HONG KONG ASIAWORLD-EXPO 亞洲國際博覽館

3RD TO 6TH DECEMBER 2025

AI-Powered Smart Table for Surgical Kit Reassembly in Sterilization Centers

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Agenda

Situation
Background and reasons behind the creation of the AI Smart Table

Task
Key features and objectives defined for the AI Smart Table

Action
Project implementation overview — technical and operational aspects

Results
Outcome analysis and key findings from the pilot project

Future
Next steps — system improvement and long-term sustainability

Situation:

Hidden Risks in Surgical Set Management

Recurring Issues in Surgical Set Packaging

Safety

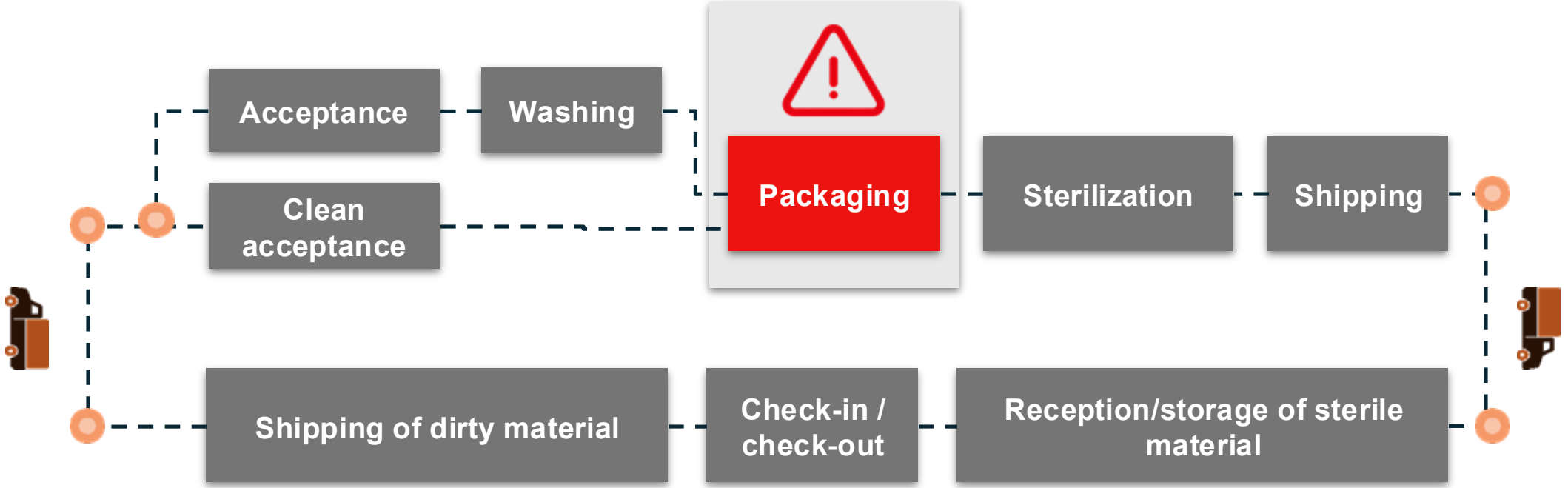
- Incomplete or incorrect kits
- Misplaced instruments
- Instrument loss

Operational Efficiency

- Non-standardized procedures
- High staff turnover / inexperienced operators

Economic Impact

- Training time and costs
- Lengthy packaging process



Task:

Automating and Supporting Surgical Set Repacking

Essential Features of the Smart Workstation

Accurate Instrument Recognition

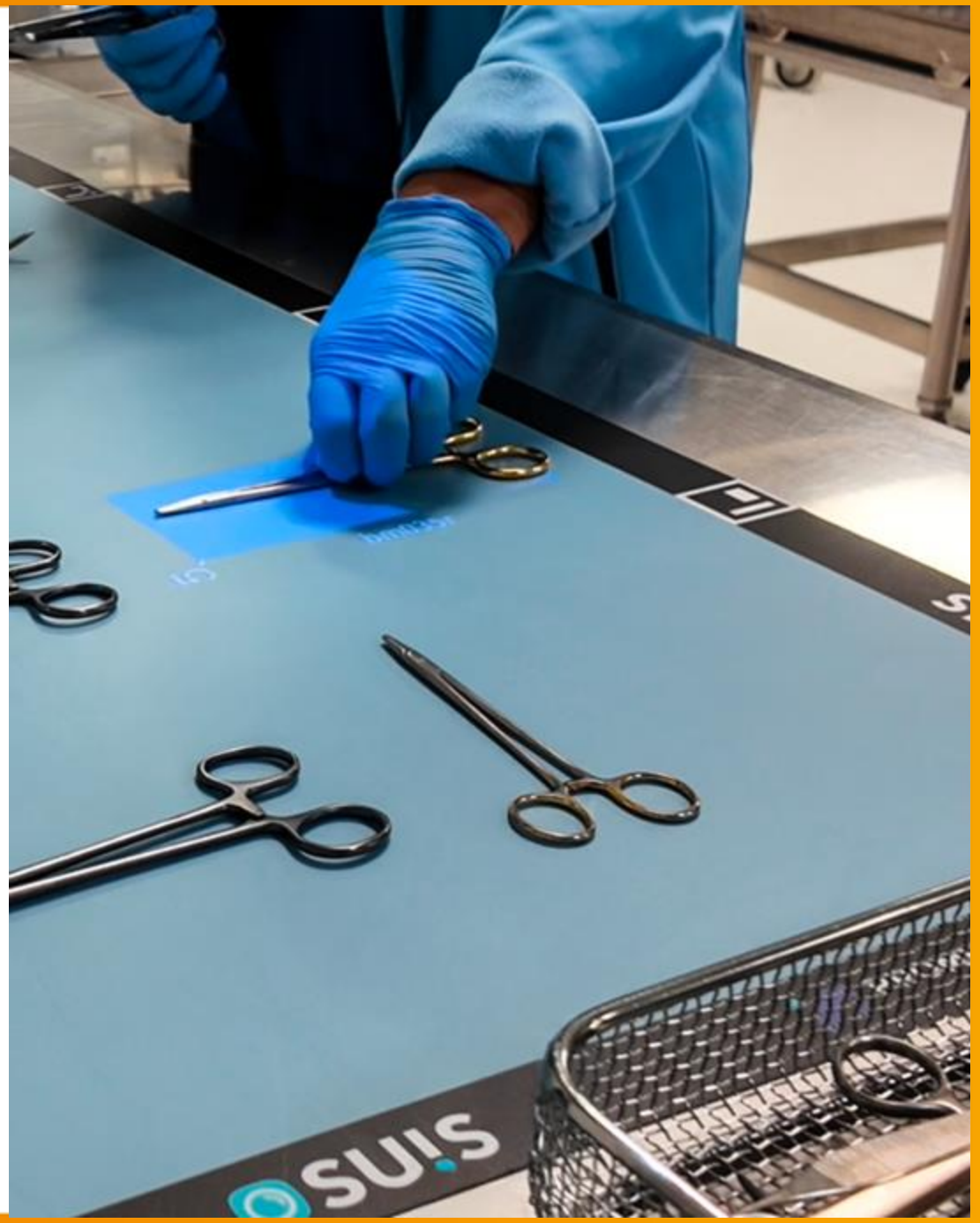
- Reliably identify instruments by shape
- No reliance on engravings or datamatrix codes
- Preserve instrument certification

