Pkt. 3 Drøftelse af Open Science arbejdsgruppens rapport

Indstilling
Det indstilles, at

- Forskningsudvalget drøfter arbejdsgruppens rapport om Open Science med fokus på de fire 'søjler', med henblik på at komme med input til prioritering af det videre arbejde med Open Science på RUC.

Sagsfremstilling
Roskilde Universitets (RUC) Open Science Arbejdsgruppe blev nedsat af Forskningsudvalget med det formål at komme med forslag til en vision for Open Science (OS) og adressere hvordan OS initiativer kan koordineres på RUC i fremtiden. Indførelse af Europa Kommissionens otte OS temaområder og deres betydning på universitetsniveau har League of European Research Universities (LERU) beskrevet i deres rapport "Open Science and its role in universities: A roadmap for cultural change."

Arbejdsgruppen består af forskere, der repræsenterer RUC's institutter og forskellige forskningsområder, såvel som administrative medarbejdere med ekspertise i OS. Arbejdsgruppen afholdt sit første møde i marts 2020. De følgende møder blev afholdt fra november 2020 til januar 2021. Forløbet har omfattet fire forskellige møder med oplæg fra eksterne eksperter, hvert med fokus på en af fire søjler fra LERU-rapporten. Disse søjler var udpeget af Peter Kjær og valget var begrundet med deres særlig relevans for RUC: Citizen Science, Future of Scholarly Publishing (Open Access (OA)), FAIR data og Rewards & Incentives/Next Generation Metrics. Et femte og afsluttende møde blev afholdt ultimo januar.

Vedhæftet er LERU-rapporten og arbejdsgruppens rapport med anbefalinger til RUC's visioner for Open Science initiativer i fremtiden.

Videre proces
FoU's input vil indgå i den videre forskningsstrategiske afklaring i Universitetsledelsen og i Forskningsservice, især i forhold til hvordan RUC samlet set skal forholde sig til kommende initiativer, og hvordan vi kan deltage mere proaktivt i arbejdet med Open Science.

Forelæggelsen er godkendt af
Prorektor Peter Kjær

Bilag

- Bilag 1: Rapport og anbefalinger fra RUC's Open Science Arbejdsgruppe
- Bilag 2: LERU Advice Paper, 2018: Open Science and its role in universities; A roadmap for cultural change

Rapport og anbefalinger fra RUC's Open Science Arbejdsgruppe

1. Introduktion

Roskilde Universitets (RUC) Open Science Arbejdsgruppe blev nedsat af Prorektoren med det formål at komme med forslag til en vision for Open Science (OS) og adressere hvordan OS initiativer kan koordineres på RUC i fremtiden. Indførelse af Europa Kommissionens otte OS temaområder og deres betydning på universitetsniveau har League of European Research Universities (LERU) beskrevet i deres rapport "Open Science and its role in universities: A roadmap for cultural change."[1]

Arbejdsgruppen består af forskere, der repræsenterer RUC's institutter og hovedområder, såvel som administrative medarbejdere med ekspertise i OS. Arbejdsgruppen afholdt sit første møde i marts 2020. De følgende møder blev afholdt fra november 2020 til januar 2021. Forløbet har omfattet fire forskellige møder med oplæg fra eksterne eksperter, hvert med fokus på en af fire søjler fra LERU-rapporten. Disse søjler var udpeget af Peter Kjær og valget var begrundet med deres særlig relevans for RUC: Citizen Science, Future of Scholarly Publishing (Open Access (OA)), FAIR data og Rewards & Incentives/Next Generation Metrics. Et femte og afsluttende møde blev afholdt ultimo januar.

Rapporten består af 3 delelementer: Open Science vision, opsummering af eksisterende aktiviteter, og anbefalinger til videre arbejde, herunder governancestruktur.

2. Vision for Open Science på RUC

OS er et område med stigende betydning og det kan beskrives som en igangværende udvikling i den måde hvorpå forskning udføres, forskere samarbejder, viden deles og videnskab organiseres[1]. OS er en ny tilgang til den videnskabelige proces hvor digitale teknologier gør det muligt at etablere nye former for samarbejde og videndeling. OS er desuden aktualiseret af den igangværende COVID-19 pandemi, hvor hurtig og åben udveksling af forskningsresultater er af afgørende betydning for udvikling af forebyggelse, diagnostik, behandling og vaccination.

RUC's vision er at være blandt de førende europæiske universiteter inden for tværfaglig videnskabelse. Det skal ske med en lokal forankring og et globalt udsyn. Herved ønsker RUC at flytte samfundet fremad i en forskningsbaseret bæredygtig retning. OS åbner nye måder hvorpå forskning, uddannelse og innovation skabes, gemmes, deles og formidles til hele verden. RUC forpligter sig til OS i *Strategi 2030: Interconnected*, hvor universitetet præsenteres som "et åbent netværk af viden". Inddragelse og videndeling er en forudsætning for den frie tanke, demokrati, tolerance og bæredygtighed. Derfor ønskes det at OS bliver et af RUC's kendetegn, hvilket er i tråd med vores dybe værdier om forskning og demokratisering af viden og vores rolle med at eksperimentere med nye måder at skabe viden. Tidligere formidling af og adgang til forskningsresultater vil medvirke til at accelerere videnskab og til at nå frem til løsninger på verdens store problemer.

Derudover passer OS godt med RUC's strategiske pejlemærke om ligestilling og mangfoldighed. OS skaber grobund for lighed i forskningen, hvor alle, uanset etnicitet, køn,

1. https://www.leru.org/publications/open-science-and-its-role-in-universities-a-roadmap-for-cultural-change

socioøkonomisk baggrund eller geografisk område, kan tilgå forskningsresultater. OS understøtter også forskere, der ikke nødvendigvis kan tiltrække så mange forskningsmidler, enten fordi de befinder sig tidligt i karriereforløbet eller fordi de er tilknyttet et universitet med begrænsede ressourcer.

RUC har valgt at fokusere sin indsats på fire sammenhængende områder indenfor OS som tilsammen tilgodeser disse målsætninger: **Citizen Science** for at inddrage borgerne og gøre dem til en del af forskningsprocessen, som ligeledes er et indsatsområde i *Strategi 2030*; **Scholarly publishing**, herunder især OA, for at skabe fokus på, at det at dele viden og bygge videre på andres viden, er en af de vigtigste hjørnesten i vores samfundsudvikling og succes; **FAIR data** for at gøre det muligt at demokratisere viden og øge transparens i forskning; og **Next generation metrics og Rewards & incentives** for at rammesætte udviklingen med meningsfulde incitamentsstrukturer.

RUC sætter pris på det tætte samarbejde mellem studerende og forskere. Derfor dækker RUC's Open Science vision også de studerende. Open Science metoder er en del af den digitale, etiske, og demokratiske dannelse som er nødvendig for at ruste kandidater til en fremtid som forandringsagenter og samfundsborgere.

RUC anerkender de udfordringer som Open Science kan udgøre i forhold til den investering i teknisk infrastruktur og administrativ støtte, der skal være på plads, såvel som den kulturelle forandring der skal ske for at forskning som udgangspunkt skal være åben. Et virkeligt Open Science landskab kan kun opnås på et internationalt niveau, men RUC forpligter sig til at bidrage til denne udvikling, der er nødvendig på lokalt, nationalt og internationalt niveau.

Dette er en mulighed for at erobre OS dagsordenen. RUC vil forholde sig kritisk og aktivt til nye udviklinger og debatter i OS så at vi kan være med til at skrive historien om OS.

2.1 Citizen Science

RUC har som et samfundsengageret universitet en lang tradition for at drive Citizen Science (CS), forstået i bredeste forstand, og vi ser et demokratisk potentiale i processerne forbundet med denne form for forskning. Ved at styrke CS på RUC kan vi tydeliggøre denne tradition både over for samfundet, men også internt over for studerende og ansatte.

På RUC definerer vi CS bredt, dvs. omfattende både CS, hvor de medvirkende borgere bidrager med viden og arbejdskraft (forskerdrevet, top-down), men også borgerinddragende aktiviteter som kan beskrives med termer som f.eks. *participatorisk* forskning, *kollaborativ* forskning og *aktionsforskning* (borgerdrevet, bottom-up). RUC er således på linje med det internationale CS-miljø, hvor der findes både snævre og brede definitioner af begrebet.

RUC kan med sin viden og styrke indenfor CS bidrage til at udvikle og udvide metoden og herigennem brande universitetet. Desuden kan aktiviteter med CS-indhold, herunder aktiviteter i samarbejde med kommuner, regioner og NGO'er, sikres beskrevet som sådan (f.eks. med dedikerede termer i PURE og i bibliotekssystemet) og herved udstilles gennem en portal. Dette vil kunne udnyttes ved ansøgninger til forskningsfonde, hvor der for tiden er fokus på netop CS (dette gælder både offentlige og private fonde).

Derudover vil det styrke RUC's CS-arbejde, hvis der blev afholdt workshops/møder/konference med fokus på at lære af de forskellige traditioner der bliver trukket på i de respektive forskningsmiljøer.

2.2 The Future of Scholarly Publishing/Open Access

RUC anerkender styrkerne i OA, og ser de umiddelbare globale og lokale fordele, og RUC står sammen med de andre danske universiteter i målsætningen om, at skabe øjeblikkelig adgang til forskningspublikationer.

I RUC's publiceringspolitik formuleres det at "RUC søger at sikre fri og åben adgang til universitetets forskning og ønsker derfor at fremme publicering, der rummer mulighed for fri adgang (OA) til forskningsresultater". Dermed ligger OA, som et kerneelement i OS, allerede indlejret i RUC's publiceringsstrategi.

RUC arbejder aktivt med OA for at spejle globale fordele, der bl.a. ligger i at understøtte den demokratiske deling og tilgængelighed af viden, og ønsker at RUC skal medvirke til den mulige accelerering af viden på denne baggrund. Dermed understøttes også de lokale fordele for RUC, herunder at OA medvirker til, at større dele af RUC's forskning bliver bredt formidlet, og dermed promoverer universitetet gennem adgang til forskningen. RUC understøtter OA ved lokalt at nytænke udstilling og adgang til egen forskning, herunder også med fokus på udstilling af forskningen til RUC's studerende.

RUC ønsker fortsat at arbejde med OA som formidlingselement, og vil gennem udvalgte indsatsområder udbygge den lokale indsamling, promovering og formidling af OA. Men RUC vil også gerne finde veje til at påvirke national politik på området, herunder indflydelse på Danmarks Nationale Strategi for Open Access og OA Indikator, samt sætte fokus på bedre nationale udgivelsesmuligheder for OA.

På RUC arbejder den enkelte forsker, i samarbejde med instituttet, med OA som et individuelt reflektionselement. OA ses her som en målsætning på RUC, ikke et styringselement. Dette henfører til blandt andet RUC's *Strategi 2030*.

2.3 FAIR data

Grundtanken i FAIR data er, at forskningsdata i fremtiden bør kunne findes, tilgås og, så vidt muligt, genbruges, samt at betingelserne for brug af forskningsdata er klar formuleret. Dvs. at forskningsdata følger FAIR[2] principperne så at de er Findable, Accessible, Interoperable og Reusable. Det understreges at FAIR data ikke er ensbetydende med åbne data, da der kan være gode grunde til, at forskningsdata ikke kan gøres åbent tilgængelig. I mange tilfælde kan forskningsdata dog alligevel gøres FAIR, hvis forskeren publicerer metadata[3] der beskriver datasættet, samt betingelser for, hvordan andre eventuelt kan få adgang til det.

At gøre forskningsdata FAIR giver oplagte muligheder i nogle discipliner, men har begrænsede anvendelsesmuligheder i andre. RUC anerkender disse forskelle. Dette betyder at vægtning og relevans af de enkelte dele i FAIR principperne kan variere per forskningsaktivitet. Forskere på RUC skal overveje, hvad FAIR data betyder i deres projekt, herunder varetagelse af etiske hensyn og de forholdsregler der gælder i forbindelse med håndtering af persondata.

Det ligger i RUC's kultur at samarbejde på tværs og dele viden. En mere demokratisk deling af forskningsdata kan medvirke til at løse nogle af de store samfundsudfordringer. Her kan FAIR data bidrage med at fremhæve forskning på RUC og give mulighed for nye samarbejder, interdisciplinære såvel som nationale og internationale. FAIR data gør forskningsprocessen

2. Wilkinson, M. D. et al. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data 3:160018*. doi: 10.1038/sdata.2016.18
3. Metadata betyder "data om data". Det er en fællesbetegnelse for mange forskellige typer af struktureret information, der bruges til at beskrive, administrere og genfinde samlinger. Hentet fra https://digitalbevaring.dk/viden/metadata/ den 15. december 2020

mere transparent og faciliterer reproducerbarhed af resultaterne, hvor det er muligt. FAIR data kan ligeledes tilgængeliggøre forskningsresultater, som ikke nødvendigvis egner sig til publicering.

2.4 Rewards & Incentives / Next generation metrics

RUC's *Strategi 2030* fremhæver, at RUC skal udføre banebrydende tværfaglig forskning på højeste internationale niveau, skal samarbejde med omverdenen i udførelsen af denne og at forskningen skal have samfundsmæssig impact.

For at kunne bedrive banebrydende tværfaglig forskning, er det vigtigt, at incitamentsstrukturerne ikke hæmmer RUC's forskere i at opnå disse idealer. Incitamentsstrukturerne skal i stedet understøtte forskerne i at opnå de mål og resultater, som er meningsfulde for den enkelte forsker. Incitamentsstrukturerne skal derfor i højere grad fremme OS end de nuværende (f.eks. BFI), som ikke nødvendigvis måler forskningshøjde. Ligeledes skal incitamentsstrukturerne være tænkt ind i både nationale og internationale standarder, som kan belyse, hvilken gennemslagskraft RUC's forskning har.

Det er vigtigt, at RUC anerkender, at der er en række forskningsaktiviteter, som ikke nødvendigvis ender ud i udgivelsen af publikationer, men som kan have høj forskningsmæssig værdi (f.eks. deltagelse i editorial boards). Sådanne aktiviteter kan indgå som valide mål, når RUC bruger metrikker i karriereforløb og ved andre evalueringssammenhænge. Disse metrikker skal ligeledes være etisk funderede, som beskrevet i forskellige Open Science vejledninger.

For at få det fulde billede af RUC's forskningsaktiviteter, kan følgende kategorier eksempelvis benyttes; deltagelse i råd/nævn, formidlingsaktiviteter, udgivelse af forskningsdata og anden samfundsmæssig impact. Således lægges al vægt ikke på de publikationsbaserede indikatorer, og belyser andre forskningsaktiviteter der har værdi for RUC og samfundet. Det er dog essentielt, at sådanne indikatorer kan understøttes af administrative systemer som Pure således, at ressourcerne til udarbejdelsen af indikatorerne ikke overstiger nytteværdien af disse.

På RUC er fagområderne repræsenteret med forskelligartede traditioner og praksis, men samtidigt arbejdes der tværfagligt. Eksempelvis kan der være forskel på, i hvilken grad der er tradition for kvalitative eller kvantitative metodikker inden for fagene, samt hvordan de bruges i den tværfaglige forskning. Disse forskelle skal der tages højde for, når RUC bruger metrikker, således at målene er meningsfulde for den enkelte forsker og fagområder, men ikke nødvendigvis sammenlignelige på tværs af discipliner/institutter.

3. Eksisterende aktiviteter

Som en del at opgaven, har Arbejdsgruppen identificeret eksisterende OS-aktiviteter på RUC, og kortlagt dem i overensstemmelse med de fire områder.

3.1 Citizen Science

- Endnu ingen konkrete overordnede/fælles aktiviteter udover bibliotekets deltagelse i nationale og internationale fora vedrørende CS.
- RUC har en lang tradition for borgerinddragende forskning, men det har ikke været muligt for arbejdsgruppen at identificere dem entydigt. Derfor "ingen nævnt, ingen glemt".

3.2 The Future of Scholarly Publishing/Open Access

RUC imødekommer i Publiceringspolitikken målsætningerne i Danmarks Nationale Strategi for Open Access (3.6. Adgang til forskningsresultater), ved at støtte grøn OA. Biblioteket er i denne

sammenhæng ansvarlige for at RUC opfylder målsætningerne i denne strategi. Dette gøres ved at have et vedvarende fokus på forlags- og fundingpolitikker samt nationale og internationale tendenser inden for området.

Derudover indsamles OA versioner af fagfællebedømte manuskripter, hovedsageligt inden for OA Indikatoren (OAI), der er et målingsredskab knyttet til Den Nationale Strategi for Open Acces. De indsamlede manuskripter publiceres efter gældende licenser, og med forskernes tilladelse, i Pure.

Samtidig arbejder biblioteket på målsætningen om at arbejde ud fra mere datadreven indsamling af OA, for dels at samle arbejdet på færre hænder, og dels at skabe ekspertisen i målrettede ressourcer inden for området.

Biblioteket tilbyder tillige løbende OA-kurser, samt oplæg for forskningsgrupper og Ph.d.-studerende, og arbejder løbende med support og formidling af OA via direkte henvendelser.

Biblioteket indgår i 2021 i et KB-projekt om at få løftet kvaliteten af danske tidsskrifter med målet om at få dem indekseret til godkendelse i den internationalt anerkendte vejviser, DOAJ – Directory of OA Journals.

3.3 FAIR data

I 2018 har RUC vedtaget en data management politik som beskriver hvordan forskere på RUC arbejder med indsamling, opbevaring og adgang til digitale forskningsdata for dermed at skabe transparens og åbenhed om forskningens 'produkter'; hvordan det sikres at data opbevares forsvarligt og hensigtsmæssigt; og hvordan forskere kan øge sandsynligheden for at data kan genbruges af andre forskere. RUC's data management politik tager udgangspunkt i at forskningsdata skal være "*as open as possible, as closed as necessary*", som flugter med FAIR principperne.

RUb yder forskersupport til at lave data management planer (DMP) ved at bruge værktøjet DMPonline.

