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Optimizing animal movement studies by evaluating study design

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CBG Max Planck Institute of Molecular Cell Biology and Genetics
UFZ HELMHOLTZ Centre for Environmental Research
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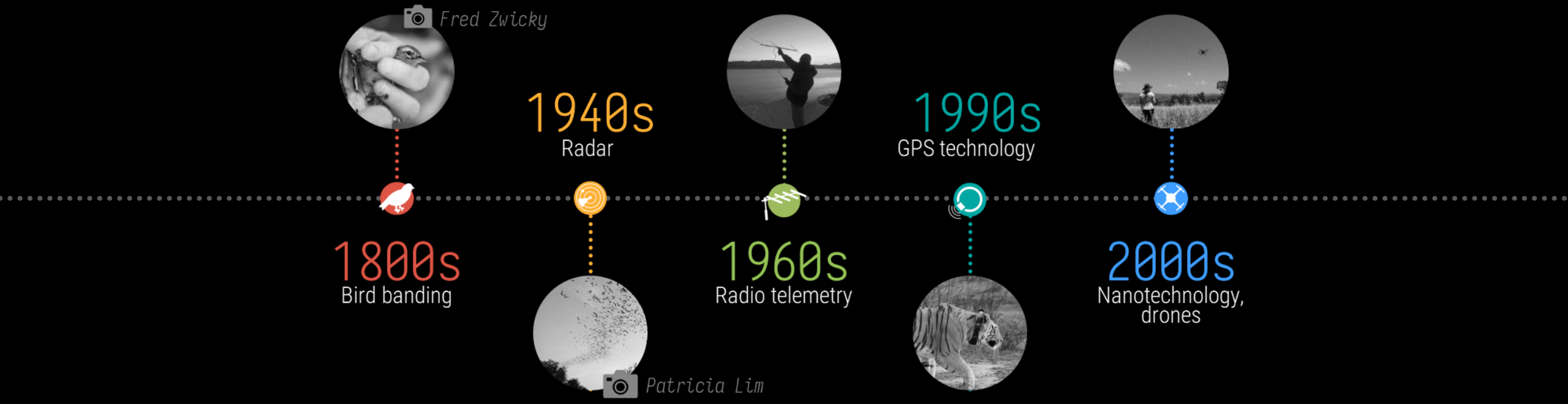
Scientists have been systematically tracking animal movement since the 1800s, employing ever-evolving technologies:



However, challenges regarding data collection and analyses have also increased in quantity and complexity.

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Fine-scale processes:

SPEED/DISTANCE — capture how far animals travel (and rate at which these distances are covered).

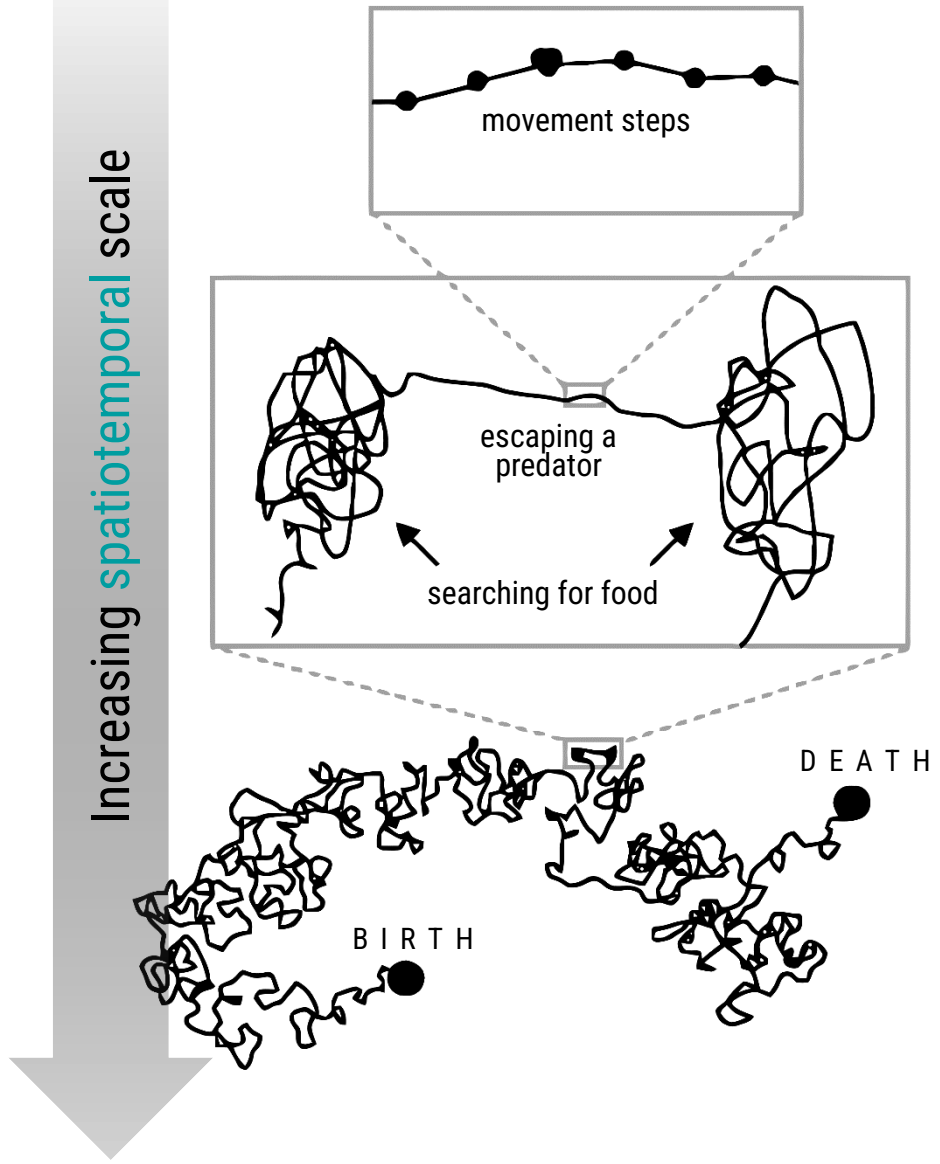
– To link behavior and energetics,
– As indicators of anthropogenic disturbance.

