

Defining Future Application Scenarios for Heterogeneous Teams: a Capability- based Approach

Carlos Ribeiro, Carlos Forster
Aeronautics Institute of Technology
Computer Science Division
São José dos Campos, Brazil



Impact of natural disasters in Brazil



Occupation of high-risk areas, combined with climate extremes, results in a growing number of people affected by disasters [1].

Important weather events in Brazil include:

- Floods and **flash floods**
- **Landslides**
- Droughts

Localized in time and space, but potentially with very high impact

Rovena Rosa, Agência Brasil

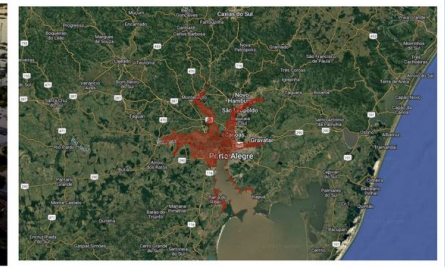
[1] DE ASSIS DIAS, Mariane Carvalho et al. Estimation of exposed population to landslides and floods risk areas in Brazil, on an intra-urban scale. **International Journal of Disaster Risk Reduction**, v. 31, p. 449-459, 2018.

Scenarios

Coordination is necessary for operations during natural disasters in order to address demands including damage assessment, victim search and rescue, and effective communication.



Source: Agência Brasil



Source: Storymaps

Figure 1: On the left, floods in Rio Grande do Sul and on the right, affected region.



Source: G1



Source: Climainfo

Figure 2: Landslides in São Sebastião

Scope: CIVIL PROTECTION, DISASTER MANAGEMENT

- Disaster risk management (before)
- Disaster management (during/after)



Contingency plan



response/recovery

Capability-based Planning

Planning under uncertainty

Wide range of hazards

Multiple governance levels



Contingency plan



Tasks to be done

Tasks to be prioritized

Capabilities needed/available for each task

Capabilities needed in emergencies ("disaster inside a disaster")

Capability-based Planning: our context

Planning under uncertainty

Wide range of hazards

Multiple governance levels



Contingency plan



aerial/terrestrial
(semi-)autonomous
assets + human/AI
supervision



Tasks to be done
Tasks to be prioritized

Capabilities needed/available for each task

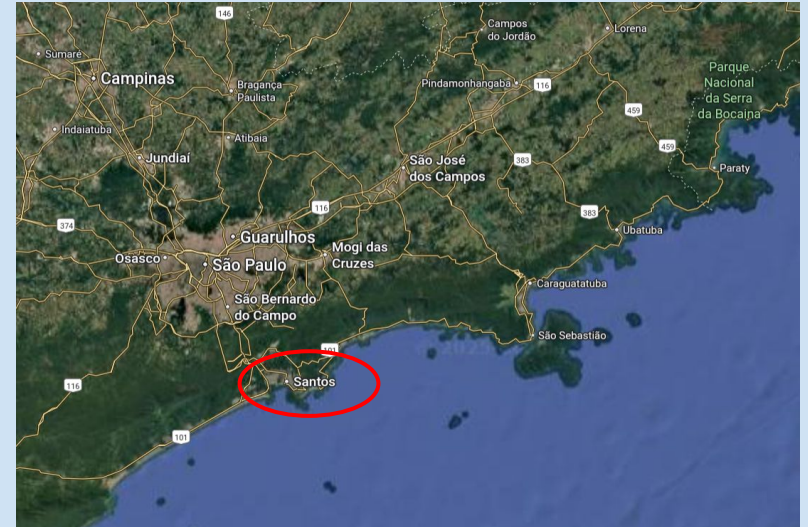
Capabilities needed in emergencies ("disaster inside a disaster")

Typical scenario



source: g1.globo.com

Baixada Santista region (São Paulo coast), March 2020: 300 mm rain in two days, 43 deaths



Typical scenario: Phase 1



- Area delimitation
- Communication network

(dynamic environment, sudden degradation, contested spectrum)

