The Role of Dublin Core Metadata in the Expanding Digital and Analytical Skill Set Required by Data-Driven Organizations

Steve Brewer

Dublin Core Metadata Initiative – 12 July 2018

Infoculture Ltd

Outline of talk

- Introduction
- Context: digital transformation
- Data and metadata
- Data Science skills and competences: EDISON overview
- Conclusions and actions

Introduction

- World is changing
- Increasing dependency on data
- Data-driven transformations
- Skills and competences
- Compatibility and interoperability

EDISON Project value contribution and legacy:

Education and training for Data Science and data related competences

EDISON Data Science Framework (EDSF)

Yuri Demchenko, EDISON Project

University of Amsterdam

April 2018, Amsterdam

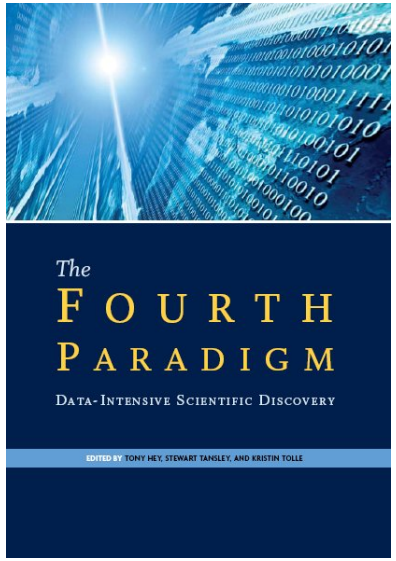
EDISON – **E**ducation for **D**ata **I**ntensive **S**cience to **O**pen **N**ew science frontiers

Grant 675419 (INFRASUPP-4-2015: CSA)

Outline of EDISON overview

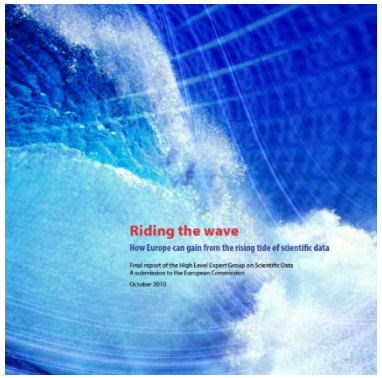
- Background: Data driven research and demand for new skills
  - Foundation, recent reports, studies and facts
- EDISON Data Science Framework (EDSF)
  - Data Science competences and skills
  - Essential Data Scientist professional skills: Thinking and doing like Data Scientist
- Data Science Professional Profiles
- Data Science Body of Knowledge and Model Curriculum
- Use of EDSF and Example curricula
  - Competences assessment
  - Building Data Science team
- Roadmap recommendations
- References and additional materials

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)
https://ec.europa.eu/research/openscience/pdf/realising_the_european_open_science_cloud_2016.pdf

Emergence of Cognitive Technologies
(IBM Watson, Cortana and others)

Initiatives: GO FAIR and IFDS

- Global Open FAIR
  - Findable – Accessible – Interoperable - Reusable
- IFDS – Internet of FAIR Data and Services = EOSC
- GO FAIR implementation approach
  - GO-TRAIN: Training of data stewards capable of providing FAIR data services
  - FAIRdICT: Top Sector Health collaboration with top team ICT
- A critical success factor is availability of expertise in data stewardship
  - Training of a new generation of FAIR data experts is urgently needed to provide the necessary capacity

https://www.dtls.nl/fair-data/

https://www.dtls.nl/fair-data/go-fair/

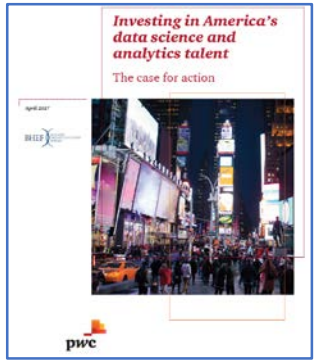
https://www.dtls.nl/fair-data/fair-data-training/

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
  - 2.35 mln postings, 23% Data Scientist, 67% DSA enabled jobs
  - DSA enabled jobs growing at higher rate than main Data Science jobs

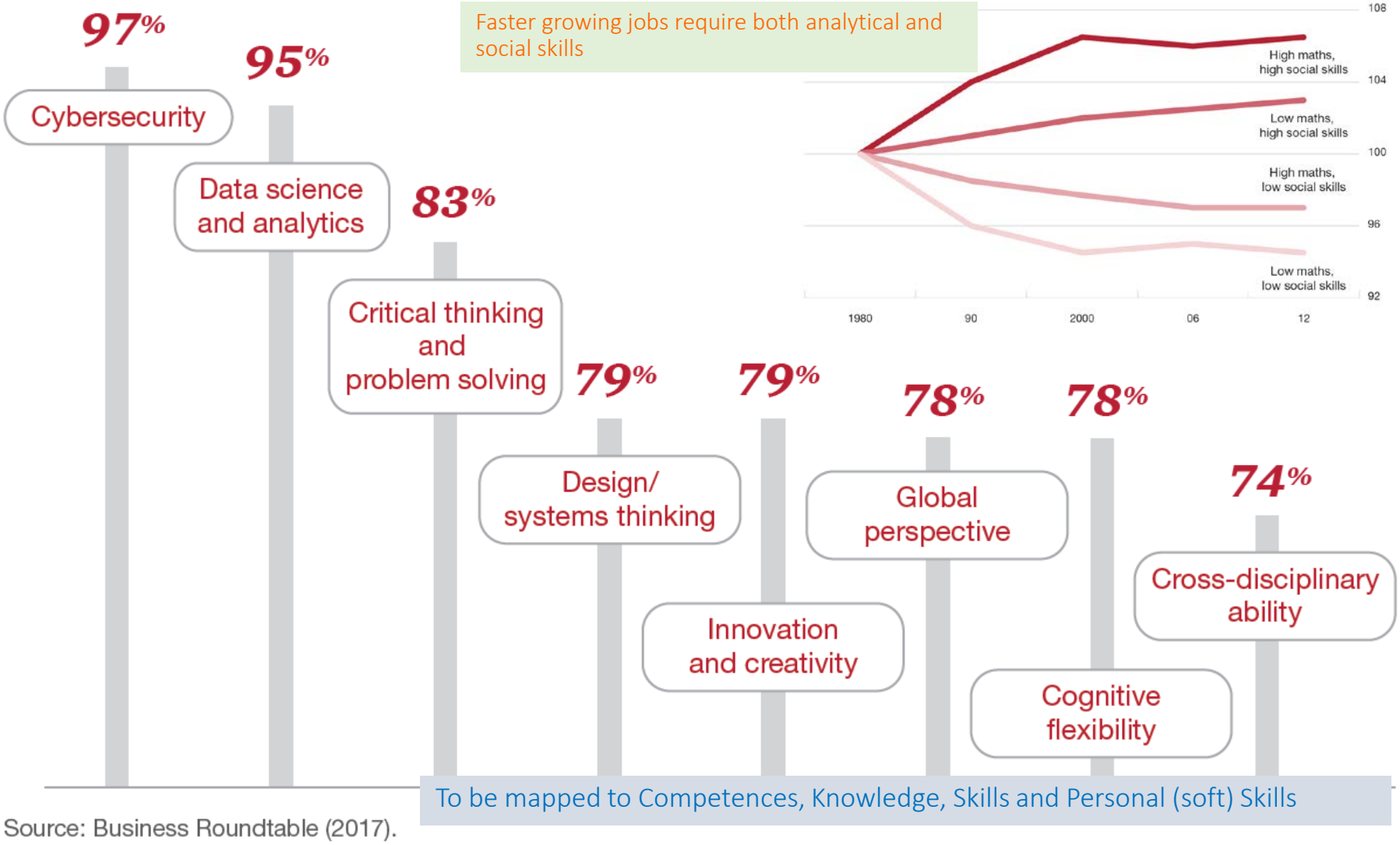
- Burning Glass Technology, IBM, and BHEF report "The Quant Crunch: How the demand for Data Science Skills is disrupting the job Market" (April 2017)
  - https://public.dhe.ibm.com/common/ssi/ecm/im/en/iml14576usen/IML14576USEN.PDF
  - DSA enabled jobs takes 45-58 days to fill: 5 days longer than average
  - Commonly required work experience 3-5 yrs



Citing EDISON and EDSF

Influenced by EDISON

PwC&BHEF: Skills that are tough to find



Source: Business Roundtable (2017).

Faster growing jobs require both analytical and social skills

Figure 8: The fastest-growing job areas require both analytical and social skills
US, change in employment skills by skills required, 1980 = 100

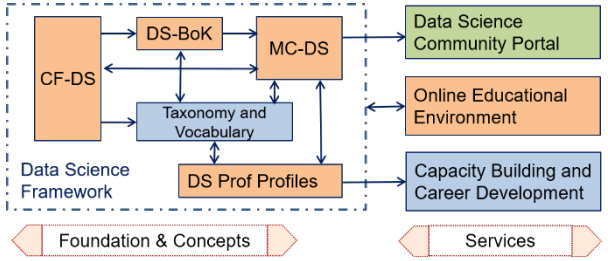
To be mapped to Competences, Knowledge, Skills and Personal (soft) Skills

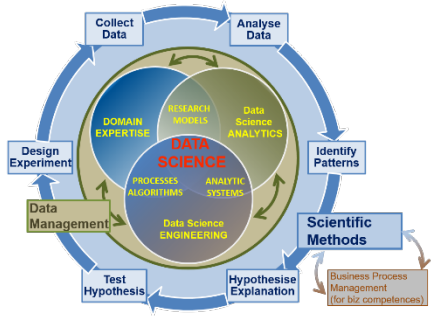
Challenge for Education: Sustainable ICT and Data Skills Development

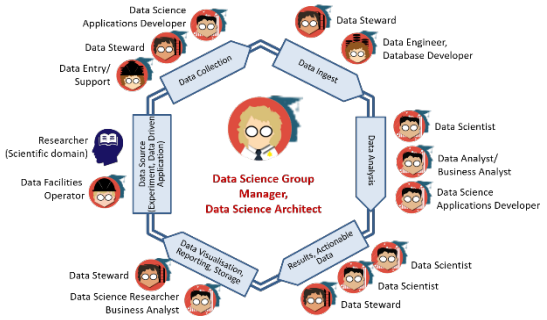
- Educate vs Train
  - Training is a short term solution
  - Education is a basis for sustainable skills development
- Technology focus changes every 3-4 years
  - Study: 50% of academic curricula are outdated at the time of graduation
- Lack of necessary skills leads to *underperforming projects* and organisations and *loose of competitiveness*
  - Challenge: Policy and decision makers still don't include planning human factor (competences and skills) as a part of the technology strategy
- Need to change the whole skills management paradigm
  - **Dynamic (self-) re-skilling:** Continuous professional development and **shared responsibility between employer and employee**
  - Professional and workplace skills and career management as a part of professional orientation
- Millennials factor and changing nature of workforce

