Sustainability in IT and Infrastructure Design and Operationalisation:

Addressing environmental issues, energy/material/carbon footprint and defining KPI

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CCI Seminar, University of Amsterdam
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Outline

- Sustainability in UN SDG and European Strategy on Sustainability and Horizon Europe Mission Goals
- Sustainability definition and KPI
- Defining Architecture model for Data Driven Applications optimisation
- Data Analytics Operationalisation with SRE
  - DevOps and SRE
  - SRE for Data Science and AI projects
- Discussion

Horizon Europe Preparation and Concepts

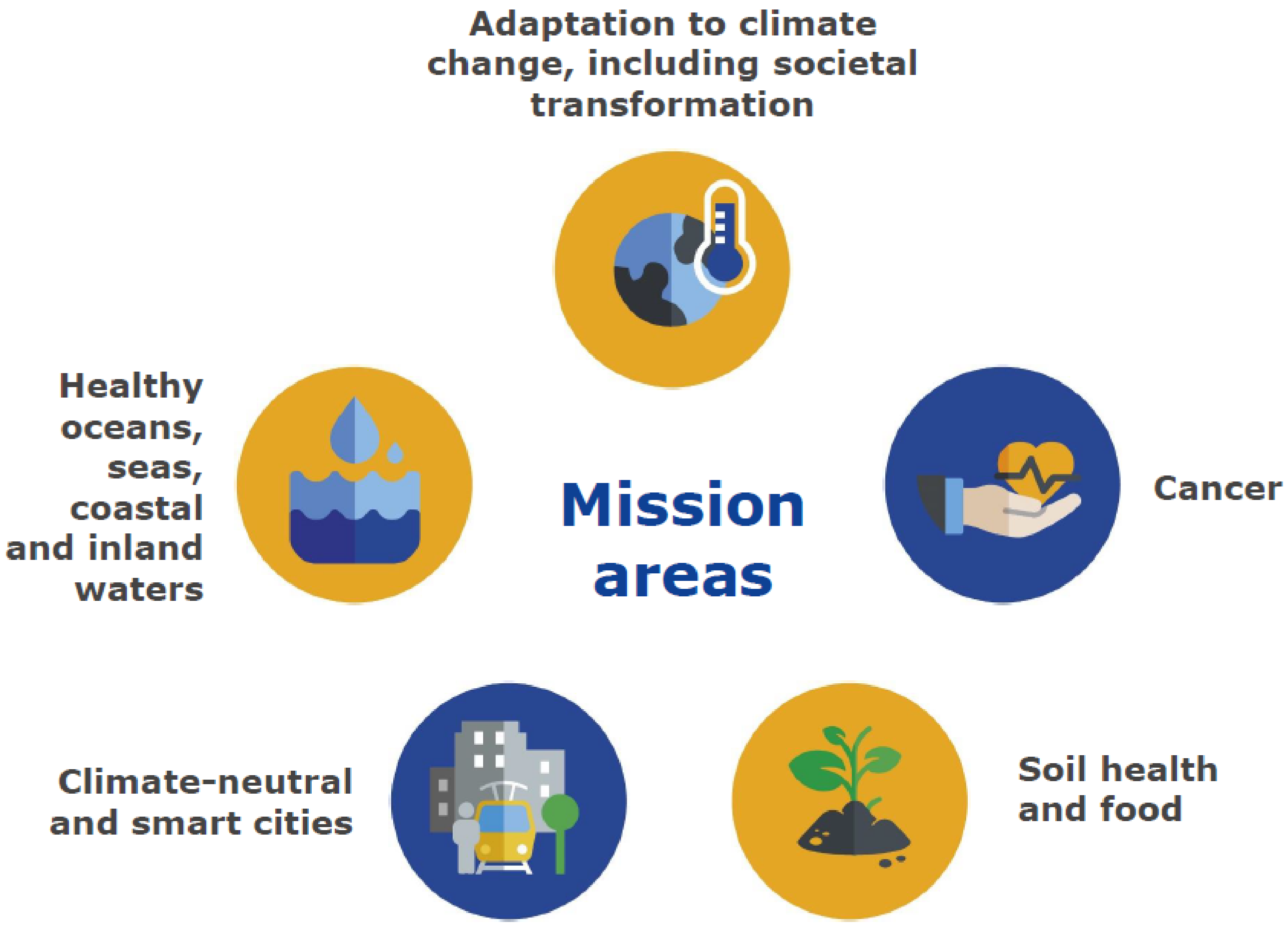
- Mission-oriented research and innovation in the European Union
- Focus on UN 17 SDG discussed during preparation stage

SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD

5 Mission areas in HE

- Adaptation to climate change including societal transformation
- Cancer
- Climate-neutral and smart cities
- Healthy oceans, seas, coastal and inland waters
- Soil health and food

- Contributing to Sustainability
  - European policy on cloud computing
  - Industry 5.0
  - European Data Spaces



European Commission

(1) HORIZON-CL4-2021-DATA-01-01: Technologies and solutions for **compliance, privacy preservation, green and responsible data operations** (RIA) – total 52Mln / 10Mln prj

- Activities are expected to start at TRL 2-3 and achieve TRL 4-5 by the end of the project

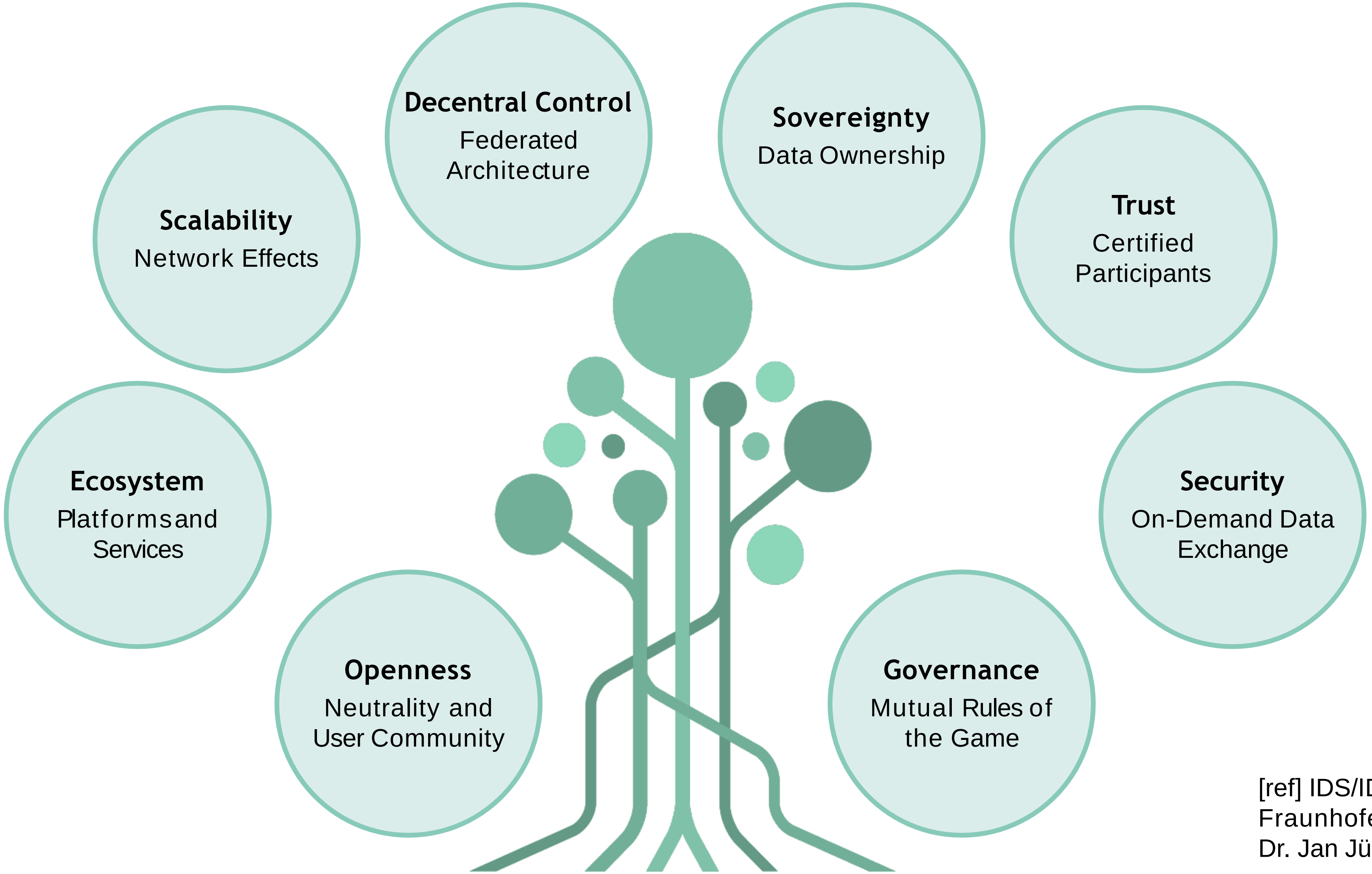
Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- **improve the efficiency and the use of trustworthy digital technologies** to address the requirements of citizens, companies and administrations/public organisations on **privacy and commercial and administrative confidentiality** as well as responsible, fair and environmentally friendly (**e.g. in terms of energy/carbon/material footprint) data operations in data spaces, across the data life cycle**.