Large-scale processes:

HOME RANGE — capture the area repeatedly used throughout an animal's **lifetime**.

– For protected area delineation,
– To reduce human-wildlife conflict,
– To control the spread of infectious diseases.

Nathan *et al.* (2008)



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Researchers design their projects without knowing how much data will be sufficient for potential research targets.


Choose sampling design


Define research questions


Collect animal tracking data

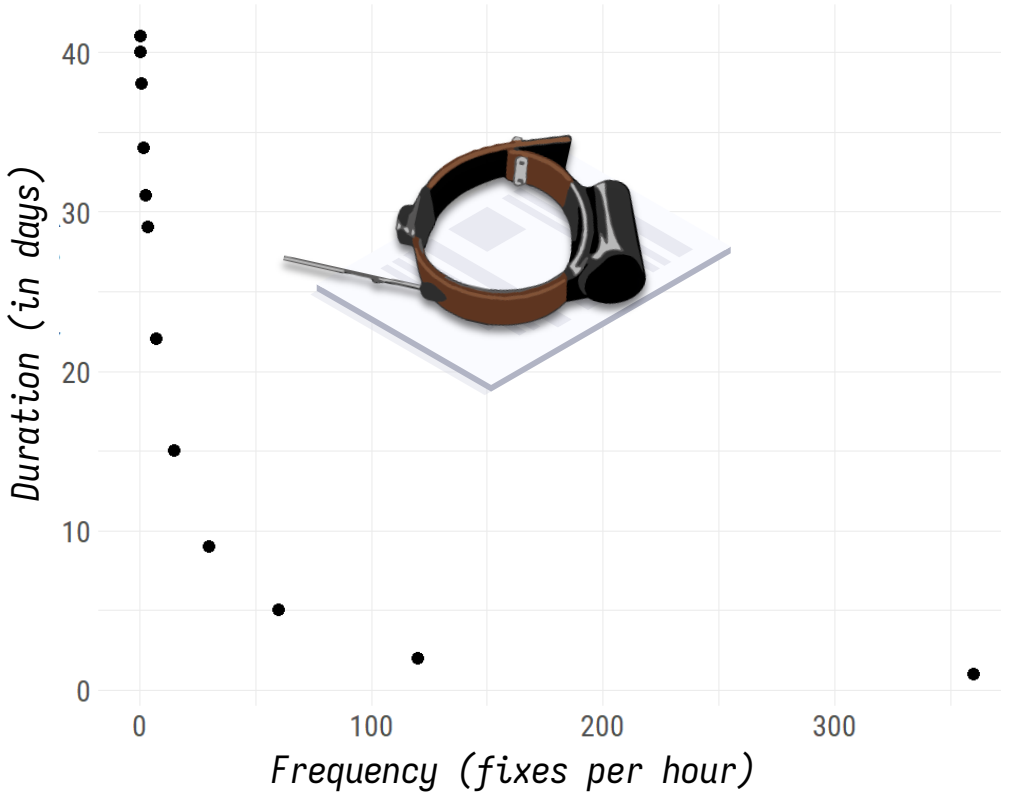
Funding and technological limitations;
Challenges during deployment.