Typical scenario: Phase 2



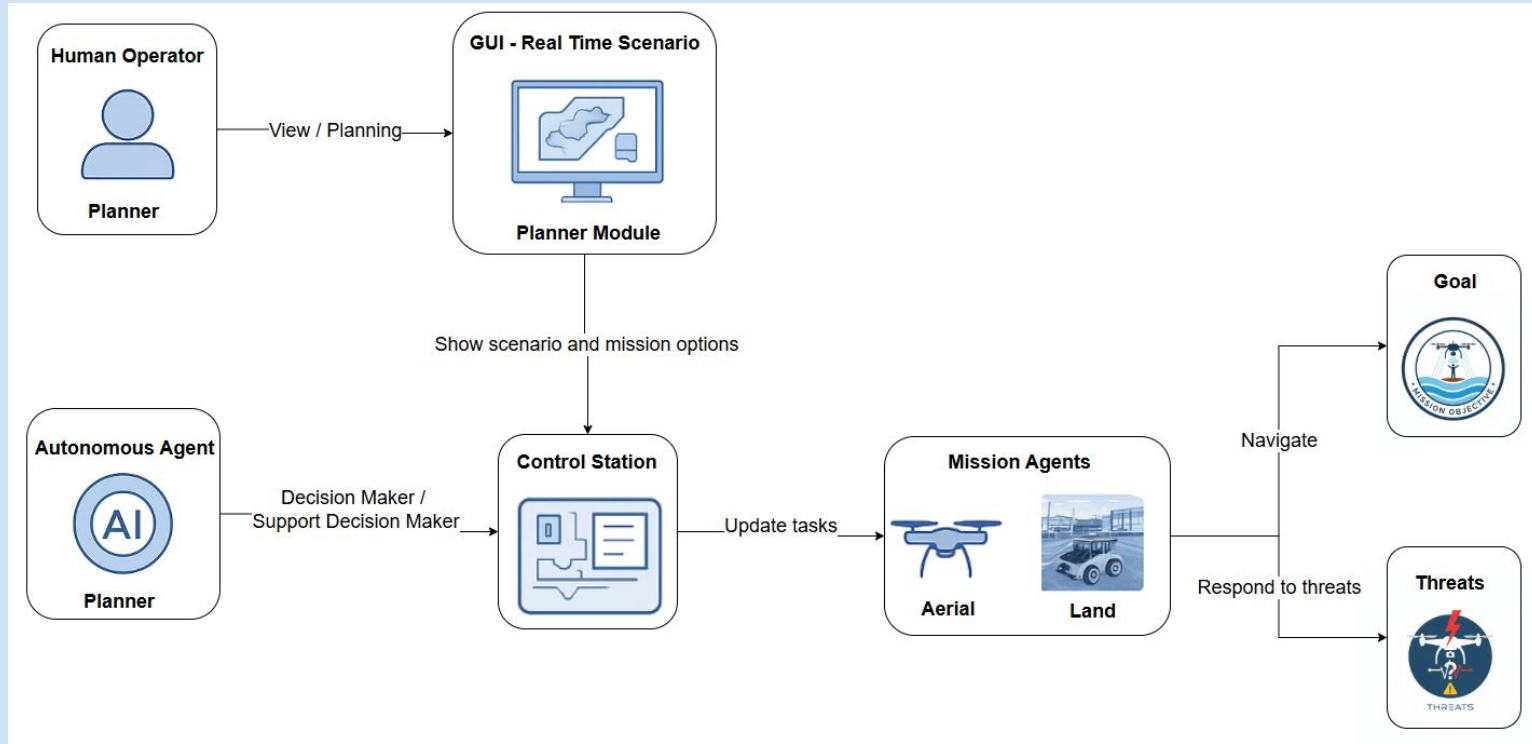
- Search
 - Images
 - RGB, thermal, RF
 - Assessment of accessibility
 - For phase 3

Typical scenario: Phase 3



- Rescue and delivery
 - Medical aid
 - Supplies
 - Personnel

Proposed architecture



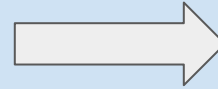
Proposed architecture - Planning/Monitoring Agents

Human Operator

Autonomous agent



Contingency plan



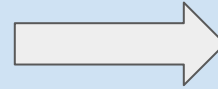
Responsible for monitoring mission status wrt contingency plan, planning/replanning asset activities, making real-time adjustments.