Set Differentiation & Operator Guidance

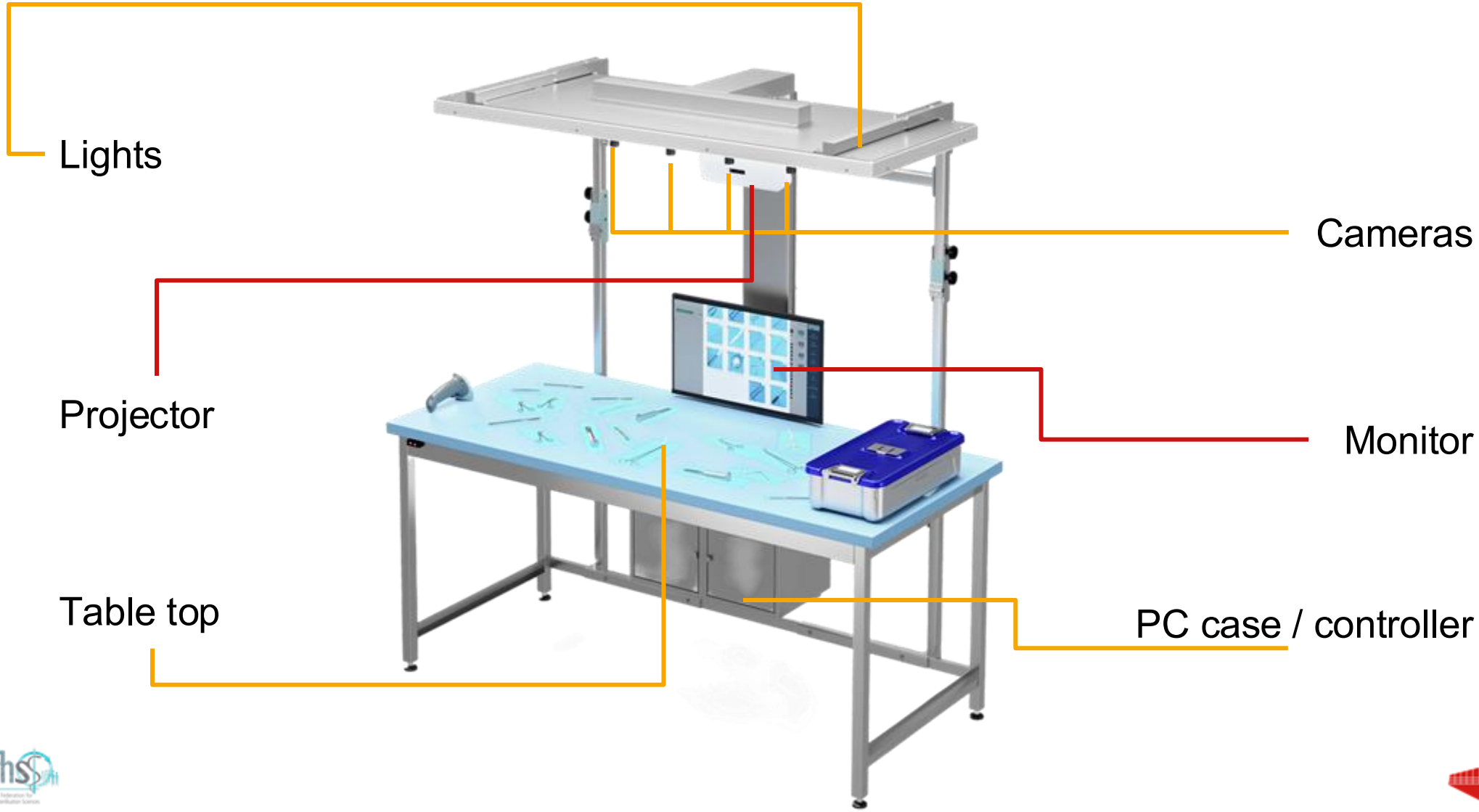
- Distinguish instruments from different sets
- Provide guidance to operators in case of uncertainty

Ergonomics & Workflow Integration

- Fast and easy to use
- Seamlessly integrated into the sterilization workflow



Visualizing the Smart Workstation



Action: Project Layout

AI Component

- Algorithms for surgical instrument recognition
- Ensures accuracy and reliability in set composition

Operational Component

- Functional collaborations with:
  - AUSL Modena, Italy
  - Massa hospital, Italy
  - IHSS, UK
- Workflow integration and real-world testing

AI Algorithm: Challenges in Instrument Identification

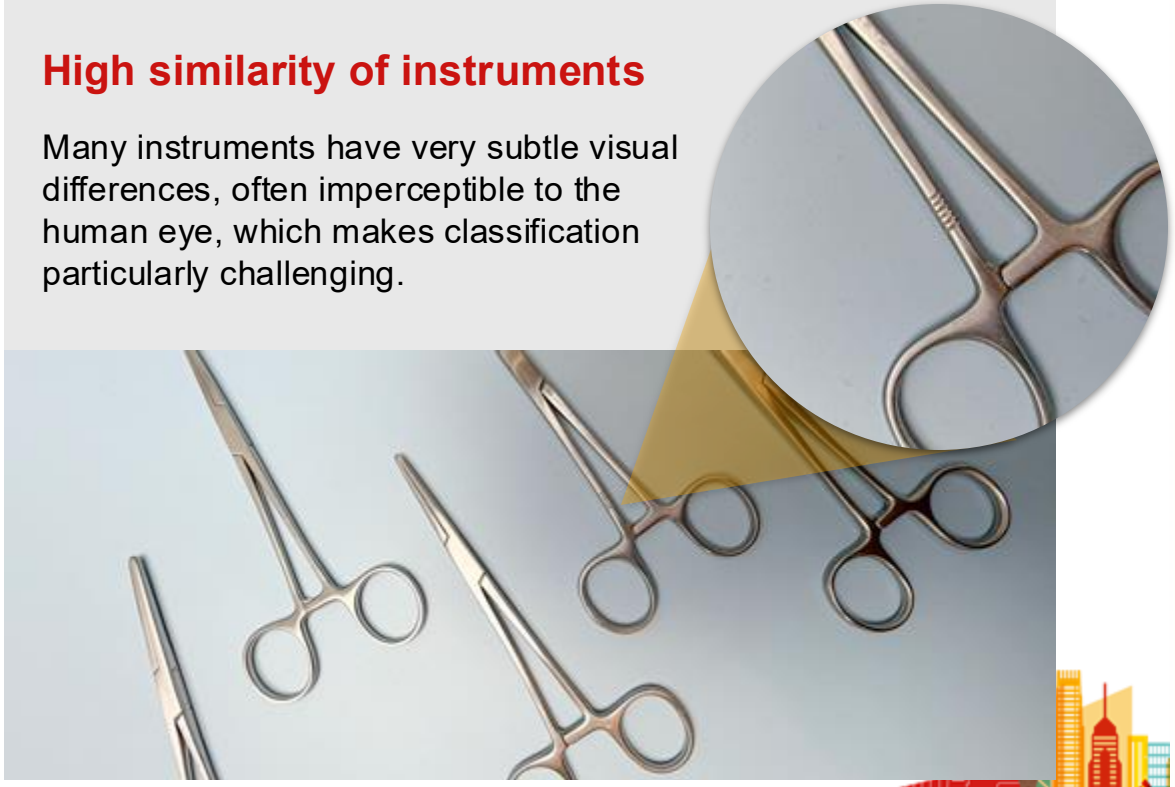
Developing a robust system for surgical instrument identification required addressing two major challenges:

High variability of instruments

The inventory is extensive and constantly evolving, making it impractical to create training pipelines tailored to specific sets.

