



Modellelezéssel Budapestről a Marsig, **avagy hogyan lehet egy BME spinoff a NASA Jet Propulsion Laboratory beszállítója?**

Dr. Debreceni Csaba
Director of Engineering, IncQuery Group



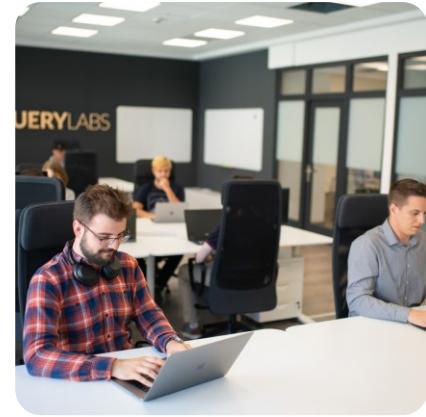
About Us

Origins



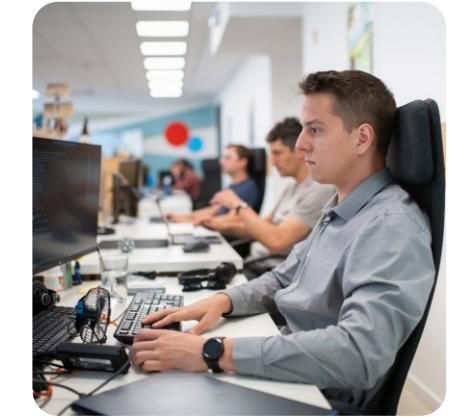
Founded in 2012 by members of the Fault-Tolerant Systems Research Group at Budapest University of Technology and Economics. Engineering staff mostly alumni from the University's established computer science and engineering programs.

Present



Extended network with strong international relationships with global companies in multiple industries. Developing own product portfolio since 2017. IncQuery Labs became part of the IncQuery Group with offices in the USA, Austria and Hungary.

Future



Ever-expanding team of qualified young and motivated employees. Strategy is to maintain sustainable growth as a family-friendly deep-tech organization.

