Friedrich-Alexander-Universität
Medizinische Fakultät

Texting Through the Silence

Medical Care over Matrix with Delay during a Simulated Moonwalk

Jan-Lukas Furmanek, M.Sc.[1,2]
[1] Chair of Medical Informatics, Friedrich-Alexander-University Erlangen-Nürnberg
[2] Medical Center for Information and Communication Technology, University Hospital Erlangen

Aileen Rabsahl, M.A.[3,4]
[3] Space Operations and Astronaut Training, COL-CC Integrated Team, European Space Agency
[4] German Aerospace Center

When real-time fails: texting a medical emergency

Why we ran care over Matrix with one-way delay

No voice communication & a severe network delay:

How do you still manage a medical emergency?

The constraints:

- Voice intentionally **off + 20sec delay**
- **Medical Emergency**: Ventricular tachycardia
- Team not clinically trained
- **Instant messaging only** [Matrix/Element]

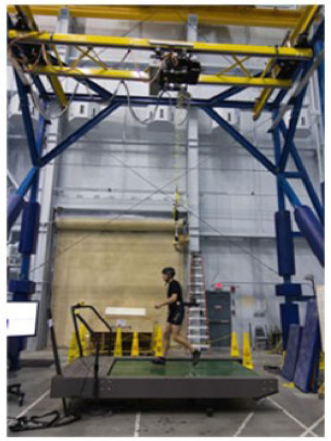
Where can we safely stage and repeat this?

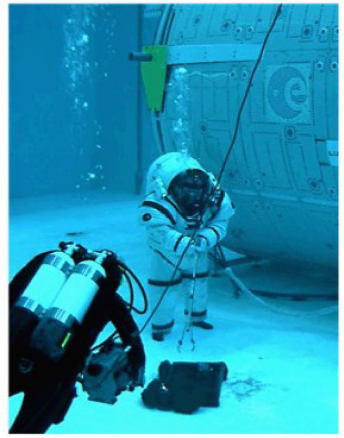
On a simulated moonwalk:
the **LUNA Analog Facility**

WHY LUNA?

Closing gaps (field vs lab)

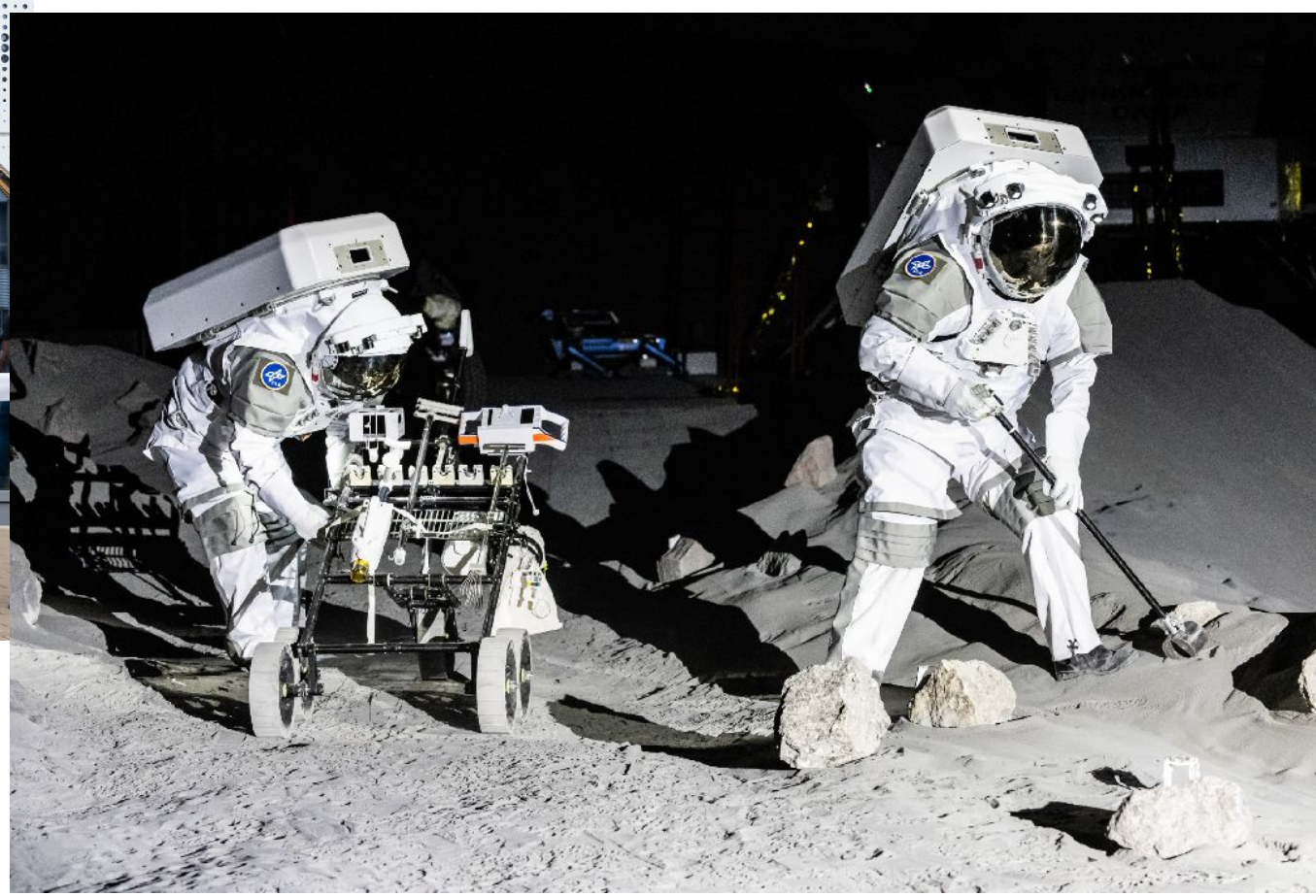
LUNA is a unique worldwide facility that addresses the testing and simulation needs of the forthcoming lunar exploration missions





