U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – C5ISR CENTER

Sensor As A Service

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SENSOR AS A SERVICE CONTEXT

- **Problem Statement: Current sensor simulations require a high degree of expertise to configure and modify. Analysts must rely on static configurations and performance characteristics, and often cannot model the correct sensor in a simulation.**

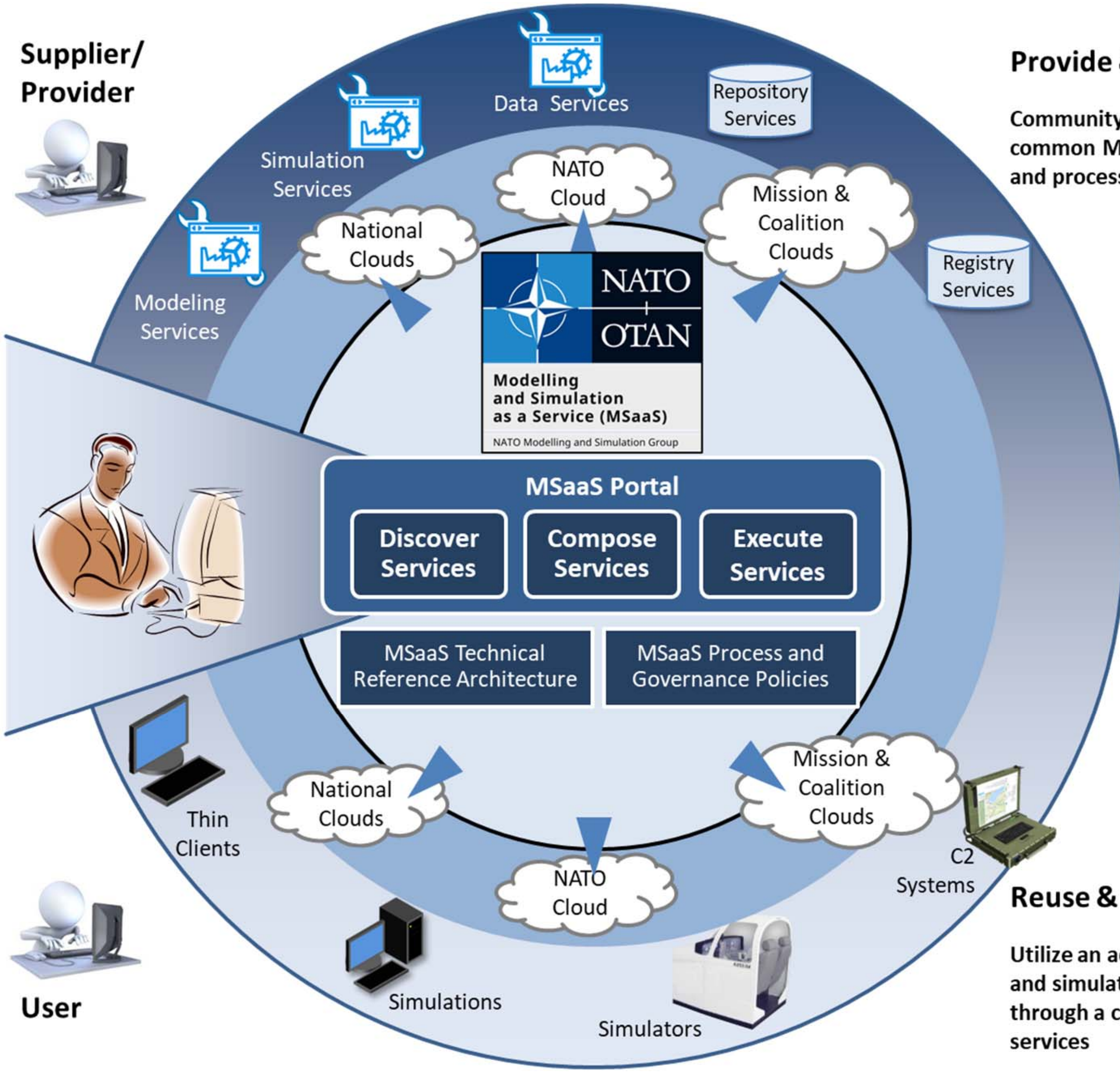
- **Problem background: Current methodology for implementing new sensor and/or target models requires off line processing, with subsequent import into constructive simulation environments. Manual process reduces resources available for individual sensor and associated collective experimentation.**

- **Purpose/Objectives: Make sensor representations available as a service to enable greater variability, and more rapid exploration of sensor/target engagement timelines and sensor performance within virtual, constructive and gaming applications.**