Scope: **Digital technologies, methods, architectures and processes for user-friendly, safe, trustworthy, compliant, fair, transparent, accountable and environmentally sustainable collection, storage, processing, querying, analytics and delivery of data**.

- The technologies shall **facilitate sharing and manipulation of data** in compliance with prevailing and emerging legislation (e.g. GDPR) for data processors and data subjects/rightholders and other stakeholders.
- The technologies and solutions shall **enable safe and secure data handling, sharing and re-use** in the context of common **European data spaces** in various situations and application areas.
- The scope also includes the combination of technological and social innovation, technologies and solutions that **enable environmentally sustainable data operations** (e.g. by **optimising/minimising/de-centralising processing, transfer and storage of data and avoiding unnecessary data manipulations, using energy-harvesting sensors/devices etc**.),
- Technologies and solutions for **ensuring human, fair and ethically sound collection, processing and manipulation of data**, in line with the principles of responsible/trustworthy AI.

Industrial Data Spaces: Sovereign Data – How sustainability can be addressed?



- Data sharing and Sovereignty are key to make value of data
- Data Sovereignty achieved by attaching policy and usage conditions to data
- Enabling regulated environment for data processing
  - Enclave computing in modern cloud technology

[ref] IDS/IDSA slides courtesy Prof. Dr.-Ing. Boris Otto, Fraunhofer ISST, Industrial Data Space Association, and Prof. Dr. Jan Jürjens Fraunhofer, ISST, University Koblenz-Landau

SDG Goals and relation to ICT

Selected SDG goals (data technologies linked)

- 9. Innovation and Infrastructure
- 11. Sustainable cities and communities
- 12. Responsible consumption
- 7. Renewable Energy

- 13. Climate actions?
- 16. Peace and justice?
- 17. Partnership for the goals

ICT as facilitating factor for SDG:

- SDG related initiatives in Data Science

Data related technologies

Discussion topic 1

- FAIR Data principles?
- GDPR?
- Data Spaces, GAIA-X and IDSA Architecture?
- Data sharing and data markets?
- Stock exchanges and Blockchain?
- Cloud – edge – mobile access - smartphones?

Industry and production

- Automation, Robotics, AI

Sustainability breakout and mapping

- Sustainability in HE (Mission areas) is considered in the context of SDG

- Societal impact
  - People and skills
- Energy efficiency as part of Environmental impact
  - Energy re-use
- Resources
  - Circular economy

- Technological continuity for sustainability
  - Architectural continuity and design patterns re-usability
  - Interoperability and technology/device lifecycle (compatibility between devices of different generation)
  - Standardisation (LTE is a good example and 5G as currently available technology)

Definition: Sustainable IT

https://circularcomputing.com/what-is-sustainable-it/

- Sustainable IT, also known as Green IT, covers the **manufacturing, use, management and disposal of information technology** in a way that minimises its impact on the environment.
  - Read about resources required for production one laptop
- The Green Software model includes
  - Software lifecycle, sustainability criteria, product metrics, procedures for stakeholders, stock recommendations, and tools that support environmentally friendly sustainable development, acquisition, supply, and use
- Sustainable capabilities in social axis
  - Practices, adding value to customers, stakeholders, and society to provide long-term benefits in economic, social, and environmental pillars

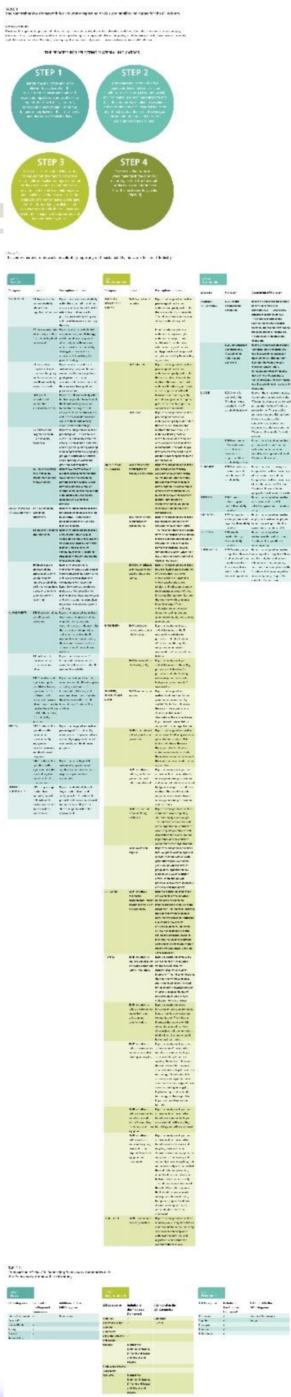
Sustainability Indicators: Key to Operationalise Sustainability

- Three main pillars of Sustainability:
  - **Economic, environmental, and social**.
- Sustainability indicator is **a measurable aspect of environmental, economic, or social systems** that is useful for monitoring changes in system characteristics relevant to the continuation of human and environmental well being
  - Sustainability indicators must cover economic, social, and sustainable aspects of human activities
  - Sustainability indicators should be politically relevant, resonant, scientifically valid and measurable, i.e. obtained information must be actionable.
- Global Standards for Sustainability Reporting – GRI, Global Sustainability Standards Board (GSSB) https://www.globalreporting.org/standards/