In numbers

162+
Projects

10
Years

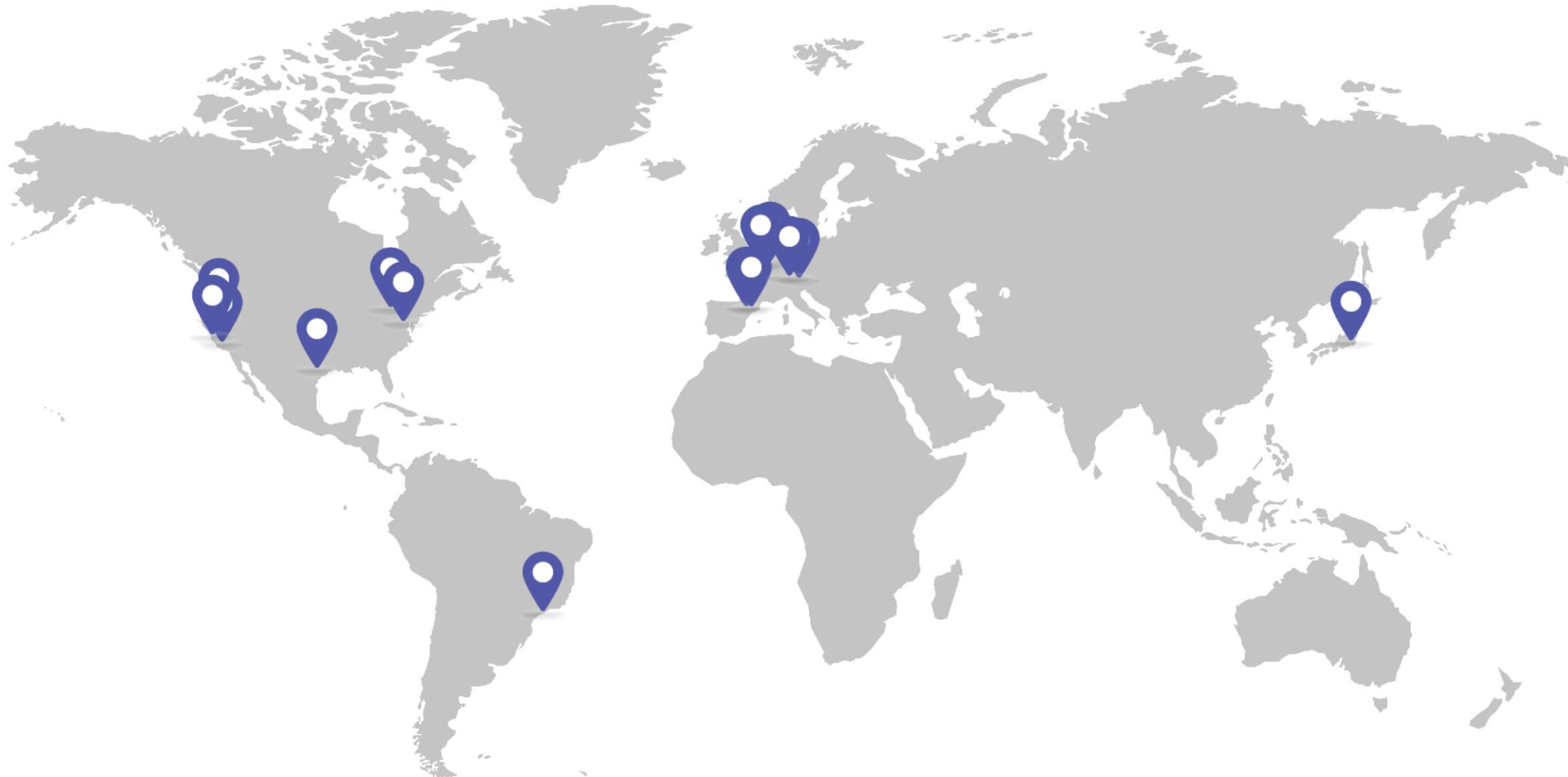
10
Countries

40
Engineers

8
Researchers



Our clients



Demonstrated history of successful collaboration
with leading international organizations

THALES

ERICSSON

Vincotech

B/S/H/

UK SPACE AGENCY

Wabtec CORPORATION

NATIONAL INSTRUMENTS™

EMBRAER

BOMBARDIER

Mercedes-Benz

RIMAC AUTOMOBILI

AUDI

PORSCHE

LEICA

ELBE

LieberLieber

MAGNA

AL AUTOMOTIVE LIGHTING | MARELLI

logi.cals

Airmatic

eclipse

OMG

AUTOSAR

Q

Our footprints

Industries:



Aerospace & Defense



Automotive (ADAS)



Industrial Automation



Biomedical



Cameo - Modeling,
Simulation & Analysis
Excellence 2018

MAJOR RECENT REFERENCES

DASSAULT SYSTÈMES A trusted Development Partnership with No Magic / Dassault proving excellence in customer and product development.

NASA JPL The IncQuery Suite serves as a central component in the Computer Aided Engineering toolchain, integrating with Open MBEE and various other engineering tools.

AIRBUS Integrated tools and complex engineering platforms through a high-impact R&D project, involving MATLAB Simulink and Cameo.

FORD Developed various MBSE solutions: model composition, report automation, verification and validation.

SIEMENS Helped Mentor Graphics to develop its Capital VSTAR product family.

THYSSENKRUPP Participated in internal product development around AUTOSAR toolchains.





Jet Propulsion Laboratory
California Institute of Technology

Taming Monsters with Dragons:

A systematic fractal oriented approach to digital twin pipelines

Robert Karban

Jet Propulsion Laboratory, California Institute of Technology

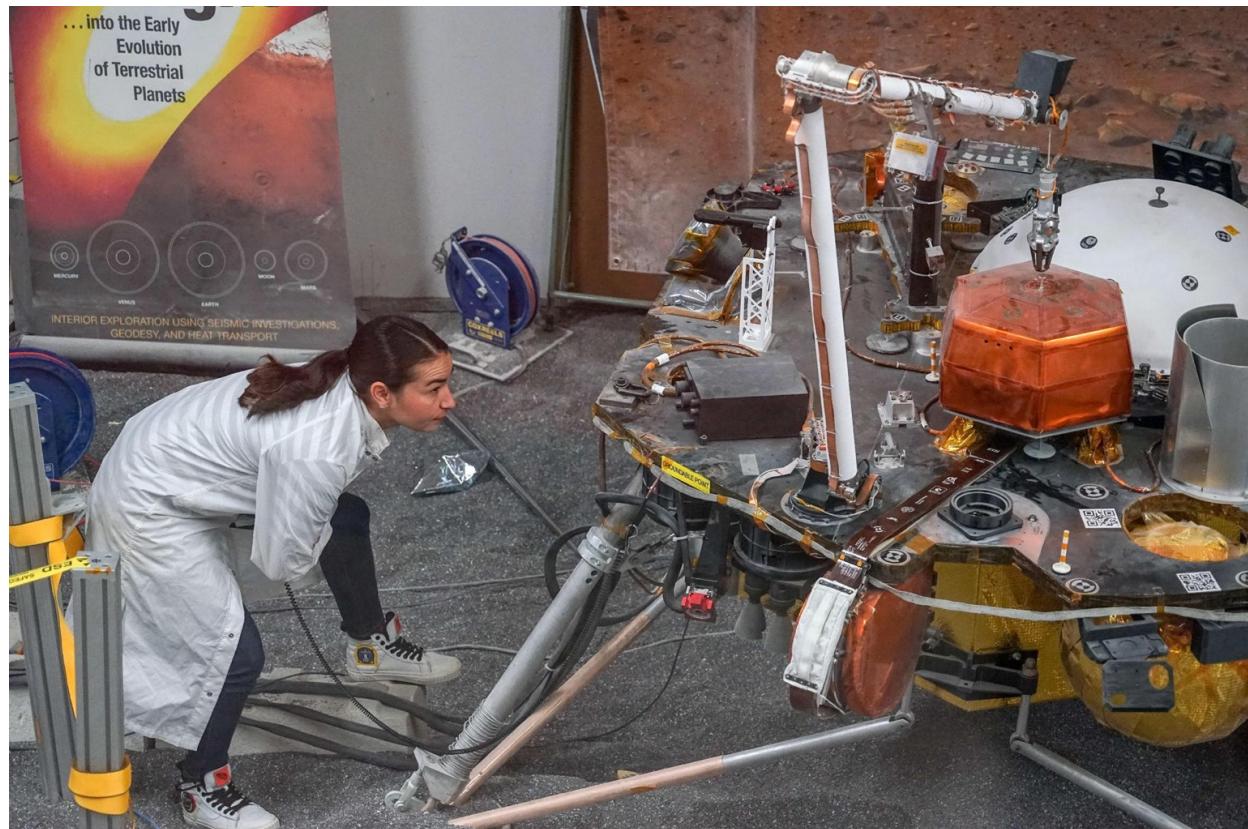
MESConf, June 2022, Munich, Germany

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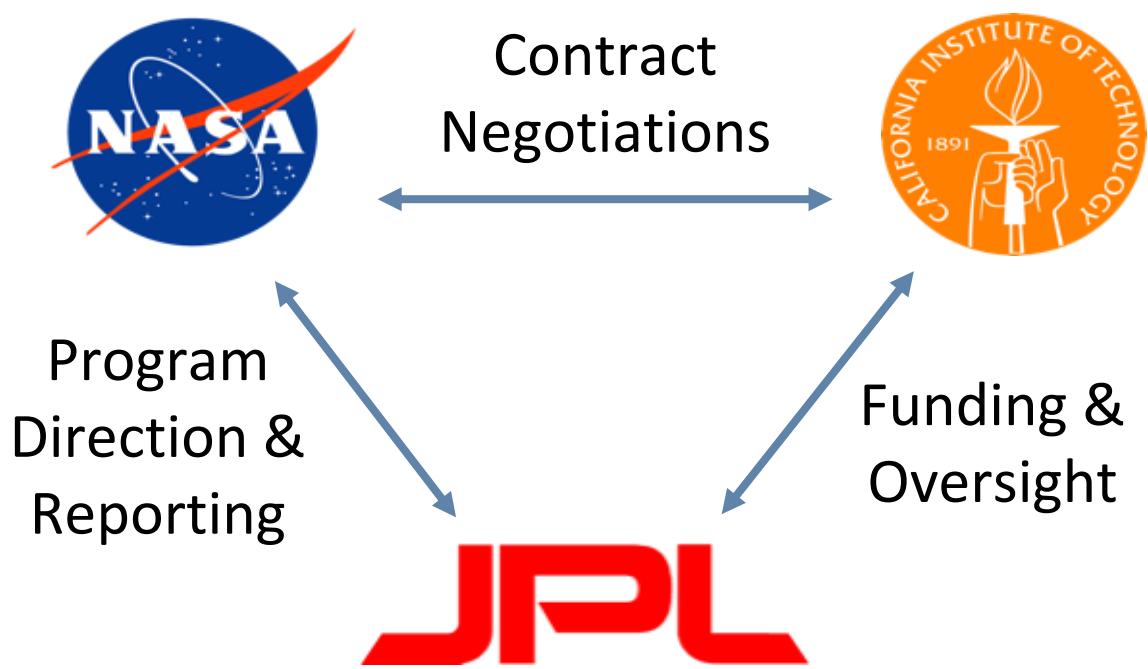
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JPL is Part of NASA and Caltech



