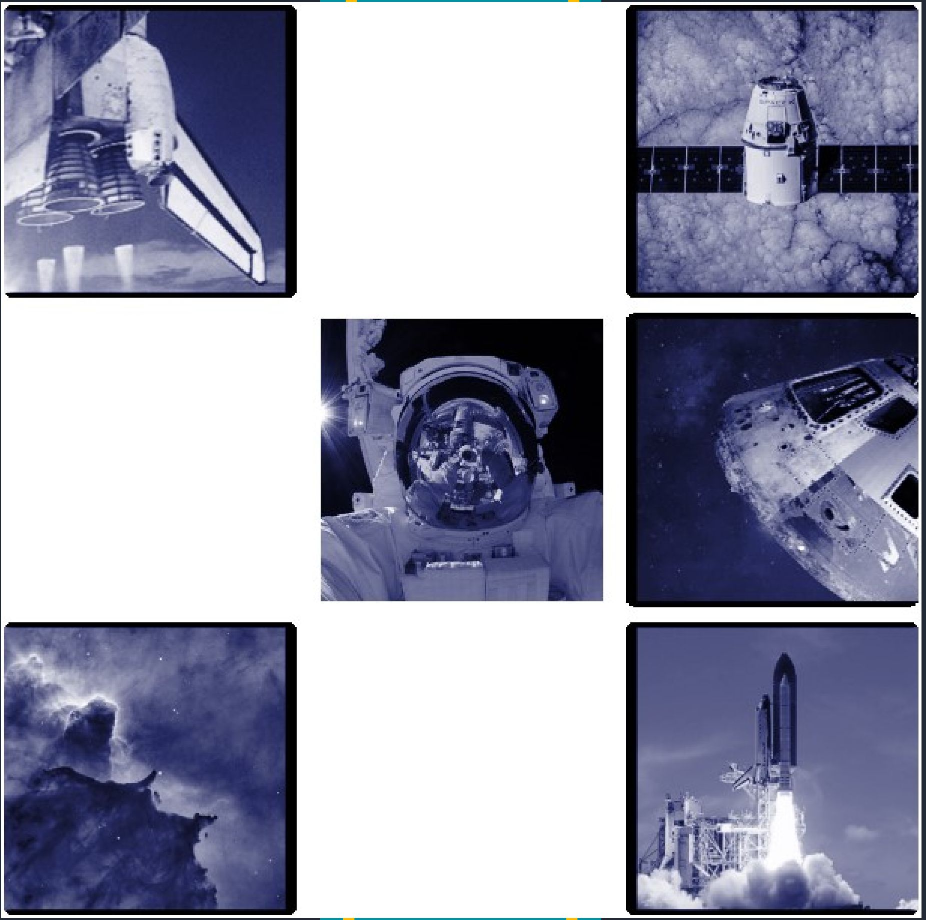

OHARA INTERNATIONAL

CREATE THE FUTURE

Delivering an ML/AI Strategy

AI for Business Leaders, Udacity

Christopher O'Hara, March 2020

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Improving AI in Space

Business Cases in Artificial Intelligence
for the International Space Station

Executive Summary

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Purpose of Project

- Space missions are safety-critical, high-risk events require autonomy for *all* applications
- Artificial agents are necessary to improve safety, performance, and feasibility

Methodology

- Analysis conducted over eight weeks
- Over 10 potential use cases underwent thorough assessment for feasibility and impact
- Incorporated both technical knowledge and user feedback

Path Forward

- Three use cases identified for implementation
- Needs and requirements to be successful
- Next steps

Initial Five Use Cases

UC1: Virtual Assistants

Employing artificial agents to reduce the cognitive load of astronauts via task automation and human factors aspects.

UC2: Multiobjective Design Exploration

Utilizing machine learning and data mining to minimize dynamic forces on structures in real-time.

UC3: Additive Manufacturing

Usage of reinforcement learning to find optimal policies minimizing material usage and maximizing quality attributes.

UC4: Planetary Exploration

Autonomous rovers and satellites scout new worlds for signs of life and rare materials.

UC5: System Design & CAD

Implementing reinforcement learning to improve robotic system design and operation.

Feasibility vs. Impact

Key criteria assessed

- Fidelity in Simulation
- Risk (mission/human)
- Human Factors
- Time Reduction
- Implementation Costs

Transformation using ML/AI with these top two use cases

UC1: Virtual Assistants

Applying new *reinforcement learning* and *transfer learning* methods, virtual assistants will be able to reduce the cognitive load of astronauts related to *working memory, response time, and situational awareness* while *saving up to 20% of the astronauts time* via automated tasks.