IT Sustainability Indicators for the IT Industry (10 July 2015) by

https://www.norea.nl/

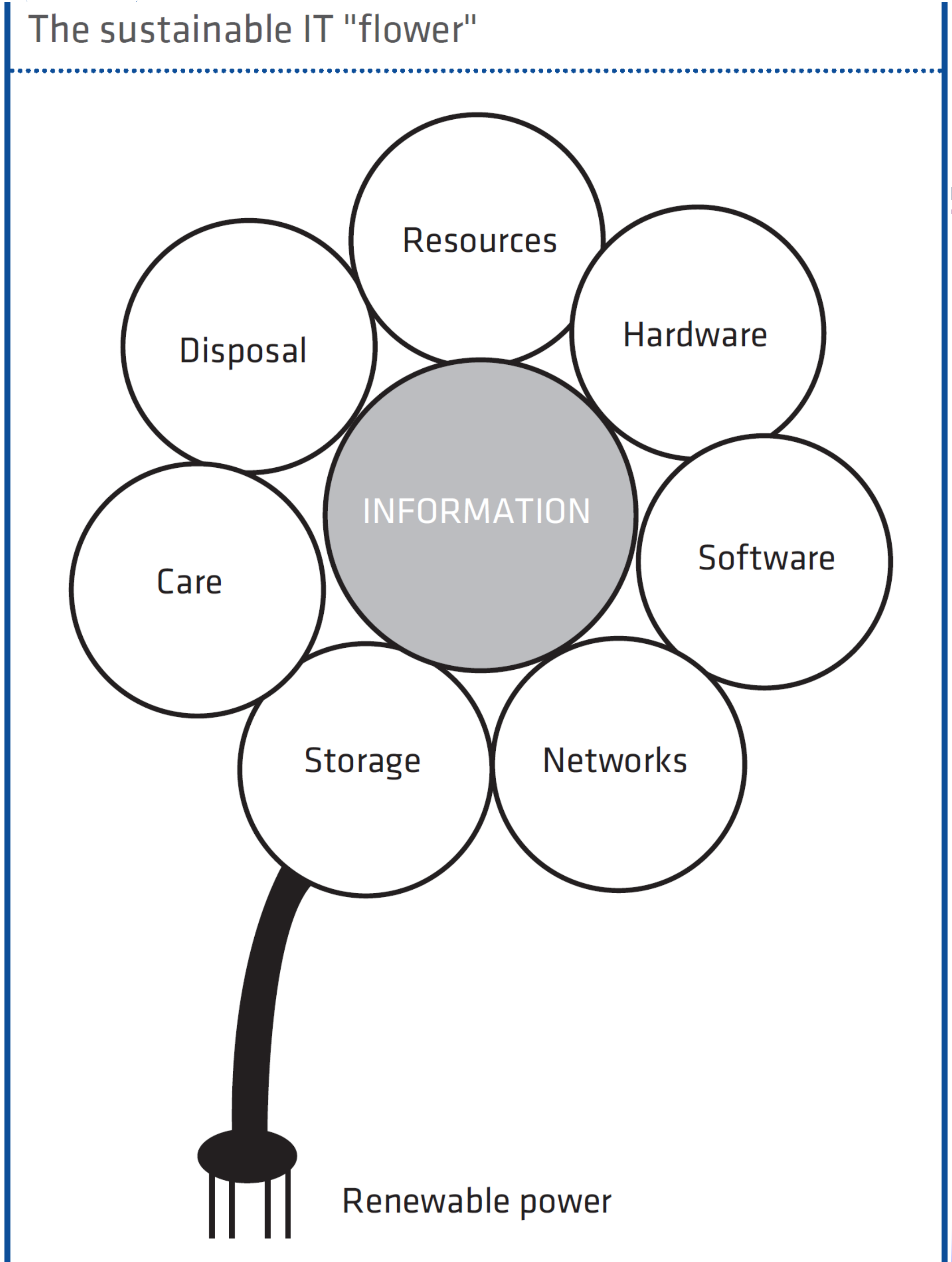
https://www.deitauditor.nl/business-en-it/it-sustainability-indicators-for-the-it-industry/



- The IT sustainability indicators are developed according to the criteria for financial statements that are set out in the International Accounting Standards Committee (IASC) framework: comprehensibility, relevance, reliability and comparability.
- The GRI Reporting framework was adopted as basis for the development of the proposed framework, because it is the world’s most widely used sustainability reporting framework.
  - Most of the core GRI Reporting framework indicators are included in the proposed framework. However, for simplicity, the framework does not distinguish between core and additional indicators.
  - The GRI framework was extended with IT sustainability indicators.
- The proposed framework to help companies with their voluntary reporting on IT sustainability’s social, environmental and economic aspects:
  - 3 aspects: Social, Economic, Environmental
  - 13 categories, including materials, products and services; energy, water and cooling; biodiversity; effluents and waste; data center; IT office; compliance
  - 44 indicators

Economic Sustainability KPI relevant to IT Operation

- GRI and IASC Framework: 13 categories defined
  - data center
  - IT office
  - compliance
  - products and services
  - Energy
  - water and cooling
  - Materials
  - effluents and waste
  - Biodiversity

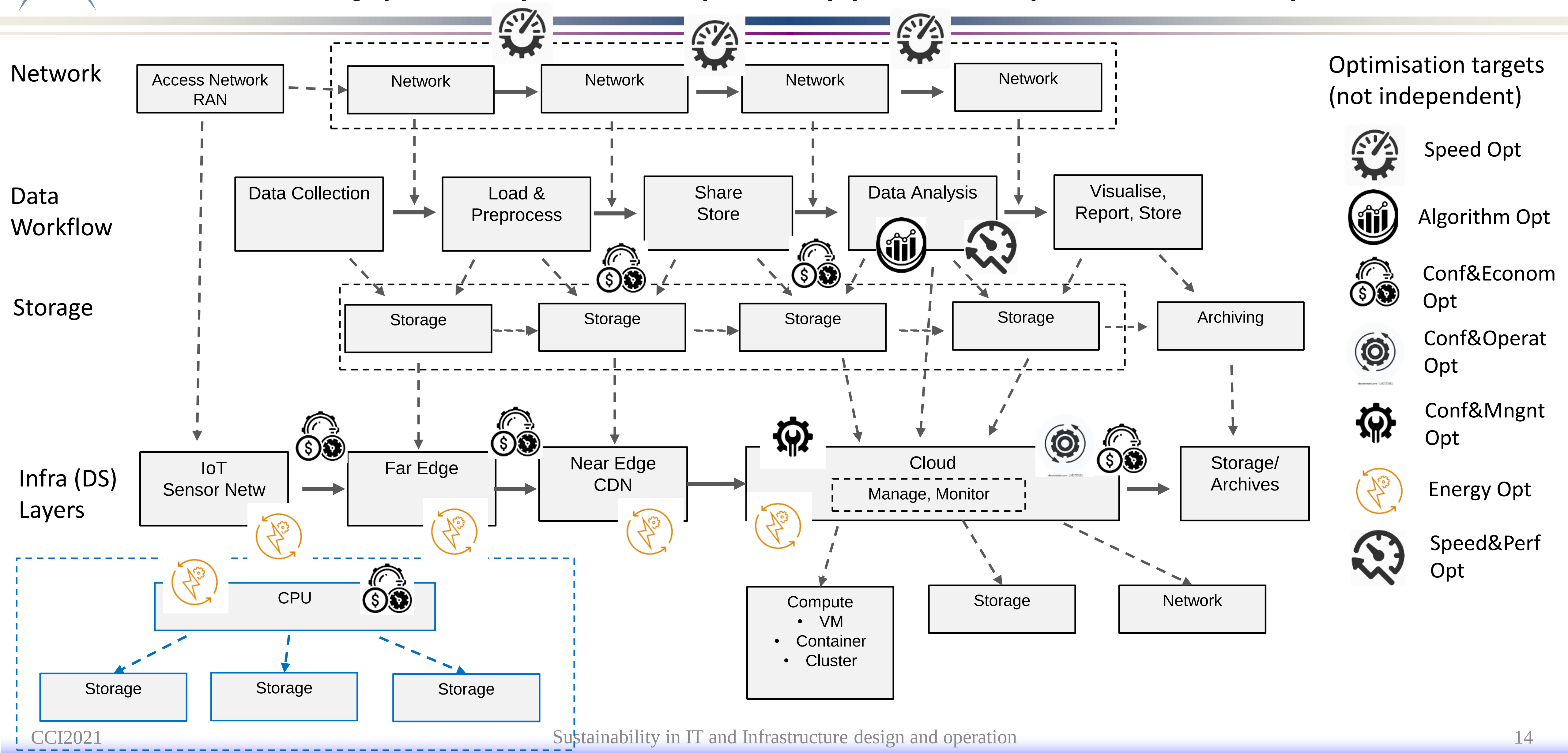


Sustainable IT components

https://www.apc.org/sites/default/files/PracticalGuideSustainableIT_Section_1.pdf

- Hardware
- Software
- Network
- Storage
- Care/Management
- Disposal
- Resources

Architecture Model for Data Driven Applications (DDA) Optimisation: Monitoring points (indicated) to support KPI (to be defined)



