich history and established pedigree in many areas, but we need to look at new frontiers and not constrain out thinking with 'the old ways'.... Hard to actually do this within the business itself - discuss

04:40:49 Caroline Robinson: Business meets demand. Government can make it easier to meet that demand.

04:40:49 Pinning, Robin (STFC,DL,HC): @mark.emerton actually not just gaming, technology startups. You can get paid double even working in a bathroom design software company!

04:40:58 jeffrey lake: Another reason for NASA's costs was that they were at the leading edge and developed the technology and materials. NASA created the first digital twin and even coined that phrase.

04:40:59 John Grant: Wardley Maps Community Hub: <https://list.wardleymaps.com/>

04:41:02 Navein Madhavan: @ Neil T +1. There is an element of legacy technology and also culture which impedes this

04:41:12 James Hetherington : I was just about to quite wardley - Bill got there first!

04:41:26 Aron Kisdi: And don't forget SpaceX&Tesla also don't avoid manufacturing. They just make hardware production very efficient, but they do not outsource.

04:41:26 Ilsa Kuiper: @NeilT. Nice one. Cost of change can be greater than just starting again...

04:41:40 Mark Girolami: Scaling digital twins from the artisanal to the industrial - <https://www.nature.com/articles/s43588-021-00072-5>

04:41:48 Pinning, Robin (STFC,DL,HC): @Jeffrey Space X sits on top of the Entrepreneurial State

- 04:42:30 Navein Madhavan: Coalition of the willing - great case study through wallstreetbets and meme stocks
- 04:42:34 Caroline Robinson: @Mark Girolami Unfortunately behind a paywall.
- 04:42:48 jeffrey lake: I am mightily impressed by the new space companies
- 04:42:50 mark.emerton@innovateuk.ukri.org: @Aron - exactly - vertical integration, which in some ways is the counter-argument to a highly collaborative and open approaches we discuss today. They also have a very important lead customer - the US DOD. So what's the anchor tenant / lead customer that we need, or government can provide?
- 04:43:27 Emmanuel Kahembwe: Bill Murray - SpaceX is good at innovation precisely because they can experiment and fail! over and over until they succeed.
- People forget that the entire space industry thought SpaceX was a joke until it wasn't..
- The problem in the UK is that failure is heavily penalized and funding tends towards "sure" things. "Sure" things often means established labs, with well-known institutes with impressive track records.. so the average PhD student/inventor has no hope of competing..
- We often focus on exploitation of what already is and less on exploration of what could be..
- 04:44:24 Caroline Robinson: @Emmanuel Kahembwe Yes, selecting 'winners' rather than encouraging competition and market to drive innovation.
- 04:44:26 Robert P-W: @Mark, Agree re government, the USA does it best of all by ensuring entities with good ideas have access to funding. 'Industrializing things faster' means seed funding experienced professionals with track records. In the USA speculative money comes from Gvt and then venture capital follows through to market.
- 04:45:14 Caroline Robinson: @Robert P-W With the advantage of the premise that public funded data is made available.
- 04:45:35 Rob Solly: When looking at uncertainty, most people focus on uncertainty in input data and how that propagates through to output data. But it's essential that we also look at uncertainty caused by incompleteness / inaccuracies in the model itself.
- 04:45:36 Mark Enzer: I agree that we can learn from Space X as Bill has said, but I'm far from convinced by the Space X model for the CPF. We need shared infrastructure, not Ironman.
- 04:45:38 Miles Elsdon: @Caroline - I agree. Government needs a better approach to Risk appetite. It links back to the need for intelligent customers in government.
- 04:45:41 Lachlan Mason: <https://t.co/oyJrAFS0ed>
- 04:45:47 Lachlan Mason: > @Mark Girolami Unfortunately behind a paywall.
- 04:46:01 Neil Tatman: Question - how is the UK's current research agenda in this space helping industry respond to new customer demands now; we have international governments requesting full digital twins of the unique assets for full 'through life' management today?
- 04:46:40 Oleg Missikoff: I'm interested in stakeholders engagement (SMEs, municipalities, etc)

04:46:51 Tony Gillespie: Agree with @Mark. US DOD essentially funds start-ups with good and critical idea until they are well-established (>50 employees) then encourages them to compete against non-US firms for US contracts. Definitely not open marketplace.

04:46:56 Caroline Robinson: @Lachlan Mason Thank you.

04:47:44 Chris Dent: Economists call this Knightian uncertainty - but Knight himself did not!

04:47:56 Miles Elsdon: I agree with Mark. Models are a crutch to decision making. They do not give you the answer.

04:48:03 John Grant: Mark Girolami, the Cynefin framework would be useful

04:48:07 Oleg Missikoff: If we don't reach the wider public we risk an escape forward

04:48:17 Liam McGee: Our own experience of engaging with innovation grants is... painful (and we have been fairly successful!). It's very different to the DOD experience, I believe (though there is always paperwork).

04:48:29 John Grant: Cynefin Community Hub: <https://cynefin.io/>

04:48:31 Alexander Tessier: @Mark Enzer -- agree - but shared infrastructure doesn't spring out of nothing - you often find many proprietary solutions that are then unified or replaced by open standards -- it is an evolutionary process and seldom evolves to be 'open' unless driven by some commercial interest...

04:48:58 Liam McGee: @James Heatherington yes! Visualising it makes it feel true... you need to be careful to keep the uncertainty shown in the system.

04:49:42 Rob Solly: @James Hetherington We cannot quantify model uncertainty for systems that do not yet exist, or for situations that have not yet occurred.

04:49:57 Liam McGee: @james Hetherington - yes, you need to show the quant distribution, not the mean..

04:50:15 Miles Elsdon: @James. So many examples of trying to do this in government (SAGE) and elsewhere. It's really difficult to retain the error bounds as the information goes up the decision making process.

04:50:33 Chris Dent: More seriously, there is a big challenge in that quite a lot is known in highly specialist communities about practically useful methods of quantifying and managing uncertainty, but that because such methods are specialist even within the statistical decision analysis (and related) communities we haven't worked out how to move them into wide practice.

04:50:45 Miranda Sharp: self reported inadequacy, perhaps not just a thing that data machines need to learn

04:50:53 Tony Fish: is it uncertainty in the data or outcome, or uncertainty that someone else thinks they know what the data is saying and you don't agree.

04:51:06 Mark Enzer: @Alexander - I think that this goes back to the earlier 'market failure' conversation. We can't assume that the market will default to a solution that is consistent with the public good, so it needs a bit of help to get there.