The LUNA Alanog Facility

Moon on Earth



PROJECT PLAN

LUNA Analog Facility

2017-2021

LUNA design

NRW funding

Technical outfitting and first 5 years of operations

Q2/2022

Supported by:

Ministerium für Wirtschaft, Industrie, Klimaschutz und Energie des Landes Nordrhein-Westfalen

Q3/2022

Outfitting project start

ESA and DLR jointly committed to erect and operate LUNA

Building start

Building erection and basic outfitting until Q3/2024

Q3/2023

25/9/2024

Inauguration event

LUNA is officially open and ready to host partners!

LUNA and the DLR Cologne-Porz campus

LUNA analog facility

MUSC

DLR

Material Physics

DLR

Competence Centre Aerospace Medicine

BUNDESWEHR

DLR

Institute for Aerospace Medicine

DLR

:envihab

DLR

Solar furnace

DLR

LUNA

esa

DLR

European Astronaut Centre

cnes

asi

DLR

esa

LUNA – Current status

Ground segment
video, voice and data to the European HSF ground network

Visitors‘ room
for outreach & education

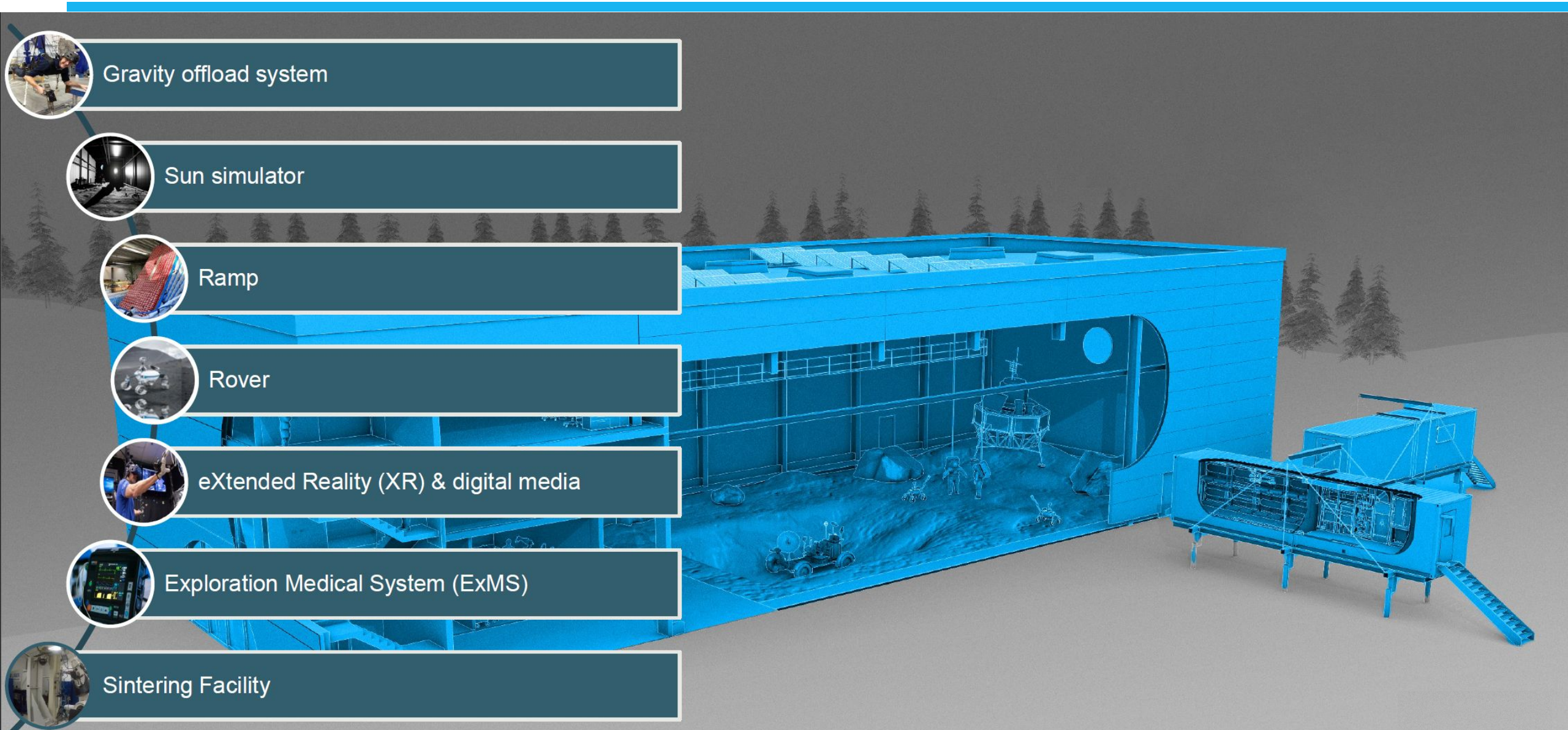
EVA suits
2 customized Atlas EXCON suit simulators

Moonbase elements
FLEXHab & EDEN-LUNA for simulations and IVA research

Regolith testbed
simulant EAC-1A, 700 m²;
depth 60 cm to 3m;
subsurface targets; rock samples;
infrastructure mockups; rovers

