Accelerating the Use of Autonomy on Robotic Space Missions - Agenda

- **Monday July 26, 2021**, 1pm-3pm Pacific time, ZOOM ROOM 3
  - Brief introduction to workshop and its concepts, then three presentations:
    - Hiro Ono – "Summary of Interviews with Mars Rover Flight Software Personnel"
    - Ken Center (Orbitlogic.com) – "Orbit Logic's Autonomous Planning System (APS)"
    - Bret Drake Cislunar / Astronauts & Autonomy
  - On-the-fly and/or after we will to start to glean examples of **impediments** and **solutions** (using Zoom chat & discussions)
- **Before 9am Wednesday**: participants encouraged to email Martin.S.Feather@jpl.nasa.gov with their "impediments" and the use case(s) to which they apply – indicate whether you wish to remain anonymous in providing these!
- **Thursday July 29, 2021**, 1pm-3pm Pacific Time, ZOOM ROOM 3
  - Go through impediments to and group them, and to ascertain whether they are common vs rare
  - Begin consideration of "solutions" – show examples of some of these
- **Before 9am Friday**: participants encouraged to email Martin.S.Feather@jpl.nasa.gov with their "solutions" and the use case(s) to which they apply – indicate whether you wish to remain anonymous in providing these!
- **Friday July 30, 2021**, 1pm-3pm Pacific time, ZOOM ROOM 3
  - Go through solutions to consolidate and group them, and to ascertain their status:
    - Mature and applied successfully (in which case, from where can we all find out more about them?)
    - Promising approaches – modest application, research quality, etc.
    - Ideas in need of development
  - Identify the GAPS - (impediments with no or inadequate solutions)
- **Friday July 30, 2021**, 3pm-4:30pm Pacific time (probably ZOOM ROOM 1)
  - MINI-WORKSHOP REPORT OUT (15 min per Workshop; we will be one of the later ones to give us time to prepare a summary!)

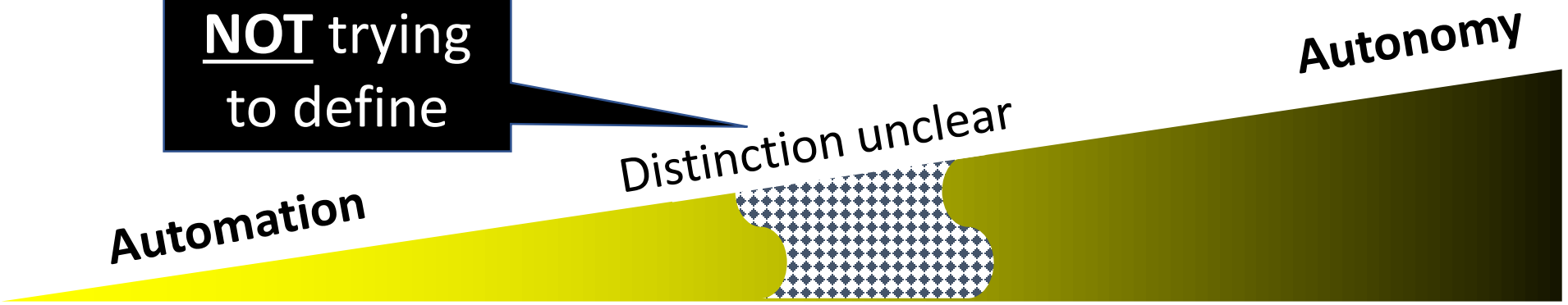
Link to enter the conference platform: https://events.rdmobile.com/Sessions/Index/14228 – use the email you registered with SMC-IT: https://smcit.ecs.baylor.edu/ This mini-workshop: https://accelerating-autonomy-workshop.github.io/
Slack channel (provided by the conference) for continuing (e.g., after sessions) this mini-workshop conversations: https://ieeesmc-itconference.slack.com/archives/C0281BCT50V

What is Autonomy?

Ability and authority to act without continuous external control in a specific environment

FOCUS – why is more autonomy not being adopted in space as fast as we think it should be?

NOT trying to define



Automation … is the automatically-controlled operation of an apparatus, process, or system using **a pre-planned set of instructions** (e.g., a command sequence).[1]

Autonomy is the capacity of a system to **achieve goals** while operating independently from external control.[1]

"Impediments"

"Solutions"

[1] NASA Technology Roadmaps – Introduction, Crosscutting Technologies, and Index https://www.nasa.gov/sites/default/files/atoms/files/2015_nasa_technology_roadmaps_ta_0_introduction_crosscutting_index_final_0.pdf [2015 roadmaps superseded, but had these nice definitions]

Example “Use Cases” for Autonomy

- Scientific data
  - Downselecting which to send back to Earth
  - Controlling data *gathering*
- Fault protection
  - “Fail operational”
  - Self-repair/adapt
- In-space assembly/manipulation
  - Giant telescope
  - Facility maintenance
- Navigation
  - Trajectory corrections
  - Critical guidance (e.g., Landing; Impacting)
- Terrain interaction
  - Driving, floating, flying
  - Sampling (e.g., drilling, scooping)

For any use case there can be a wide variety of:

- Criticality: how much is it needed?
  - Just “extra” science.
  - Essential for success
- Consequence – how badly could it fail?
  - No impact on assets
  - Catastrophic! (e.g., drive off cliff)
- Control: how soon and how often can/do humans intervene?
  - Astronauts close by
  - Ground control (minutes to hours light delay)
  - Intermittent access

Impediments – categories and examples

- Verification and Validation challenges
  - Assessing risk
  - Veracity of perception
- Engineering gaps – lack of knowledge
  - Cost and schedule estimation
- Concerns
  - Operations teams may not know why autonomy behaved the way it did
- Infusion barriers
  - Reviewers unfamiliarity leads them to rate autonomy as too risky
- Institutional concerns
  - Autonomy never the first priority for research and development funding

Solutions – categories and examples

- Verification and Validation challenges
  - Apply formal methods to check correctness of decision algorithms
- Engineering gaps – lack of knowledge
  - Gather development effort data from many sources (cf. COCOMO)
- Concerns
  - Have autonomy report back its decision rationale
- Infusion barriers
  - Educate reviewer community with autonomy success, avoiding hype
- Institutional concerns
  - Earmark funding for autonomy maturation

Aspects of Autonomy

Sense, Decide, Act – cf. the OODA loop (Observe, Orient, Decide, Act)

- Sense:
  - Will the autonomy correctly interpret the information from its sensors?
  - What if those sensors are imperfect?
  - What if those sensors do not include all the relevant information?
- Decide:
  - Will the autonomy make the “correct” decision based on the information at hand?
  - Will the autonomy take too long to make its decision?
  - Did you have the right problem formulation? (e.g., reward function)
- Act:
  - Will the autonomy’s control be capable of achieving the objective?
- Loop: Will errors accumulate?
  - Sense errors – growing inaccuracies
  - Decision errors – one bad decision leads to another
  - Action errors – cumulative mistakes