- 04:51:32 Kara Cartwright - Innovate UK UKRI: Uncertainty is an interesting area because we make decisions every day on uncertain data - if the CPF and DTs can provide more consistency or additional insight then this is maybe better than what we have? We don't always need to be aiming for 100% - incremental improvements have value too?
- 04:51:52 mark.emerton@innovateuk.ukri.org: @Liam - this reminds me a of a fascinating story of a wind turbine owner who trialled a drone inspection service, which used photogrammetry to produce an HD scan of the turbine blade. The drone operator proudly declared he spotted a crack at exactly 105m radius and showed the visualisation. The turbine owner pointed out the blade was only 85m long. The photogrammetry was optimised to minimise visual stitching artifacts, not minimise compounding errors. So yes, visualisation, particularly pretty visualisation, hides errors.
- 04:51:57 Mark Wharton: @bill, you're mirrored!
- 04:51:57 Caroline Robinson: Can we have the person speaking on the main window?
- 04:52:03 Ben Pritchard, Thales: I can see Mark... looking at Bill... looking at his map...
- 04:52:09 Rob Buckingham: Living Labs
- 04:52:09 Miranda Sharp: back to episiotology I think @Tony
- 04:52:12 John Beard: re uncertainty - there is practical experience to be had from deployed military and from law enforcement (have I got enough confidence to take physical action) - may be way short of the high-end ideas for computation of uncertainty but could be a source of case studies
- 04:52:14 Rob Solly: @Kara agreed - we can never be perfect so we need to take small steps forward
- 04:52:20 Chris Dent: A project I led at the Turing Institute discussed this in some detail, see <https://www.turing.ac.uk/blog/how-model-future-risks-support-better-decision-making> and the underpinning white paper <https://www.turing.ac.uk/research/publications/use-multiple-models-within-organisation> (which discussed both Knight and Cynefin!)
- 04:52:29 Emmanuel Kahembwe: @Mark Wharton - Yes, a Cyber-Physical Innovation Village could be cyber-physical.. including a virtual component...
- The key thing would be ensuring a tight coupling between research, private industry, policy makers and other stakeholders..
- This summit is a good example of events that should be held regularly.. but with more input from the business and investment world.
- Also more input from the relevant government standards and regulatory boards
- 04:52:39 Louise Wright: I think that having better visual tools for presentation of uncertainty helps. Even if we move to a traffic-light type system it helps people understand "definitely OK" "definitely bad" and "not sure" that can help.

- 04:52:43 Liam McGee: @mark.emerton :-) beauty!=truth (though it can point the way)
- 04:53:26 Robert P-W: SpaceX hired the best senior and principal engineers they could find and focused on CPS simulation, CFD, FEA etc. Hordes of PhDs did the grunt work. The combination of risk free capital and a huge pool of graduates from the USA and overseas underlies their success. I doubt the UK can create the same environment. As an anecdote, I visited a high tech company in Illinois and was amazed at how many of the technical staff were from the EU - at a guess 50%.
- 04:53:29 Tony Fish: "market failure and public good" Is public good raising education, improving health care and adding wealth. Does public good have to be direct or indirect. Is it a failure if the person with agency choices not to do public good with what they have been given?
- 04:53:39 Mark Wharton: I'd like to see the models comparable to the real world data to check their accuracy
- 04:53:43 Liam McGee: @louise there are better approaches than traffic light... but just showing the uncertainty *in any way* is a big step forward as it stops us using cognitive short cuts that fool us that the map is the terrain.
- 04:53:47 Jeremy Watson: Concerning metadata surrounding the elements of DTs - concepts of 'Data Quality' apply e.g. confidence limits / provenance / timeliness / validation, etc. NPL is doing good work in this area
- 04:54:04 Mark Enzer: @Kara - the fundamental property of information is that it destroys uncertainty, so we just need to work out how much is 'enough' information 'to make better decisions faster and cheaper'. I believe this is key to releasing value from the CPF.
- 04:54:20 Paul Clarke: @Bill. Moonshots can help driving that propagation. Testing the Lego, discovering the missing Lego shapes, demonstrating the value, creating the legacy for future missions and moonshots, driving alignment on funding, research, competencies, technology etc
- 04:54:27 Mark Wharton: ... e.g. a digital twin of the algorithm next to a DT of the "real" thing
- 04:54:36 James Hetherington : Btw, I am not saying that every situation admits of a quantitative model with quantified uncertainty - as Girolami said, there are forms of uncertainty that make that impossible. I AM saying that a quantitative approach that doesn't address uncertainty at all is unprofessional and unethical.
- 04:54:37 Liam McGee: Note that people like actuaries and reinsurers have to deal with visualising risk and probability all the time. So do flood mappers and meteorologists.
- 04:55:03 Tony Fish: does real world accuracy matching a model mean the model is good today or tomorrow?
- 04:55:25 Laurie Reynolds: @Bill Murray. BRILLIANT! Thanks. Business/product research is urgently needed.
- 04:55:45 Mark Wharton: @tony.fish -> have the model predict next tuesday, then measure next tuesday to see if it was right?...

04:55:57 Tony Gillespie: Great idea to look at power grid, but also look at mobile phones and GSM which was a government led initiative which quickly displaced all open-market models but took several years to develop.

04:56:05 Liam McGee: @caitlin can you post some examples?

04:56:11 Rob Solly: @Tony Fish - it just means the model is good for the exact situation you've tested it in. Any extension to that requires a degree of faith

04:56:14 Chris Dent: @james - but as you say people often give up too easily, or say that because we cannot pin down the one definitive quantification of uncertainty in a particular case then we cannot use probabilities or quantify at all (the classic misquote of Knight)

04:56:42 Tony Fish: GSM was not government led.....

04:57:16 Jeremy Watson: Models will not be time-stationary - they will constantly need to be re-tuned and tested against reality

04:57:52 Caroline Robinson: @Jeremy Watson Yes, and systems will need to be constantly evaluated to keep up-to-date.

04:57:56 Mark Wharton: @jeremy.watson thank-you for making my point more clearly than I did

04:57:59 Tony Fish: because it is good next Tuesday does that make is more trustworthy compared to one that got next Tuesday wrong but a full moon later correct?

04:58:01 peter w: In the EU the EASME agency has been moving to ensure that VC effort is applied much more within member states. We can learn from them

04:58:15 mark.emerton@innovateuk.ukri.org: 'Market Failure' doesn't have to imply reactive rather than proactive, and doesn't imply a failure has taken place, just that the innovation has not, or may not occur without government intervention.

04:58:20 Chris Dent: I have been a bit confused by the emphasis placed on "market failure" in this workshop, as across very wide areas the government funds low TRL research without needing to have that discussion about "market failure".

04:58:21 Caitlin McDonald : Here's the Data & Society research I mentioned:
<https://points.datasociety.net/strategic-knowledge-6bbddb3f0259>

04:58:56 Robert P-W: Caroline, I agree about public data being accessible to the public, but it will need wrangling and curation. Who pays? And part of the problem is client-server access to data. An improved version of DDS (publisher and subscriber) might be a better path to take. I would be interested in the views of those in the know (I am an engineer).

04:59:21 Holger Kessler: AOB: I have just realised how much I am missing being at a conference with my team mates next to me....part of how I take things away from these discussions is to play them back to people...and trying to make notes and share them is impossible and not the same....

04:59:52 Matthias Gropp: Every engineer uses tolerances, and for them to be applied they need a confidence interval parameter (certainty) of the data they work and design their solutions for. Very few things are absolute correct and most are dynamic, ageing, changing and require updating all the time - living.

04:59:55 Mark Wharton: @robert p-w completely agree. Polling APIs sucks

04:59:59 Caroline Robinson: @Robert P-W This is the eternal problem: who pays? If this is for public good, then public purse.

05:00:31 Oleg Missikoff: Who paid for the WWW?