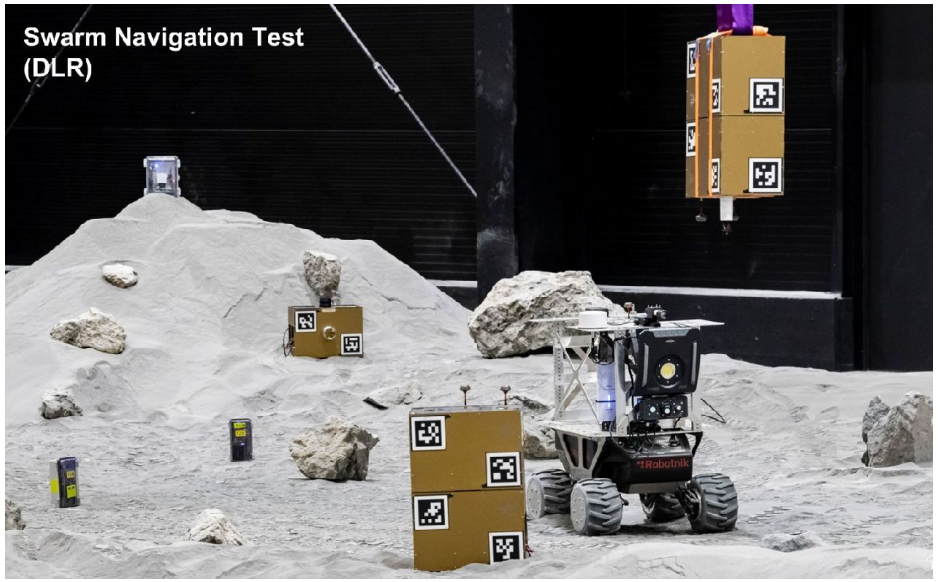
Hall elements still under development…

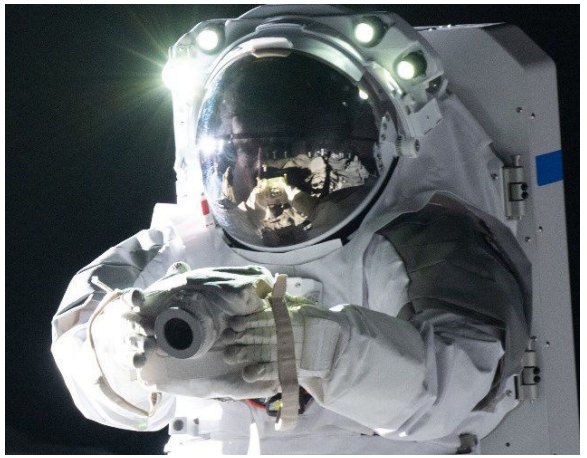
LUNA Analog Facility

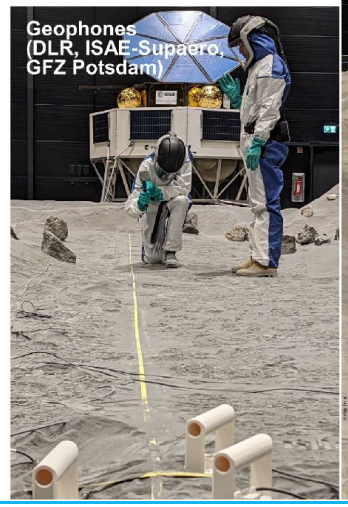


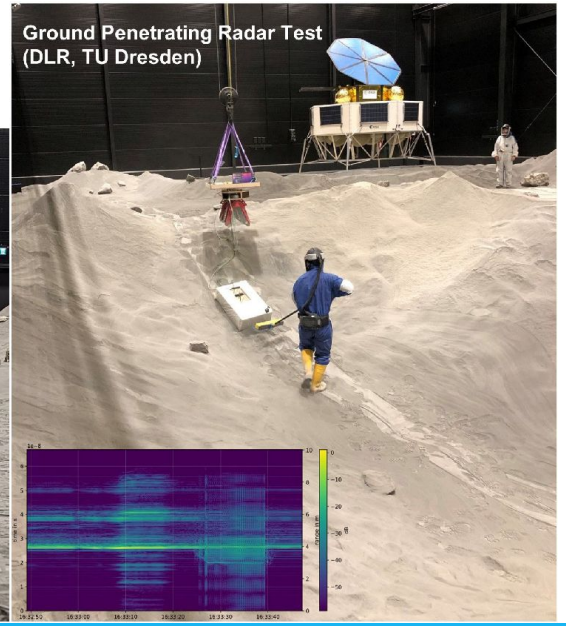
LUNA Utilization campaigns

LUNA Analog Facility







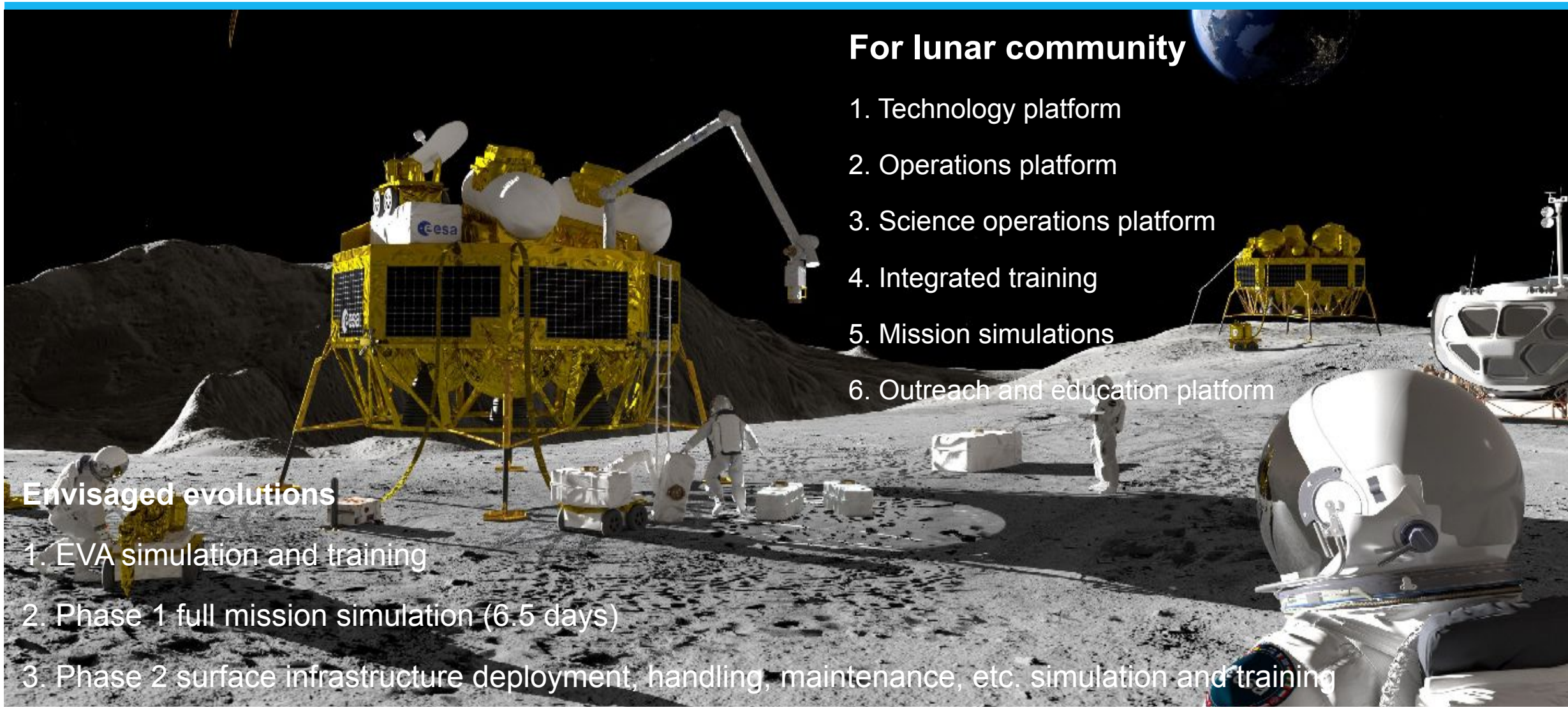


LUNA - EVA

LUNA Analog Facility

LUNA Utilization Plans

LUNA Analog Facility



For lunar community

1. Technology platform
2. Operations platform
3. Science operations platform
4. Integrated training
5. Mission simulations
6. Outreach and education platform

Envisaged evolutions

1. EVA simulation and training
2. Phase 1 full mission simulation (6.5 days)
3. Phase 2 surface infrastructure deployment, handling, maintenance, etc. simulation and training

LUNA Conclusions

LUNA Analog Facility

Method Overview

Voice OFF • 20s OWD • Matrix/Element only • Three phases

What we ran

Voice OFF, **instant messaging only:** Element

Three phases:

1. **Nominal**
2. **Emergency**
3. **Evacuation**

Roles:

- **EV1/EV2/EV3** (Field)
- **Medical Officer** &
- **LUNCOM** (ground)

How we ran it

Delay:
planned **20-second one-way** via DTN;
executed fallback: manual gating (≈40-s)

Four runs, Two days, new Matrix room per run, full logs

Two messaging modes:

