CRAFT PROSPECT

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Autonomy Assurance for Small Earth Observation Satellites

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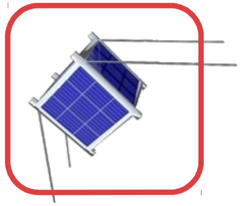
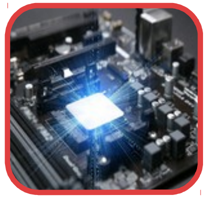
About Craft Prospect



Mission & System Engineering



Enabling Technologies & Services

Novel Downstream Applications

Products
e.g. Forwards Looking Imager

MISSION DESIGN

Revenue

- Targeted customers only
- Builds reputation / position
- Provides revenue to invest

RESPONSIVE OPERATIONS

Enables

- Develops first product revenues
- Addresses a 1B market (2021/2)

KEY AUGMENTATION SERVICE

- Provides flight heritage
- Develops mission capability
- Addresses a 2B market (2021/2)

Throughout all investing in the development of systems engineering and processes

Opportunity

- Growth in demand for real-time actionable data from space
- Resource-constrained small satellites dominating manifests
- Intensive applications like space video and IoT communications
- Need to manage complex networked concept of operations
- Existing operation paradigms are outdated
- Rapidly-evolving consumer-driven autonomy market

Develop common product components to enable more responsive operations

What is Responsive Operations?

- Shift in the concept of operations paradigm
- (Near) real-time actionable delivery
- Onboard autonomy and decision making
- Bypassing the human in the loop
- Retasking assets on-the-fly
- Networks of networks: sensing, processing, delivering

Machine learning	Blockchai n
Adaptive comms	Emerging standards
Data fusion	Internet of things

Onboard Data Autonomy for Small EO Satellites

- CEOI-funded project
- **Aim:** Lay end-to-end framework that unlocks potential of Earth-observing nanosatellites for onboard data autonomy
- **Outputs:**
  - Use cases for realistic end applications
  - System architecture for autonomous nanosatellite operations
  - Prototype for standalone nanosatellite feature-detection payload