What are your priorities?

I want to know everything!

Trade-off between long battery life and high resolution of GPS devices.

Choosing a higher fix rate leads to lower battery life.



'movedesign'
Silva *et al.* (2023)

Objectives:
Develop a systematic approach, akin to statistical power analysis, to determine optimal sampling parameters in animal tracking projects.

Analytical targets:
We considered three common estimates —home range area, speed and distance traveled.

'ctmm' R package
Calabrese *et al.* (2016)

Like any statistical tool, these methods still require sufficiently large sample sizes to achieve high accuracy.

A successful animal tracking project requires a sampling schedule that leads to sufficiently large (effective) sample sizes.

For autocorrelated data, $N < n$, and often $N \ll n$

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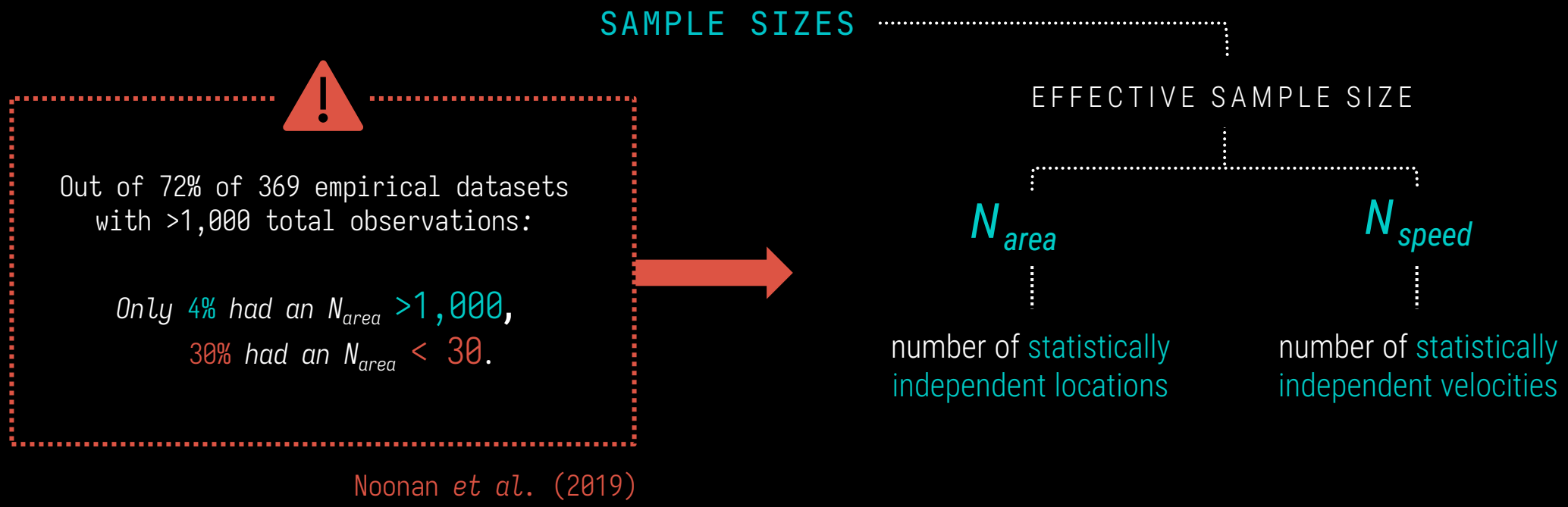

For autocorrelated data, $N < n$, and often $N \ll n$

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- Define research questions
- Identify spatiotemporal scales
- Choose sampling design
- Collect animal tracking data
- Analyze data, mitigate biases
- Assess conclusions

1.

Animal movement paths are realizations of **continuous stochastic processes**,

2.