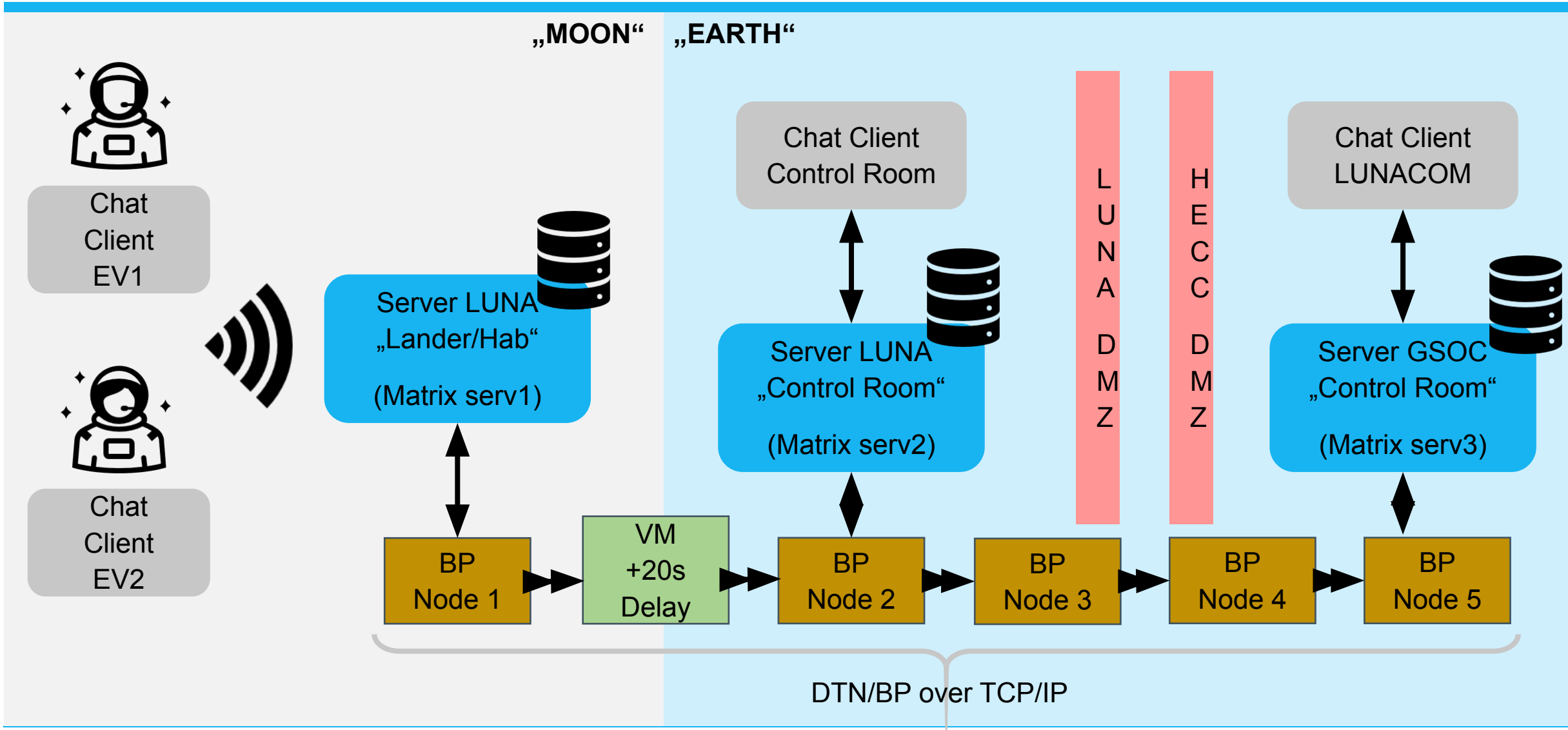
A **Free-text**
B **Structured text**

Why we ran it

1. See if **structure reduces ping-pong & ambiguity** under delay
2. Keep **decisions moving** with clear, small steps
3. Generate **practical patterns** for Matrix/ Element in outages