High similarity of instruments

Many instruments have very subtle visual differences, often imperceptible to the human eye, which makes classification particularly challenging.



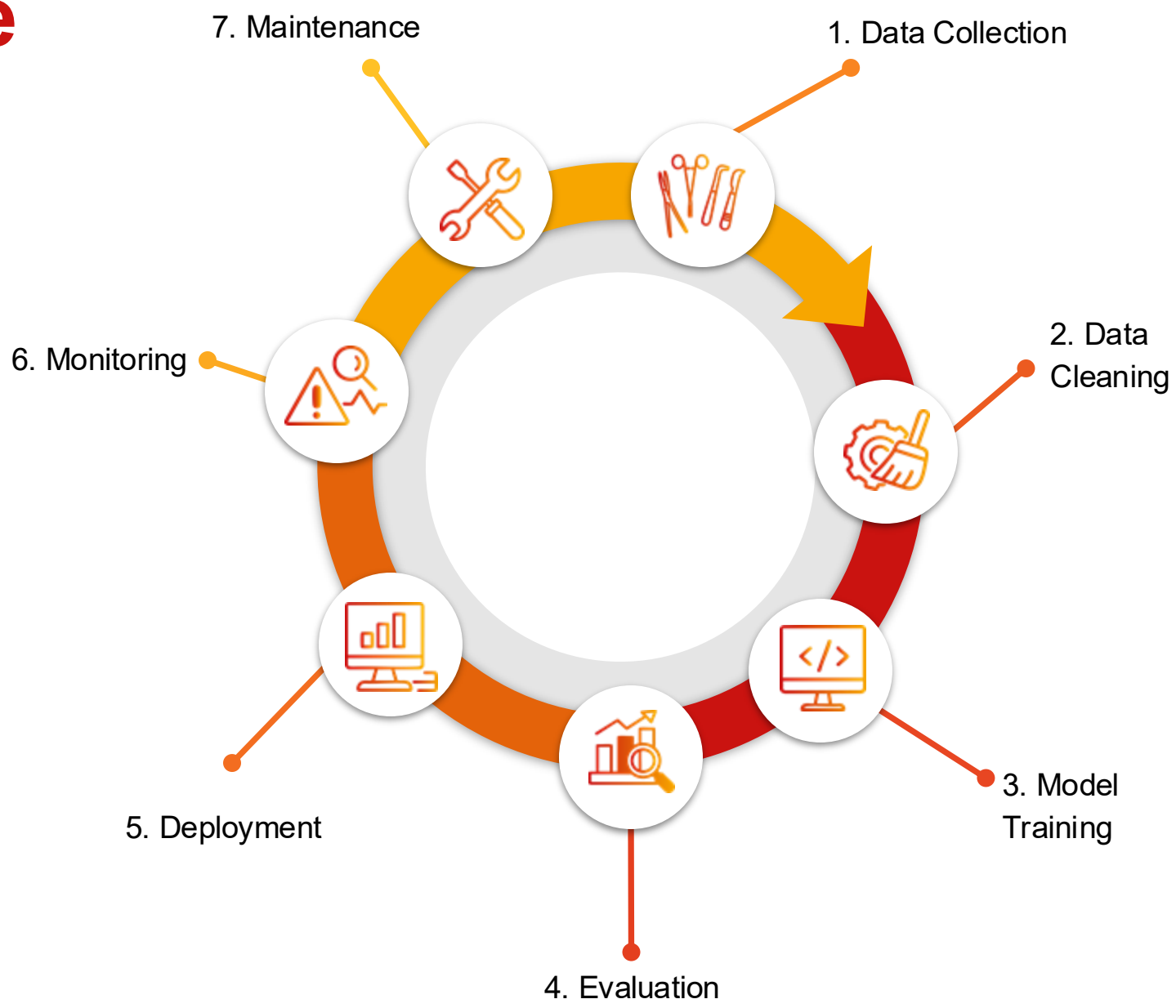
Limitations of the Initial Approach

Classical Supervised Learning Pipeline

- > 25 images per instrument under controlled conditions
- Model trained per-set, sharing images across sets

Limitations:

- Computationally expensive and time-consuming
- Each set modification requires retraining
- Cannot detect foreign objects or missing instruments
- Accuracy sensitive to lighting and set composition
- Single reference marker → limited measurement precision



Evolved Approach: scalable and generalizable pipeline

Enhanced Segmentation: Deep learning model removes background artifacts and isolates instruments.

Evolved Approach
scalable and generalizable pipeline

Advanced Representation:
Generates high-dimensional numerical representations to capture fine-grained distinctions between objects.

Combined Classification Approach:
Integrates visual features and supplementary information for a scalable, accurate, and adaptable system.

Data Acquisition Optimization:
Minimized the number of photographic captures per instrument from 25 to 8, preserving full informational coverage.

HDR Imaging: Ensures consistent image quality across varying lighting conditions.

