# EDISON Project Overview:

## Activities, developments and products to establish the Data Science profession

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University of Amsterdam

3rd EDISON Champion Universities Conference

19-20 June 2017, Warsaw

EDISON – **E**ducation for **D**ata **I**ntensive **S**cience to **O**pen **N**ew science frontiers

Grant 675419 (INFRASUPP-4-2015: CSA)

# Outline

- Background
  - Recent EU Initiatives, European Digital Single Market (DSM) and demand for data enabled skills
  - Challenges with growing demand and gap for Data Science competences and skills
- EDISON Data Science Framework (EDSF)
  - From Data Science Competences and Skills to Body of Knowledge and Model Curriculum
  - Data Science Professional Profiles family and organisational skills management
- Use of EDSF for Data Science curricula design and skills management
- Further activities and sustainability
- Summary and discussion

UvA Universiteit van Amsterdam

University of Southampton

inmark europa

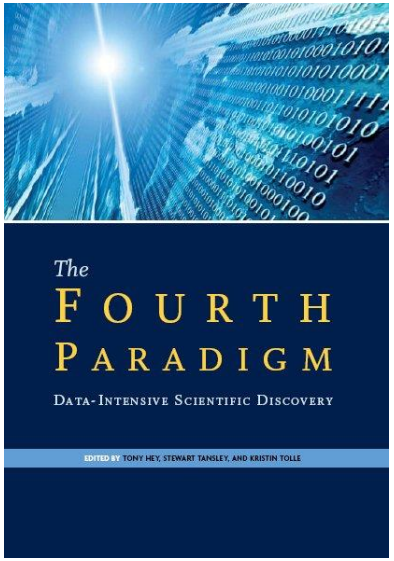
University of Stavanger

EGI

ENGINEERING

FTK Forschungsinstitut für Telekommunikation und Kooperation

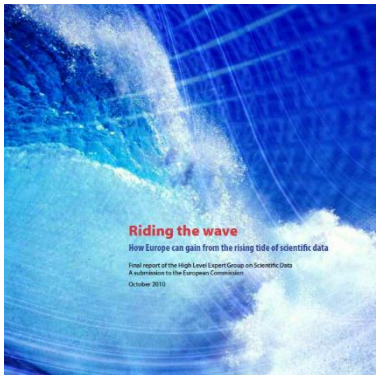
# Visionaries and Drivers: Seminal works, High level reports, Activities




**The Fourth Paradigm: Data-Intensive Scientific Discovery**.

By Jim Gray, Microsoft, 2009. Edited by Tony Hey, Kristin Tolle, et al.

http://research.microsoft.com/en-us/collaboration/fourthparadigm/




**Riding the wave: How Europe can gain from the rising tide of scientific data.**

Final report of the High Level Expert Group on Scientific Data. October 2010.

http://cordis.europa.eu/fp7/ict/e-infrastructure/docs/hlg-sdi-report.pdf

RDA RESEARCH DATA ALLIANCE

Research Data Sharing without barriers

https://www.rd-alliance.org/


**The Data Harvest: How sharing research data can yield knowledge, jobs and growth.**

An RDA Europe Report. December 2014

https://rd-alliance.org/data-harvest-report-sharing-data-knowledge-jobs-and-growth.html

**HLEG report on European Open Science Cloud**

(October 2016)


**Emergence of Cognitive Technologies**

(IBM Watson and others)

# The Fourth Paradigm of Scientific Research

1. Theory, hypothesis and logical reasoning
2. Observation or Experiment
   - E.g. Newton observed apples falling to design his theory of mechanics
   - But Gallileo Galilei made experiments with falling objects from the Pisa leaning tower
3. Simulation of theory or model
   - Digital simulation can prove theory or model
4. Data-driven Scientific Discovery (aka Data Science)
   - More data beat hypnotized theory
   - e-Science as computing and Information Technologies empowered science
5. Computer-human- driven science?
   - Machine discovers new patterns and formulates hypothesis in one or multiples knowledge spaces

# Recent European Commission Initiatives 2016

**Digitalising European Industry**: Reaping the full benefits of a **Digital Single Market**. COM(2016) 180 final, Brussels, 19.4.2016

- The need for **new multidisciplinary and digital skills in particular Data Scientist**
  - Expected rapidly growing demand will lead to more than 800 000 unfilled vacancies by 2020

**A New Skills Agenda for Europe**, COM(2016) 381 final Brussels, 10.6.2016

- Launch **Digital Skills and Jobs Coalition** (1st December 2016, Brussels) to develop comprehensive national digital skills strategies by mid-2017

**European Cloud Initiative** - Building a competitive data and knowledge economy in Europe, COM(2016) 178 final, Brussels, 19.4.2016

- **European Open Science Cloud (EOSC)** and European digital research and data infrastructure
  - To offer 1.7 million European researchers and 70 million professionals in science and technology open and seamless services for ***storage, management, analysis and re-use*** of research data

**HLEG report on European Open Science Cloud** (October 2016) identified need for data experts and data stewards

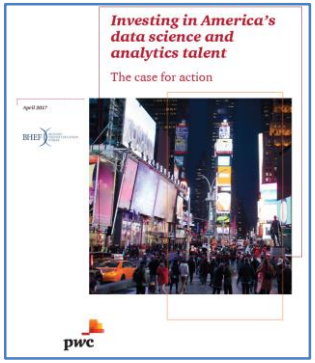
- Estimation: More than 80,000 data stewards (1 per every 20 scientists)
- **Core Data Experts** need to be trained and their career perspective improved

# Industry reports on Data Science Analytics and Data enabled skills demand

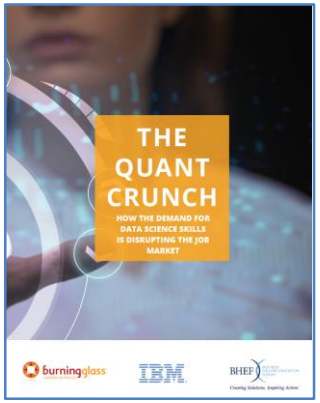
- Final Report on European Data Market Study by IDC (Feb 2017)
  - The EU data market in 2016 estimated EUR 60 Bln (growth 9.5% from EUR 54.3 Bln in 2015)
    - Estimated EUR 106 Bln in 2020
  - Number of data workers 6.1 mln (2016) - increase 2.6% from 2015
    - Estimated EUR 10.4 million in 2020
  - Average number of data workers per company 9.5 - increase 4.4%
  - Gap between demand and supply estimated 769,000 (2020) or 9.8%

- PwC and BHEF report “Investing in America’s data science and analytics talent: The case for action” (April 2017)
  - http://www.bhef.com/publications/investing-americas-data-science-and-analytics-talent
  - 2.5 mln postings, 23% Data Scientist, 67% DSA enabled jobs
  - DSA enabled jobs growing at higher rate than main Data Science jobs

- Burning Glass Technology, IBM, and BHEF report “The Quant Crunch: How the demand for Data Science Skills is disrupting the job Market” (April 2017)
  - https://public.dhe.ibm.com/common/ssi/ecm/im/en/iml14576usen/IML14576USEN.PDF
  - DSA enabled jobs takes 45-58 days to fill: 5 days longer than average


Citing EDISON and EDSF




Influenced by EDISON

# ICT and Data related Skills shortage - Impact

- Problems with hiring (skilled) ICT related staff
  - At least one year for training and acquiring experience
  - As soon as new employees are confident with their skills, they leave for big(ger) companies or industry
- Open Data Science/Stewards positions stay unfilled longer
  - In research institutions for months and years
  - In industry for months
- Companies/organisations want experienced Data Science workers
  - There is no time to acquire necessary experience
- Millennials factor
  - Do we understand difference of the millennials workforce?

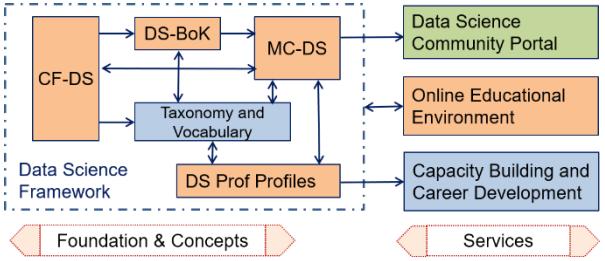
- Challenges: How to obtain, train in shorter period and sustain new digital (ICT and Data related) skills in organisations

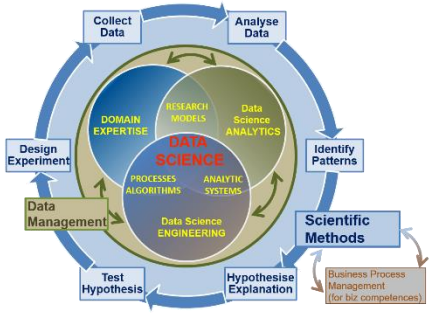
# Sustainable ICT and Data Skills Development

