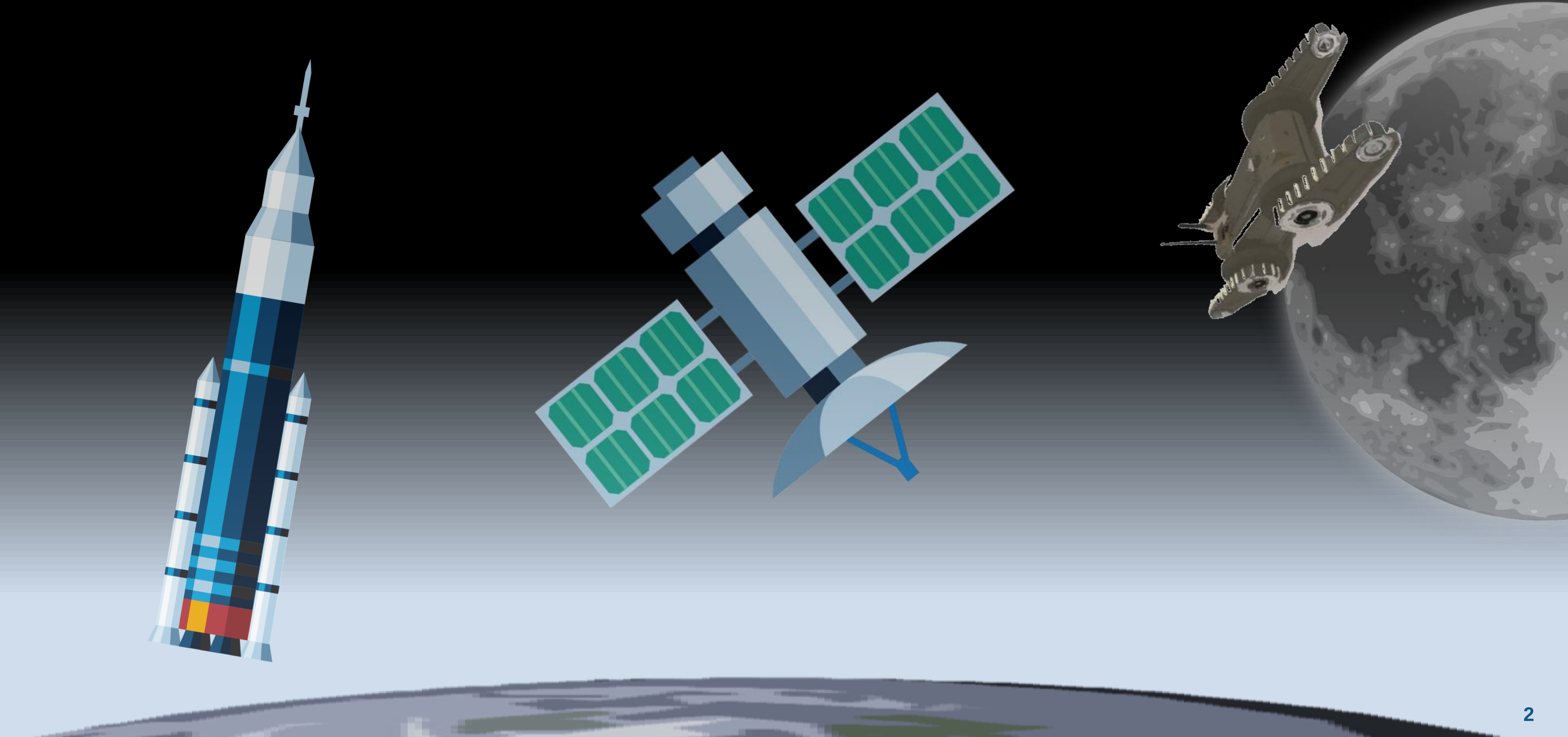
９月18日（水） 最新宇宙機システム設計【東大 宇宙航空 中須賀先生/川端先生ご登壇】
～最新トレンド･制御･自律システム･通信～

