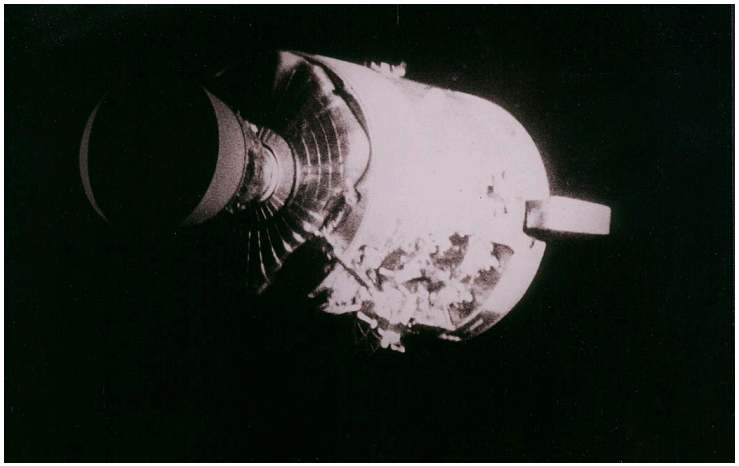
FRAMily 2023, Copenhagen

Revealing success factors of cooperative operations in space manned missions: crucial factors in Apollo missions



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Apollo missions

Apollo 11

- First manned landed mission on Moon.
- “Eagle Has Landed”

Apollo 13

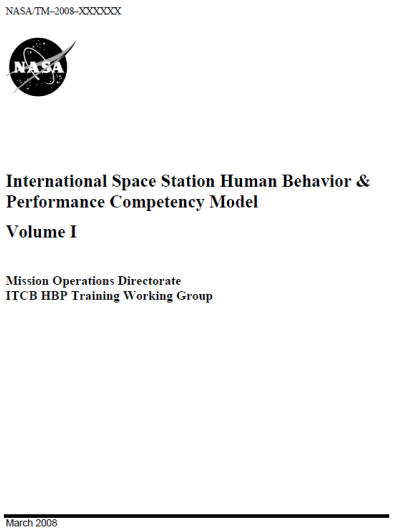
- 3rd lunar landing attempt, but the mission was aborted after rupture of service module oxygen tank.
- “Successful failure" as an experience gained in rescuing the crew.

Purpose of this research

- To reveal **crucial factors of successful rescue** in space missions using FRAM
- To validate FRAM model with analyzing dialogues of Apollo 11 and 13

Information to develop FRAM model of Astronaut

- **Interviews with two astronaut instructors**
- International Space Station (ISS) astronaut **competency model**



NASA/TM–2008–XXXXXX

International Space Station Human Behavior & Performance Competency Model

Volume I

Mission Operations Directorate
ITCB HBP Training Working Group

March 2008

1. Self-care self management
2. Communication
3. Cross cultural
4. Teamwork and group living
5. Leadership
6. Conflict management
7. Situational awareness
8. Decision making and problem solving