RUb yder også support til forskere for at implementere FAIR principperne:

- Findable
    - Metadata til forskningsdata som gør at de kan (gen)findes af andre
    - DOI (digital object identifier) hvilket giver entydig placering af data
- Accessible
    - Valg af repository
- Interoperable
    - Overholdelse af standarder og dataformater
- Reusable
    - F.eks. ved sammenligning (reproducerbarhed) hvis de tre første punkter er opfyldt
    - Tilknytning af licenser for genbrug af data

I visse tilfælde yder RUb support til analyser (statistisk behandling og visualisering) af forskningsdata. RUb har udarbejdet en library guide hvor der gives information om de vigtigste aspekter i forskningsdatas livscyklus.

Hos RUC Digital kan forskere få IT hjælp til data storage support hvis de henvender sig til servicedesk. RUC's informationssikkerhedskonsulent vejleder forskere i en sikker håndtering af personlige og fortrolige data. RUC Koncernjura yder support i juridiske godkendelser, kontrakter, opfindelser og patenter. RUC Forskningsservice yder support til ansøgninger til en

række fonde, særdeles EU-ansøgninger. OS er en politisk prioritet for Europa-Kommissionen og standardmetoden for at arbejde under EU-rammeprogrammer for forskning og innovation, da det forbedrer kvalitet, effektivitet og ansvarlighed af forskning. Horizon Europe, der starter i januar 2021, er EU-rammeprogram for forskning og innovation (opfølger af Horizon 2020). Horizon Europe kræver at forskningsdata er FAIR og åbne som standard (med undtagelser især ved kommercielle formål).

RUC er med i DeiC (Danish e-infrastructure Cooperation), som har udarbejdet en National strategi for data management baseret på FAIR principper. DeiC arbejder også på at definere det fremtidige HPC-landskab og lagrings- og datastyringssystem på nationalt plan, samt på at oprette en organisation der kan understøtte implementeringen af dette.

3.4 R&I/ Next generation metrics

RUC benytter primært traditionelle bibliometriske mål, eksempelvis mål fra den strategiske rammekontrakt (antal BFI-point og Scopus publikationer), men er dog i forskellige sammenhænge begyndt at inkludere andre former for indikatorer, såsom mediebidrag. Institutterne er dog i færd med at udarbejde publikationsstrategier som i højere grad sætter OS på dagsordenen i henhold til RUC's *Strategi 2030*, med OS målsætninger, eksempelvis OA mm. Derudover har RUC i 2020 indført årlige forskningsevalueringer, hvor hvert institut på tur skal reflektere over deres forskning, baseret på både kvalitative og kvantitative analyser. Eksempelvis benyttes der både klassiske bibliometriske mål, men der inkluderes også impact- og samarbejdscases.

RUC har endnu ikke etableret en politik for RUC's brug af bibliometri, men har en publiceringspolitik. Heri beskrives, hvordan bibliometri bruges i forskellige sammenhænge, eksempelvis til MUS og måling af gennemslagskraft. Derudover beskrives i Faculty Expectations, hvad der forventes af VIP personale inden for de forskellige stillingskategorier således, at en ph.d.-studerende ikke skal publicere på samme måde som en professor.

RUC benytter primært klassiske bibliometriske opgørelser af publikationer, herunder måling af BFI-niveauer/point, volumen, internationaliseringsgrad mm., og i mindre grad andre former for OS metrikker, såsom måling af interesse via "next-generation metrics"/altmetrics (downloads, bogmærker, medieomtale mm.). RUC er i færd med at undersøge, hvordan Pure systemet kan understøtte registreringen af andre former for typer aktiviteter, så disse på sigt ville kunne indgå i analytiske sammenhænge.

3.5 Studenterforskning

Som et tillæg til de fire nævnte områder nævner vi desuden her RUC's eksperimenter med deling af studenterforskning gennem forskningsprojektet Third Room[4], en kollaborativ projektplatform som muliggør formidling og samarbejde med eksterne partnere. Platformen omfatter meget af den ånd og indstilling som kendetegner Open Science – et ønske om at åbne andre elementer i "forskningens livscyklus" for at finde nye samarbejdsmuligheder, men den er ikke primært opbygget af Open Science principper eller practices.

4. Anbefalinger til fremtidigt arbejde

Der findes ikke en "one-size-fits-all" tilgang til implementering af Open Science, hvorfor RUC skal arbejde med de OS-områder der giver bedst mening for universitetet. Den største udfordring er behovet for grundlæggende kulturel forandring for at gøre det muligt at gå over til OS løsninger. For at kickstarte processen anbefaler vi en række specifikke aktiviteter.

4. https://ruc-thirdroom.dk/

4.1 Specifikke aktiviteter, eller initiativer, der skal sættes i gang

Citizen Science

- Fokus på profilering af udvalgte CS-projekter f.eks. i RUC's kommunikationsstrategi.
- Synliggørelse af RUC's CS-aktiviteter (tidligere, nuværende kommende) på web-portal, f.eks. ved høstning af aktiviteter (projekter, publikationer, datasæt) der er opmærket med fokuserede emneord i Pure som f.eks. "Citizen Science", "Participatorisk forskning" og "Borgerinddragende forskning".
- Workshops/møder/konference (gerne internationalt) med fokus på at lære af de forskellige CS-traditioner der bliver trukket på i de respektive forskningsmiljøer.
- Etablering af "Single point of contact" funktion, hvor CS-projekter kan få support, f.eks. til tidlig borgerinddragelse hvor det er muligt.

The Future of Scholarly Publishing/Open Access

- Styrket samarbejde med RUC Forskningsservice om formidling og support af OA.
- Formidling til RUC's forskere og studerende om mulighederne for at finde OA, herunder formidling af hjælpemidler som f.eks. Unpaywall.
- Styrket formidling til RUC's ledelse ang. OA-performance på OA Indikatoren (OAI).
- OA-kampagne i samarbejde med KB, rettet mod institutternes forskningsmiljøer om muligheder for publicering i OA.
- Udforske tekniske løsninger (eks. Chronos), for at optimere indhentning af diverse artikelversioner til opfyldelse af grøn OA.
- Fokus på opfyldelse af funding-krav, med særligt blik på EU-midler.
- Øge dækningsgraden af OA, bl.a. ved at arbejde med andre former for publikationer, end dem, der ligger inden for OAI's genstandsfeltets fokus.

FAIR data

- Implementering af RUC's Data Management Politik.
- Guidelines og infrastruktur, som gør det så let som muligt for forskere at gøre forskningsdata så FAIR som muligt.
- Ressourcer og incitamenter for forskere, så at de kan leve op til FAIR principperne.
- Metadata af forskningsdata gøres synlige.
- FAIR som princip inkorporeres i RUC's og institutternes forventninger til forskere ("Faculty Expectations" samt publiceringspolitikker).

Rewards & Incentives / Next generation metrics

- Udarbejde politik for ansvarlige evalueringer (herunder bibliometri) med udgangspunkt i eksisterende vejledninger, såsom Leiden Manifesto[5], DORA deklarationen[6], SCOPE[7], Hong Kong [8].m.fl.
- Klarlæg hvilke indikatorer, som er meningsfulde inden for RUC's forskellige fagområder og undersøg, hvorvidt disse datamæssigt kan understøttes af Pure eller andre administrative systemer på RUC.
- Inkorporer OS aktiviteter i karriereforløb, hvor metrikker i dag benyttes. RUC kan eksempelvis tage udgangspunkt i Open Science Career Assessment Matrix (OS-CAM)[9].

5. http://www.leidenmanifesto.org/
6. https://sfdora.org/
7. https://thebibliomagician.wordpress.com/2019/12/11/introducing-scope-aprocess-for-evaluating-responsibly/
8. https://wcrif.org/guidance/hong-kong-principles
9. https://ec.europa.eu/research/openscience/pdf/os_rewards_wgreport.pdf

4.2 Anbefalinger vedrørende governance

Escience styregruppe
For at sikre fremgang med OS på RUC, skal der være en koordinering af aktiviteter med målsætninger hvor det giver mening. Det forventes, at anbefalinger fra FAIR data søjlen skal tænkes ind i det kommende Escience styregruppe, som koordinerer aktiviteter i IT-, HPC- og forskningsdata-områder på tværs af RUC.

Open Science program
I forhold til anbefalinger til de andre tre søjler: CS, OA og Rewards & Incentives/Next Generation metrics, anbefaler arbejdsgruppen af der etableres et 2-årig Open Science program på RUC som har til formål at udvikle roadmap og at drive aktiviteter der skal adressere de specifikke anbefalinger, der nævnes i denne rapport, såvel som at tage ejerskab for den kulturelle forandring der skal ske for at forankre OS tankegang og praksis på universitet. Programmet skal styres af en frikøbt forsker samt administrativ leder, og referer direkte til Universitetsledelsen.

Programgruppen skal bestå af repræsentanter fra institutterne, som fungerer som ambassadører i det enkelte institut og sikrer en forankring på dette niveau. Derudover skal der være repræsentanter fra alle administrative enheder på RUC som medvirker til at visionen bliver til virkelighed, dvs. HR, Digital, Forskningsservice og Bibliotek. Andre enheder, bl.a. Økonomi & Campus, Koncernjura og informationssikkerhedskonsulent bliver inddraget løbende, hvor det giver mening. EScience gruppen inddrages med henblik på, at initiativer vedr. RUC's Open Science fokusområder spiller ind i hinanden. Derudover skal programmet undersøge synergierne mellem Third Room projektet og Open Science og hvordan de to dele kan spille sammen.

Derudover anbefaler arbejdsgruppen, at der afsættes ressourcer til Open Science programmet, både i form af bevillinger til nye initiativer og infrastrukturer, men også til den nødvendige involvering af forskere. Dette skal ske efter fremlæggelse af prisberegnet roadmap for Universitetsledelsen.

LE RU

PUSHING THE FRONTIERS OF INNOVATIVE RESEARCH

ADVICE PAPER
NO.24 - MAY 2018

Open Science and its role in universities:

A roadmap for cultural change

LEAGUE OF EUROPEAN RESEARCH UNIVERSITIES

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Contents

Acknowledgements

Lead author: Dr Paul Ayris, Chair of the LERU Information & Open Access policy group and Pro-Vice-Provost (UCL Library Services)

Co-authors: Alea López de San Román, Policy Officer, LERU
Dr Katrien Maes, Deputy Secretary-General LERU
Dr Ignasi Labastida, Member of the Information & Open Access policy group and Head of the Office for Knowledge Dissemination and the Research Unit at the CRAI (Library) of the University of Barcelona.

The members of the LERU policy groups Information & Open Access, Research and Doctoral Studies and of the thematic groups Research Careers & HR and Research Integrity have been instrumental in developing the ideas expressed in the paper and in enriching the paper with examples from LERU universities´ policies and practices. Sincere thanks go to them, and to the LERU Rectors, Vice-Rectors and members of the several LERU groups that gave valuable feedback on the paper. Special thanks go to Prof. Bert van der Zwaan, former Rector Magnificus Utrecht University and LERU Chair, for his guidance and support.

About LERU

LERU was formed in 2002 as an association of research-intensive universities sharing the values of high-quality teaching in an environment of internationally competitive research. The League is committed to: education through awareness of the frontiers of human understanding; the creation of new knowledge through basic research, which is the ultimate source of innovation in society; the promotion of research across a broad front, which creates a unique capacity to reconfigure activities in response to new opportunities and problems. The purpose of the League is to advocate these values, to influence policy in Europe and to develop best practice through mutual exchange of experience.

Executive summary

Open Science, perhaps more properly termed Open Scholarship in English, represents a culture change in the way stakeholders in the research, education and knowledge exchange communities create, store, share and deliver the outputs of their activity. For universities and other stakeholders to embrace Open Science principles, policies and practices, there needs to be a culture change in these organisations if this transition is to be successfully negotiated. Section I of this paper sets out the nature of that cultural change for universities, suggesting ways in which change can be successfully embedded in organisations and what has to happen to effect that vital change. There are challenges, which the paper identifies, which mean that this transition will not be straightforward to deliver.

Section II discusses the eight pillars of Open Science identified by the European Commission:[1] the future of scholarly publishing, FAIR data, the European Open Science Cloud, education and skills, rewards and incentives, next-generation metrics ('Altmetrics'), research integrity and citizen science. It analyses what the introduction of Open Science approaches means at university level in each of these eight themed areas and identifies the benefits which accrue to the individual academic, the institution, the user of research/educational outputs and to other stakeholders in the research/educational chain. Research funders have a particular role to play in working with institutions to bring about such fundamental change. For each of the eight Open Science areas, recommendations about what universities can do are formulated. Whilst they have been developed on the basis of LERU universities' experience, the recommendations are relevant to universities across the globe and can serve as a roadmap in their journey to embrace Open Science. Evidently, they imply a broader supportive environment and productive interactions with external stakeholders, too.

Section II identifies real challenges in universities embracing Open Science principles and values. How willing are individual researchers to move from traditional models and practices to new systems and values which are to a large extent untried and untested over time? Consider the theme of scholarly publishing. To what extent will writers of research monographs accept Open Access to such products as the future publication model? Do individual journal titles have a future, or are research platforms such as Wellcome Open Research[2] the future of scholarly publishing in those disciplines where the article is the main form of research output? How should such outputs be evaluated? Do traditional metrics work in an open environment? Are open approaches recognised in in evaluation systems, such as academic promotion? How is the cost of doing Open Science calculated and who pays for what? These are all questions which any move to an Open Science system and values poses.

The paper offers a set of high level conclusions in section III, which underline the value of Open Science approaches, but also indicate the profound challenges in any such development. A transition to Open Science is a process, not a single event. Such a transition will take years to effect, not months or days. To transition at the institutional level, we suggest universities should develop a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings. Universities can establish advocacy programmes, which should identify the benefits of Open Science approaches, whilst being realistic about the challenges. They may wish to draw up a communication strategy, which enables the whole university body to become familiar with Open Science practices, and they may want to appoint a senior manager to lead Open Science approaches across all eight pillars of Open Science.

In a first appendix all 41 recommendations in each of the eight areas are grouped together for easy reference. Open Science represents a complex and multi-dimensional process of transition, different for every university. The recommendations in this LERU paper do not represent a prioritisation of topics, nor an exhaustive list of actions to be taken by universities. They, and the paper as a whole, are intended to serve as a roadmap to accompany universities´ efforts towards Open Science, leaving room for each institution to carve out its own path, strategy and actions.

In a second appendix a set of 37 questions is provided, which universities can use to measure their progress in implementing Open Science approaches institutionally. These questions can be used iteratively over a period of time to measure a university's growth in Open Science activity and any remaining challenges.

1 Collected from European Commission – Open Science: https://ec.europa.eu/research/openscience/index.cfm; last accessed 2 May 2018.

2 Wellcome Open Research: https://wellcomeopenresearch.org/; last accessed 17 April 2018.

Open Science: Opportunities, challenges and cultural change in universities

Open Science is not about dogma; it is about greater efficiency and productivity, more transparency and a better response to interdisciplinary research needs

Open Science is a "movement which aims to make scientific research, data and dissemination accessible to all levels of an inquiring society".[3] On the continent of Europe, the movement is more commonly called Open Science. In truth, Open Scholarship is a better title because in English the word 'Science' covers just a sub-set of all academic disciplines. The phrase Open Science is retained throughout this paper, as this is the description used by the European Commission. In using this phrase, however, it should be stressed that *all* academic disciplines fall within its purview. In the chapters which follow, the eight pillars of Open Science (as defined by the European Commission) are used as exemplars of the potential impact of this movement in European universities. These eight themes are all inter-related and LERU views them as an inter-linked set of activities which *together* contribute to the Open Science agenda.

There are a number of reasons why there is an emphasis on Open Science now. The prevalence of digital delivery and the omnipresence of the internet means that new ways of doing things are possible. There are other drivers. A perceived disjoint between universities and Society has led many universities individually to investigate new ways of engaging with the general public. The prevalence of 'fake news' and society's distrust of expert opinion underlines the need for universities to make themselves even more open and relevant to Society.

There are important policy drivers too, and the European Commission has made Open Science a priority. Together with "Open Innovation" and "Open to the World", Open Science is one of the three goals set by Commissioner Moedas for EU research and innovation policy during his mandate (European Commission, 2016). Speaking at the ERA Conference 'A new start for Europe: Opening up to an ERA of Innovation' in Brussels in June 2015, Commissioner Moedas (Research, Science and Innovation) highlighted the importance of Open Science where "new knowledge is created through global collaborations involving thousands of people from across the world and from all walks of life". The Commissioner therefore called for drawing up "a new path for European research and innovation policy", fit for an open, digital and global environment (Moedas, 2015). The guidelines in the revised Recommendation on access to and preservation of scientific information -published in April 2018 by the European Commission- support EU Member States in transition to Open Science (European Commission, 2018).

Open Science opens up new ways in which research/education/innovation are undertaken, archived and curated, and disseminated across the globe. Open Science is not about dogma *per se*; it is about greater efficiency and productivity, more transparency and a better response to interdisciplinary research needs. All this can have a profound impact on universities because, to deliver Open Science, both universities and university researchers should develop new perspectives. To embrace Open Science, universities and researchers need to embrace cultural change in the way they work, plan and operate. The result will infuse a culture of Open Science throughout the academic organisation and may support other evolutions in academic practice, such as the use of next-generation metrics in the evaluation of research output.

Implementation of Open Science is key: Neither the European Commission nor university organisations can be complacent. The need now is for action, not words

The Amsterdam Call for Action emanated from the input of many participating experts and stakeholders in the Amsterdam Conference 'Open Science – From Vision to Action', hosted by the Netherlands' EU Presidency on 4 and 5 April 2016. The Amsterdam Call for Action establishes two major goals, namely that full Open Access for all publicly-funded scientific publications should be achieved by 2020, and that open data – the sharing and re-use of data – should be the standard, where possible, for all publicly-funded

3 FOSTER: https://www.fosteropenscience.eu/foster-taxonomy/open-science; last accessed 12 February 2018.

How does Open Science work for the researcher?