Centre for EO Instrumentation

bright ascension

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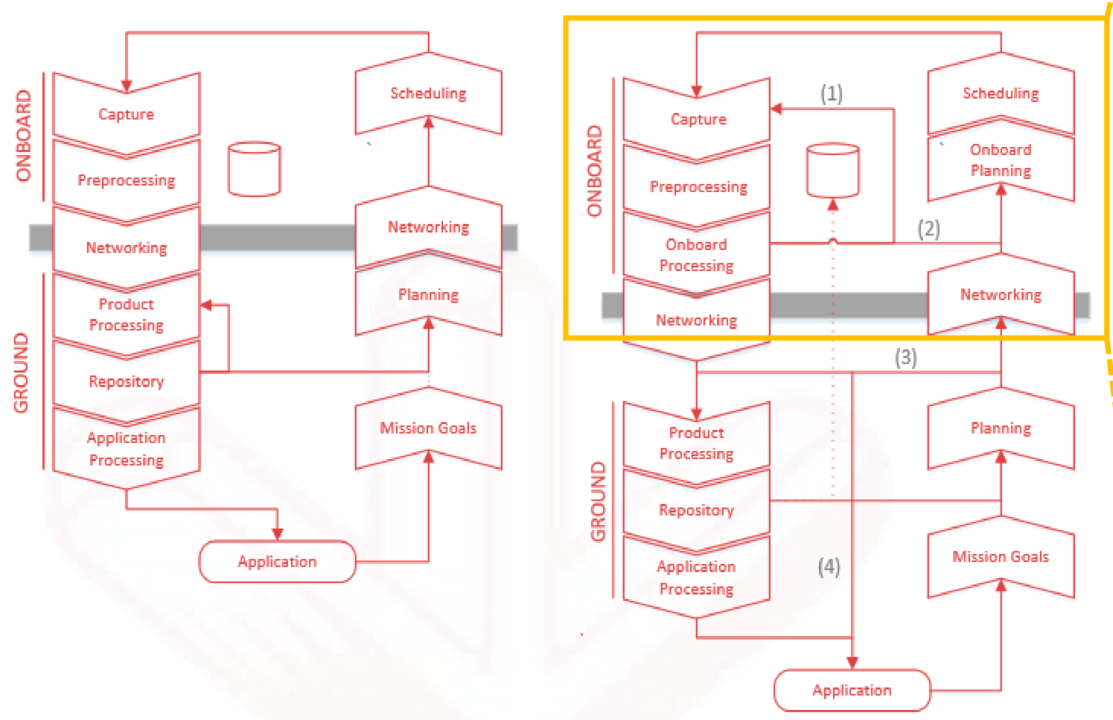
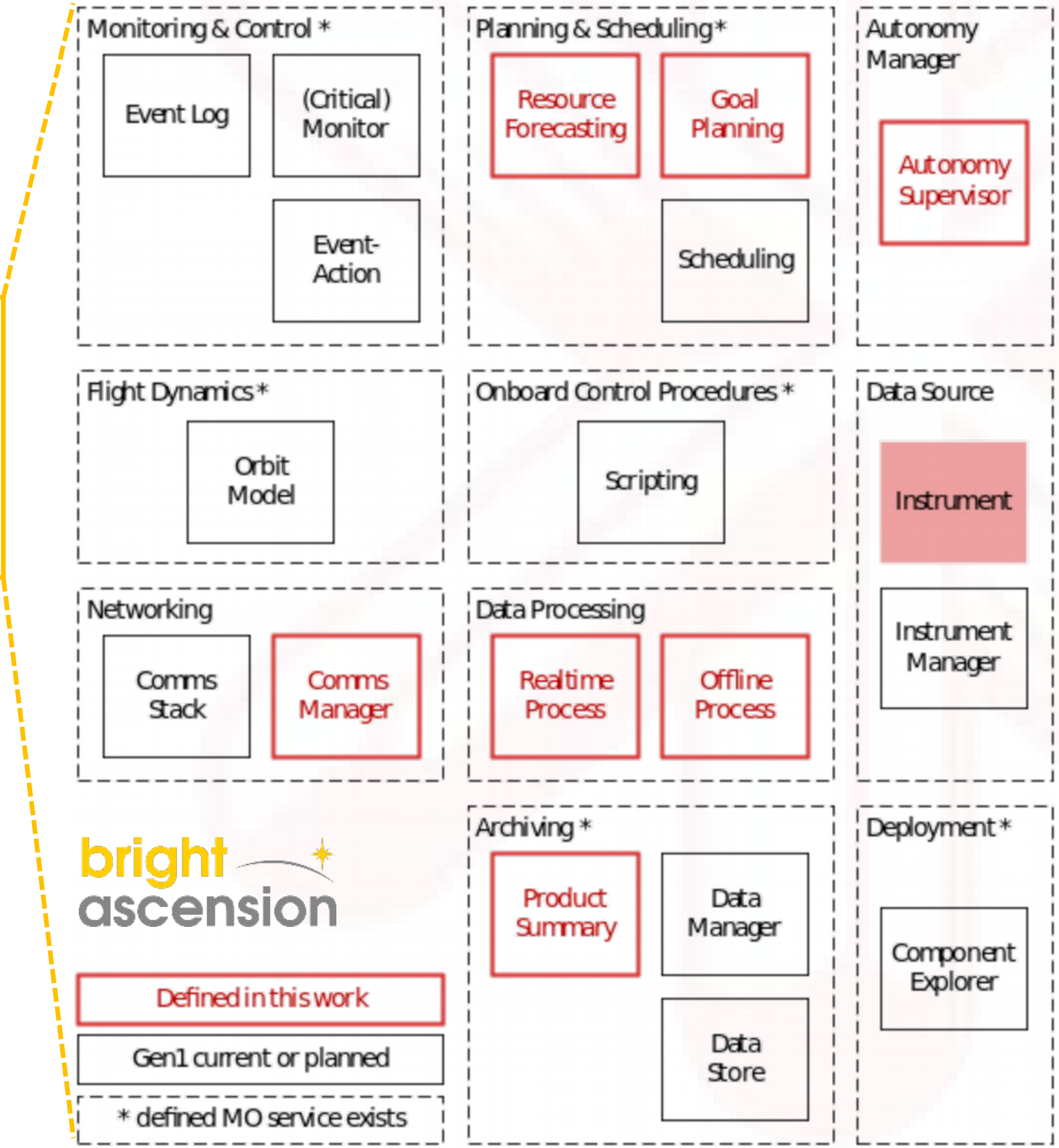
The University of Manchester