宇宙機システム開発のトレンド･課題

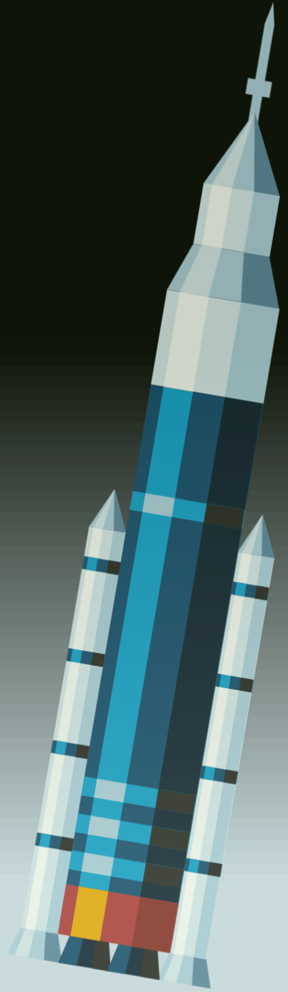
MathWorks Japan
インダストリーマーケティング
能戸 フレッド

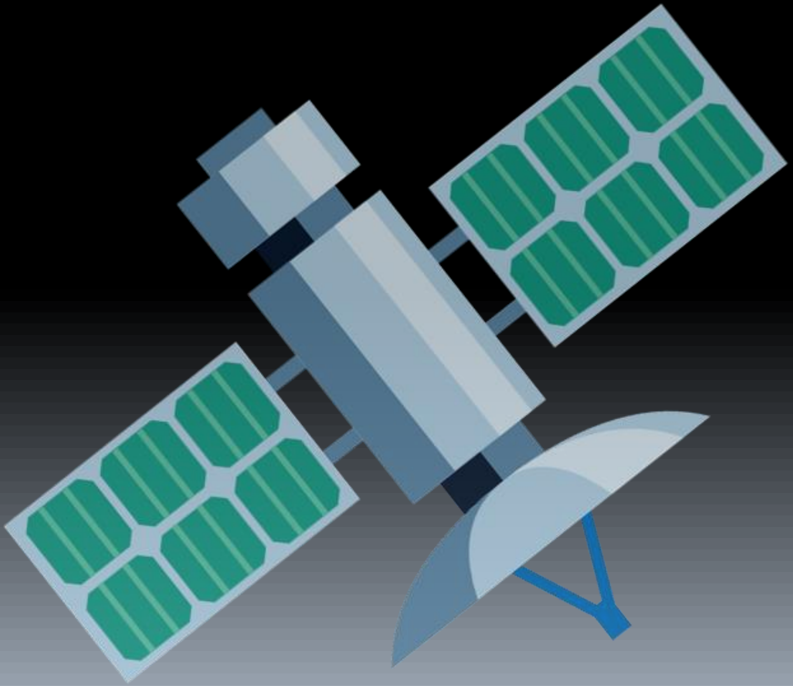
宇宙システム開発の加速化

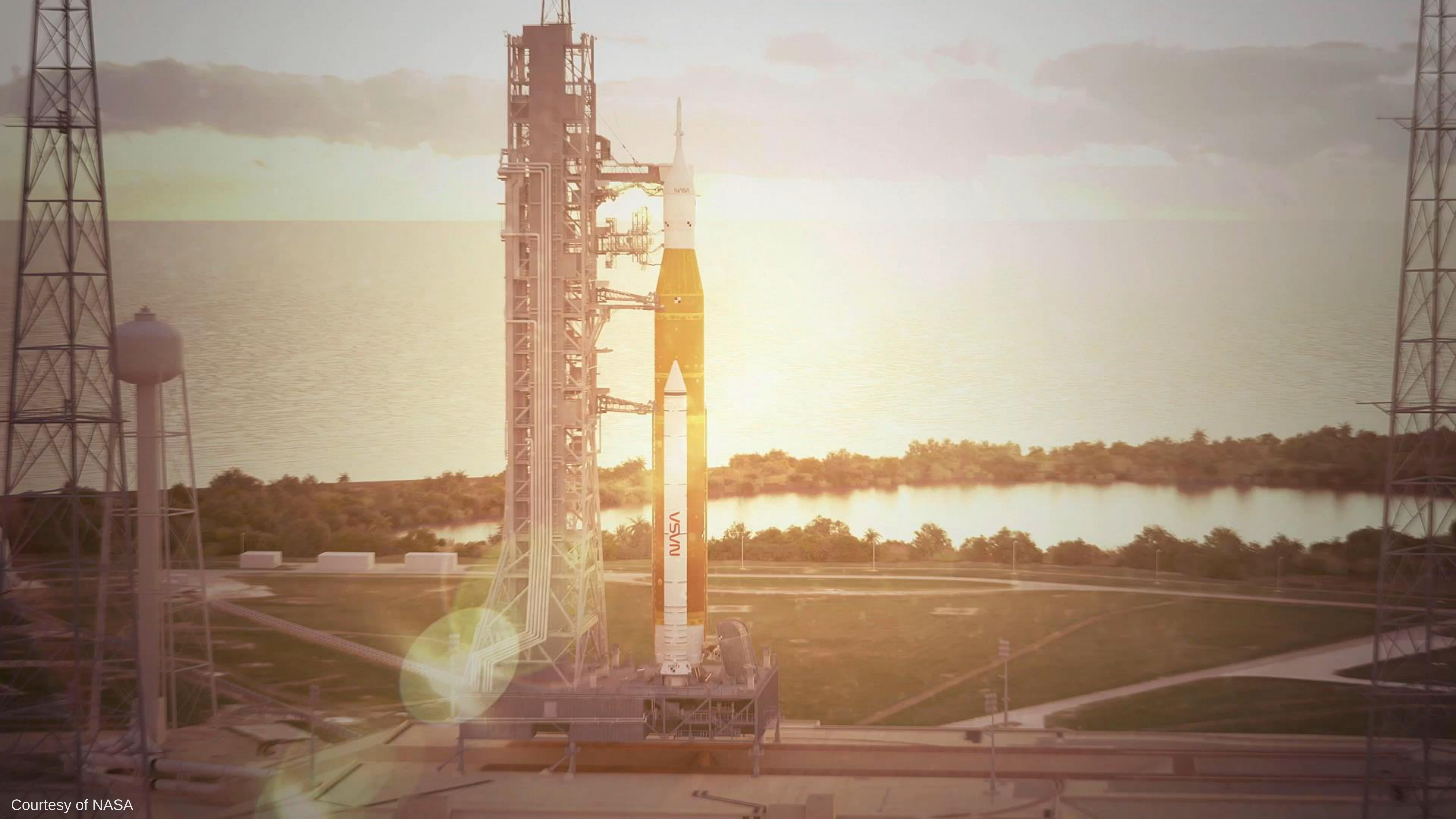


宇宙システム開発の加速化

ロケット



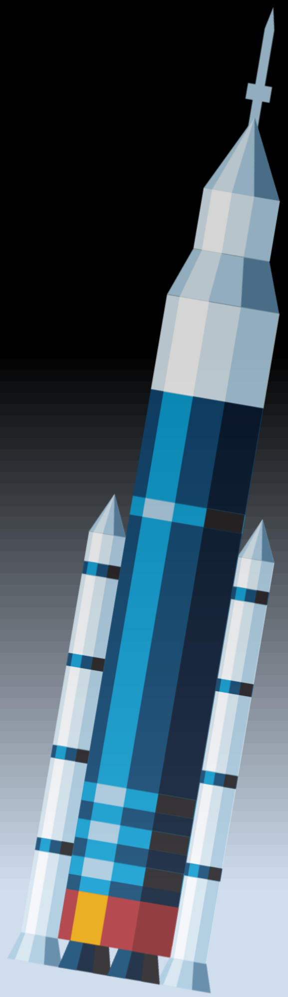




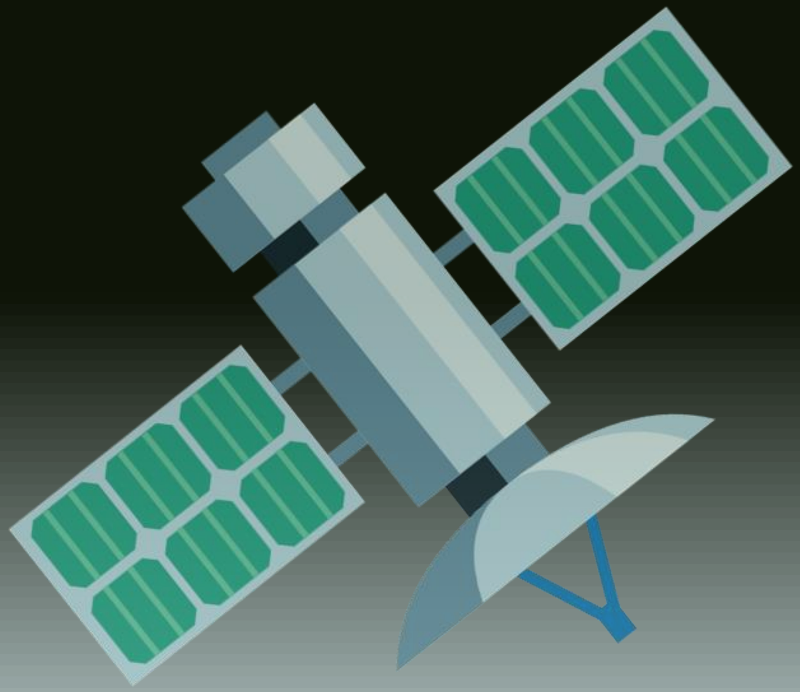
Courtesy of NASA

Courtesy of NASA