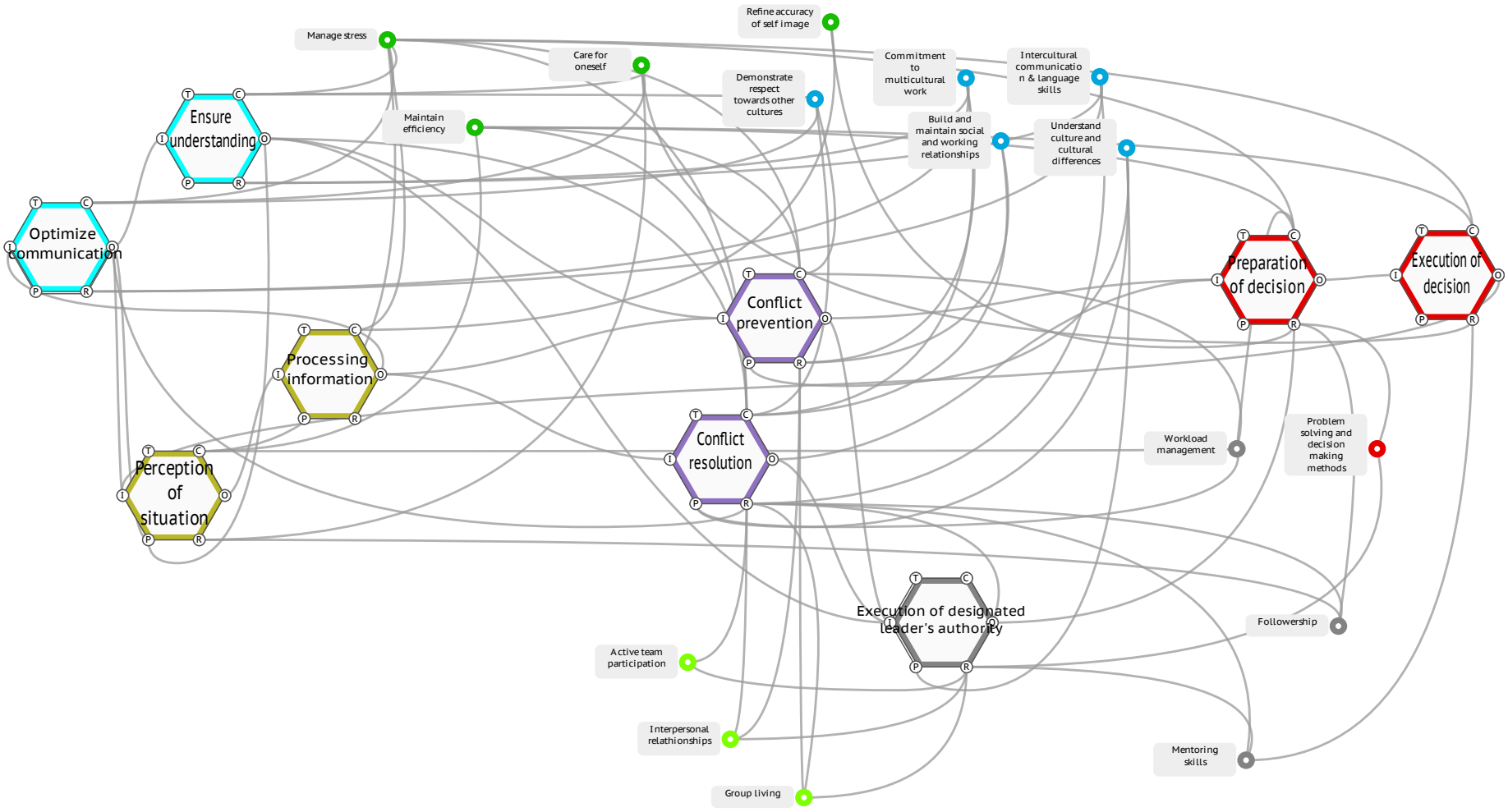
2.1 SELF-CARE SELF MANAGEMENT

Competency	REF	Behavioural Marker
Refine accuracy of self image	CSM1	Identifies personal tendencies and their influence on own behaviour.
	CSM2	Identifies factors for personal successes or failures
	CSM3	Seeks formal and informal feedback to understand impact of own behaviour on others
	CSM4	Assesses own skills knowledge and abilities against task requirements
Manage stress	CSM5	Identifies symptoms and causes of personal stress
	CSM6	Takes action to prevent and mitigate stress, negative mood, or low morale
	CSM7	Uses calm and flexible approach in dealing with unfamiliar situations

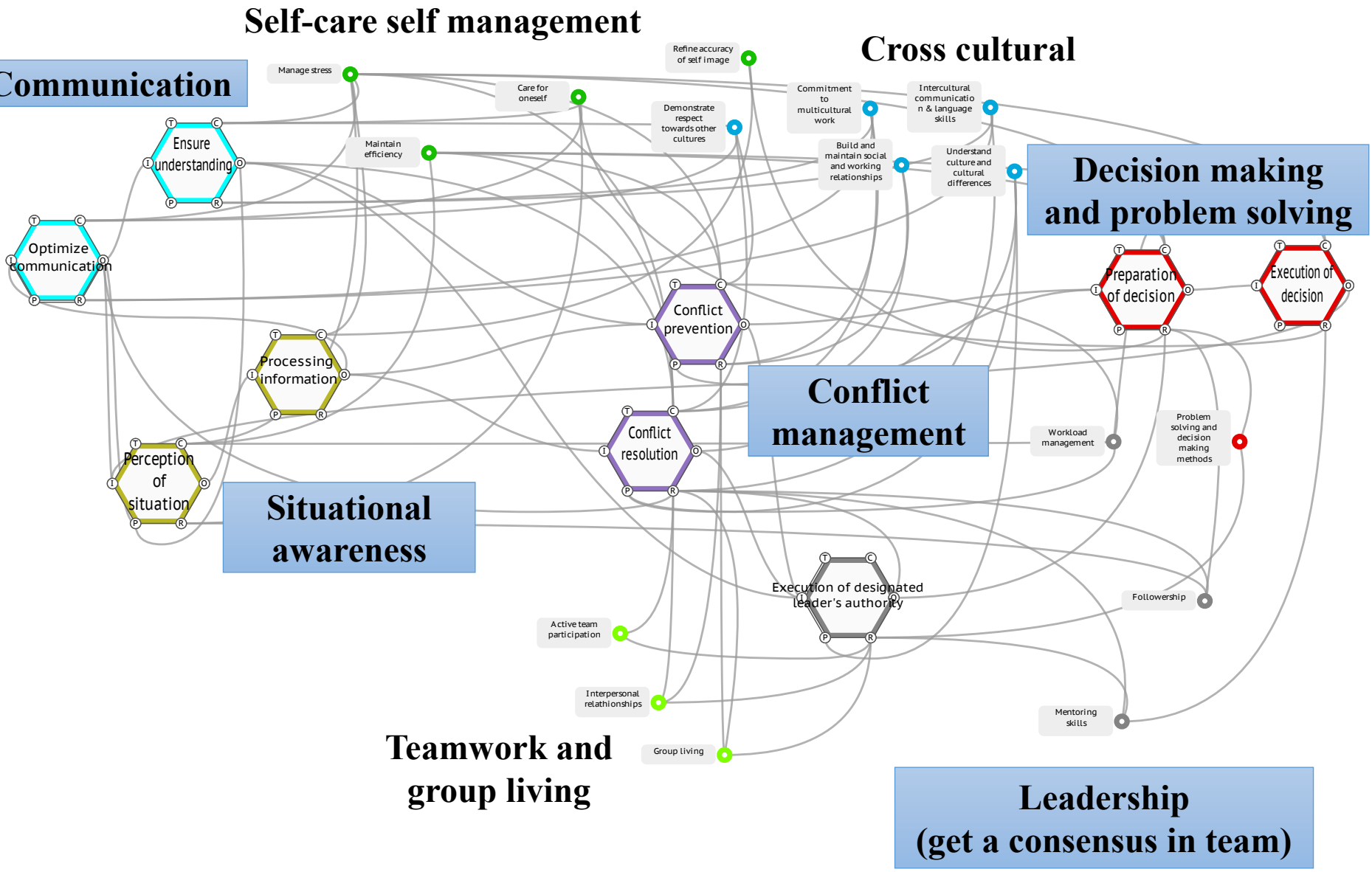
※Flight controllers should also have those factors

(NASA, 2008)