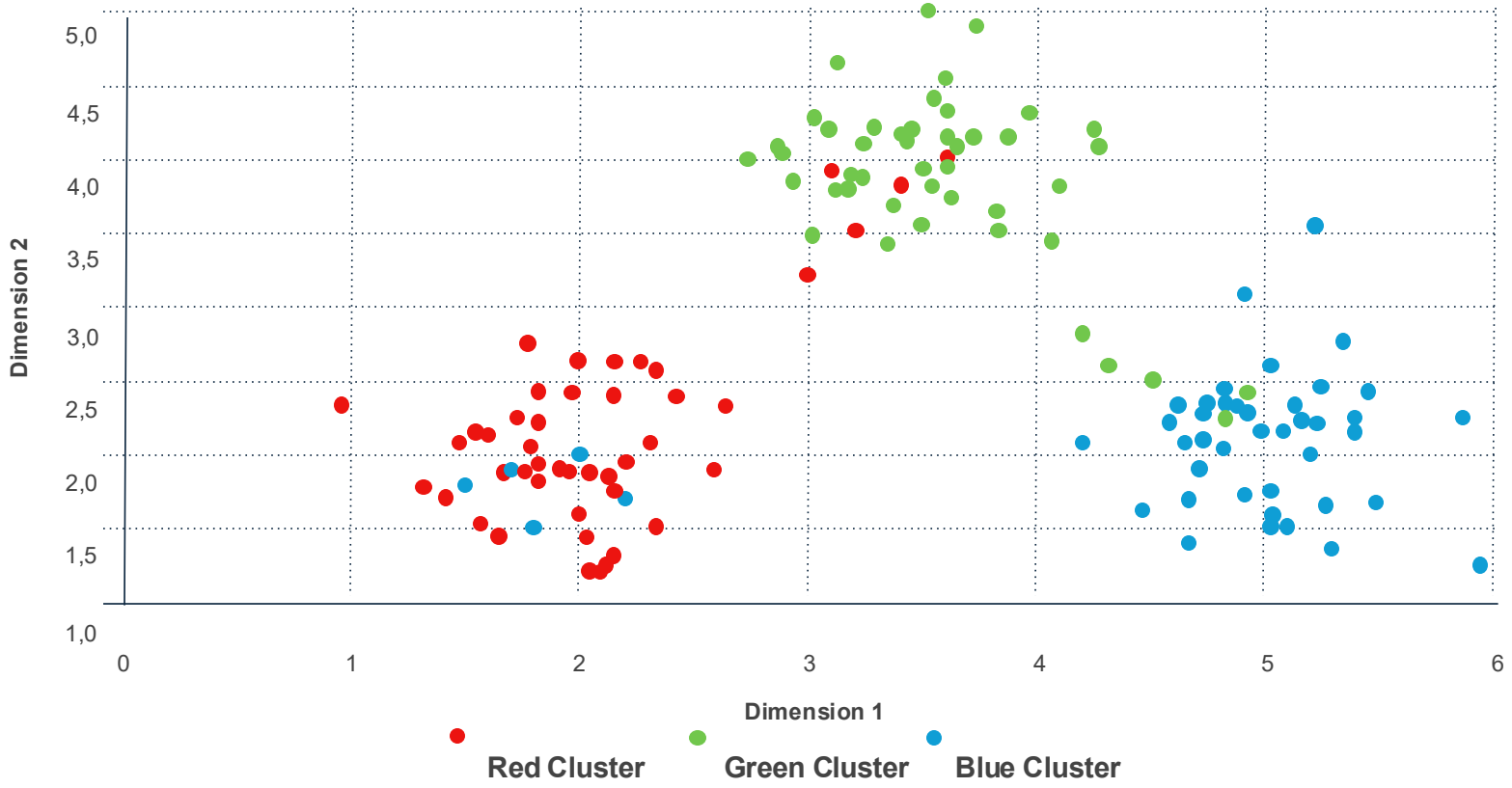


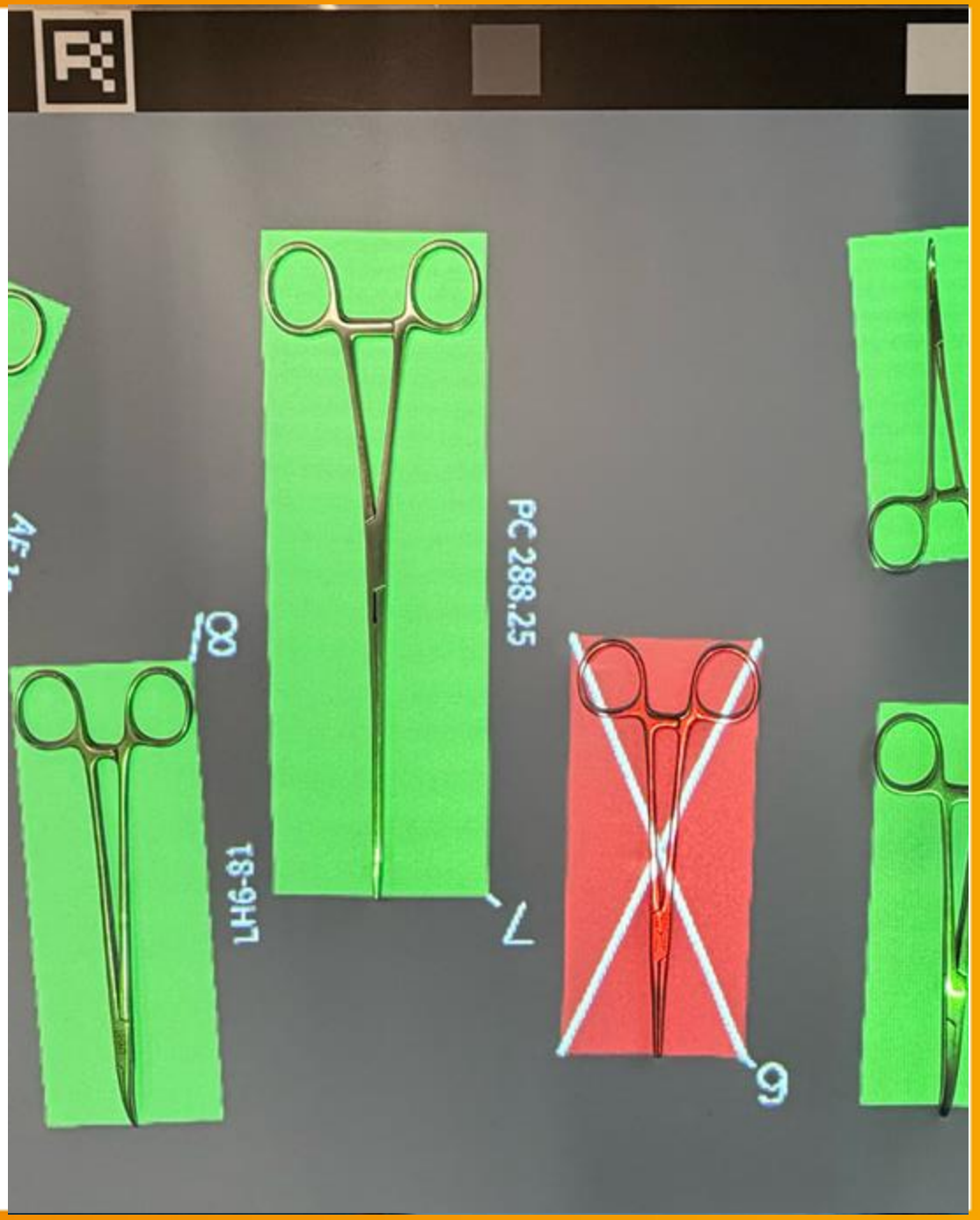
Fig. Images grouped into clusters with some nearby clusters and outliers