Open Science looks at all aspects of the workflow in, say, research or education and identifies which processes would be better performed if they were Open. So, in the writing of an article or a book, an Open approach could look like this:

1. Make the resulting output, book or article, available as an Open Access output under an appropriate licence, ideally one of the Creative Commons licences.
2. Make the underlying research data, certainly the data used in the publication, available as an open dataset so that the conclusions reached in the publication can be checked and verified.
3. Make the research software, used for analysis, available so that the research is reproducible.
4. During the course of the research, consider making both the underlying research data and the publication available, the latter perhaps as a Green Open Access pre-print in a subject or institutional repository at each stage of the editing and review cycle prior to publication.
5. Of course, the activity in step 4 may not always be possible. For example, researchers may wish to retain primary use of their data until they have finished the round of publications which are to be based upon it. However, even in these cases, the actual processed data used in each publication could be made available as an open dataset.
6. In the publication and opening up of the supporting research data, it is highly desirable that a number of standard identifiers/processes be used to help discoverability and re-use of open outputs – ORCID[4] to identify the authors; FundRef[5], a common taxonomy of research funder names; DOIs[6] to identify and locate publications; DataCite[7] to identify and locate datasets; Open Citations[8], a movement to promote the unrestricted availability of scholarly citation data, and to make these data available.

The benefits of Open Science

The workflow in the example outlined above is very different from the way many researchers work at the moment and represents a fundamental change in academic culture. What are the benefits of openness? While the following list is not exhaustive, a number of benefits can be identified when analysing the workflow described above:

1. The visibility of all research outputs will be increased once they are open. This should lead to a citation advantage, as users who can easily download open versions of outputs will cite these versions as everyone with an Internet connection will have access
2. Making the underlying research data and methodology available allows individual users to replicate the results of the original authors, and to spot any errors/slips. This level of transparency is good for researchers and good for research
3. Pursuing the steps above will add to the visibility of the outputs and also allow readers to see how the text/conclusions have evolved at different stages in the process
4. As a minimum, research data used in the publication should be made available as a supporting dataset
5. The use of recognised identifiers/processes gives due acknowledgement to authors and external funders and improves citation analysis. It rewards all stakeholders in the research process and enriches the research landscape as a result

4 ORCID: https://orcid.org/; last accessed 24 May 2018.

5 Crossref Funder Registry: https://www.crossref.org/services/funder-registry/; last accessed 20 May 2018.

6 DOIs: https://www.doi.org/; last accessed 7 April 2018.

7 DataCite: https://www.datacite.org/; last accessed 2 May 2018.

8 Open Citations: http://opencitations.net/; last accessed 22 May 2018.

research. In order for these goals to be achieved, universities should align their assessment, reward and evaluation systems with Open Science developments.[9]

In May 2016, the Council adopted Conclusions on 'The transition toward an Open Science system', calling 'on the Commission, the Member States and the stakeholders to take the necessary actions needed for making open science a reality' (Council of the European Union, 2016). Earlier that year, the European Commission had set up an Open Science Policy Platform[10] (OSPP) to develop policy and to turn it into practice and identified eight pillars which underpin its definition of Open Science. Several expert and working groups have been created so as to examine the eight topics and formulate recommendations.[11] The eight pillars below illustrate the broad scope of Open Science and that multiple groups within the university need to contribute towards implementation. Implementation, indeed, is the key and neither the Commission nor university organisations can be complacent. The need now is for action, not words.

Future of Scholarly Communication
EOSC (European Open Science Cloud)
FAIR Data
Skills
Research Integrity
Rewards
Altmetrics
Citizen Science

Source: European Commission

By developing a roadmap for universities, with implications for other stakeholders such as governments and research funders, LERU wants to stimulate real change in Open Science approaches

LERU has already published several papers which examine and make recommendations on aspects of the Open Science agenda.[12] LERU, as a grouping of research-led universities, has a mission to lead by example. With this new paper LERU wishes to stimulate real change in Open Science, both at universities and elsewhere. It does so by elaborating a comprehensive vision for Open Science from the perspective of some of Europe's leading research-intensive universities. The paper examines what LERU universities and others are doing, can or should do to embed Open Science and its various dimensions in their policies and practices as a way of changing culture. Conceived as a roadmap, the paper sets outs what the destinations are for universities' Open Science ambitions. It formulates recommendations for universities and research institutions, but also for other stakeholders, such as funders and policymakers, because change is not only required at universities. Particularly important is the role of research funders. Their decisions and policies are fundamental for creating the momentum towards openness. The German Research Foundation (DFG), for example, funds actions on Open Science within its joint research projects and expects publications in open access formats. Within Research Training Groups they require training courses on the collection, storage, editing and sustainable provision of research data for doctoral researchers.[13] All stakeholders need to be committed to change for Open Science to become embedded.

Successful engagement with Open Science requires a holistic vision by the institution, working together to deliver a set of goals in a complex and evolving mix of themes and priorities, to which all members can commit

For research performing organisations such as universities, Open Science represents both challenges but also significant opportunities. It is important that universities identify the goals they wish to achieve and the methods by which success can be delivered. Academic, administrative and cultural issues need to be taken into account. These include legal issues, e.g. advice on licensing and copyright issues. A key concern will be costs to the institution. In this paper, costs for particular developments are identified as exemplar costs to guide decision making.

Universities are well placed to undertake a series of actions

9 Amsterdam Call for Action: https://www.government.nl/documents/reports/2016/04/04/amsterdam-call-for-action-on-open-science; last accessed 12 February 2018.

10 Open Science Policy Platform: https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform; last accessed 12 February 2018.

11 At the time of writing (May 2018), there are reports on the European Open Science Cloud, Rewards, Skills, Next-Generation Metrics and Open Science Publishing. The OSPP will be producing consolidated recommendations on all the eight areas identified above.

12 These are on Open Access (LERU, 2011), Research Data Management (LERU, 2013), Citizen Science (LERU, 2016c), and academic careers (2018b).

13 German Research Foundation: http://www.dfg.de/formulare/54_07/54_07_en.pdf; last accessed 2 May 2018.

which will together help to effect the necessary transformation to deliver the change in culture which will deliver Open Science.

Policy development is crucial and the university can draw up either a single policy covering the various areas of Open Science; or, more likely, an overarching policy or statement on the commitment of the university to Open Science approaches, accompanied by individual policies on each area of Open Science, which advocate an Open Science approach. Individual policies might be needed in each of the eight areas of Open Science outlined in this paper. Some of these might update existing policy statements, for example in the area of Open Access where many universities already have such statements. Other areas will require completely new policies, for example in the area of bibliometrics where, as the chapter on next-generation metrics below shows, the principles of the San Francisco Declaration on Research Assessment (DORA)[14] and the Leiden Manifesto[15] provide a useful framework for universities developing such policies. Governance is an issue which all universities embracing Open Science practices will want to consider. How is such a university-wide approach to Open Science to be managed? Some universities may wish to nominate an individual at a senior level to be Open Science Coordinator. In some countries, such coordinators could work with national coordinators for Open Science. In the Netherlands, the steering group of the National Platform Open Science has appointed former Delft University of Technology Rector Karel Luyben as the National Coordinator for Open Science.[16]

Governance at university level may well be conducted by means of a pan-university committee, working with the Open Science coordinator. A university equivalent of the European Commission's Open Science Policy Platform is a vehicle by which all the component parts of the Open Science agenda can be studied from the point of view of policy development, strategy and implementation. Such a high-level committee would be a vehicle for liaison with other university committees which have dedicated remits such as HR or IT, the purpose of such contact being to ensure that Open Science principles are adopted and implemented in specific university policies and activities.

Policy development and governance are an important part of a university's activities in the area of Open Science.

However, by themselves they will not deliver the change in culture which Open Science requires. Alongside such activities, there are a range of issues where the university can help facilitate the required change. Here the university should work in partnership with members of staff in a mutually supportive dialogue and series of actions which will together deliver the cultural change required to embrace Open Science approaches in the institution. This is a vision of the whole institution working together to deliver a set of goals which all members embrace and to which they are committed.

Universities will also wish to address perceived gaps in their Open Science provision and plans. The European Commission has identified eight component parts of Open Science, but universities may feel that there are additional areas that should be catered for. Copyright regimes allied to Open Science principles, infrastructure development, sustainable research software, open education, and artificial intelligence are examples of areas which are not explicitly treated in the Commission's vision. Open Science is therefore not a series of static issues, but a complex mix of themes and topics yet to be identified. Universities will need to ensure that they are fully informed on the potential impacts of Open Science as the concept develops.

Bringing about change at universities requires 1/ leadership, vision, strategy and adequate resources for implementation, 2/ a mix of targeted measures to achieve cultural change, 3/ transparency, accountability and monitoring, and 4/ trust and confidence in a shared vision

To embed openness in the way universities, academics and students work requires a cultural change in the way each member of Society operates. In part, cultural change can be delivered by the development of policies, strategies and the evaluation of work and outputs against open criteria. However, cultural change requires more than a series of actions. Change can only take place where there is trust, collaboration and commitment to a shared vision for the future. Arguably, the latter is a greater challenge to achieve than the former.

14 Declaration On Research Assessment (DORA): http://www.ascb.org/dora/; last accessed 24 May 2018.

15 Leiden Manifesto for Research Metrics: http://www.leidenmanifesto.org; last accessed 24 May 2018.

16 National Plan Open Science: https://www.openscience.nl/en/press-release; last accessed 12 February 2018.

17 For a practical example in the field of digital education, see Ehlers, U., Schneckenberg, D. (eds) (2010). Changing Cultures in Higher Education: Moving Ahead to Future Learning (Berlin: Springer).

Nonetheless, it is only where all stakeholders work together, building a trusted community, and developing policies and strategies agreed by all parties that true change can become embedded in organisations and research communities.[17]

First, realising change successfully requires leadership, vision, strategy and adequate resources for implementation. Leaders should work with the community to explain why change is necessary and to support change, while upholding the principles of excellence and community building advocated by the university.

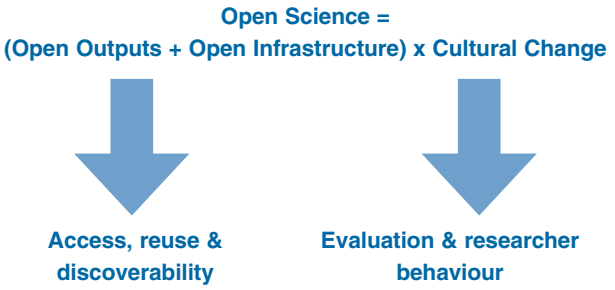
Second, to achieve change, universities can and should develop and implement targeted measures to help spread Open Science throughout the organisation. Universities should select the right mix of measures in accordance with their institutional, national and other situations. Measures can be directed at some or all of the eight Open Science dimensions identified by the European Commission, or others. They should aim to achieve structural and cultural change at the university. To ensure buy-in, any measures adopted should explain the benefits for individual researchers and their subject areas. Change is a 2-way process where new developments serve to support and develop researcher behaviour, leading to agreed changes of practice.

Third, to ensure effective implementation across the institution, transparency, accountability and monitoring are crucial. Policies and actions should be clearly described and communicated. In complex and multi-layered organisations such as universities, accountability must be given and taken at all organisational levels. Monitoring Open Science is necessary for the university to measure progress on the road to Open Scholarship and to benchmark itself against other organisations. Italy has taken a lead in this area where the University of Milan publishes an annual report each year on Open Science achievements.[18]

Fourth, there needs to be trust and confidence in a shared vision between university decision makers, academics and students. Change will not become embedded unless all stakeholders in the institution are confident enough to work together on the journey towards Open Science. Change is not a top-down activity, imposed by the university on its members. For Open Science to flourish, there needs to be partnership with dialogue and consultation to achieve mutually-agreed goals.

Universities need to be able to decide which mix of policy decisions, measures and ways to engage with stakeholders best fulfils their needs in view of the institutions' overall strategies and national or other agendas. Since these vary widely across Europe, it is impossible to have identical goals or measures across all universities, even within the group of LERU universities. One-size-fits-all solutions are in most cases inappropriate and unlikely to be successful; but there will be areas where large groups can work together on shared goals. This paper contains many examples of and references to LERU universities' policies and initiatives, which are shared as a source of innovative practice and inspiration for universities and other interested parties.

Building on the academic concept of cultural change, Dr Catriona MacCallum (Director of Open Science, Hindawi) has applied three themes to the embedding of Open Science principles and practice in the researcher landscape. Her approach is innovative and perhaps the first to anchor the required cultural change into the process of embracing Open Science principles and practices (MacCallum, 2018).[19]



There are at least seven challenges in moving to an Open Science environment, from copy-right, to costs, to data privacy, and more, but the most difficult one may be cultural change

A first challenge is the prevalence of copyright assignment to commercial publishers and weak copyright literacy amongst researchers. A number of options have been developed to counter wholesale assignment to publishers. The UK Scholarly Communications Licence[20], for example, is an attempt to retain copyright for the academic whilst granting the publisher a non-exclusive licence to publish. However, by no means do all publishers currently accept such a bold

18 University of Milan: http://www.unimi.it/cataloghi/unicom/Scienza%20Aperta%20-%20Relazione%202017.pdf; last accessed 24 May 2018.

19 For another interesting concept, which considers Open Science as a workflow, see https://101innovations.wordpress.com/; last accessed 6 April 2018.

20 UK Scholarly Communications Licence: http://ukscl.ac.uk/; last accessed 6 April 2018.

approach to copyright management. The limitations that artistic authorship implies in research processes in art and design should also be borne in mind. In some disciplines, such as artistic ones, it is not easy to fulfil the requirements of Open Access because research activities and results are far from the format of publications; they may comprise complex outputs or formats challenging copyright and openness.

Second, there are costs involved in developing Open Science approaches, particularly in terms of constructing local infrastructure to deliver Open Science solutions. This will require economic changes (Knowledge Exchange, 2017) and such developments have to be funded.

Third, not everything can be open. With patient data, for example, there are good reasons why such information cannot be made generally available. The same is true of information which would endanger national security. Openness is not a panacea which will cure *all* the ills in Society.

Fourth, statements such as the San Francisco Declaration[21] are by no means universally accepted across academic communities. The use of Journal Impact Factors as a measure for quality is deeply embedded in some research communities. Finding agreement on metrics, and agreeing new models for evaluation, will be a slow task.

Fifth, communities throughout the world are not all equally committed to openness. In a time of transition, therefore, it is inevitable that there will be leaders and followers. Not all countries and continents are equally committed to the open agenda. As such Europe, as a world leader in Open Science, must accept that where it leads, it must be a generous partner so that others will follow.

Sixth, related to this, it is important for Europe that all stakeholders start the journey to embrace Open Science principles, policies and practices. Getting everyone moving together will be a significant task.

Seventh, and perhaps most challenging, is the change of culture required to move to Open Science activity. Open Science, that is Open Scholarship in its fullest sense, requires a change of culture by all those involved in the workflow. Culture does not change overnight and so a parallel programme of change management needs to accompany and support any move to Open Science principles and practices. There are real dangers in trying to introduce new practices without carrying the academic community with the leaders of those changes. It would be wrong to think that Open Science is simply a blueprint which can be introduced in a mechanistic way into institutions. In many ways, cultural change is the most difficult outcome to achieve in embracing Open Science approaches and this represents a real challenge for universities beset by a host of competing requirements.

LERU formulates four high-level recommendations for universities to embrace Open Science

Scholarship is a complex system. Open Science increases that complexity by explicitly increasing the number of relevant players to include a wider public, new technology and service providers (and their investors), and a broader inclusion of the users of research, alongside traditional players. The transition to Open Science affects all stakeholders in the academic process – universities, researchers, teachers, students, academic support staff, research funders, academic publishers and policy makers. Recognising the challenges of achieving a systems-level change to Open Science, LERU universities agree on four high-level recommendations for how universities can proceed:

1. Appoint a senior manager to lead Open Science approaches across all eight pillars of the Open Science debate identified by the European Commission.

2. Develop a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings.

3. Establish advocacy programmes, which should identify the benefits of Open Science approaches, whilst being realistic about the challenges.

4. Draw up a communication strategy, which enables the whole university body to become familiar with Open Science practices.

21 The Declaration on Research Assessment (DORA) was developed in 2012 during the Annual Meeting of the American Society for Cell Biology in San Francisco.

The eight dimensions of Open Science: A roadmap for universities

1/ The future of scholarly publishing

The changing research landscape and Open Access

"In 1662, the newly formed 'Royal Society of London for Improving Natural Knowledge' was granted a charter to publish by King Charles II, and on 6 March 1665 the first issue of *Philosophical Transactions* appeared under the visionary editorship of Henry Oldenburg, who was also the Secretary of the Society". […] *Philosophical Transactions* established the important principles of scientific priority and peer review, which have become the central foundations of scientific journals ever since. In 1886, the breadth and scope of scientific discovery had increased to such an extent that it became necessary to divide the journal into two, *Philosophical Transactions* A and B, covering the physical sciences and the life sciences respectively".[22]

The research landscape has changed a good deal since the foundation of The Royal Society. Widespread access to the World Wide Web from the 1990s has encouraged take-up of the Open Access movement – where outputs are freely available without the requirement to pay subscriptions; and where resulting materials are available for sharing and re-use, ideally supported by the appropriate licence (such as Creative Commons).[23]

Not everyone is convinced about Open Access approaches. 'In a statement released on February 28, 2007, the Association of American University Presses (AAUP) outlined its position on the problematic—and often contentious—issue of providing open access to scholarly information, and declared that what was needed at this juncture was careful experimentation and development and not any risky plunging straight into "pure open access." '[24] This view is echoed in several academic disciplines in the humanities, which see Open Access as an issue for science, technology and medicine. They also have reservations on some forms of Open Access licensing. In the Creative Commons suite of licences, for example, some Humanities scholars would only feel comfortable with the most restrictive form of CC licence – CC-BY-NC-ND.

Open Access is not always easy to define in some subject and discipline areas. Exhibitions that constitute, or partly constitute, the publication of art- or design-based research can be considered Open Access if they are presented in public institutions, and announced accordingly. However, they are not accessible for (research) audiences without physical proximity to the presentations/exhibitions. This has to be accounted for as documentation of the event, and this can be made public and openly accessible in wider contexts, and electronically distributed.

This goes also for architectural works that may be presented as artistic works, and as part of artistic research. Such documentation can be reflected in terms of new forms of measurement for impact: the quality does not show in the number of such documented shows, but perhaps in evaluations of those shows, including public critique in journals or mass media, perhaps also in forms of social media.