UCL

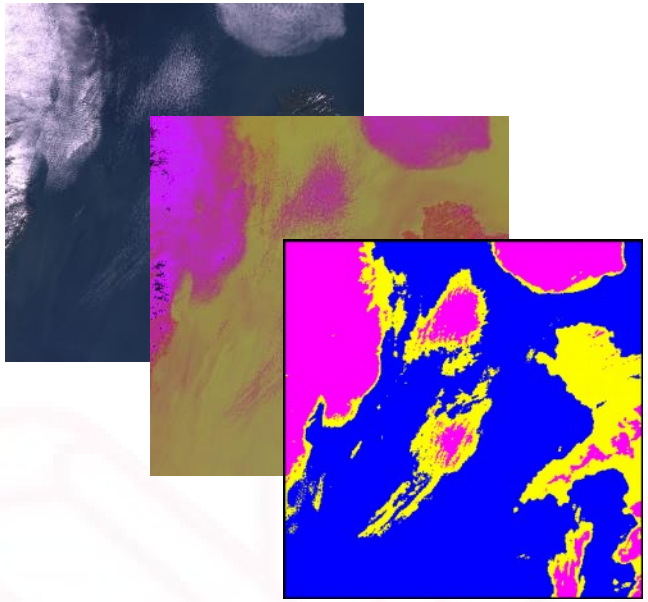
Architecture



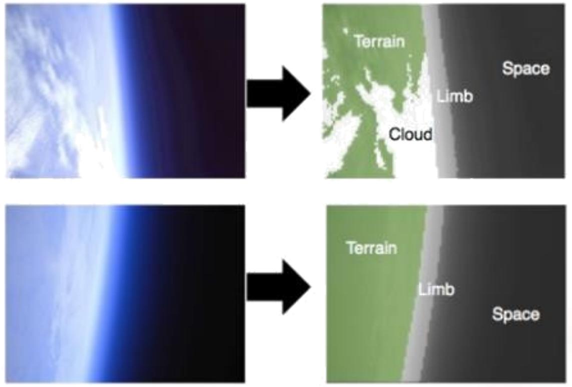
Current → Future



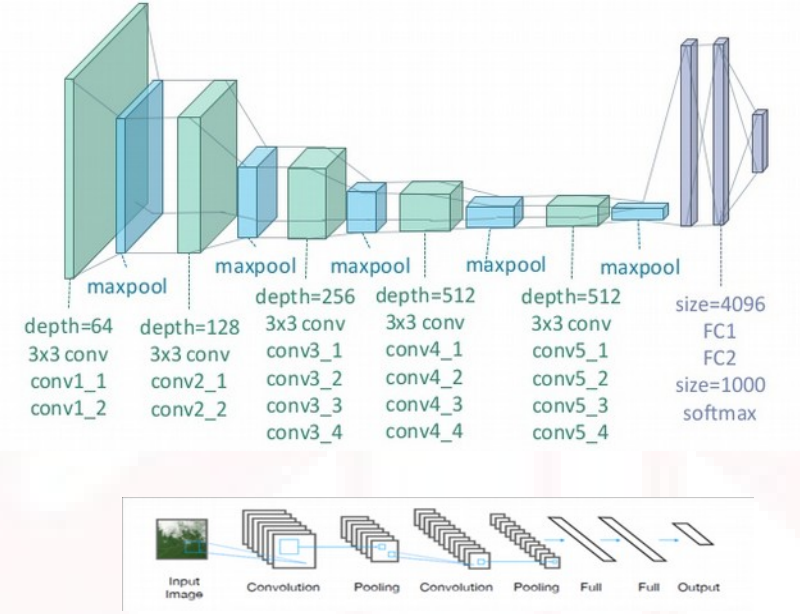
Cloud Detection Algorithm



Fmask



TextureCam



Deep learning

Increasing applicability across domains