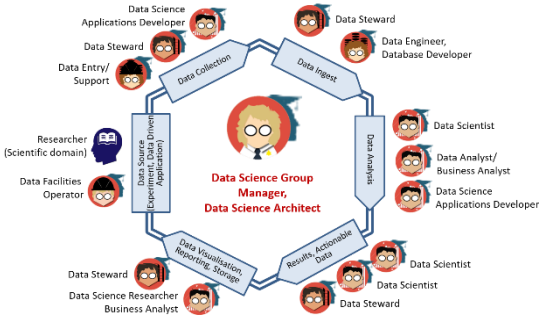
- HLEG report on EOSC rose question about critical need for Core Data Experts
  - Not much changes since report publication in October 2016
  - Some minor disconnected plans for future H2020 WP2018-2020
- Educate vs Train
  - Training is a short term solution
  - Education is a basis for sustainable skills development
- Technology focus changes every 3-4 years
  - Study: 50% of academic curricula are outdated at the time of graduation
- Lack of necessary skills leads to underperforming projects and organisations and loose of competitiveness
  - Challenge: Policy and decision makers don't have mind set to plan human factor (competences and skills) as a part of technology strategy
- Need to change skills management paradigm
  - **Dynamic (self-) re-skilling:** Continuous professional development and shared responsibility between employer and employee
  - Skills and career management as a part of professional orientation

# EDISON Products for Data Science Skills Management and Tailored Education

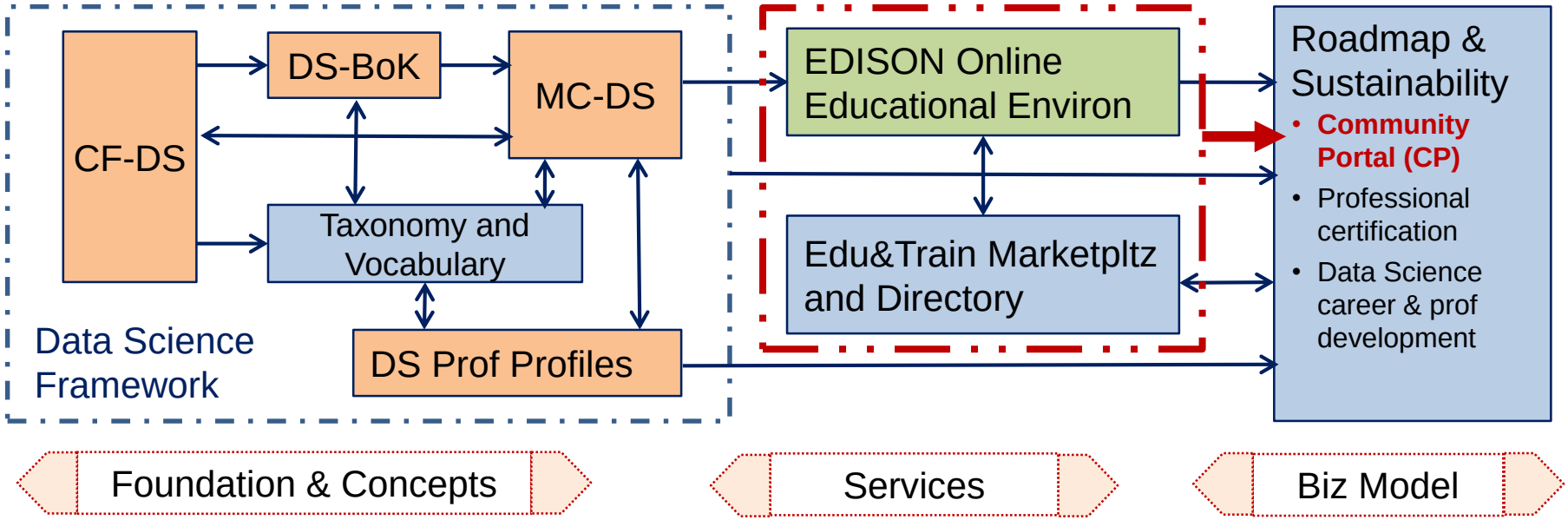
- EDISON Data Science Framework (EDSF)
  - Compliant with EU standards on competences and professional occupations e-CFv3.0, ESCO
  - Customisable courses design for targeted education and training
- Skills development and career management for Core Data Experts and related data handling professions
- Capacity building and Data Science team design
- Academic programmes and professional training courses (self) assessment and design
- EU network of Champion universities pioneering Data Science academic programmes
- Engagement in relevant RDA activities and groups
- Cooperation with International professional organisations IEEE, ACM, BHEF, APEC (AP Economic Cooperation )



# EDISON Data Science Framework (EDSF)




## EDISON Framework components

- CF-DS – Data Science Competence Framework
- DS-BoK – Data Science Body of Knowledge
- MC-DS – Data Science Model Curriculum
- DSP – Data Science Professional profiles
- Data Science Taxonomies and Scientific Disciplines Classification
- EOEE - EDISON Online Education Environment

## Methodology

- ESDF development based on job market study, existing practices in academic, research and industry.
- Review and feedback from the ELG, expert community, domain experts.
- Input from the champion universities and community of practice.

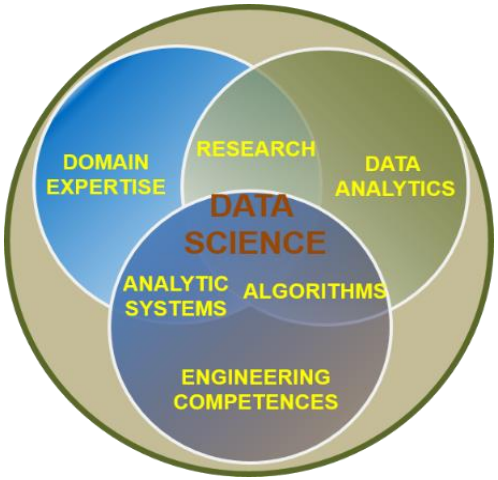
# EDSF Background: Standards and Best Practices

- e-CFv3.0 - European e-Competence Framework for IT
  - Structured by 4 Dimensions and organizational processes
    - Competence Areas: Plan – Build – Run – Enable - Manage
    - Competences: total defined 40 competences
    - Proficiency levels: identified 5 levels linked to professional education levels
    - Skills and Knowledge
- CWA 16458 (2012): European ICT Professional Profiles Family Tree
  - Defines 23 ICT profiles for common ICT jobs
- ESCO (European Skills, Competences, Qualifications and Occupations) framework
  - Standard for European job market since 2016
  - Expected inclusion of the Data Science occupations family – end 2017
- ACM Classification of Computer Science – CCS (2012)
- ACM Computer Science Body of Knowledge (CS-BoK) and ACM and IEEE Computer Science Curricula 2013 (CS2013)
- NIST SP 1500-1 NIST Big Data interoperability Framework (NBDIF): Volume 1: Definitions, September 2015

# Data Scientist definition

Based on the definitions by NIST Big Data WG (NIST SP1500 - 2015)

- *A **Data Scientist** is a practitioner who has sufficient knowledge in the overlapping regimes of expertise in **business needs, domain knowledge, analytical skills, and programming and systems engineering expertise** to manage the end-to-end scientific method process through each stage in the **big data lifecycle***
  - *… Till the delivery of an **expected scientific and business value** to science or industry*
- *Profession is defined via **Competences** mapped to*
  - ***Skills and Knowledge***
  - ***Proficiency levels***