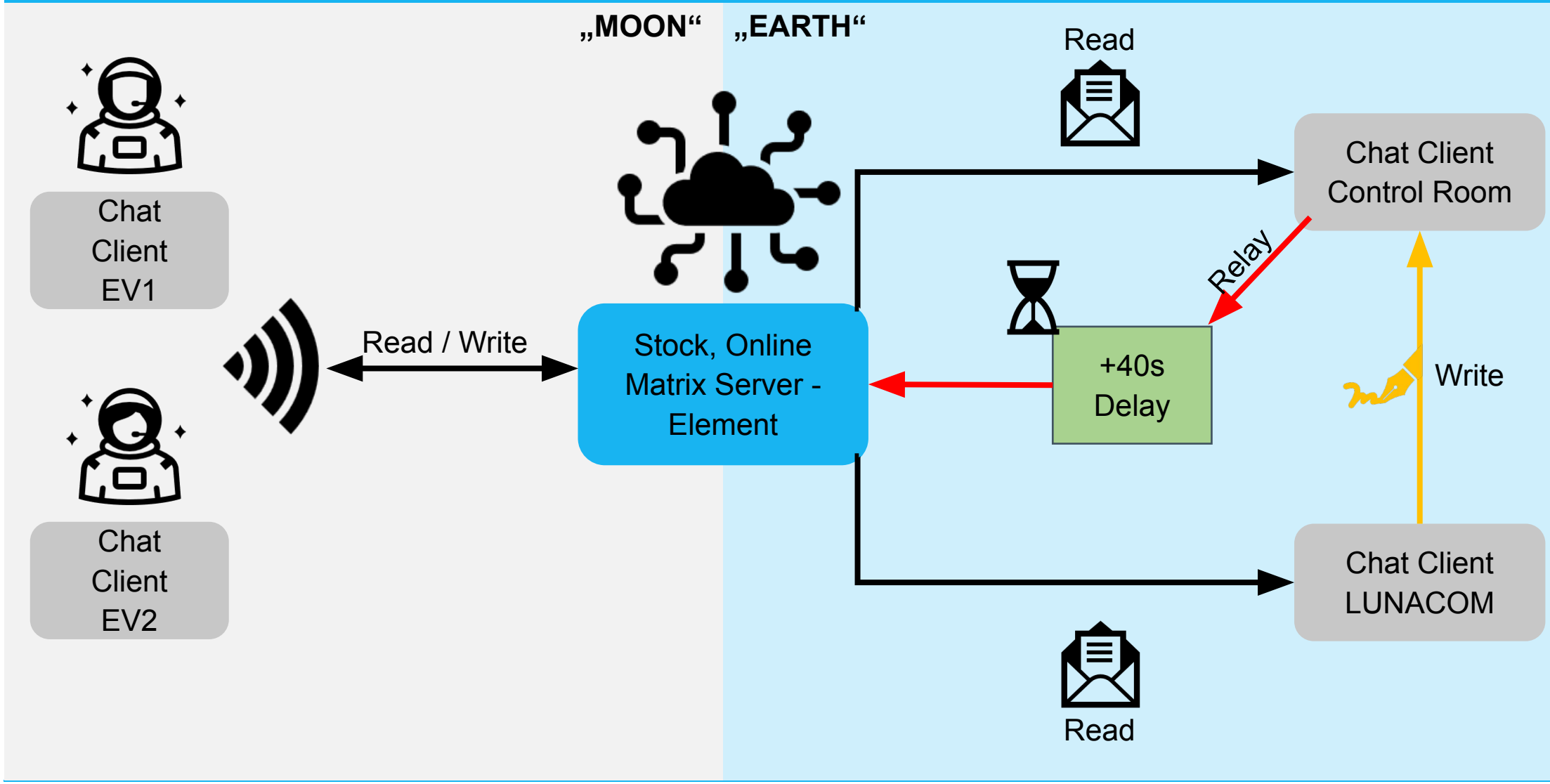
Architecture — Intended

Delay via DTN/Bundle v7 across federated homeservers



Architecture — Shipped

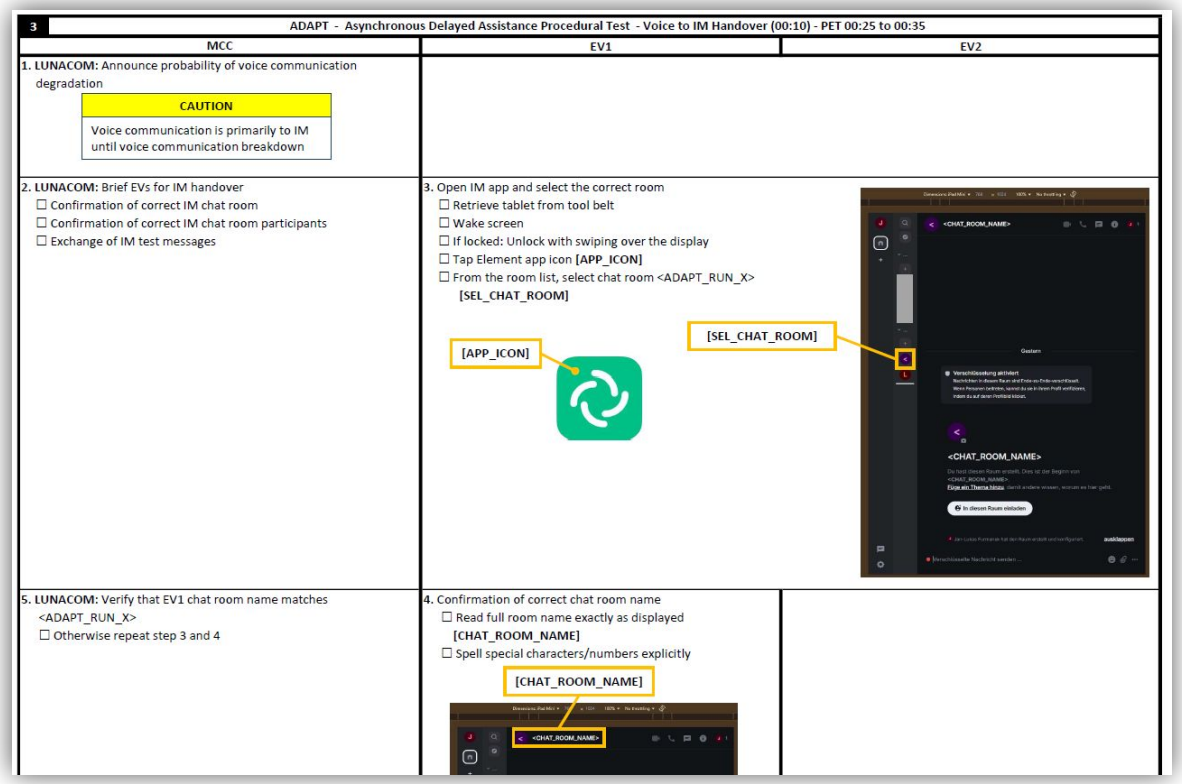
Manual 40s gate, stock clients, normal federation