12:04:45
Altitude: 400 km
Velocity: 7.67 km/s
Response time: 14.0 s
Pitch: -90 deg, FOV: 1.0 deg, Swath: 5.59 km
Slew: 0.07 deg
High res imager
Tracking: Clear
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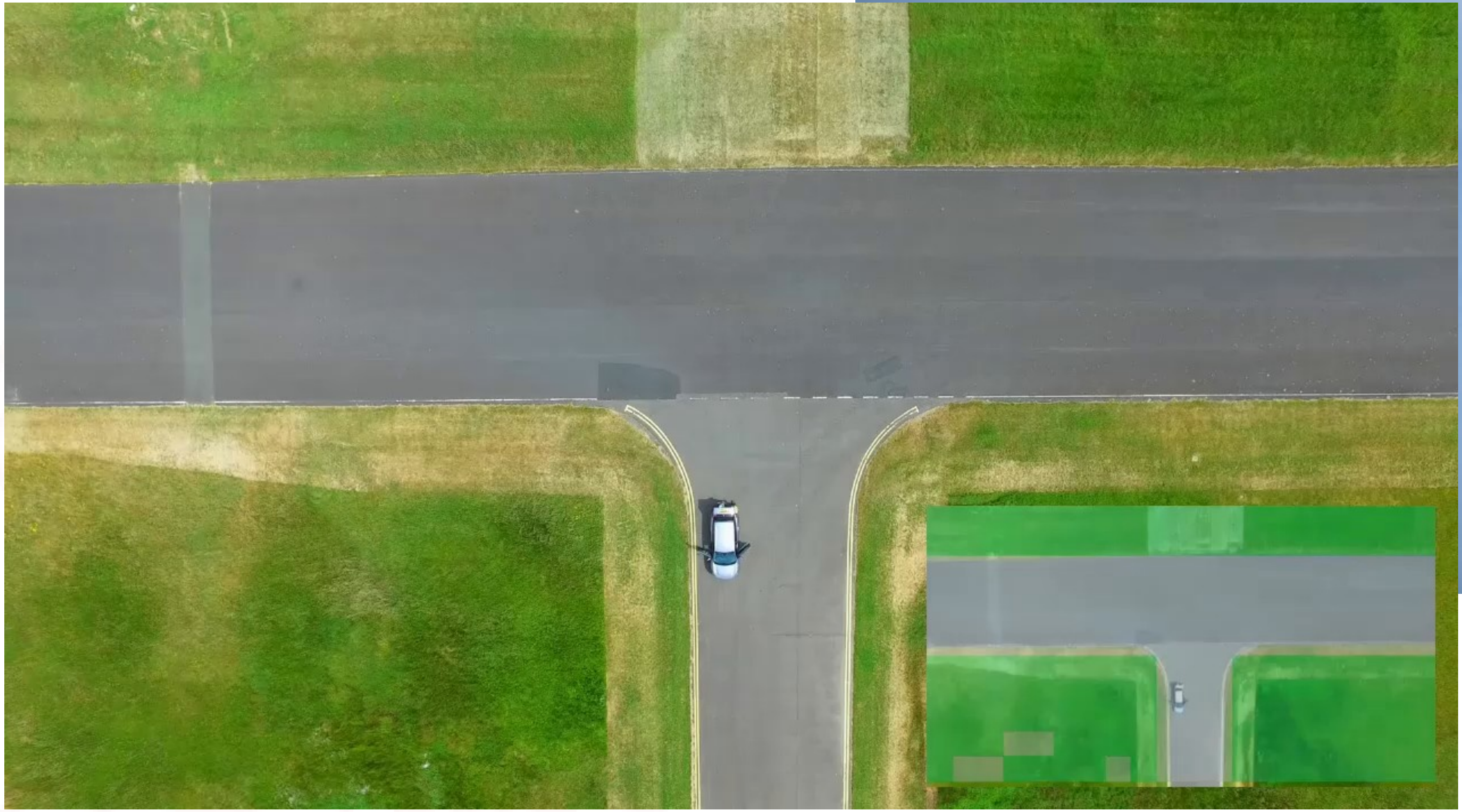
Product