05:00:35 Mark Girolami: here is a very simple example of a Living Lab in Amsterdam
<https://www.turing.ac.uk/news/world-first-3d-printed-steel-smart-bridge-opens-pedestrians-amsterdam>

05:00:47 Caroline Robinson: @Robert P-W Biggest initial users of paid-for NASA data was other governmental departments... so they actually saved money by making it open.

05:00:52 Tony Fish: market failure - but when was the market asked to solve this problem (whatever the problem is) ? For failure the market either decided not to solve it (which is not a market failure) or it tried but could not do it. If it has not tried, what do we call it?

05:01:49 Caroline Robinson: @Mark Girolami With integrated data collection built-in for measuring people traffic flows.

05:01:49 Liam McGee: Not only changing past and future but changing predictions of past and future. Meta-time :-)

05:01:59 Tony Fish: +fablab's +greenlabs

05:02:22 Liam McGee: also shifting confidence in predictions. Two steps of meta.

05:02:41 Lachlan Mason: Feast (an open-source feature store) is good for "point-in-time correct" training datasets. <https://feast.dev/>

05:03:58 Jeremy Watson: I buy into James' points

05:04:15 Tony Fish: who would take on a KP/ target to earn their basic salary that means they always have to do the right thing?

05:05:22 Paul Clarke: Living labs are almost as misunderstood as digital twins. Lot of confusion with technology testbeds which are completely different

05:05:39 Tony Fish: +1 paul

05:05:45 Graham Meaden: we need a logical capability model to describe these things that havent yet been built in the eco system

05:06:20 Liam McGee: STEAM degrees? Science, Technology, Engineering, Arts and Technology...

05:06:50 Liam McGee: s/Technology/Medicine (sigh)

05:06:52 Joseph Weston: I'm from Hartree centre, part of UKRI. If anyone has projects they would like to discuss on CPF please contact me joseph.weston@stfc.ac.uk

05:07:13 Pinning, Robin (STFC,DL,HC): @Joe Hi!

05:07:15 Mark Wharton: @liam - Collusion in Cambridge deliberately put tech and arts together to get a perspective on new tech

05:07:25 Joseph Weston: Hi Robin :D

- 05:07:26 Laurie Reynolds: I don't recognise the term 'market failure' unless it's helpful to prioritise generates govt. funding. The problem is more that markets change and timescales become compressed. This is why from Bill's example, business research used to be done by businesses because timescales were extended. In modern times it is impossible for even large businesses to do the necessary industrial research, especially when big companies are under such intense from market pressures. Furthermore, even the biggest companies don't have the breadth of experience to do the necessary collaborative research. We need to embrace stakeholder capitalism to build the convincing business case.
- 05:07:37 Ges Rosenberg (UoB): James - agree - impact-oriented research prioritised
- 05:07:38 Holger Kessler: @James totally agreed!! REF has to be totally redesigned
- 05:07:45 Robert P-W: @Mark Wharton, are you familiar with DDS? Have you used it?
- 05:07:47 Paul Hunter: We create datum points which can be read and cross referenced with the update that has been applied, using the like of AI ??
- 05:08:17 peter w: but there is a mechanism for keeping hold of research papers for posterity, there is no mechanism for sustaining things like software and datasets. So many projects set up websites that then disappear
- 05:09:25 Caroline Robinson: We are trying essentially to not only put infrastructure into a Digital Twins, but society too.
- 05:09:41 Mark Wharton: Hi Robert - we've built a semantic decentralised Digital Twin platform based on a brokered pub-sub model
- 05:09:44 Laurie Reynolds: @Veronica - Absolutely! As an SME, I'm desperate to find tools similar to the Wardley maps.
- 05:09:59 peter w: and on the research papers point, IT has a habit of using conference reports as publications, but these are held in costly books that are not available generally, and when PDFs are, there is no provenance information. Compared with biomed sci, it's a mess and needs improving
- 05:10:00 Chris Dent: @holger - I am not sure that REF needs to be totally redesigned. Two very positive things are that it does have a significant impact component (which often has an effect on universities out of proportion to its financial value), and on research it emphasises quality over quantity.
- So no doubt one can (as with anything like this) identify unfortunate incentives, but REF is pretty good compared to many quantative metric based assessments I could think of!
- 05:10:14 Steve Maclaren: Love the idea of Honeypot use cases
- 05:10:16 Cambridge CDBB: This conversation can be continued on the DT Hub here: Panel 3 – Research
- <https://digitaltwinhub.co.uk/forums/topic/432-cyber-physical-fabric-summit-panel-3-research/>
- 05:10:22 James Hetherington : F.A.I.R. > Open
- 05:10:24 Tony Fish: thank you +1

05:10:29 Emmanuel Kahembwe: A point was made that a lot of the publicly-funded research code out there is basically only accessible and usable by the researcher that developed and worked on it.. maybe we should also push for more democratisation and accessibility here.

05:10:30 James Hetherington : Open is good, but FAIR is better

05:14:04 Tom Russell: (Reposting to all attendees) The software sustainability institute is a good place to start for leads on how to sustain, archive, make accessible software and data. Plenty of archival projects from Environmental Information Data Centre to Zenodo, GitHub, university archives and librarians do think about this.

05:14:57 Cambridge CDBB: Just to repeat for those who have joined us after lunch - the video for the day, chat and follow-up summary will all be available on the DT Hub www.digitaltwinhub.co.uk

05:16:09 Robert P-W: @

05:21:31 Miles Elsdon: As Jennifer is saying - co-creation is key. And the points about shared understanding (and language) about each others needs and constraints applies equally with policy makers.

05:21:41 Caroline Robinson: I missed this speaker's name...

05:22:15 Cambridge CDBB: Jennifer Schooling - Director of Centre for Smart Infrastructure and Construction

05:22:31 Caroline Robinson: Thank you.

05:26:19 Jeremy Watson: The aviation industry tests airframes by high fidelity modelling pre-flight - can we do the same?

05:26:40 Paul Hunter: Jennifer, you made a good point about people asking why, we have had the ability to create the digital twin decades ago, but as always people didn't understand the worth to allow this information to be shared. We need to answer that first

05:27:27 Andy Parnell-Hopkinson: @Jeremy Watson yes

05:27:32 Ana MacIntosh: And particularly interesting in the context of assuring autonomous systems too (I have a vested interest in this!)

05:27:42 Miles Elsdon: I completely agree on the assurance point

05:27:54 Robert P-W: Can the presenter tell us what they are using for Simulation of the automobiles.

05:28:52 Andy Parnell-Hopkinson: @Robert P-W auto OEMs and suppliers use dozens of simulation packages, it depends on what you're testing

05:29:22 Oleg Missikoff: @Paul - The world is undergoing a disruptive digital transformation. Just like of websites 20 years ago, who's left behind will disappear

05:29:27 Ben Pritchard, Thales: <https://www.ideuk.org/digitalisation-roadmap>

05:29:31 julian klein: <https://roadmap.ide.uk/?theme=digital-engineering>

05:29:34 Kara Cartwright - Innovate UK UKRI: Are the costs of development of twins and the ongoing maintenance of both the data and the twin cost prohibitive? I feel as Bill said earlier that a modular approach may be much more accessible and support growth?