Proposed architecture - Executing Agents

Aerial Vehicle



Land Vehicle



Responsible for executing the mission, moving toward the objectives, defining the routes, detecting/avoiding/informing potential threats.

Aspects



Aspects (preliminary results)



Preliminary results (1)

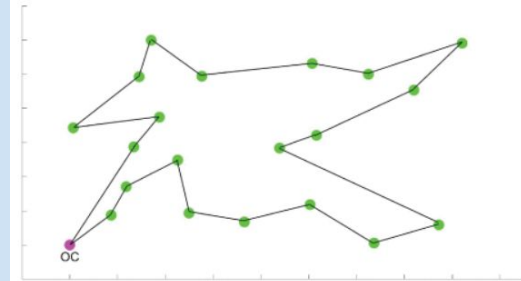
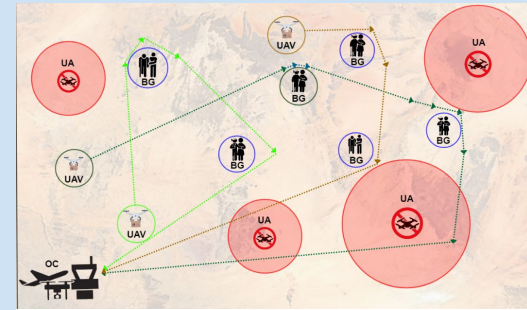
Mitigating Risk in UAV Aid Delivery Missions: A Safe Path Prioritization Approach ^[2]

UAVs deliver critical aid to hazardous or remote areas. Real-time route adaptation is vital for safety and mission success.

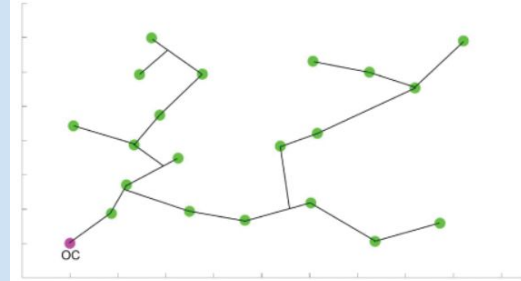
Method: Safe Path Prioritization (SPP): prefers verified safe routes over unknown areas. Combines RRT (path-planning) and Genetic Algorithms (task assignment). Integrates a Dynamic Risk Map for safety and energy balance.

Conclusion: SPP improves mission reliability, ensuring UAV safety and timely aid delivery.

[2] N. P. Borges, C. G. Ghedini and C. H. C. Ribeiro, "Mitigating Risk in UAV Aid Delivery Missions: A Safe Path Prioritization Approach", in **IEEE Access**, vol. 12, pp. 168765-168778, 2024, doi: 10.1109/ACCESS.2024.3491893.



(a) Without Safe Path Prioritization



(b) With Safe Path Prioritization

Preliminary results (2)