EDISON Products for Data Science Skills Management and Tailored Education

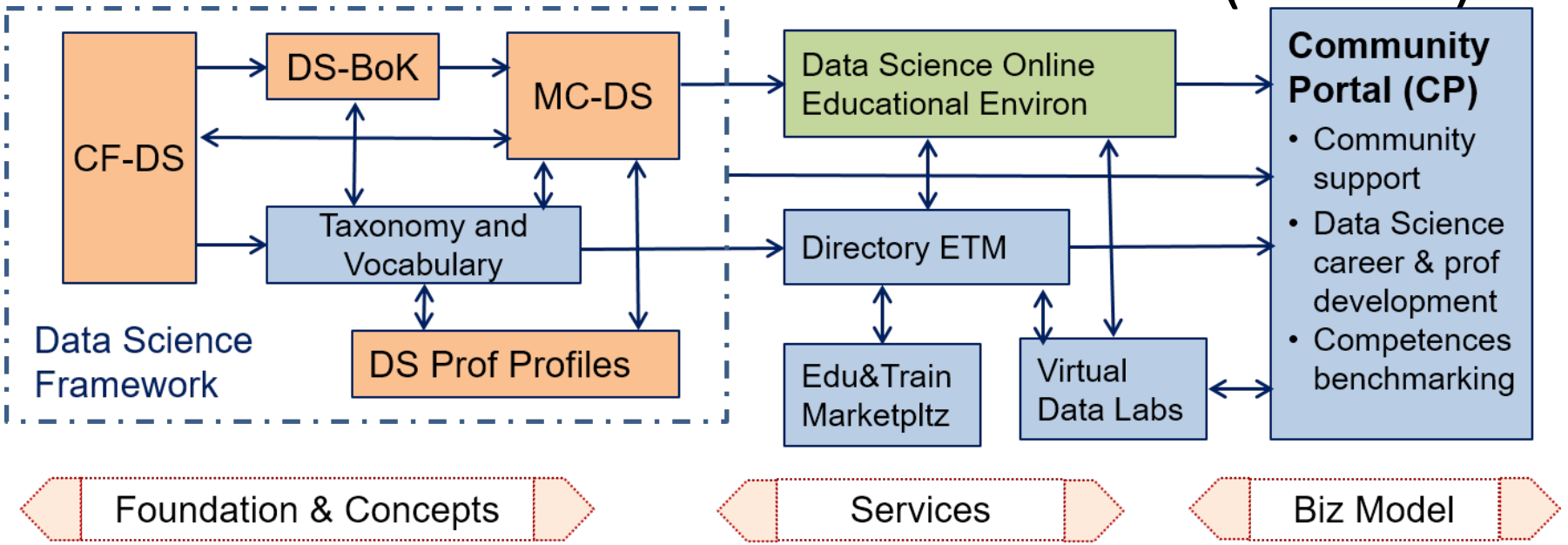
- EDISON Data Science Framework (EDSF)
  - Compliant with EU standards on competences and professional occupations e-CFv3.0, ESCO
  - Customisable courses design for targeted education and training
- Skills development and career management for Core Data Experts and related data handling professions
- 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

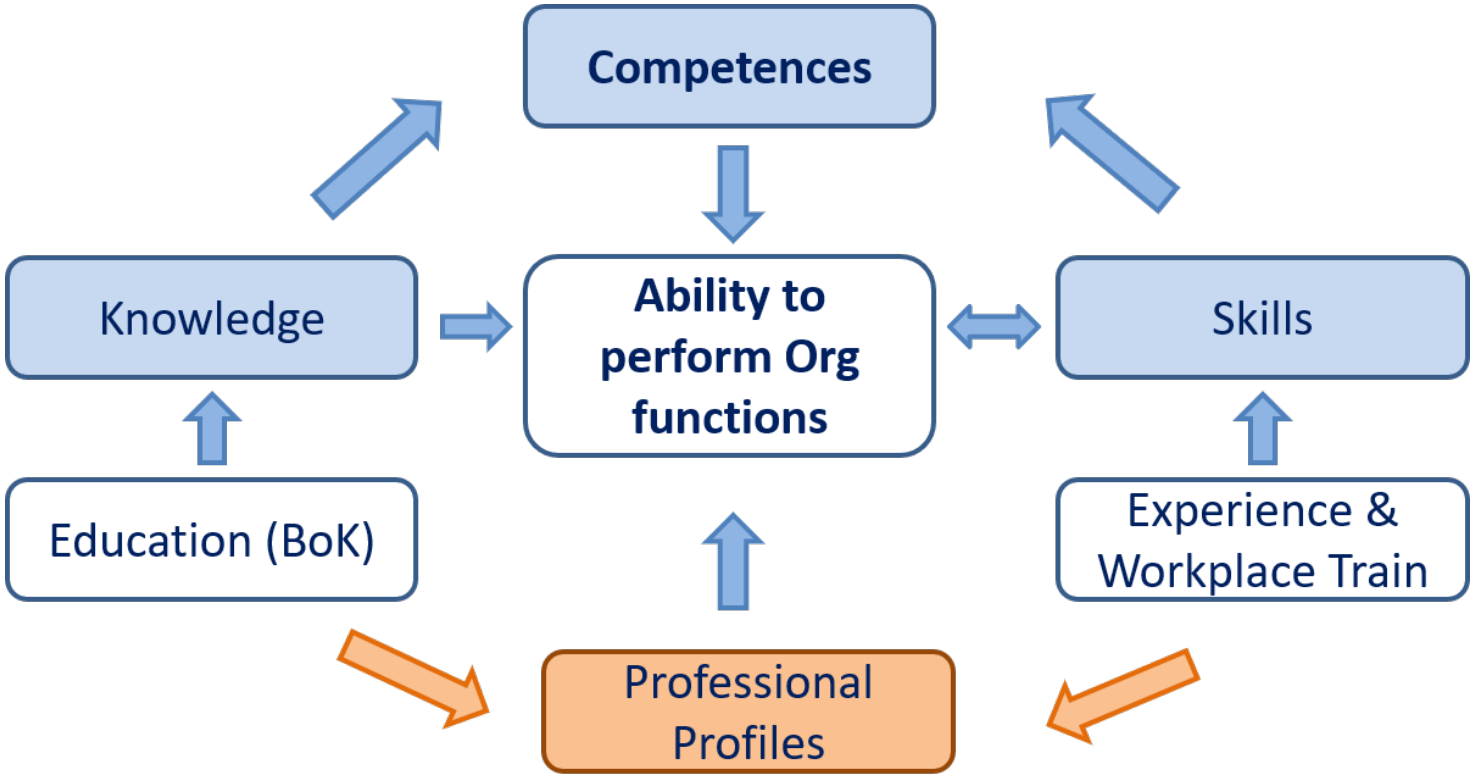
- ESDF development based on job market study, existing practices in academic, research and industry.
- Review and feedback from the ELG, expert community, domain experts.
- Input from the champion universities and community of practice.

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

Competences Map to Knowledge and Skills

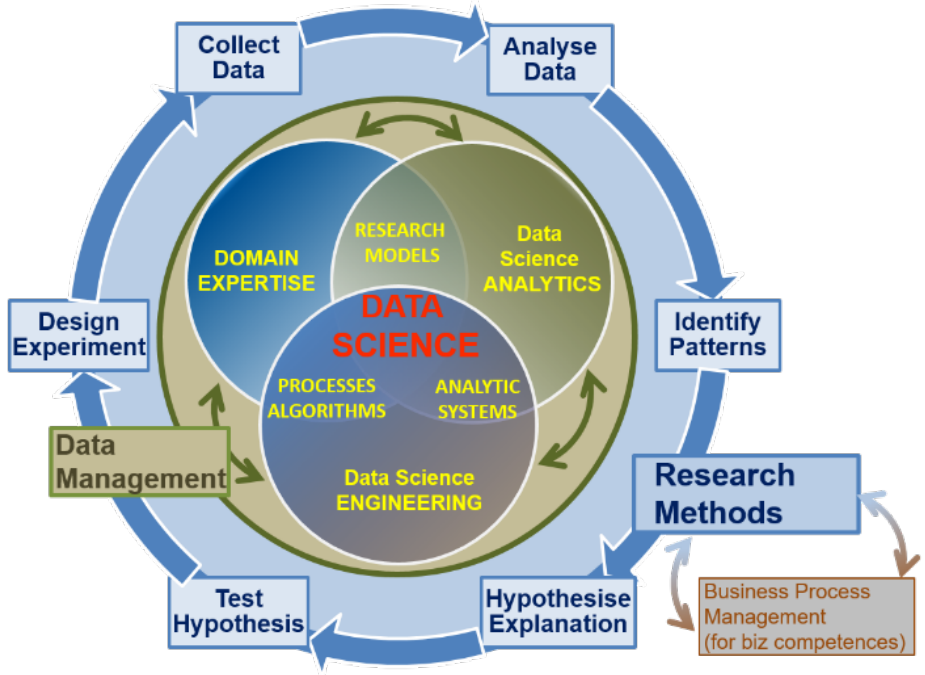
- **Competence** is a demonstrated ability to apply knowledge, skills and attitudes for achieving observable results