Open Access initiatives

In 2016, the Amsterdam Call for Action on Open Science called for full Open Access for all scientific (research) publications.[25] LERU has made a number of important contributions in this area. In 2011, it published The LERU Roadmap towards Open Access (LERU, 2011) which gave guidance on how to embrace Open Access at an institutional level. In its 'Christmas is over' campaign, LERU issued a statement in 2016 to support the Dutch Presidency of the EU. 'Research funding should go to research, not to publishers!' (LERU, 2016). Almost 10,000 people and organisations signed up to the statement.

A number of European countries have attempted to make

22 Reproduced from Royal Society: http://rstl.royalsocietypublishing.org/; last accessed 24 May 2018.

23 Creative Commons: https://creativecommons.org/licenses/; last accessed 24 January 2018.

24 Association of American University Presses: http://blog.historians.org/2007/03/aaup-calls-for-cautious-approach-to-open-access/; last accessed 15 April 2018.

25 Amsterdam Call for Action: https://www.government.nl/documents/reports/2016/04/04/amsterdam-call-for-action-on-open-science; last accessed 2 May 2018.

the transition to Open Access publishing. The Netherlands (Butler, 2016), Finland[26], Germany (Schiermeier, 2017) and Switzerland have all been active in this respect. In Germany, Project DEAL "want[s] a deal that would give most scientists in Germany full online access to 2,500 or so Elsevier journals, at about half the price that individual libraries have paid in the past. Open Access is proving to be the sticking point in the talks: under the deal sought, all corresponding authors affiliated with German institutions would be allowed to make their papers free to read and share by anyone in the world at no extra cost"[27].

In the UK, the Finch Report (2012) recommended the gold route as the preferred route for Open Access publication. Bodies such as the Wellcome Trust and Research Councils UK give monies to researchers to fund Article Publication Charges (APCs) in both hybrid journals and pure gold journals. The purpose of funding such publishing activity was to transition UK Higher Education to full Open Access. That transition has clearly not worked and the reason is financial. The average cost of an APC paid by a British university is £1700 and, for a productive institution, this average will increase its publishing costs above the current cost of accessing these resources through subscriptions.

New publishing models

It may well be that the current commercial publishing model cannot be adapted to full Open Access publishing. If that is the case, new publishing models need to be identified which will deliver full affordable Open Access. Research monographs are prime candidates for publication as Open Access monographs. The current market in scholarly monograph publishing is collapsing and new providers are appearing (Barclay, 2016). UCL Press, for example, is the UK's first fully Open Access University Press and is an active Open Access monograph publisher[28], with 56 published books (as of November 2017), with 632,281 downloads from 218 countries and 5,866 print-on-demand copies sold. Helsinki University Press is also in the process of being established as an Open Access publisher.[29]

Another model for Open Access research monographs is the Freemium model, used by bodies such as OpenEdition, where "OpenEdition Freemium is a programme for the development of open access academic publishing in the humanities and social sciences. This partnership, on offer exclusively to institutions (libraries, campuses, research institutes) aims to create an innovative and sustainable economic model. All income generated by the programme is reinvested in the development of open access academic publishing."[30]

Open Access publishing clearly provides a new route of dissemination for the scholarly monograph. Rather than talk of the death of the monograph, we can now envisage a future for this key research output which increases its impact.

Typically, all such approaches to openness include the use of ORCID IDs to help identify authors systematically. ORCID purports to provide "a persistent digital identifier that distinguishes you from every other researcher and, through integration in key research workflows such as manuscript and grant submission, supports automated linkages between you and your professional activities ensuring that your work is recognized."[31]

There are a number of options for introducing openness into educational outputs. MOOCs (Massive Open Online Courses) and Open Educational Resources (OERs) are common ways to make an entry into the Open Educational landscape. One of the universities with the biggest investment in MOOCs is the University of Edinburgh.[32] MOOCs are freely-accessible, open-licensed short courses delivered to large cohorts of students fully online. To date more than 2 million people have signed up to such courses with Edinburgh University. In an Open Access environment, Open Access digital textbooks are a new form of output which can support the Student Experience. UCL Press has launched an Open Access

26 For Finland, see http://www.nodealnoreview.org/2017/08/29/divide-and-conquer-elsevier-approaches-academic-institutions-and-individual-researchers/, last accessed 12 February 2018.

27 Project DEAL: https://www.projekt-deal.de/about-deal/ ; last accessed 7 May 2018.

28 UCL Press publishes annual Reports and financial statements; see https://www.ucl.ac.uk/ucl-press/docs/UCL_Press_Annual_Report/; last accessed 15 April 2018.

29 Helsinki University Press: https://hup.fi/; last accessed 2 May 2018.

30 OpenEdition: https://www.openedition.org/14043?lang=en; last accessed 15 April 2018.

31 ORCID: https://orcid.org/; last accessed 15 April 2018.

32 University of Edinburgh: https://www.ed.ac.uk/studying/moocs; last accessed 24 May 2018.

textbook project which will produce a dozen textbooks by UCL authors. Such textbooks are fully Open Access stored in the institutional repository[33]. The default delivery format is a flat PDF, but an innovative model for textbooks using a new BOOC (Books as Open Online Content) platform is also available.

As part of its work on Open Science, the European Commission has set up the Open Science Policy Platform,[34] and a Horizon 2020 expert group on The Future of Scholarly Communication and Scholarly Publishing[35]. The European Commission has not only introduced requirements in relation to publishing, but also offers support infrastructure, OpenAire,[36] and associated services. The Commission also supports the development of this infrastructure through its funded projects under OpenAire+.

A challenging area in which to deliver full Open Access is in the realm of journal publishing. A number of options are available. Where universities have established their own Open Access University Presses, some have started their own Open Access journals. There are other providers of Open Access journals – a well-known provider is the Open Library of Humanities, which currently publishes 20 journals.[37] A new approach is also the megajournal model. In essence, a megajournal is a peer reviewed platform presenting scholarly content to a global audience. In scope and concept, it is bigger that the traditional span of a journal.

The advantages of the megajournal approach are many:

- Open peer review, where the reviewers' names and the text of their reviews are fully open
- Post-publication peer review is possible
- Fast turn-around between receiving a manuscript and publishing it
- Megajournals facilitate inter-disciplinary and cross-disciplinary work since they have a broad subject scope which covers a multiplicity of traditional disciplines

However, there are also perceived disadvantages in the megajournal approach. Some would argue that there are already sufficient megajournals (e.g. funder platforms such as the Wellcome's Open Research platform[38] and the new platform being funded by the European Commission [European Commission, 2017b]) and that the market is saturated. Another problem with a megajournal is it decreases the discoverability of work – a journal name helps pinpoint an article within a discipline.

One way to tackle the challenge of numbers would be via collaboration. Universities could collaborate in producing megajournals. LERU could develop a megajournal platform where member universities could collaborate together over journal production. Another model for journal production is to retain the traditional notion of a journal 'title', but to make the outputs open. This is a model which has been adopted by some universities. The University of Milan has implemented an OJS platform that publishes 30 journals with 600,000 downloads per year. The journals are indexed in Scopus and the Emerging Sources Citation Index from the Web of Science. Clearly, there are a growing number of ways in which universities can take back publishing into the academic community and themselves take on the role of publisher, using new publishing paradigms.

The role of research funders in supporting and fostering the transition to Open Access and new publishing models is key. The Horizon 2020 Research and Innovation programme has strict rules about the need for funded research outputs to be Open Access. The Model Grant Agreement sets out detailed legal requirements on Open Access to scientific publications: under Horizon 2020, each beneficiary must ensure Open Access to all peer-reviewed scientific publications relating to its results (European Commission, 2017a). Similar arrangements are expected for it successor, the Horizon Europe programme. Horizon Europe will be regarded as an intervention to help the transition towards Open Science and we expect the current rules of Horizon 2020 in relation to Open Access and research data to continue in Horizon Europe, and that in general Open Science will become even more important.

33 See UCL Discovery webpage: http://discovery.ucl.ac.uk/; last accessed 22 May 2018.

34 European Commission´s Open Science Policy Platform: https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-policy-platform; last accessed 12 February 2018.

35 Horizon 2020 expert group on The Future of Scholarly Communication and Scholarly Publishing: http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3463; last accessed 7 May 2018.

36 OpenAire: https://www.openaire.eu/; last accessed 15 April 2018.

37 Open Library of Humanities: https://www.openlibhums.org/journals/; last accessed 24 January 2018.

38 Wellcome Open Research: https://wellcomeopenresearch.org/; last accessed 15 April 2018.

Recommendations on the future of scholarly publishing

LERU recommends that universities:

1. Have institutional mandates to support the move to full Open Access, whose implementation can be monitored regularly.
2. Deliver a roadmap for how they, or specific groupings, can develop agreed plans for the future of scholarly publishing in their institution.
3. Advocate the use of author identifier systems such as ORCID across their institution.
4. Consider supporting new forms of scholarly publishing from third parties dedicated to Open Access approaches.
5. Where appropriate, establish new mechanisms for scholarly publishing based on the good practice identified in this paper.

2/ FAIR data

Research data sharing

For the last fifteen years, research performing institutions have been focused in trying to share their publications as openly as possible. However, now the focus has shifted to research data because publications are already being shared in institutional repositories and open access journals, and research data is seen as the needed element to validate and reproduce research outcomes. Nowadays, in the current data-intensive landscape, it is not enough to disseminate research results as publications. Sharing research data is part of a general move to give such research outputs at least the same visibility as publications. The EU-funded LEARN[39] project created a number of outputs to support responsible research data management (RDM): case studies of best practices, a model research data management policy, Key Performance Indicators, and an RDM Readiness survey.

There are challenges to establishing responsible RDM practices. Some researchers feel challenged by the need for research data management plans and the requirements of the General Data Protection Regulation (GDPR).[40] To improve research data management, research funding and research performing organisations increasingly require researchers to develop a Data Management Plan (DMP) for their project proposals or their evaluation. Science Europe has developed a Framework for Domain Data Protocols. The Framework's set of minimum requirements (or terms of reference) encompasses matters such as the implementation of applicable laws and regulations, references to standard data formats and software principles. It also deals with references to FAIR data and elements that allow for funding agencies and governments to be properly accountable for the funds spent on research. This Framework should be considered as the basis for the development of Domain Data Protocols by the various scientific communities (Science Europe, 2018).

Peers and citizens are demanding from researchers access to their texts and to all the elements underpinning their findings. The findings of the public consultation on Science 2.0 showed that researchers were interested in data sharing, stating that:

> *A final policy intervention discussed by several stakeholders was support for data sharing, management, curation and storage. Specific interventions would include building relevant infrastructure, developing data skills, incentivising data sharing, and nurturing the development of good practice in handling data.*[41]

To share data is not new because some scientific disciplines have been doing so for many years, whilst other researchers may have published such outputs sporadically along with their publications. However, now there are many infrastructures providing storage for and access to research data. Policies from funders and publishers, requiring a broader dissemination of research data, are being produced. Research performing institutions must be prepared to fulfil these expectations and to provide suitable tools and services for their researchers.

39 LEARN: http://learn-rdm.eu; last accessed 17 April 2018. The EU-funded LEARN project took the LERU Roadmap for Research Data and developed a model research data management policy for research institutions, a set of 20 recommendations on how to embed research data management into research activity, a series of best practice case studies, an executive briefing in 6 languages for senior institutional managers, a series of key performance indicators which would measure success in embedding research data management in an institution or research group, and a self-assessment tool to help identify areas of weakness.

40 For more information about the GDPR see: https://ec.europa.eu/info/law/law-topic/data-protection_en; last accessed 23 May 2018.

41 Science 2.0 consultation: https://ec.europa.eu/digital-single-market/en/news/final-report-science-20-public-consultation, section 3.2; last accessed 17 April 2018. Regarding evidence from citizens, see Schade, S. et al. (2017).

The FAIR DATA principles

Sharing data is not just a question of publishing some figures or files. Data must be shared in a way that machines and humans can understand them and re-use them. For that purpose, a few years ago a group of researchers published the FAIR Data Principles which describe how research data should be shared (Wilkinson, 2016).[42] FAIR stands for Findable, Accessible, Interoperable and Reusable and these are the features that research data should possess when shared.

Research performing institutions must therefore foster the adoption of these FAIR principles among their researchers when sharing data and extend them to any other research output. This is an activity best undertaken in partnership with others, where appropriate. Therefore, research funders can take a relevant role in the adoption of FAIR principles by including them by default as a mandatory research requirement in any funded research activity. There are challenges in adopting such a position, not least the disciplinary differences that exist between subject areas. We should be sensitive to such disciplinary differences in research practice, particularly whilst we are in a transition period to full Open Science practices. A historian, for example, may be building a single dataset over their academic lifetime which is never 'finished' and which defines their scholarly persona. It is very different for a scientist who produces a dataset as part of a project and then moves on to a new project. The requirement for FAIR data brings with it a need for universities, research funders and other stakeholders to understand what FAIR means in each subject area.

Recommendations on FAIR data

LERU recommends that universities:

1. Adopt or update an institutional policy on research data management –ideally modelled on the template produced by LEARN[43]- embracing the FAIR principles and based on an 'as open as possible, as closed as necessary' philosophy, and that they establish a dedicated committee on research data management to monitor the implementation and uptake of such a policy.
2. Design and establish services for data stewardship, provide researchers with suitable infrastructures, and identify funding and resources to archive and to publish data.
3. Create a catalogue of where researchers have published data (or stored if not available for any reason) as is currently done with publications, and consider how to use this information in any research assessment or evaluation (cf. recommendations on rewards).
4. Provide free access to metadata in order to facilitate the discovery of data for which access must be restricted because of privacy, security, or confidentiality issues, making sure such metadata fulfill the FAIR principles, and establish a grade of accessibility to those restricted research data.[44]
5. Establish training sessions on research data management at all levels, starting from students (cf. recommendations on education and skills).
6. Work together with any local, national or international activities, using for instance Research Data Alliance national groups[45] or the Digital Curation Centre´s Data Management Tool.[46]

3/ The European Open Science Cloud (EOSC)

The European Open Science Cloud

The European Open Science Cloud is a major component of the European Commission's concept of Open Science. The Report which supported the development of the Cloud, 'Realising the European Open Science Cloud', identified a strong vision for this key piece of Open Science infrastructure, stating that:

> *The European Open Science Cloud (EOSC) aims to accelerate and support the current transition to more effective Open Science and Open Innovation in the Digital Single Market. It should enable trusted access to services, systems and the re-use of shared scientific data across disciplinary, social and geographical borders (Mons, 2016: 6).*[47]

42 See also The FAIR Data Principles: https://www.force11.org/group/fairgroup/fairprinciples; last accessed 17 April 2018.

43 LEARN Research Data Management toolkit: http://learn-rdm.eu/en/research-data-management-toolkit-now-available/; last accessed 7 May 2018.

44 An example of degrees of access for sensitive research data is available at http://datatags.org; last accessed 17 April 2018.

45 Research Data Alliance: https://www.rd-alliance.org/groups/national-groups; last accessed 17 April 2018.

46 The Digital Curation Centre´s Data Management tool: http://www.dcc.ac.uk/resources/data-management-plans; last accessed 8 May 2018.

47 'The EOSC is indeed a European infrastructure, but it should be globally interoperable and accessible. It includes the required human expertise, resources, standards, best practices as well as the underpinning technical infrastructures. An important aspect of the EOSC is systematic and professional data management and long-term stewardship of scientific data assets and services in Europe and globally. However, data stewardship is not a goal in itself and the final realm of the EOSC is the frontier of science and innovation in Europe' (Mons, B. et al., 2016: 6)

There are two big challenges here for universities. First, the technical standards and protocols for accessing the EOSC remain to be confirmed. The European Commission's vision is for these arrangements and protocols to be as easy as possible to embrace, taking inspiration for this from the way the Internet has grown around use of the http: protocol. That being said, arrangements are still unclear but light is being shed on them by the EOSC pilot, which has as its mission:[48]

- Facilitating access of researchers across all scientific disciplines to data
- Establishing a governance and business model that sets the rules for the use of EOSC
- Creating a cross-border and multi-disciplinary open innovation environment for research data, knowledge and services
- Establishing global standards for interoperability for scientific data

A second point that universities should note is that the EOSC will not build a central infrastructure or data archive or repository. Rather, it will link interoperable infrastructures where they exist. Countries, research organisations and universities must thus invest in such infrastructures in order to engage with the EOSC as a pan-European development. Cost is an important factor in such developments. How much will institutions have to pay in order to have the necessary infrastructure in place to interact with the EOSC? This is a key question for all universities and one that is extremely difficult to answer, since universities either do not have all the necessary infrastructure in place or else do not disclose their costs. The Horizon 2020-funded LEARN project, led by UCL with Barcelona as a member, found this question extremely challenging to answer. In a survey of European universities, they were able to identify costs for research data storage at the University of Edinburgh.[49]

The European Commission is investing extensively in the EOSC, but the services that are being developed are sometimes far removed from the day to day realities of all European researchers. The EOSC needs to embrace a more inclusive and practitioner-oriented approach to engage researchers, support staff and service providers at universities in the development of its services. The EOSC should develop a more customer-centric approach to stakeholder outreach, which would facilitate engagement with researchers, academic support staff and service providers at universities in the development of its services.

It is sometimes a challenge for universities to engage with such externally-developed products and services. With limited capacity, this is often not a straight forward task. A more inclusive approach to the development of infrastructure projects financed by the European Commission would invite universities to share knowledge and experience. Such collaboration in the early stages of new developments would facilitate better alignment of the required support structures within universities to the EOSC requirements.

The EOSC represents a major shift in the culture of how to share the outcomes and outputs of research and educational activity and has the potential to put Europe in a position of leadership in the global research environment.

EOSC Declaration

LERU is a signatory to the 'EOSC Declaration',[50] which propounds 33 goals for European organisations engaged in research data management under the following headings:

- Data culture and FAIR data (15)
- Research data services and architecture (11)
- Governance and Funding (7)

Fundamental to realising the concept of EOSC is the requirement that all research data produced by European researchers is, where possible, FAIR – Findable, Accessible, Interoperable and Reusable. This is treated in more detail in the chapter on FAIR research data. The EOSC Declaration builds in part on work which LERU has already undertaken in the field of research data management. The 'LERU Roadmap for Research Data' made 44 recommendations aimed at different stakeholders in the research data landscape (LERU, 2013: 31-33) .