Summarize behavior using **characteristic timescales**,

τ_p — *Position autocorrelation timescale*

τ_v — *Velocity autocorrelation timescale*

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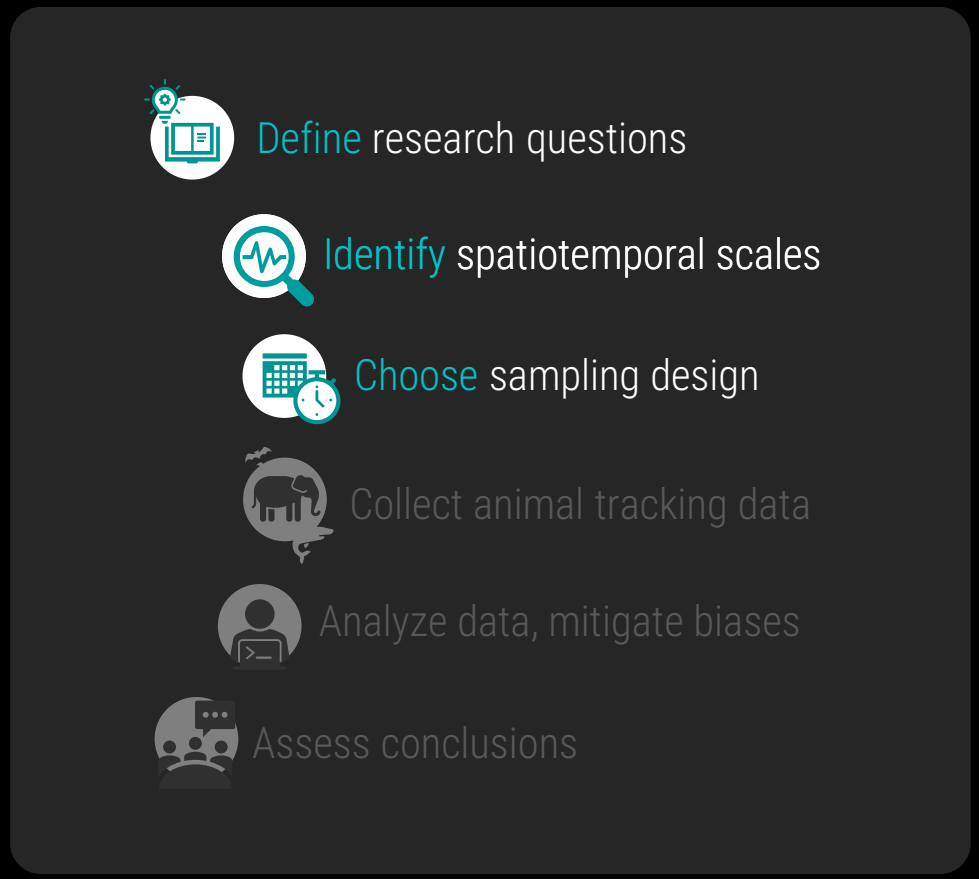

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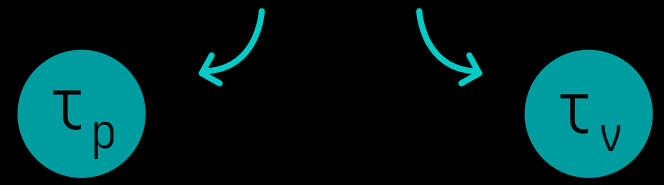
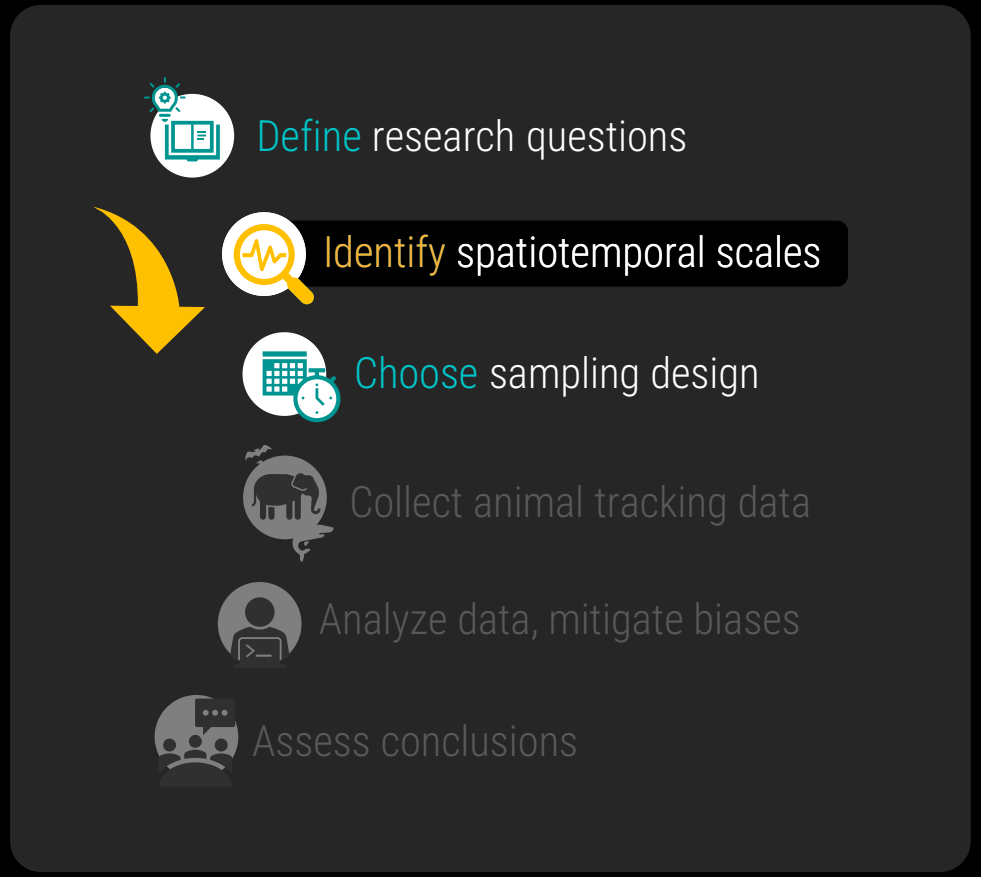


Position autocorrelation timescale

Velocity autocorrelation timescale

3.