Data Scientist definition

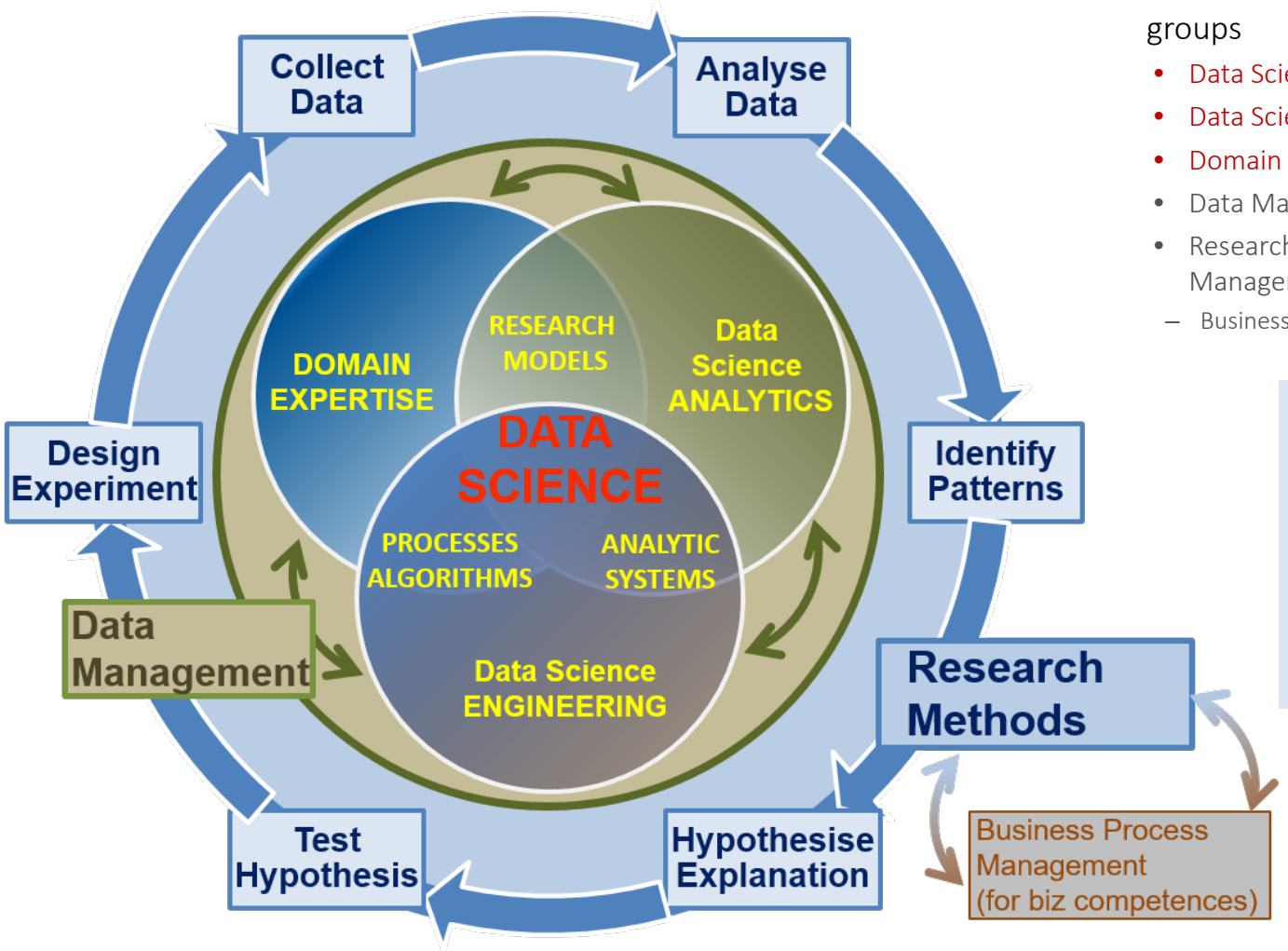
Based on the definitions by NIST SP1500 – 2015, extended by EDISON

- *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 organisation or project.*



- Core Data Science competences and 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 2 additional competence groups demanded by organisations
  - Data Management, Data Governance, Stewardship, Curation, Preservation
  - Research Methods and/vs Business Processes/Operations
- 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
- Research Methods and Project Management
  - Business Process Management (biz)

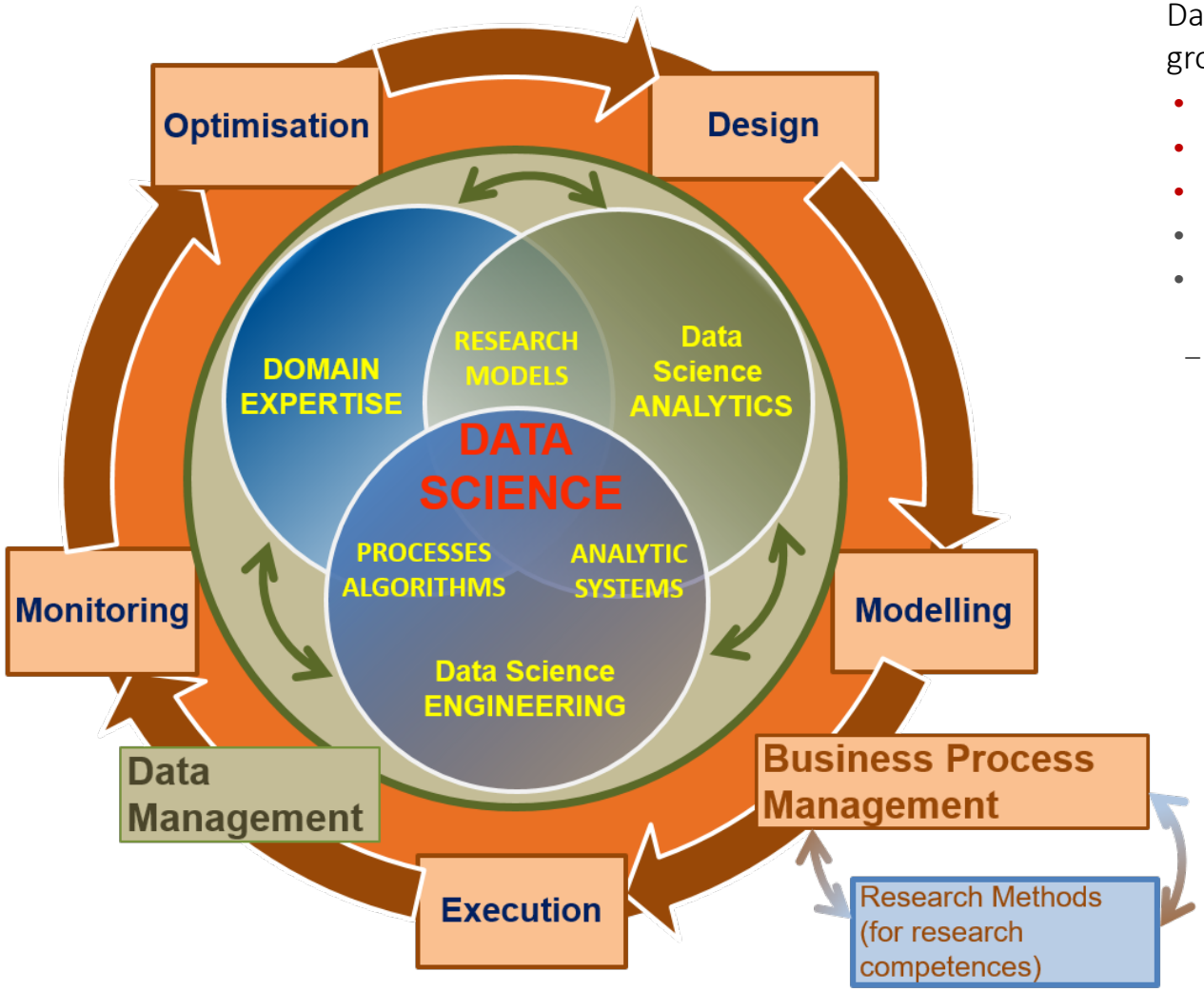
Scientific Methods

- 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



Data Science Competences include 5 groups

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  - Business Process Management (biz)

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 Science Engineering (DSENG)	Data Management and Governance (DSDM)	Research/Scientific Methods and Project Management (DSRMP)	Data Science Domain Knowledge, e.g. Business Analytics (DSDK/DSBPM)
0	Use appropriate data analytics and statistical techniques on available data to deliver insights into research problem or org. processes and support decision making	Use engineering principles and modern computer technology to research, design, implement new data analytics applications, develop experiments, processes, instruments, systems and infrastructures to support data handling during the whole data lifecycle	Develop and implement data management strategy for data collection, storage, preservation, and availability for further processing.	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	DSDK/DSBA Use domain knowledge (scientific or business) to develop relevant data analytics applications; adopt general Data Science methods to domain specific data types and presentations, data and process models, organisational roles and relations
1	**DSDA01** Effectively use variety of data analytics techniques	**DSENG01** Use engineering principles (general and software) to research, design, develop and implement new instruments and applications	DSDM01 Develop and implement data strategy, in particular, Data Management Plan (DMP)	**DSRMP01** Create new understandings and capabilities by using scientific/ research methods	**DSBPM01** Understand business and provide insight, translate unstructured business problems into an abstract mathematical framework
2	**DSDA02** Apply designated quantitative techniques	**DSENG02** Develop and apply computer methods to domain related problems	DSDM02 Develop data models including metadata	**DSRMP02** Direct systematic study toward a fuller knowledge or understanding of the observable facts	**DSBPM02** Participate strategically and tactically in financial decisions
3	**DSDA03** Pull together data from diff sources …	**DSENG03** Develop and prototype data analytics applications	DSDM03 Collect integrate data	**DSRMP03** Undertakes creative work	**DSBPM03** Provides support services to other
4	**DSDA04** Use diff perform techniques	**DSENG04** Develop, deploy operate Big Data storage	DSDM04 Maintain repository	**DSRMP04** Translate strategies into actions	**DSBPM04** Analyse data for marketing
5	**DSDA05** Develop analytics applic	**DSENG05** Apply security mechanisms	DSDM05 Visualise cmplx data	**DSRMP05** Contribute to organis goals	**DSBPM05** Analyse optimise customer relatio
6	**DSDA06** Visualise results of analysis, dashboards	**DSENG06** Design, build, operate SQL and NoSQL	**DSRM06** Develop and manage prolicies	**DSRMP06** Develop and guide data driven projects	**DSBPM06** Analyse data for marketing

Identified Data Science *Skills/Experience* Groups

Skills Type A – Based on knowledge acquired

- **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)
- **Group 2: Mathematics and statistics**
  - Mathematics and Statistics and others

Skills Type B – Base on practical or workplace experience

- **Group 3: 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 4: Data analytics programming languages and IDE**
  - General and specialized development platforms for data analysis and statistics
- **Group 5: Soft skills and Workplace skills**
  - Data Science professional skills: Thinking and Acting like Data Scientist
  - 21st Century Skills: Personal, inter-personal communication, team work, professional network

Data Science Professional Skills: Thinking and Acting like Data Scientist (1)

1. **Recognise value of data**, work with raw data, exercise good data intuition, use SN and Open Data
2. Accept (be ready for) **iterative development**, know when to stop, comfortable with failure, accept the symmetry of outcome (both positive and negative results are valuable)
3. Good **sense of metrics**, understand importance of the results validation, never stop looking at individual examples
4. **Ask the right questions**
5. **Respect domain/subject matter knowledge** in the area of data science
6. **Data driven problem solver** and **impact-driven mindset**
7. **Be aware about power and limitations** of the main machine learning and data analytics algorithms and tools
8. 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