Go FAIR

The Go FAIR[51] initiative follows a bottom-up open implementation strategy for the technical governance and funding needed to establish the first phase of the EOSC as part of a broader global Internet of FAIR data and services. The activities of the GO FAIR initiative focus on FAIR data and services, technology, training and certification.

48 EOSC Pilot: https://eoscpilot.eu; last accessed 15 April 2018.

49 LEARN: http://learn-rdm.eu/toolkit, case study 17; last accessed 15 April 2018.

50 EOSC Declaration: https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud; last accessed 28 January 2018.

51 Go FAIR: https://www.go-fair.org/; last accessed 17 April 2018.

Recommendations on EOSC

LERU recommends that universities:

1. Ensure institutional access to the requisite infrastructure, such as a locally-managed data repository where research data is available for sharing and reuse, or that they ensure researchers understand where third-party storage solutions are available, which can themselves be part of the EOSC.
2. Provide a search and discovery service, enabling users to find what research data is available and where it is located, as it is key to the wider use of such resources and, therefore, of the vision embodied in the EOSC.
3. Move to sign the EOSC Declaration over time, as a statement of commitment at a local level, as LERU has done as an international network.
4. Develop their research data management offering so that it is aligned with the principles of engagement with the EOSC, once the latter are agreed and available, and in the expectation that the EOSC develops a more customer-centric approach to stakeholder outreach, which would facilitate engagement with researchers, academic support staff and service providers at universities in the development of its services.

4/ Education and skills

In order to infuse an Open Science culture throughout the university, the organisation and all the people in it – students, researchers, teachers, support staff, management and leadership – need to understand the benefits of Open Science along its various dimensions. Raising awareness about Open Science and its potential benefits and providing skills training in Open Science practices are crucial to achieve the culture shift which is needed to open up universities to an Open Science culture.

Open Science comprises several dimensions. Clearly, there is an evident need for skills training with regard to scholarly publishing and research data management; those are the areas of Open Science in which universities tend to invest most at the moment. Also research integrity and ethics courses, and increasingly, citizen science courses, are important. A survey of doctoral programmes at LERU universities revealed that one of the most common (out of few) *mandatory* skills training courses for doctoral students were research integrity courses. LERU itself has dedicated doctoral summer schools to the topics of Open Science, data stewardship and research integrity.

Open Science skills training is beneficial to a variety of audiences at universities, such as researchers at all career phases (from doctoral researchers to senior professors (R1-R4), and students at the bachelor and masters' levels.[52] Also teachers, research management staff, data scientists, data stewards, copyright officers, librarians and citizen scientists may benefit from Open Science training, which needs to be tailored to the needs of specific subgroups. Finally, supporting role models and training the trainers may need to be considered.

How training is delivered should be considered carefully, as it will vary according to needs, audiences and resources. Skills may develop in different learning contexts, including in-person or distance, classroom, webinars, blended or not. Universities develop and deliver (some of) their own training and often also work with external providers. Examples of many kinds of innovative training are available for universities to use or to get inspired. While formal training is almost always needed, researchers can and do also acquire Open Science skills in informal training circumstances, on-the-job and at-the-research-bench.

Elements of Open Science skills training should be required. Universities can use a variety of mechanisms to record and acknowledge the training (e.g. credits, certificates of attendance, etc.), so that one can demonstrate Open Science competencies as part of career development, appraisals or promotions. For example, it is quite common at LERU universities to log skills development by doctoral researchers (LERU, 2016a, 2016e) in online progress tools or similar study management and supervisory systems. Open Science skills training should be firmly embedded in this and should be acknowledged in professional development and career progression of all university staff.

Given that comprehensive universities are complex organizations with many faculties, units and services and that they operate in a rich variety of national (and other) contexts, the provision of skills training is generally also rich, varied and distributed. It is useful for universities to map or revisit their (needs for provision of) skills development with a view to develop an agreed, strategic approach to Open

52 Elements of Open Science should also be given a place in pre-tertiary education, even with young school children. However, this discussion is beyond the scope of this paper.

Science skills training, the overall aim of which is to bring about Open Science cultural change. Mutual learning and exchange of good practice between universities at several levels (regional, national, European) are instrumental in working towards bringing about comparability and portability of Open Science skills training for mobile students and staff. LERU believes that to prescribe a uniform or standardized approach to Open Science training at universities would ineffective and could even be counter-productive.

In developing this approach, universities will need to take into account the actions and policies of other research stakeholders, including funders, publishers, governments, professional societies. Broad dialogue and concerted efforts across the research community will be needed, as has been suggested in the Open Science skills working group report prepared for the Open Science Policy Platform (O´Carroll, 2017b).

Recommendations on education and skills

LERU recommends that universities:

1. Integrate Open Science concepts, thinking, and its practical applications in educational and skills development programmes, analysing and mapping their needs for Open Science skills training, taking into account the different Open Science dimensions and the varying needs of different audiences, different disciplines, etc.
2. Encourage, incentivise, support and recognise staff and students with regard to Open Science skills development.
3. Determine how to resource Open Science skills training in a sustainable manner.
4. Monitor the take-up and impact of Open Science skills training to determine progress towards its cultural integration in the institution.
5. Explore innovative mechanisms and tools to provide Open Science skills training, and engage with others outside the university to exchange good practice.

5/ Rewards and incentives

LERU is not only a strong supporter of Open Science, it has also been actively engaged on the topic of researchers' careers (LERU, 2010, 2014, 2018a, 2018b). Moreover, researchers' careers have also been a European Commission priority, from the inclusion in the European Research Area (ERA) priorities to initiatives such as the European Charter for Researchers and Code of Conduct, the Human Resources Strategy for Researchers (HRS4R), the Euraxess portal and the pension scheme Resaver.

Many researchers increasingly or (more or less) routinely adopt Open Science approaches, thus ensuring that the benefits which openness brings, such as the accessibility, reproducibility and transparency of research, are available to students, colleagues, and to society as a whole. It is only fair that such efforts should not only be incentivised and valued, but also and professionally recognised and rewarded. In reality however, appointment, promotion and advancement processes (and also funding processes) still have to catch up to Open Science. They still tend to rely heavily on traditional and often quantitative measurements to evaluate researchers' performance, some of which are not fit-for-purpose, e.g. journal impact factors. To be sure, both quantitative (metrics-informed) and qualitative (involving expert judgement) approaches to assessment are appropriate in science (open or closed). LERU views the role of the former to support, not to replace, the latter (LERU, 2012).

With the rapid growth of Open Science, a whole range of alternative or new metrics are developing, not only in response to Open Science, but also as a result of other drivers, such as the societal impact agenda with its focus on public engagement (cf. citizen science). It is important to realise that alternative or next-generation metrics (e.g. Altmetric, Plumx, ImpactStory) are in theory susceptible to the same pitfalls as traditional metrics, i.e. they need to be scientifically grounded and handled sensibly, they can be "gamed", "over-commercialised", etc.

The transition to Open Science coincides with a movement away from exclusively or primarily quantitative and metrics-focused assessment to a better and sensible mix of quantitative and qualitative assessment. To be successful, it should also be aligned with a transition to assessing researchers' performance on a broader, multi-dimensional basis, which includes not only research and their Open Science activities but also a broader set of other professional achievements, ranging from educational engagement, to teamwork and collaboration, supervision of junior colleagues, institutional citizenship, service to the profession or to society at large, etc.

Arguably, this part of the transition to Open Science is one of the biggest challenges and requires a profound shift in the minds and hearts of people and institutions, not only universities but also governments and funders. As was stated in a recent report by the European Research Area Committee (ERAC, 2018), incentives and rewards are a sensitive policy issue, closely linked to research careers and promotion, and there are significant national, regional and institutional differences, although there is broad consensus

on the necessity of reform. An EU-level policy approach on assessment, evaluation and reward systems thus has to happen in close coordination with the member states (and associated countries).

Recommendations on rewards and incentives

LERU recommends that universities:

1. Endeavour to integrate Open Science dimensions in their HR and career frameworks as an explicit element in recruitment, performance evaluation and career advancement policies, so that research and teaching staff are appropriately recognised and rewarded for practicing Open Science.
2. Develop institutional policies for recognising and rewarding Open Science practice anchored in broad-based support; communicate them clearly and transparently, make them easy to find and access, and provide proper guidance or training to those who are involved in staff recruitment, appraisal and promotion in the university.
3. Develop individual HR criteria for recognising and rewarding Open Science in job descriptions, performance appraisals and promotion criteria, for all or most research and teaching staff, which take into account their multiple responsibilities, in terms of research output, process, impact, teaching and supervision, leadership, service to the university, public engagement, professional experience, as well as considering collaborative and team accomplishments in addition to individual accomplishments when appropriate.
4. Embed Open Science principles in the institutional research assessment system[53], shifting away from an excessive reliance on publication-based journal impact factors and citation cultures and recognising Open Science approaches such as OA publishing, data/code/reagent sharing, recognising pre-prints, etc.
5. Offer appropriate support, professional development and training opportunities for Open Science, aligned with employees' different needs depending on discipline, career progression, seniority and goals, including moving outside the university (cf. recommendations on education and skills).
6. Periodically monitor, reflect on and update their Open Science rewards system so it remains fresh and fit-for-purpose.

6/ Next-generation metrics

Next-generation metrics and bibliometrics

Next-generation metrics is the name used in this paper to describe the activity which some stakeholders misleadingly refer to as Altmetrics. It is one of the eight pillars of the European Commission's definition of Open Science, although the name does not do justice to the importance of the topic. It would be much more accurate to say that the issue refers to (a) the responsible use of existing bibliometrics and (b) the use of new bibliometric measures which are aligned with the ambitions of Open Science. For this reason, the phrase next-generation metrics is used in this paper.

Traditionally, bibliometrics is the use of statistical analysis to evaluate the importance and impact of publications on the wider community. In an Open Science environment, the challenge is to extend the range of bibliometrics to cover new forms of output, such as research data and research software, with new metric measures; and also to agree principles for the responsible use of metrics. The change in culture needed to achieve these objectives is one of the biggest challenges facing those who embed Open Science practices into the academic environment.

Journal Impact Factors

One of the most common bibliometric measures used by researchers, journals and universities is the Journal Impact Factor (JIF). The JIF is a measure reflecting the yearly average number of citations to recent articles published in that journal. It is often used as a surrogate for the quality of individual articles in a journal. This is a mistaken use of this particular measure. JIFs say nothing about the academic quality of individual articles in journal runs. As such, the JIF cannot and should not be used as a surrogate for the quality of individual articles. As the UK REF (Research Excellence Framework) has stated, neither journal impact factors, nor the journal title in which research outputs are published, should be used as proxies for the assessment of the quality of research outputs (Hill, 2013). That being said, very many individuals and committees in European universities do use the JIF as a surrogate for quality. It is a practice which is deeply embedded and a great challenge to change.

53 The Open Science Career Assessment Matrix (OS-CAM), proposed by the EU Working Group on Open Science Rewards (O´Carroll, 2017: 15-17), may provide a useful starting point to develop an institutional system.

DORA (San Francisco Declaration on Research Assessment), the Leiden Manifesto and the Metric Tide

A major move towards new ways of evaluation is the San Francisco Declaration on Research Assessment (DORA). The Declaration makes 18 recommendations, including 2 aimed directly at universities[54]. LERU is a signatory to DORA, but whilst DORA itself identifies principles for future activity, there is no accompanying roadmap or activity to 'operationalise' the DORA principles into good practice. This has been a major weakness in moving to change the assessment culture in the academic community.

The Leiden Manifesto for research metrics[55] proposes 10 principles for the responsible use of metrics. The best decisions are taken by combining robust statistics with sensitivity to the aim and nature of the research that is evaluated. Both quantitative and qualitative evidence are needed.

A third influential report on the responsible use of metrics is 'The Metric Tide', produced by James Wilsdon (2015), Professor of Research Policy and Faculty Director of Research & Innovation, Faculty of Social Sciences, University of Sheffield (UK). The review identified 20 recommendations for further work and action by stakeholders across the UK research system[56].

Open Science Policy Platform: Next-generation metrics

A European Commission Open Science Policy Platform expert group has produced a report on next-generation metrics (Wilsdon, 2017). Given the hesitations in using the name Altmetrics outlined above, the European Commission should dispel confusion by choosing a new name to describe its work in this area and to standardise on its use.

The report identifies five headline findings, supported by 12 targeted recommendations (Wilsdon, 2017: 15-17). The findings are:

1. An Open Science system should be grounded in a mix of expert judgement, quantitative and qualitative measures;
2. Transparency and accuracy are crucial;
3. Make better use of existing metrics for Open Science;
4. Next-generation metrics should be underpinned by an open, transparent and linked data infrastructure;
5. Measure what matters.

Next-generation metrics are a difficult concept to take forward. It is easy to say that quality cannot be reduced to a mere numerical value. It is much less easy for the academic community to agree what could take their place. There has been a sharp growth in recent years in various commercial services. These often use similar source data (e.g. number of tweets or download figures) but interpreted and presented in different ways. Depending on what indicators are used, they can show scholarly interest (e.g. Mendeley bookmarking), media interest (e.g. news stories), or public interest (e.g. social media activity). They can also be used to identify the use of research in policy documents or other official publications which may not appear in the conventional citation databases. Spikes in activity may come if a piece of work is particularly contentious, timely, or simply on a topic that catches the public imagination. It is harder to gather standardised and comprehensive data in this environment than citation data.

In general, it is best to treat next-generation metric figures as broad indicators – high activity tells us that there is something interesting there, but the details should be examined before drawing conclusions. They should not be used to quote a single numeric 'score' for ranking a paper or author.

Recommendations on next-generation metrics

LERU recommends that universities:

1. Develop a bibliometrics policy grounded in the principles of the Leiden Manifesto, with the aim of changing the culture in the academic community about research assessment.
2. Embed the new forms of research evaluation in its internal processes for promotion/reward and research evaluation.

54 DORA: https://sfdora.org/; last accessed 24 May 2018. In relation to academic appointments, it says: '4. Be explicit about the criteria used to reach hiring, tenure, and promotion decisions, clearly highlighting, especially for early-stage investigators, that the scientific content of a paper is much more important than publication metrics or the identity of the journal in which it was published.'

55 The Leiden Manifesto for Research Metrics: http://www.leidenmanifesto.org/; last accessed 24 May 2018.

56 Many of the findings are applicable across the globe, including:

- There is considerable scepticism among researchers, universities, representative bodies and learned societies about the broader use of metrics in research assessment and management.
- Carefully selected indicators can complement decision-making, but a 'variable geometry' of expert judgement, quantitative indicators and qualitative measures that respect research diversity will be required.

3. Construct, via appropriate internal bodies, guidance for research administrators and academics on good and bad practice in the use of traditional bibliometrics and in the development of new metrics, and that they work with the scientific community in this endeavour.
4. Provide training to junior researchers, particularly early-stage doctoral researchers, enabling them to embrace the change of culture and practice which the responsible use of metrics brings (cf. recommendations on education and skills).

7/ Research integrity

Research integrity is one of the cornerstones on which science is built. There can be no excellent science if research practices are not based on reliability, honesty, respect and accountability, principles identified as fundamental by the European Code of Conduct for Research Integrity[57]. Research integrity is the basis of trust (Science Europe, 2015) [58], and Open Science –as a new approach to scientific process- should maintain research integrity at its core.

Open Science practices, such as open access publishing, open data, open peer review and open research, have the potential to bring about new and exciting pathways for supporting a culture of research integrity. By diffusing knowledge at an earlier stage in the research process and opening up access to research data and research results, Open Science increases transparency and encourages dissemination. Wider dissemination and increased openness help to demonstrate the responsible conduct of research, enable errors or omissions to be addressed and facilitate verification and reproduction of findings. Reproducible research[59] is imperative and Open Science fosters it. Open Science practices may also discourage and reduce the incidences of fabrication, falsification, plagiarism and other unacceptable practices by making them easier to detect, but do require legal and ethical awareness on the part of researchers. Open Science can also strengthen the leading role that Europe should develop in research integrity at the global level. Universities are ready to rise to the challenge and play a key role in achieving this.

Next to the opportunities, Open Science practices also bring about new challenges to the responsible conduct of research. As indicated by the EU Research, Innovation and Science Policy Experts, without research integrity, "data are at best worthless" and "at worst, poor data are positively dangerous" (Ritter, 2017: 87). The relationship between open data and ethical and privacy standards becomes increasingly complex and relevant in a context of data-intensive research.

Recommendations on research integrity

LERU recommends that universities:

1. Promote and develop awareness amongst the research community of how Open Science can ensure the highest standards of research.
2. Have a research integrity code which embraces the principles of Open Science or that they abide by the European Code for Research Integrity (ALLEA Code), in which, next to general principles of reliability, honesty, respect and accountability, good research practice includes inter alia:
   a. Research institutions rewarding open and reproducible practices in hiring and promotion of researchers (cf. recommendations on recognition and rewards);
   b. Authors ensuring that their work is made available to colleagues in a timely, open, transparent, and accurate manner, unless otherwise agreed;
   c. Making research data as open as possible, as closed as necessary, in line with the FAIR principles for research data management;
   d. Partners in research collaborations agreeing at the outset on the goals of the research and on the process for communicating their research as transparently and openly as possible;
   e. Researchers adhering to the same criteria whether they publish in a subscription journal, an open access journal or in any other alternative publication form.

8/ Citizen science

The past decades have witnessed an upsurge in "citizen science", the active involvement of non-professional

57 The European Code for Research Integrity: http://www.allea.org/wp-content/uploads/2017/03/ALLEA-European-Code-of-Conduct-for-Research-Integrity-2017-1.pdf; last accessed 24 May 2018.

58 "Therefore, research integrity is at the core of science and scholarship. It is the basis for researchers to trust in each other as well as in the research record. Equally importantly, it is the basis of society's trust in the research system." (Science Europe, 2015: 3)

59 New York University Libraries started a service to support researchers with the reproducibility of their research: https://guides.nyu.edu/data_management/reproducibility

scientists in research. From grassroots community initiatives to university-based projects managed by professional scientists, citizens´ involvement in science takes many forms and has brought about a wide range of activities. In a paper published in 2016[60], LERU analysed trends in citizen science, formulated actionable guidelines for scientists and gave recommendations for universities, policymakers and funders.

