



AIR VEHICLE DIGITAL TWINS – ENABLING INTERACTION BETWEEN PHYSICAL AND VIRTUAL SPACES

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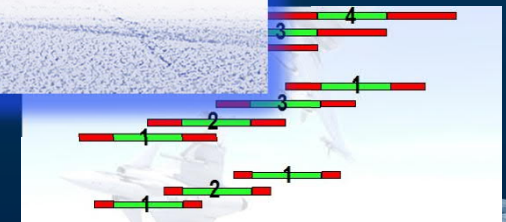
OUTLINE

Air Vehicle Digital Twin

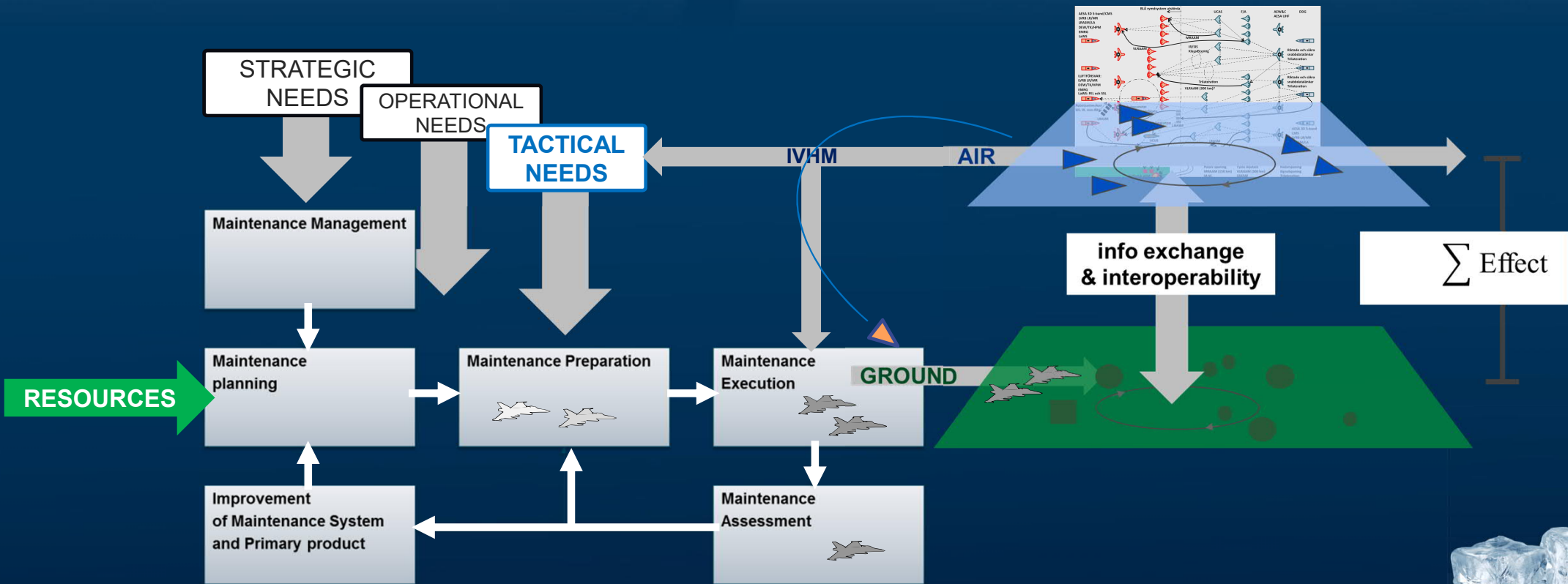
- WHY?
- WHAT?
- HOW?