Problems identified: Sustainability modeling, Monitoring, Optimisation

- Revise existing definitions of Sustainability
- Define model for data lifecycle and whole infra stack
  - Exchange data between domains (data spaces – federated data spaces)
- Model definition and simulation – use Digital Twins
- Model to adopt technology change that solve many early optimis problems
- Are KPI defined?
- Measurement for KPI?
  - Digital Twin as a container for a model
  - Sensitive information
- Operationalising of analytic and AI models
  - DevOps and SRE (Site Reliability Engineering) practice for continuous monitoring and improvement (KPI and Service Level Objectives based)
  - What actions to take and how? Translate model output to action
- Review IoT community experience

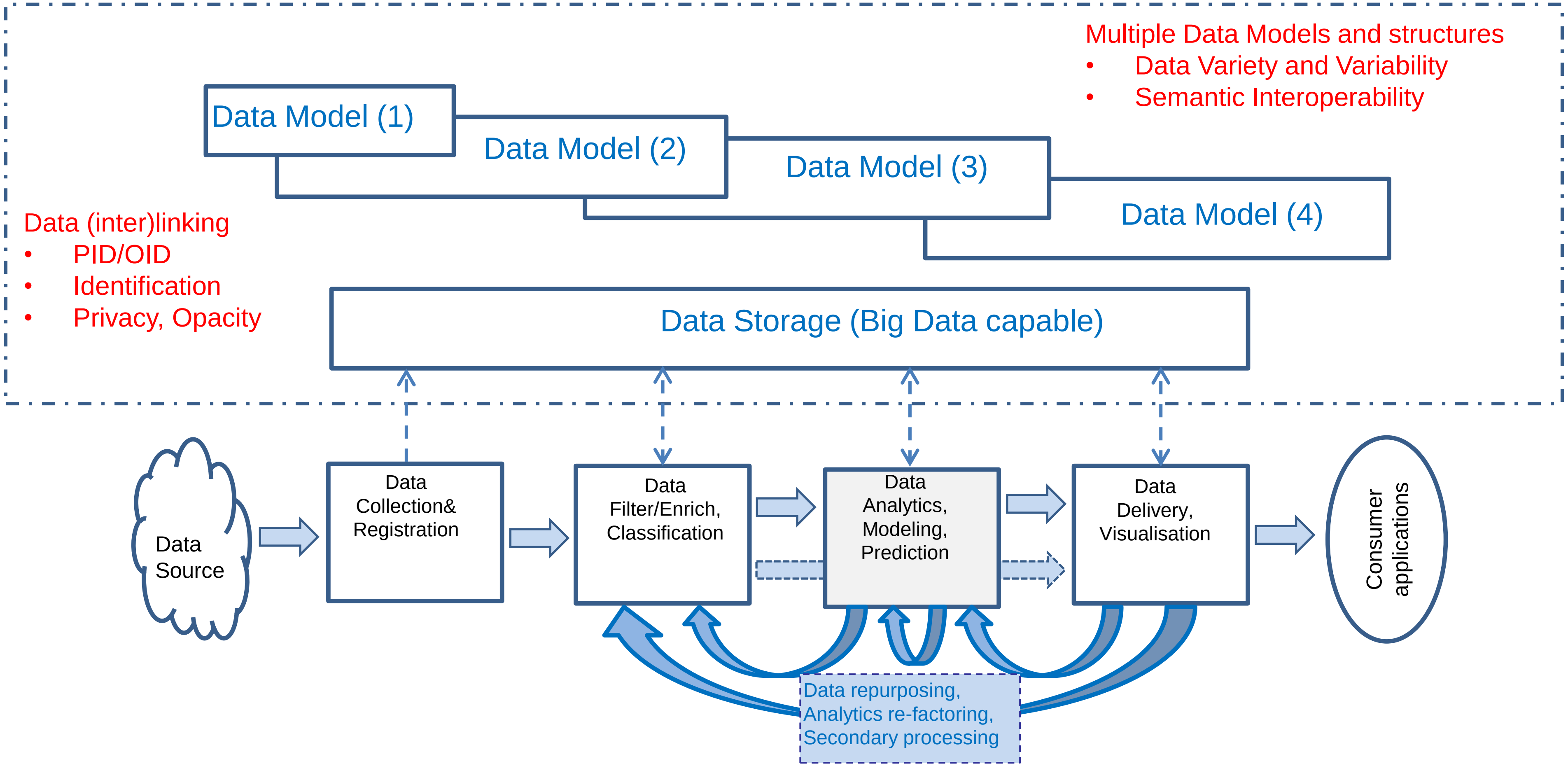
From DevOps to SRE: Operationalising SE/Apps, Data Analytics/DataOps and MLOps

- Benefit from current trends to operationalize engineering/development process
- SRE (Site Reliability Engineering) introduces practice of monitoring and fulfilling Service Level Objectives (SLO, subset of SLA) by defining Service Level Indicators (SLI)
  - To be leveraged to Data Analytics model monitoring and improvement
- SRE may provide an approach to facilitate early DA model deployment and testing with real data

From Data Lifecycle to Data Science Project Stages

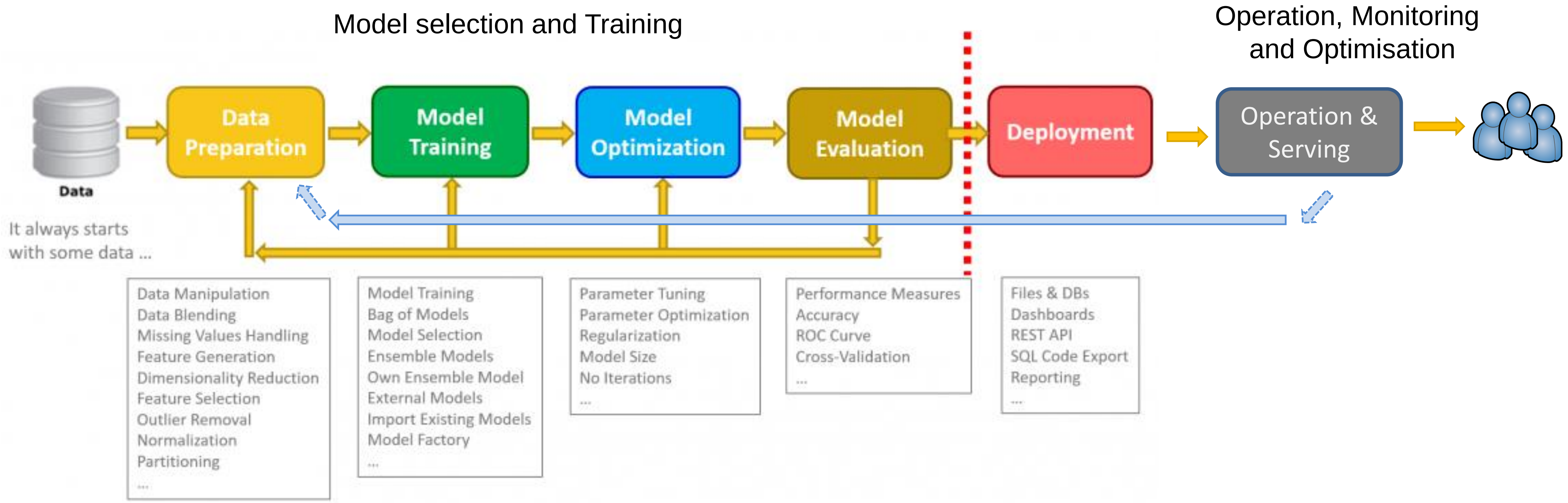
- Data Lifecycle
- Data Science project stages: Dataflow and Lifecycle
- Services/Applications Development Lifecycle
- DevOps cycle

Data Lifecycle/Transformation Model



- Data Model changes along data lifecycle or evolution (Variability)
- Data provenance (lineage) is a discipline to track all data transformations along their lifecycle
- Identifying and linking data
  - Persistent data/object identifiers (PID/OID)
  - Traceability vs Opacity
  - Referral integrity