Citizen science results from and contributes to Open Science. It is enabled by the rise of new technologies (such as the internet, the web or mobile phones), open source software and hardware tools or online social network platforms. At the same time, citizen science actively contributes to furthering Open Science by "opening up" the scope of academic research and the actors involved in the research process.

Citizen science allows research projects to use large and varied data sets collected by citizens, to tap the experience and knowledge of citizens; it enhances universities´ engagement with society and fosters citizens´ scientific involvement. Both universities and society at large can benefit from citizen science. However, for citizen science to be "science" it needs to adhere to scientific standards. Citizen´s involvement in science has to abide by fundamental research principles, methods and procedures so as to ensure accuracy and validity and be truly beneficial to research.

Although acknowledging the vast array of activities falling within the concept of "citizen science", the focus is here on research and universities, providing recommendations to support professional researchers who engage with citizen science.

Researchers developing citizen science projects should invest in outreach and community management to ensure adequate numbers and diversity in the project, they should clearly define the impact they aim to have and encourage all participants fully to contribute their talents and creativity to the project. Citizen participants should be recognized properly and provided with clear terms and conditions of participation and the adoption of codes of conduct should be encouraged. Researchers should also adopt Open Science standards consistent with their institutional policies (open access publication, open data standards, open source software, and extending to full transparency of research methods). A long-term data preservation plan that enables open access to results and data, ideally sustainable beyond the end of the project should be adopted.

To support these efforts, research funding organisations are encouraged to promote the use of Open Science practices in citizen science projects (by requiring open access to publications, open data standards, use of open source software, …), to recognise a wide range of success criteria when supporting citizen science projects and to ensure adequate funding for community management, platform development and other non-research functions characteristics of citizen science.

Policy making bodies are encourage to develop guidelines for legal, ethical, commercial and privacy issues, to encourage long-term collaboration between research universities and non-governmental organisations and to commission independent studies to evaluate the reliability of citizen science and help ensure projects use evidence-based methodologies.

Recommendations on citizen science

LERU recommends that universities:

1. Recognise citizen science as an evolving set of research methods, as well as its societal and educational benefits.
2. Consider creating, where viable, a single point of contact for citizen science within the institution.
3. Raise awareness amongst researchers of criteria for successful citizen science and ensure compliance with ethical, legal and privacy regulations.
4. Develop ways of assessing citizen science contributions and adapt research evaluation and reputation systems accordingly.
5. Ensure that proposals to granting bodies for citizen science projects include long-term commitment for infrastructures and data repositories.

60 This chapter is built upon the LERU paper (LERU, 2016c).

Conclusions

In the 16th century, the invention of moveable type printing in the West revolutionised the way ideas were transmitted and received. The Protestants in particular seized on the printing press to disseminate their ideas in the vernacular tongue of the country where they were based. The result was to change forever the way society behaved and what it believed. So too in the 21st century, Open Science has the power to change how universities produce, store and disseminate their research and educational outputs. This increased openness also has the power to change the way universities interact with society.

The LERU universities agree that overall there are great benefits to be derived from embracing Open Science approaches. Perhaps one of our most important messages in this paper is to emphasise the need for cultural change at the university level. We suggest universities should develop a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings. Universities can establish advocacy programmes, which should identify the benefits of Open Science approaches, whilst being realistic about the challenges. They may wish to draw up a communication strategy, which enables the whole university body to become familiar with Open Science practices, and they may want to appoint a senior manager to lead Open Science approaches across all eight pillars of Open Science.

We are convinced Open Science brings new and exciting opportunities for the scholarly community and for how academics interact with society. For example, in the area of scholarly publishing we see the impact of Open Access research monographs with high download figures when currently sales of traditional, commercially-produced academic monographs are under significant pressure. In the area of research data and FAIR data, the adoption of the principle 'As open as possible, as closed as necessary' means that the building blocks on which publications are based can be made available for the scholarly community to replicate and verify research findings. This transparency is good for the university, good for the researcher and hence good for the role of the university in society.

Although the potential benefits outlined in our paper are substantial, the challenges for universities on the road to Open Science are not to be underestimated. For one, costs are always an issue and can be hard to determine, as is the case in the area of research data management, where the true costs of establishing credible infrastructures and for interfacing with the emerging European Open Science Cloud are a particular difficult challenge. Another important challenge is academic reluctance to change well-honed practices. For next-generation metrics, it is clear that traditional forms of evaluation may not easily work in an open landscape. Nevertheless, the community is still far from clear about what can replace them. Options exist, but these have not yet received universal acceptance. The Journal Impact Factor is still alive in many institutions despite the publication of the San Francisco Declaration on Research Assessment (DORA).

Our paper illustrates a model by which universities can embrace change and embed new policies, practices and principles at university level and points out innovative practice as it emerges at LERU universities and in other organisations. To engage with Open Science, universities can work with the 41 recommendations we make for all its eight areas (grouped together in appendix 1). We also offer a set of 37 questions (in appendix 2) which universities can use to monitor progress in adopting Open Science principles, practices and policies at a local level. Each of the questions is drawn from the recommendations in the present paper and, taken together, the answers to the questions will provide a compelling narrative locally regarding progress in the Open Science agenda. The questions can be used iteratively to monitor performance periodically (preferably annually), so that progress can be identified and remaining priorities established.

Open Science represents a fundamental change in the way universities and their scholars work. It brings many benefits, but also many challenges. Universities that are able to capitalise on the opportunities that Open Science brings stand to gain a lot in terms of competitive advantages and added value for the organisation, the people in it and society at large.

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Appendix 1 - Recommendations

In order to benefit from the opportunities -and rise up to the challenges- that Open Science brings to universities, LERU puts forward a set of recommendations in each of the priority areas identified by the European Commission. These recommendations are based on the experiences of the LERU members in dealing with Open Science and are intended to serve as a roadmap for universities to take Open Science forward. Although derived from the experience of LERU members, these recommendations can also chart the course of action for *any* university. Open Science represents a complex and multi-dimensional process of transition, different for every university. The recommendations in this LERU paper do not represent a prioritisation of topics, nor an exhaustive list of actions to be taken by universities. They, and the paper as a whole, are intended to serve as a roadmap to accompany universities´ efforts towards embracing Open Science, leaving room for each institution to carve out its own path, strategy and actions. Below are LERU's recommendations for universities on cultural change and the eight dimensions of Open Science.

Cultural change

1. Appoint a senior manager to lead Open Science approaches across all 8 pillars of the Open Science debate identified by the European Commission.
2. Develop a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings.
3. Establish advocacy programmes, which should identify the benefits of Open Science approaches, whilst being realistic about the challenges.
4. Draw up a communication strategy, which enables the whole university body to become familiar with Open Science practices.

The future of scholarly communication

5. Have institutional mandates to support the move to full Open Access, whose implementation can be monitored regularly.
6. Deliver a roadmap for how they, or specific groupings, can develop agreed plans for the future of scholarly publishing in their institution.
7. Advocate the use of author identifier systems such as ORCID across their institution.
8. Consider supporting new forms of scholarly publishing from third parties dedicated to Open Access approaches.
9. Where appropriate, establish new mechanisms for scholarly publishing based on the good practice identified in this paper.

FAIR data

10. Adopt or update an institutional policy on research data management -ideally modelled on the template produced by LEARN[61]-, embracing the FAIR principles and based on an 'as open as possible, as closed as necessary' philosophy, and establish a dedicated committee on research data management to monitor the implementation and uptake of such a policy.
11. Design and establish services for data stewardship, provide researchers with suitable infrastructures, and identify funding and resources to archive and to publish data.
12. Create a catalogue of where researchers have published data (or stored if not available for any reason)– as is currently done with publications, and consider how to use this information in any research assessment or evaluation (cf. recommendations on rewards).
13. Provide free access to metadata in order to facilitate the discovery of data for which access must be restricted because of privacy, security, or confidentiality issues, making sure such metadata fulfil the FAIR principles, and establishing a grade of accessibility to those restricted research data.[62]

61 LEARN Research Data Management toolkit: http://learn-rdm.eu/en/research-data-management-toolkit-now-available/; last accessed 7 May 2018.

62 An example of degrees of access for sensitive research data is available at http://datatags.org; last accessed 17 April 2018.

14. Establish training sessions on research data management at all levels, starting from students (cf. recommendations on education and skills).
15. Work together with any local, national or international activities, using for instance Research Data Alliance national groups[63] or the Digital Curation Centre's Data Management Planning Tool.[64]

The EOSC

16. Ensure institutional access to the requisite infrastructure, such as a locally managed data repository where research data is available for sharing and reuse, or that they ensure researchers understand where third-party storage solutions are available, which can themselves be part of the EOSC.
17. Provide a search and discovery service, enabling users to find what research data is available and where it is located, as it is key to the wider use of such resources and, therefore, of the vision embodied in the EOSC.
18. Move to sign the EOSC Declaration over time, as a statement of commitment at a local level, as LERU has done as an international network.
19. Develop their research data management offering so that it is aligned with the principles of engagement with the EOSC, once the latter are agreed and available, and in the expectation that the EOSC develops a more customer-centric approach to stakeholder outreach, which would facilitate engagement with researchers, academic support staff and service providers at universities in the development of its services.

Education and skills

20. Integrate Open Science concepts, thinking, and its practical applications in educational and skills development programmes, analysing and mapping their needs for Open Science skills training, taking into account the different Open Science dimensions and the varying needs of different audiences, different disciplines, etc.
21. Encourage, incentivise, support and recognise staff and students with regard to Open Science skills development.
22. Determine how to resource Open Science skills training in a sustainable manner.
23. Monitor the take-up and impact of Open Science skills training to determine progress towards its cultural integration in the institution.
24. Explore innovative mechanisms and tools to provide Open Science skills training, and engage with others outside the university to exchange good practice.

Recognition and rewards

25. Endeavour to integrate Open Science dimensions in their HR and career frameworks as an explicit element in recruitment, performance evaluation and career advancement policies, so that research and teaching staff are appropriately recognised and rewarded for practicing Open Science.
26. Develop institutional policies for recognising and rewarding Open Science practice anchored in broad-based support; communicate them clearly and transparently, make them easy to find and access, and provide proper guidance or training to those who are involved in staff recruitment, appraisal and promotion in the university.
27. Develop individual HR criteria for recognising and rewarding Open Science in job descriptions, performance appraisals and promotion criteria, for all or most research and teaching staff, which take into account their multiple responsibilities, in terms of research output, process, impact, teaching and supervision, leadership, service to the university, public engagement, professional experience, as well as considering collaborative and team accomplishments in addition to individual accomplishments when appropriate.

63 Research Data Alliance: https://www.rd-alliance.org/groups/national-groups; last accessed 17 April 2018.

64 The Digital Curation Centre´s Data Management tool: http://www.dcc.ac.uk/resources/data-management-plans; last accessed 7 May 2018. For Finnish examples, see DMPTuuli at https://www.dmptuuli.fi/; last accessed 17 April 2018: a Data Management Planning tool Tuuli which helps in the construction of data management plans. See also the work by Universities Finland UNIFI (a co-operative organisation for Finnish universities), in particular its Open Science and Data Action Plan Project; see http://www.unifi.fi/in-english/; last accessed 17 April 2018.

28. Embed Open Science principles in the institutional research assessment system[65], shifting away from an excessive reliance on publication-based journal impact factors and citation cultures and recognising Open Science approaches such as OA publishing, data/code/reagent sharing, recognising pre-prints, etc.
29. Offer appropriate support, professional development and training opportunities for Open Science, aligned with employees' different needs depending on discipline, career progression, seniority and goals, including moving outside the university (cf. recommendations on education and skills).
30. Periodically monitor, reflect on and update their Open Science rewards system so it remains fresh and fit-for-purpose.

Next-generation metrics

31. Develop a bibliometrics policy grounded in the principles of the Leiden Manifesto, with the aim of changing the culture in the academic community about research assessment.
32. Embed the new forms of research evaluation in its internal processes for promotion/reward and research evaluation.
33. Construct, via appropriate internal bodies, guidance for research administrators and academics on good and bad practice in the use of traditional bibliometrics and in the development of new metrics, and that they work with the scientific community in this endeavour.
34. Provide training to junior researchers, particularly early-stage doctoral researchers, enabling them to embrace the change of culture and practice which the responsible use of metrics brings (cf. recommendations on education and skills).

Research integrity

35. Promote and develop awareness amongst the research community of how Open Science can ensure the highest standards of research.
36. Have a research integrity code which embraces the principles of open science or that they abide by the European Code for Research Integrity (ALLEA Code), in which, next to general principles of reliability, honesty, respect and accountability, good research practice includes inter alia:
    a. Research institutions rewarding open and reproducible practices in hiring and promotion of researchers (cf. recommendations on recognition and rewards);
    b. Authors ensuring that their work is made available to colleagues in a timely, open, transparent, and accurate manner, unless otherwise agreed;
    c. Making research data as open as possible, as closed as necessary, in line with the FAIR principles for research data management;
    d. Partners in research collaborations agreeing at the outset on the goals of the research and on the process for communicating their research as transparently and openly as possible;
    e. Researchers adhering to the same criteria whether they publish in a subscription journal, an open access journal or in any other alternative publication form.

Citizen science

37. Recognise citizen science as an evolving set of research methods, as well as its societal and educational benefits.
38. Consider creating, where viable, a single point of contact for citizen science within the institution.
39. Raise awareness amongst researchers of criteria for successful citizen science and ensure compliance with ethical, legal and privacy regulations.
40. Develop ways of assessing citizen science contributions and adapt research evaluation and reputation systems accordingly.
41. Ensure that proposals to granting bodies for citizen science projects include long-term commitment for infrastructures and data repositories.

65 The Open Science Career Assessment Matrix (OS-CAM), proposed by the EU Working Group on Open Science Rewards, may provide a useful starting point to develop an institutional system. See https://ec.europa.eu/research/openscience/pdf/os_rewards_wgreport_final.pdf

Appendix 2 - Checklist of questions for universities

This appendix provides a set of questions which universities can use to monitor their progress in implementing Open Science principles, practices and policies at a local level. Each of the 37 questions is drawn from the recommendations in the paper and, taken together, the answers to the questions will provide a compelling narrative regarding universities' progress in the Open Science agenda. The questions can be used iteratively to monitor performance periodically (preferably annually), so that progress can be identified and remaining priorities established. The RAG system (red-amber-green) can be used to assess how the university is (or sub-units are) progressing towards a goal, with green indicating activity in progress to being completed, amber meaning that some progress is made, but challenges remain, and red denoting that the activity has not been delivered and there are no plans to deliver such an outcome.

	Topic	Question	Assesment of progress	RAG Status
Cultural change				
1.	**Leadership**	Has your university appointed a senior manager to lead Open Science approaches across all eight pillars of the Open Science debate identified by the European Commission?		
2.	**HR**	Has your university developed a programme of cultural change, which is necessary to support the changes in principle and practice which Open Science brings?		
3.	**Advocacy**	Does your university have advocacy programmes to identify the benefits of Open Science approaches, whilst being realistic about the challenges?		
4.	**Communication**	Does your university have communication strategies which enable the whole university body to become familiar with Open Science practices?		
The future of scholarly publishing				
5.	**Compliance**	Does your university have institutional mandates to support the move to full Open Access and does it monitor implementation of these mandates?		
6.	**Planning**	Can relevant stakeholders work together to deliver a roadmap for how they, or specific groupings, can develop agreed plans for the future of scholarly publishing in their institution?		
7.	**Advocacy**	Does your university advocate the use of author identifier systems such as ORCID across the institution?		
8.	**Innovation**	Has your university considered supporting new forms of scholarly publishing from third parties, such as OpenEdition and Knowledge Unlatched, which are dedicated to Open Access approaches?		
9.	**Innovation**	Where appropriate, has your university established new mechanisms for scholarly publishing based on the good practice identified in this chapter?		

66 Knowledge Unlatched: http://www.knowledgeunlatched.org/; last accessed 15 April 2018.

	Topic	Question	Assesment of progress	RAG Status
FAIR data				
10.	**Institutional policy**	Has your institution a research data policy or strategy?		
11.	**Institutional policy**	Does your institution research data policy or strategy include FAIR principles?		
12.	**Institutional support**	Has your institution established a dedicated service to provide data stewardship to its researchers?		
13.	**Infrastructure**	Does your institution provide access to an infrastructure storage and publication of research data ? If it does not, does your institution inform its researchers of available infrastructures that follow the FAIR principles?		
14.	**Data**	Does your institution gather information about the data archived and published by its research community?		
15.	**Metadata**	Does your institution publish all metadata about research data generated or obtained within its research community?		
16.	**Assessment**	Does your institution include research data as a valuable output in research assessments?		
The European Open Science Cloud				
17.	**Infrastructure development**	Has your university established a data repository, or does it have access to a 3rd party repository/repositories which can interact with the EOSC?		
18.	**Infrastructure development**	Does your university have a search and discovery service, enabling users to find what research data is available, and where it is located?		
19.	**Policy development**	Has your university signed the EOSC Declaration as a statement of commitment at a local level?		
20.	**Co-operation and collaboration**	Will your university develop their research data management offering so that it is aligned with the principles of engagement with the EOSC, once the latter are agreed and available?		
Education and skills				
21.	**Training**	Does your institution offer skill straining specifically in Open Science (in all or certain of the eight areas, or other Open Science aspects)?		
22.	**Audience**	Is any Open Science skills training mandatory, and for which categories of staff/researchers/students?		
23.	**Assessment**	Does your institution monitor or assess the provision, uptake and impact of Open Science skills training?		
Recognition and rewards				
24.	**HR policy**	Does your institution integrate Open Science in its HR and career frameworks as an explicit element in recruitment, performance evaluation and career advancement policies?		
25.	**Assessment**	Does your institution assess the extent to which individuals, teams or units integrate Open Science in their daily practice? And does it recognize and/or rewards them for this?		
26.	**Communication**	Does your institution make information about its policies on researcher evaluation open and easily accessible?		