宇宙システム開発の加速化



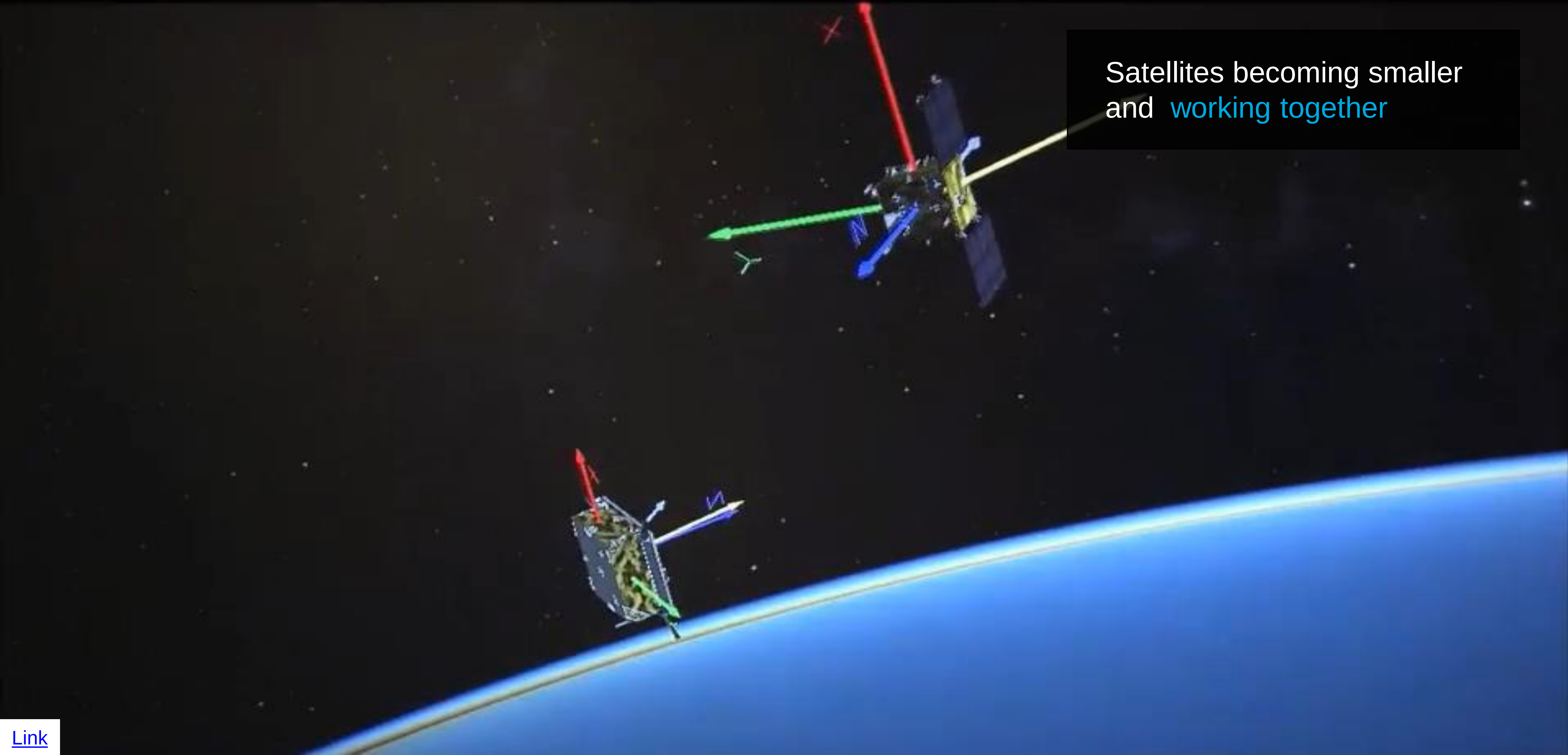
人工衛星




Courtesy of NASA


Courtesy of NASA

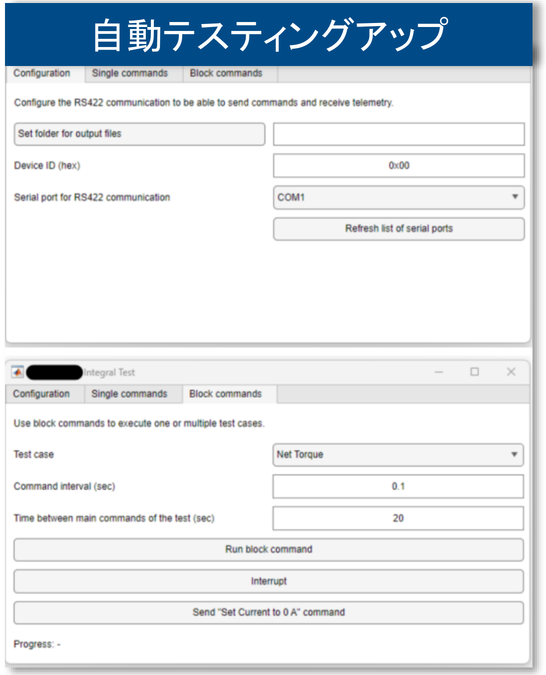
OHB Develops Satellite Guidance, Navigation, and Control Software for Autonomous Formation Flying



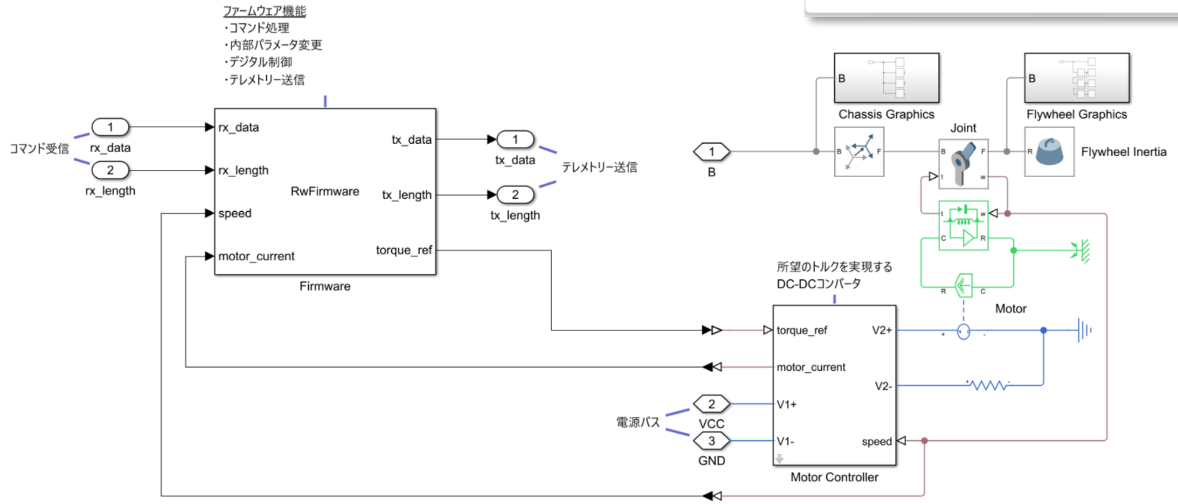
Satellites becoming smaller and working together