These **timescales** impose **constraints on sampling design** that *must* be met for sufficiently **large (*effective*) sample sizes**.



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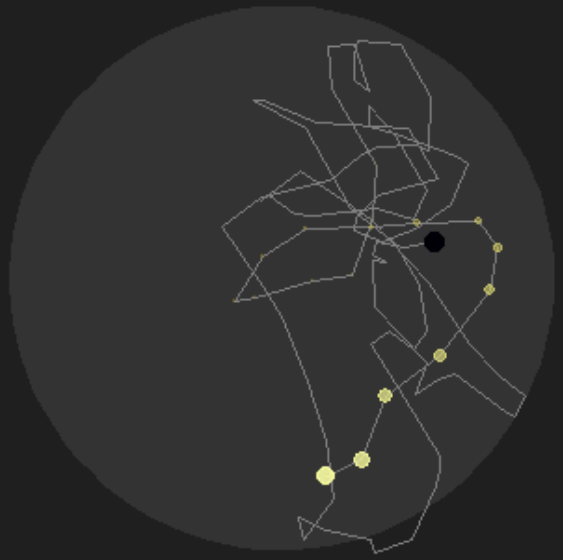
τ_p

Position autocorrelation timescale

τ_p = 1 hour



τ_p = 1 day

τ_p = 5 days

τ_p = 10 days

T

SPACE-USE ◄····· SAMPLING DURATION

☑ HOME RANGE

How long is an animal tracked for?

MOVEMENT BEHAVIOR

☐ SPEED & DISTANCE

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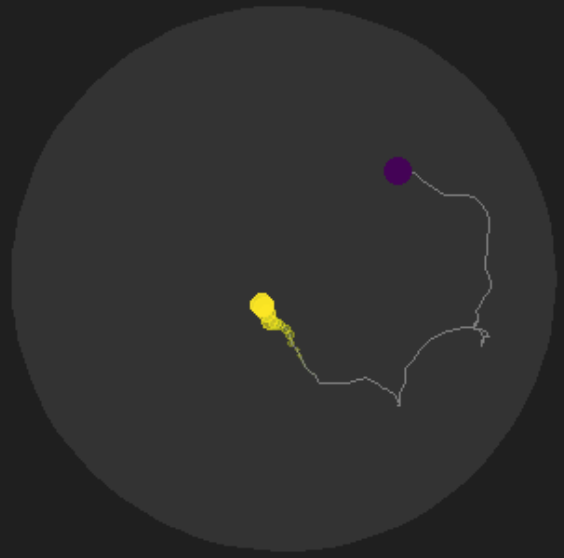
τ_v