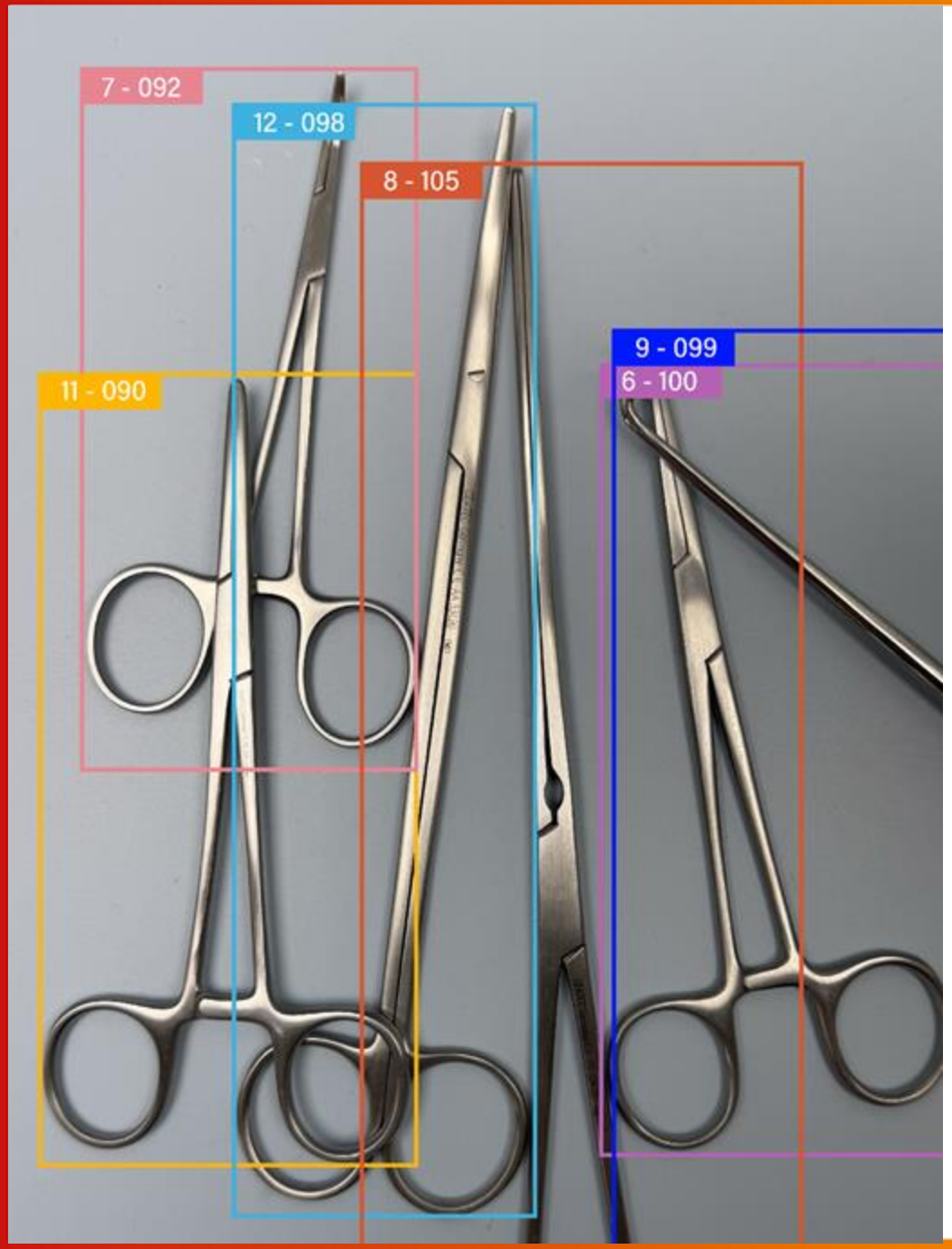
Results & Benefits of the New Approach

- No set-specific training required
- Incremental accuracy improvement by adding images without retraining
- Robust outlier detection (foreign or missing instruments)
- Automatic reassignment of instruments to the correct set
- 99.5% prediction accuracy, with uncertain cases still correct within top-3

Achieved Outcomes:

➔ Scalability across evolving instrument sets
➔ Flexibility in correcting misclassifications
➔ Accuracy in detecting outliers and foreign objects
➔ Efficiency in acquisition and preprocessing





Exploring Future Improvements

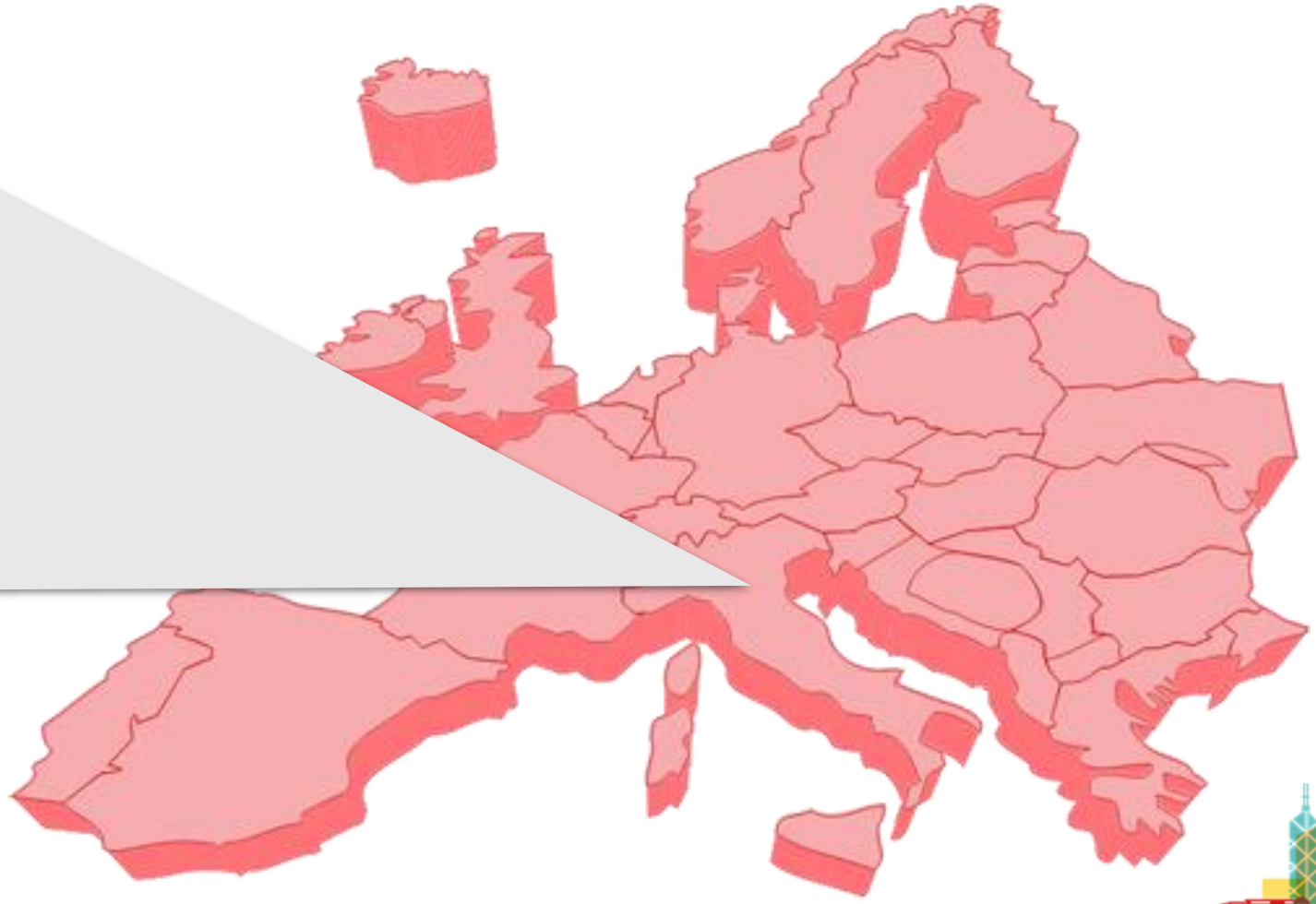
Optimized Image Acquisition - Reduce required images via improved camera setup and wider field-of-view lenses.