- Engineering models of the FLI MVP now available
- Delivered to first customers for third party performance benchmarking and interface testing
- FPGA-based (2W), but extendable with Myriad VPUs for additional low-power neural networks
- Integrates with HIL simulation for testing
- Reconfigurable for real-time ops
  - Tile-size, sensor input, resamples, field of view, responsive time
  - Network updates
- Internal or external camera sources

Flight Testing



Autonomy Assurance for Small EO Missions

- CEOI-funded project
- **Aim**:
  - Deliver prototype solutions, from TRL 2 to TRL 4, which satisfy end user requirements for assuring onboard autonomy in small and nanosatellite EO missions
- **Outputs**:
  - Autonomy components implemented in BAL spacecraft software
  - System-in-loop prototypes for use cases
  - Components flight-tested on drones

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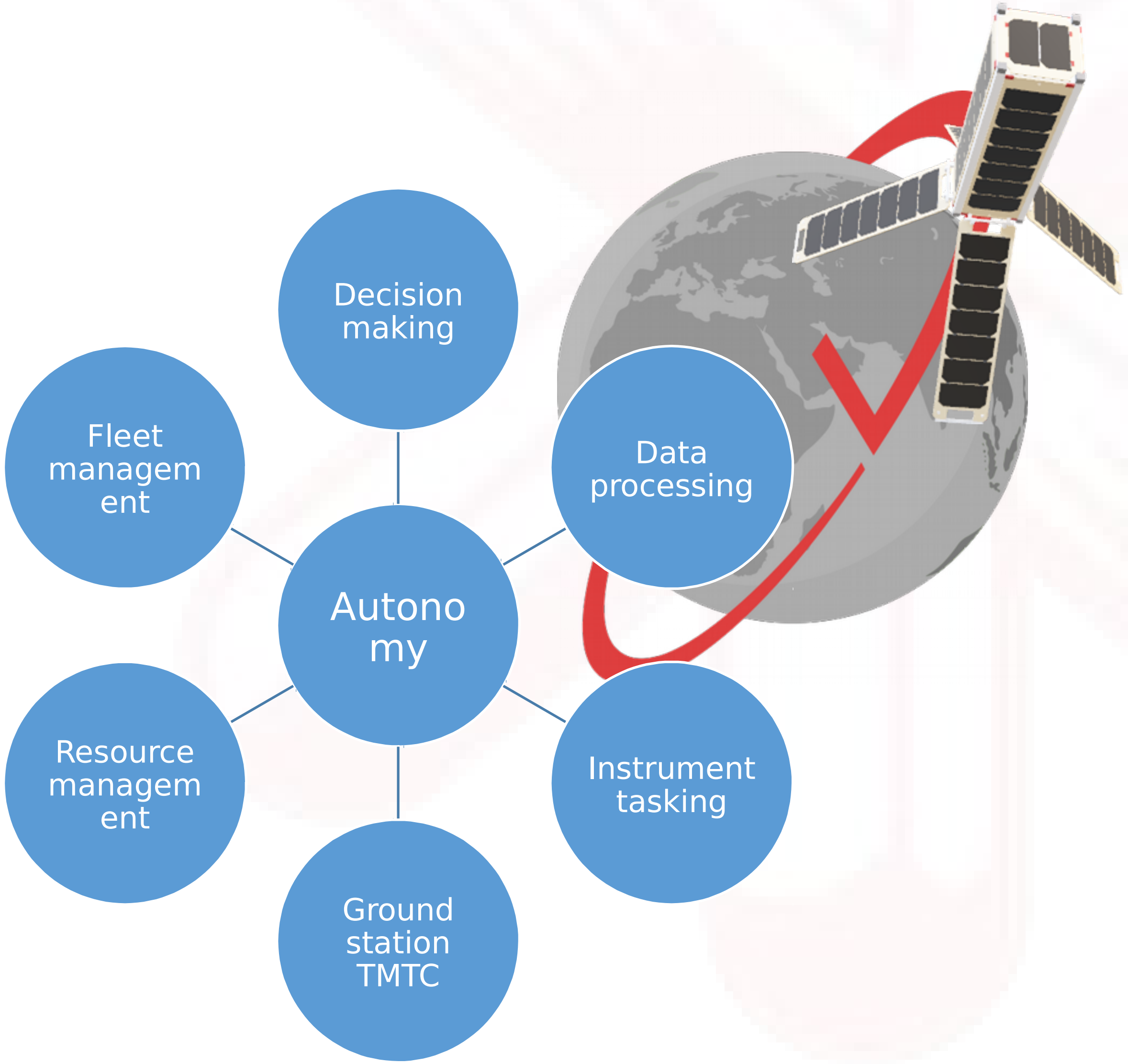
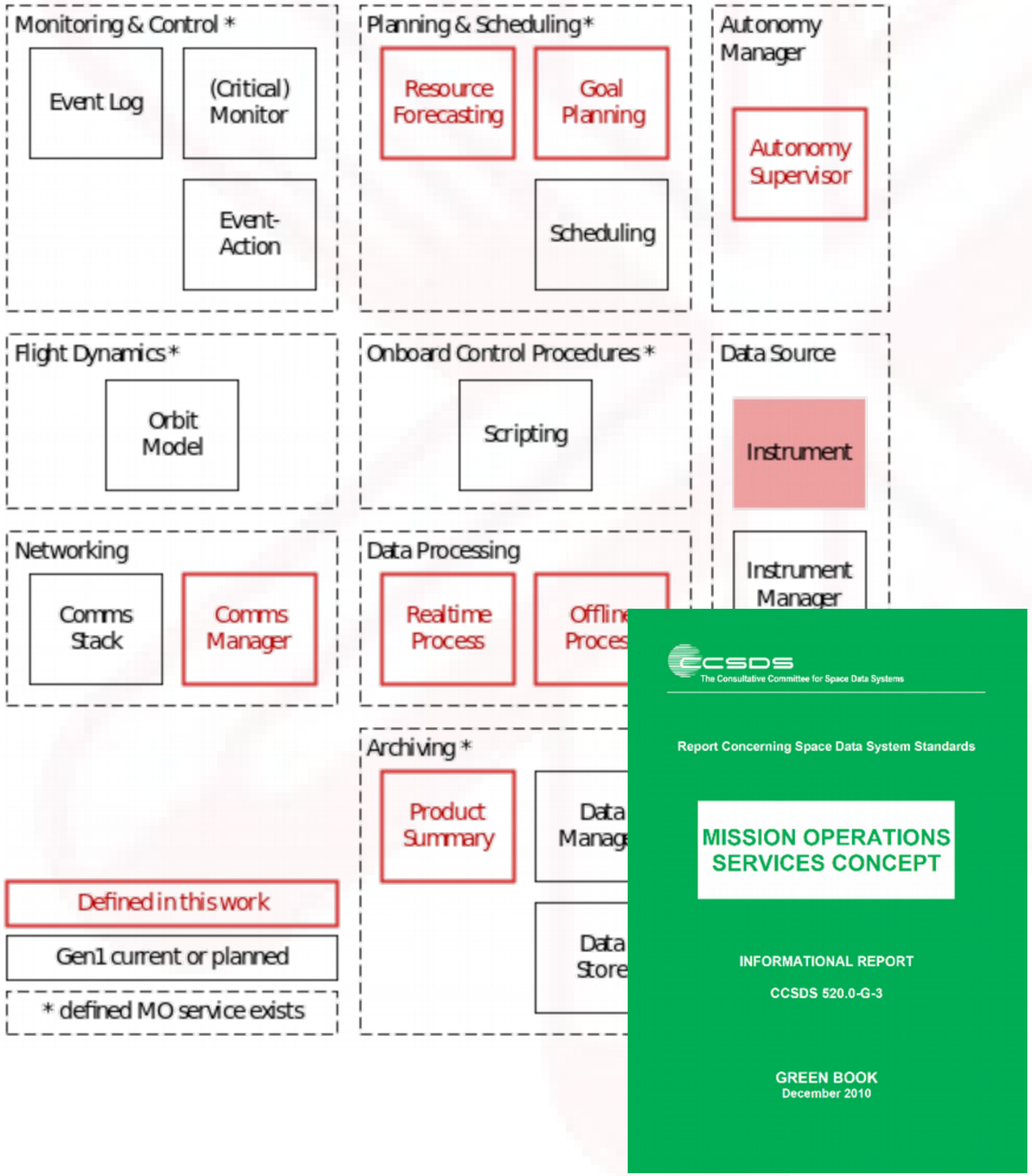
Autonomy Assurance