FRAM model of Astronaut

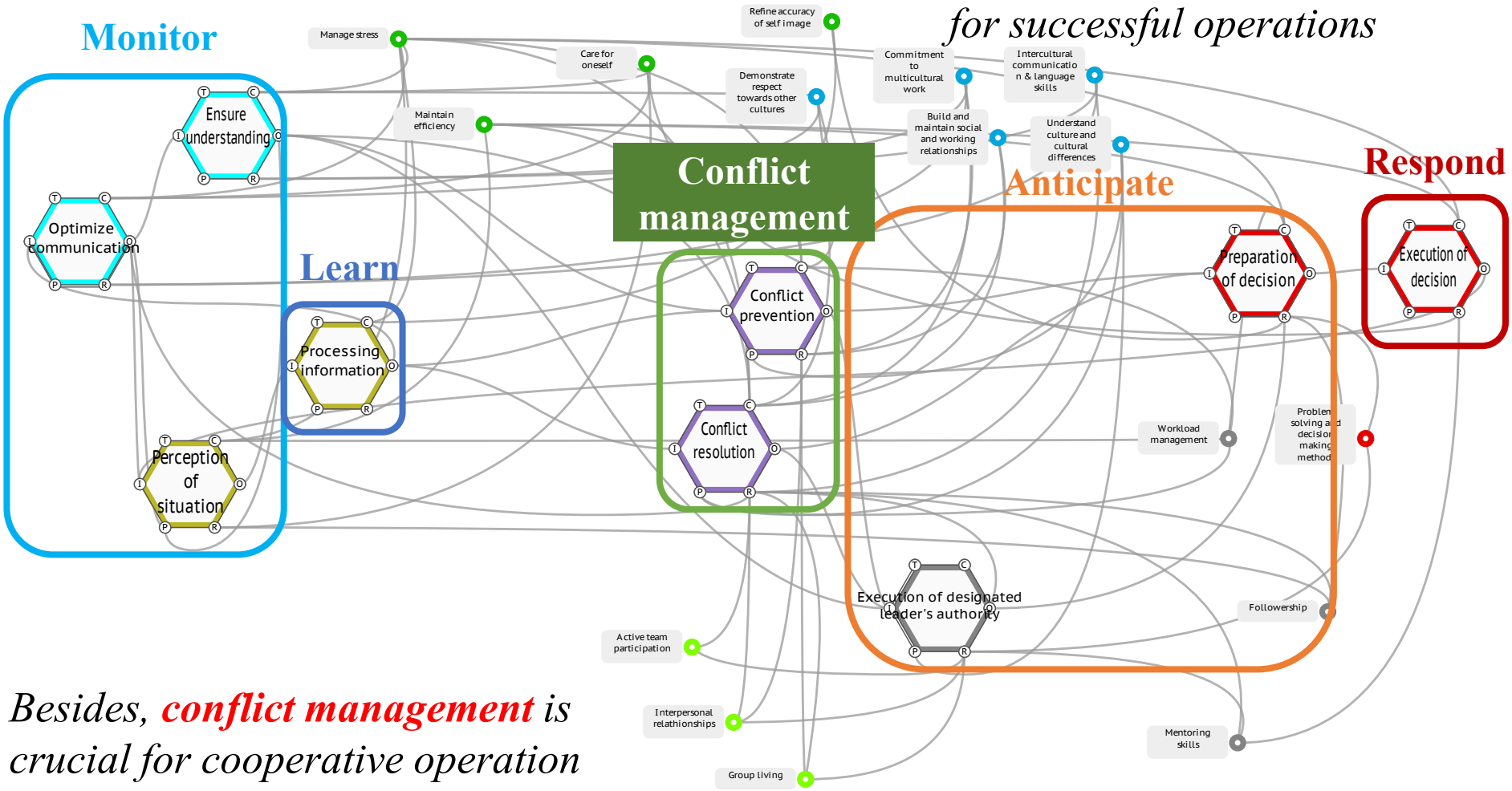


FRAM model of Astronaut



4 Resilience factors + Conflict management

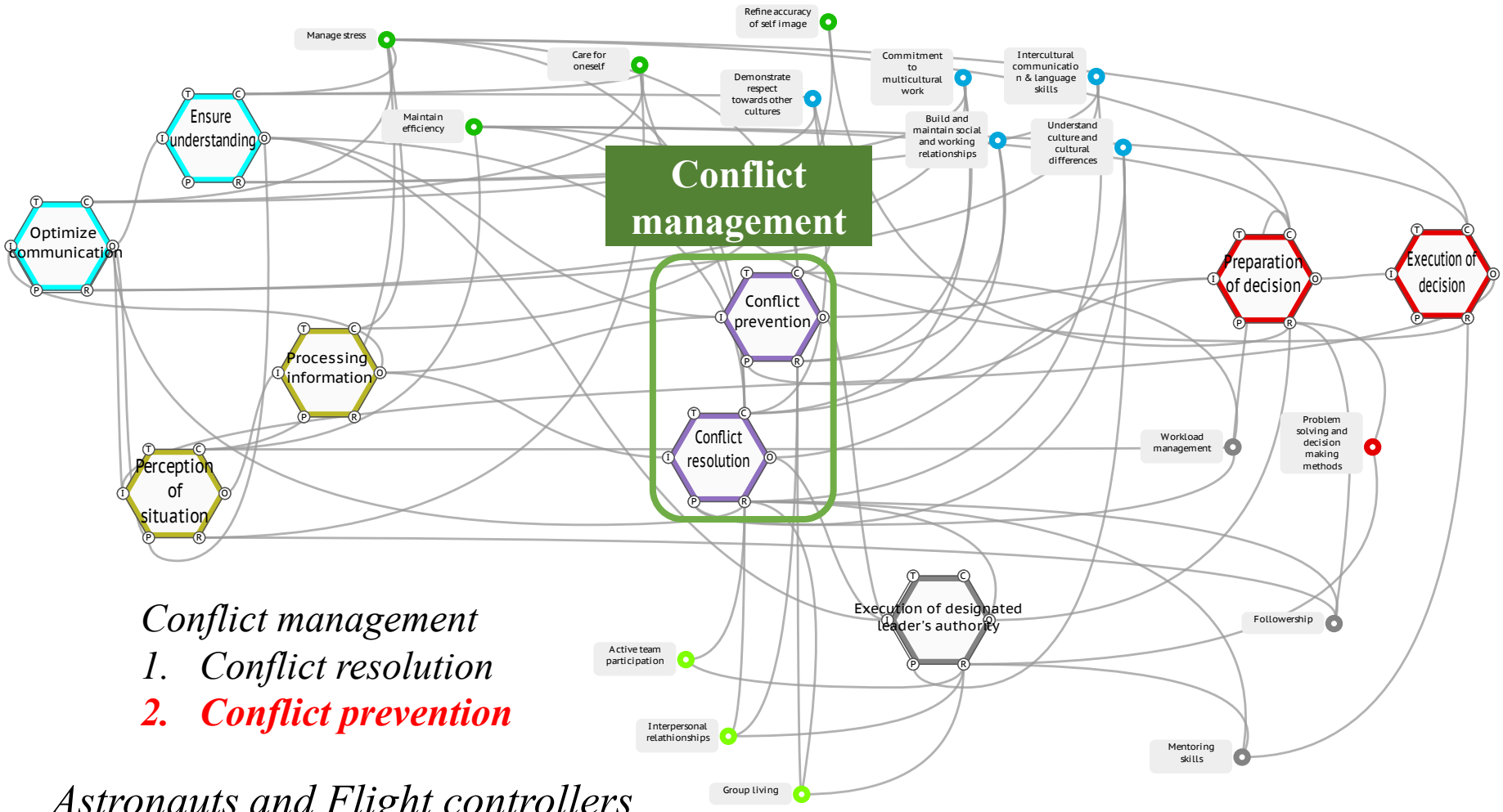
*Astronaut needs **resilience functions** for successful operations*