Link

モデルベースデザインを活用した人工衛星開発



リアクションホイール全体モデル

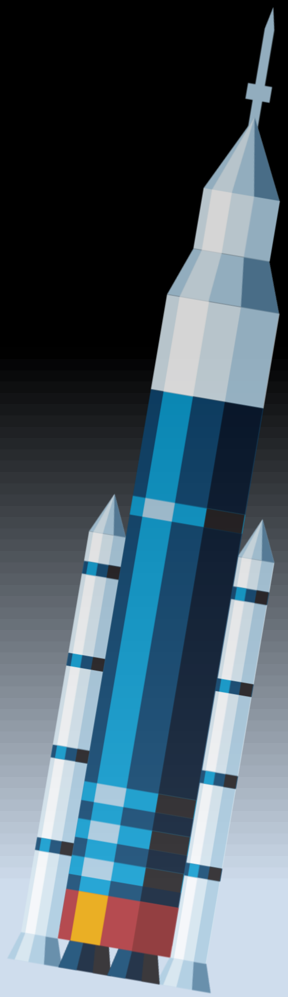


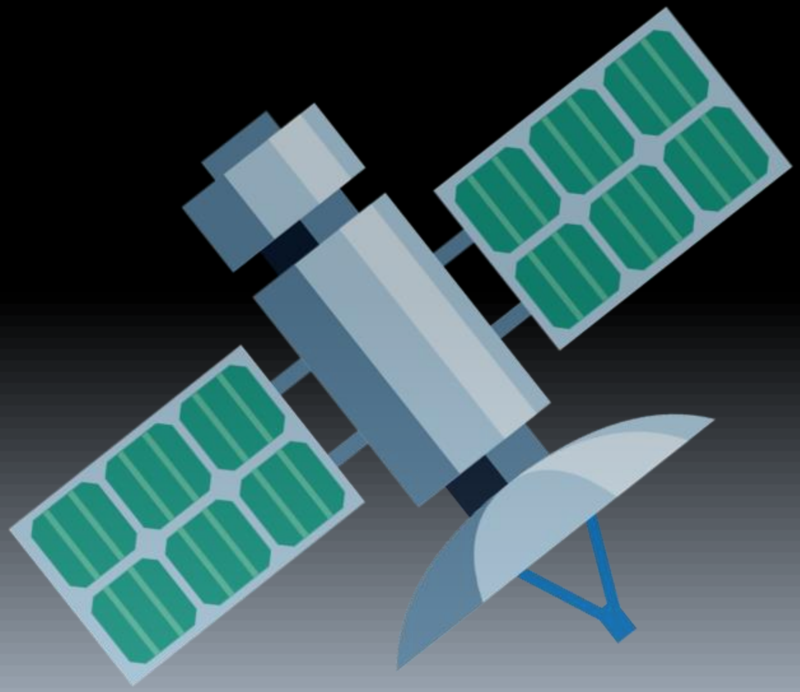
現在

- 姿勢制御ソフトウェア
  - Simulink, Stateflow → コード生成
- ソフトウェア単体テスト
  - MATLABテストクラス, Simulink
- シミュレーション
  - Simulink, Simscape, Simscape Multibody
- コンポーネントテスト
  - App Designerアプリによるほぼ自動化

https://www.mathworks.com/videos/model-based-design-to-support-the-development-of-small-synthetic-aperture-radar-sar-satellites-1719034583678.html

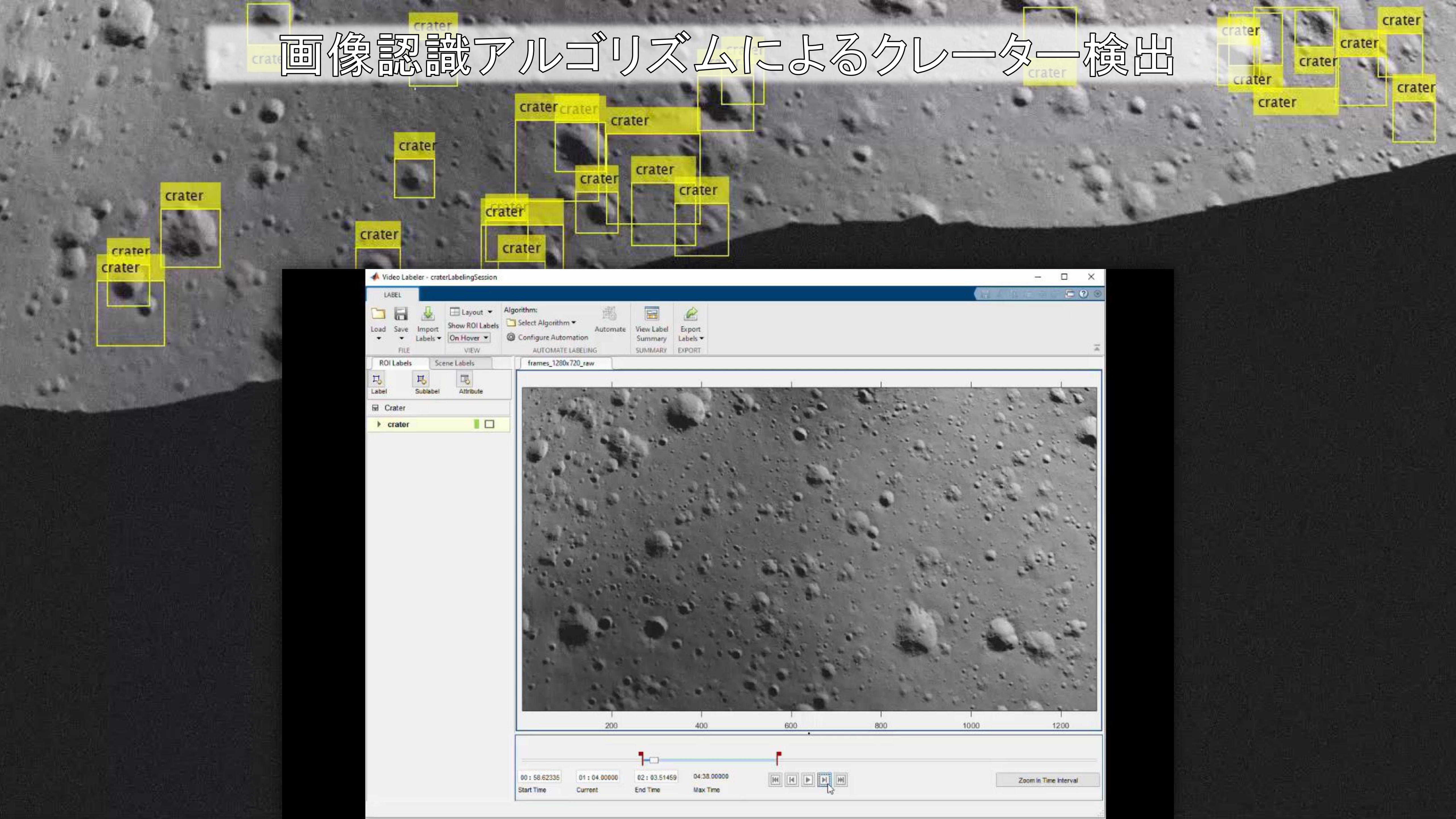
宇宙システム開発の加速化





宇宙探索

画像認識アルゴリズムによるクレーター検出



自律型ローバー開発でのMATLAB/Simulink活用例

DEFENCE AND SPACE

High Autonomy

Detect
- Using NavCam on mast
- Visual Based Detection System (Machine Learning Algo.)
- Identify sample + position relative to rover
- Point cloud of terrain to avoid obstacles