UC4: Planetary Exploration

Implementing new *reinforcement learning* and *transfer learning* models combined with *deep learning* for *classification*, rovers, drones, and satellites will be able to share information (IoT) to create maps with *at least 40% higher precision* and *500% faster* than current methods.

By executing on these two projects, I believe we can drive technological demand for our business by 500% within two years and become a critical space business.

UC1: Virtual Assistants - Deep Dive

Process Today

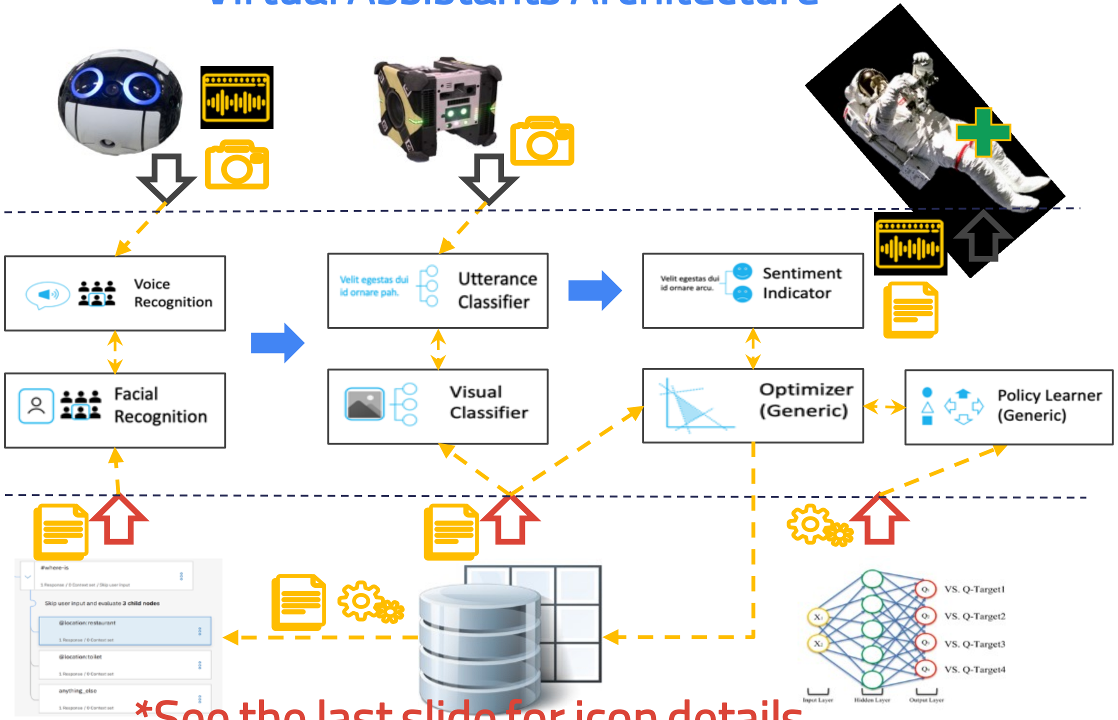
- Small decrease in cognitive load
- Static intents and responses
- Constant performance/accuracy
- Single agent only

Process Tomorrow

- Large decrease in cognitive load
- Gradual improvement to dialogs
- Continual improvements to accuracy, performance, and confidence
- Multi-agent communication

The impact on human factors will be massive thanks to AI!