Data Science Professional Skills: Thinking and Acting like Data Scientist (2)

9. Recognise what things are **important** and what things are **not important** (in data modeling)
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)

21st Century Skills (DARE & BHEF & EDISON)

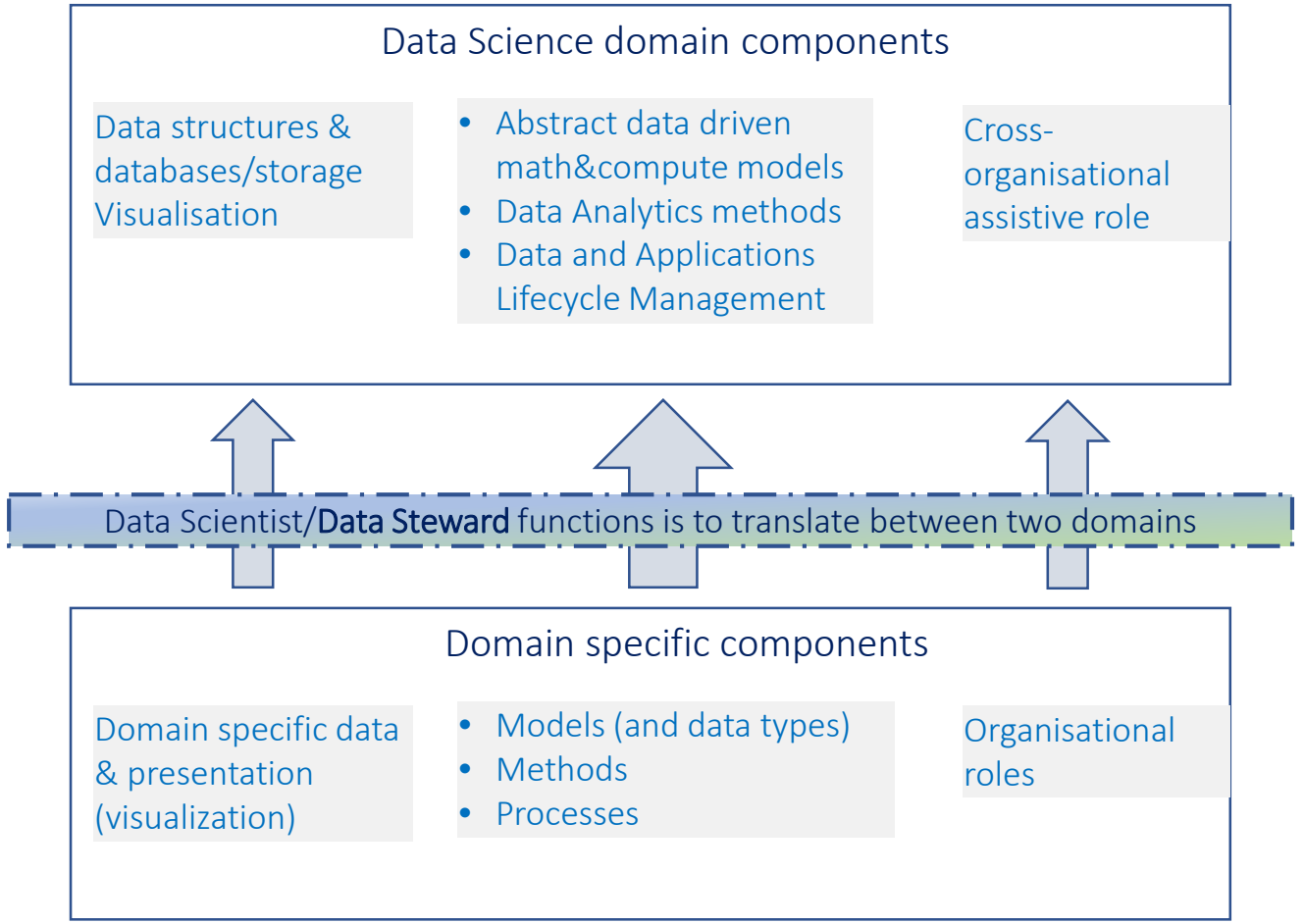
1. **Critical Thinking:** Demonstrating the ability to apply critical thinking skills to solve problems and make effective decisions
2. **Communication:** Understanding and communicating ideas
3. **Collaboration:** Working with other, appreciation of multicultural difference
4. **Creativity and Attitude:** 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 Scientist and Subject Domain Specialist

- **Subject domain components**
  - Model (and data types)
  - Methods
  - Processes
  - Domain specific data and presentation/visualization methods
  - Organisational roles and relations

- **Data Scientist is an assistant to Subject Domain Specialists**
  - Translate subject domain Model, Methods, Processes into abstract data driven form
  - Implement computational models in software, build required infrastructure and tools
  - Do (computational) analytic work and present it in a form understandable to subject domain
  - Discover new relations originated from data analysis and advice subject domain specialist
  - Present/visualise information in domain related actionable way
  - Interact and cooperate with different organizational roles to obtain data and deliver results and/or actionable data

Data Science and Subject Domains



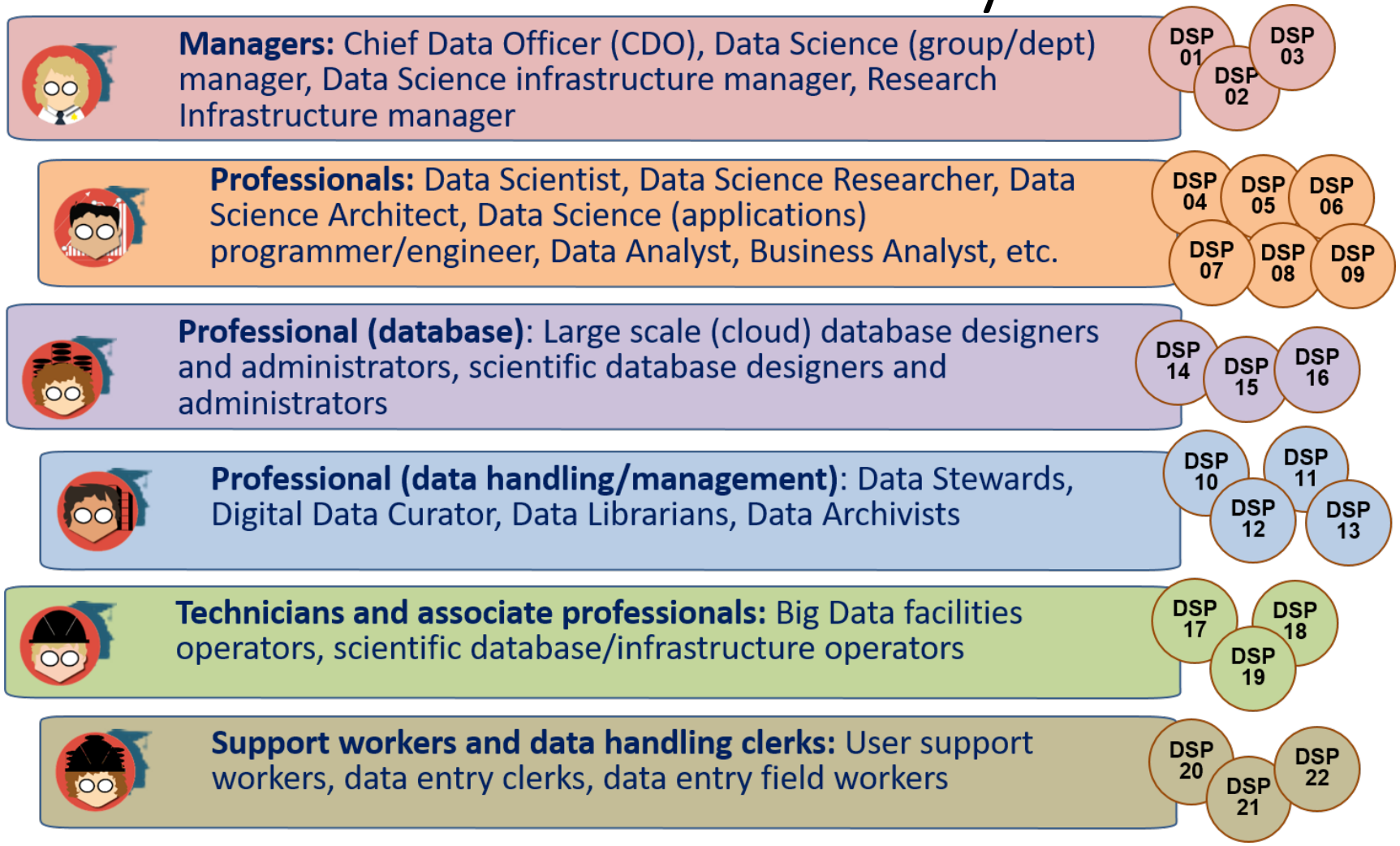
Data Scientist role is to maintain the Data Value Chain (domain specific):

- Data Integration => Organisation/Process/Business Optimisation => Innovation

Practical Application of the CF-DS

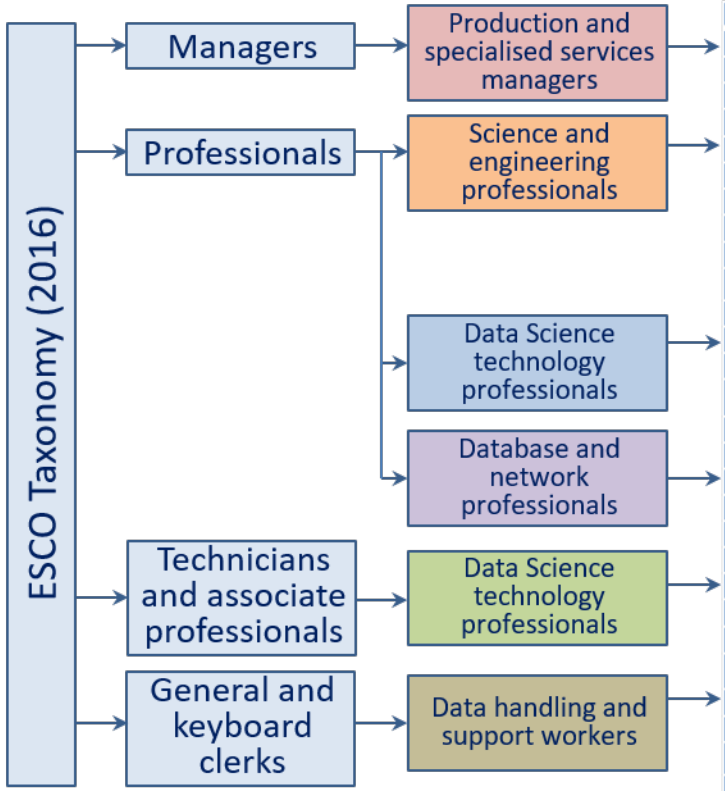
- Basis for the definition of the Data Science Body of Knowledge (DS-BoK) and Data Science Model Curriculum (MC-DS)
  - CF-DS => Learning Outcomes (MC-DS) => Knowledge Areas (DS-BoK)
  - CF-DS => Data Science taxonomy of scientific subjects and vocabulary
- Data Science professional profiles definition
  - 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