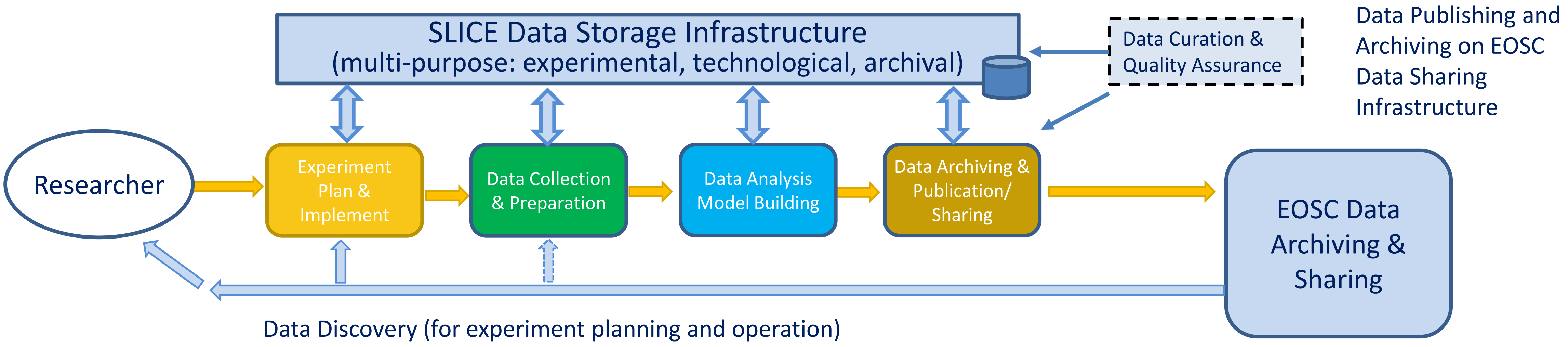
Data Science Project/Research is based on Dataflow/Lifecycle



- **Each phase** – data preparation, model training and evaluation, and model deployment – operates on **its own data set**. All these data sets need to be isolated but linked. The pollution of data sets across the data science assembly line is one of the most frequent mistakes in model production.
- The data science project is typically starts with some ***historical data*** *or* ***sample dataset*** can be somewhere in existing repositories.
- Data preparation may also include connecting external data sources – ***data blending***

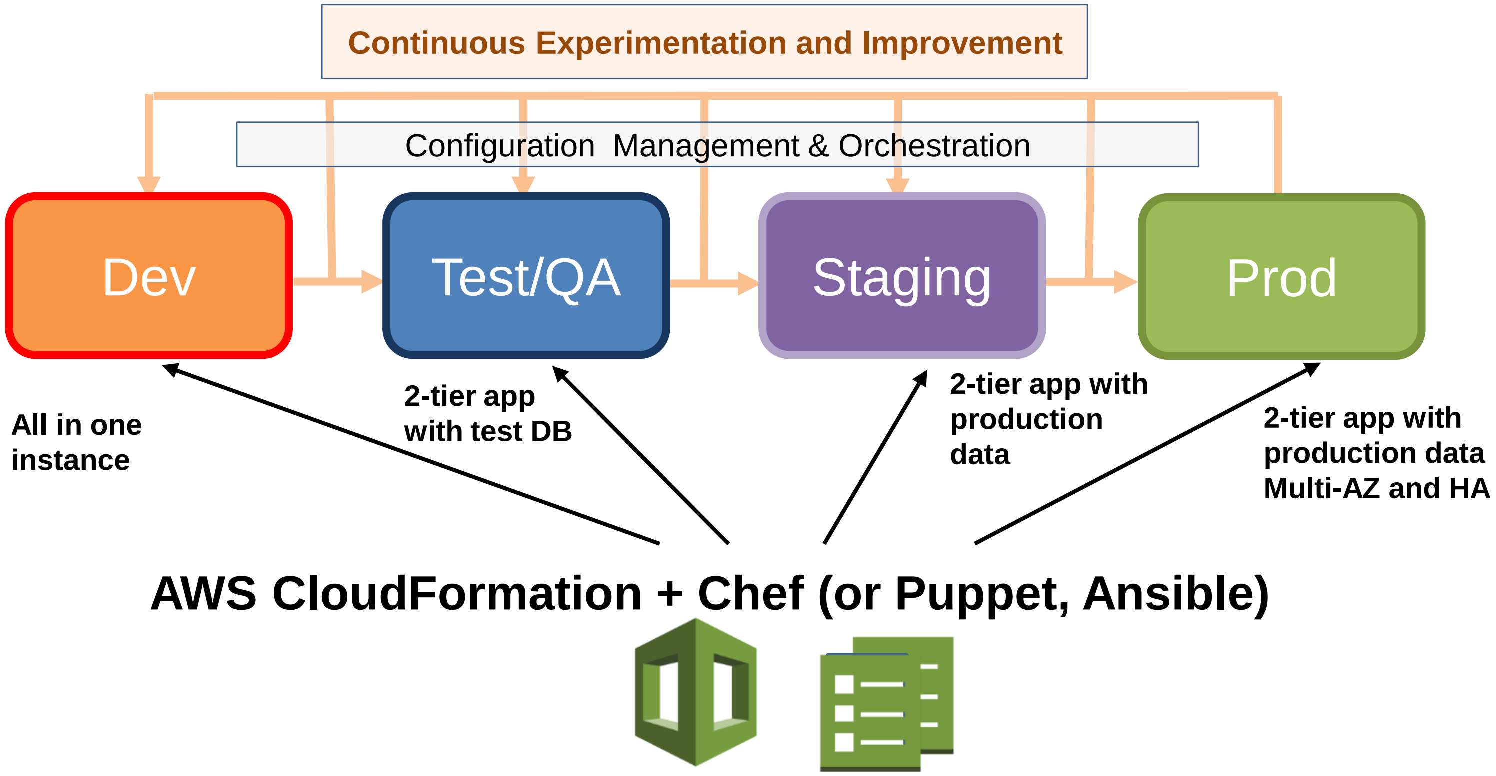
[Ref] https://www.knime.com/blog/analytics-and-beyond

SLICES Data Lifecycle Model and Dataflow – Work in Progress



- **Each Data Lifecycle stage**– experiment, data collection, data analysis, and finally data archiving, works with own **data set, which are however connected**. All these data sets need to be stored and possibly re-used in later processes.
- Many experiments and research require already existing datasets that will be available in the SLICES data repositories or can be obtained/discovered in EOSC data repositories