Grasp
- Arm and Gripper System calculating trajectories based off position and terrain
- Visually check the grasping in gripper

Stow
- Manipulate the delicate sample for storage

12 7 March 2020 Mars Sample Return, Sample Fetch Rover - Mission Overview

DEFENCE AND SPACE

High Autonomy

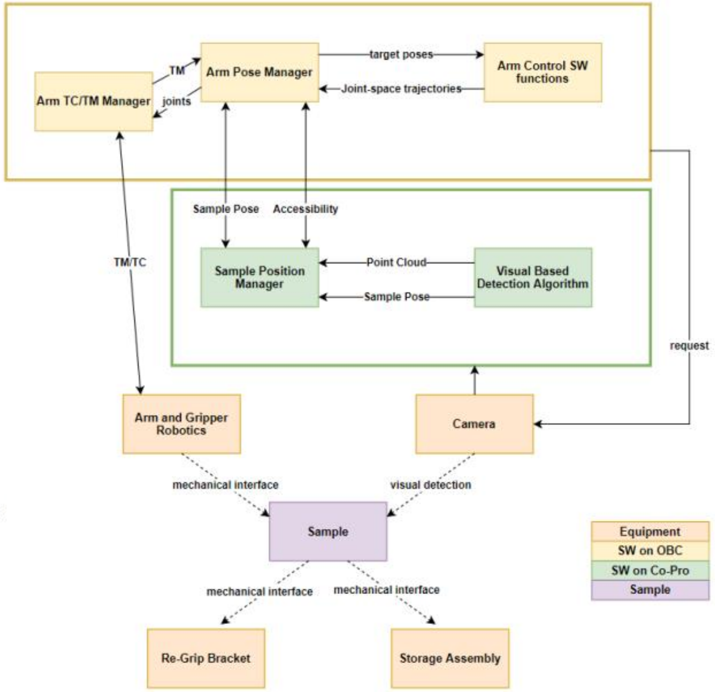
Vision and arm system fully integrated with autonomous logic with
- Robotics ToolBox
- Statistics and Machine Learning Toolbox

MATLAB SIMULINK

- State-machine with visibility of all the equipment
- Asynchronous processer for computation intensive tasks
- Arm/Gripper and Camera interact with Sample

Visual Detection
- Request Camera image
- Detect Sample with Machine learning
- Use Sample Pose and Point Cloud for accessibility to plan arm mc

Arm motions
- Target poses sent to Arm Control SW
- Joint space trajectories sent to Arm TC/TM manager
- TM received of moving arm



13 7 March 2020 Mars Sample Return, Sample Fetch Rover - Mission Overview

AIRBUS

**AIを含む認識・モーション
プランニングの自律系アルゴリズム
をMATLAB・Simulinkで設計**

[Link (Customer Presentation)](#)

ユーザ事例: 自律型ローバー

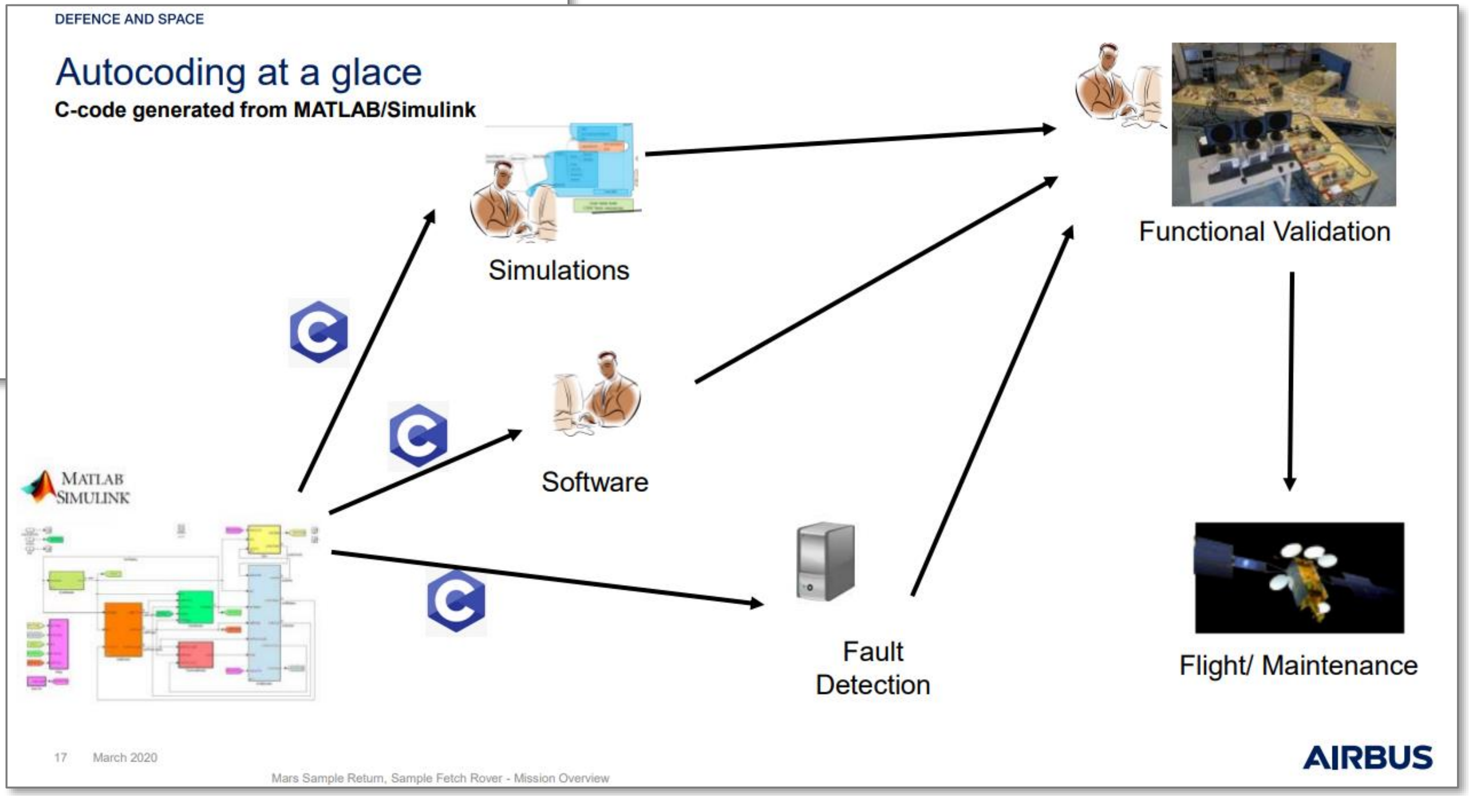
DEFENCE AND SPACE

Autocoding / Code Generation

Objective: to optimize our process by exploiting full capability of MATLAB/Simulink environment, and keeping the ECSS compliancy