Data Science Professions Family



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

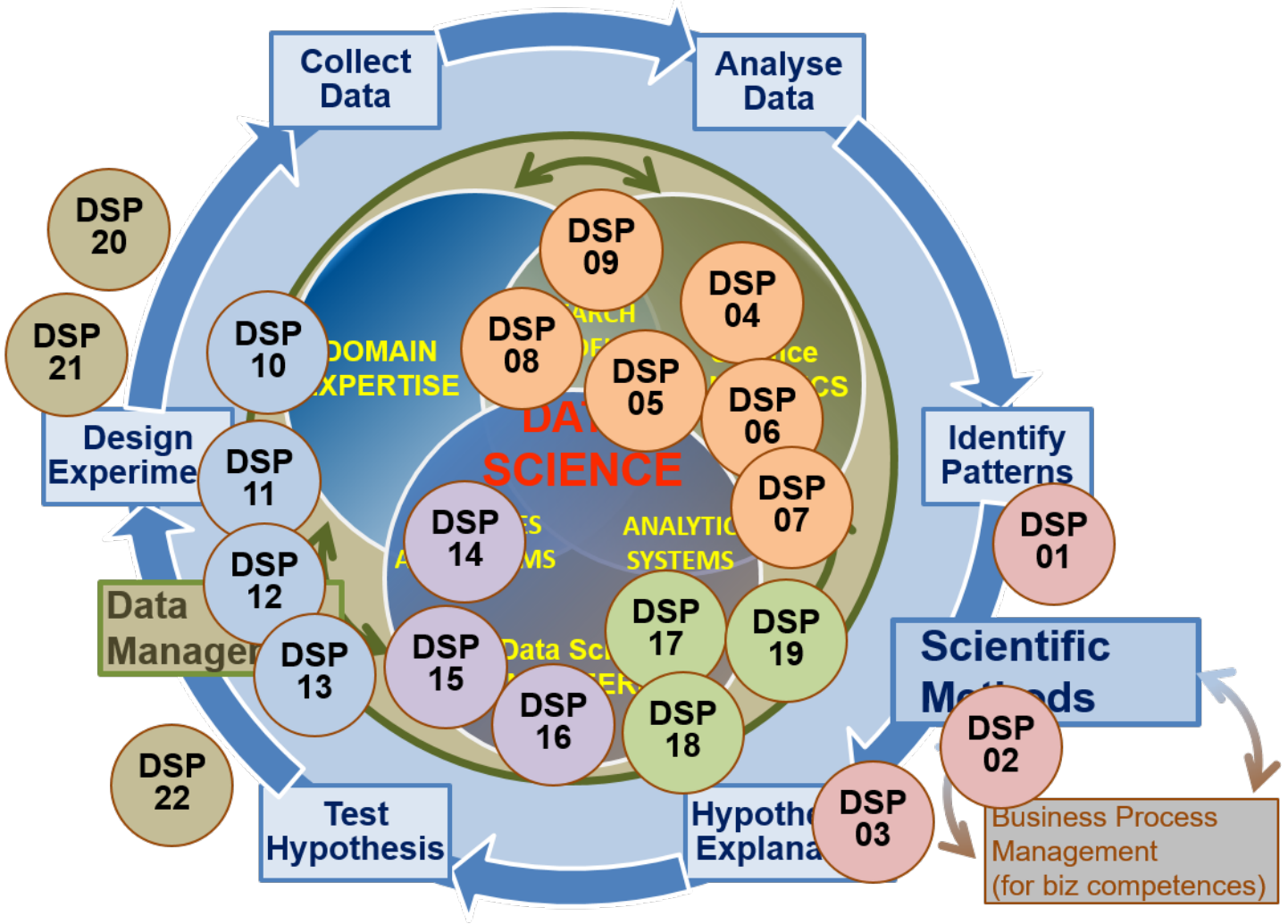
DSP Profiles mapping to ESCO Taxonomy High Level Groups



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

CF-DS and Data Science Professional Profiles



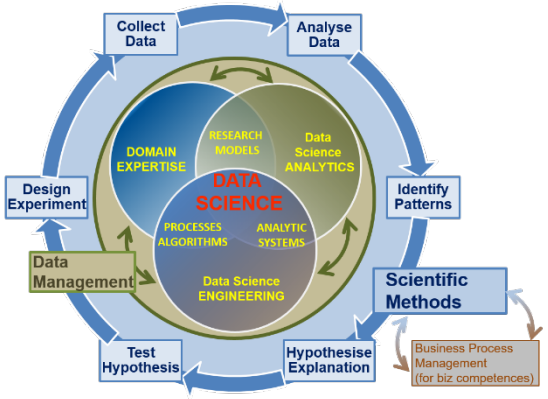
Example DS Professional Profile Definition (compliant with CWA)

Profile title	**Gives a commonly used name to a profile. TEMPLATE**		
Summary statement	**Indicates the main purpose of the profile.** **The purpose is to present to stakeholders and users a brief, concise understanding of the specified ICT Profile. It should be understandable by ICT professionals, ICT managers and Human Resource personnel. It should provide a statement of the job's main activity.**		
Mission	**Describes the rationale of the profile.** **The purpose is to specify the designated job role defined in the ICT Profile.**		
Deliverables	Accountable (A)	Responsible (R)	**Contributor (C)**
	Specifies the Profile by key deliverables. **The purpose is to illuminate the ICT Profiles and to explain relevance including the perspective from a non-ICT point of view.**		
Main task/s	**Provides a list of typical tasks to be performed by the profile.** **A task is an action taken to achieve a result within a broadly defined context. Tasks may be associated with deadlines, resources, goals, specifications and/or the expected results.**		
e-CF competences assigned	**Provides a list of necessary competences (from the e-CF) to carry out the mission.** **Must include 1 up to 5 competences.** **Level assignment is important. Can be (usually) 1 or (maximum) 2 levels.**		
KPI Area	**Based upon KPIs (Key Performance Indicators) KPI area is a more generic indicator, congruent with the overall profile granularity level. It is deployed to add depth to the mission.** **Not prescriptive. Non-specific measurements. Use general examples.** **The principle is to provide KPI areas (which are stable, general and long lasting) providing users with an inspiration to enable development of specific KPI's for specific roles** **Must be related to the key deliverables in order to measure them.**		

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 and Project Management group*
- KAG5-DSBA: Business Analytics and Business Intelligence

- KAG* - DSDK: Data Science domain knowledge to be defined by related expert groups

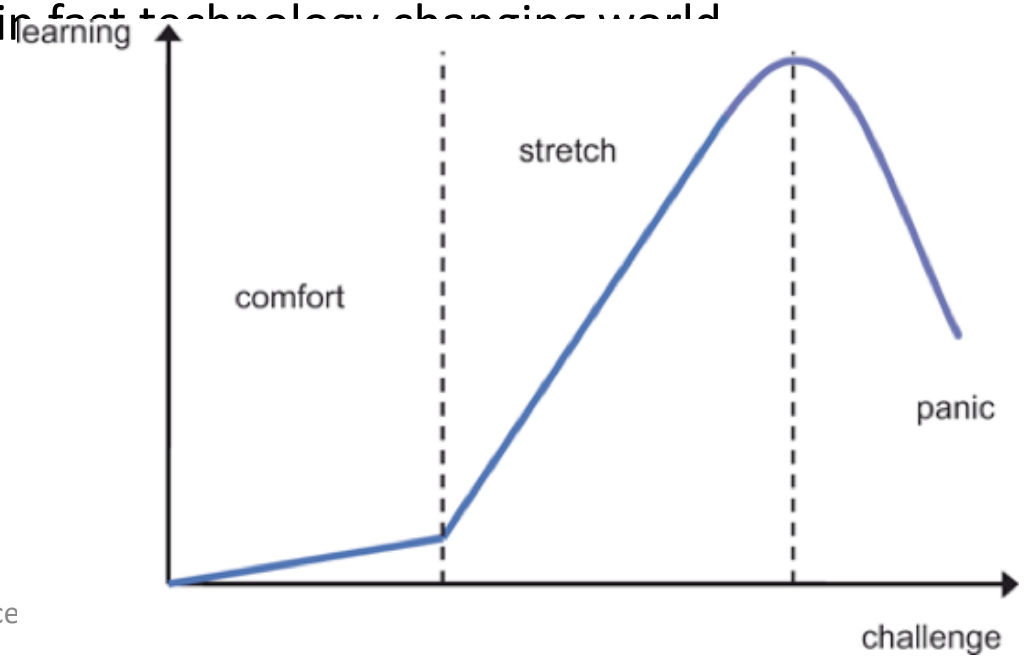
Data Science Model Curriculum (MC-DS)

Data Science Model Curriculum includes

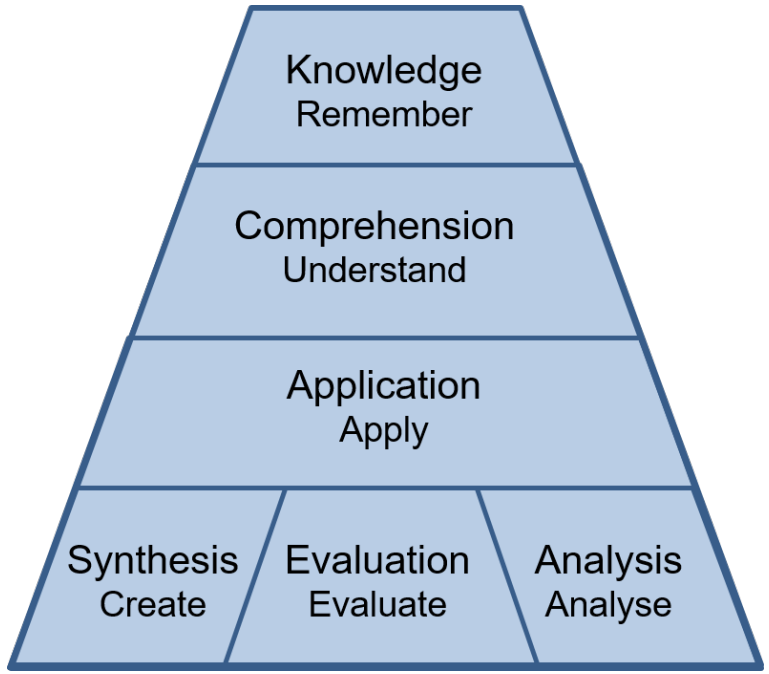
- Learning Outcomes (LO) definition based on CF-DS
  - LOs are defined for CF-DS competence groups and for all enumerated competences
  - Knowledge levels: Familiarity, Usage, Assessment (based in Bloom's Taxonomy)
- LOs mapping to Learning Units (LU)
  - LUs are based on CCS(2012) and universities best 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)