*Besides, **conflict management** is crucial for cooperative operation*

1. *Team management on-board*
2. *Cooperative with ground teams*

4 Resilience factors + Conflict management



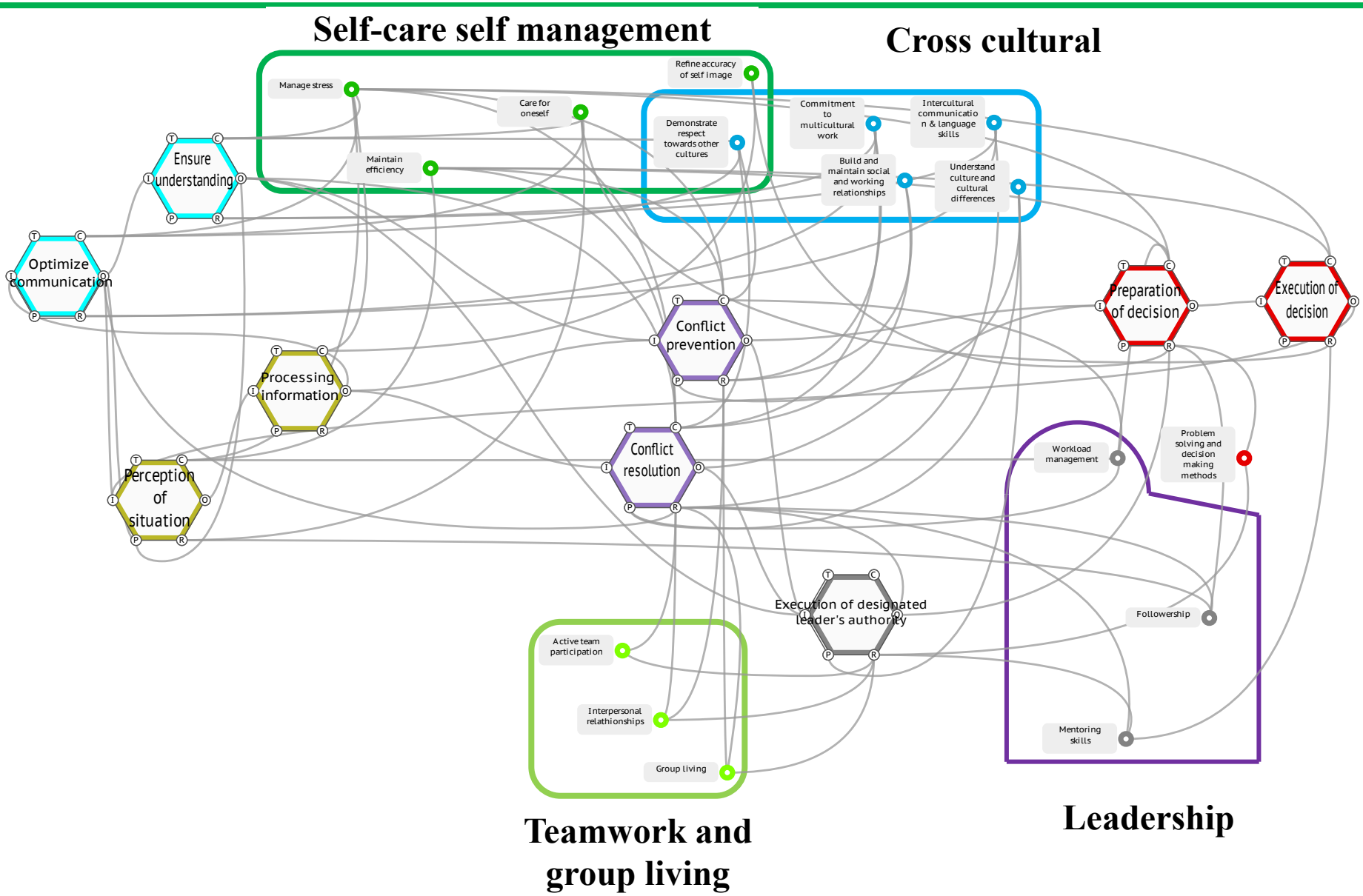
Conflict management

1. *Conflict resolution*
2. ***Conflict prevention***