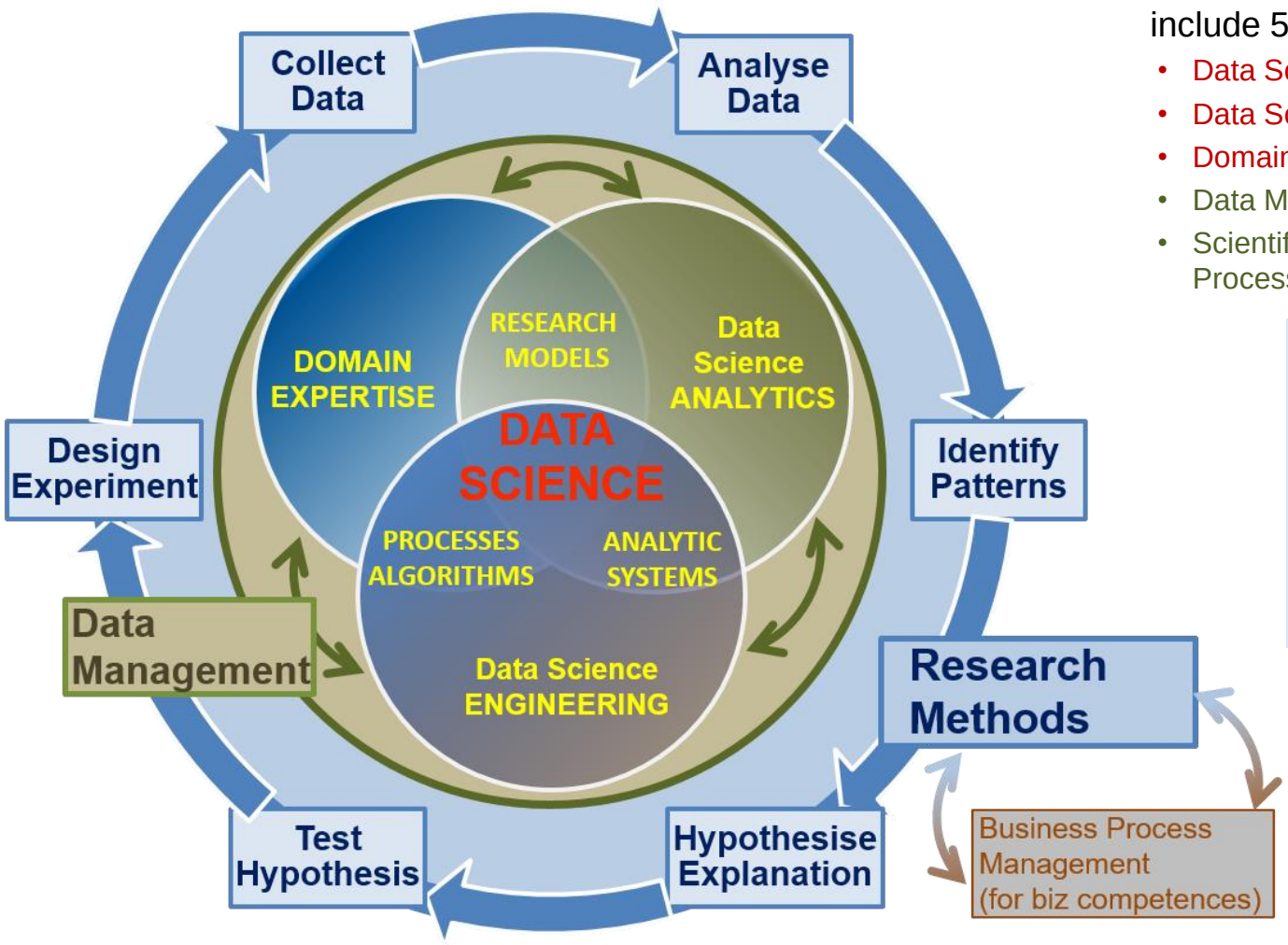

[ref] Legacy: NIST BDWG definition of Data Science

- ***Data science** is the empirical synthesis of actionable knowledge and technologies required to handle data from raw data through the complete data lifecycle process.*
- ***Big Data** is the technology to build system and infrastructures to process large volume of structurally complex data in a time effective way*

# Identified Data Science Competence Groups

- Core Data Science competences/skills groups
  - **Data Science Analytics** (including Statistical Analysis, Machine Learning, Business Analytics)
  - **Data Science Engineering** (including Software and Applications Engineering, Data Warehousing, Big Data Infrastructure and Tools)
  - **Domain Knowledge and Expertise** (Subject/Scientific domain related)
- EDISON identified 5 core competence groups demanded by organisations
  - **Data Management, Curation, Preservation**
  - **Scientific or Research Methods and/vs Business Processes/Operations**
- Other skills commonly recognized aka “soft skills” or personal
  - **21st Century Skills** – required to effectively work in the modern agile organisations
  - **Data Science professional skills**: Thinking and acting like Data Scientist – required to successfully develop as a Data Scientist and work in Data Science teams

# Data Science Competence Groups - Research




Data Science Competences include 5 groups

- Data Science Analytics
- Data Science Engineering
- Domain Knowledge and Expertise
- Data Management
- Scientific Methods or Business Process Management

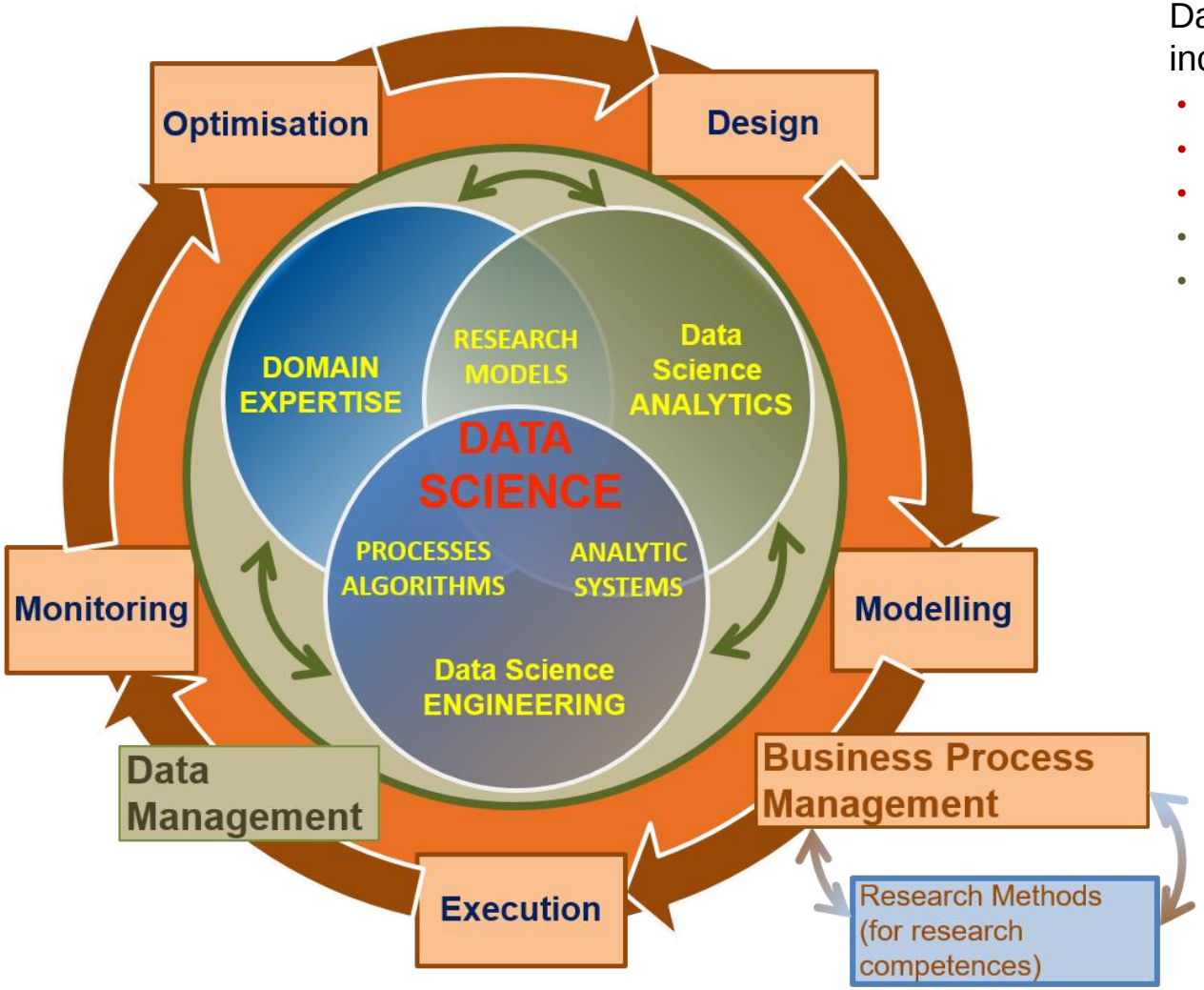
Scientific Methods

- Design Experiment
- Collect Data
- Analyse Data
- Identify Patterns
- Hypothesis Explanation
- Test Hypothesis

Business Operations

- Operations Strategy
- Plan
- Design & Deploy
- Monitor & Control
- Improve & Re-design

# Data Science Competences Groups – Business

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Scientific Methods

- Design Experiment
- Collect Data
- Analyse Data
- Identify Patterns
- Hypothesise Explanation
- Test Hypothesis

Business Process Operations/Stages

- Design
- Model/Plan
- Deploy & Execute
- Monitor & Control
- Optimise & Re-design

# Identified Data Science Competence Groups

| | Data Science Analytics (DSDA) | Data Management (DSDM) | Data Science Engineering (DSENG) | Research/Scientific Methods (DSRM) | Data Science Domain Knowledge, e.g. Business Processes (DSDK/DSBPM) |
|---|---|---|---|---|---|
| 0 | Use appropriate statistical techniques and predictive analytics on available data to deliver insights and discover new relations | Develop and implement data management strategy for data collection, storage, preservation, and availability for further processing. | Use engineering principles to research, design, develop and implement new instruments and applications for data collection, analysis and management | Create new understandings and capabilities by using the scientific method (hypothesis, test/artefact, evaluation) or similar engineering methods to discover new approaches to create new knowledge and achieve research or organisational goals | Use domain knowledge (scientific or business) to develop relevant data analytics applications, and adopt general Data Science methods to domain specific data types and presentations, data and process models, organisational roles and relations |
| 1 | **DSDA01** Use predictive analytics to analyse big data and discover new relations | **DSDM01** Develop and implement data strategy, in particular, Data Management Plan (DMP) | **DSENG01** Use engineering principles to design, prototype data analytics applications, or develop instruments, systems | **DSRM01** Create new understandings and capabilities by using scientific/ research methods or similar domain related development methods | **DSBPM01** Understand business and provide insight, translate unstructured business problems into an abstract mathematical framework |
| 2 | **DSDA02** Use statistical techniq to deliver insights | **DSDM02** Develop data models including metadata | **DSENG02** Develop and apply computational solutions | **DSRM02** Direct systematic study toward a fuller knowledge or understanding of the observable facts | **DSBPM02** Participate strategically and tactically in financial decisions |
| 3 | **DSDA03** Develop specialized … | **DSDM03** Collect integrate data | **DSENG03** Develops specialized tools | **DSRM03** Undertakes creative work | **DSBPM03** Provides support services to other |
| 4 | **DSDA04** Analyze complex data | **DSDM04** Maintain repository | **DSENG04** Design, build, operate | **DSRM04** Translate strategies into actions | **DSBPM04** Analyse data for marketing |
| 5 | **DSDA05** Use different analytics | **DSDM05** Visualise cmplx data | **DSENG05** Secure and reliable data | **DSRM05** Contribute to organizational goals | **DSBPM05** Analyse optimise customer relatio |