Learning methods and learning models

- Bloom's Taxonomy and Cognitive learning activities
  - BT application areas and limitations
- Constructive Alignment and Intended Learning Outcome (ILO)
  - ILO is formulated from the student perspective
  - Outcome Based Learning (OBL)
- Other education technologies for teaching in fast technology changing world
  - Project Based Learning (PBL)
  - Flipped classroom
  - Activating teaching and activating strategies



Bloom's Taxonomy and Knowledge Levels for MC-DS



Level	Action Verbs
Familiarity	Choose, Classify, Collect, Compare, Configure, Contrast, Define, Demonstrate, Describe, Execute, Explain, Find, Identify, Illustrate, Label, List, Match, Name, Omit, Operate, Outline, Recall, Rephrase, Show, Summarize, Tell, Translate
Usage	Apply, Analyze, Build, Construct, Develop, Examine, Experiment with, Identify, Infer, Inspect, Model, Motivate, Organize, Select, Simplify, Solve, Survey, Test for, Visualize
Assessment	Adapt, Assess, Change, Combine, Compile, Compose, Conclude, Criticize, Create, Decide, Deduct, Defend, Design, Discuss, Determine, Disprove, Evaluate, Imagine, Improve, Influence, Invent, Judge, Justify, Optimize, Plan, Predict, Prioritize, Prove, Rate, Recommend, Solve

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- Learning methods and learning models (in progress)

Data Science Engineering (KAG2-DSENG)

- KA02.01 (DSENG/BDI) Big Data infrastructure and technologies, including NOSQL databased, platforms for Big Data deployment and technologies for large-scale storage;
- KA02.02 (DSENG/DSIAPP) Infrastructure and platforms for Data Science applications, including typical frameworks such as Spark and Hadoop, data processing models and consideration of common data inputs at scale;
- KA02.03 (DSENG/CCT) Cloud Computing technologies for Big Data and Data Analytics;
- KA02.04 (DSENG/SEC) Data and Applications security, accountability, certification, and compliance;
- KA02.05 (DSENG/BDSE) Big Data systems organization and engineering, including approached to big data analysis and common MapReduce algorithms;
- KA02.06 (DSENG/DSAPPD) Data Science (Big Data) application design, including languages for big data (Python, R), tools and models for data presentation and visualization;
- KA02.07 (DSENG/IS) Information Systems, to support data-driven decision making, with focus on data warehouse and data centers.

KAG3-DSDM: *Data Management group: data curation, preservation and data infrastructure*

DM-BoK version 2 “Guide for performing data management”
– 11 Knowledge Areas

(1) Data Governance

(2) Data Architecture

(3) Data Modelling and Design

(4) Data Storage and Operations

(5) Data Security

(6) Data Integration and Interoperability

(7) Documents and Content

(8) Reference and Master Data

(9) Data Warehousing and Business Intelligence

(10) Metadata

(11) Data Quality

Other Knowledge Areas motivated by RDA, European Open Data initiatives, European Open Data Cloud

(12) PID, metadata, data registries

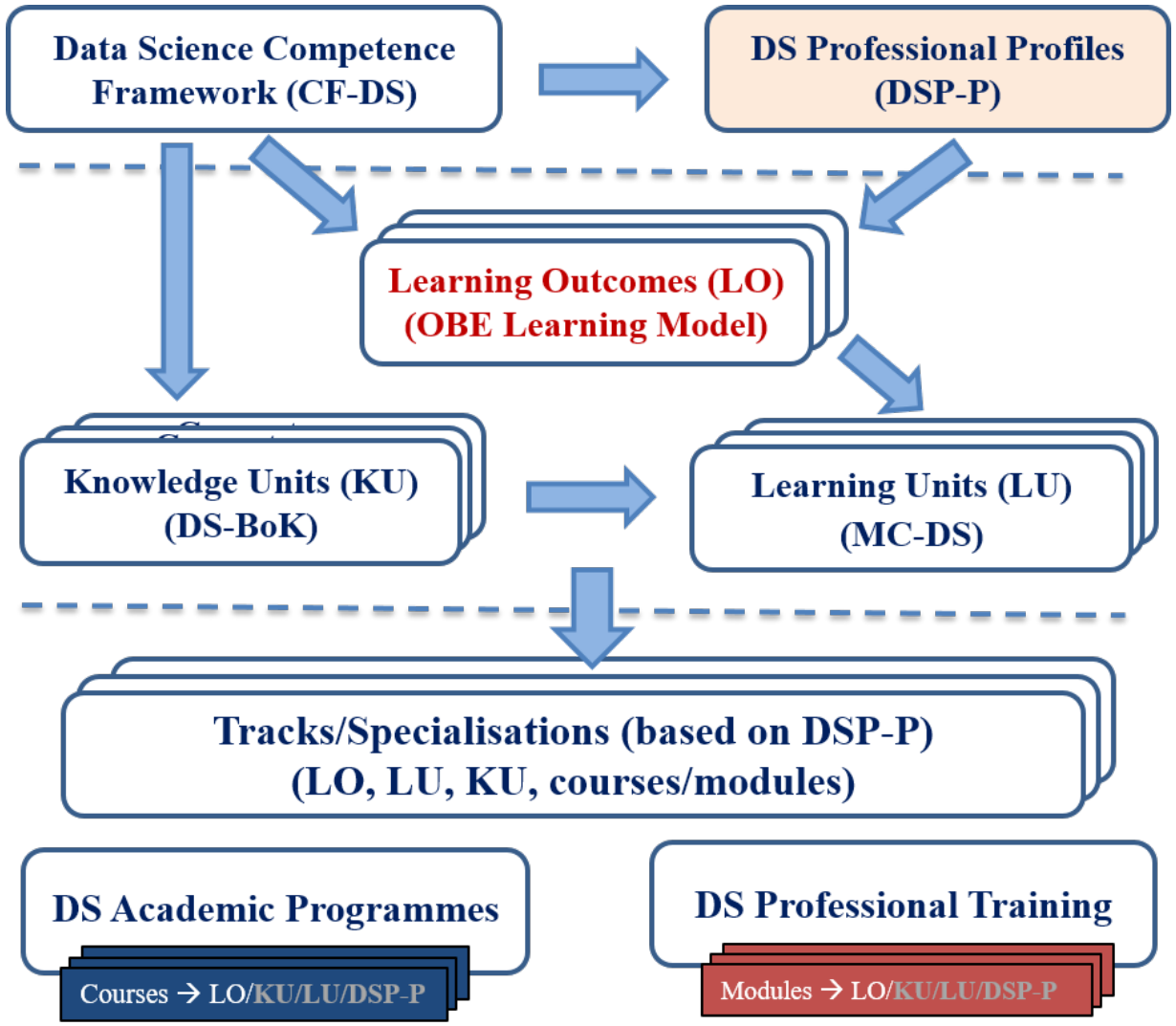
(13) Data Management Plan

(14) Open Science, Open Data, Open Access, ORCID

(15) Responsible data use

- Highlighted in red: Considered (Research) Data Management literacy (minimum required knowledge)