WHY SENSOR AS A SERVICE

- **US Army Cross Functional Teams (CFTs) need the ability to represent sensors**
  - Variable fidelity, multiple configurations for trade-off analyses
  - Provide performance parameters for new sensor modalities, "virtual prototyping"
- **The Synthetic Training Environment (STE) CFT**
  - Building the infrastructure and implementation of the next generation training capability
  - Includes simulation of sensors for weapons, navigation, situational awareness
  - Requirement to provide accurate sensor performance
- **Model Based Systems Engineering (MBSE)**
  - Overcomes the gap between the system model specification and the respective simulation software
  - Transitions from traditional Systems Engineering processes that are document-based and code-centric to more effective and efficient processes that are model-based
- **Machine Learning Data Augmentation for Training and Verification**
  - Provides large scale volumes of synthetic sensor data required to train AI/ML algorithms. Equivalent field collection would be cost prohibitive, time consuming, and not always possible for atmospherics. Synthetic approach also enables desireable background variations.
  - Provides verification that algorithms perform and provide correct information

THE NATO M&S AS A SERVICE (MSAAS) CONCEPT



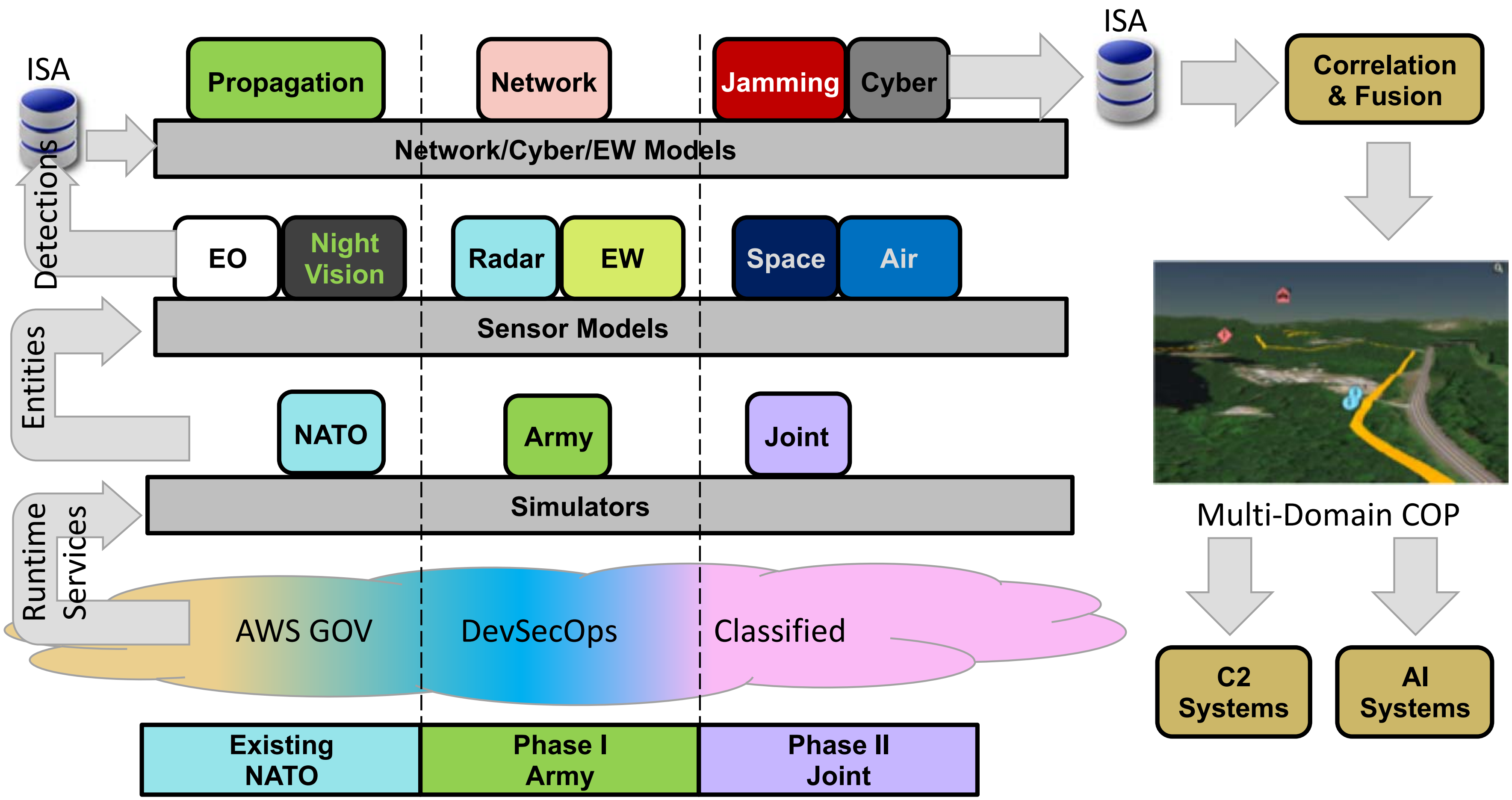
Provide & Share

Community of Interest to share common M&S products, data and processes

Reuse & Benefit

Utilize an adaptive modelling and simulation capability through a combined set of M&S services