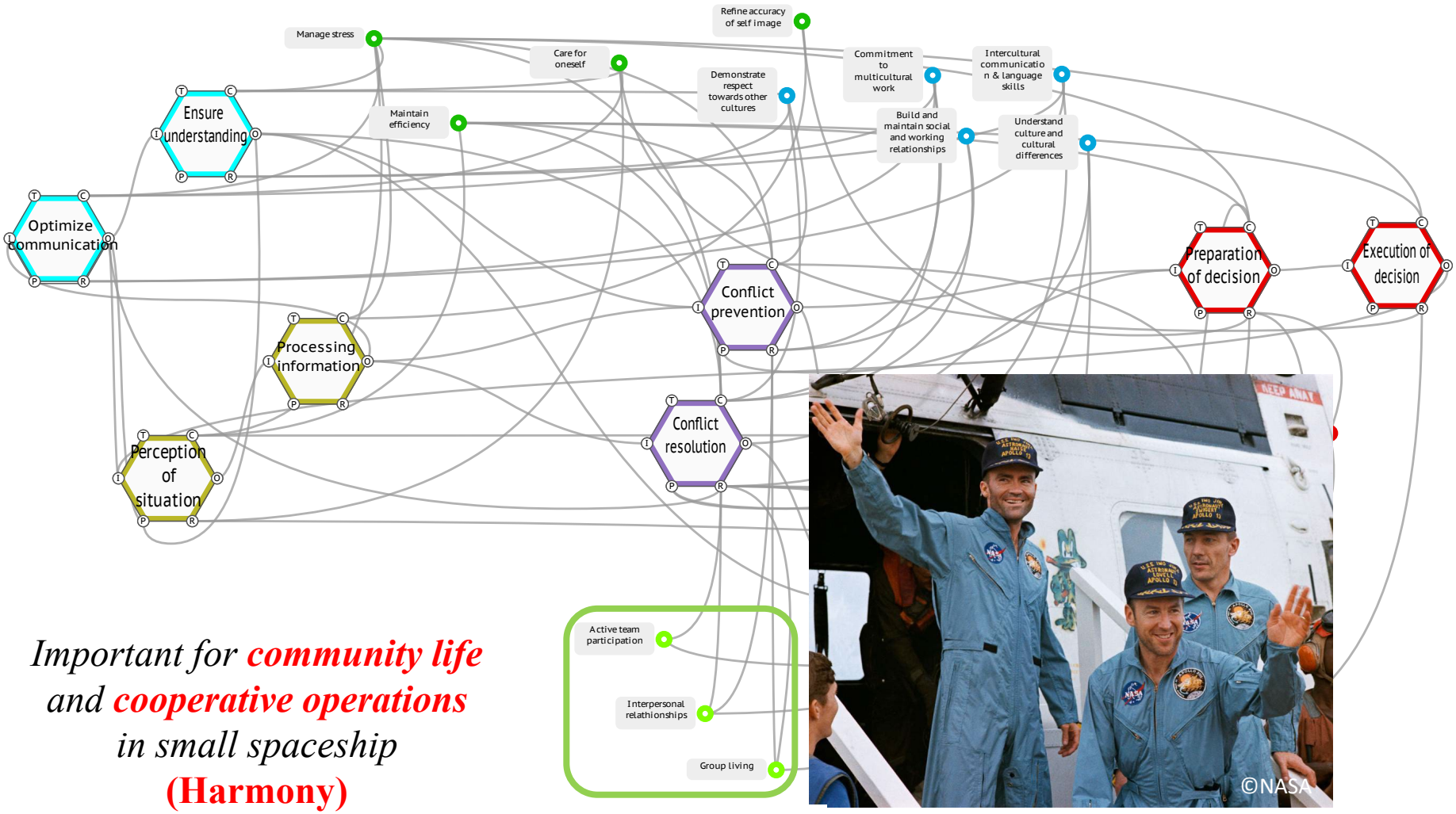
Astronauts and Flight controllers

prevents disagreements beforehand

Key background functions



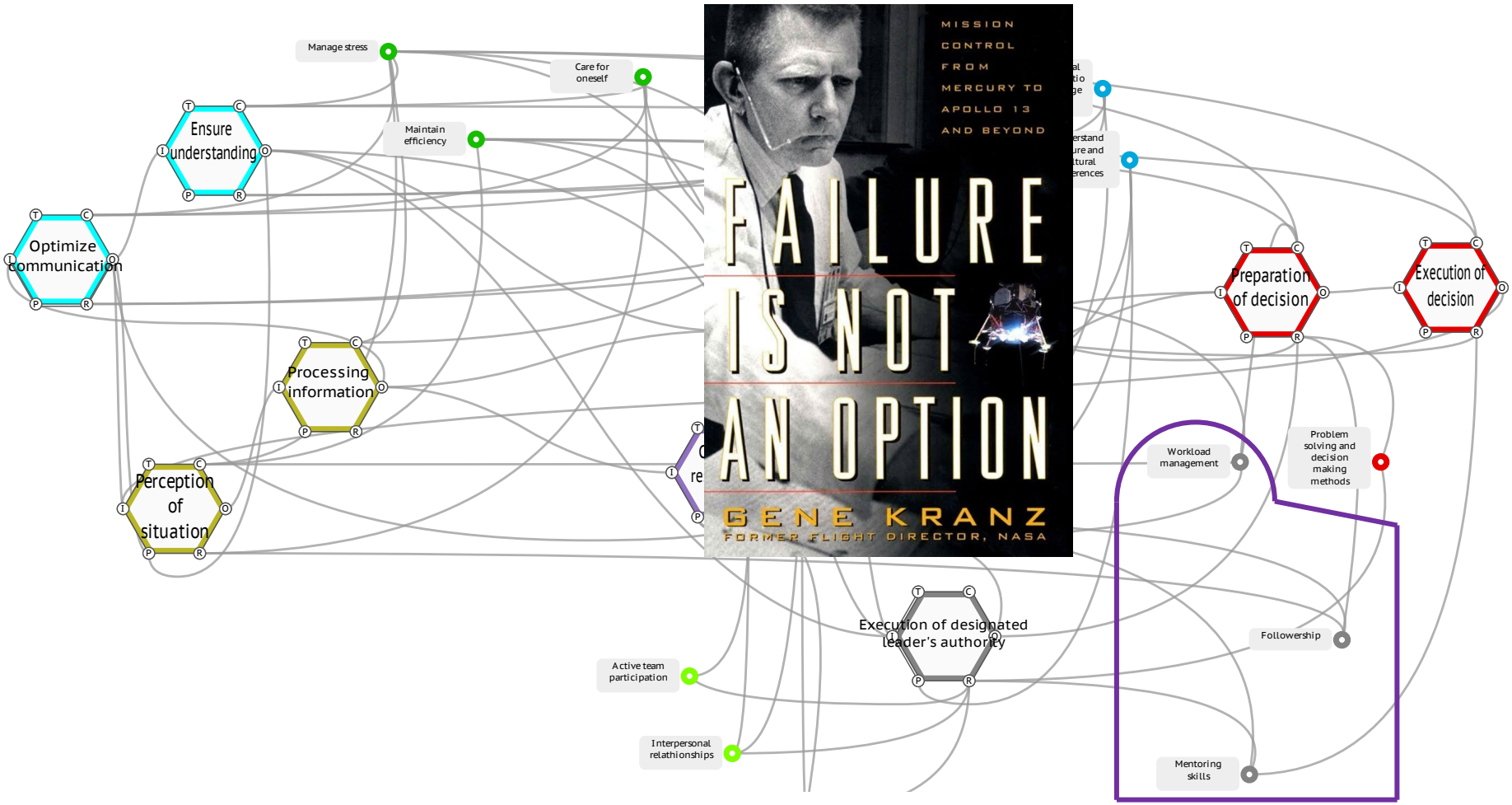
Key background functions



*Important for **community life** and **cooperative operations** in small spaceship*
(Harmony)