Compare: Services/Applications Development Lifecycle



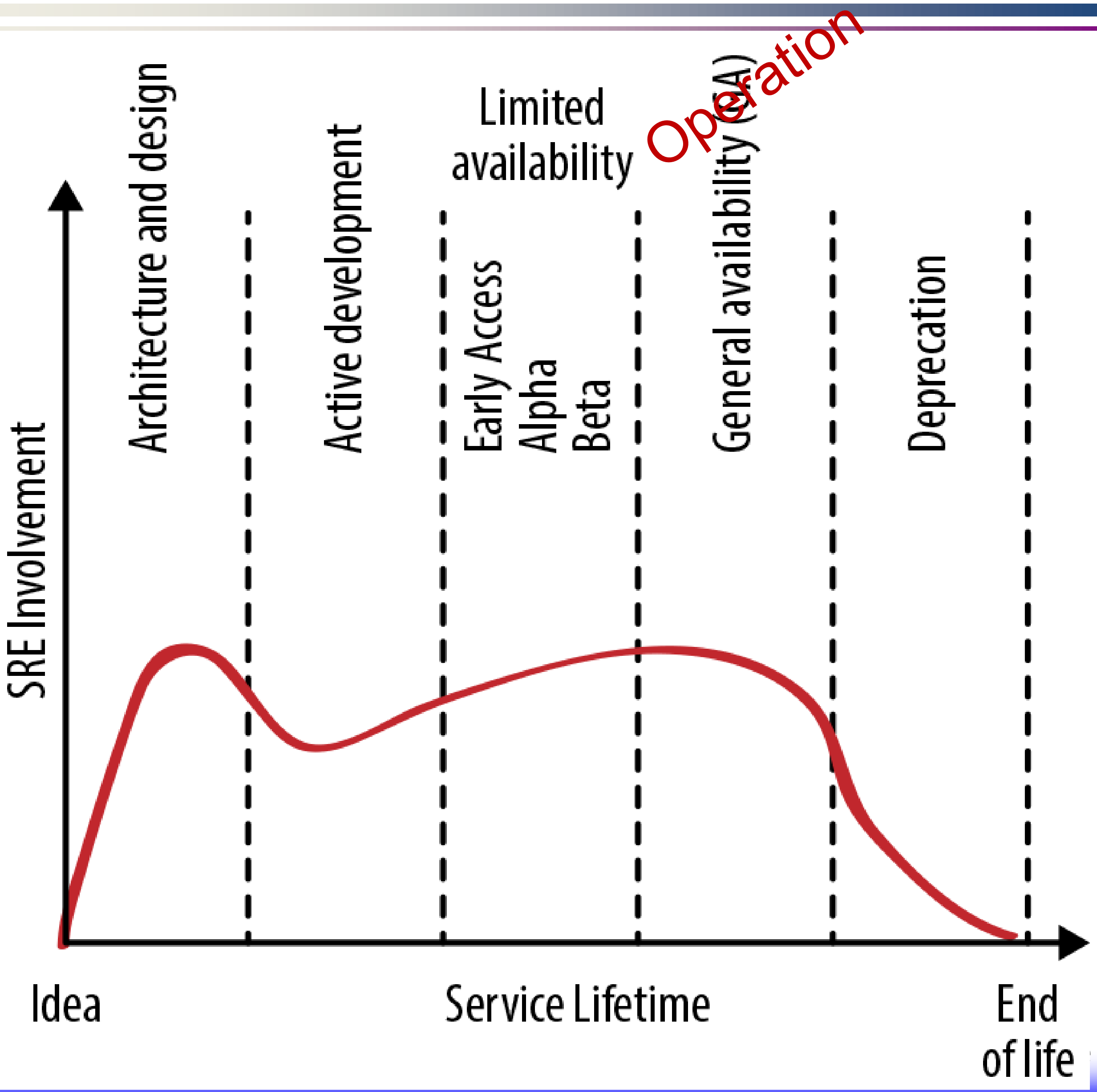
- Easily creates test environment close to real
- Powered by cloud deployment automation tools
  - To enable configuration Management and Orchestration, Deployment automation
- Continuous development – test – integration
  - CloudFormation Template, Configuration Template, Bootstrap Template
- Can be used with Chef, Puppet and Ansible, deployment automation and management tools for clouds

Overview: SRE and DevOps for Data Analytics Operationalisation

- DevOps and SRE
- SRE Engagement along Service lifecycle
- SRE for Data Science and ML
- SRE vs Platform Engineering

- Note: Not much information available: Search for blogs and tweets

SRE and Data Analytics Engagement



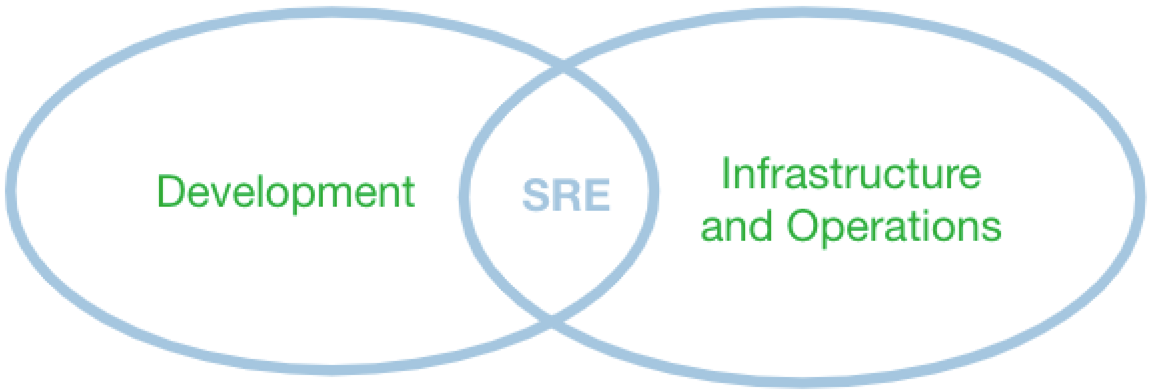
What are benefits of such fusion/integration

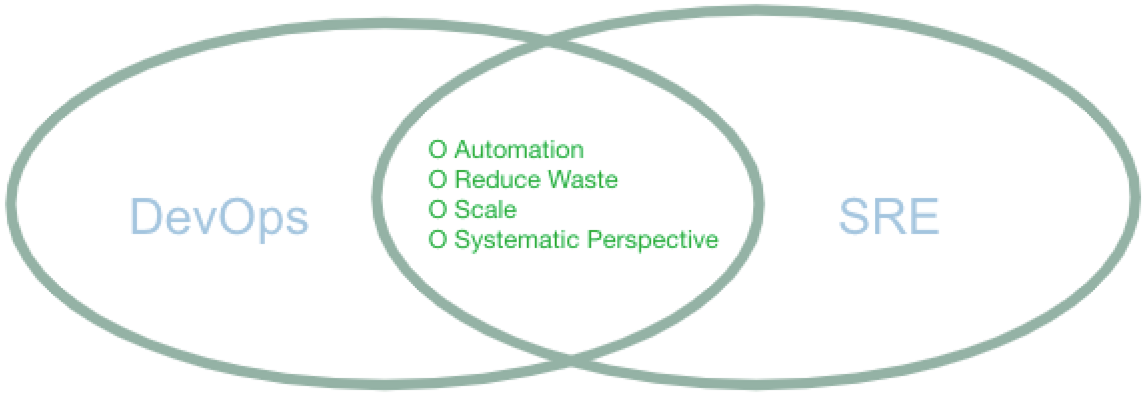
- Continuous model improvement
  - Essential for operational AI and Digital Twins
- Monitoring and optimization on both measurable and assessable/ranked KPI

[ref] https://sre.google/workbook/engagement-model/

https://www.pagerduty.com/blog/building-scaling-sre-team/

- In general, an SRE looks to bridge the gap between development and operations teams to ensure the reliability of the systems and are responsible for availability, latency, performance, efficiency, change management, and monitoring.





SRE and DevOps
https://www.ibm.com/cloud/learn/site-reliability-engineering

- **DevOps principles**: Reduce organizational silos, leverage tooling and automation
- **SRE practice**: Use the same tooling to automate and improve operations as developers use to develop and improve software