05:30:05 Sunniva: IDE's digitalisation roadmap can be found here: <https://roadmap.ide.uk/>

05:30:56 Andy Parnell-Hopkinson: @Kara IMO all digital projects should start with POC/prototypes. If you start by trying to boil the ocean you'll fail

05:31:01 Alexandra Robasto: Join the Digital Twin Hub Community (www.digitaltwinhub.co.uk), a space for digital twin owners and suppliers, as well as information management experts, to come together and collaboratively enable this world-leading vision. Register here <https://digitaltwinhub.co.uk/register>

05:31:14 Bradley Yorke-Biggs: Digitalisation Roadmap at roadmap.ide.uk and our Technology Manager and Roadmap lead should be on this chat if you have any questions...

05:32:06 Caroline Robinson: I found the Digital Hub information useful as a quick up-to-date research pool on current thinking.

05:33:19 Robert P-W: Thanks Andy, I should be more specific. What are they using for multi-physics simulation of say coupled engine thermodynamics, ECU, transmission and kinematics. All of those would be required for a car DT. Is modeling at that level.

05:34:49 Matthew West: @Paul Hunter: We did create Digital Twins years ago, but it was early in the technology development and was very expensive and so only viable for very high value applications. Today it is much cheaper and we are starting to see an explosion.

05:34:50 Caroline Robinson: Breaking silos is very much a challenge.

05:35:29 Oleg Missikoff: @Caroline - Unavoidable though

05:36:00 julian klein: Connectivity between organisations should be channelled through the supply chain

05:36:15 Miles Elsdon: @Caroline @Oleg - Necessary rather than unavoidable!

05:36:17 jeffrey lake: there has to be a pull as much as a push when sharing knowledge , just 'pushing' does not work

05:36:18 Tony Fish: shout to my dad - happy days

05:36:19 Andy Parnell-Hopkinson: @Robert P-W different vendors use different tools. It's a competitive market

05:36:55 Matthew West: @Caroline: With the Foundation Data Model and Reference Data of the IMF, the idea is to syphon the data from the silos rather than break them.

05:37:11 Karen Feinberg: one needs 'boundary spanning leadership:

05:37:19 Caroline Robinson: @Matthew West I like that.

05:37:36 John Beard: @Karen - yes!

05:37:38 Caroline Robinson: @Karen Feinberg I like that too.

05:37:51 Greg Demchak: I have been wondering: could silos be broken down if there was an open market for solving problems that could be brokered? think task rabbit for solving cyber-physical problems.

05:38:13 Robert P-W: @Andy, if you can give some examples, i would like to check them out.

05:38:20 Mark Wharton: @karen - it's *all* boundary spanning. Tech, leadership, funding, use-cases....

05:38:54 Caroline Robinson: A Minister for Data?

05:39:06 Tony Fish: @wendy - here is the point of trust and data - my dad is Michael Fish and I am his son, which michael fish? but he was on the news the day after the strom

05:39:11 Oleg Missikoff: Open data

05:39:16 Andy Parnell-Hopkinson: @Robert you know the question, Google has the answer :-)

05:39:18 Karen Feinberg: great wiki and lots of articles... I think it can be a person, a way of thinking that 'should' be taught in schools and orgs... I work across silos in my work and one can begin to see connections and patterns in a way that can produce new ideas, partnerships, funding, combos of things in general (from my experience (:). here is a wiki: https://en.wikipedia.org/wiki/Boundary_spanning

05:39:25 Liam McGee: Other modelling: insurance? What about Flood Re and Pool Re?

05:39:35 Caroline Robinson: @Tony Fish That's awesome.

05:39:45 Jordan@melioro.co: I like the term co-development (and co-delivery) rather than co-creation. For me, co-creation might not mean delivering something that makes a difference. Let's find lots of small experiments that illuminate the bigger issues, deliver value at each stage, accrete new capabilities and grow out from there.

05:40:33 John Beard: Give data its rights - its rights to be found and to be used by all who can benefit from it. Though this perspective is a bit radical for some of the silo owners though.

05:41:34 Tony Fish: @john data does have rights (read, write, copy, delete) it is who and why and how do you know (attestation)

05:41:48 Paul Hunter: @Matthew West. agree, we still need to answer the questions around digital twin etc as there is still confusion

05:42:03 Oleg Missikoff: Light bulb have been disruptive for candle makers

05:42:07 Mark Wharton: @john beard <https://www.go-fair.org/>

05:43:32 Karen Feinberg: as a boundary spanner, I am fairly new to this topic/issues at hand, thus an amazing opportunity to add to my knowledge pool.... and continue my connections to the UK community... would be lovely to connect to those inclined to do so : <https://www.linkedin.com/in/karen-feinberg-4b75a3/> (see 2nd narr under profile for more nuance with 'glocal, transdisciplinarity as a framework, ED&I, etc.

05:43:37 Tony Fish: can you be a water company without water - surly yes. you never own the water and you don't create it. you move it. Can a bank be a bank without money (revolut ?)

05:44:02 David Lane : @TonyFish - nice play on your Dad, lovely way to make the data point

05:45:28 David Lane : Matt's points are true across other industries. Offshore Energy is the same - wind, oil@gas - and they are now coming out of the data dark ages as they push forward to net zero

05:46:19 Jeremy Watson: @ TonyF Airbnb doesnt own hotels...

05:46:58 Andy Parnell-Hopkinson: Service vs product, yeah?

05:47:22 Oleg Missikoff: Processes?

05:47:31 Chris Courtney - UKRI INNOVATEUK: but it wouldn't work if there were no properties to rent. water companies need water to exist to have services to sell.

05:47:58 Andy Parnell-Hopkinson: AMC Bridge doesn't own software :-)

05:48:12 David Lane : UKRI programmes such as the ORCA and RAIN Hubs are working on MVPs of digital twins and smart machines for inspection, repair and maintenance of assets, doing the prognostics and diagnostics that I think Matt was alluding to for Water. <https://orcahub.org> <https://rainhub.org.uk>

05:48:31 jeffrey lake: I did a workshop with a water company looking at Digital Transformation . I had thought that they may have wanted to go for IoT given their assets. In the end we were all surprised when we all came to the conclusion that data was their biggest issue. the lesson is ; don't assume that you know the answer.

05:48:36 Jeremy Watson: Yep - but if the primary deliverable is via physical infrastucture; e.g. road/rail/water/energy, wow betide us if we underinvest in improving the physical assets

05:48:38 Wendy Hall: @Tony Fish - too confusing for me. In a similar vein, I played at Wimbledon in 1969 (mixed doubles against John Newcomb)

05:48:40 Paul Clarke: @Stephen B. Last Monday parts of North London were in complete chaos because we got the "wrong type of rain". It was a microcosm of the terrible flooding in mainland Western Europe but what they had in common is that the weather forecasts may have predicted that action needed to be taken but seemingly it wasn't and the infrastructure could not cope. So to you point, we need joined up modelling including of human behaviours to stress test infrastructure but we also need smart infrastructure connected to those models in order to create model driven resilience. Little point doing the digital without the coupling to the physical

05:49:27 Tony Fish: @ david thank you - it would have made him laugh, unlike "the wrong snow" which he did say.