From procedures to message-sized actions

Nominal vs. malfunction—brought into chat

Nominal procedure

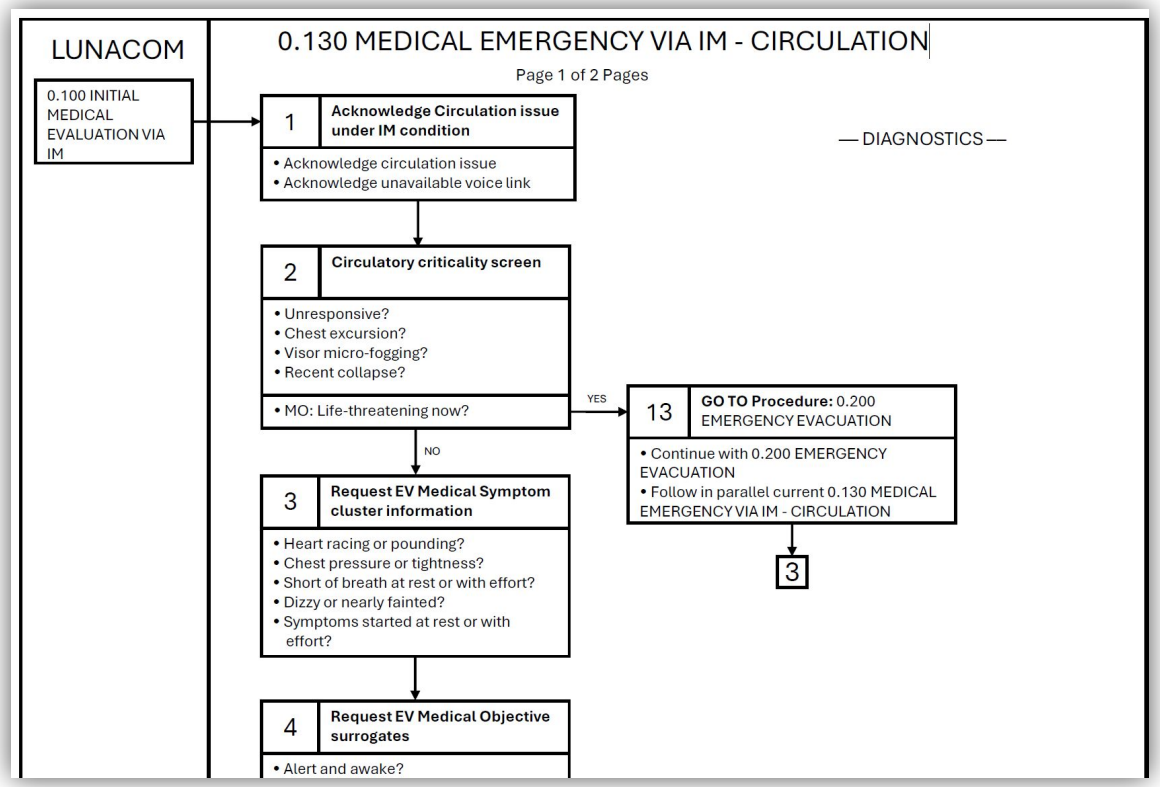


3 ADAPT - Asynchronous Delayed Assistance Procedural Test - Voice to IM Handover (00:10) - PET 00:25 to 00:35

MCC	EV1	EV2
1. LUNACOM: Announce probability of voice communication degradation **CAUTION** Voice communication is primarily to IM until voice communication breakdown		
2. LUNACOM: Brief EVs for IM handover ☐ Confirmation of correct IM chat room ☐ Confirmation of correct IM chat room participants ☐ Exchange of IM test messages	3. Open IM app and select the correct room ☐ Retrieve tablet from tool belt ☐ Wake screen ☐ If locked: Unlock with swiping over the display ☐ Tap Element app icon **[APP_ICON]** ☐ From the room list, select chat room <ADAPT_RUN_X> **[SEL_CHAT_ROOM]** [APP_ICON] [SEL_CHAT_ROOM] <CHAT_ROOM_NAME>	
5. LUNACOM: Verify that EV1 chat room name matches <ADAPT_RUN_X> ☐ Otherwise repeat step 3 and 4	4. Confirmation of correct chat room name ☐ Read full room name exactly as displayed **[CHAT_ROOM_NAME]** ☐ Spell special characters/numbers explicitly [CHAT_ROOM_NAME] <CHAT_ROOM_NAME>	

- Standard mission steps
- Predefined sequence → **one action per message**
- **Voice → IM handoff** covered when comms drop

Malfunction procedure



- Emergency/deviation path
- Decision nodes → **clear, short requests**
- **IM → voice handback** when voice returns

Two ways to talk medicine over chat

Mode A: Free-text vs. Mode B: Structured grammar

Mode A (Free-text)

- Write anything, natural phrasing
- Fast to start, flexible
- Under delay: more back-and-forth

Example:
“we’re behind the boulder … what next?”

Mode B (Structured)

Example:

“**ACTION** TO: *ev1*

TASK: *elevate chest*

LOC: near boulder

NEED: *confirm breathing pattern*

EOM”

Callouts & Tags

TYPE + TO = intent & recipient (e.g., ACTION TO: ev1)

FIELDS (critical first) = TASK / LOC / NEED …
EOM = end-of-message marker

ACK with WILCO/ETA = single read-back under latency

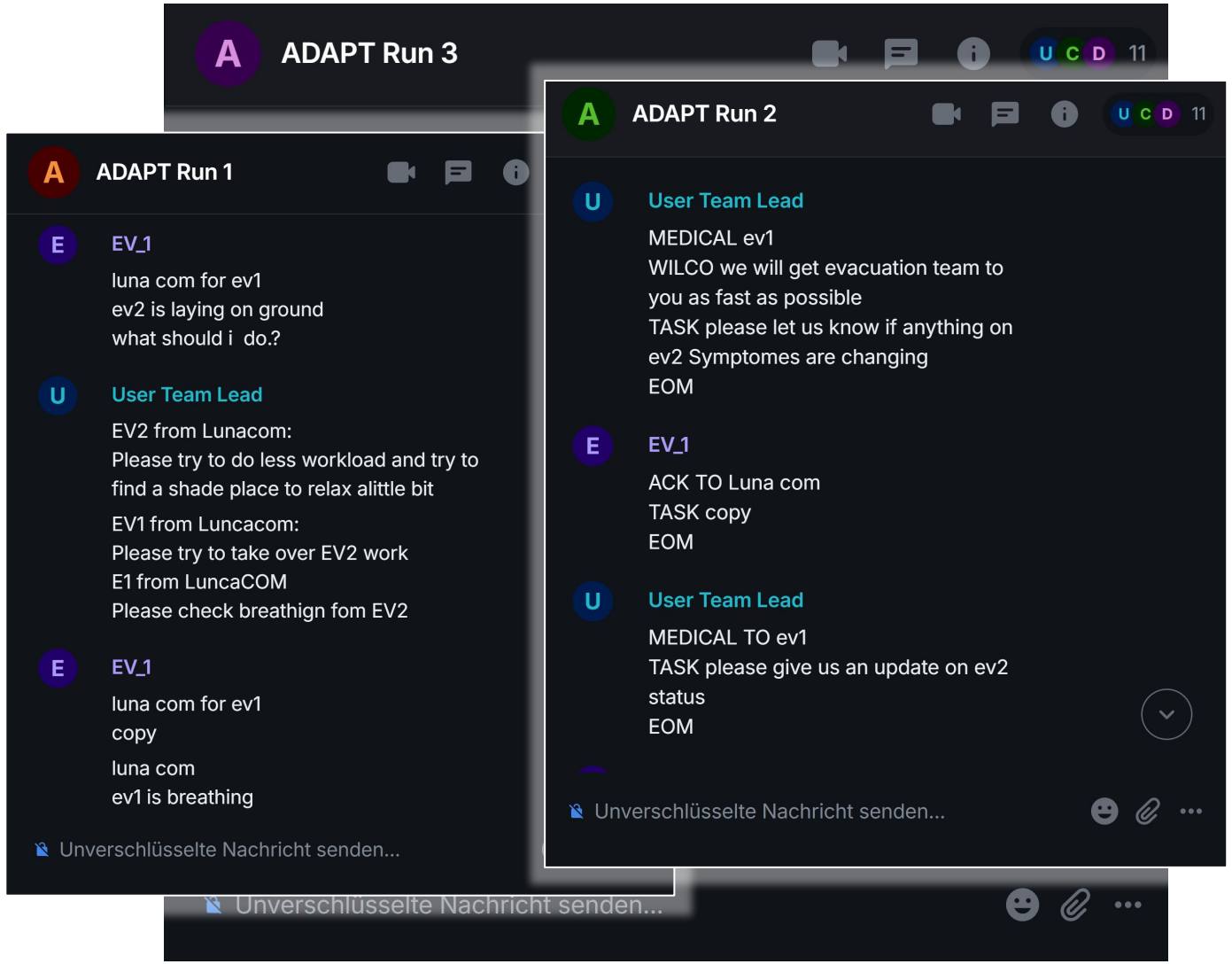
Tiny conventions that did the heavy lifting