SENSOR AS A SERVICE ARCHITECTURE



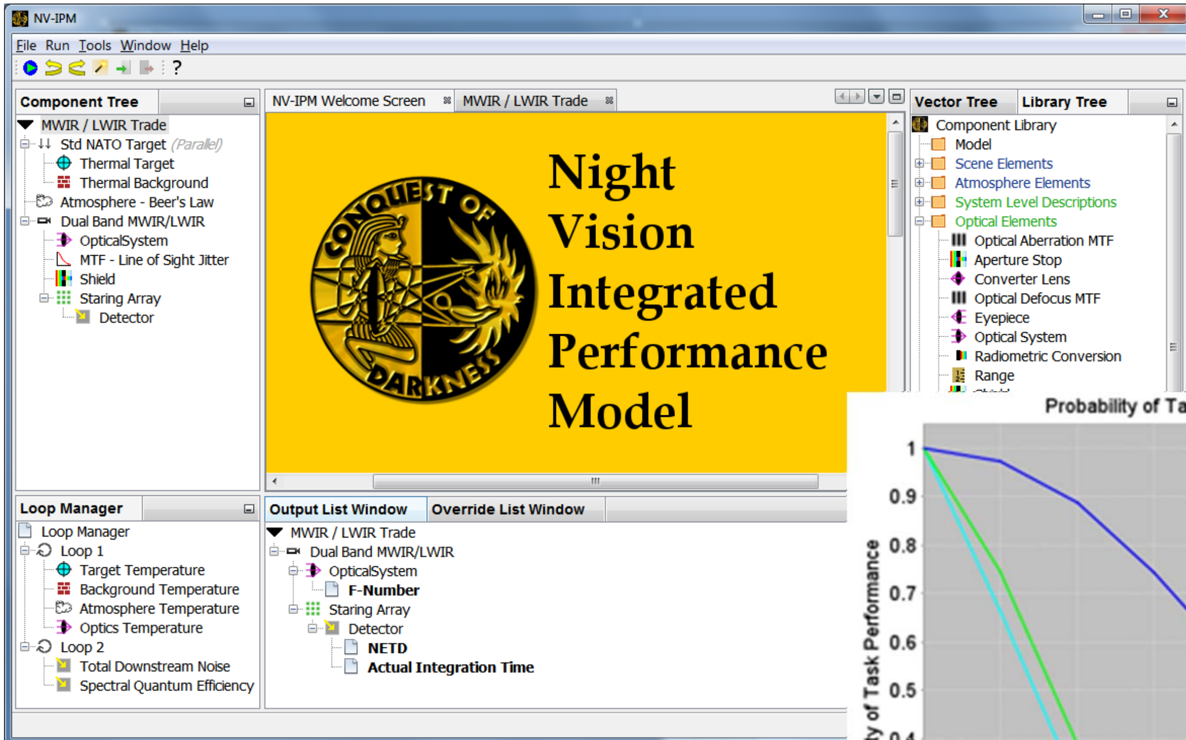
IMPLEMENTATION CHOICES AND HOSTING

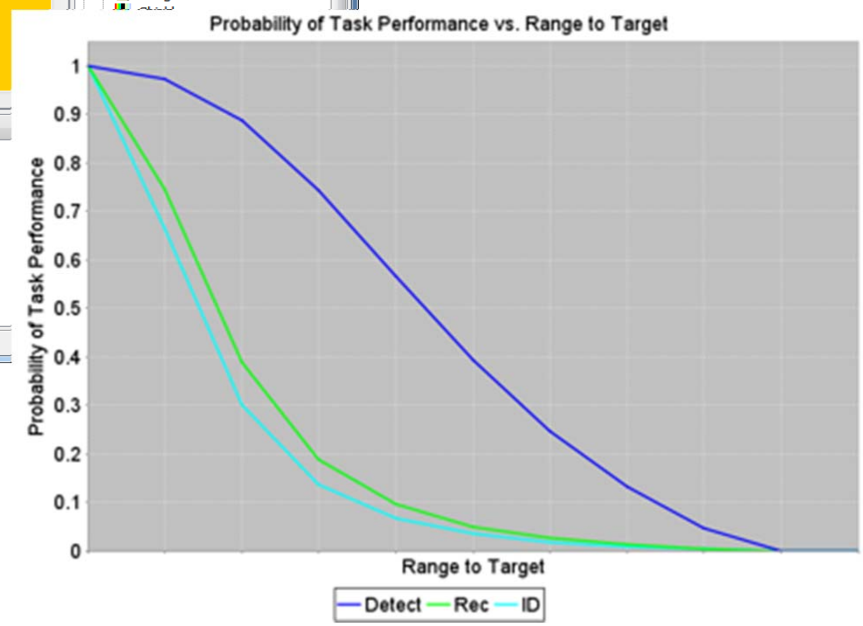
- **Container Orchestration – Kubernetes**
  - Private, on premise cluster
  - Amazon's Elastic Kubernetes Service (EKS)
  - Microsoft's Azure Kubernetes Service (AKS)
  - Google's Kubernetes Engine (GKE)

- **Container runtime – Docker**
  - Open Container Initiative (OCI)
  - Container Runtime Interface (CRI)