05:49:43 Tony Fish: @wendy - beautiful

05:50:03 David Lane : @Wendy @Tony - I directed the Thunderbirds TV show as a kid in the 60s :) Makes you wonder how I got into what I do ...

05:50:22 Karen Feinberg: boundary spanning leadership (:

05:50:32 Caroline Robinson: @Paul Clarke Yes. Digital infrastructure should support the physical infrastructure, for the benefit of everyone.

05:50:39 Holger Kessler: Great stuff @Matt

05:50:44 Tony Fish: @david - now that is top

05:50:50 Jeremy Watson: Fully agree - balanced investment - digital to understand the physical infrastructure (in real time) and do preventative maintenance, etc.

05:51:03 Laurie Reynolds: @ Matt Edwards, excellent summary and challenge.

05:51:04 Tony Fish: +1 to all the business idea which don't need something

05:51:07 Paul Hunter: great stuff, Matt

05:51:15 Andrew Jordaan: Fully agree @Matt

05:51:30 Melissa Zanocco, ICG: Agreed @holger - amazing stuff as always @matt edwards

05:51:52 Caroline Robinson: Digital Twins are definitely a means to an end, rather than the primary objective.

05:54:03 Melissa Zanocco, ICG: System of systems = Our Vision for the built environment www.visionforbuiltenvironment.com

05:54:14 Jeremy Watson: Bringing it together? A substantial government-funded (or private public) honeypot use case that mandates the use of DT principles (to be carefully defined!)

05:54:35 Melissa Zanocco, ICG: System of systems = Flourishing Systems https://www.cdbb.cam.ac.uk/files/flourishing-systems_revised_200908.pdf

05:54:36 Graham Meaden: We need specialist generalists to span across boundaries

05:54:56 Caroline Robinson: @Graham Meaden Yes.

05:55:38 Karen Feinberg: BS really needs to be taught in universities...

05:55:46 David Lane : @Jennifer +1 System of Systems. Key opportunity with CPF. Do MVPs have to start with something more manageable tho? Build something simple and valuable on a reasonable timescale to demonstrate the value to Ministers and the Public

05:55:50 Tony Fish: "boundary spanning" - recommend look up a new book "the neo-generalist" from Mikkelsen and martin - all those who are neuro-diverse do this all the time. You have always wanted to label us into a bucket and now see that we are specalists in many areas and generalist but don't do boundaries, or job titles, or have roles in corporates. Welcome to the neuro-diverse world.

05:55:54 Oleg Missikoff: @Graham - After decades of extreme specialization, generalists are very rare indeed ;-)

05:56:14 Holger Kessler: @Karen - Acronym check - I suspect it is not the common BS you are referring to :-)

05:56:29 Paul Clarke: And crowdsource real-time data from sensors and citizens to drive real time "intelligence". Then use inline digital twins that are part of the underlying control systems to model how best to respond and return to the steady state from a given set of starting conditions. We need this real-time intelligence for terrorist attacks, natural disasters, cyber attacks etc etc

05:57:00 Graham Meaden: @oleg, it requires strong abstraction skills to mentally "contain" and manage complexity and detail

05:57:05 Karen Feinberg: depths of knowledge certainly is absolutely key as well.. totally agree Tony Fish and thanks for the read recommendation.

05:57:12 Mark Wharton: @paul clarke. Love that. A kid with a Raspberry Pi should have a say, too

05:57:15 Caroline Robinson: @Tony Fish 'Welcome to the neuro-diverse world.' I like that.

05:57:24 jeffrey lake: There are a few of us 'generalists' around who have worked right across industries and technologies but people want to discuss with specialists

05:57:30 Andy German: Interest in how we define and create a "good digital culture" beyond the Gemini Principles.

05:57:49 Karen Feinberg: yes I meant to clarify that holger (:

05:57:58 Oleg Missikoff: @Graham - Systems thinking is valuable in this

05:58:00 jeffrey lake: the reality is 'People like their siloes'

05:58:18 Graham Meaden: @oleg yep

05:58:37 Oleg Missikoff: @Jeffrey - Until they go bankrupt

05:58:40 Caroline Robinson: Fascinating discussion on video and in chat. :)

05:58:47 John Beard: Maybe there could be an example from a town/area which have been badly affected by heavy rain in multiple ways - affecting power, water, transport etc - which could bring together multiple industries and businesses to be better prepared for next time.

05:58:53 Sam Chorlton : @jeffrey lake I think more broadly people don't like change. Doesn't mean we shouldn't aspire to drive that change.

05:58:54 Rob Buckingham: Something I mentioned briefly in my talk early this morning was the role of the end user. (In nuclear the end user is often Gov.). Linked to this we need Viable Innovation Pipelines. Often this means co-location on location to enable deeper faster conversations, which can also align with level up ambitions. We are thinking about RAICo One as a prototype for RAICo X which might be in a hospital or retail park or suburb. The point is the nuclear sector needs to learn with others... HMG could initiate this because HMG plays a key role in many sectors.

05:59:02 Paul Clarke: @Mark. Indeed. A new form of distributed "hive mind" democracy but not a referendum :-)

05:59:15 Holger Kessler: Interestingly @Jeffrey - as a Geographer I never liked silos at all.....which is why I ended up where I am, trying to integrate, coordinate and collaborate....

05:59:23 Mark Wharton: @paul clarke - smart city from the bottom up!

05:59:27 Veronica Martinez: Stephen Belcher - great point :)

05:59:34 Paul Hunter: One of the problems to allow cross industry information is the ability to interrupt the info to those that don't deal with it on a regular basis. Keeping things simple

will enable the ability to understand and be used. Also the quality of the system is a must, again something can be introduced but if complicated then again it could fail.

- 05:59:39 Pinning, Robin (STFC,DL,HC): @John beard - talk to Sarah Hayes about CReDo
- 06:00:00 Caroline Robinson: @John Beard There has been in Yorkshire (?)... National Trust EA, Waterboard and farmers coming together to divert excess water from going down stream. Was a success! :)
- 06:00:21 jeffrey lake: I agree Sam, but it is very hard going ! People always think their industry etc is unique - the reality is that they are more alike . However trying to get across that barrier to share knowledge is tough.
- 06:00:27 Tony Fish: the labels are wrong - it is not about generalist or specialists - it is about how individual make sense of the fabric in front of them. Labels are wrong (back to ontologies and epistemology (wrong labels will create rubbish data) wrong labels of those trusted to do the work - likely to get the wrong result.
- 06:01:22 Veronica Martinez: Bradley - I agree The PURPOSE of use is a key glass lens to look at future strategies
- 06:01:30 Chris Courtney - UKRI INNOVATEUK: @rob i think this more clustered/integrated living lab type environment is vital and missing. We have a fairly siloed approach in this space, but lots of new value to come from bringing together an ecosystem but also focus it on some real challenge and opportunities. drive radical innovation including the social and human factors.
- 06:01:33 John Beard: @Caroline - that's the sort of 'panic driver' that gets progress to happen
- 06:02:25 Andy Parnell-Hopkinson: @Jeffrey surely one man's silo is another man's specialisation? The problem is not the silo, it's using and connecting the output from all the silos.
- 06:02:32 Greg Demchak: tight control over IP and patents could be keeping information from flowing across the divide. Even when people jump from one company to the next, there can be non-compete rules that will slow down the flow of information. How to deal with that? Hyperloop...?
- 06:02:43 Matthias Gropp: From my experience as a structural health monitoring provider. People react very similar to bad data there as to climate change. They usually ignore it if it looks really bad. Although all info is there, as long as they people are part of the problem they very much want to ignore serious problems. The consequences of accepting them seem too serious to accept them.
- 06:02:54 Caroline Robinson: @John Beard I like to think of it as 'Common Purpose'.
- 06:02:55 David Lane : @Bradley - caution 'Use Case Money pots' from the detractors!
- 06:03:04 Rab Scott: Agree Bradley - Leadership isn't only top down - we must allow the newer generations to teach upwards
- 06:03:09 Andy German: Beware - honeypot in cybersecurity :(
- 06:03:21 mark.emerton@innovateuk.ukri.org: @Andy - intentional or?