Solution: C-code generated vis embedded coder from MATLAB/Simulink, with automatically generated documentation

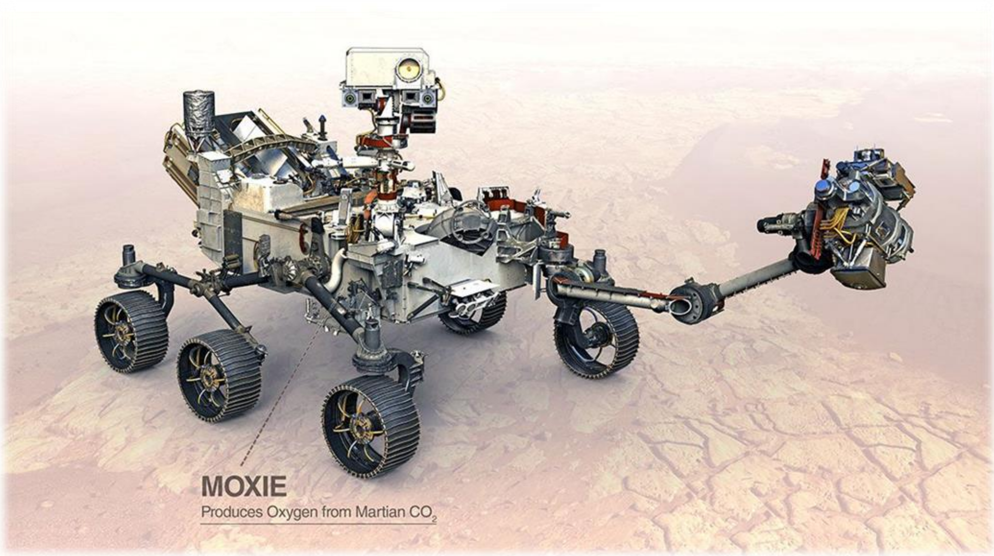
- Airbus developing autocode systems for a long time
- OneWeb: first autocoded control system in flight
  - Software modules integrated autocode / generated code
  - All 3 modes have been run
  - Nominal spacecraft behaviour achieved + delivered on time
- Ensures ECSS standards:
  - ECSS E-60: AOCS
  - ECSS E-40: SW
  - ECSS Q-80: SW PA
  - Automatic Code Generation for AOCS/GNC SW Handbook

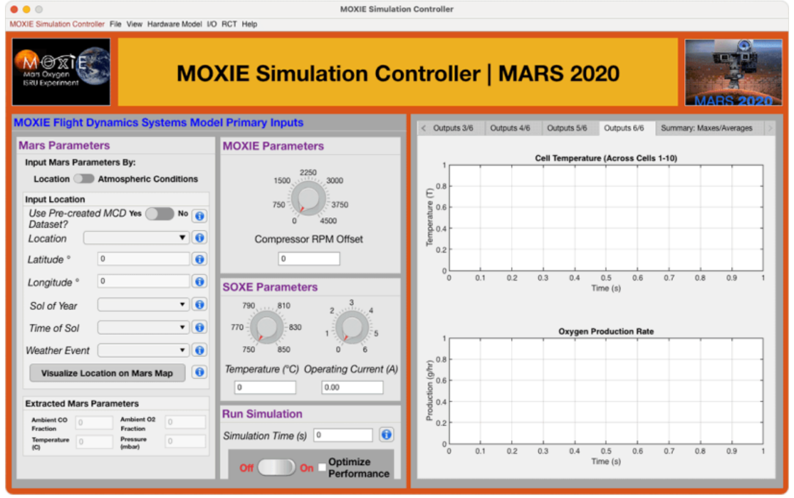


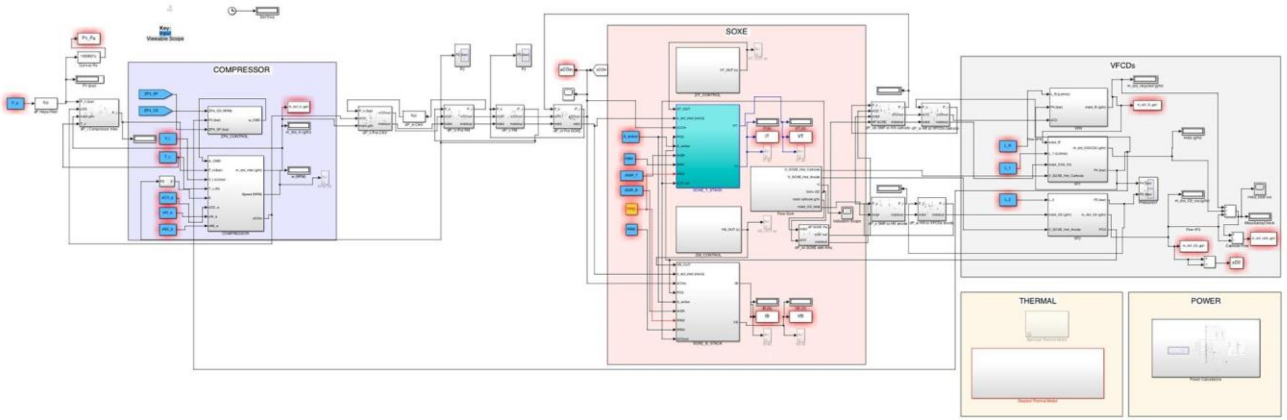
規格・品質を考慮した
自動コード生成プロセスを適用

Link (Customer Presentation)

MIT、火星の大気から酸素を生成するMOXIEを開発







Use Simulink to model and simulate the Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) and MATLAB to analyze data from both the Simulink model and the real MOXIE on Mars

https://www.mathworks.com/company/mathworks-stories/moxie-converts-mars-co2-to-oxygen.html

デジタルエンジニアリングの更なる普及

NASA Human Landing System Requirements Document:

Revision: Initial Release	Document No HLS-RQMT-001
RELEASE DATE: September 27, 2019	Page: 7 of 315
Title: HLS Requirements Document (SRD)	

2 Documents

For the purpose of this document, the term ‘document’ can also refer to ‘digital artifacts,’ ‘models,’ or ‘viewpoints’ as needed to convey and exchange configuration managed data or information. An objective of the HLS Program is to advance towards a digital engineering environment and away from the traditional document-based approach for capturing data, reports and baselines.

https://forum.nasaspaceflight.com/index.php?action=dlattach;topic=50843.0;attach=1944357;sess=0

ESA Agenda 2025:

“ESA will therefore digitalise its full project management, enabling the development of digital twins, both for engineering by using Model Based System Engineering, and for procurement and finance, achieving full digital continuity with industry.”