- **Distributions**
  - Rancher, chosen by NATO for experimentation
  - Multiple Linux distributions (Redhat / CentOS, Debian, …)
  - Windows Server 2016(?) and 2019
  - Docker for Desktop – Windows development
    - Supports Linux and Windows containers
    - Integrated Kubernetes single node cluster
    - Hyper-V based
  - Minikube – Desktop development single node Kubernetes distribution
    - Supports Hyper-V, Virtual Box, KVM

SENSOR AS A SERVICE NV-IPM FOUNDATION

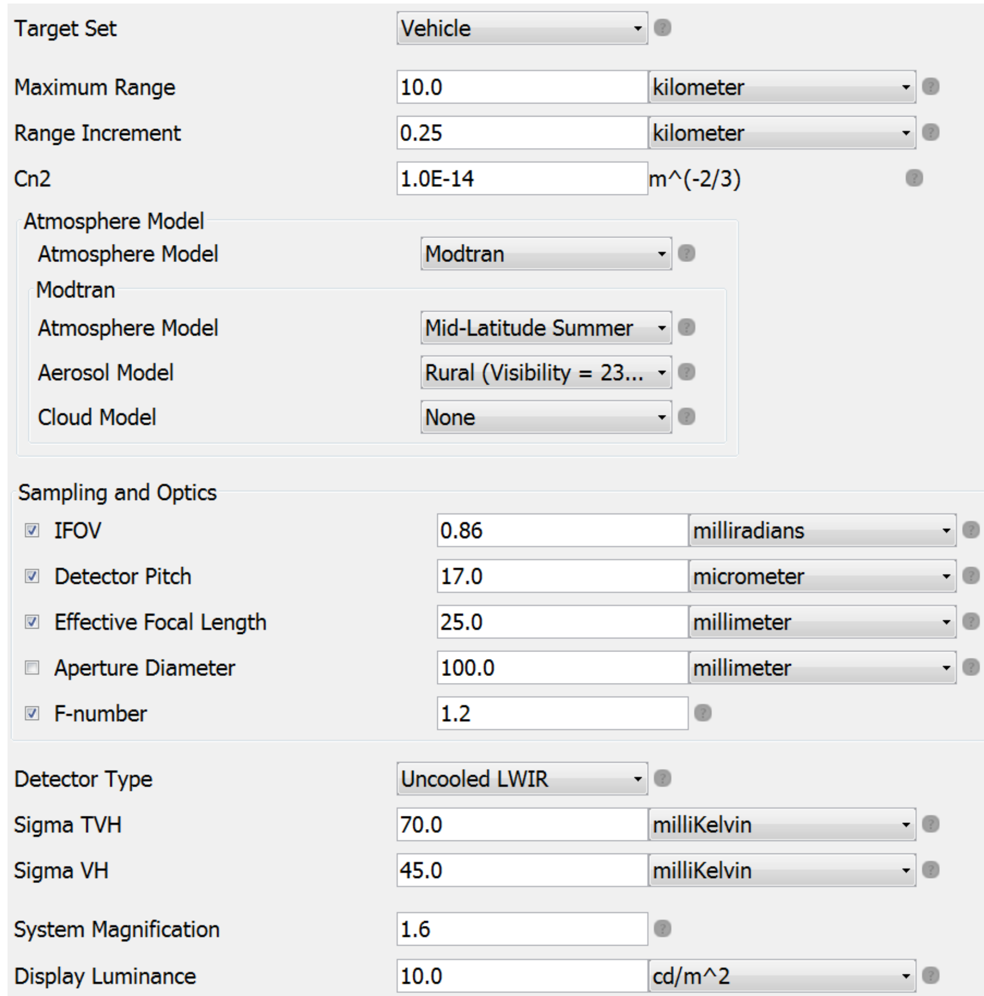




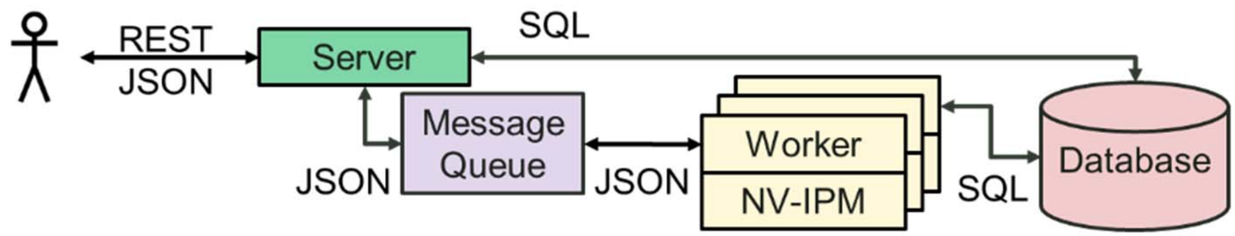
- **Key Features**
  - Component level system construction
  - Field and lab system representations
- **External application interfaces**
  - OneSAF, NVIG, NVLabCap, IRWindows™