Uncertainty Reduction - Refine training parameters to minimize uncertain predictions.

Overlapping Instruments - Enable accurate recognition of tools in contact or close proximity.

Detecting non-compliances - Identify improper cleaning and physical defects.

Testing the Proposed Solution at Ausl Modena Hospital



Modena hospital: case study - Stage 1

Pilot implementation and data collection overview

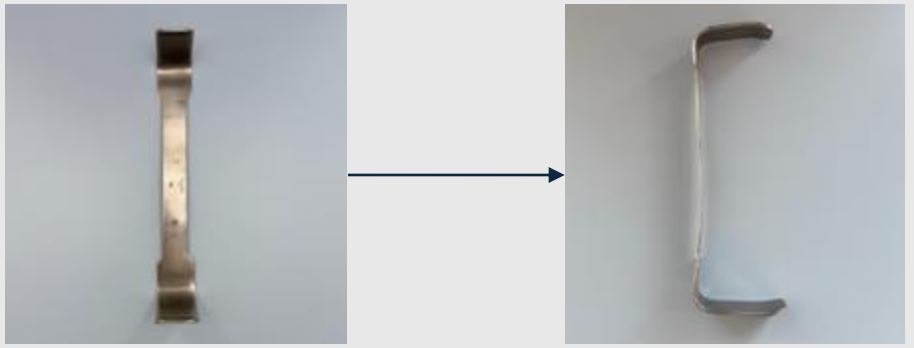
Pilot Information

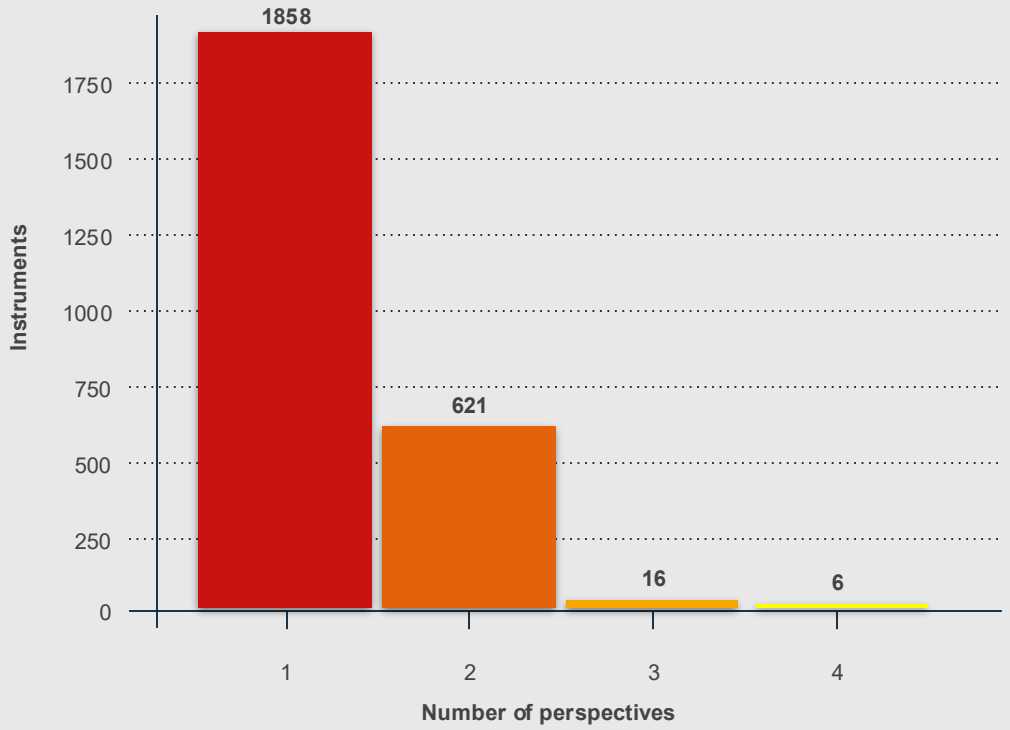
- *Start:* **November 2024**
- *Operators:* **15 total (4 with packaging experience)**
- *Total kits:* **470**
- *Total instruments:* **4,864**
- *Average workload:* **1,159 kits / month**

Data Collection Results

- *November 2024 - January 2025*
- Started from
  Orthopedics: most complex sets
  General Surgery: covers **77%** of most frequent instruments
- *Avg. capture time per instrument view:* **1 min 49 sec**
- *Kits acquired:* **292**
- *Instruments acquired:* **2,731**

An instrument can have more than one specific viewpoint from which it can be observed





Modena hospital: case study - Stage 2 (Jan–Jun 2025)

Operational Feedback and System Optimization

From **January to July 2025**, we worked **on-site with hospital operators** to collect feedback and improve both **hardware and software** for greater usability and efficiency.

Main Improvements

Ergonomics

- Redesigned workstation for **adjustable touchscreen positioning**
- Introduced a **peg-based system** for orderly instrument placement
- Added **customizable accessories** to suit different surgical sets

Personalization

- Developed **different collection modes** tailored to operator experience
- Supported less experienced users without slowing down experts
- Introduced a **training mode** for independent practice in kit assembly

Accessibility

- Adjustable search **speed**
- Automatic display of **packaging notes**
- **Simplified menu** for quick access to key functions
- **Audio guidance** to assist during operation

Results:

Measurable Impact – Reliable Performance for Every Operator

Outcome Analysis of the Modena Hospital Pilot

Bulgarelli Antonella
CSSD Coordinator
Modena Hospital

"The table pilot yielded very positive results, especially in terms of speeding up operations, enabling an increase in work volumes."

Luana Ghizzoni
Senior Nurse
CSSD Modena Hospital

"The smart table brought a tremendous improvement: we enhanced both accuracy and packaging times, significantly reducing human errors caused by oversight or visual mistakes."