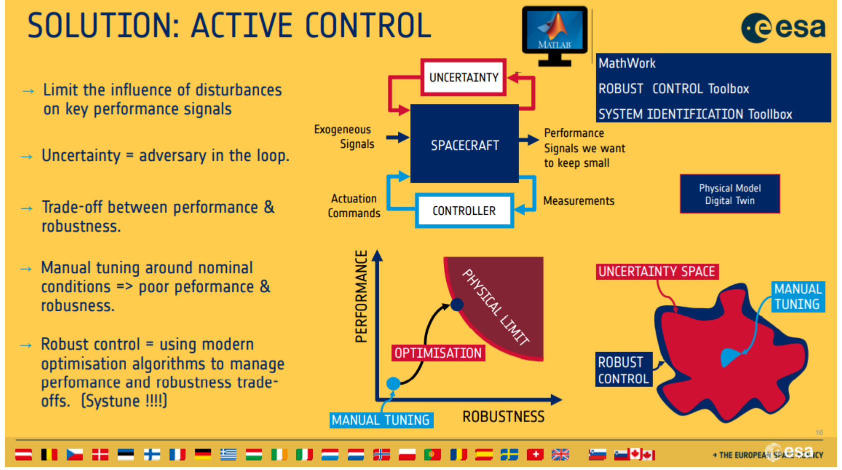
https://esamultimedia.esa.int/docs/ESA_Agenda_2025_final.pdf

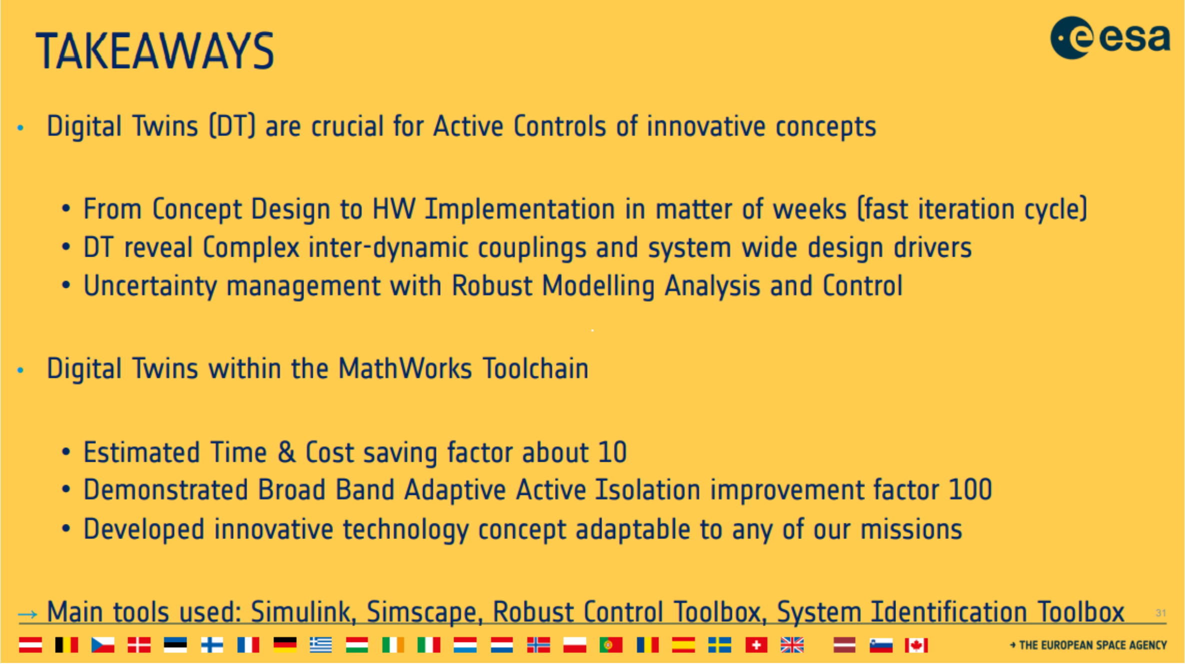
規格と認証

- **宇宙システム関連:**
  - **NASA: NPR 7150.2** NASA Software Engineering Requirements
  - **ESA: ECSS-E-ST-40C** Space Engineering - Software
- **航空機関連:**
  - **ARP-4754A**: Guidelines for Development of Civil Aircraft and Systems
  - **ARP-4761**: Guidelines for Conducting Safety Assessment Process on Civil Airborne Systems and Equipment
  - **DO-178C**: Software Considerations in Airborne Systems and Equipment Certification
  - **DO-254**: Design Assurance for Airborne Electronic Hardware
  - **DO-278A**: Guidelines for Communication, Navigation, Surveillance, and Air Traffic Management (CNS/ATN) Systems Software Integrity Assurance