Nr.	Status	Commentary	Step
216	M	Nose wheel brake is stuck TS W120	D40 S13
225	C		
228	C	119 M31W11 NVG Locker	
SV		Ready W120	F1 M1
245	C		
207	C		

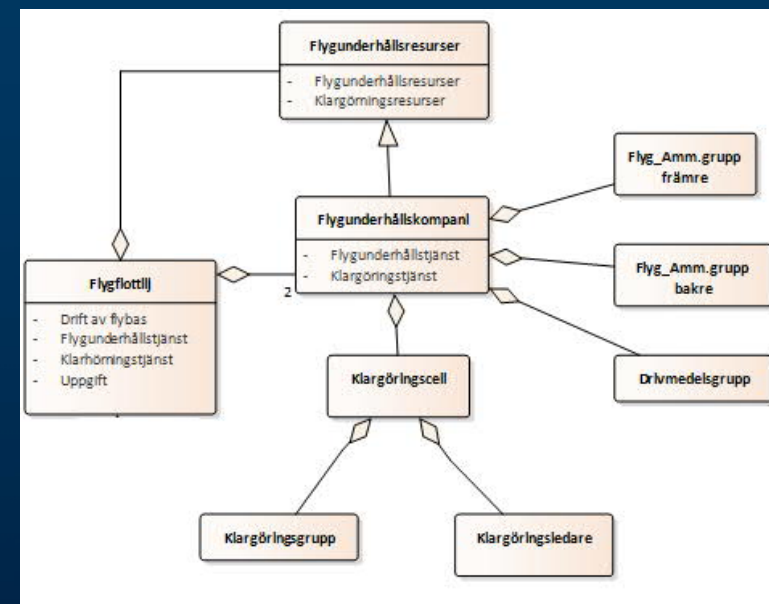
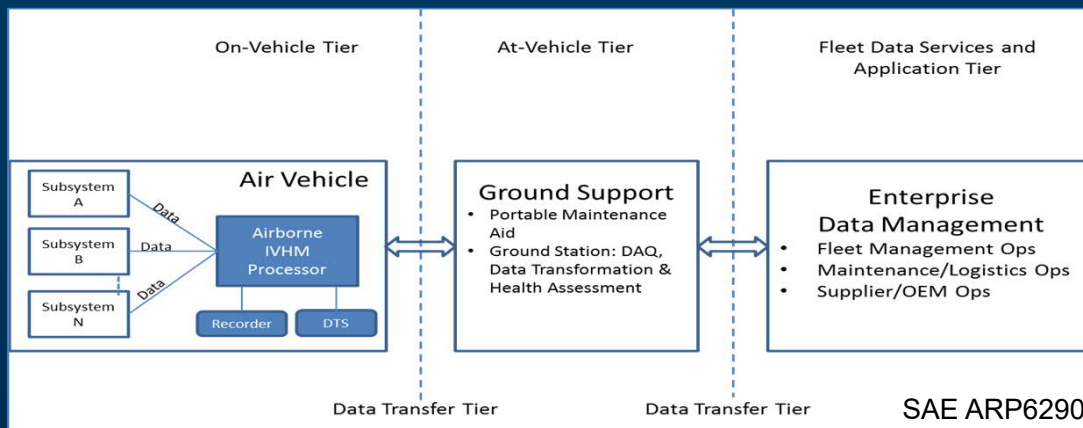


MILITARY AVIATION RATIONALE



DIGITAL TWIN – OP. AVAILABILITY, MAINTENANCE AND SUPPORT PERSPECTIVES

- AIR VEHICLE AND SUPPORT SYSTEM IN AIR OPERATIONS
- MAINTENANCE, LOGISTIC SUPPORT AND LIFECYCLE SUSTAINMENT



Bridging physical space and the virtual space with AC individual data integration for real-time information

IVHM AND DIGITAL TWINNING

Digital Twin technologies to improve IVHM and support in **individual air vehicle** coordinated:

- Air asset status representations, has-been, as-is and to-be:
 - Technical (TBD)
 - Operational (TBD)
- ICT service integration of:
 - on-vehicle data
 - ground support data
 - logistic C2, MRO and CLS/PBL
- Condition Based Maintenance algorithms
- AI/ML
- Continuous sys. evaluation of operational data for re-design/mod and development
- Matching of op/tactical efforts and maintenance resources
- Transaction management incl sub-sys/components
- Tracking, analysis and optimization in Multi-echelon maintenance/MRO and Supply Network
- Entire lifecycle: design, engineering, commissioning, service and decommissioning
- ...