NV-IPM SIMPLIFIED INPUT FORMAT

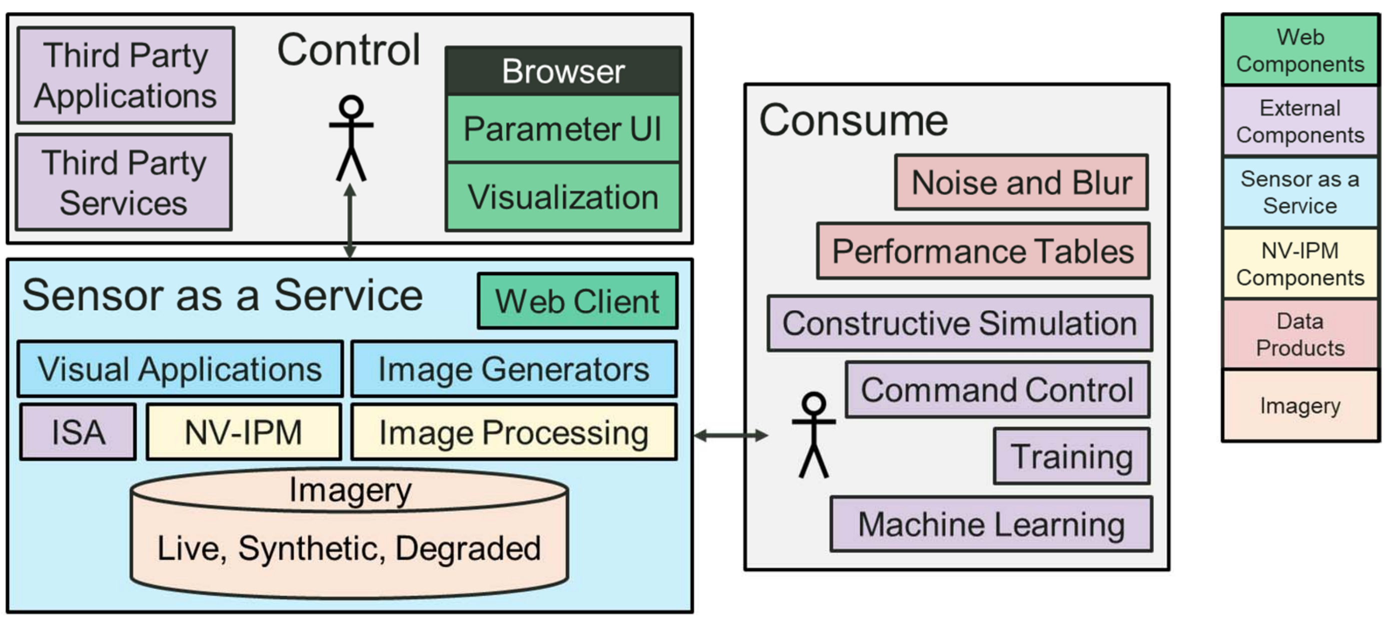
- **Introduced simplified input files in NV-IPM**
  - Build system models from a sub-set of parameters
  - Elements selected to capture largest contributions to system
- **Standard definitions for targets and atmospheres**
  - Vehicle / Human based on validation performance data
- **Optimization of end-to-end-system magnification**