# Identified Data Science *Skills/Experience* Groups

- **Group 1: Skills/experience related to competences**
  - Data Analytics and Machine Learning
  - Data Management/Curation (including both general data management and scientific data management)
  - Data Science Engineering (hardware and software) skills
  - Scientific/Research Methods or Business Process Management
  - Application/subject domain related (research or business)
  - **Mathematics and Statistics**
- **Group 2: Big Data (Data Science) tools and platforms**
  - Big Data Analytics platforms
  - Mathematics & Statistics applications & tools
  - Databases (SQL and NoSQL)
  - Data Management and Curation platform
  - Data and applications visualisation
  - *Cloud based platforms and tools*
- **Group 3: Programming and programming languages and IDE**
  - General and specialized development platforms for data analysis and statistics
- **Group 4: Soft skills or 21st Century Skills**
  - Personal, inter-personal communication, team work, professional network

# Key Data Science Analytics Competences by EDISON and DARE Project for APEC countries

- Core/foundational competences (starting from entry level to expert level)
  - Statistics, Probability theory, mathematics, calculus
  - Statistical programming languages, frameworks, tools
  - Computational methods and document processing tools (including Excel, Office visualization, or similar)
  - Data Visualisation, and tools (e.g. Tableau, SPSS)
- Data Science Analytics (including Data Mining, Machine Learning)
  - Extended (data driven technologies): Optimization, simulation, etc.
- Data Science Engineering
  - Including applications development, Big Data Infrastructure design and operation, Data Warehousing, Data and infrastructure Security
- Research methods and Business process methods
- Domain related knowledge (e.g. scientific domains, business, industry, public sector)
- 21st Century Skills

# 21st Century Skills (DARE & BHEF & EDISON)

1. **Critical Thinking:** Demonstrating the ability to apply critical thinking skills to solve problems and make effective decisions
2. **Communication:** Understanding and communicating ideas
3. **Collaboration:** Working with other, appreciation of multicultural difference
4. **Creativity and Attitude:** Deliver high quality work and focus on final result, intitiative, intellectual risk
5. **Planning & Organizing:** Planning and prioritizing work to manage time effectively and accomplish assigned tasks
6. **Business Fundamentals:** Having fundamental knowledge of the organization and the industry
7. **Customer Focus:** Actively look for ways to identify market demands and meet customer or client needs
8. **Working with Tools & Technology:** Selecting, using, and maintaining tools and technology to facilitate work activity
9. **Dynamic (self-) re-skilling:** Continuously monitor individual knowledge and skills as shared responsibility between employer and employee, ability to adopt to changes
10. **Professional networking:** Involvement and contribution to professional network activities
11. **Ethics:** Adhere to high ethical and professional norms, responsible use of power data driven technologies, avoid and disregard un-ethical use of technologies and biased data collection and presentation

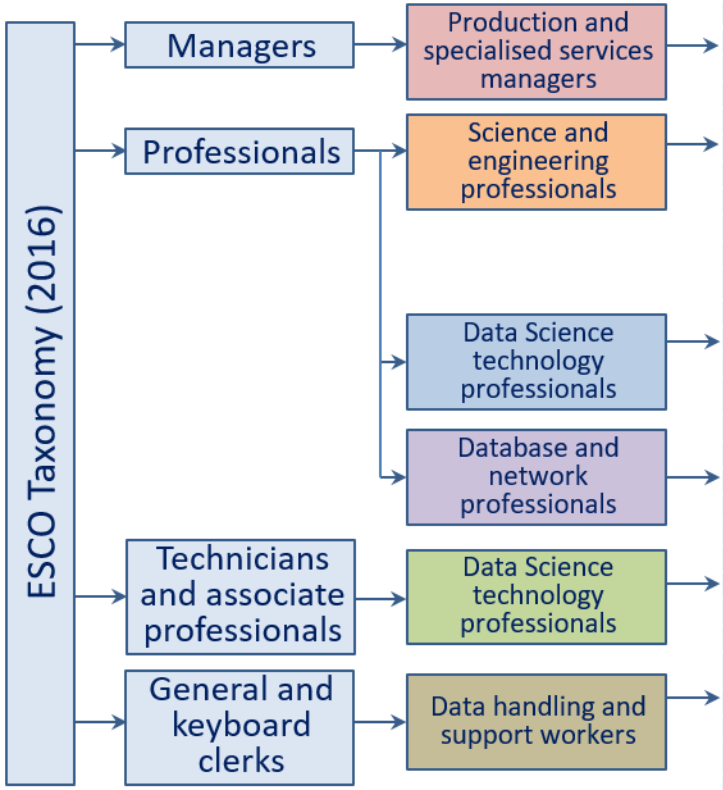
# Data Science Soft Skills: Thinking and Acting like Data Scientist

1. Accept/be ready for **iterative development**, know when to stop, comfortable with falure, accept the symmetry of outcome (both positive and negative results are valuable)
2. **Ask the right questions**
3. Recognise what things are **important** and what things are **not important**
4. **Respect domain/subject matter knowledge** in the area of data science
5. **Data driven problem solver** and **impact-driven mindset**
6. **Recognise value of data**, work with raw data, exercise good data intuition
7. Good **sense of metrics**, understand importance of the results validation, never stop looking at individual examples
8. **Be aware about power and limitations** of the main machine learning and data analytics algorithms and tools
9. Understand that most of **data analytics algorithms are statistics and probability based**, so any answer or solution has some degree of probability and represent an optimal solution for a number variables and factors
10. Working in **agile environment** and coordinate with other roles and team members
11. Work in **multi-disciplinary team**, ability to communicate with the domain and subject matter experts
12. Embrace **online learning**, continuously improve your knowledge, use **professional netw**orks and communities
13. **Story Telling**: Deliver actionable result of your analysis
14. **Attitude**: Creativity, curiosity (willingness to challenge status quo), commitment in finding new knowledge and progress to completion
15. **Ethics and responsible use** of data and insight delivered, awareness of dependability (data scientist is a feedback loop in data driven companies)

# Practical Application of the CF-DS

- Basis for the definition of the Data Science Body of Knowledge (DS-BoK) and Data Science Model Curriculum (MC-DS)
  - CF-DS => Learning Outcomes (MC-DS) => Knowledge Areas (DS-BoK)
  - CF-DS => Data Science taxonomy of scientific subjects and vocabulary
- Data Science professional profiles definition
  - Extend existing EU standards and occupations taxonomies: e-CFv3.0, ESCO, others
- Professional competence benchmarking
  - For customizable training and career development
  - Including CV or organisational profiles matching
- Professional certification
  - In combination with DS-BoK professional competences benchmarking
- Vacancy construction tool for job advertisement (for HR)
  - Using controlled vocabulary and Data Science Taxonomy

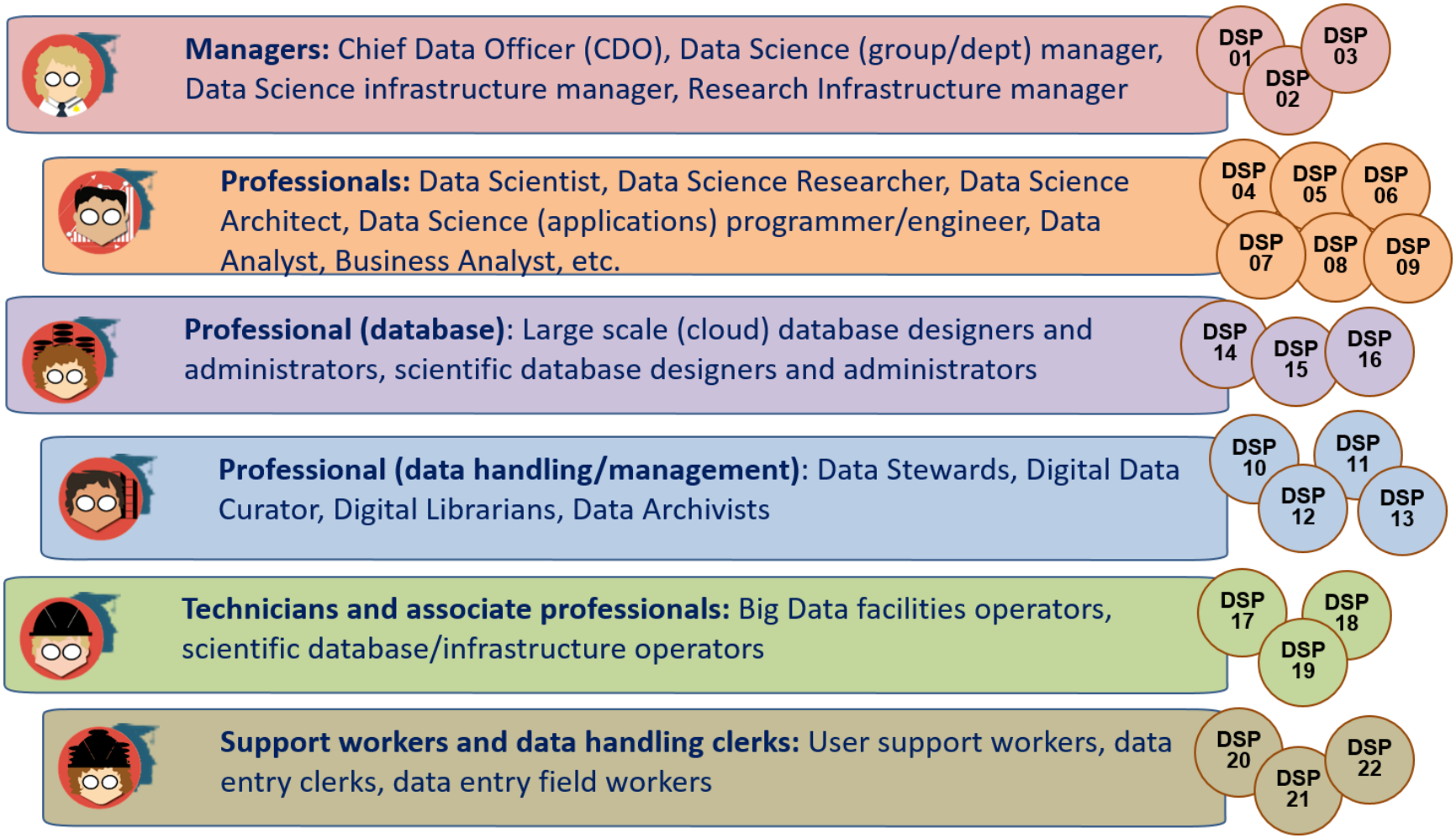
# DSP Profiles mapping to ESCO Taxonomy High Level Groups