EOM, roles, micro-acks, bounded size, priority cues

Ground typed as **LUNACOM**; after the one-way delay, messages were **forwarded by the User Team Lead** account to the EVA room.

Headers kept identities unambiguous during forwarding
(e.g., **ACTION TO: ev1**, **ACK TO: lunacom**).

We marked **handover moments** (back to voice) explicitly when coverage returned.



Early signals from the runs

What helped — and what participants wanted

FAU

What worked

Structured messages were easier to parse under one-way delay *(TYPE/TO + a few fields + EOM).*

Single, short exchanges *(request → one ACK/UPDATE)* kept decisions moving.

Clear headers supported forwarding *(e.g., ACTION TO: ev1; ACK TO: lunacom).*

What slowed the loop

Typing burden, especially with gloves/on-screen keyboards; strong desire for **softkeys/text blocks** and larger touch targets.

Serial procedures under latency: medical work wants parallel steps, but our chat/procedures enforced a **strict queue**.

Free-text reformulations added extra hops when context wasn't explicit.

What we'd try next

Concrete experiments to push Matrix/Element for clinical resilience

FAU

Technical (Matrix & transport)

- **Edge homeserver per astronaut**; sync via **opportunistic federation**
- **DTN PoC (BPv7)**: bridge bundles ⇄ Matrix rooms (lab)
- **Local-only rooms**, **eventual sync** when links return
- **Prioritised events** (safety/medical > info) under constrained links
- **Offline/local clients**: robust cache & retry windows

Operational (workflow & UI)

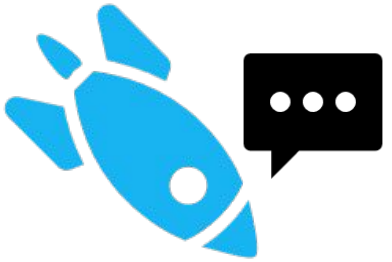
- **Templates & softkeys** + **EVA-friendly keyboard** (eg.predictive snippets) to cut keystrokes.
- **Role/priority/location tagging** with simple filters + **one-tap ACK/WILCO/ETA/DONE** to close loops fast.
- **Voice↔IM malfunction procedure**: clear trigger to switch when voice drops; scripted recovery cues when voice returns.

From moonwalk to hospital outages

Resilient, message-driven workflows with Matrix/Element

We used an extreme case to extract patterns that **transfer to Earth outages**.

In line with (Matrix-based) **TI-Messenger,** but **broadened** for **outage & emergency operations**.



What transfers: **structured steps**, **one closed-loop ACK per action**, **clear roles/priorities**, **templates**, and **local/edge homeservers**.

Why it matters for Matrix: these patterns **improve reliability under degraded links** and clarify ops in clinical settings.

IM-CURE: when networks fails, care must not

Structured, asynchronous messaging for crises and outages

IM-CURE: Instant Messaging for Crisis & Urgent Response in Emergencies

A PhD project to examines resilient clinical communication via IM during IT outages and disasters.

Focus: continuity of clinical care during IT outages, disasters, and other special situations.
Goal: keep treatment safely moving via resilient instant messaging when “real-time” systems are unavailable.
Outcome: patients stay cared for, even when infrastructure doesn’t work.

Friedrich-Alexander-Universität
Medizinische Fakultät

Kontakt

Jan-Lukas Furmanek, M. Sc.

Wissenschaftlicher Mitarbeiter
Institut für Medizininformatik,
Biometrie und Epidemiologie
Lehrstuhl für Medizinische Informatik

Wetterkreuz 15
91058 Erlangen-Tennenlohe
Bayern

Telefon: +49 9131 85-67780
Faxnummer: +49 9131 85-26754
E-Mail: jan-lukas.furmanek@fau.de

SCAN ME

Thank you and see you soon at the ESA-DLR LUNA facility in Cologne!

#MoonOnEarth

Do you want to know the latest LUNA updates?

Visit the official website:

https://luna-analog-facility.de/en/

or simply scan the QR code

…and don't forget to register to the Newsletter!