	Topic	Question	Assesment of progress	RAG Status
Next-generation metrics				
27.	**Policy development**	Will your university develop a bibliometrics policy grounded in the principles outlined in this paper, with the aim of changing the culture in the academic community about research assessment?		
28.	**HR**	Will your university embed the new forms of research evaluation in its internal processes for promotion/reward and research evaluation?		
29.	**Best practice guidance**	Will your university, via appropriate internal bodies, construct guidance for research administrators and academics on good and bad practice in the use of traditional bibliometrics and in the development of new metrics, working with the scientific community in this endeavour?		
30.	**Training for early career researchers**	Will your university give particular focus to early career researchers, particularly those embarking on a course of doctoral study, providing training to enable them to embrace the change of culture and practice which the responsible use of metrics brings?		
Research integrity				
31.	**Communication**	Does your institution promote awareness amongst the research community of how Open Science can ensure the highest standards of research?		
32.	**Policy**	Does your university have a research integrity code which embraces the principles of Open Science? If not, does your institution abide by the European Code for Research Integrity (ALLEA Code) and the Open Science provisions it contains?		
Citizen science				
33.	**Policy**	Does your university recognise citizen science as an evolving set of research methods, as well as its societal and educational benefits?		
34.	**Communication**	Is there a single point for citizen science within your institution?		
35.	**Communication**	Does your university raise awareness amongst researchers of criteria for successful citizen science?		
36.	**Assessment**	Are citizen science contributions assessed and research evaluation and reputation systems adapted accordingly?		
37.	**Policy**	Do proposals for granting bodies for citizen science projects include long-term commitment for infrastructures and data repositories?		

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PUSHING
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LERU Office

Minderbroedersstraat 8
3000 Leuven
Belgium

tel +32 16 32 99 71
info@leru.org
www.leru.org

@LERUnews

Pkt. 4 Orientering om arbejdet med E-science nationalt og på RUC

Indstilling
Det indstilles, at

- Forskningsudvalget tager orienteringen om arbejdet med E-science til efterretning med eventuelle bemærkninger vedrørende det videre arbejde på RUC på institut- og forskningsgruppeniveau.

Sagsfremstilling
RUC er ligesom de øvrige danske universiteter del af organisationen DeiC, Danish e-Infrastructure Cooperation. DeiC blev oprettet i 2012, men blev omorganiseret i 2019 i forlængelse af en ny strategi for digital forskningsinfrastruktur. DeiC koordinerer blandt nationale HPC (High-Performance Computing)-anlæg og arbejdet med datalagring og Data Management.

Prorektor orienterer kort om DeiC's arbejde, og hvad oprustningen af DeiC betyder for RUC's forskere og forskningsmiljøer.

Vedhæftet er et uddrag af Uddannelses- og Forskningsministeriets strategigruppes anbefalinger med fokus på visioner og principper for det nationale DeiC-samarbejde samt et statusnotat fra DeiCs bestyrelsesformand, som giver overblik over hvor langt implementering af strategien var i december 2020.

Videre proces
RUC skal i løbet 2021 etablere en lokal supportstruktur for hhv. HPC og Data Management. Sagen vil blive taget op i FOU, når der foreligger et mere samlet koncept herfor.

Forelæggelsen er godkendt af
Prorektor Peter Kjær

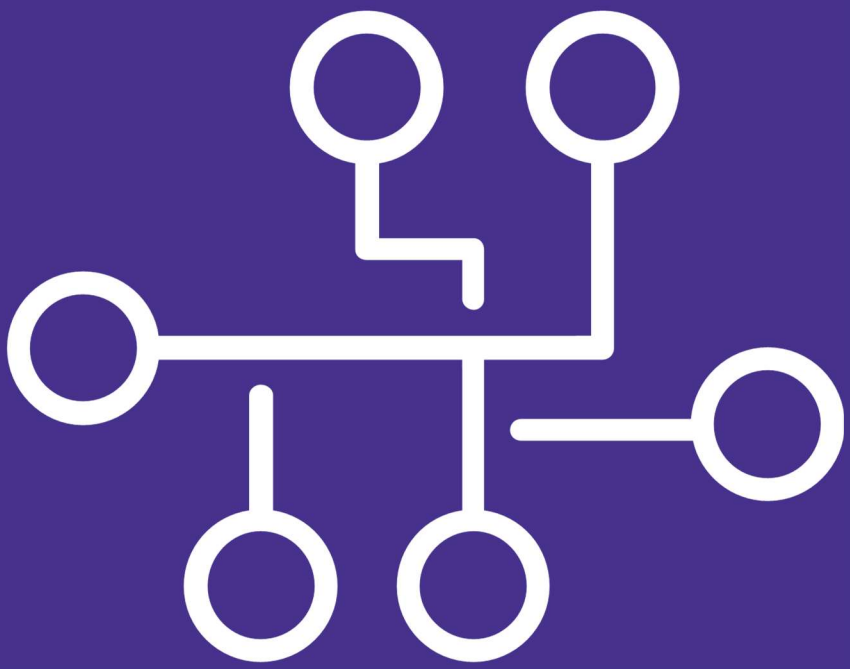
Bilag

- Bilag 1: Anbefalinger fra strategigruppen: Strategi for nationalt samarbejde om digital forskningsinfrastruktur, december 2018 (uddrag)
- Bilag 2: Statusnotat vedr. implementering af Strategi for nationalt samarbejde om digital forskningsinfrastruktur, december 2020.

Strategi for nationalt samarbejde om digital forskningsinfrastruktur

Anbefalinger fra strategigruppen

December 2018



Uddannelses- og Forskningsministeriet

Styrelsen for Forskning og Uddannelse

Udgivet af Styrelsen for Forskning og Uddannelse
Bredgade 40
1260 København K
Tel.: 3544 6200
sfu@ufm.dk
www.ufm.dk

Publikationen kan hentes på ufm.dk/publikationer

ISBN (elektronisk publikation): 978-87-93706-24-8

1. Resumé

Der sker i disse år et paradigmeskifte inden for forskning og videnskab. Omfanget af digitale data, der generes inden for alle videnskabelige hovedområder, er i eksponentiel vækst og ændrer muligheder og betingelser for at bedrive forskning på højeste niveau.

En fuld udnyttelse af de muligheder, som udviklingen i data rummer, kræver en understøttende infrastruktur, der kan tage vare på transport (forskningsnet), behandling og opbevaring af data (beregnings- og lagringsfaciliteter) og en praksis og politik for håndtering af data (data management). Fællesbetegnelsen for dette er digital forskningsinfrastruktur, der er nødvendig for, at udviklingen vil kunne udnyttes og omsættes til videnskabelige nybrud og banebrydende forskningsresultater. Dette gælder på europæisk som på nationalt plan.

På europæisk niveau tiltrækker digital forskningsinfrastruktur i disse år stor bevågenhed. Europa-Kommissionen har således lanceret en række politiske og strategiske initiativer, der har til formål at understøtte en bedre forsknings- og samfundsmæssig udnyttelse af forskningsdata, herunder blandt andet European Open Science Cloud.

Danmark har selv allerede taget de første vigtige skridt i retningen af et fungerende nationalt økosystem for digital forskningsinfrastruktur i forbindelse med etableringen af Danish e-Infrastructure Cooperation (DeIC) i 2012. Initiativet blev etableret i et samarbejde mellem Danmarks otte universiteter og Styrelsen for Forskning og Uddannelse.

Men der er behov for national handling, hvis Danmark fortsat skal være en forskningsnation i den absolutte verdenselite, som er ambitionen i regeringens forsknings- og innovationspolitiske strategi fra december 2017. Derfor fremgår det også af denne strategi, at der skal udarbejdes en national strategi for digital forskningsinfrastruktur. På den baggrund nedsatte universiteterne og Uddannelses- og Forskningsministeriet en arbejdsgruppe, der skulle udarbejde forslag til en ny strategi for nationalt samarbejde om digital forskningsinfrastruktur.

Det er gruppens overordnede anbefaling, at fremtidens samarbejde skal bygge videre på DeIC's indsats, erfaringer og resultater. Men der skal sættes fart i og føres ressourcer til det nationale samarbejde på tværs af aktørerne i det danske forskningslandskab, hvor særligt universiteterne spiller en naturlig og afgørende rolle.

Arbejdsgruppen fremsætter i denne strategi en række konkrete vurderinger og anbefalinger til et styrket nationalt samarbejde. De væsentligste strategiske anbefalinger er:

- Samarbejdet får til ansvar at være spydspids for en styrkelse af det danske internationale engagement, således at Danmark er fuldt udrustet til at gribe de nye internationale muligheder. Dette gælder særligt i forhold til data management og European Open Science Cloud, men også i forhold til High Performance Computing (HPC), hvor uddannelses- og forskningsministerens nylige beslutning om Danmarks medlemskab af EuroHPC er et skridt i denne retning.
- Samarbejdet bliver en central aktør i udviklingen og udrulningen af en national strategi for data management baseret på FAIR-principper, der skal understøtte

det danske kodeks for integritet i forskningen fra 2014, og som vil sætte retning på en koordineret data management-praksis i Danmark. Arbejdet skal involvere alle relevante aktører i det danske forskningslandskab.
- Selve samarbejdet foreslås reorganiseret og oprustet. Både for at sikre et øget ejerskab blandt universiteterne til samarbejdet og for at indlejre ansvaret og opgaverne vedrørende sensitive data, som pt. er forankret hos Det Koordinerende Organ for Registerforskning med henblik på at skabe mest mulig national synergi og sammenhæng. Samarbejdet foreslås blandt andet derfor nedsat med en bestyrelse med ledelsesrepræsentanter fra de danske universiteter.

Strategien foreslår tre scenarier for implementering af strategiens anbefalinger. En fuld udrulning af samtlige anbefalinger skønnes at kræve en samlet årlig investering på ca. 199-234 millioner kroner. Den nuværende årlige investering fra Uddannelses- og Forskningsministeriet og universiteterne i det nationale samarbejde svarer til 77 millioner kroner.

Endelig foreslås en overordnet implementeringsplan for ændringerne, som vil betyde, at det nye nationale samarbejde er fuldt etableret per 1. januar 2020.

4. Vurderinger og anbefalinger

Dansk digital forskningsinfrastruktur har et godt udgangspunkt. DeIC blev evalueret i 2015 af et internationalt panel, som fremhævede en række positive resultater af DeIC's virke, men som også kom med anbefalinger til forbedring af samarbejdet.

Uddrag af evalueringspanelets konklusioner

DeIC har formået at

- Samle og skabe synergi på komplementære områder
- Udbrede digital infrastruktur til nye fagområder
- Skabe fremdrift mod fælles indsats på data management-området
- Skalere en begrænset økonomi gennem fælles finansiering.

Anbefalinger fra evalueringspanelet

- Stærkere forankring i universiteternes øverste ledelse
- Totale og faktiske omkostninger for aktiviteten på området bør synliggøres
- HPC-ressourcers anvendelse og fordeling bør være tydelige og ens for alle.

Kilde: Evaluering af DeIC, 2015

Fremtidens samarbejde skal derfor også i altovervejende grad bygge videre på DeIC's indsats, erfaringer og resultater. Men der er behov for at sætte fart i og tilføre ressourcer til det nationale samarbejde i form af en styrket national indsats og samarbejde på tværs af aktørerne i det danske forskningslandskab, hvor universiteterne spiller en naturlig og afgørende rolle.

4.1 Vision og principper

Udvalget har derfor i sine anbefalinger taget afsæt i en ambitiøs vision for det nationale samarbejde og har ligeledes lagt sig fast på fire principper, som det nationale samarbejde skal basere sig på.

Vision

Forskere ved de danske universiteter skal have adgang til en digital infrastruktur, der muliggør forskning og uddannelse i verdensklasse.

Principper

- Forskere inden for alle hovedområder skal have adgang til digital infrastruktur på transparente vilkår
- Der skal være en klar og tydelig rolle- og arbejdsfordeling mellem aktiviteter på det nationale niveau og på institutionsniveau
- Investeringer i kostbar digital infrastruktur til forskning skal koordineres og udnyttes og drives effektivt
- Der skal etableres et langtidsholdbart og fleksibelt samarbejde med en stærk international forankring
- Der skal være stabilitet omkring økonomi for at sikre kontinuerlig modernisering af teknologi og løbende kompetenceudvikling.

4.2 Konkrete vurderinger og anbefalinger

De konkrete vurderinger og anbefalinger til en ny national strategi er struktureret efter følgende tre tematikker - HPC, forskningsnet og data management – som det nye nationale samarbejde får ansvaret for. Desuden beskrives de afledte implikationer for organisation/governance og økonomi. På tværs af disse kategorier har anbefalingerne forskellig karakter. Nogle vedrører kapacitet og effektivitet, andre kompetencer, mens nogle har karakter af strategiske og politiske valg.

4.2.1 High Performance Computing (HPC)

Danske forskere har i dag adgang til forskellige typer af HPC-anlæg. Der findes anlæg lokalt på de enkelte forskningsinstitutioner defineret efter institutionelle behov og dedikeret til specifikke forskningsformål.

På nationalt niveau eksisterer tre nationale HPC-anlæg, jf. Appendiks 2, forstået som anlæg, hvortil der er adgang for forskere uafhængigt af institutionelt tilhørsforhold, og som er baseret på en klart defineret finansierings- og adgangsmodel. På Danmarks Tekniske Universitet i samarbejde med Københavns Universitet er der etableret et nationalt computeranlæg, Computerome, som er dedikeret de særlige beregningsbehov, som life science-området har. På Syddansk Universitet er der etableret et generelt beregningsanlæg, ABACUS. Endeligt er der på Det Kongelige Bibliotek Aarhus etableret et kulturarvscluster, som er et mindre HPC-anlæg, som giver forskere adgang til store mængder digitaliseret kulturarvsmateriale.

På europæisk plan er Danmark medlem af PRACE (Partnership for Advanced Computing in Europe), som gennem en fælles aftale sikrer europæiske forskere adgang til nogle af de største computeranlæg i Europa via ansøgning og peer review. Samtidigt har Europa-Kommissionen i samarbejde med en række lande, inklusive Danmark, søsat HPC-initiativet EuroHPC, som skal sikre etablering af ny storskala HPC-infrastruktur, der fremmer europæiske forskeres adgang til nogle af de største computere i verden.

Statusnotat vedr. implementering af *Strategi for nationalt samarbejde om digital forskningsinfrastruktur*.

8. december 2020

Bestyrelsesformand John Renner Hansen

Formål

Dette notat beskriver status for implementeringen af strategien ultimo 2020.

Der er taget udgangspunkt i strategiens anbefalinger på de fem hovedområder

- High Performance Computing
- Forskningsnettet
- Datamanagement
- Organisering og governance
- Økonomi og finansiering

Strategiens anbefalinger er gengivet i den venstre kolonne, mens status for hver anbefaling er beskrevet i den højre kolonne.

Notatet er tænkt som et dynamisk dokument, som 2 gange årligt (juni og december) opdateres og sende til UFM, DKUNI, Bestyrelsen og CIO gruppen.

Strategiens anbefalinger	Bestyrelsens beslutninger
HPC (Strategien side 15)	
Etablere en ny fælles model for åben adgang til nationale HPC-anlæg	
Der efterspørges en transparent national model for adgang til beregningsres-sourcer, og samarbejdet får til opgave at **udfolde en ny konkret model for adgang.** Modellens hjørnesten skal være, at den enkelte bruger, afhængigt af beregningsbehovet, kan få direkte adgang til HPC-ressourcer eller adgang via ansøgning og peer-review uafhængigt af institutionelt tilhørsforhold og **uden selv at skulle betale direkte for adgang.** Det er ligeledes afgørende, at der i adgangsmodellen inkluderes **adgang til personale med tekniske kompetencer**, der kan bistå brugeren i at foretage beregninger. En forudsætning for modellen er, at der indgås en **finansieringsaftale mellem de involverede universiteter**	*Et notat om oprettelse af et uddelings-udvalg, med repræsentation fra alle universiteter og en bred sammensætning på tværs af fagområder, er udarbejdet.* *Udvalget er nedsat og havde første møde i november 2020. En arbejdsgruppe udarbejder forslag til proces og ansøgningsskemaer.* *Denne forudsætning er grundlæggende for arbejdet med uddelingsprincipperne.* *Det forudsættes af universiteterne opretter brugernære kompetencecentre (front-office) og at der opbygges ekspertfunktioner ved de nationale HPC-Centre til understøttelse af front-office (back-office).* *Aftalen er indgået med Danske Universiteter marts 2019. Der blev som aftale afsat 10 MDKK på FL20 og 20 MDKK på FL21 som matches med tilsvarende beløb fra universiteterne.*
Sikre drift og opgradering af eksisterende nationale HPC-ressourcer	
Åben adgang for forskere forudsætter, at **det nationale samarbejde påtager sig ansvaret for at lave fælles aftaler, som sikrer den løbende drift og**	*Der er udarbejdet samarbejdsaftaler for fire HPC driftscentre og et projekt, som skal sikre sømløs adgang til DeiC's*

opgradering af nationale HPC-ressourcer. Erfaringerne fra de eksisterende installationer bør indgå i udformningen af en ny fælles model. Det er en forudsætning, at investeringer i kostbar beregningskapacitet for offentlige midler koordineres og alt andet lige skaleres således, at den kan anvendes af forskere på tværs af institutionerne.	*ressourcer.* *I aftalerne indgår brug af allerede anskaffet udstyr, som lever op til de krav der er udarbejdet til det nationale HPC-centre* *Aftalerne blev underskrevet af formanden for DeiC's bestyrelse på vegne af UFM og formanden for DKUNI i november 2020.*
Tilvejebringe øgede HPC-ressourcer	
Evalueringen og behovskortlægningen har begge adresseret, at særligt forskere inden for naturvidenskab og teknisk videnskab i dag ikke i tilstrækkelig grad kan få deres særlige behov for stor regnekraft dækket via de nationale HPC-anlæg. **Omvendt står det ikke klart, om etablering af et nyt nationalt anlæg er den mest omkostningseffektive og optimale løsning, eller om de danske behov vil kunne varetages mere fleksibelt og billigere ved for eksempel at etablere et dansk medlemskab af fælles computerressourcer i Europa, eller ved direkte køb af regnetid på et stort nationalt anlæg i Europa.**	*På baggrund af erfaringer fra de tre tidligere DeiC-centre (ABACUS, Kulturarvsclustet og Computerome) samt det internationale projekt PRACE og på baggrund af indstilling af den nationale HPC-referencegruppe, blev det besluttet at opbygge fire teknologisk forskellige nationale HPC-centre, samt at melde Danmark ind i EuroHPC og blive medejer af LUMI, som er et af flere HPC-centre under EuroHPC. På den måde sikres en bred vifte af teknologier til danske forskere og studerende, med et tidsperspektiv på 3 til 5 år.*
Styrke og koordinere HPC-kompetencer i Danmark	
Der er et generelt behov for at styrke kompetencerne til at udnytte HPC i forskningen effektivt. **Langt**	*Det er aftalt at universiteterne opretter brugernære kompetencecentre (front-office) og at der opbygges*