| Profile ID | Data Science Profile title | DSDA | DSDM | DSENG | DSRM | DSDK |
|---|---|---|---|---|---|---|
| **Data Science Services/Infrastructure Managers** | | | | | | |
| DSP01 | Data Science (group) Manager | 3 | 4 | 3 | 3 | 2 |
| DSP02 | Data Science Infrastr Manager | 2 | 4 | 4 | 2 | 2 |
| DSP03 | Research Infrastructure Manager | 2 | 4 | 4 | 3 | 2 |
| **Data Scince Professionals** | | | | | | |
| DSP04 | Data Scientist | 5 | 3 | 4 | 5 | 3 |
| DSP05 | Data Science Researcher | 4 | 3 | 2 | 5 | 4 |
| DSP06 | Data Science Architect | 4 | 3 | 5 | 3 | 3 |
| DSP07 | Data Science Applic Programmer | 4 | 2 | 5 | 3 | 4 |
| DSP08 | Data Analyst | 5 | 3 | 3 | 3 | 4 |
| DSP09 | Business Analyst | 5 | 3 | 3 | 4 | 5 |
| **Data handling professionals not elsewhere classified** | | | | | | |
| DSP10 | Data Stewards | 3 | 5 | 3 | 3 | 3 |
| DSP11 | Digital data curator | 1 | 5 | 2 | 2 | 3 |
| DSP12 | Digital Librarians | 2 | 5 | 2 | 2 | 3 |
| DSP13 | Data Archivists | 1 | 5 | 1 | 1 | 3 |
| **Database and network professionals not elsewhere classified** | | | | | | |
| DSP14 | Large scale database designer | 2 | 4 | 4 | 3 | 3 |
| DSP15 | Large scale database admin | 2 | 4 | 3 | 2 | 3 |
| DSP16 | Scientific database administrator | 2 | 4 | 3 | 2 | 3 |
| **Data Infrastructure engineers and technicians** | | | | | | |
| DSP17 | Big Data facilities Operator | 1 | 4 | 4 | 2 | 3 |
| DSP18 | Large scale data storage operator | 1 | 4 | 3 | 1 | 1 |
| DSP19 | Scientific database operator | 1 | 4 | 3 | 2 | 3 |
| **Data and information entry and access** | | | | | | |
| DSP20 | Data entry/access worker | | 2 | 1 | | 2 |
| DSP21 | Data entry field workers | | 2 | 1 | | 2 |
| DSP22 | User support data services | | 3 | 2 | | 2 |

- DSP Profiles mapping to corresponding CF-DS Competence Groups
  - Relevance level from 5 – maximum to 1 – minimum

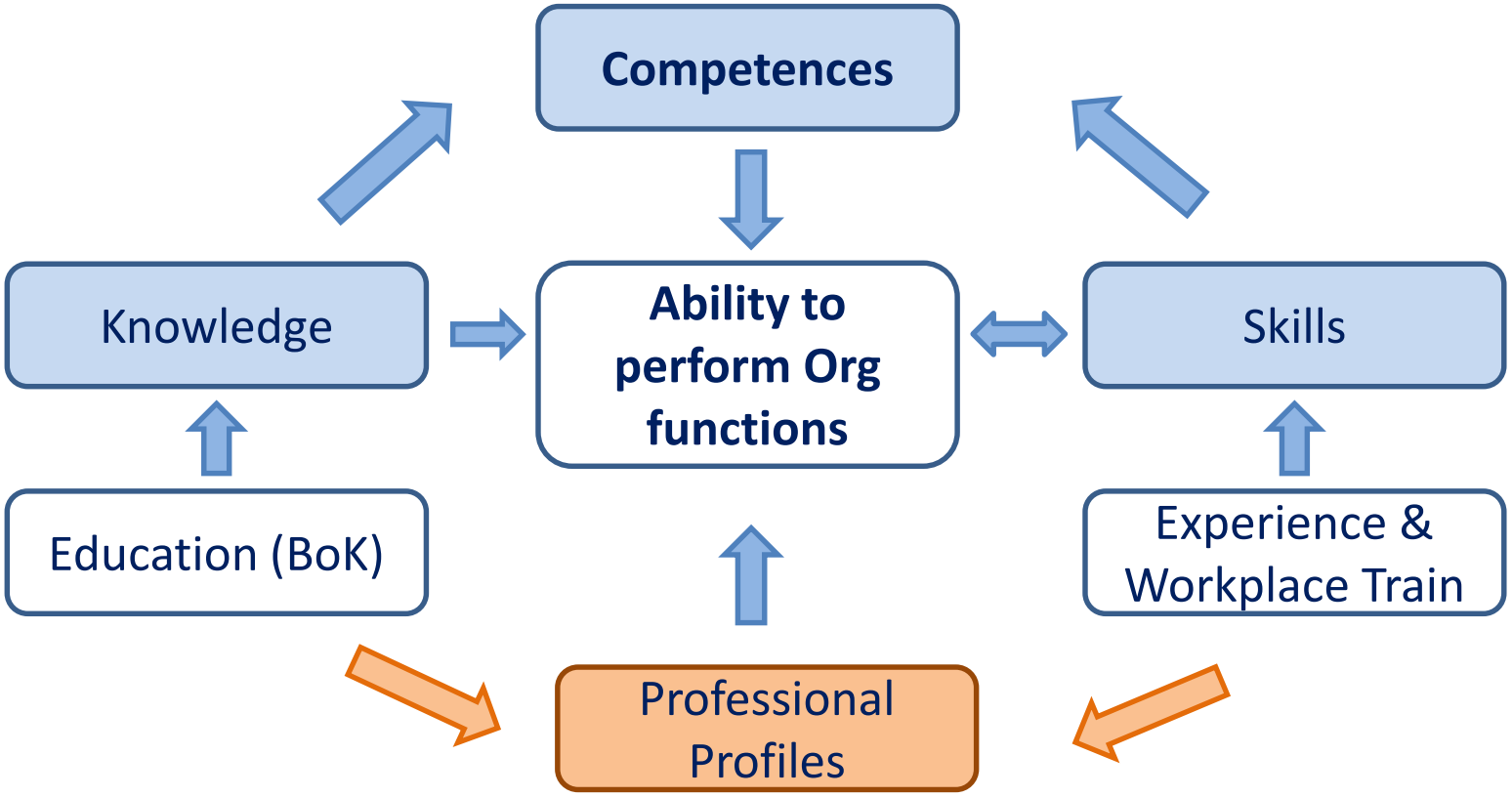
# Data Science Professions Family




Icons used: Credit to [ref] https://www.datacamp.com/community/tutorials/data-science-industry-infographic

# Competences Map to Knowledge and Skills (2)

- **Competence** is a demonstrated ability to apply knowledge, skills and attitudes for achieving observable results

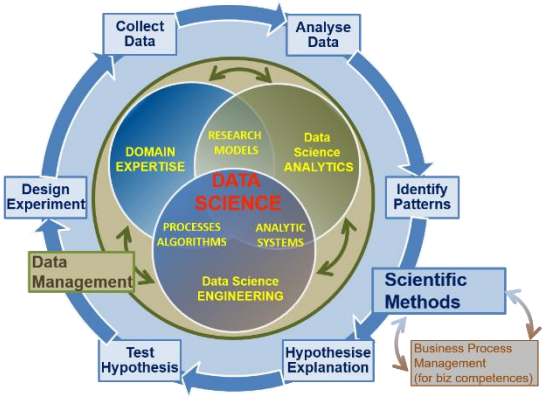


# EDSF for Education and Training

- Foundation and methodological base
  - Data Science Body of Knowledge (DS-BoK)
    - Taxonomy and classification of Data Science related scientific subjects
  - Data Science Model Curriculum (MC-DS)
    - Set Learning Units mapped to CF-DS Learning and DS-BoK Knowledge Areas/Units
  - Instructional methodologies and teaching models
- Platforms and environment
  - Virtual labs, datasets, developments platforms
  - Online education environment and courses management
- Services
  - Individual benchmarking and profiling tools (competence assessment)
  - Knowledge evaluation tools
  - Certifications and training for self-made Data Scientists practitioners
  - Education and training marketplace: Courses catalog and repository