06:03:43 Tony Fish: @andy @ Jeffrey the opportunities are in the gaps between the silos. Those bi

06:03:43 Miles Elsdon: @Andy PH - we need more T shaped people!

06:04:24 Andy Parnell-Hopkinson: @Miles ?

06:04:26 Tony Fish: those blind spots and places that are out of bounds

06:04:50 Oleg Missikoff: In my group rather than a binary top-down/bottom-up approach, we're working on an inside-out model

06:05:08 Veronica Martinez: Bradley - I like your perspective - top down, allow people to experiment, look for longer term Purpose. this is why Silicon Valley is successful. They are able to experiment and think different.

06:05:17 Rab Scott: @Andy PH - https://en.wikipedia.org/wiki/T-shaped_skills

06:05:19 Anthony Dennis: Listening to the discussion today and reading the chat messages, there are a lot of like minded people on this call, which makes the topic easy to discuss. However, what I am missing for such a broad topic with so many links to different sectors, different industries etc is 'Who drives this topic from an over-arching UK Plc perspective?' Apologies if I missed it somewhere during the presentations.

06:05:51 Caroline Robinson: Require motivation for change and data transformation.

06:06:06 Pedro: Fix your organisations first: transparency, fairness

06:06:14 Paul Hunter: collaboration for the common goal- to provide first class wholesome water, protecting the Environment- the supply chain has this desire

06:06:25 Paul Clarke: @Bradley. Helping leaders see what they can't see, embrace uncertainty, risk and ambiguity, embrace non-linear thinking, create bold transformative visions, bet the farm (because otherwise there will be no farm) is hard :-)

06:06:37 Andy Parnell-Hopkinson: @Rab ta!

06:06:39 Holger Kessler: Question to the organisers: How many people from government departments, Agencies, Local Authorities and Regulators are on here?

06:06:51 Chris Courtney - UKRI INNOVATEUK: @anthony im pretty sure there are plenty of people who are responsible for creating that are here and listening

06:06:58 Sarah Hayes : @John Beard yes that's what we're exploring in CReDo - the Climate Resilience Demonstrator project, which is developing a thin slice of the Information Management Framework and to demonstrate it is possible to know more about how to adapt to climate change

06:07:24 Anthony Dennis: @Chris - I hope so!

06:07:53 Karen Feinberg: andy, agree!

06:07:56 Andrew Jordaan: It is only a common purpose, combined with collaborative working that will aid the right continued solutions.

06:08:04 Miles Elsdon: @Andy PH T shaped people - depth of experience in one area but an ability to think more broadly across the system.

06:08:15 Laurie Reynolds: @ Andy-Parnell. I agree, talk about breaking silos is the wrong language, the silos often have best data quality. We need to speak about linking to silos with a common understanding of how to translate and link to the silo information content

06:08:35 Karen Feinberg: another phrase I like: the boundary jumping issues of our time!

06:08:46 Matthew West: I strongly agree with what Matt Edwards was saying about education in data basics. In Computer Science courses you see lots of maths, but no information basics, which is what IT is really there to support.

06:08:59 Andy German: from X shaped people

06:09:11 Pinning, Robin (STFC,DL,HC): @Sarah - I could see CReDo become a use case example (I stop short of honeypot!) - technical but very much sociotechnical. As Bill would say #Deepsocio

06:09:23 John Beard: @Sarah - thank you - Gloucestershire's 2007 heavy rain and flooding - a few years ago now but a real example of a complex system that had a multi-party problem.

06:09:59 Andy Parnell-Hopkinson: Agreed. @Laurie. We need the best people without constraining them. Sharing of knowledge, data, results, inspiration etc is a management problem

06:10:21 Caroline Robinson: If you would like to discuss later, please do get in contact: <https://nl.linkedin.com/in/caroline-robinson-560a1b35>

06:10:22 Oleg Missikoff: Great Matt! Education is everything!

06:10:23 Pinning, Robin (STFC,DL,HC): I live in the Calder Valley (Todmorden) - it floods here and a full data driven model would help greatly

06:10:27 John Grant: Max Boisot gives a good intro and a useful way of thinking about boundary spanning here
<https://www.youtube.com/watch?v=MRHzHmmlmYc>

06:10:53 Andy Parnell-Hopkinson: Yes Sam!

06:11:11 Mark Wharton: Start small, think big

06:11:34 Andy Parnell-Hopkinson: That's the point of Agile - it's allowed to fail

06:11:43 Laurie Reynolds: ...or even Think big but start soon.

06:11:44 Caroline Robinson: I have a whole bunch of reading from this webinar, thank you everyone. :)

06:11:44 Oleg Missikoff: We need practical examples to show around

06:11:45 Andy Parnell-Hopkinson: Doesn't have to be a perfect plan

06:11:56 julian klein: Government increase in R&D funding, say 1% of GDP

06:11:57 Sarah Hayes : @Robin Pinning yes CReDo is a use case example and we need lots more of these to grow the ecosystem of connected digital twins all focused on solving specific problems

06:12:31 Tony Fish: ahahahhahahah data is not oil

06:12:41 Miranda Sharp: uranium?

06:12:50 mark.emerton@innovateuk.ukri.org: How clear is the intervention ask? if this community was to ask three ministers what they understood we needed, we'd probably get three very different answers.

06:13:14 Jeremy Watson: If data was oil, we'd be energy rich...

06:13:15 mark.emerton@innovateuk.ukri.org: 'Just do it' - sounds a little like 'Brexit means Brexit' - the intervention needs to be clearly understood, and bounded.

06:13:16 Sam Chorlton : Information is even better

06:13:21 Mark Wharton: @tony fish. Agree. data can be duplicated, Oil cannot

06:13:41 Rab Scott: Oil, until it is refined, is a risk and a cost...

06:14:00 Jeremy Watson: Perhaps we need some hackathons around DTs - so we move from theory to MVP and learning by doing

06:14:10 Tony Fish: +1 Jennifer (governance)

06:14:11 jeffrey lake: PoC's in differing areas, focussing on differing aspects of digital - there must be an overall umbrella set of objectives and all projects must have external boundaries defined so as to ensure that all can be tied together. Metrics for success need to be defined

06:14:27 Pinning, Robin (STFC,DL,HC): +1 Jennifer re: value vs cost

06:14:31 Paul Clarke: We are not going to predict all the first order benefits of CPF, let alone second and third order ones. This sort of transformation will require a bold leap of faith based on a vision driven sense of the possible

06:14:41 Tony Fish: what happens when the earth has no value ?