Outcome Based Educations and Training Model



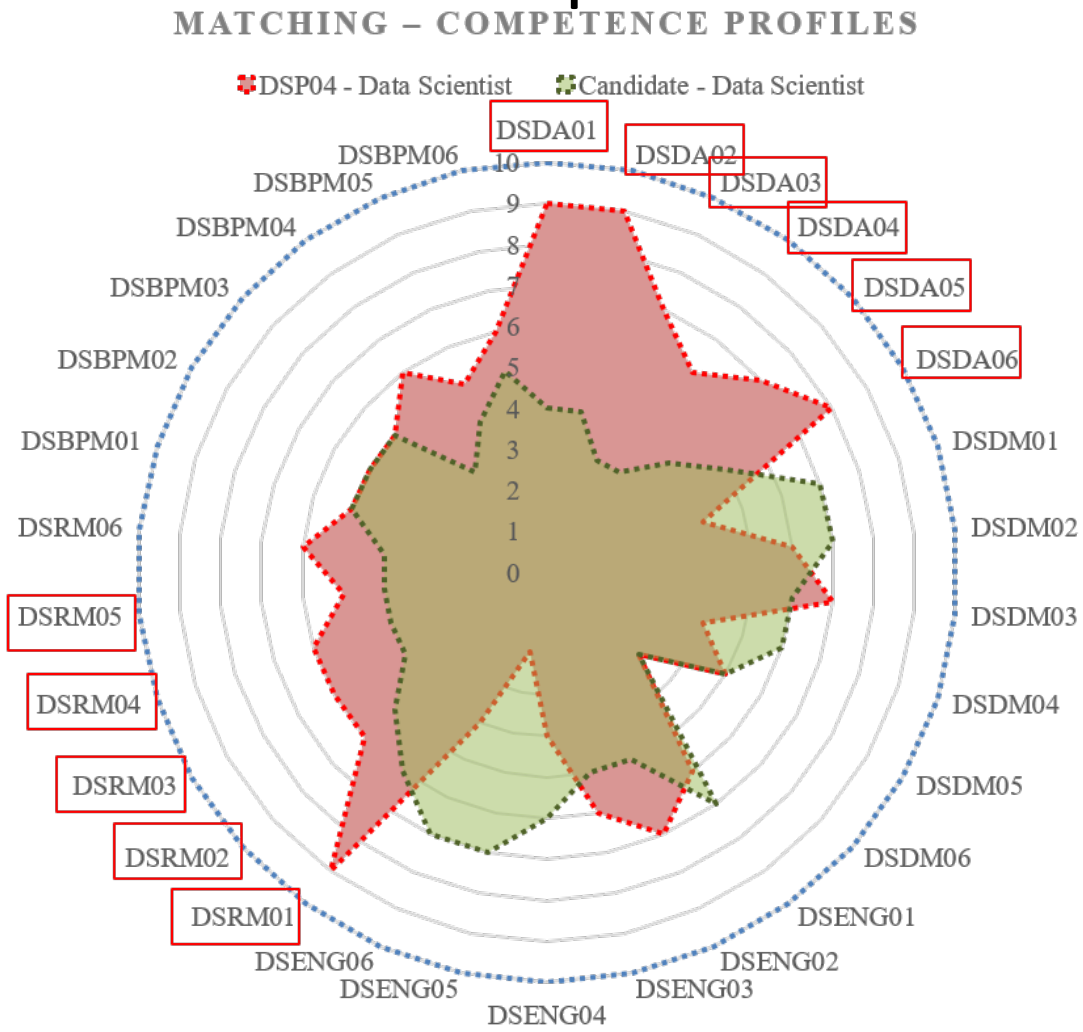
From Competences and DSP Profiles

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

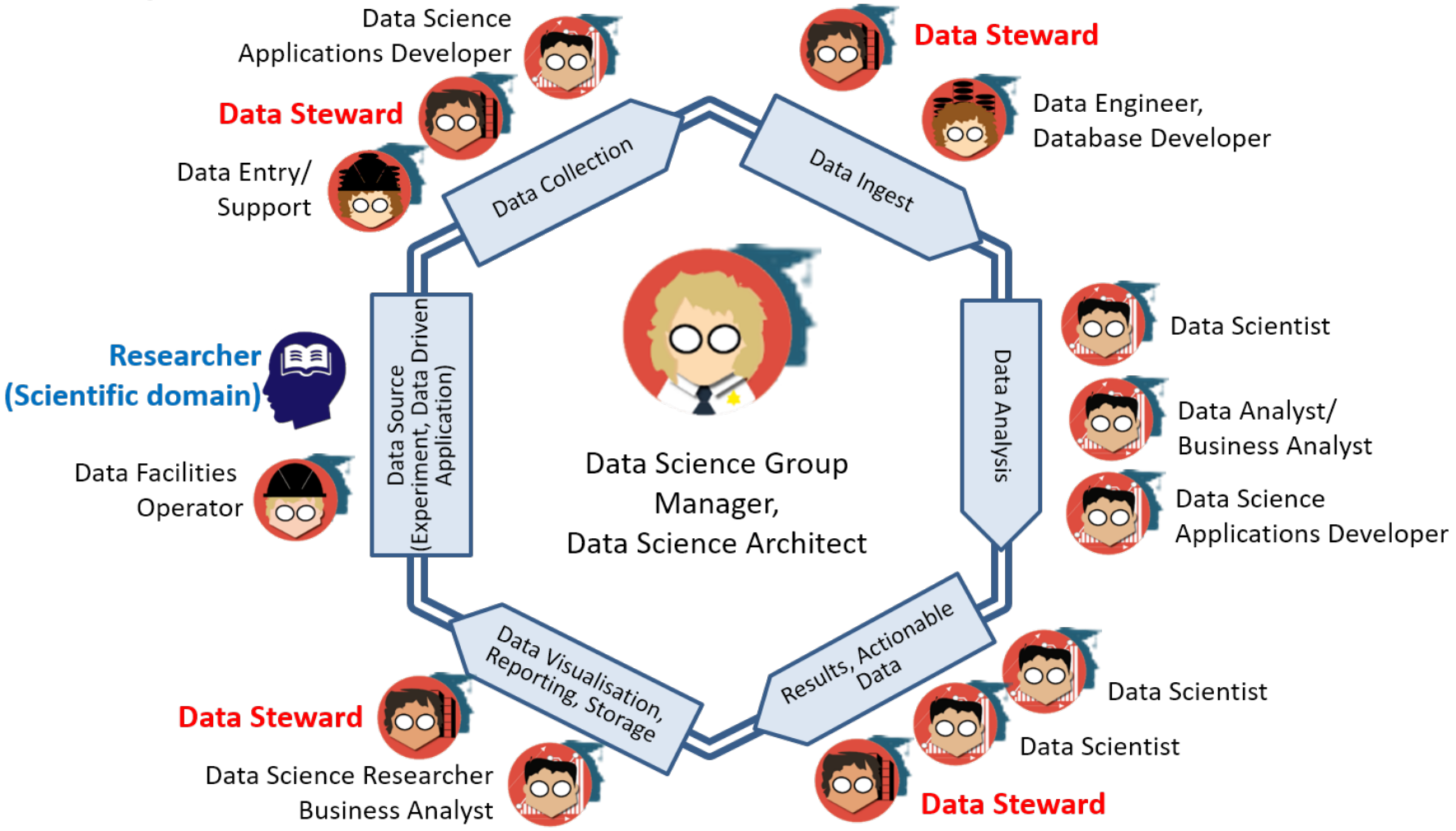


Individual Education/Training Path based on Competence benchmarking

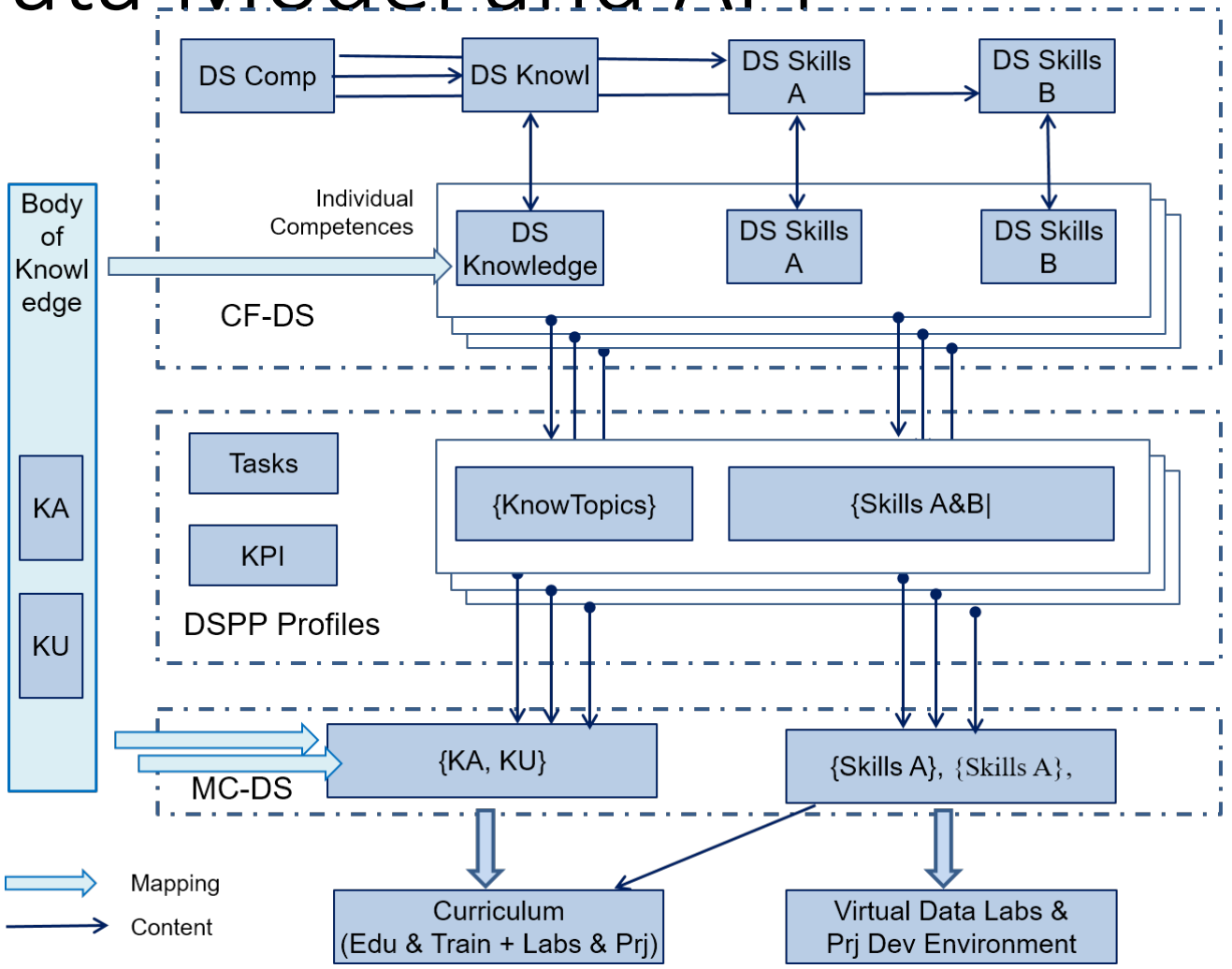
- Red polygon indicates the chosen professional profile: Data Scientist (general)
- Green polygon indicates the candidate or practitioner competences/skills profile
- Insufficient competences (gaps) are highlighted in *red*
  - *DSDA01 – DSDA06 Data Science Analytics*
  - *DSRM01 – DSRM05 Data Science 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