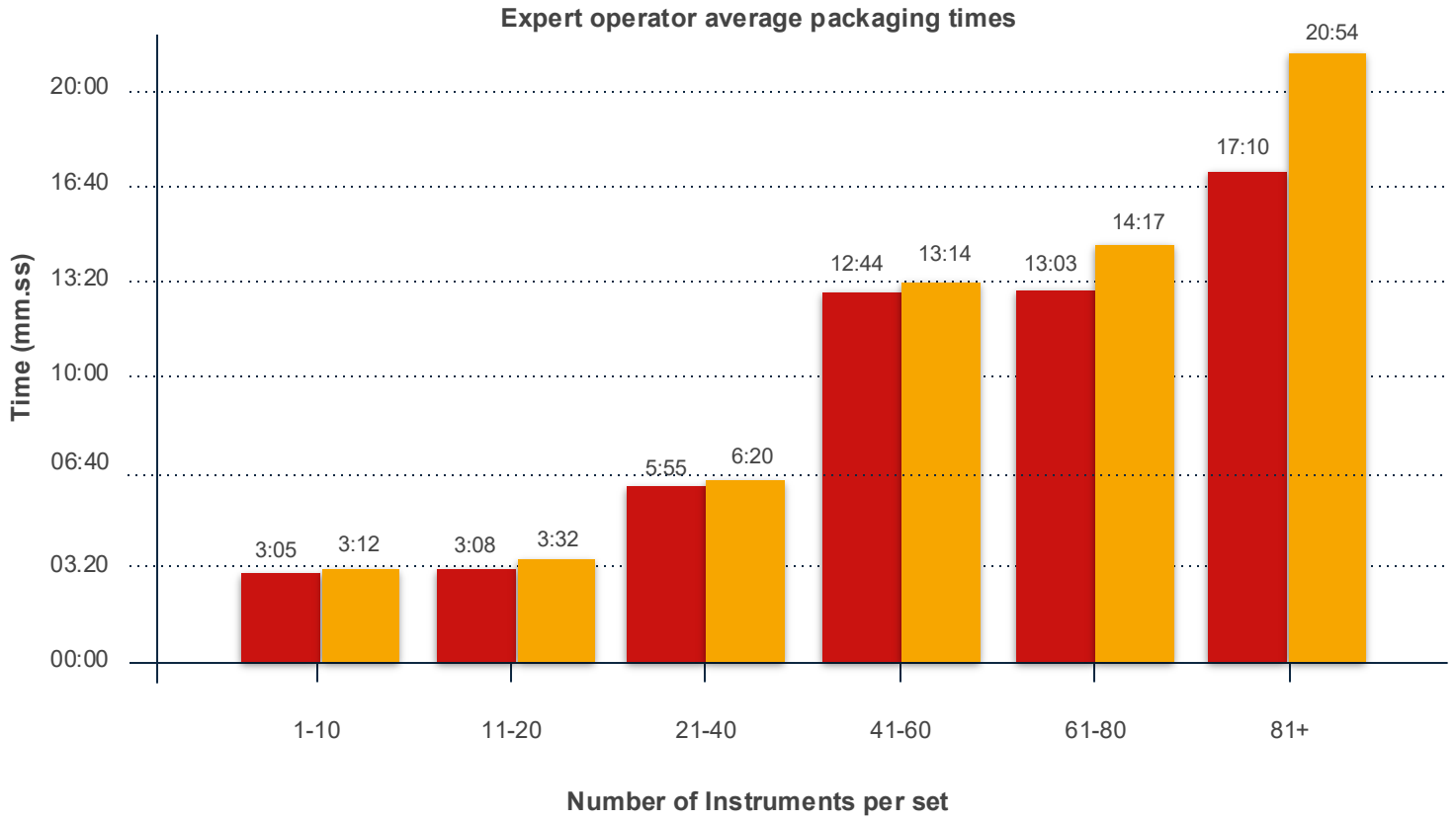
"The smart table also supports training for new staff. New employees, nurses, or healthcare assistants—who may be inexperienced in packaging or unfamiliar with surgical instruments—benefit from comparing the recognized photo with reference images."

Modena Hospital: Case Study – Stage 3 (Ongoing-from July 2025)

Based on data collected over 2870 packaging using the AI smart table.

Key Observations:

- **Fewer OR Reports:** monthly reports from the operating rooms decreased from **5 to 1**.
- **Improvement in Packaging Times for** experienced operators: measurable increase in efficiency.



Legenda

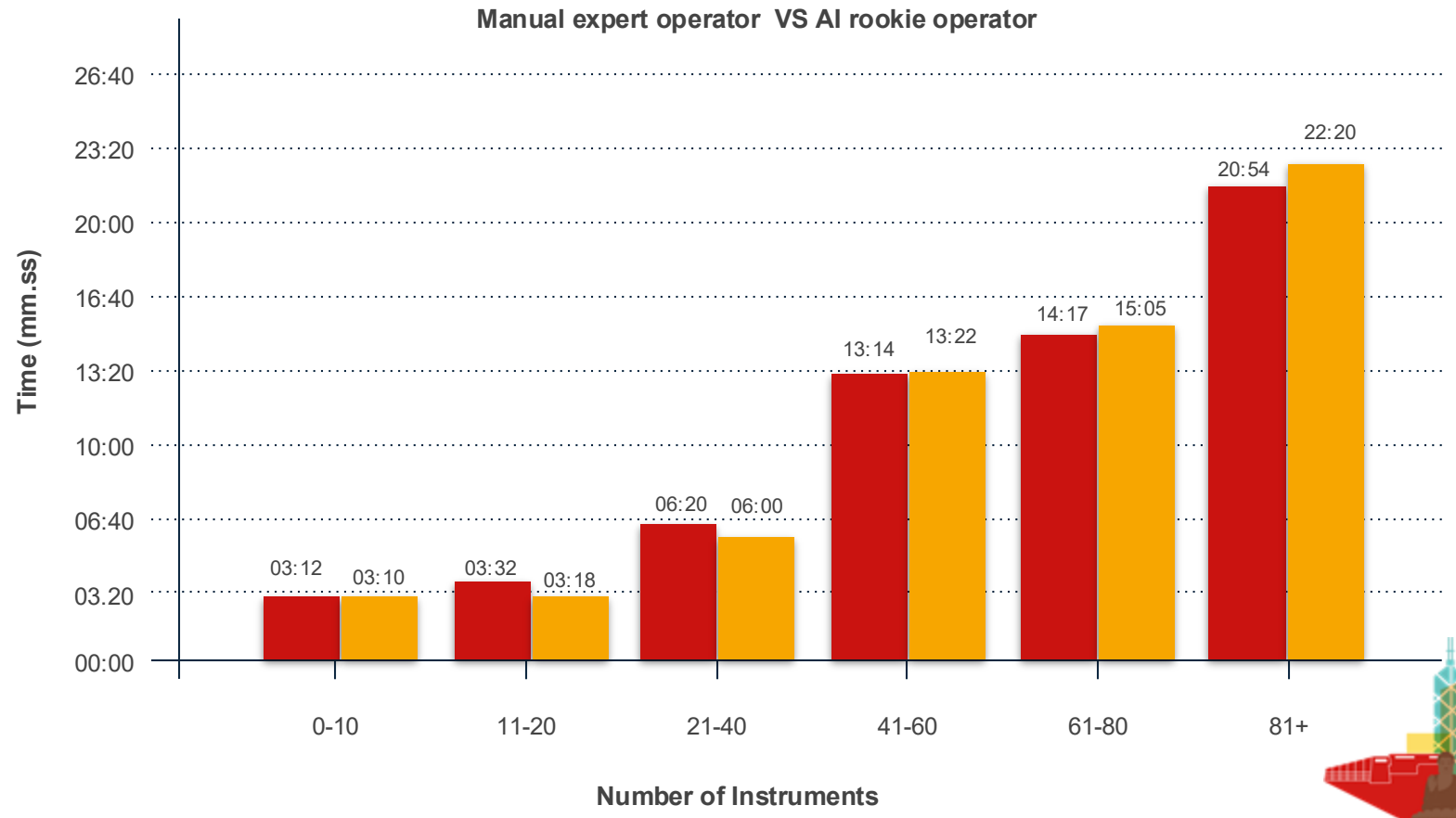
AI smart table

Manual

Modena Hospital: Case Study – Stage 3 (Ongoing-from July 2025)

Key Result – Full Operator Capability:

- Using the **Smart AI Table, all operators** are now able to assemble surgical kits efficiently.
- **New operators** started from zero and quickly reached **performance comparable to experienced staff**, sometimes even exceeding their speed.