Velocity autocorrelation timescale

τ_v = 1 minute

τ_v = 1 hour

τ_v = 12 hours



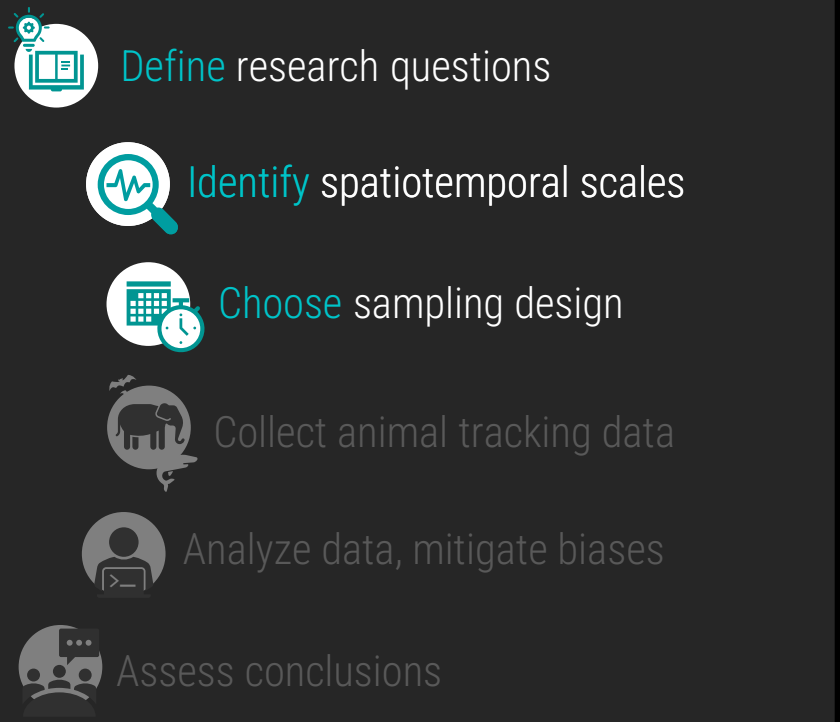
τ_v = 1 day

Δt

SPACE-USE
☐ HOME RANGE

SAMPLING FREQUENCY ⋯⋯▸ MOVEMENT BEHAVIOR
How frequently are locations collected?

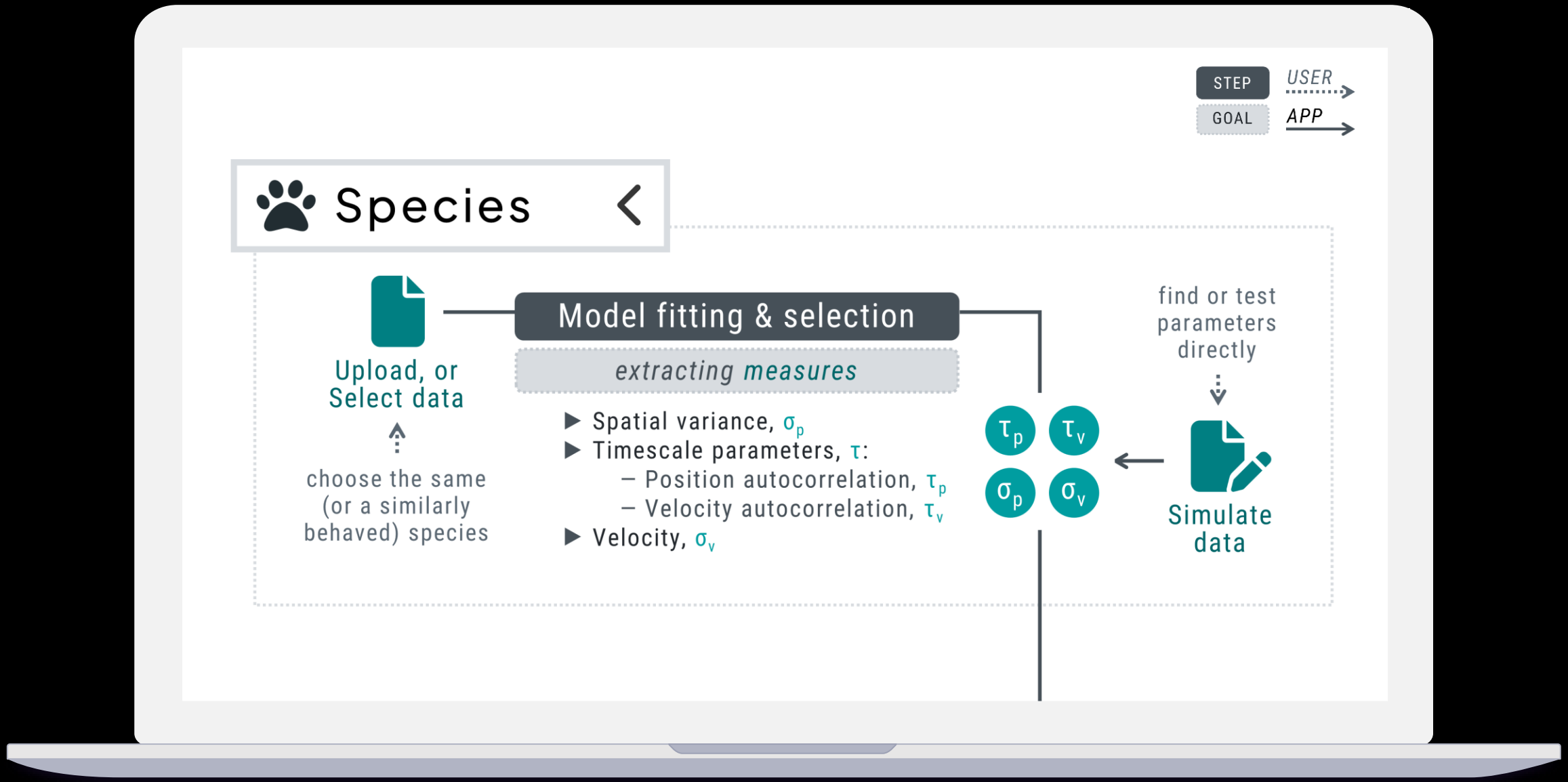
☑ SPEED & DISTANCE



It is not physically possible for animal movement to be uncorrelated. Now, the questions are:

1. Can you detect a signature of these correlations in your data?

2. And is this data sufficient to answer specific research questions?


STEP
GOAL
USER
APP
Species
Upload, or Select data
choose the same (or a similarly behaved) species
Model fitting & selection
extracting measures
Spatial variance, σ_p
Timescale parameters, τ:
– Position autocorrelation, τ_p
– Velocity autocorrelation, τ_v
Velocity, σ_v
τ_p τ_v σ_p σ_v
find or test parameters directly
Simulate data

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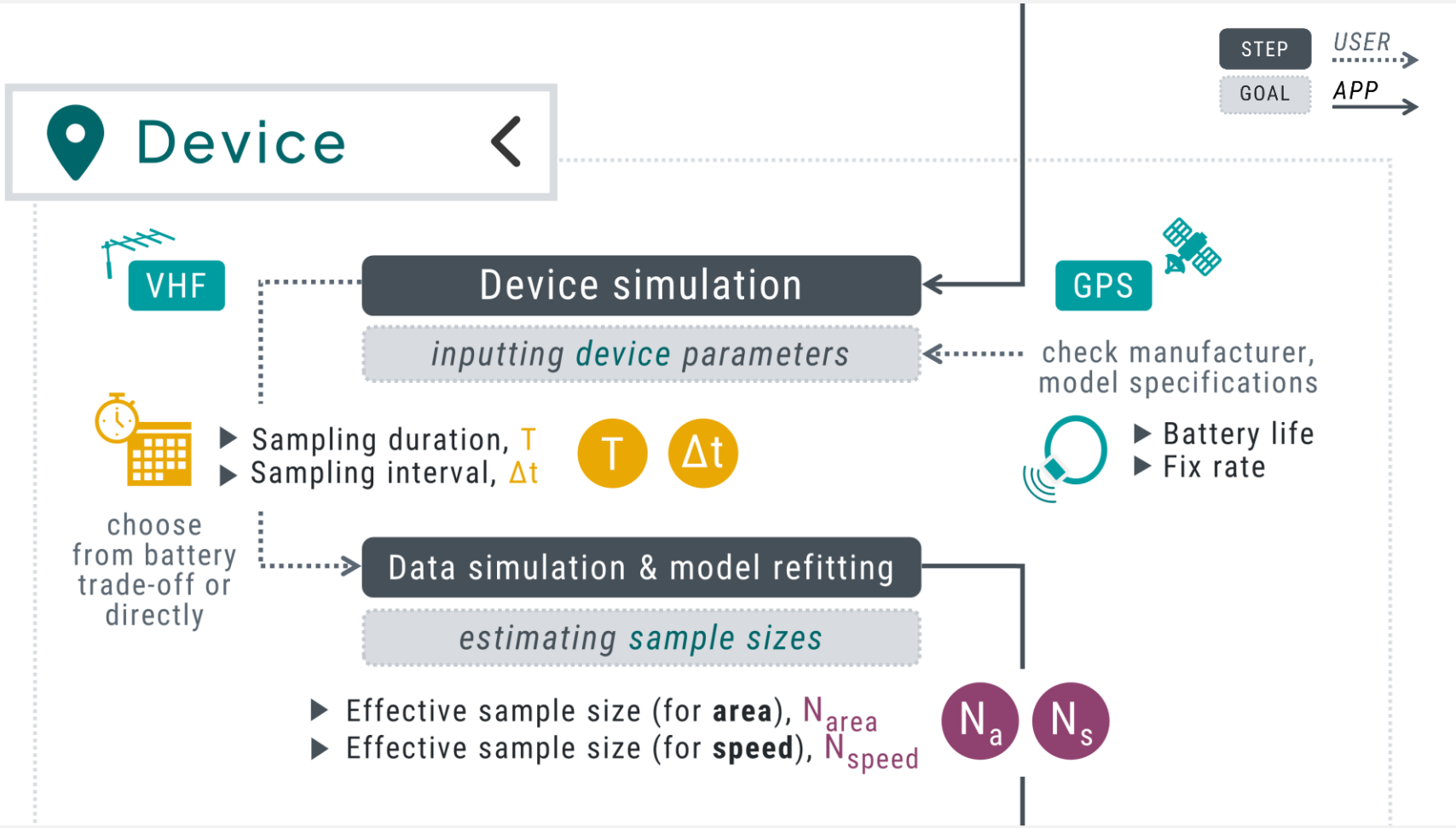