# Data Science Body of Knowledge (DS-BoK)

## DS-BoK Knowledge Area Groups (KAG)




- KAG1-DSA: Data Analytics group including Machine Learning, statistical methods, and Business Analytics
- KAG2-DSE: Data Science Engineering group including Software and infrastructure engineering
- KAG3-DSDM: *Data Management group including data curation, preservation and data infrastructure*
- KAG4-DSRM: *Research Methods group*
- KAG5-DSBP: Business process management group

- Data Science domain knowledge to be defined by related expert groups

# Example DS-BoK Knowledge Areas definition and mapping to existing BoKs and CCS (2012)

| Knowledge Area Groups (KAG) | Knowledge Areas (KA) | Suggested Knowledge Units (KU) | Mapping to CCS2012 (including suggested Data Science extensions) and existing BoKs |
|---|---|---|---|
| KAG1-DSDA: Data Analytics group (including Machine Learning, statistical methods) | Theory of computation | Design and Analysis of Algorithms | CCS2012: Theory of computation<br>Design and analysis of algorithms<br>Data structures design and |
| | | Machine Learning Theory | |

| Knowledge Area Groups (KAG) | Knowledge Areas (KA) | Suggested Knowledge Units (KU) | Mapping to CCS2012 (including suggested Data Science extensions) and existing BoKs |
|---|---|---|---|
| KAG2-DSENG: Data Science Engineering group including Software an infrastructu engineering | Computer systems organisation for Big Data | Parallel and Distributed Computer Architecture | **CCS2012: Computer systems organization**<br>Architectures<br>Parallel architectures |
| | | Computer networks: architectures | |

| Knowledge Area Groups (KAG) | Knowledge Areas (KA) | Suggested Knowledge Units (KU) | Mapping to CCS2012 (including suggested Data Science extensions) and existing BoKs |
|---|---|---|---|
| | Data Management and Enterprise data infrastructure | Data management, including Reference and Master Data | **DM-BoK selected KAs**<br>(1) Data Governance,<br>(2) Data Architecture,<br>(3) Data Modelling and Design,<br>(4) Data Storage and Operations,<br>(5) Data Security,<br>(6) Data Integration and Interoperability,<br>(7) Documents and Content,<br>(8) Reference and Master Data,<br>(9) Data Warehousing and Business Intelligence,<br>(10) Metadata, and<br>(11) Data Quality. |
| | | Data Warehousing and Business Intelligence | |
| | | Data storage and operations | |
| | | Data archives/storage compliance and certification | |
| | | Metadata, linked data, provenance | |
| | | Data infrastructure, data registries and data factories | |
| | | Data security and protection | |
| | | Data governance, data quality, data Integration and Interoperability | |

- Mapping suggested to CCS2012 and existing BoKs

# Data Science Model Curriculum (MC-DS)

Data Science Model Curriculum includes

- Learning Outcomes (LO) definition based on CF-DS
  - LOs are defined for CF-DS competence groups and for all enumerated competences
- LOs mapping to Learning Units (LU)
  - LUs are based on CCS(2012) and universities best practices
  - Data Science university programmes and courses inventory (interactive) http://edison-project.eu/university-programs-list
- LU/course relevance: Mandatory Tier 1, Tier 2, Elective, Prerequisite
- Learning methods and learning  models (in progress)

# Example MC-DS Mapping Learning Units to DS-BoK and CCS (2012)

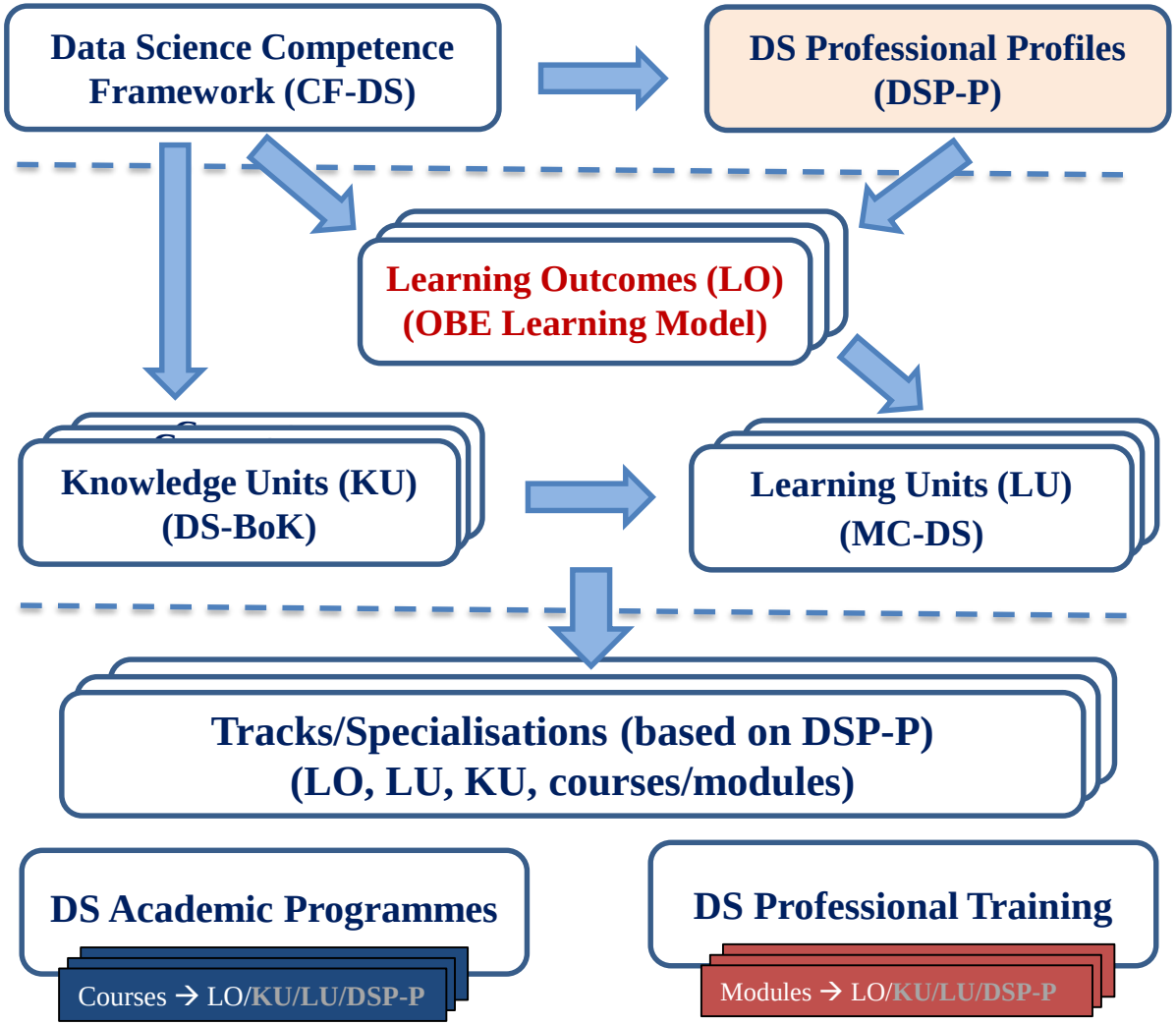
| KAG/ LU# *) | Learning Unit (course name) [2] | Type/relevance [3] | | | | Map to DS-BoK, CCS2012 and known BoKs | |
|---|---|---|---|---|---|---|---|
| | | Tier 1 | Tier 2 | Elective | Pre requisite | CCS2012 based academic subjects | DS-BoK and other BoKs |
| | Software requirements and design | | | | | Extensions are suggested from SWEBOK | SWEBOK selected KAs<br>• Software requirements |

| KAG/ LU# *) | Learning Unit (course name) [2] | Type/relevance [3] | | | | Map to DS-BoK, CCS2012 and known BoKs | |
|---|---|---|---|---|---|---|---|
| | | Tier 1 | Tier 2 | Elective | Pre requisite | CCS2012 based academic subjects | DS-BoK and other BoKs |
| | Information theory | | | | | Mathematical analysis | |
| | Mathematical analysis | | | | | | |
| | *Extensibility point for adding new courses* | | | | | | |
| | Artificial Intelligence | | | | | omputing methodologies<br>Artificial intelligence | No specific BoK are defined |
| | Natural Language Processing | | | | | | |
| | Knowledge Represer Reasoning | | | | | | |
| | Data mining and knc discovery | | | | | | |
| | Text analysis, Data n | | | | | | |
| | Text analytics includ linguistic, and struct techniques to analys and unstructured da | | | | | | |
| | Machine Learning th algorithms | | | | | | |
| | Classification metho | | | | | | |

| KAG/ LU# *) | Learning Unit (course name) [2] | Type/relevance [3] | | | | Map to DS-BoK, CCS2012 and known BoKs | |
|---|---|---|---|---|---|---|---|
| | | Tier 1 | Tier 2 | Elective | Pre requisite | CCS2012 based academic subjects | DS-BoK and other BoKs |
| | Data type registries, PID, metadata | | | | | Extended with the general Data Management Knowledge Areas and related academic subjects. | General Data Management KA's<br>Data Lifecycle Management<br>Data archives/storage compliance and certification<br>New KAs to support RDA recommendations and community data management models (Open Access, Open Data, etc)<br>Data type registries, PIDs<br>Data infrastructure and Data Factories<br>TBD – To follow RDA and ERA community developments |
| | Research data infrastructure, Open Science, Open Data, Open Access, ORCID | | | | | | |
| | *Extensibility point for adding new courses* | | | | | | |
| | Research methodology, research cycle | | | | | Extended with the general Scientific/Research Methods subjects and related academic subjects. | Suggested KAs to develop DSRM related competences:<br>Research methodology, research cycle (e.g. 4 step model Hypothesis – Research Methods – Artefact – |
| | Modelling and experiment planning | | | | | | |