WHAT IS GOING ON

DOMAINS

- Mobility
- Mining
- Aviation
- Manufacturing
- Process
- Energy
- ICT
- Medicine
- Finance



BUSINESS

- **Sustainability**
 - Save the planet
- **DigitalOps**
 - Value creating
- **Autonomy**
 - Increased efficiency
- **Augmentation**
 - Enhance decision-making
- **Advanced analytics**
 - Improve effectiveness
- **Robotics**
 - Reduce liveware intervention
- **Security & Safety**
 - Improve system resilience



CONCEPTUAL

- PHM
- Industrial AI
- IVHM
- Digital Twins
- Fleet Management
- Asset Management



TECHNOLOGY

- Intelligence
- System-thinking
- Distributed computing
- Augmented Human
- Digital Ecosystems
- Sensing & Mobility
- Postclassical computing
- Advanced AI & Analytics
- Open data



ASSET MANAGEMENT

- **Asset** is an item, thing or entity that has potential or actual value to an organization. The value will vary between different organisations and their stakeholders, and can be tangible or intangible, financial or non-financial
- **Asset management** involves the balancing of costs, opportunities and risks against the desired performance of assets, to achieve the organizational objectives.
- Asset management enables an organization to examine the need for, and performance of, assets and asset systems at different levels. Additionally, it enables the application of analytical approaches towards managing an asset over the different stages of its lifecycle

(ISO 55001:2014)

PROGNOSTICS & HEALTH MANAGEMENT

- **Prognostics** is the process of monitoring the health of a product and predicting its remaining useful life (RUL) by assessing the extent of deviation or degradation from its expected state of health in its expected usage conditions
- **Health Management** utilizes prognostic information to make decisions related to safety, condition-based maintenance, ensuring adequate inventory, and product life extension
- **Prognostics and Health Management (PHM)** permits the evaluation of a system's reliability in its actual life-cycle conditions

(CALCE, 2019)