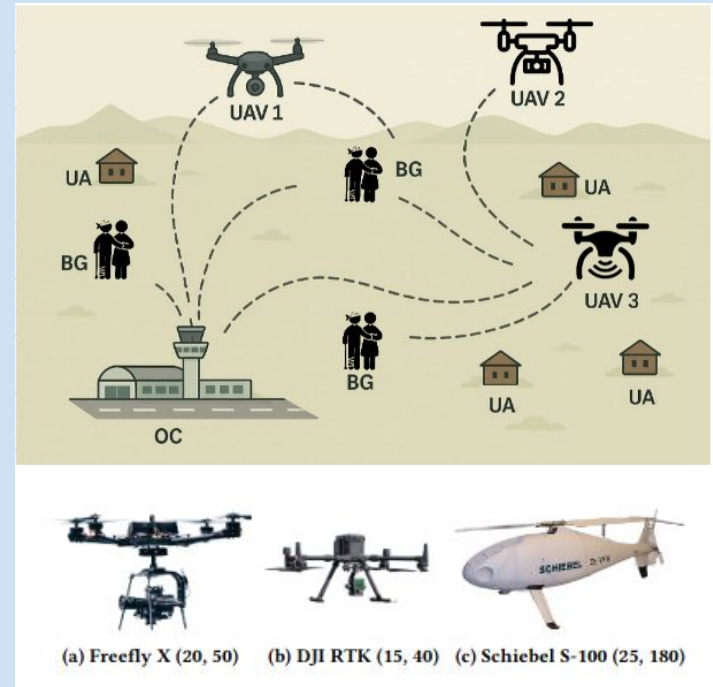
Safe Path Prioritization for Missions in Scenarios with Heterogeneous Agents ^[3]

Heterogeneous set of UAVs (wrt capabilities) deliver critical aid to hazardous or remote areas.

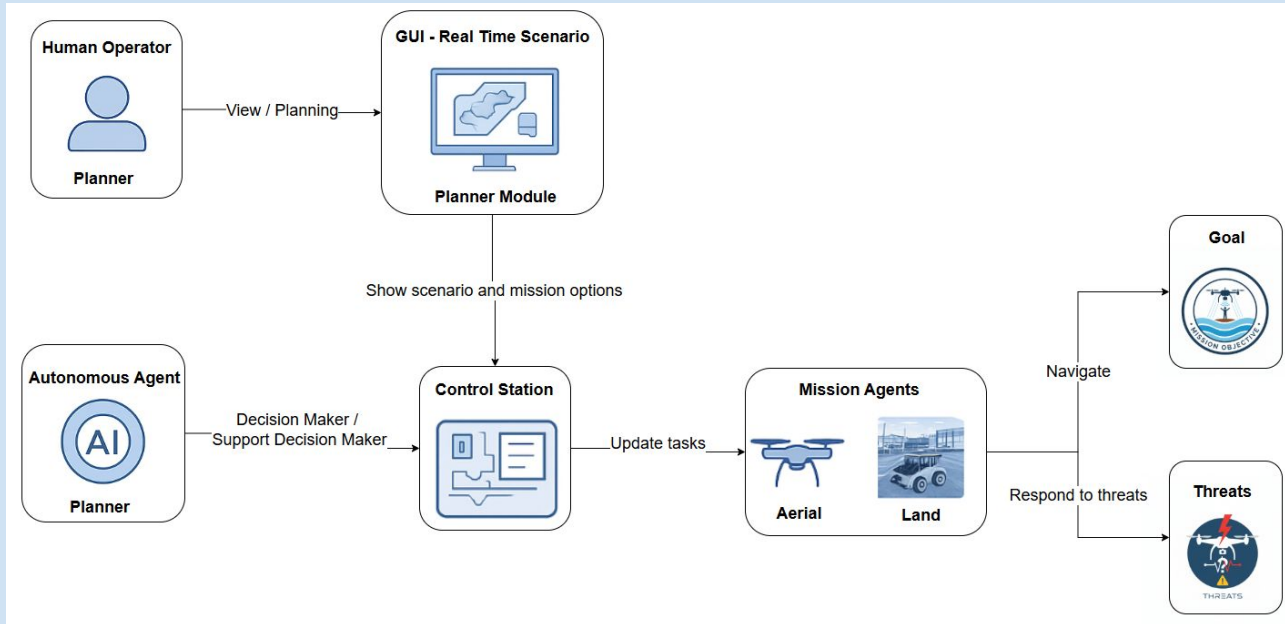
Method: Same as before, but for an adaptation for the fitness function of the Genetic Algorithms (task assignment considering UAV capabilities).