Legenda

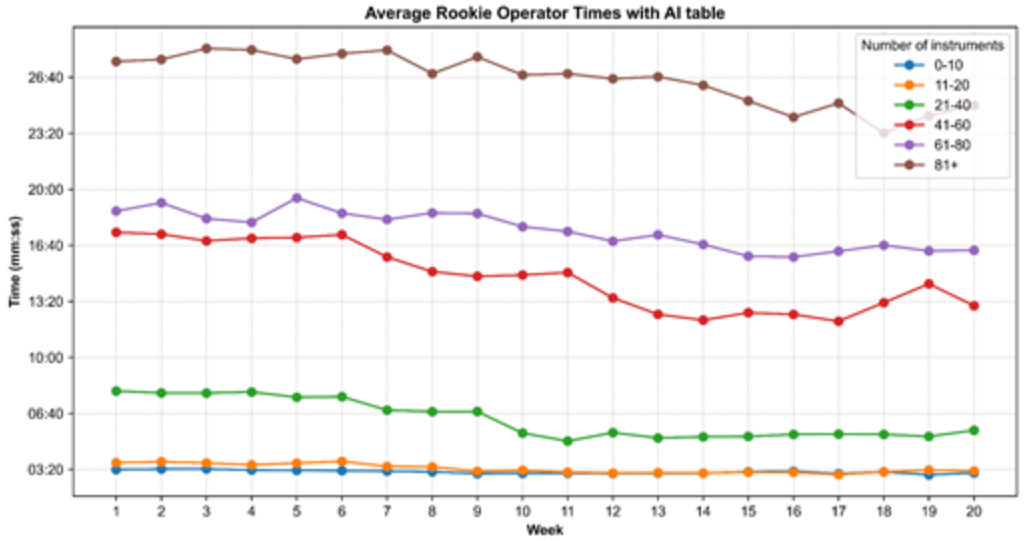
- Manual expert operator
- AI rookie operator

Modena Hospital: Case Study – Stage 3 (Ongoing-from July 2025)

Without AI-Powered Smart Table

Without the AI smart table, training a new operator takes 3–6 months under expert supervision.

With AI-Powered Smart Table



Impact with AI smart table:

- Eliminates skill gaps among operators
- Standardizes workflow and ensures consistent quality
- Reduces training time and accelerates onboarding

Future:

Next steps - system improvement and long-term sustainability

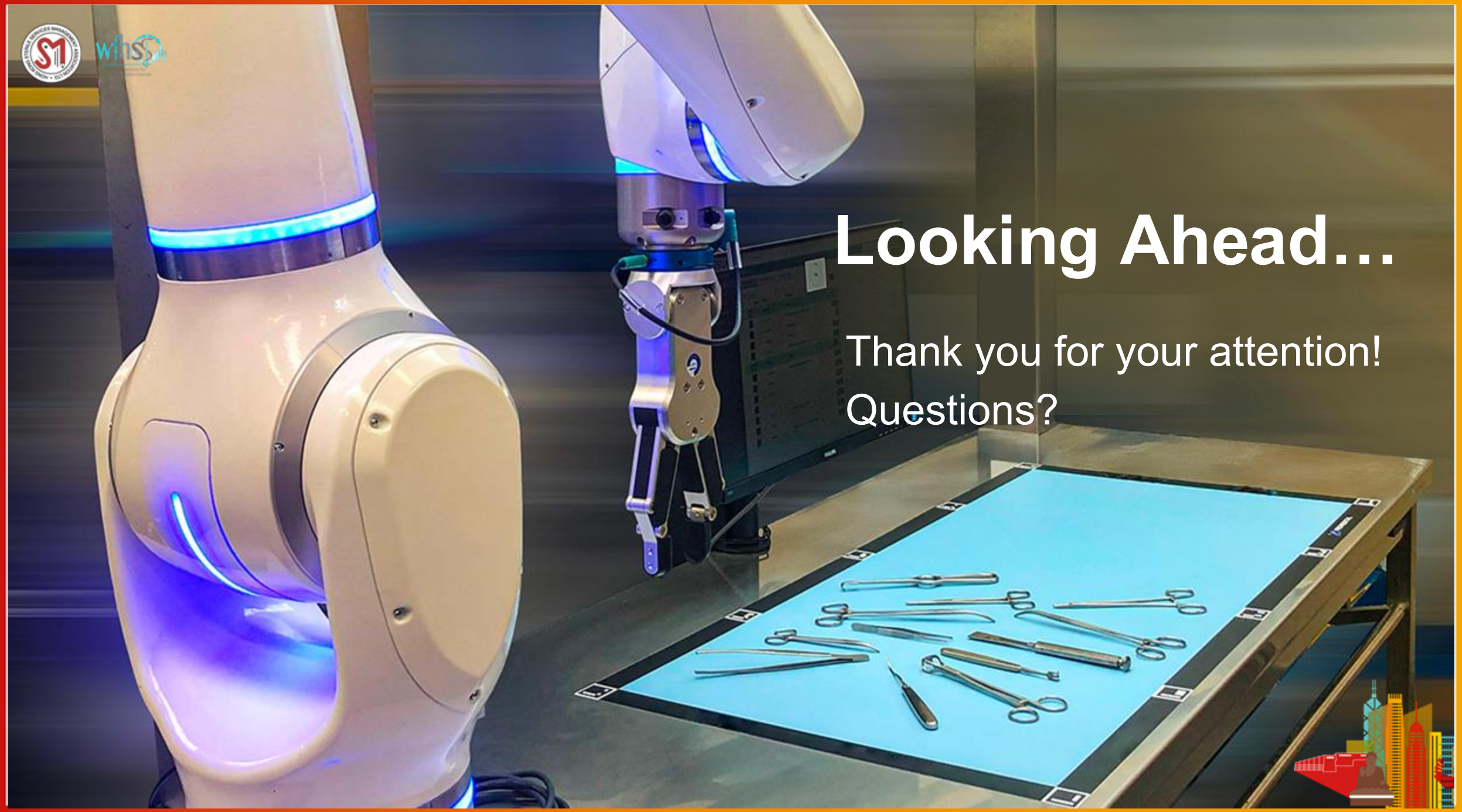
Work in progress…

Immediate Improvements:

- LED indicators for pegs and drawers
- Detailed instructions covering full kit preparation, not just instrument recognition
- Widgets for further personalization of the operator experience

Sustainability Enhancements:

- Replace projector with integrated screen in the workstation
- Optimize lighting to reduce energy consumption


Looking Ahead…
Thank you for your attention!
Questions?