Links: NPR 7150.2, ECSS-E-40 , DO-178, DO-254

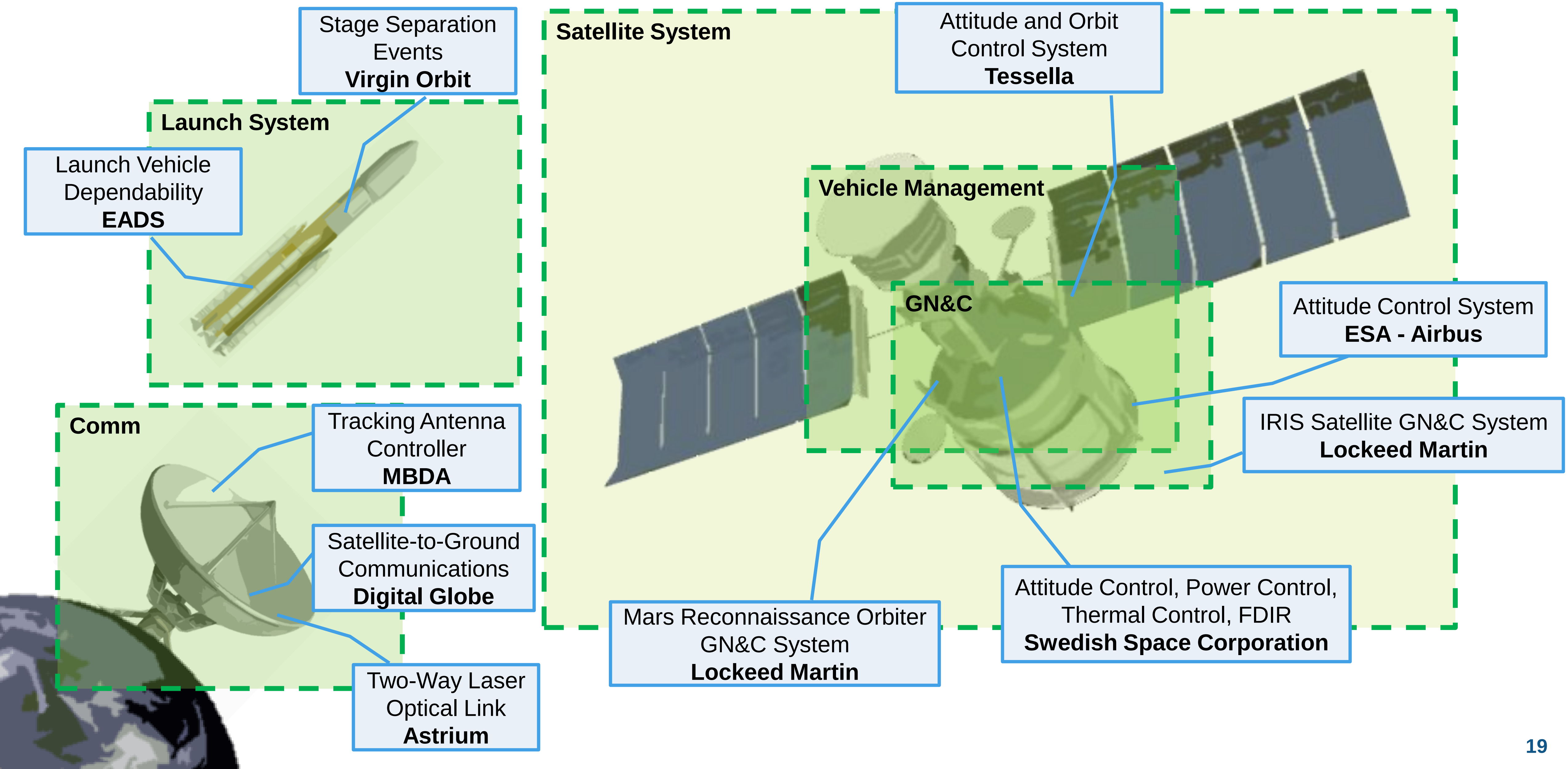
ESAでのMATLAB/Simulink活用





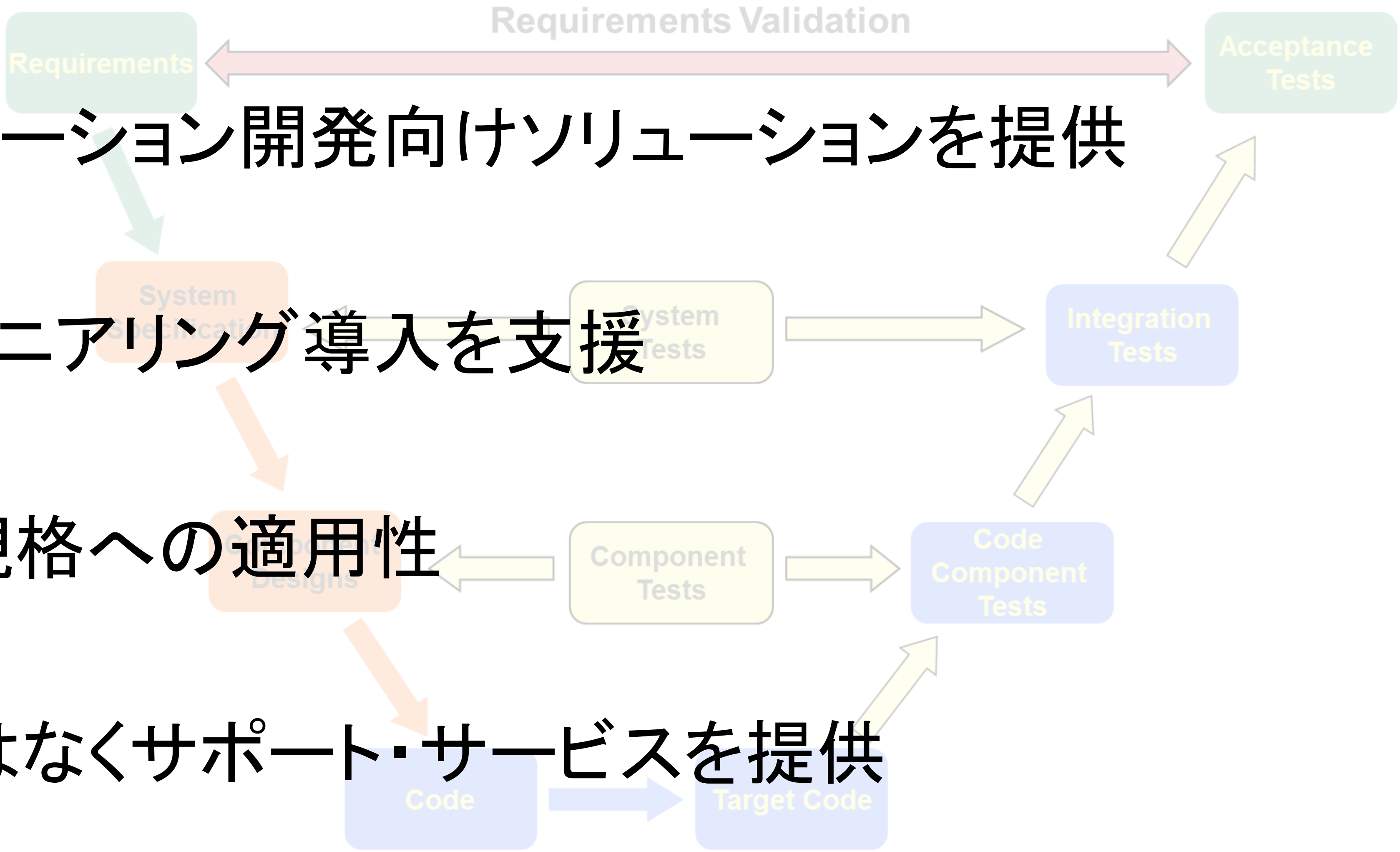
Link

宇宙システム関連ユーザ事例



宇宙機システム開発に対するMATLAB･Simulinkの適用性

- 幅広いアプリケーション開発向けソリューションを提供
- デジタルエンジニアリング導入を支援
- スタンダード･規格への適用性
- ツールのみではなくサポート･サービスを提供



Accelerating the pace of engineering and science

本日のアジェンダ

時間	タイトル
14:00-14:10	**宇宙機システム開発のトレンド・課題** MathWorks Japan インダストリーマーケティング部 能戸フレッド
14:10-14:40	**実ミッションにおけるMATLABを活用した宇宙機の軌道設計および運用事例** 東京大学 大学院工学系研究科 航空宇宙工学専攻 中須賀 真一 先生、　川端 洋輔 先生
14:40-14:50	**Q&A, 休憩**
14:50-15:10	**宇宙機システムのプラントモデリングと誘導制御系開発** MathWorks Japan アプリケーションエンジニアリング部 岩本 光平
15:10-15:30	**月面探査ローバーの自律アルゴリズム開発と3Dシミュレーション** MathWorks Japan アプリケーションエンジニアリング部 木川田 亘
15:30-15:50	**衛星通信システム設計と解析** MathWorks Japan アプリケーションエンジニアリング部 田中 明美