Teamwork and group living

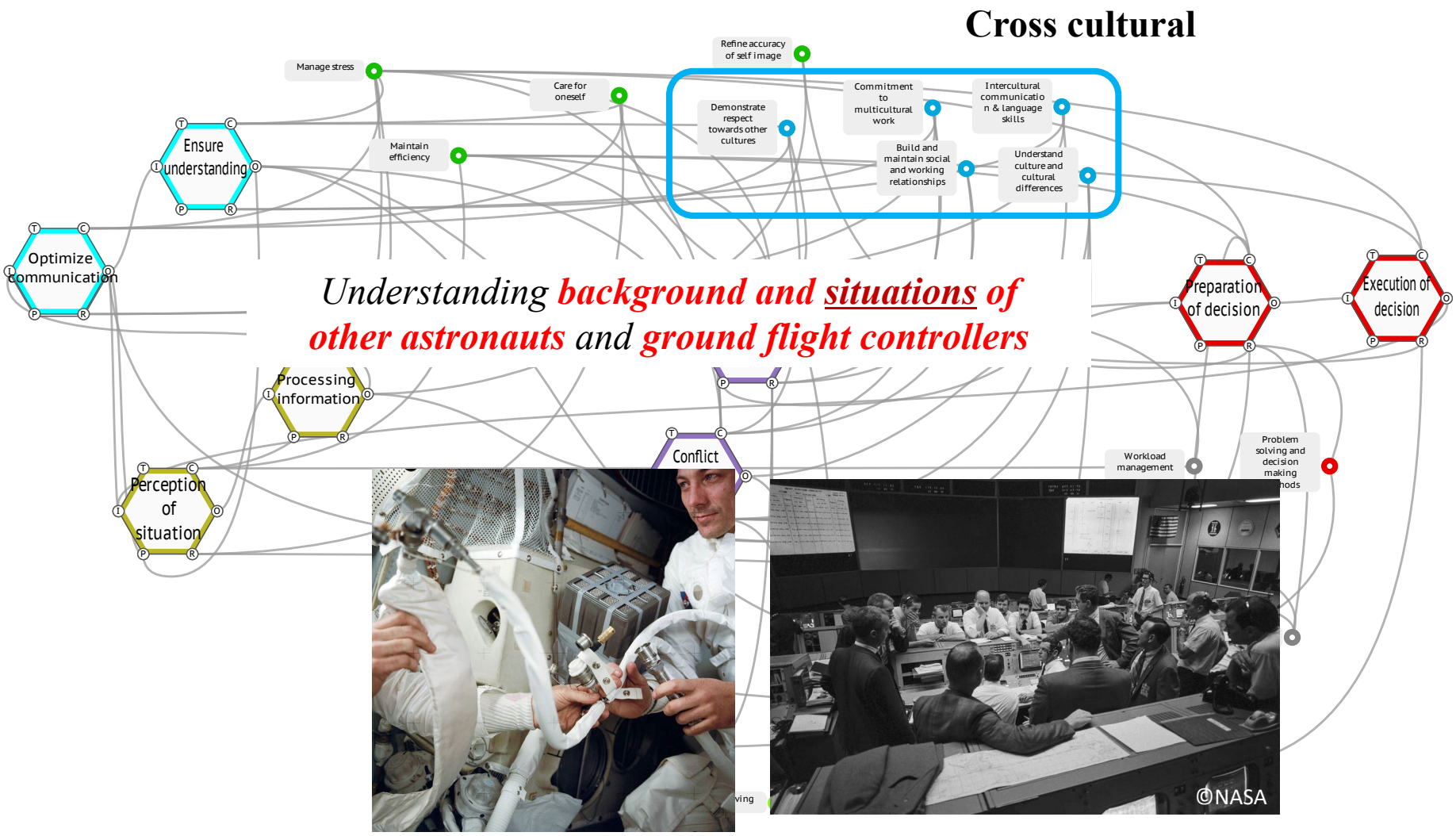
Key background functions



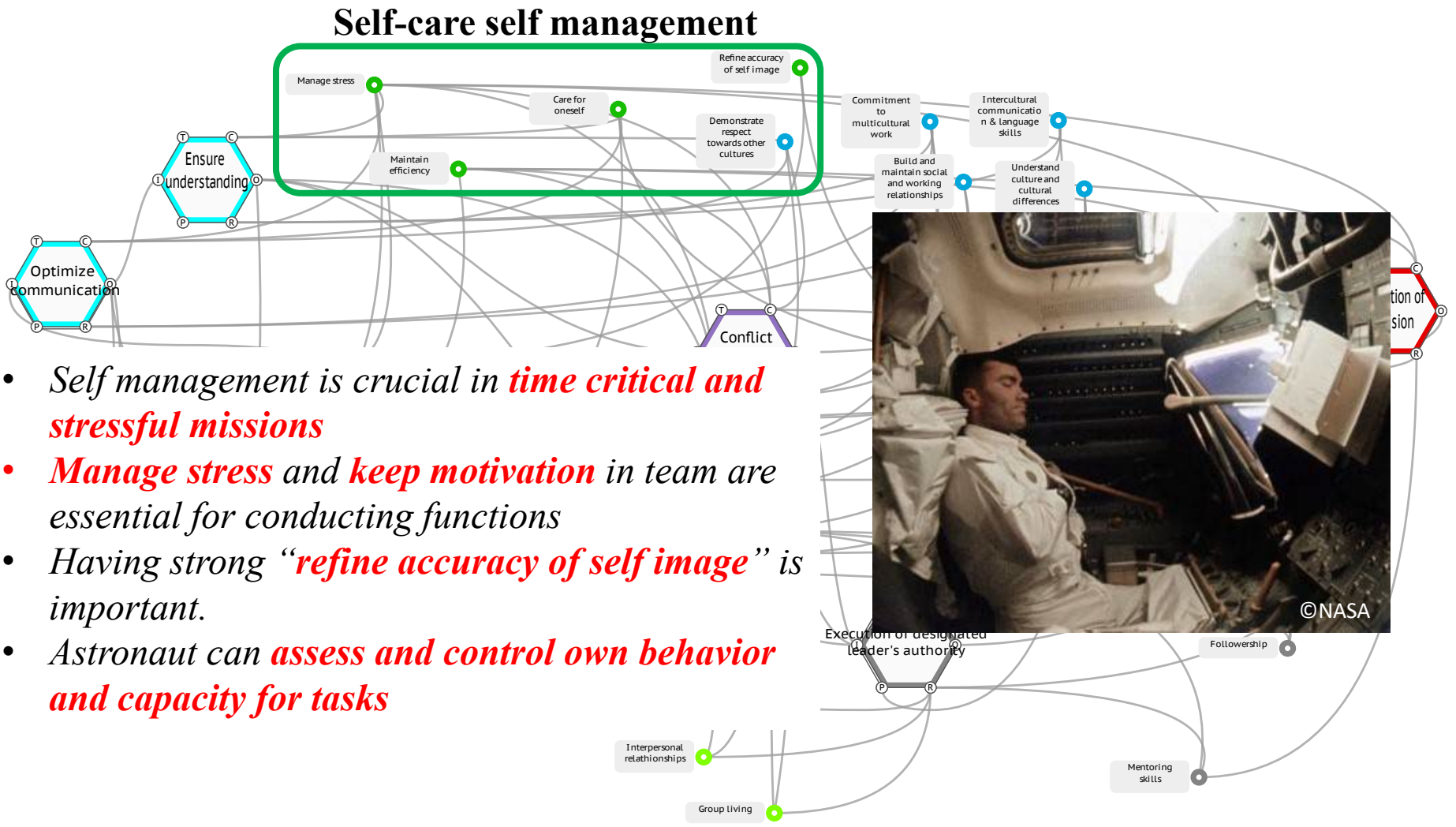
*Important for **team management** to get a consensus with **workload management***

Leadership

Key background functions



Key background functions



- *Self management is crucial in **time critical and stressful missions***
- ***Manage stress** and **keep motivation** in team are essential for conducting functions*
- *Having strong "**refine accuracy of self image**" is important.*
- *Astronaut can **assess and control own behavior and capacity for tasks***

Observed behaviors in Apollo 13

Situation
1.5 hours after tank explosion.
Ground flight controllers requested AC bus reconfiguration to crews.

Ground

On-board

Crews didn't know why explosion happened and trouble shooting plans. (Very stressful)
Ground reported the status **to reassure**
(great example of **Conflict prevention**)

056:24:42
13, Houston. We need to get some more instrumentation up. We'd like you to put INVERTER 1 on both AC BUSES. Over.