- End users have provided realistic and valuable use cases for the introduction of autonomy
- Autonomy can benefit different mission aspects:
  - Data processing
  - Satellite operations
  - Pass operations
- How can we provide confidence to customers that autonomous satellite operations can be trusted?



Approach

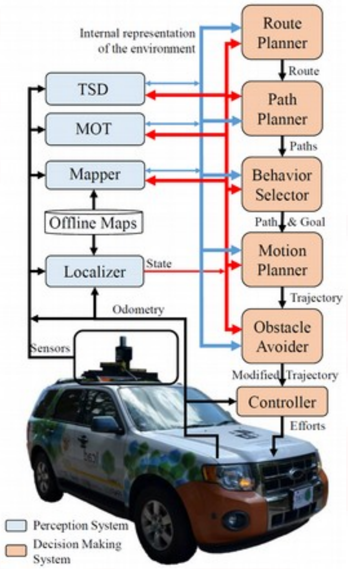
- Requirements captured from established end users
- Target autonomy components defined in previous project
- Inspiration from self-driving cars and other autonomous robots
- Align to existing standards
  - CCSDS MOSC green book
  - ECSS
- Safety- and mission-critical checks on all automatic/autonomous operations



Approach

USE CASES

REQS.



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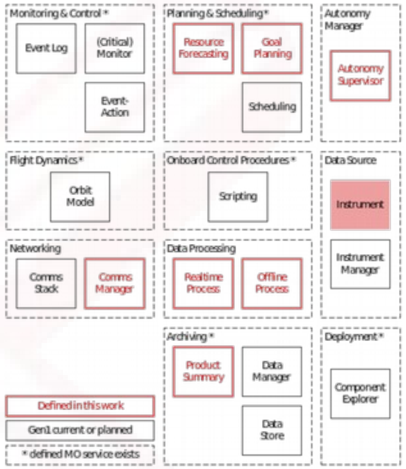
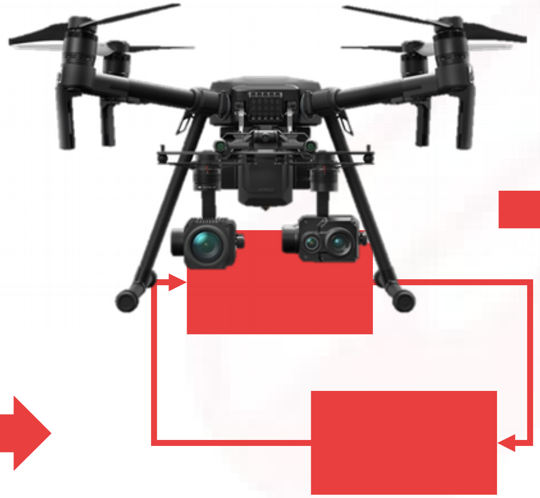


Flight testing
- Real-time autonomy
- Closed-loop control



SIL simulation
- Bright Ascension SW
- Space-ready components
- Simulated

In-orbit demonstration
- Flight/sim-tested components
- BAL SW
- Continuous testing + quality assessment
- In-orbit updates

Closing Remarks

- Nanosatellite autonomy developed to tackle real-world problems
  - Several end users engaged
  - Further interested parties welcome
- Close collaboration between CPL and BAL
  - Space-ready and tested software
  - Team with significant in-orbit experience
- Flexible and modular autonomy-enabling components
  - Hardware portability
  - Third-party instruments and sensors
  - Software agnostic

Thanks for your time
Questions are welcome

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