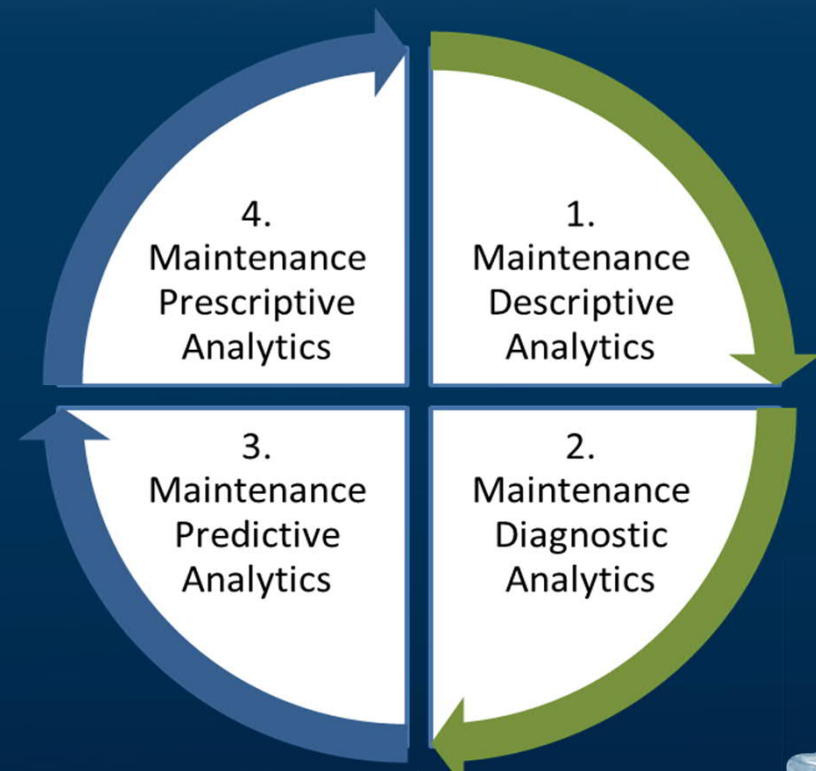
FLEET MANAGEMENT

- Fleet Management (FM) is about management of mobile machinery (cars, locos, aircraft, vehicles ...)
 - **PHM** is one the prerequisites to enable the concept of advanced FM
 - **IVHM** is considered as the technology enabler for FM



AUGMENTED ANALYTICS AND DECISION-MAKING

- **Now casting**
 - 1) What happened in the past
 - 2) Why something happened
- **Forecasting**
 - 3) What will happen in the future
 - 4) What need to be done next, augmented decision-making





HOW?