Okay. Okay, you got INVERTER 1 on both AC BUSES now. And Jack, one of the items that we turned off was the - all the fuel cell pumps. Okay, and you might let us know when fuel cell 2 needs its pump back; we ought to take care of that guy.

056:25:37
Roger. Okay, Fred, we want FUEL CELL 2 PUMPS to ACl, please.

056:25:55
FUEL CELL 2 to ACl. Roger.

056:28:06
Okay, 13. **We've got lots and lots of people working on this; we'll give you some dope as soon as we have it, and you'll be the first one to know.**

056:28:19
Oh, thank you.

Observed behaviors in Apollo 13

Ground

On-board

056:28:47
Roger. We'll give you an answer.

056:28:29
Okay, Jack, and the weird configuration we're sitting in now is we have the hatch installed, **we still have the probe and drogue inside the command module, and we're going to stay in this situation until you - kind of give us an okay to reinstall the probe and drogue.**

056:28:48
Or, if necessary, to use the LM consumables.

056:28:52
Roger.

Crew proposed **an operations of probe and drogue positively.**

This led to **successful return with the fuel of lunar module.**

Observed behaviors in Apollo 11

Situation
Final phase of landing (500 feet)

Ground

On-board

Armstrong changed from auto piloting to ***manual piloting because of rocky areas without reporting***

Control:
Attitude hold.

Flight:
Ok, ATT hold

CAPCOM:
I think **we better be quiet** by now.

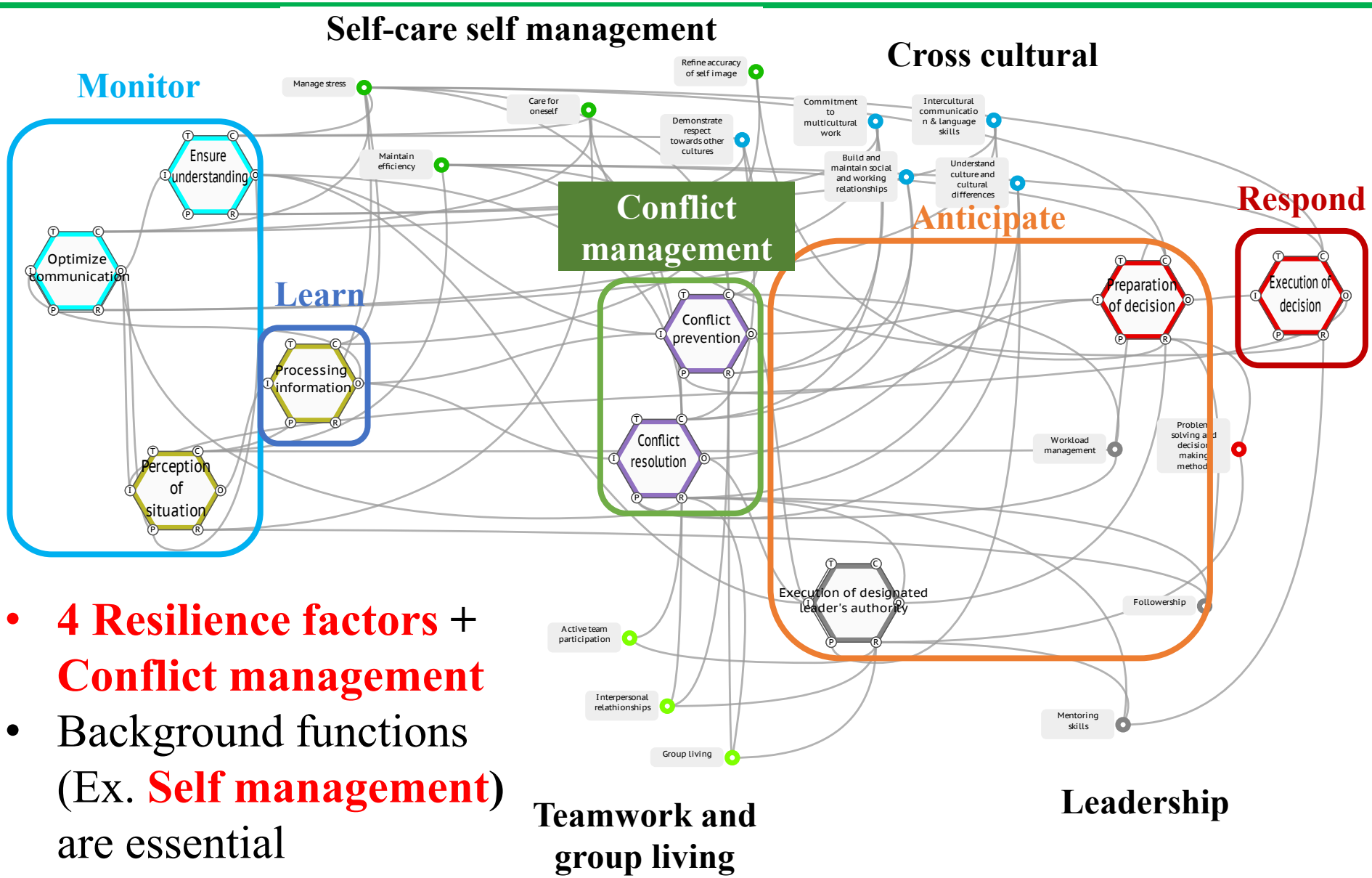
Flight:
Rog. Ok, **the only call-outs from now on will be fuel.**

Aldrin (EAGLE):
540 feet, down at - 30 and at 15.

In time-critical phase, ground flight controllers trusted on-board decision.
(great example of Conflict prevention)

Aldrin (EAGLE):
At 400 feet, down at 9.

Success factors of space missions



- **4 Resilience factors** + **Conflict management**
- Background functions (Ex. **Self management**) are essential