06:14:56 Pinning, Robin (STFC,DL,HC): I was about to make a comment like that @paul

06:14:57 Claire Ellul, UCL: @jeremy Watson +1

06:15:22 Neil Tatman: Too much discussion and focus on data; too little reference to much needed context based information at what cost to achieve..... Hindsight; Insight & Foresight..... Where on that scale does the UK want to be. Digital Twins are only part of this solution.....

06:15:28 Pinning, Robin (STFC,DL,HC): Government need to trust the intuition of those that deliver the case for that leap of faith

06:15:36 David Lane : @Jennifer - startups do the value piece par excellence. They need LargeCos as customers to justify them doing this.

06:15:39 Andrew Scullion: If the value is realised beyond the timeframe of the political cycle then it never justifies the logical investment, so how do you get the long term investment?

06:15:44 Cambridge CDBB: Continue this conversation on the DT Hub: Panel 4 – Adoption
<https://digitaltwinhub.co.uk/forums/topic/433-cyber-physical-fabric-summit-panel-4-adoption/>

06:15:46 Andy Parnell-Hopkinson: All the government needs to do is pay for (and use) the data to populate digital twins of assets. That would give the industry all the motivation it needs

06:16:03 Paul Hunter: thanks Mark

06:28:03 Rob Solly: @Tony - value can be expressed in terms of re-use, minimising waste etc too

06:28:26 Tony Fish: so is it that our need for PAYE and our incentives mean we are blinded and feel unable to change the system - boundary breakers who are not able to be free from the boundaries. Honey pot seekers who just want to find the pot.

06:29:11 Pinning, Robin (STFC,DL,HC): @Tony - the fixation partly comes down to business cases to governments in this community

06:29:14 Tony Fish: @rob - totally agree, but framing value with market failure would not say we have a narrow definition and not a wide one

06:29:46 Holger Kessler: I (and the Geospatial Commission) would be very interested in receiving a summary from the event, especially the "what you would do if you were in government" replies from the panellists and also any thoughts on Matt Edward's challenge as to who is/should be leading this from the centre.

06:30:26 Rob Solly: @Tony - yes I missed the bit at the start where "market failure" was introduced as a driver for this. I see it far more in opportunity terms than failure / risk

06:30:29 Andy Parnell-Hopkinson: @Mark search me. There's a lot of nit-picking over definitions and semantics, not so much on specifying deliverables. Make no mistake, I'm on the side of industry - we deliver this stuff.

06:32:07 Claire Ellul, UCL: @Matthew - thanks ..as you say, sort of the converse of the cost of poor quality data, and you'd need to consider both. I think that in my world (geospatial) people are relatively reluctant to publicise the actual cost in ££ incurred due to poor quality data.

06:32:20 Sophie Peachey: Ali Nicholl refers to the challenge ahead of us as Cooperative Transformation.

06:32:21 Tony Fish: @paul +1

06:32:49 Pinning, Robin (STFC,DL,HC): @Tony and Rob Solly - most industries understand the boundary between govt and commerce in terms of market failure

06:33:09 Matthias Gropp: wld say there is no poor quality data, as long as you know what quality they have is

06:33:14 Mark Wharton: @sophie +1

06:33:29 Matthew West: @Holger: Mark Enzer and I were talking about this the other day, and Mark came up with an octopus analogy, where there is intelligence in the arms as well as the

brain, so a lot of collaboration rather than command and control with centres of excellence and careful coordination at the centre.

- 06:33:45 Mark Wharton: @matthia - Describe data well, and it's all useful.
- 06:34:13 Holger Kessler: @matthew - love that
- 06:36:15 Claire Ellul, UCL: @mark Wharton - agree re: describing the data well - and that's a challenge itself, as the 'description' that is useful to an analyst is very different to that useful to a decision maker, and the producer of the original dataset (who creates the description) often doesn't have any idea who the users will be ..
- 06:36:20 Tom Henderson: @matthew How about a set of Octopuses talking to each other on an international level? :D
- 06:37:14 Pinning, Robin (STFC,DL,HC): @tom tentacle to head? ;)
- 06:37:22 Matthew West: @Claire: I agree, when you go into an organization they usually think their data is wonderful, and are concerned to share their crown jewels. By the time you've finished they are aware how awful their data is and don't want you to talk about it because of that. Noone wants to publicise how bad their data was and what that was costing them.
- 06:37:33 Oleg Missikoff: Are we aiming at a DTP?
- 06:37:39 Claire Ellul, UCL: @matthew west - sort of an 'autonomous, interacting vehicles with some central control' approach?
- 06:37:44 Paul Hunter: @Matthew West. there is a lot of intelligence in the arms, we are driven to believe it has to be change from the brain, but it receives the info and coordinates this, you are correct, now how to harness this is the goal !
- 06:37:58 Mark Wharton: @claire I agree, but even a bad description is better than no description. Granularity of source is also important. The smaller the granules, the easier the reuse.
- 06:38:51 Tony Fish: @wendy +10000 governance + ethics
- 06:38:58 Claire Ellul, UCL: @mark - yes, 100% agree re having some description - and some dates - is fundamental
- 06:39:45 Karen Feinberg: regarding data and gender:, an interesting org (out of Stanford University: women in Data science: with worldwide chapters: <https://www.widsconference.org/>
- 06:40:06 Oleg Missikoff: How about introducing the theme of a Digital Twin Protocol?
- 06:40:21 Matthew West: @Claire: I think there needs to be some central direction setting, or policy. But it should be relatively lightweight rather than controlling.
- 06:40:42 jeffrey lake: Oleg: with what objective?
- 06:41:14 Oleg Missikoff: Easing interaction on the subject?
- 06:41:17 Mark Wharton: @claire - equivalent standards are ok, too. You measure in Fahrenheit, I measure in Celsius . As long as you *tell* me, I can cope
- 06:41:37 Mark Wharton: @wendy <3
- 06:41:59 jeffrey lake: I am not sure that I understand?

06:42:28 Oleg Missikoff: Interoperability standard

06:42:35 Wendy Hall: We don't have a website yet but if you are interested in joining the 4DSIG, you can email 4DSIG-enquiries@soton.ac.uk

06:42:49 Ian Bailey: The IMF team are developing the protocol

06:42:57 Ian Bailey: ...at least for the national digital twin

06:43:18 Oleg Missikoff: I'll look through it

06:43:41 jeffrey lake: i think that we will need to play with this for a while to find out what works, as we get familiar then start the discussion on protocols. If we try and do i remotely we risk setting the wrong standards

06:43:52 John Beard: @Mark Wharton - a simple acceptance test for standards being equivalent is: can I round-trip between them in both directions without information loss?

06:44:41 Rob Solly: Has anyone described the shifts we are looking to create here in terms of how they differ from what happens today? For example in my previous organisation, we had hundreds of models but integrated them manually. We are now looking to automate or at least semi-automate that integration. This will be a huge step forward but it is just in one sector (Defence and Security). In today's meeting we are also looking to integrate models and data across sectors. I'd argue this is taking two major steps forward from where we are today - because at present we mostly exchange ideas about models across sectors rather than integrating them.