- Mapping suggested to ACM CCS2012, DS-BoK and other related BoKs

# Outcome Based Educations and Training Model



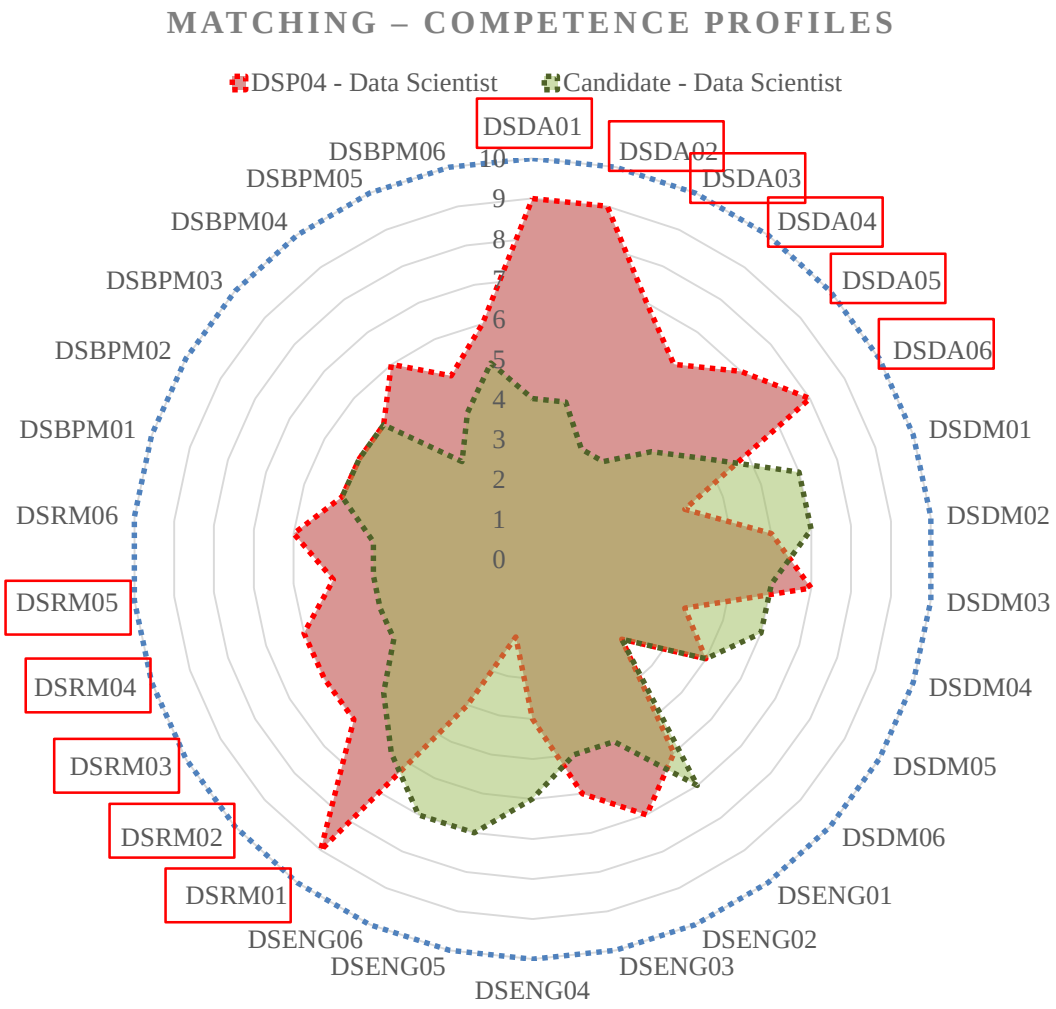

From Competences and DSP Profiles

to Learning Outcomes (LO) and

to Knowledge Unites (KU) and Learning Units (LU)

- EDSF allow for customized educational courses and training modules design

# Individual Competences Benchmarking

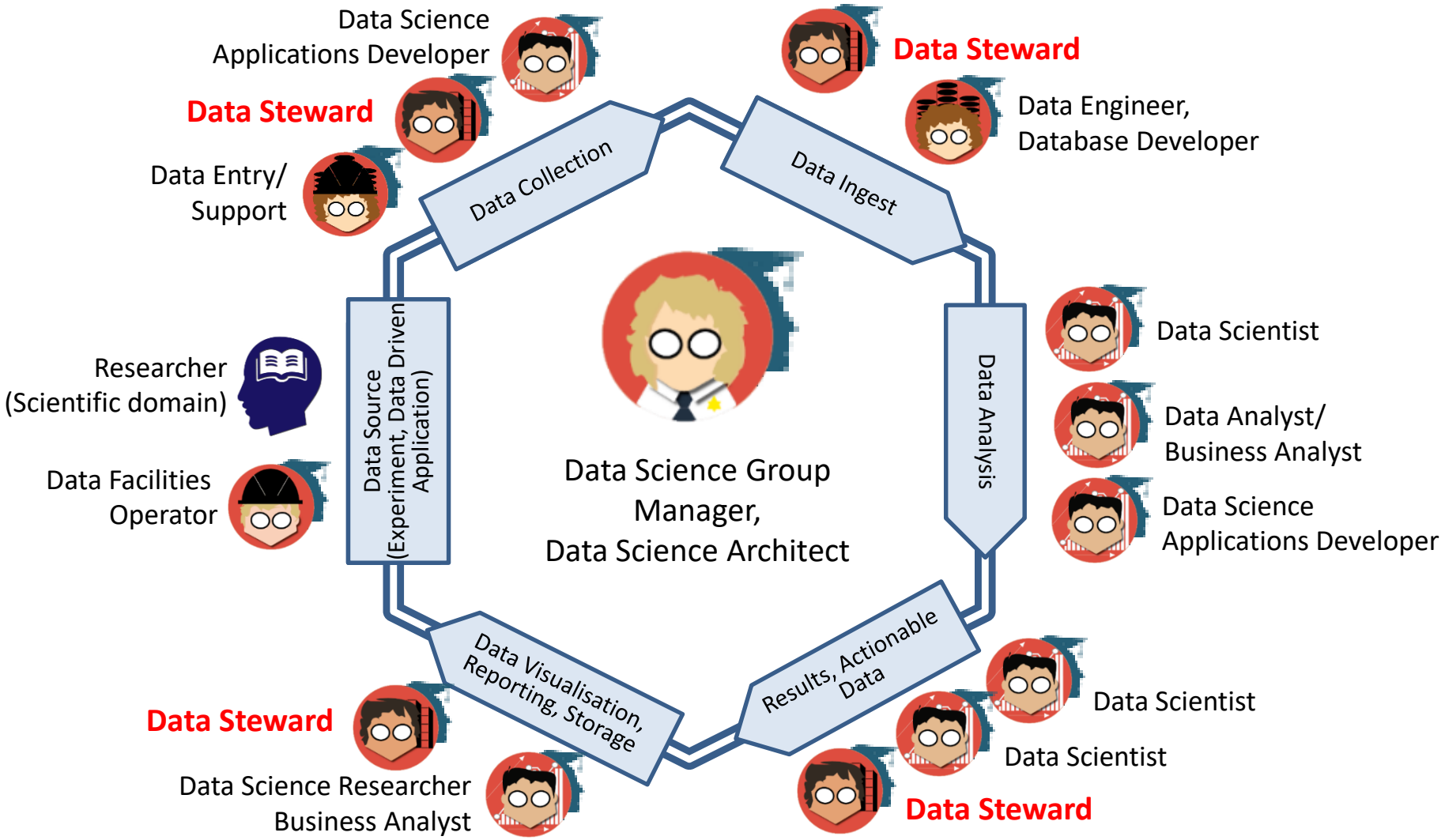



## Individual Education/Training Path based on Competence benchmarking

- Red polygon indicates the chosen professional profile: Data Scientist (general)
- Green polygon indicates the candidate or practitioner competences/skills profile
- Insufficient competences (gaps) are highlighted in *red*
  - *DSDA01 – DSDA06 Data Science Analytics*
  - *DSRM01 – DSRM05 Data Science Research Methods*
- Can be use for team skills match marking and organisational skills management

[ref] For DSP Profiles definition and for enumerated competences refer to EDSF documents CF-DS and DSP Profiles.

# Building a Data Science Team



# Data Science or Data Management Group/Department: Organisational structure and staffing - EXAMPLE

## Data Science or Data Management Group/Department

>> Reporting to CDO/CTO/CEO
- Providing cross-organizational services

- (Managing) Data Science Architect (1)
- Data Scientist (1), Data Analyst (1)
- Data Science Application programmer (2)
- Data Infrastructure/facilities administrator/operator: storage, cloud, computing (1)
- **Data stewards**, curators, archivists (3-5)

Estimated: Group of 10-12 data specialists for research institution of 200-300 research staff.

Growing role and demand for Data Stewards and data stewardship

# Data Stewards – A rising new role in Data Science ecosystem

- Data Stewards as a key bridging role between Data Scientists as (hard)core data experts and scientific domain researchers (HLEG EOSC report)
- Current definition of Data Steward (part of Data Science Professional profiles)
  - Data Steward is a data handling and management professional whose responsibilities include planning, implementing and managing (research) data input, storage, search, and presentation.
  - Data Steward creates data model for domain specific data, support and advice domain scientists/ researchers during the whole research cycle and data management lifecycle.