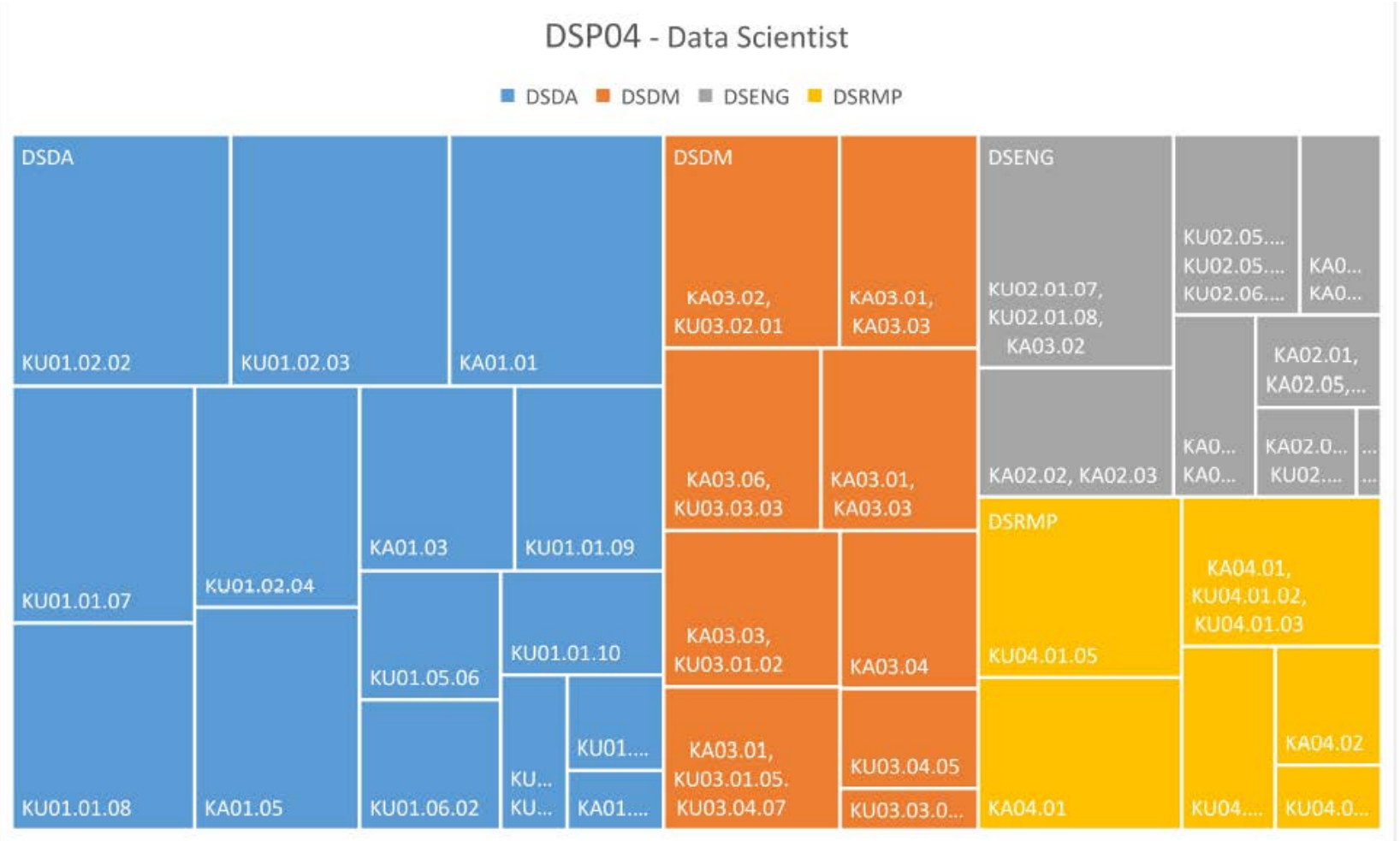


EDSF Data Model and API

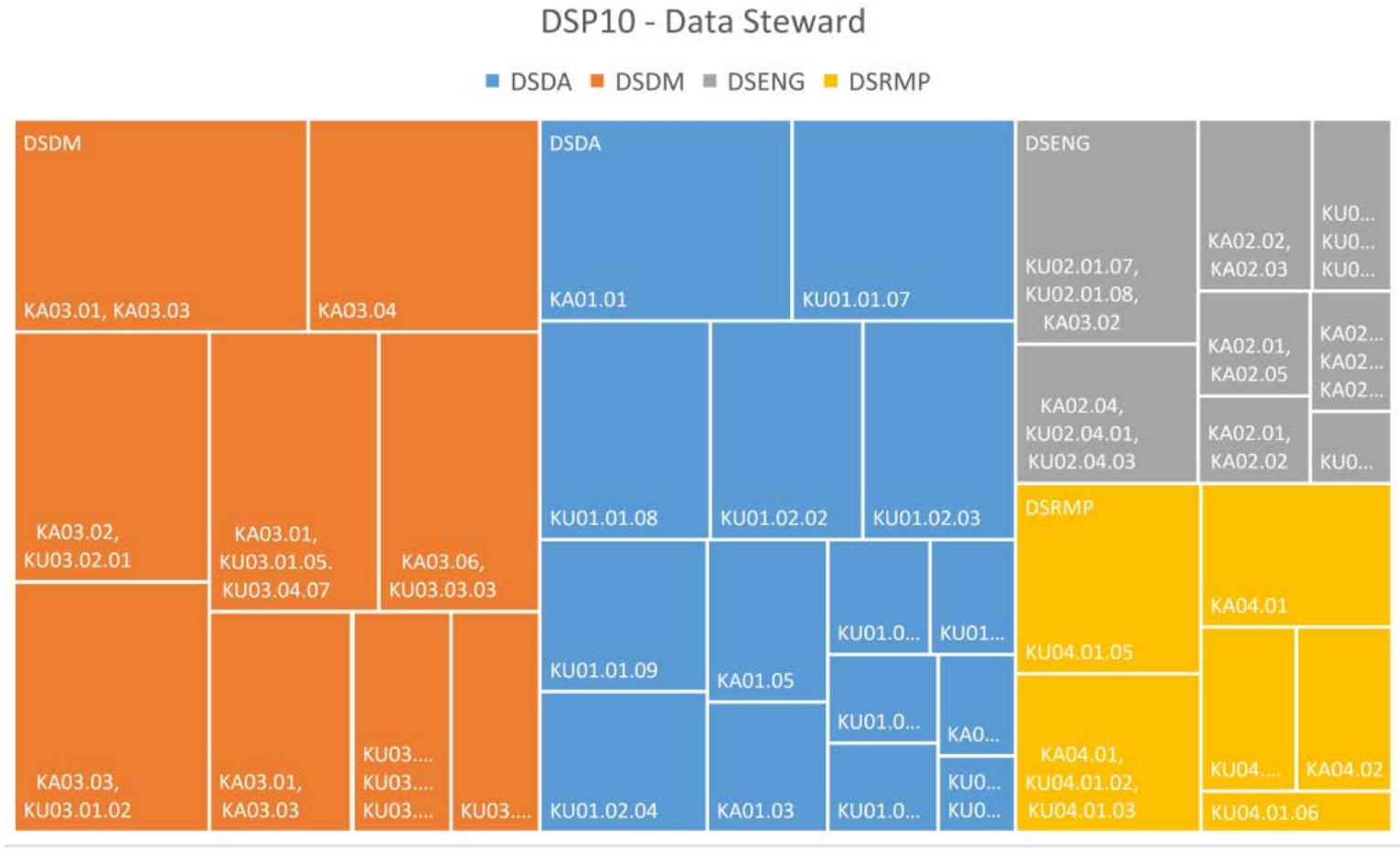


- EDSF API provides access to all EDSF functionality

DSP04 – Data Scientist MC structure



DSP10 – Data Steward MC structure



Roadmap recommendations: Data Science Education and Training for Europe

A. Policy recommendations for the EC and Member States

- R1. Critical skills management and training
- R2. Gender balance and multi-cultural environment
- R3. Common data literacy
- R4. Data driven technology and education divide.
- R5. European studies on demand and role of Data Science and Analytics skills
- R6. Include the above actions in the European Digital Single Market Scoreboard

EDISON project Deliverable D4.4 Content

- EU strategy for European Digital Single Market and European Open Science Cloud
- Overview of Recent Studies on Data Science and Analytics skills demand
- EDISON Data Science Framework (EDSF) and Educational Model
- EDISON Data Science Framework (EDSF) and Educational Model
- Priority, Timeline and ongoing activities

B. Recommendations to universities and professional training organisations

- R7. EDSF adoption by universities
- R8. Addressing Data Science professional and workplace skills in university curricula
- R9. Multiple delivery form
- R10. Sharing experience, courses and instructors
- R11. Supporting technical infrastructure for Data Science and data related education and professional training

C. Recommendations for Research (e) Infrastructures

- R12. Critical skills management in Research (e) Infrastructures

D. Required support and contribution to the standardisation bodies

- R13. The following are essential measures to achieve EDSF support existing and new standards.

Next steps (1) – Further development and exploitation

- EDSF Release 3 (End 2017)
  - Fully enumerated CF, BoK, MC, DSPP in machine readable format
- Development of EDSF based tools:
  - Self assessment and Market monitoring
- Certification Framework for at least two levels of Data Science competences proficiency: Associates and Professionals
  - Data Science knowledge and competences for decision makers

- Toward EDSF and Data Science profession standardisation
  - ESCO (European Skills, Competences and Occupations) taxonomy
  - 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)

Next steps (2) – Community Activities and Initiatives

- Data Science Manifesto – Primarily focused on professional and ethical issues in Data Science, new type of professional
  - Professional and ethical issues as a primary focus

- Inter-universities initiative “Data Science for UN’s Sustainable Development Goals” to focus in-curricula research (projects) on UN priority goals

- Build a wider network of early adopters, champions and ambassadors in Europe and world wide
  - EDISON team information and advice support will continue through out 2017-2018

Ongoing activities and developments

https://github.com/EDISONcommunity/EDSF

- **EDISON Community Initiative and Call for contribution EDSF Release 3**
  - Call for comments and contribution - Deadline 30 June 2018
  - Editorial team work June – July 2018
  - Target publication EDSF Release 3 – end July 2018
  - Call for sponsorship

- **Industry digitalisation projects and data literacy skills training**
  - **MATES project funded by EU ERASMUS Programme -** EU Maritime industry digital transformation, data skills development and Data + Ocean literacy
  - Port Rotterdam Data Management training for data driven digital transformation
  - Skills for SME: Data Science, IoT, Cybersecurity: Prepare to Data Economy and Industry 4.0

- **DARE project by APEC** (Asia Pacific Economic Cooperation)
  - Continuing cooperation for Asia Pacific region
  - Recommended Data Science and Analytics Competences published August 2017 - https://www.apec.org/Press/Features/2017/0620_DSA

Further development and exploitation

- Development of EDSF based tools
  - Competences benchmarking and Job market monitoring
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- Data Science Manifesto – Primarily focused on professional and ethical issues in Data Science, new type of professional
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Conclusion and actions

- More work needed to develop the third release of the EDISON Data Science Framework (EDSF release 3)
- More work needed to operationalise the Framework for professionals, employers and universities and other learning and training organisations
- Interesting to explore in practice how Dublin Core could be of benefit in new business sectors to expand the data-driven innovation in the digital economy

Thank you

- Information points:
- EDSF github project - https://github.com/EDISONcommunity/EDSF
  - Component documents CF-DS, DS-BoK, MC-DS, DSPP
- EDISON Community work area and discussions - https://github.com/EDISONcommunity/EDSF/wiki/EDSFhome
- Mailing list - edison-net@list.uva.nl
- EDISON project website (still active) http://edison-project.eu/
  - EDISON Data Science Framework Release 2 (EDSF), 3 July 2017 http://edison-project.eu/edison-data-science-framework-edsf
- Infoculture: http://infoculture-lab.com/
- Steve Brewer: hello@infoculture-lab.com