06:44:44 Sophie Peachey: Always a danger of UKRI funding being directed at something that UK SMEs have already cracked - threatening their market.

06:44:44 Mark Wharton: @john beard - Haha! Like translating from English to Greek and back to English - will it still make sense?

06:45:23 Wendy Hall: Here you go. An internet for the Solar System
<http://ipnsig.org/2021/06/30/announcing-strategy-working-group-report/>

06:45:25 Aron Kisdi: David, completely agreed. Need to get ideas to Series A rounds in robotics.

06:45:56 Caroline Robinson: @Rob Solly Yes, this is an important issue. Within some organisations even they don't have cross-comparative datasets.

06:46:08 Ian Bailey: Seed investment used to be easier than Series A in the UK, but David's right, it's tougher at the moment

06:46:11 jeffrey lake: I am an engineer. 150 years ago we had so many standards for bolts, each industry and manufacturer had their own standard. Now we have a few global standards because it is in everyone's interest.

06:46:51 jeffrey lake: but we had to go through a transition. I don't suggest it will take 150 years, it will be a fraction of that

06:46:52 Navein Madhavan: @Ian B It's almost impossible to get seed investment in engineering/manufacturing

06:47:06 Tony Fish: @davidlane - is the start up/ growth rooted in solving the problem or using an idea that will motivate a few, not solve the problem as it was the very thinking that got us to where we are?

06:47:31 Caroline Robinson: Sometimes we have the answers already, but they are not deployed for other reasons.

06:47:51 Tony Fish: @jeffrey - I have a selection of over 400 different taps and dies - living library of that truth.

06:48:00 Oleg Missikoff: @Ian - We're launching a DT Hub here in Rome, and have already organised an event with the Cdbb crew. How about starting to develop a shared core ontology, t begin with?

06:48:26 Ian Bailey: @oleg - sounds interesting !

06:48:32 jeffrey lake: @Navein: I agree , within key sectors they are still cutting back . One MD told me 10 days ago that they are now so lean they do not have any capacity for digital investment. He was from a tier 1 group

06:49:02 Oleg Missikoff: @Ian - Let's dig deeper then

06:49:21 Tony Fish: @davidlane = not sure I agree on UK, soverign - do it here, lead. we are global citizens with global problems.

06:49:46 Paul Hunter: we can work on different data, AI could enable the information to be displayed to you in the format you want

06:49:52 Caroline Robinson: @Tony Fish Agreed. Why not a global leader?

06:49:56 jeffrey lake: oleg, I would be interested in that

06:49:57 Steve Maclaren: Completely align to the living labs narrative, great to hear Davids perspective

06:50:41 Oleg Missikoff: @Jeffrey - Let's get in touch on LinkedIn and move on

06:50:54 Simon Hart: Living Labs require stable funding over a 5 year timescale. Securing this funding will be challenging given the uncertainty of the next Treasury Spending Review.

06:50:56 David Lane : @Tony - sure. We provide global leadership initially. When it takes off its rock and roll, and we look to our creativity to stay ahead, or at least keep up

06:51:29 jeffrey lake: ok oleg

06:51:40 Caroline Robinson: OGC does create international digital standards:
<https://www.ogc.org/>

06:51:44 Chris Courtney - UKRI INNOVATEUK: we shouldn't underestimate the extent to which industry is already just doing it. But to marks point there isn't sufficient common underpinnings to really unlock best value and new opportunities

06:51:50 John Beard: @Caroline - global leader - that's an excellent ambition for UK on this topic - we're not big in manufacturing, nevertheless we can be big on ideas

06:52:03 Tony Fish: @navein having invested in quite a few engineering companies over the past 30 years, there is money. however far to many I see don't understand (and assume) what an investor is looking for.

06:52:22 Caroline Robinson: And the OGC is industry-led.

06:53:54 Tony Fish: @david we should be part of a leadership - not sure nation state ideals are the right model

06:53:56 Miranda Sharp: where is the value? Depends what you mean by value doesn't it @Tony Fish? Currently the effort and money wasted is not counted so it's hard to make the case. Hence we need to find the "boundary-spanning" problems that cannot be solved in silos. Tangible examples of cross sector resilience and net zero are good places to start, I would argue.

06:54:45 Sophie Peachey: Some major infrastructure projects need to establish themselves as the living labs from which everyone can learn - with good investment in dissemination about what works and what doesn't!

06:54:49 Caroline Robinson: @Miranda Sharp Value to government to start and then private enterprise... like NASA/ESA?

06:55:03 jeffrey lake: tony fish : are you on linkedin?

06:55:09 Caroline Robinson: Value can be quantified afterwards. :)

06:55:11 Claire Ellul, UCL: @miranda sharp +1 - the basic question you're asking - I think - is 'why integrate' (so why do we need all this effort, what can't we do that we need to do)

06:55:15 Chris Courtney - UKRI INNOVATEUK: for info in made smarter we run a digitisation programme across all manufacturing sectors now, including aero, auto, pharma, food, checmicals, construction and others. There is buy in to 'boundary spanning' or cross sector approach. and are beginning to build living labs (but early stage and not 'integrated' around a bigger ambition). The journey has strted in many sectors, what we need to do is accelerate it

06:55:22 Tony Fish: thank you +1

06:55:24 Paul Hunter: thank you as well

06:55:40 Tony Fish: @miranda - speak soon I hope - yes

06:55:45 Caroline Robinson: Great conversation. Thank you panelists.

06:55:47 Veronica Martinez: Thank you, great conference.

06:56:01 Steve Maclaren: Great event, thank you very much indeed all

06:56:07 Ivo Willems: Thank you for sharing all this information. Much appreciated!

06:56:10 Tony Fish: @jeffrey <https://www.linkedin.com/in/tonyfish/>

06:56:10 Poppy Harrison:Great conference and really interesting chat - Thanks all

06:56:18 Michael Herrmann: Thank you! See you all again soon in the ontoverse.

06:56:21 John Beard: Thank you all - let's charge ahead!

06:56:39 Sophie Peachey: Thanks everyone - extremely well executed. Really look forward to the summaries.

06:56:43 Oleg Missikoff: I had an Amazing day! It'll take a couple of days to reorganize the information overload, but at the end I'll be a better scholar. Thank you very much for this incredible opportunity. Something big happened here today!

06:56:44 Mark Wharton: Absolutely the best online conference I've ever been on. The day has whizzed by!

06:56:48 Anthony Denniss: very interesting, now to build on todays momentum !

06:56:51 Sabine Hauert: Great summit - thank you.

06:56:54 Rab Scott: Don't let the conversations and activities stop - just make sure they are joined up

06:56:54 Claire Ellul, UCL: thanks panellists, and thanks participants - this has been one of the best chats in a conference!

06:56:59 Mark Bass: Thanks again sorry if I was uninformative!

06:57:11 Holger Kessler: super stuff!

06:57:13 Chris Courtney - UKRI INNOVATEUK: great stuff panel and team

06:57:14 Andrew Jordaan: Great event, and great discussions today

06:57:15 Gordon Masterton: Well done to all for a really interesting day.

06:57:22 Rob Solly: thanks everyone!