SAAS IMPLEMENTATIONS



NV-IPM implementation

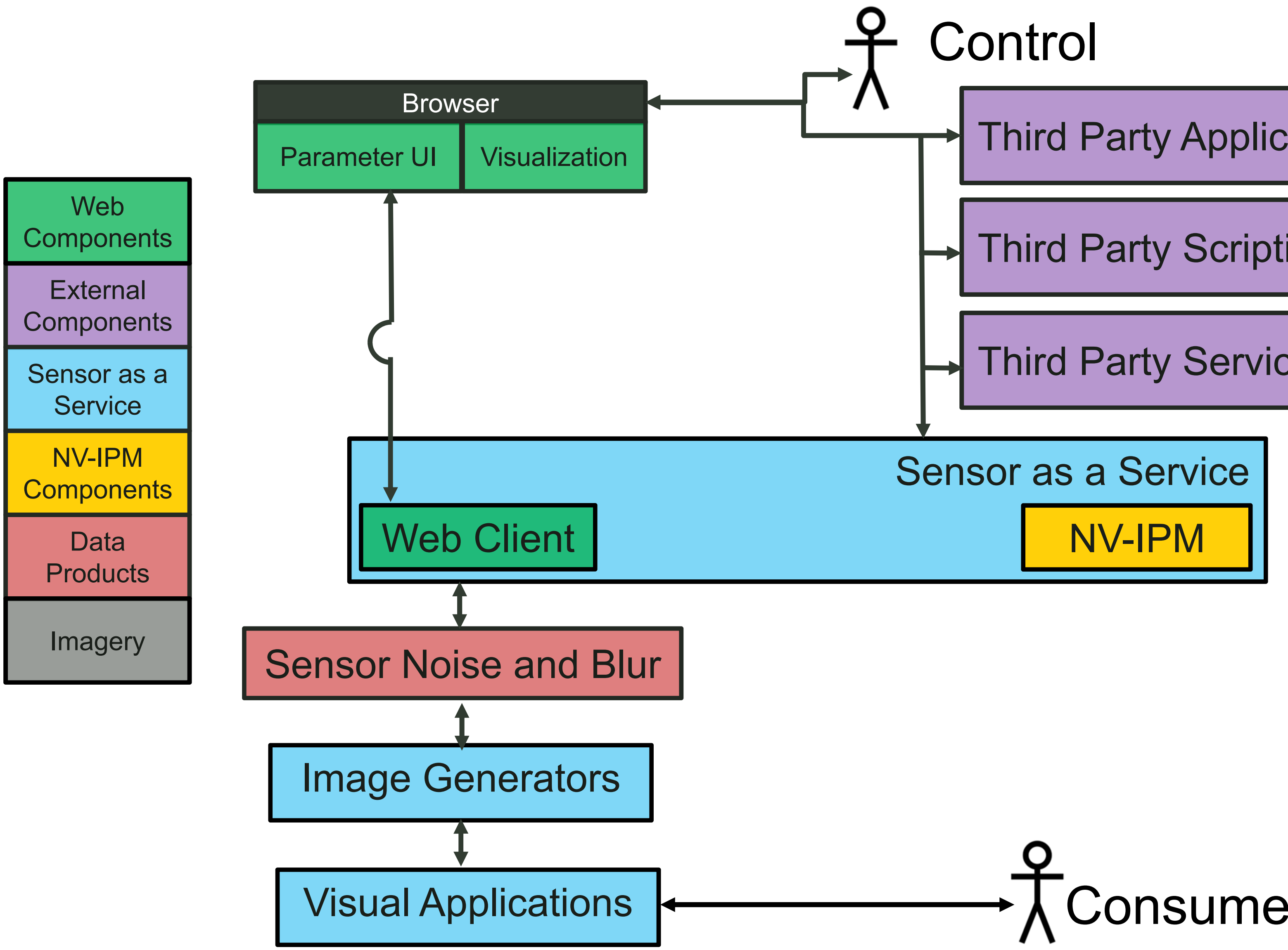


Objective implementation

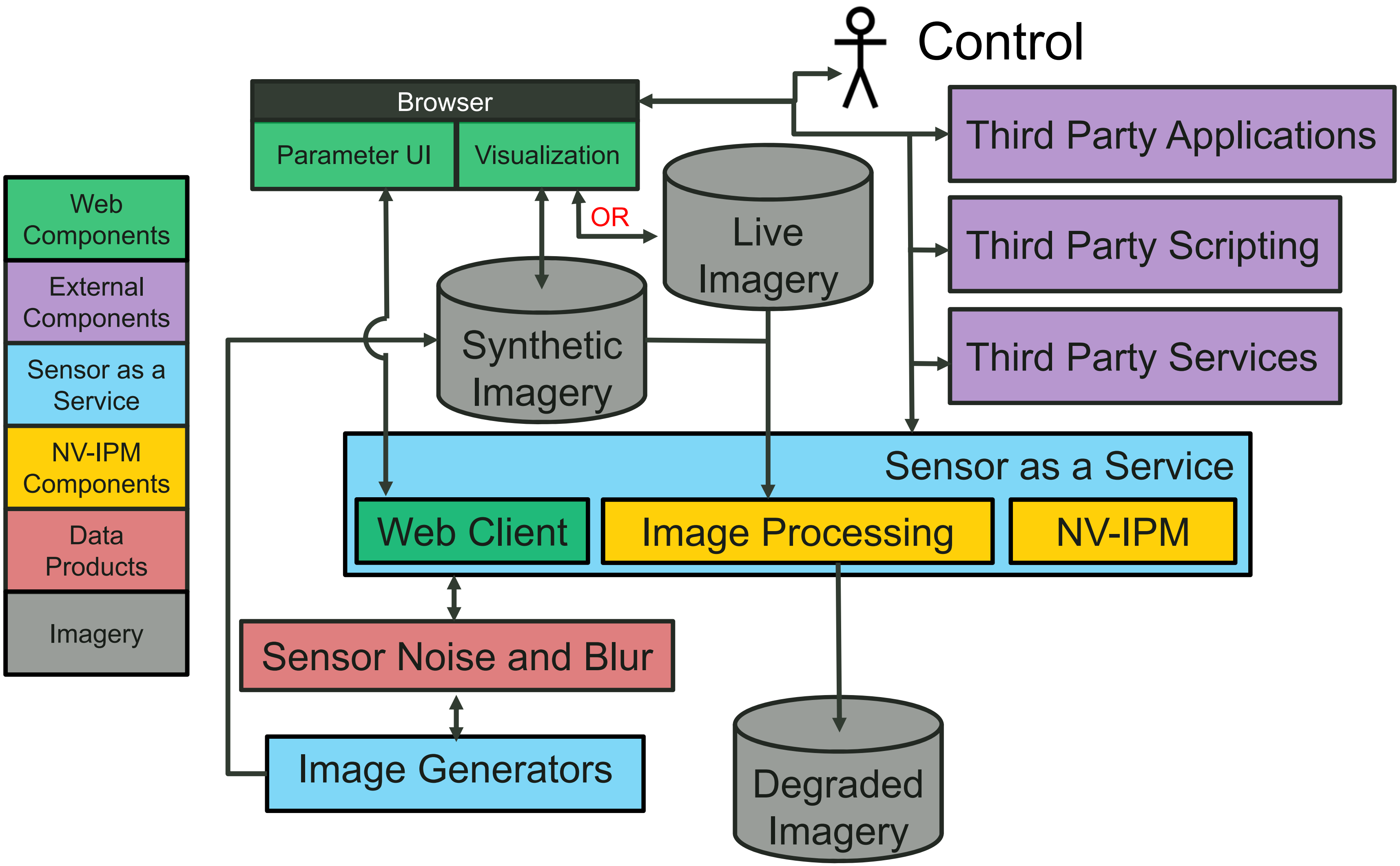
SENSOR AS A SERVICE FUTURE PHASES

- **Update Sensor as a Service to fully integrate with other simulations.**
  - Expand Input Application Programming Interface (API) to include simulation specifics such as image generator post processing module set.
  - Expand Results API to transform NV-IPM returns into simulation specific formats such as OneSAF, Combat XXI and NVIG sensor configurations.
  - Expand Results API to provide simulation neutral performance characteristics along with noise and blur parameters.
  - Integrate, as feasible, run time dynamic updates of consuming simulations.
- **Update Sensor as a Service to provide imagery and video on demand**
  - Integrate NV-IPM image transformation from either live or synthesized source imagery.
    - Compose image transformation stage as desired by user.
  - Enhance Night Vision Toolset API to:
    - Deeply integrate with Python compute environments (dominant in Data Science).
    - Provide higher level API supporting scene composition, viewpoint path following, and other customer driven use cases.
  - Package Sensor as a Service system components as composable containers.