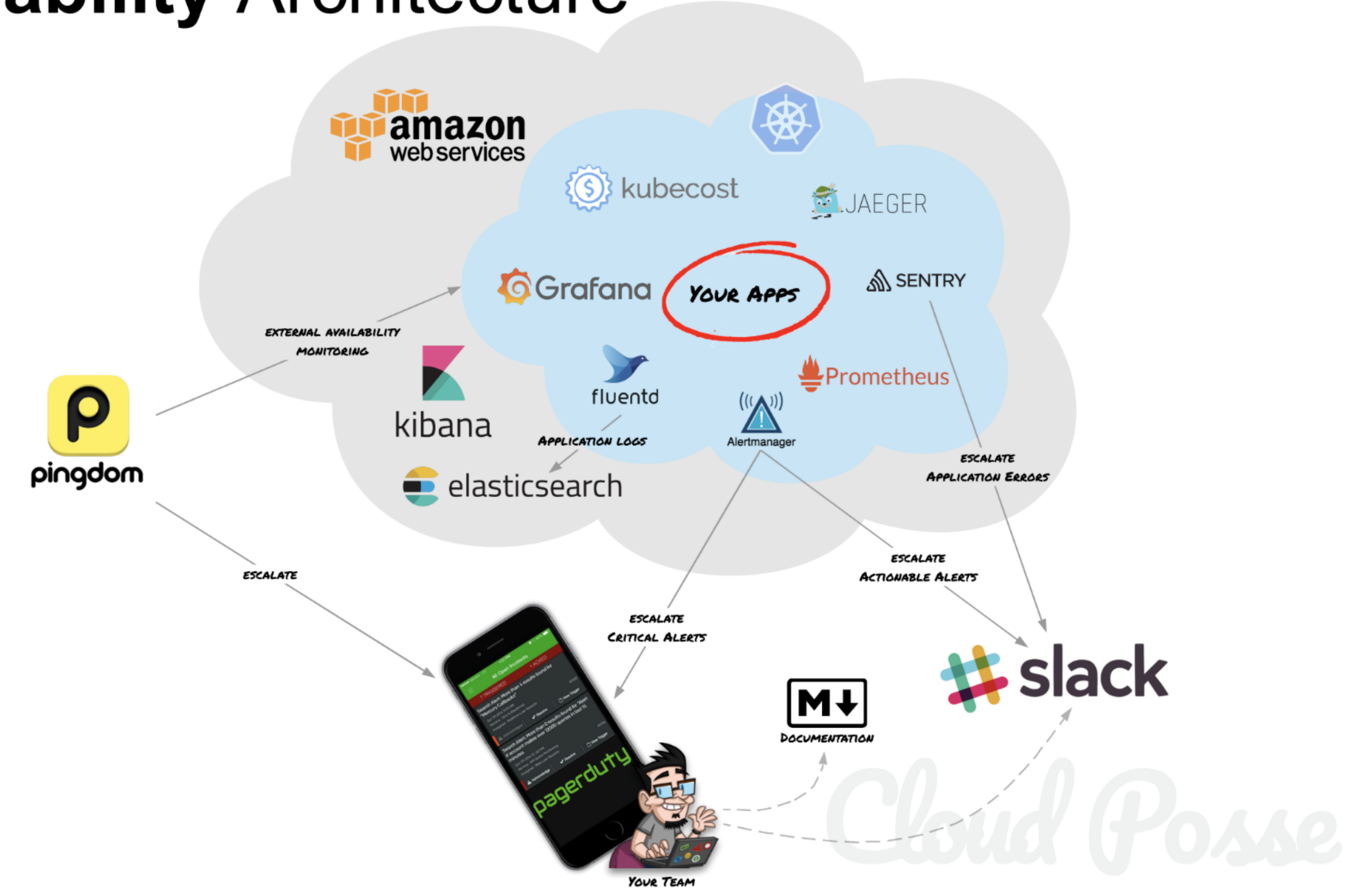
- **DevOps principles**: Accept failure as normal, implement gradual changes
- **SRE practice**: Use error budgets to continually deploy new features and functionality within acceptable levels of availability

- **DevOps principle**: Measure everything
- **SRE practice**: Base decisions to release new software on SLA metrics

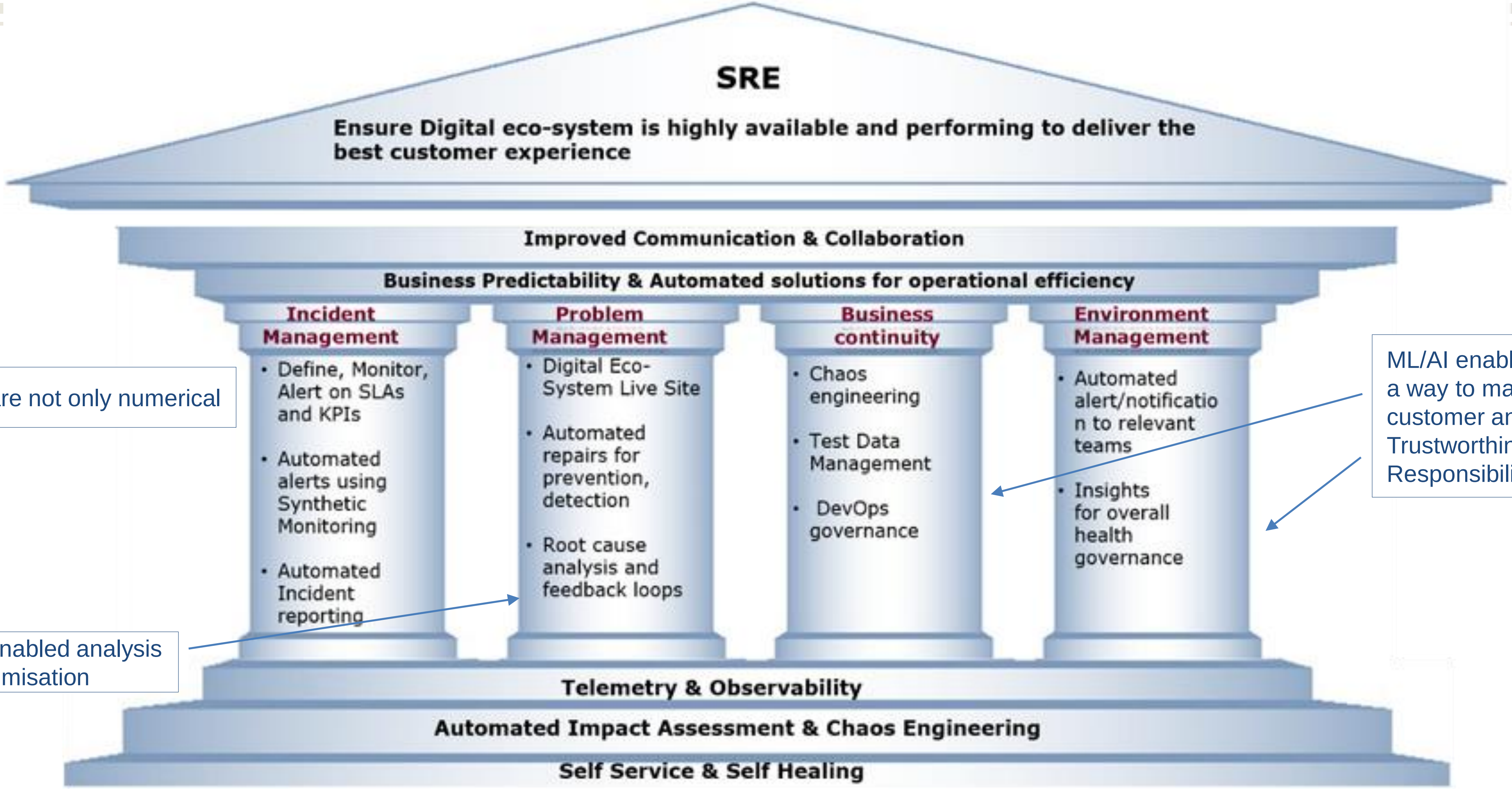
Example SRE Architecture at Cloud Posse
https://cloudposse.com/demo/site-reliability-engineering/

Our Site Reliability Architecture

- ✓ Capacity Planning
- ✓ Cost Visibility
- ✓ Application Telemetry
- ✓ Exception Tracking
- ✓ Distributed Tracing
- ✓ Log Search
- ✓ Actionable Alerts
- ✓ Runbooks
- ✓ Slack Integration



SRE Pillars according to Capgemini [ref]