Conclusion: Same as before, but with the empirical observation that diversified set of UAVs, particularly high-endurance ones, significantly boost safe path benefits.

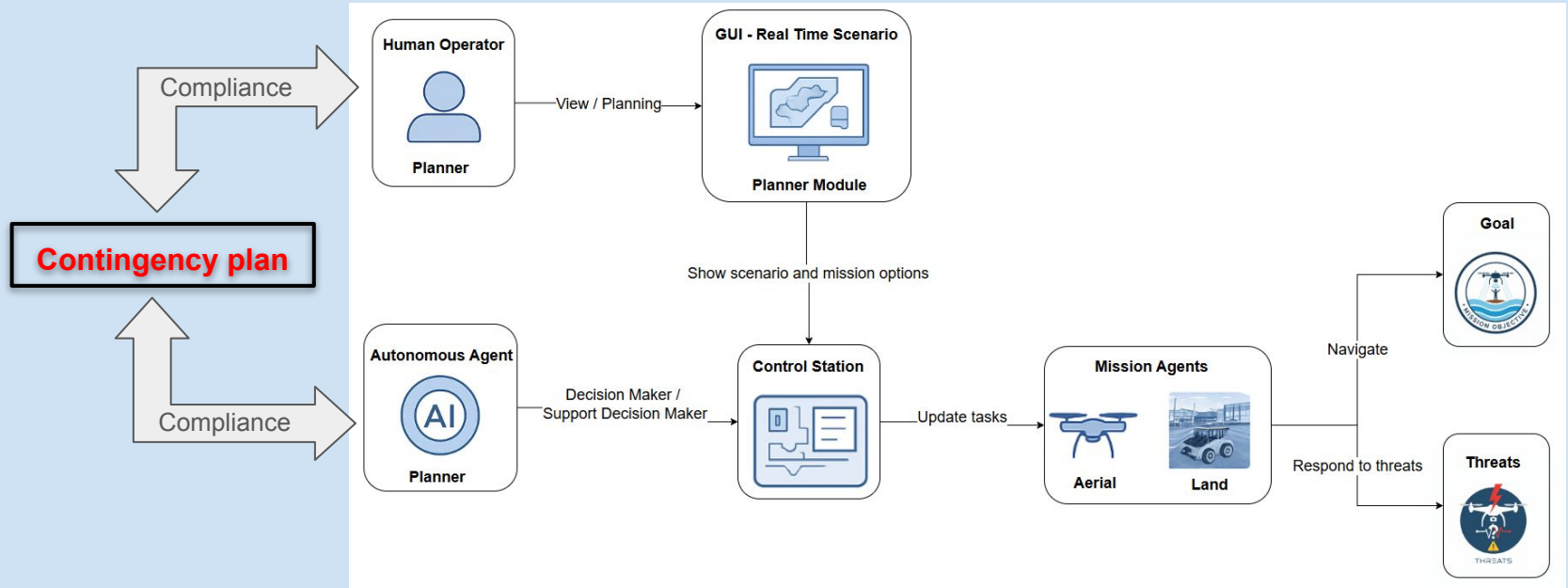
[3] N. P. Borges and C. H. C. Ribeiro, "Safe Path Prioritization for Missions in Scenarios with Heterogeneous Agents", submitted to The **41st ACM/SIGAPP Symposium On Applied Computing**.