størstedelen af arbejdet bør foregå lokalt tæt på de faglige miljøer, men der er ligeledes behov for at styrke og koordinere de tekniske HPC-kompetencer på de nationale anlæg. Formålet er dels at styrke serviceniveauet og dermed tilgængeligheden af HPC-ressourcer og dels **at styrke de tekniske HPC-kompetencer i Danmark i forhold til deltagelse i fælleseuropæiske udviklingsaktiviteter i relation til PRACE og EuroHPC**	*ekspertfunktioner ved de nationale HPC-Centre til understøttelse af front-office (back-office).* *Der opbygges kompetencefunktioner for EuroHPC og LUMI både ved front-office og ved back-office.*
Styrke fortsat dansk medlemskab af det europæiske HPC-samarbejde	
PRACE-samarbejdet giver danske forskere adgang til markant større HPC-anlæg, end der er adgang til i Danmark. Danske forskeres fortsatte adgang til disse er af afgørende betydning og skal fortsætte. Ligeledes skal dansk medlemskab af det nye HPC-projekt, EuroHPC, som Danmark netop har besluttet at deltage i, varetages i samarbejde med Uddannelses- og Forskningsministeriet. Snitfladen mellem PRACE og EuroHPC skal følges, og det nationale samarbejde skal rådgive ministeriet om udviklingen i begge samarbejder samt snitflader og synergier i forhold til udvikling af national HPC.	*Danmark er nu medlem af EuroHPC og* *er medejer af LUMI, som er et af flere HPC-centre under EuroHPC.* *Der er løbende dialog med ministeriet om hvordan Danmark bedst positionerer sig i forhold til de internationale faciliteter.*
Forskningsnettet (Strategien side 16)	
Opretholde og varetage forskningsnettet baseret på bidrag fra	

universiteterne	
Forskningsnettet skal fortsat være fuldt finansieret af brugerne som i dag og med obligatorisk tilslutning af universiteterne. Forskningsnettet er en helt basal national forskningsinfrastruktur og er naturligt forankret på det nationale niveau. Som en integreret del af ansvaret for forskningsnettet skal samarbejdet sikre, at det til hver en tid er opdateret sikkerhedsmæssigt	*Forskningsnettet er videreført på samme betingelser som før 2019 og alle relevante tjenester som gør nettet stabilt, fleksibelt og sikkert er bevaret. Betalingsmodellen er uforandret.*
Evaluere forskningsnettet	
Det er indtrykket, at forskerne er tilfredse med kapaciteten og driften af forskningsnettet. **Det nationale samarbejde skal undersøge muligheden for, at de enkelte institutioner i højere grad end nu kan til- og fravælge services efter behov**. Samarbejdet skal endvidere forholde sig til, hvorvidt det **er forskningsnettets opgave at tilbyde højhastighedskapacitet til adresser, hvor der ikke drives forskning, herunder kollegier og studenterhuse**. Den nuværende betalingsmodel og fordelingsnøgle, baseret på universiteternes årsomsætning, skal også omfattes af evalueringen.	*Bestyrelsen bad i foråret 2019 CiO-gruppen (forsamlingen af IT-ansvarlige på universiteterne) om at gennemgå listen af services. Resultatet blev et forslag til revision af listen, hvor nogle blev bibeholdt, som de var, nogle blev overført til brugerbetaling og nogle blev nedlagt.* *Der er ikke taget stilling til om Forskningsnettet fortsat skal yde service til institutioner som ikke bedriver forskning.* *Der er ikke fremlagt forslag til en ændret betalingsmodel.*
Sikre, at forskningsnettet fortsat er internationalt opkoblet	
En fortsat international forbindelse fra det danske forskningsnet til institutioner i Norden, Europa og globalt er af afgørende betydning for dansk	*Ingen ændringer siden 1. januar 2019*

forsknings position internationalt. Samarbejdet skal derfor fortsat repræsentere Danmark i NORDUnet og GEANT	
Øge samarbejdet med de nordiske lande	
De nordiske forskningsnet er hver for sig forholdsvis små i en international kontekst. Det nye samarbejde skal afdække, om der er mulighed for effektiviseringer, stordriftsfordele og styrket samarbejde på nordisk niveau mod et samlet nordisk forskningsnet og med øget europæisk indflydelse til følge.	*Den næste generation af det fysiske netværk, som binder de nordiske lande sammen intern bliver baseret på kapacitet i de nationale netværk, og ikke som hidtil på et dedikeret fysisk nordisk netværk. Dette er både en direkte økonomisk gevinst, men det kræver også et meget tættere samarbejde på tværs af de nationale netværk, med en betydelig øget kompetencedeling til følge.*
Data management (Strategien side 17)	
Bidrage til en national strategi baseret på FAIR-principperne	
Der er pt. ingen FAIR-politik i Danmark, og set i lyset heraf fremstår de lokale danske anstrengelser som relativt ukoordinerede. Det er ligeledes indtrykket, at universiteterne og øvrige relevante aktører har meget forskellige udgangspunkter og modenhed i forhold data management generelt og i særdeleshed i forhold til FAIR-principperne. En national, koordinerende strategi vil både understøtte det danske kodeks for integritet i forskningen fra 2014 og vil sætte samlet retning på FAIR i Danmark.	*Der er nedsat to arbejdsgrupper og en styregruppe, bredt sammensat af interessenter, med det formål at tilvejebringe en dansk strategi for danamanagement af forskningsdata, basseret på FAIR principper. Den ene arbejdsgruppe skal se på principper og forslag til implementering, den anden ser på de økonomiske konsekvenser og de private bidrag til implementeringen.* *Strategien er sendt i en bred høring primo november 2020, med høringsfrist 1. februar 2021. Det forventes at strategien præsenteres for ministeren i*

Det nye nationale samarbejde skal have en væsentlig rolle i dette arbejde, i et tæt samarbejde med en bred skare af interessenter såsom, Uddannelses- og Forskningsministeriet, universiteterne, sektorforskningsinstitutioner, bevaringsinstitutioner, Danmarks Elektroniske Fag og Forskningsbibliotek, offentlige og private fonde og andre ministerier (for eksempel Erhvervsministeriet og Sundheds- og Ældreministeriet).	*løbet af andet kvartal 2021.* *Strategien vil udgøre den danske politik på DM området for forskningsdata, som forudsat i direktivet om åbne data (tidligere psi-direktivet) artikel 10. Digitaliseringsstyrelsen er ansvarlig for udarbejdelsen lovforslag.*
Styrke lokal og national lagringskapacitet	
Behovsanalysen udtrykker et klart behov for øget lagringskapacitet, samt styrket koordinering, herunder behov for bedre mulighed for at arbejde og **dele data på tværs af datalagre nationalt og internationalt.** Hvorvidt data lagres lokalt eller nationalt er mindre vigtigt. Det vigtigste er, at data lagres i en **koordineret og sammenhængende løsning,** hvor data kan tilgås på tværs af organisatoriske og tekniske løsninger. Det foreslås herunder, at **der indgås dialog med private kommercielle datacentre i Danmark med henblik på afdækning af synergimuligheder.**	*Der er nedsat et Data Management Forum som arbejder på en plan for udbygningen af de fysiske lagre. Der er ingen beslutning. Brug af kommercielle datalagre er en mulighed, som skal indgå i overvejelserne om fremtidige nationale datalagre.* *Deltagelse i EOSC hjælper til at gøre data let tilgængelige og delbare.*
Etablere en sikker struktur for sensitive data	
Der pågår i øjeblikket et pilotprojekt mellem Det Koordinerende Organ for Registerforskning, Danmarks Statistik og DeIC om etablering af en sikker løsning	*Samarbejdet om udvikling og opbygning af en sikker e-infrastruktur mellem Sundheds- og Ældreministeriet og universiteterne fortsætter. I KOR regi er*

for forskning på sensitive data. Behovskortlægningen viser en stor efterspørgsel efter en sådan HPC løsning. Udviklingsarbejdet skal fortsættes og intensiveres i det nye samarbejde og skal udvides til at involvere dialog med relevante sundhedsaktører, blandt andet med det nyligt etablerede Nationale Genom Center, Danske Regioner og Sundhedsdatastyrelsen, med henblik på skabe synergi om etablering og drift af beregnings- og lagringsressourcer for forskning relateret til personlig medicin. Perspektivet indgår allerede i Sundheds- og Ældreministeriets strategi for Personlig Medicin for perioden 2017-2020.	*der afsat midler til at støtte denne udvikling, som inddrager Danmarks Statistik og Sundhedsdatastyrelsen*
Styrke dialogen og samarbejdet med Danmarks Elektroniske Fag- og Forskningsbibliotekog bevaringsinstitutioner om data management	
Digitaliseringen har medført en markant ændring i biblioteks- og arkivvæsenet, opgaver og rolle. Udviklingen på området rejser spørgsmålet om, hvorvidt samarbejde og snitflader i forhold til Danmarks Elektroniske Fag- og Forskningsbibliotek og bevaringsinstitutioner, herunder Det Kongelige Bibliotek og Rigsarkivet på data managementområdet kan optimeres og styrkes. Den nye organisation får til opgave at initiere en dialog med relevante aktører om organiseringen af området. En konkret opgave bliver i dialog med Rigsarkivet at tilvejebringe et beslutningsgrundlag med henblik på stillingtagen til Rigsarkivet Sundheds finansielle og organisatoriske fremtid.	*Bevaringsinstitutionerne er partnere i udarbejdelsen af National Datamanagement Strategi baseret på FAIR* *<u>Dialog om fremtidig organisering er ikke indledt.</u>*

Være Danmarks spydspids og indgang i forhold til European Open Science Cloud	
Det nationale samarbejde skal spille en aktiv rolle i forhold til aktivering af danske aktører og deltagelse i relevante fora og samarbejder. Udvikling og koordinering på internationalt og EU-plan er i hastig udvikling, og **dansk involvering i European Open Science Cloud udestår.** Ydermere er danske forskere og tekniske eksperter i lav grad repræsenteret i konsortier inden for Horizon 2020 med tab af dansk integration på internationalt plan som følge. Der er behov for en væsentlig styrkelse af det danske engagement i forhold til European Open Science Cloud og den europæiske udvikling generelt.	*Danmark er nu associeret medlem af EOSC og DeiC spiller sammen med UFS en aktiv rolle i udviklingen af EOSC.* *DTU påtager sig officielt medlemskabet, indtil DeiC er etableret som en selvstændig juridisk enhed.*
Etablere et samarbejde med European Spallation Source Data Management and Software Centre (ESS DMSC) om kompetencer og metoder	
Danmark vil blive vært for datamanagement-centeret, for verdens kraftigste neutronkilde. ESS DMSC er placeret i København og bliver et centralt omdrejningspunkt for forskningen og metodeudviklingen ved ESS, når denne efter planen går i drift i 2025. Den nationale organisation skal etablere et samarbejde med ESS DMSC med det formål at arbejde for, at den kompetence- og metodeopbygning, der finder sted ved ESS, indlejres i de danske forskningsmiljøer	*De danske universiteter har et tæt samarbejde med ESS Lund og med ESS Datamanagement og Software Centret i København.* *DeiC mangler at etablere et fast samarbejde med ESS/DMSC*

DeiC's organisation og governance (Strategien side 20)	
Have styrket forankring blandt "ejerne"	
For at styrke ejerskabet til det nationale samarbejde sættes "ejerkredsen", det vil sige universiteternes rektorer og direktøren for Styrelsen for Uddannelse og Forskning formelt ind i governance-struktur således, at bestyrelsen refererer direkte til "ejerkredsen". Dette sikrer den efterspurgte og ønskede forankring på universiteterne og et overordnet og strategisk perspektiv på den digitale forskningsinfrastruktur på tværs af forskningsområder og institutioner. **Det foreslås, at "ejerkredsen" mødes minimum en gang årligt til et dedikeret møde om samarbejdet.**	*Er implementeret.* *Er aftalt med DKUNI formanden og direktøren for UFS.*
Have ny bestyrelse med ledelsesrepræsentanter udpeget af ejerne	
Bestyrelsen udpeges af "ejerkredsen" og skal i modsætning til nu bestå af en ledelsesrepræsentant fra hvert af de otte universiteter med mandat til at træffe beslutninger på det enkelte universitets vegne. Styrelsen for Forskning og Uddannelse rolle i bestyrelsen skal afklares nærmere alt afhængigt af den valgte organisationsform. Bestyrelsen får til ansvar at være samarbejdets overordnede strategiske beslutningsorgan og udarbejder blandt andet årlige handlingsplaner med udgangspunkt i den langsigtede strategi. Tillige rådgiver bestyrelsen om	*Fuldt implementeret.*

udvikling, lovgivning, policy og investeringer på området. I det hele taget påhviler der bestyrelsen en stor opgave i at initiere og konsolidere det nye nationale samarbejde	
Have en styrket organisation og med øget kapacitet til det internationale arbejde	
Det foreslås, at samarbejdet etableres som en organisation med en lille kerne af fuldtidsansatte (8-10 ansatte) med en direktør, der er sekretariat for og refererer til bestyrelsen, og som har ansvar for den daglige drift, strategisk planlægning, internationale relationer, brugerdialog og kommunikation. Der skal i en ny organisering være en internationalt dedikeret ressourceperson, der kan varetage det internationale område, da den nationale koordinering og oplysningsindsats skal styrkes markant. Derfor foreslås en international chef/koordinator. Desuden foreslås samarbejdet operationelt organiseret omkring de tre gennemgående tematikker – HPC, forskningsnet og data management. DeIC's nuværende, fjerde organisatoriske ben, kompetencer, foreslås indlejret på tværs i de tre tematikker. Det foreslås, at der til hver tematik knyttes et eller flere rådgivende og faglige referencefora, der har repræsentanter fra de relevante interesser på området, og som dermed også kan favne andre institutioner end universiteterne – for eksempel bevaringsinstitutionerne på data	*Arbejdet med at udvikle en helt ny organisation, som skal varetage en lang række funktioner på tværs af universiteterne er for omfattende til at kunne varetages af 8-10 personer. Der pågår et udredningsarbejde som forelægges bestyrelse snarest.* *En fuld implementering at DeiC som en selvstændig organisation ved lov, forventes gennemført 1. januar 2022.*

management-området	
Sikre øget dialog og brugerinddragelse af miljøerne	
Evalueringen peger på, at der er et behov for at **styrke dialogen og inddragelse af brugerne af digital infrastruktur i Danmark. Etablering af en referencegruppe – med repræsentanter fra alle videnskabelige hovedområder** – og en strategisk plan for brugerinvolvering af de relevante miljøer er nødvendig for at sikre både legitimitet og effektivitet og koordinere **kompetenceudviklingsaktiviteter med brugerne.**	*Der foreligger et dokument, som beskriver referencegruppestrukturen, hvor brugere og eksperter inddrages på forskellige tidspunkter i forhold til infrastrukturens udvikling og brug.* *Kompetenceudvikling er et centralt element i opbygningen af et Front-office, Back-office system.*
Integrere opgaverne vedrørende sensitive data i organisationen og opgaveløsningen	
Som allerede nævnt er der et pilot-samarbejde mellem DeIC, Det Koordinerende Organ for Registerforskning og Danmarks Statistik vedrørende sensitive data, og det foreslås at bygge videre på dette arbejde. Det vurderes derfor hensigtsmæssigt at sammentænke og integrere området for sensitive data i det nationale samarbejde med henblik på at skabe bedre sammenhæng og synlighed. Det Koordinerende Organs kompetencer, erfaringer og viden er fortsat afgørende, og derfor foreslås det, at Det Koordinerende Organ for Registerforskning indtænkes i det nationale samarbejde som et rådgivende, fagligt referenceforum.	*KOR har udarbejdet et forslag til arbejdsprogram for 2021-2024, der foreslår, hvordan KOR og DeiC kan samarbejde om bedre forhold for forskning med sensitive data. Programmet er sendt til drøftelse i DeiC bestyrelse. Hovedpunkterne indeholder:* - *Infrastruktur for registerforskning* - *Nationalt beregningsanlæg for sensitive data* - *Internationale samarbejder om anvendelse af sensitive data* - *GDPR compliance* - *Samarbejde med dataleverandører* *Desuden har KOR:* *Indsendt ansøgning om ny infrastruktur for generationsdata til Novo Nordisk*

	Fonden (42M DKK) - i samarbejde med Rigsarkivet
Være i dialog med ejerne om midler til fuld udrulning af anbefalingerne (Strategien side 21)	
Det nye nationale samarbejde er i 2019 født med de gældende økonomiske rammer, som i dag gælder for DeIC's virke, og 2019 vil i høj grad være et organisatorisk transitionsår, jævnfør næste afsnit. Fra og med 2020 kan man økonomisk forestille sig tre scenarier for samarbejdets virke, hvor scenarie tre afspejler økonomien for en fuld implementering af samtlige anbefalinger i denne strategi. Beløbene er skønnede og tager afsæt i udredninger fra DeIC.	*DeiC's bestyrelse er i løbende dialog med UFS og DKUNI om den fremadrettede finansiering.*
Arbejde for yderligere finansiering til samarbejdet	
Samarbejdet skal opsøge yderligere finansiering til understøttelse af det nationale samarbejde. Her tænkes både på dialog med andre finansieringskilder i Danmark, såsom private fonde, og ikke mindst en	*Der er en løbende kontakt til fondene. Denne er styrket med disses deltagelse i udarbejdelse af en strategi for data management baseret på FAIR principper.* *DeiC har opnået bevillinger fra EU i forbindelse med EuroHPC kompetenceudvikling.*