Governance

Rules

Business

Sustainability

Performance

Cost

Convergence

Cyber/Physical

IT/OT

Digital Twin

Algorithm

Reward/penalty

Decision

Data

Availability

Accessibility

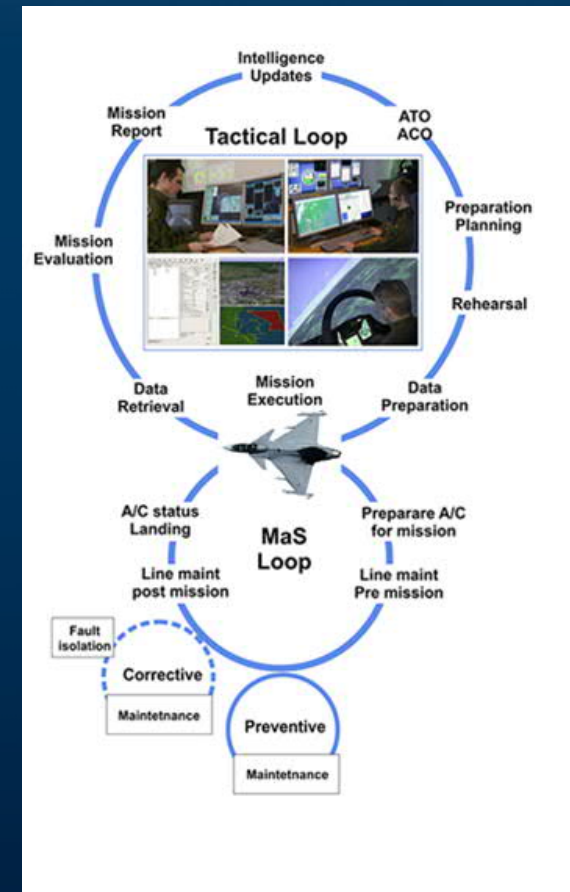
Digitalisation

Digital Twin

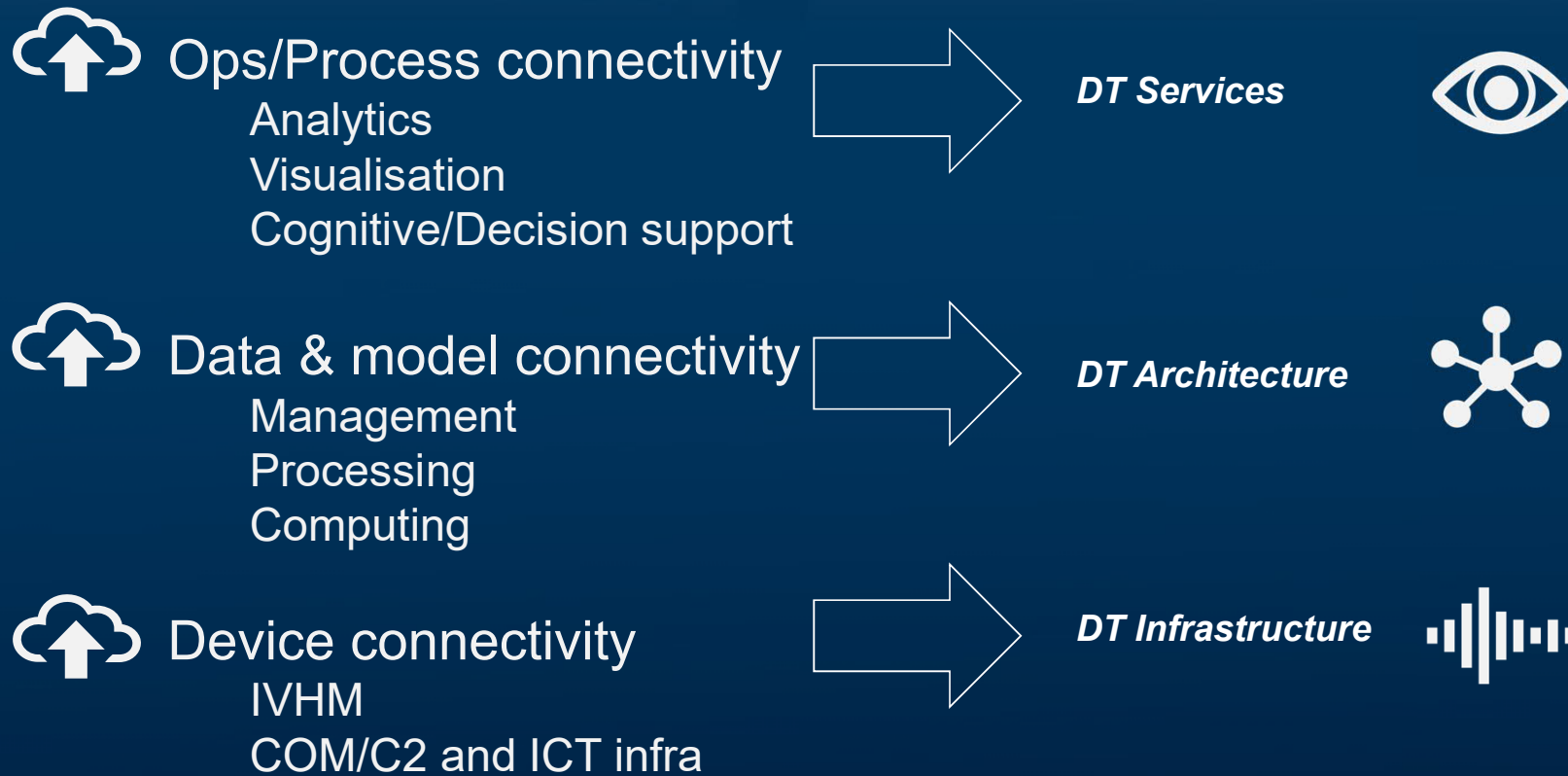
Simulation

NEEDS AND CONTEXT

- Support strategy
- CONOPS
- ICT eco-system, military C2 and COM's
- Integrate several data concepts
- Collected in 'knowledge graphs/network' of inter-related data
- Data may remain in its normal storage and is only mirrored as a digital twin (... -as-a-Service)




CAPABILITIES AND SERVICES 'BY DIGITAL TWIN'





TECHNOLOGY CHALLENGES

- **Cloud2Edge** –defining strategies and approaches to distribute and execute of DT services and (AI) components close to the asset
- **Data accuracy and usefulness** –the characteristics, e.g. quality, completeness, and consistency, of the datasets need to be fed to the models
- **Analysis fidelity** – the identification and definition of functions to assess the fidelity of models as predictors
- **Explainable AI** –the development and implementation of mechanisms to enhance AI-models with capability to explain the analysis



VINNOVA NFFP7 2017-04880 Dynamic matching of
Aircraft Maintenance Capabilities and Tactical Needs

eMaintenance LAB, Luleå University of Technology

THANK YOU FOR YOUR ATTENTION