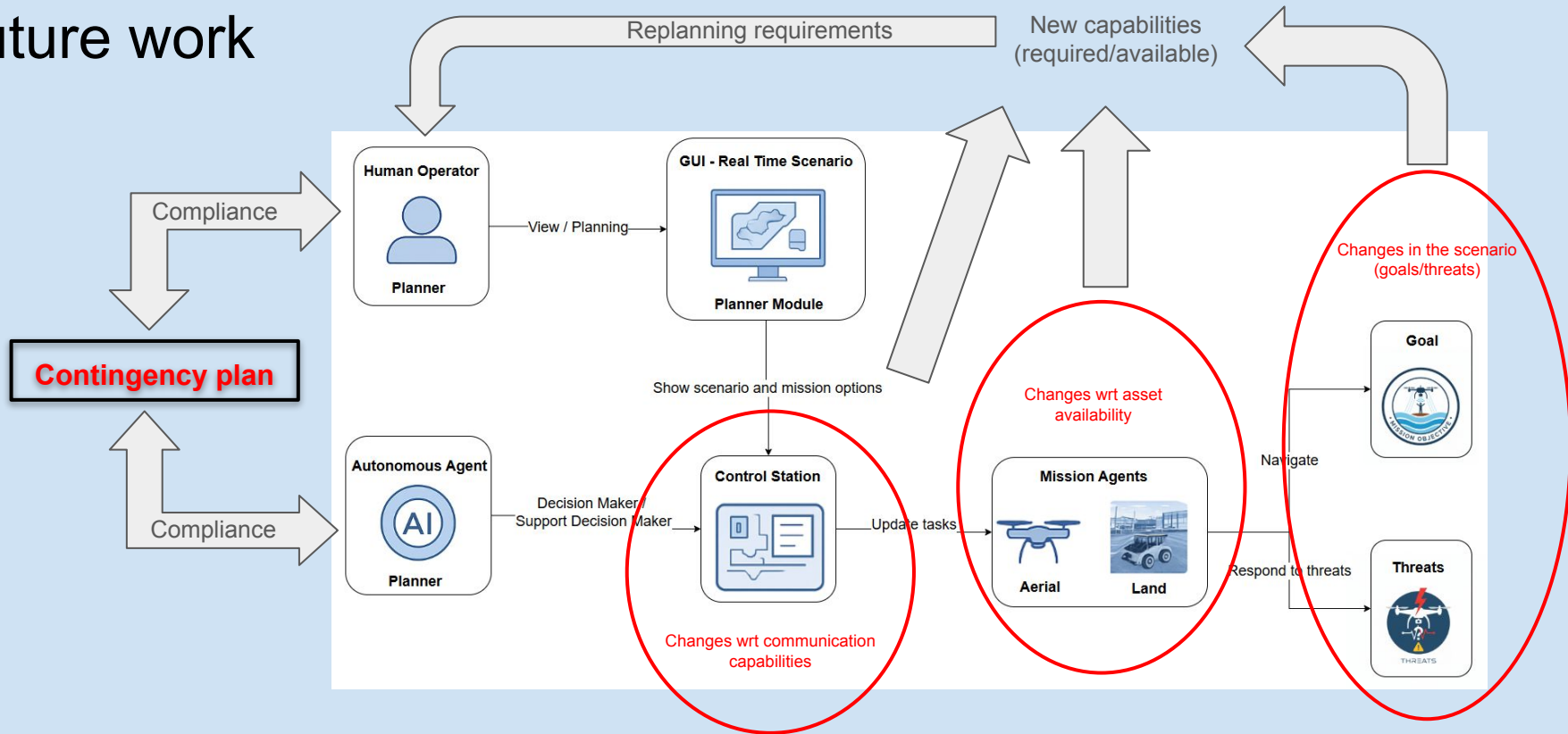
Future work



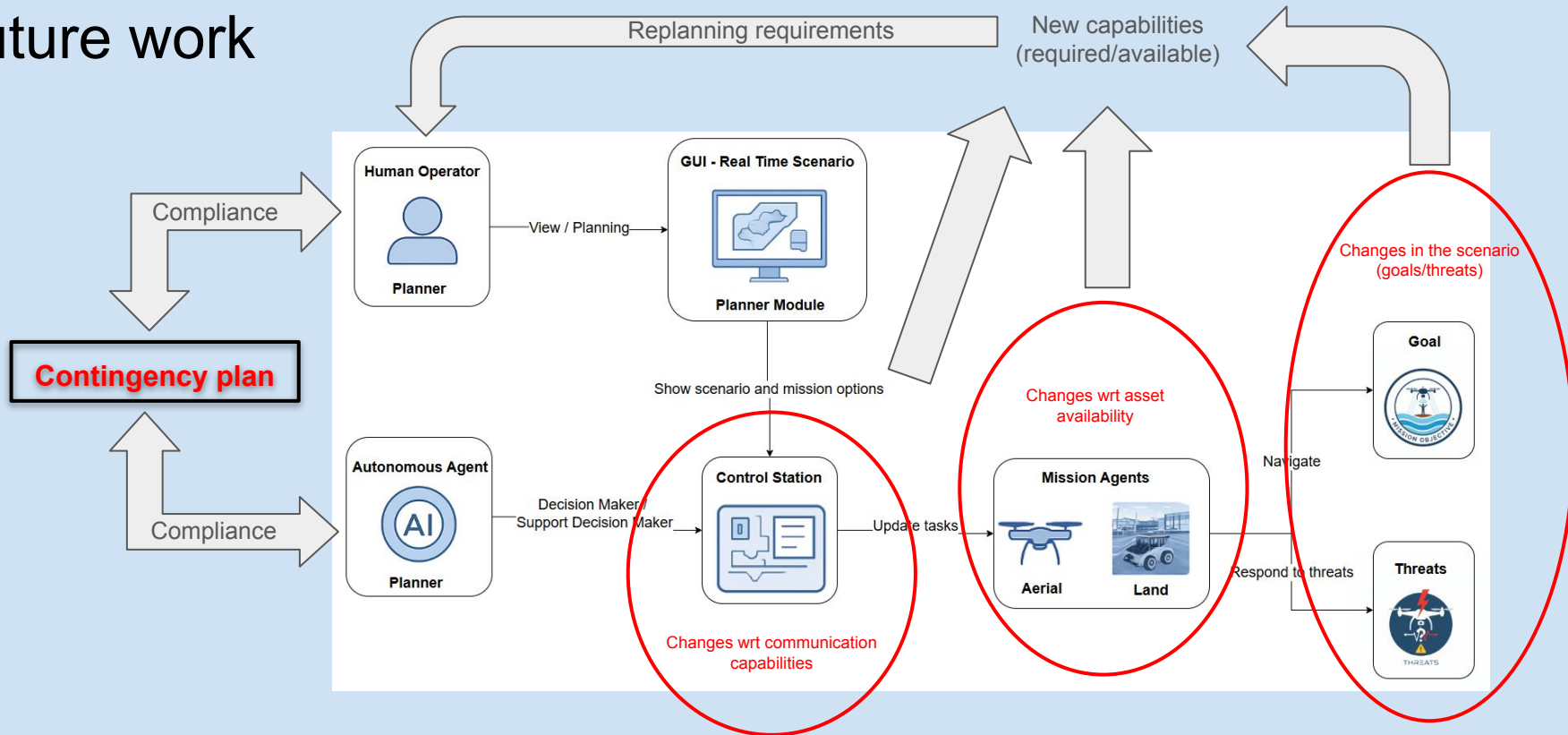
Future work



Future work

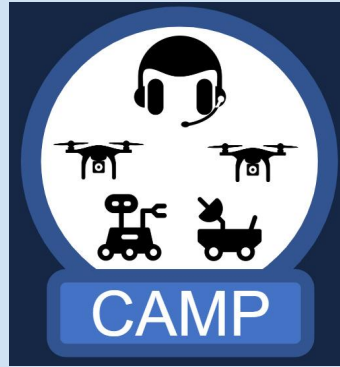


Future work



+ simulation model (concept.io), GUI design/validation, proof of concept...

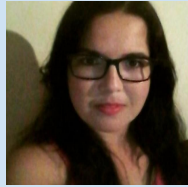
Thank you!



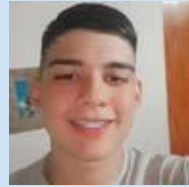
Carlos Forster



Carlos Ribeiro



Débora Freitas



Eduardo Sousa



Flavio Souza



Juan Silva



Klaifer Garcia



Nicolas Borges



Rafael Azevedo