Virtual Assistants Architecture*



*See the last slide for icon details

UC4: Planetary Exploration - Deep Dive

Process Today

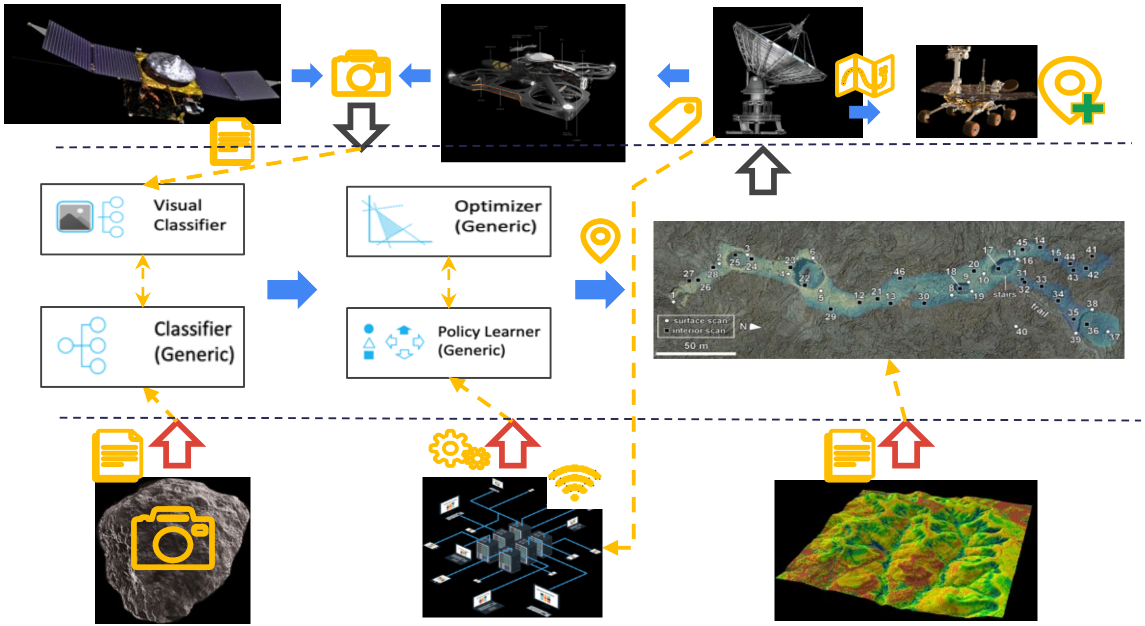
- No robot-to-robot (R2R) communication
- Faulty/missing data
- Static sampling rates (orbit/path)
- One-shot path from static map

Process Tomorrow

- Optimized R2R communication
- High fidelity and precision in data
- Dynamic orchestration for sampling rates and paths
- Real-time mapping and path planning

The impact of R2R communication will be revolutionary thanks to ML/AI!

Planetary Exploration Architecture*



*See the last slide for icon details

BIG IDEA

Progress in Space Missions is only feasible via implementing new artificial intelligence and machine learning paradigms.

RISK MITIGATION

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Risk Avoidance and Mitigation Strategy

	UC1: Virtual Assistants	UC4: Planetary Exploration
Accuracy *F1-Score results*	Concerns: Small amount of useable data Plan: Acquire new data continuously	Concerns: High variability in data Plan: Resample outliers
Underfitting/Overfitting *Poor fit for robustness*	Concerns: Overfitting for single astronaut Plan: Acquire new data continuously	Concerns: Convergence on results Plan: Multiple sampling profiles
Ethical Concerns *Risks towards privacy/security*	Concerns: PII and GDPR Plan: Local data storage w/o remote access	Concerns: IoT device hacking Plan: Blockchain broker for security