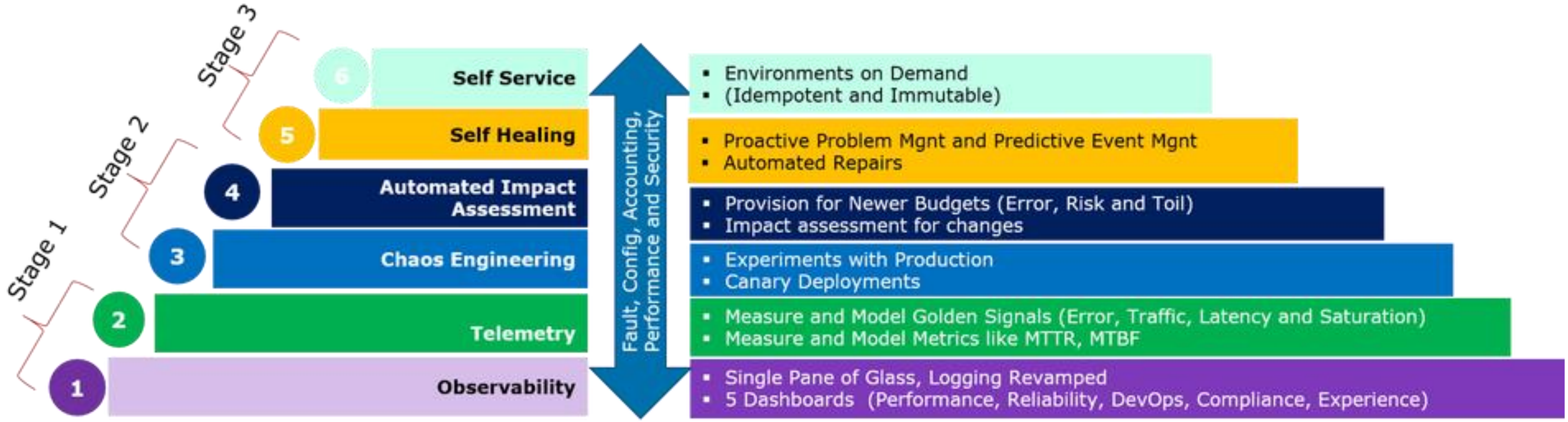
KPIs are not only numerical

ML/AI enabled analysis and optimisation

ML/AI enabled monitoring as a way to manage complex customer and environment KPI: Trustworthiness, Sustainability and Responsibility

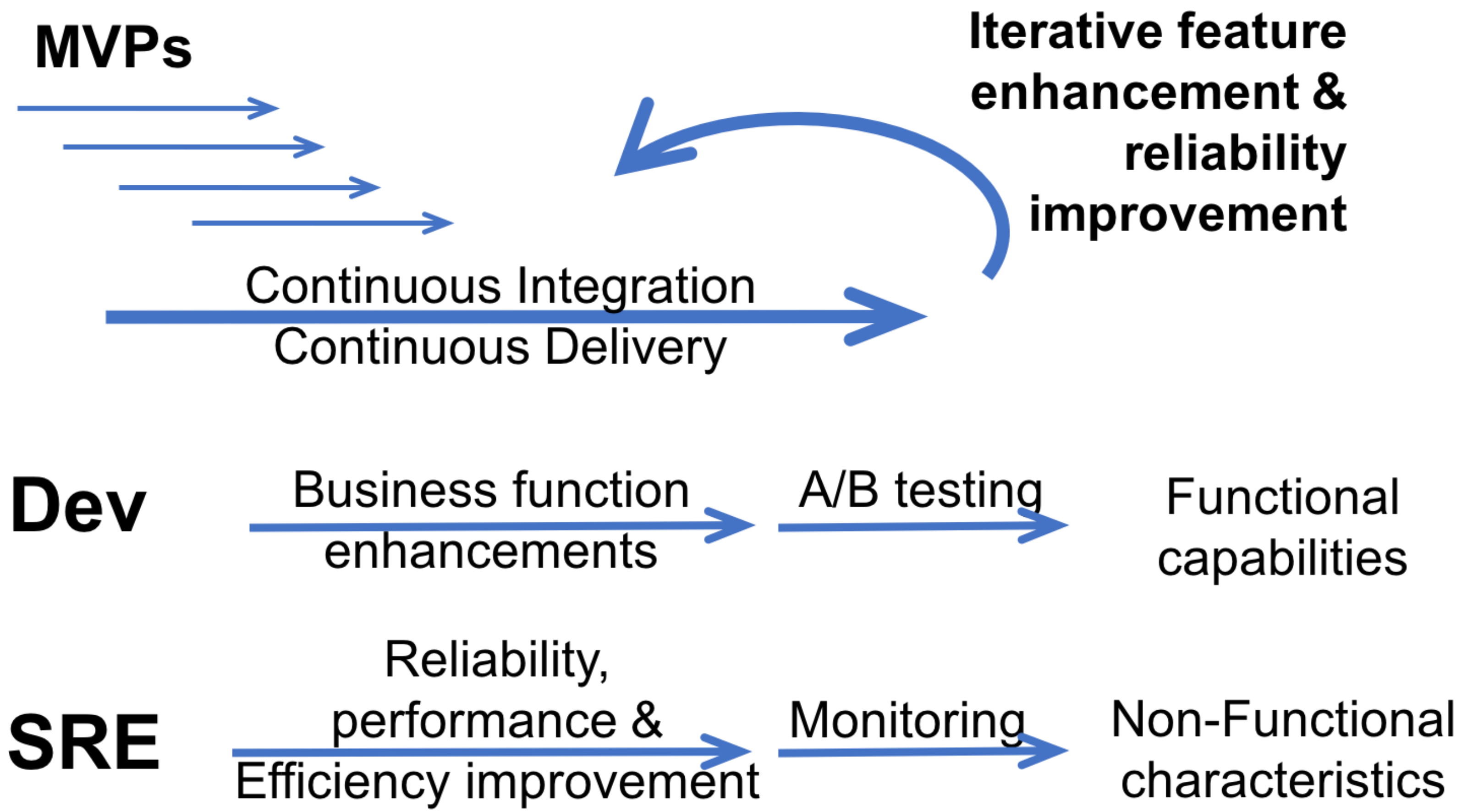
[ref] https://www.capgemini.com/2020/08/site-reliability-engineering-2/

Staged SRE implementation https://www.capgemini.com/2020/08/site-reliability-engineering-2/



- Leveraging DevOps process and practice to facilitate SRE implementation
- SRE is based on well defined business process and KPI

https://www.ibm.com/cloud/blog/site-reliability-engineering-cloud-approach-operations



5 Keys to Operationalizing Data Analytics in the Cloud

https://www.informatica.com/blogs/5-keys-to-operationalizing-data-analytics-in-the-cloud.html

Problems with Data Science and AI project

- **Take too long to build** and realize benefits. Most analytics projects take 6 to 12 months to go to production and gain enterprise-wide adoption.
- **Lack collaboration** among data engineers for analytics data pipeline building and sharing. There's also a lack of collaboration between business and IT, that is, data analysts, data scientists, and data engineers.
- **Never go into production**. According to research, 60% of the analytical projects developed by organizations never are operationalized, or put into use.
- **Not in scaled production**. Many analytics projects are never deployed at large scale. McKinsey research indicates only 8% of companies successfully scale their analytics.
- **Lack trust and governance**. Without proper data quality or data protection, you can't reliably use such insights or inform actions.
- **Are rarely successful**. In the case of AI/ML and predictive analytics projects, Databricks' research suggests only 1% are successful
- **Aren't complete.** Many analytics projects don't handle a variety of data, so they are incomplete. Without streaming data processing, analytics projects can result in decisions made without complete data, and consequently, they don't produce the desired results.

Discussion

- Topic 1: Sustainability of the key IT technologies of our economy
- Topic 2: What existing model (engineering and business) can be using for intended service optimisation for the whole service and/or data lifecycle
- Topic 3: How much DevOps and SRE methods and practices are applicable to Data Science and AI projects
  - Is SRE just a practice? Does SRE imply transformational methodology (re-thinking) for operational objectives delivery?

Discussion Topic 1: Data related technologies: How much they contribute to sustainability?

- FAIR Data principles?
- GDPR?
- Data Spaces and IDSA Architecture?
- GAIA-X?
- Data sharing and data markets?
- Cloud – edge – mobile access - smartphones?
- Stock exchanges and Blockchain? Ethereum 2.0?

Discussion topic 2: Engineering and business for full apps development cycle and operations

- Discussion topic 2: What existing model (engineering and business) can be used for intended service optimisation for the whole service and/or data lifecycle

Discussion topic 3: How much DevOps and SRE methods and practices are applicable to Data Science and AI projects