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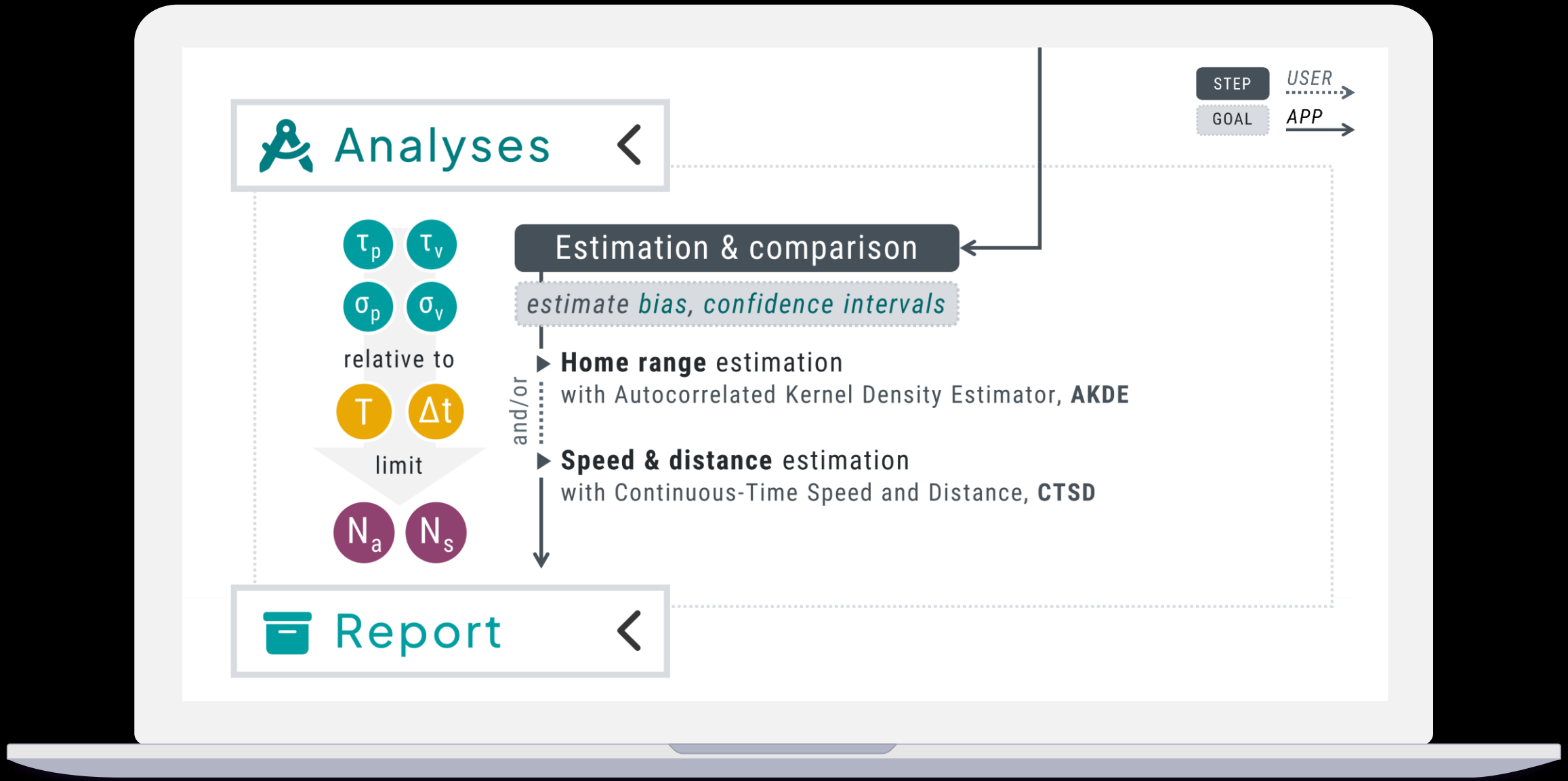
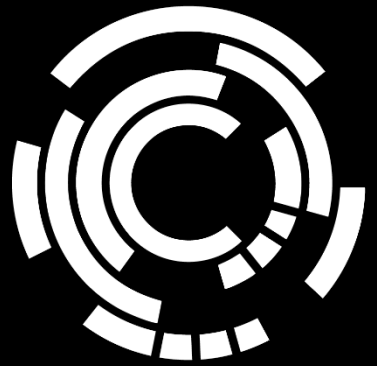


Our workflow allows users to evaluate a wide range of potential sampling designs, which can then serve as a **solid foundation for ongoing and future tracking projects, or even the evaluation of published studies.**

Future goals:

Explore new case studies and analyses,
Address more challenging study design questions.

Leon Berard



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Thank you! Any questions?

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