# Further developments and Next steps (1)

- Next EDSF release 2 (planned for June 2017) will link competences to skills and knowledge
- Final EDSF project deliverables (due August 2017) will include:
  - Data Science Education Sustainability Roadmap
    - Will involve wide consultation with experts community and also with EU policy makers
    - Will be reviewed by the EDISON Liaisons Groups (ELG)
  - Certification Framework for at least two levels of Data Science competences proficiency
    - Consultation with few certification providers is in the progress
- Toward EDSF and Data Science profession standardisation
  - ESCO (European Skills, Competences and Occupations) taxonomy – extending with the Data Science related occupations, competences and skills
  - CEN TC428 (European std body) – Extending current eCFv3.0 and ICT profiles towards e-CF4 with Data Science related competences
  - Work with the IEEE and ACM curriculum workshop to define Data Science Curriculum and extend current CCS2012 (Classification Computer Science 2012)
- Number of Case studies is planned in cooperation with active EU projects EDSA, EOSCpilot, BDVe, etc. (not limited to the project lifetime)

# Further developments and Next steps (2)

- The EDISON project legacy will include
  (linked to the current project website and migrated to CP in the future)
  - EDSF – EDISON Data Science Framework
  - Data Science Community Portal (CP) - http://datasciencepro.eu/
  - EDISON project network including
    - EDISON Liaison Groups
    - Data Science Champions conference
    - Cooperative networks with European Research Infrastructures (e.g. HEP, Bioinformatics, Environment and Biodiversity, Maritime, etc),
    - International cooperative links BHEF, APEC, IEEE, ACM
- Applications and tools development
  - Prototypes will be produced in the timeline of the project but further development is a subject to additional funding
- Sustainability of the project legacy/products will be ensured by the project partners voluntarily for the period at least 3 years
  - EDSF will be maintained by UvA
  - CP by Engineering (Italy)

# Further developments and Next steps (3)

- Further dissemination, engagement and outreach activity
  - Publishing final deliverables as BCP and books
  - Data Science Manifesto – Primarily focused on professional and ethical issues in Data Science, new type of professional
  - Inter-universities initiative “Data Science for UN’s Sustainable Development Goals” to focus in-curricula research (projects) on UN priority goals

- Wider engagement into EOSC activities related to RI data related skills management and capacity building

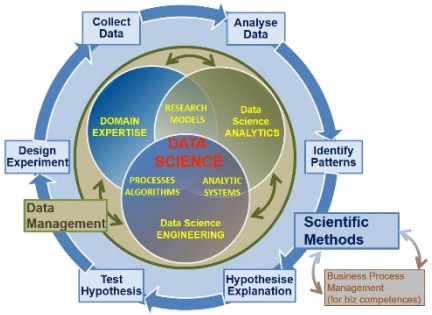
# Summary: Services and References

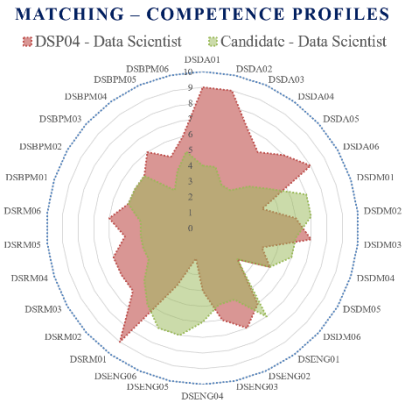
- EDISON Website http://edison-project.eu/
- EDISON Data Science Framework (EDSF) http://edison-project.eu/edison/edison-data-science-framework-edsf
- Directory of University programs http://edison-project.eu/university-programs-list
- Community Portal http://datasciencepro.eu/

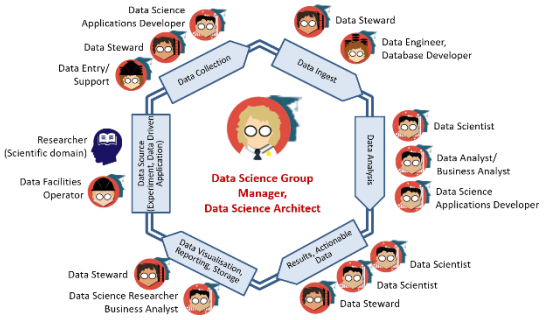
DATASCIENCEPRO

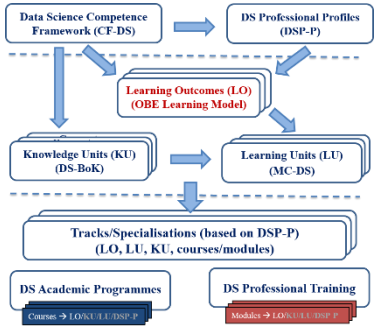
- Survey Data Science Competences: Invitation to participate https://www.surveymonkey.com/r/EDISON_project_-_Defining_Data_science_profession

- Competences benchmarking and tailored training for practitioners
- Data Science Curriculum advice and design for universities
- Data Science team building and organizational roles profiling



# Links to EDISON Resources

- EDISON project website http://edison-project.eu/

- EDISON Data Science Framework Release 1 (EDSF)
  http://edison-project.eu/edison-data-science-framework-edsf
  - Data Science Competence Framework
    http://edison-project.eu/data-science-competence-framework-cf-ds
  - Data Science Body of Knowledge
    http://edison-project.eu/data-science-body-knowledge-ds-bok
  - Data Science Model Curriculum
    http://edison-project.eu/data-science-model-curriculum-mc-ds
  - Data Science Professional Profiles
    http://edison-project.eu/data-science-professional-profiles-definition-dsp

- Survey Data Science Competences: Invitation to participate
  https://www.surveymonkey.com/r/EDISON_project_-_Defining_Data_science_profession

# Other related links

- Amsterdam School of Data Science
  - https://www.schoolofdatascience.amsterdam/
  - https://www.schoolofdatascience.amsterdam/education/
- Research Data Alliance interest Group on Education and Training on Handling of Research Data (IG-ETHRD)
  - https://www.rd-alliance.org/groups/education-and-training-handling-research-data.html
- Final Report on European Data Market Study by IDC (Feb 2017)
  - https://ec.europa.eu/digital-single-market/en/news/final-results-european-data-market-study-measuring-size-and-trends-eu-data-economy
- PwC and BHEF report “Investing in America’s data science and analytics talent: The case for action” (April 2017)
  - http://www.bhef.com/publications/investing-americas-data-science-and-analytics-talent
- Burning Glass Technology, IBM, and BHEF report “The Quant Crunch: How the demand for Data Science Skills is disrupting the job Market” (April 2017)
  - http://www.bhef.com/publications/quant-crunch-how-demand-data-science-skills-disrupting-job-market
  - https://public.dhe.ibm.com/common/ssi/ecm/im/en/iml14576usen/IML14576USEN.PDF

# Additional materials

# OECD and UN on Digital Economy and Data Literacy

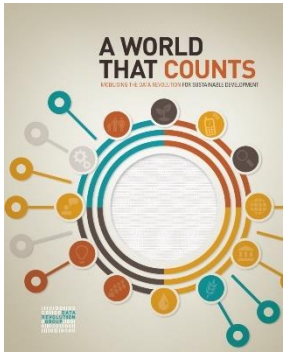
OECD

- Demand for new type of *"dynamic self-re-skilling workforce"*
- Continuous learning and professional development to become a shared responsibility of workers and organisations

[ref] SKILLS FOR A DIGITAL WORLD, OECD, 25-May-2016
http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/IIS(2015)10/FINAL&docLanguage=En

UN

- Data Revolution Report "A WORLD THAT COUNTS" Presented to Secretary-General (2014)
  http://www.undatarevolution.org/report/
- Data Literacy is defined as key for digital revolution
- **Data literacy** = critically analyse data collected and data visualised



# EDSF Recognition, Endorsement and Implementation

- **DARE (Data Analytics Rising Employment)** project by APEC (Asia Pacific Economic Cooperation)
  - DARE project Advisory Council meeting 4-5 May 2017, Singapore
- **PcW and BHEF Report "Investing in America's data science and analytics talent"** April 2017
  - Quotes EDSF and Amsterdam School of Data Science
- **Dutch Ministry of Education recommended EDSF** as a basis for university curricula on Data Science
  - Workshop "Be Prepared for Big Data in the Cloud: Dutch Initiatives for personalized medicine and health research & toward a national action programme for data science training", Amsterdam 28 June 2016
  - Currently working with Dutch Gov on re-skilling IT/data workers for DSA competences
- **European Champion Universities network**
  - 1st Conference (13-14 July, UK), 2nd Conference (14-15 March, Madrid, Spain)
  - 3rd Conference 19-20 June 2017, Warsaw

# What challenges related to skills management the EDSF can help to address?

1. Guide researchers in using right methods and tools, latest Data Analytics technologies to extracting value from scientific data
2. Educate and train RI engineers dev to build modern data intensive research infrastructure  and understand trends and project for future
3. Develop new data analytics tools and ensure continuous improvement (agile model, DevOps)
4. Correctly organise and manage data, make them accessible (adhering FAIR principles), education new profession of Data Stewards
5. Help managers to facilitate career dev for researchers and organise effective teams
6. Ensure skills and expertise sustain in organisation
7. Help research institutions to sustain in competition with industry and business in data science talent hunting