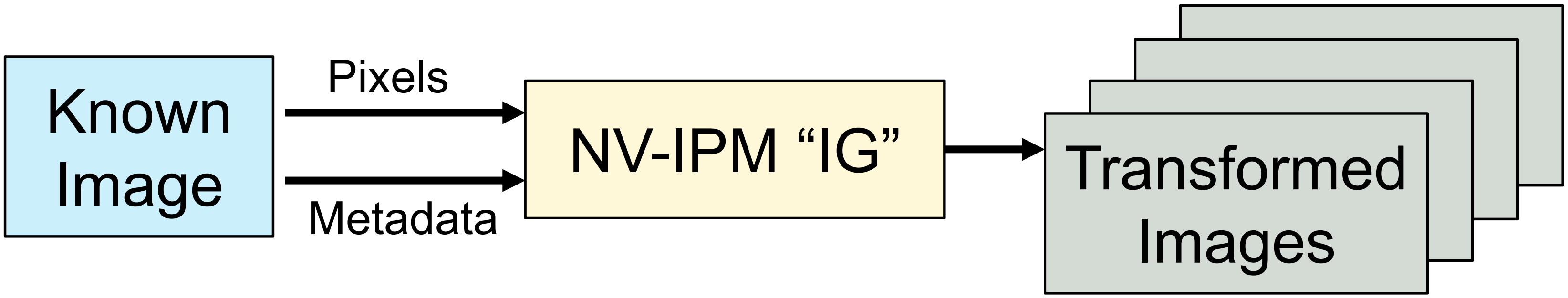
SENSOR AS SERVICE VIRTUAL SENSOR APPS



SENSOR AS SERVICE IMAGERY GENERATION

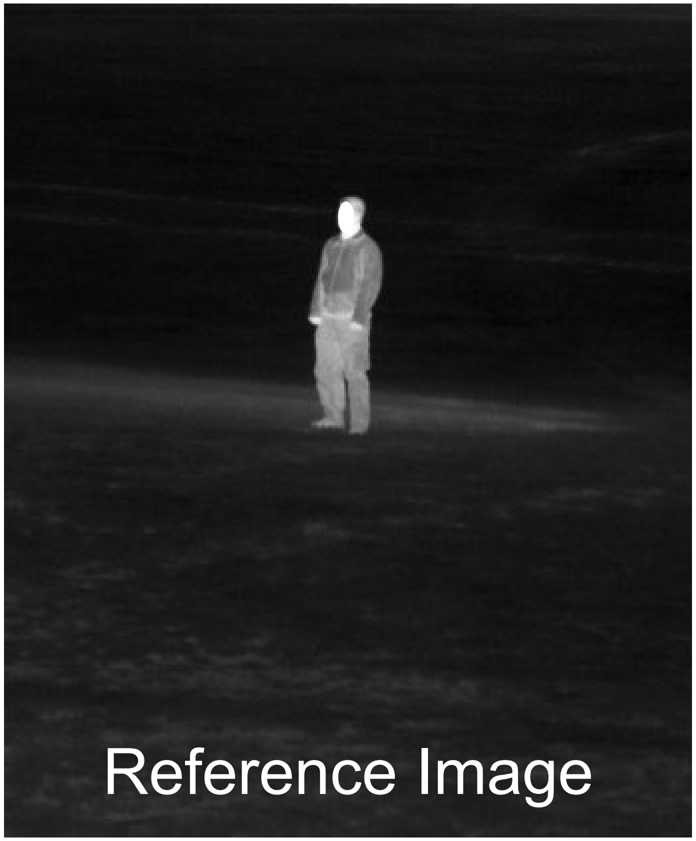


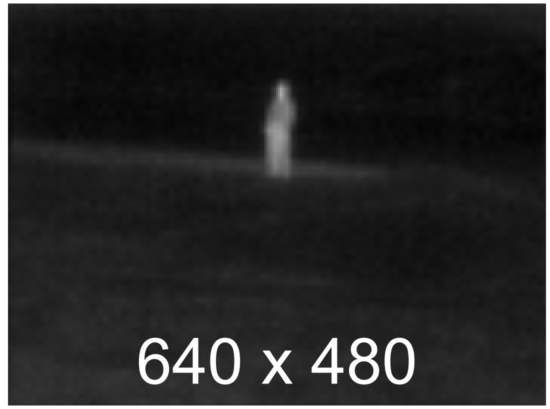
NV-IPM IMAGE PROCESSING

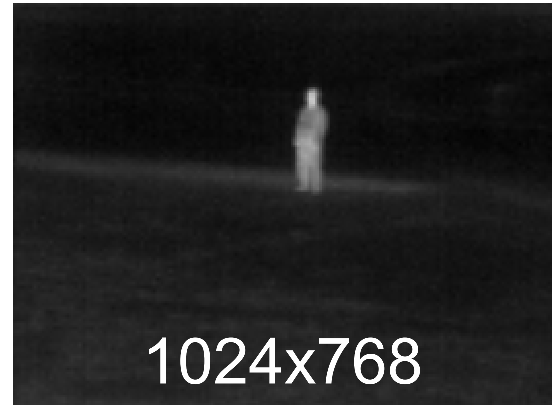


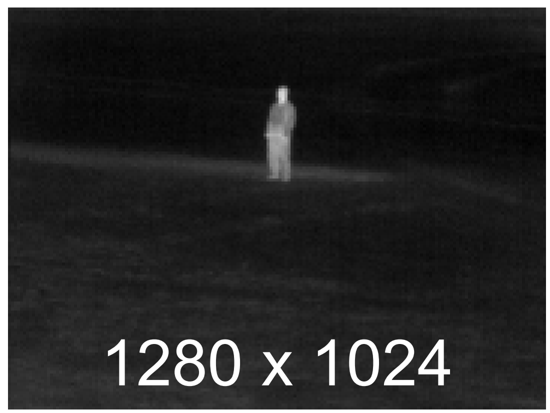
- **Collection metadata**
  - Reference camera sampling (pixels on target)
  - Reference camera resolution (how much blur is present in original image)
  - Reference camera intensity transfer (how many gray shades per degree)
- **Transformations**
  - Apply notional camera effects mapping known image to transformed image
  - Internal effects include blur introduced by camera system and system noise
  - External effects include atmospheric blur, motion blur, atmospheric transmission
  - Range based, pixels on target, image degradations
- **Planned updates to image process**
  - Improved turbulence simulation
  - Additional image distortions and processing
  - Additional ranged based degradations
- **Applicable to "live" and simulated imagery**

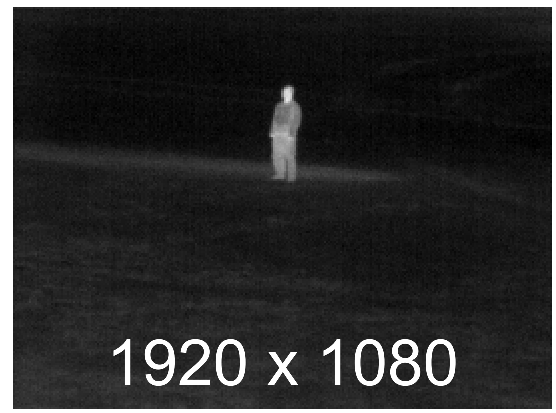
IMAGE PROCESSING EXAMPLE











Degraded images at range

BENEFITS

- **Sensor as a Service enhances Digital Engineering; a few examples:**
  - What sensor performance characteristics influence Man In The Loop (MITL) and / or Machine Learning (ML) Detection Classification Recognition Identification (DRI) accuracies?
  - Given weight, power, and physical package constraints, what sensor performance is possible and how does that affect force and platform battlefield outcomes?
- **Sensor as a Service supports Machine Learning (ML) through Data Augmentation**
  - Ground truth tagging automated when synthesizing imagery and degradation.
  - Additional variation available through image processing of atmospheric effects.
  - Mix of live or synthesized data improves ML transference to live domain.
- **Composition of sensor services enables Sensor as a Service to address specific use cases without extensive reconfiguration**
  - Experimentation of ML algorithms may require limited target type variation yet large variations in atmospherics.
    - Apply live imagery NV-IMP image processing to develop imagery set.
  - Development of ML algorithms to discriminate between target types in clutter may require a few targets of interest with randomly generated backgrounds.
    - Synthesize background and target set through IG automation.