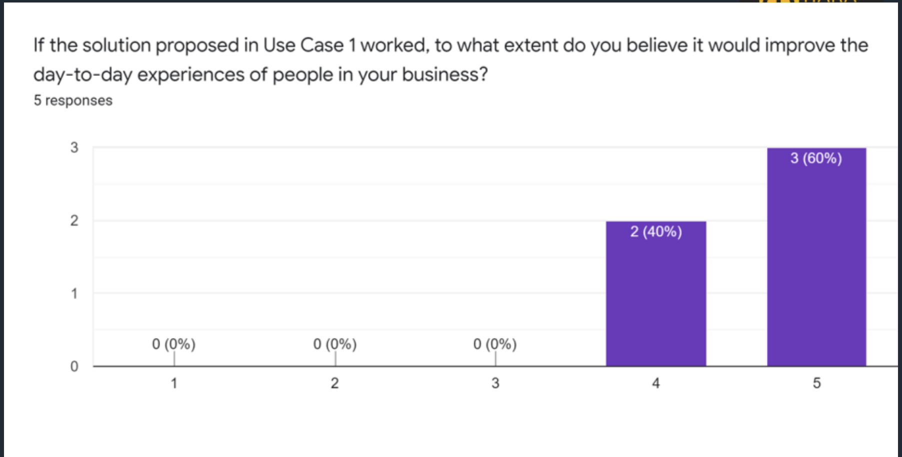
Illustrative Quotes & Visuals

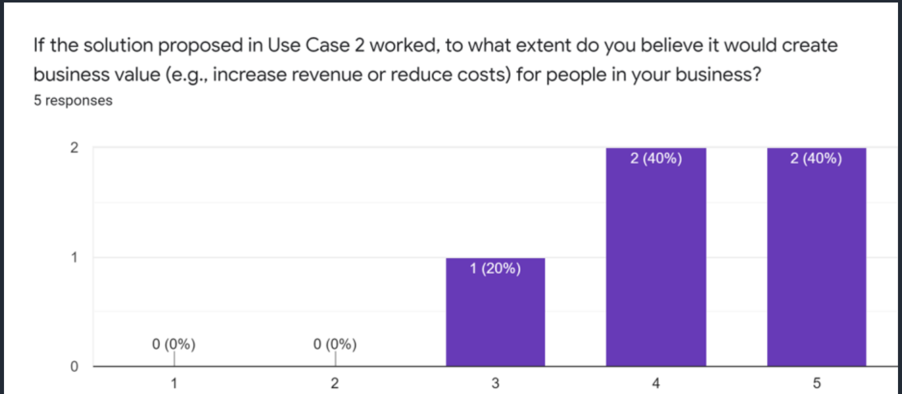
"If successful, this will allow for geo-spatial maps to be created much fast which allows for mission approval sooner."

"Many more experiments will be possible in the future with this implementation."

"If it works, it would change the future."

"There is a really big impact and this could also be used in factories and other smart places like homes in the future."





Planetary Exploration

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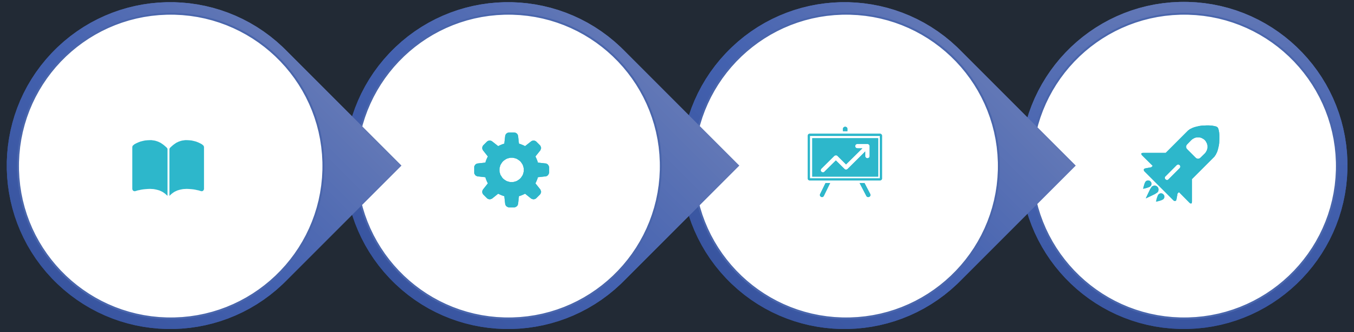
STEPS TO SUCCESS

FIRST STEP

Conduct a detailed literature review and consult directly with industry experts.

FOURTH STEP

Deploy beta-testing during analog missions (AMADEE, NEEMO, etc.). Once optimized, deploy final versions on the International Space Station.



SECOND STEP

Create configurations and machine learning models. Perform analysis and setup up environments, databases, and containers.

THIRD STEP

Analyze simulation results and (re)-iterate through the process. Update architectures and conduct create proof-of-concepts.

TIMELINE INFOGRAPHIC

Our Journey Through Space

JUN 2020

Evaluate research and current methods. Collaborate with experts in NASA, ESA, JAXA, and DLR. Research the latest models via IEEE conferences (e.g. IROS2020).

OCT 2020

Ideate and prototype software solutions. Prepare simulated examples and conduct unit testing. Ensure all acceptance criteria and functional requirements are met.

OCT 2021

Test proof-of-concepts in analog missions (e.g. pre-AMADEE-22). Use results of earth-bound experiments for further improvements in ML/AI models.

FEB 2022

Finalize architecture based on requirements engineering. Verify and validate all quality and non-functional requirements. Report initial findings to stakeholders.

DEC 2022

Deploy working versions on the International Space Station in collaboration with NASA and JAXA. Feed real-time results back into networks to continually improve the results. Conquer space one heavenly body and one productive astronaut at a time.

The Future of Space is Enabled by AI

Future space exploration will be vastly improved by the incorporation of artificial agents using the most advanced ML/AI paradigms and models.

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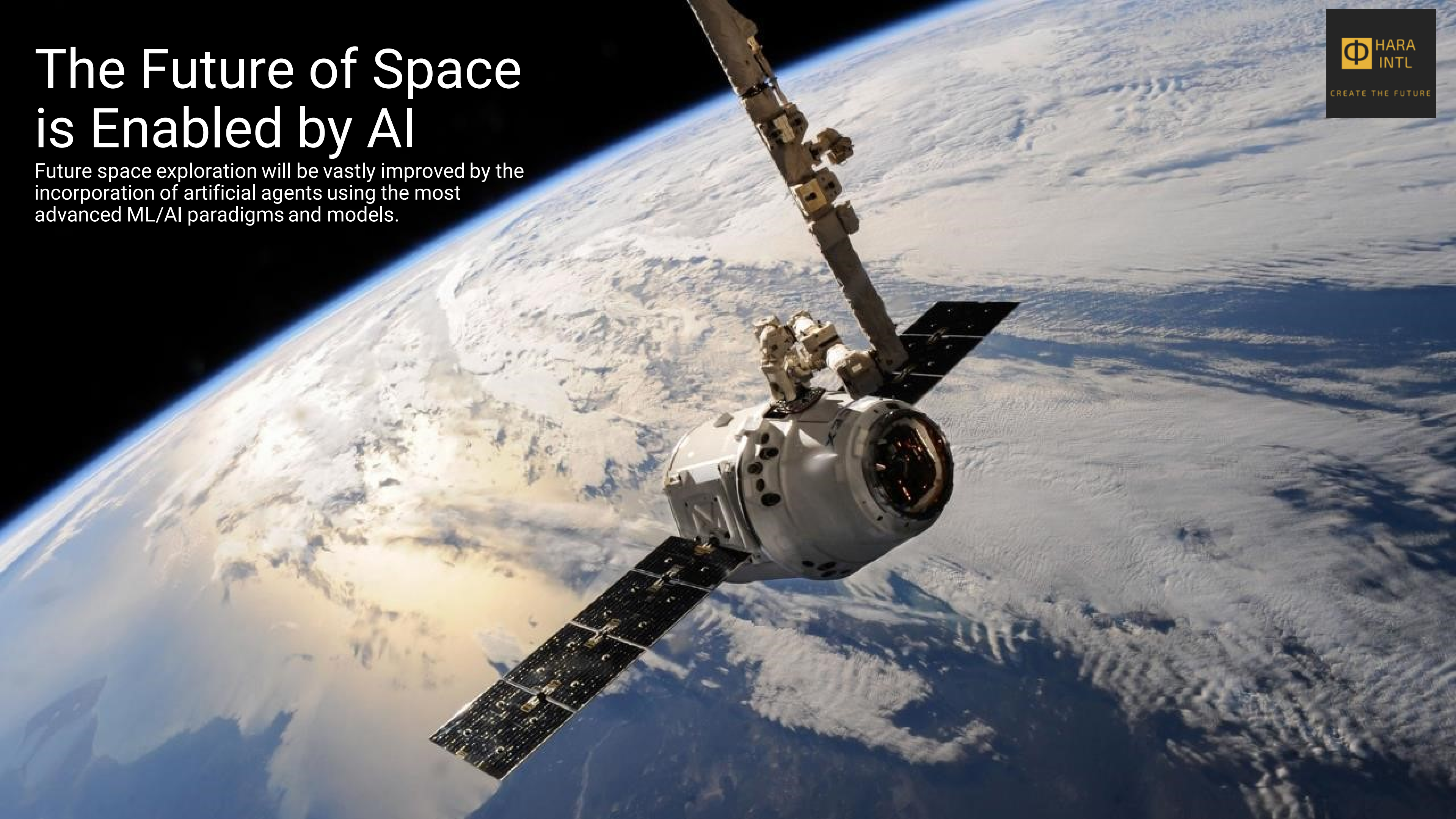
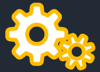


AI/ML Toolkit - Icons

Sound Files (Voice) 

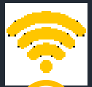
Images (Camera) 

Documentation (Data) 

Configurations/Setup Files 

Map (Coordinates) 

Geo-Tag (Coordinates) 

Communications (Signal) 

Goal (Coordinates) 

Performance (Increased)