Federally-funded (NASA-owned) Research and Development Center (FFRDC)
University Operated (Caltech)
\$2.7B Business Base
6,000 Employees



167 Acres (includes 12 acres leased for parking)
139 Buildings; 36 Trailers
673,000 Net Square Feet of Office Space
906,000 Net Square Feet of Non-Office Space (e.g., Labs)

Some Notable Firsts



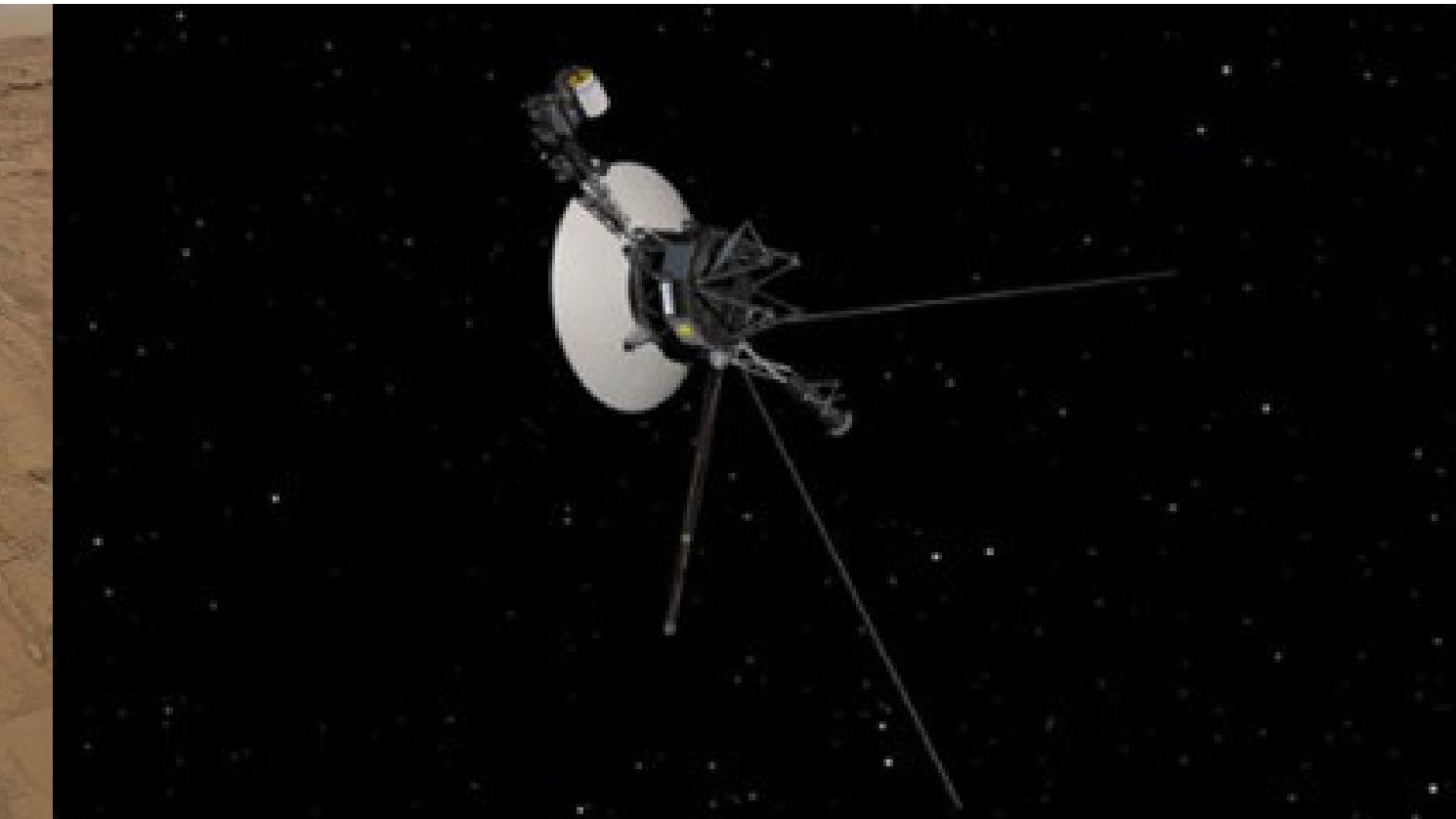
Surveyor 1, First soft landing on the moon



Viking, first landing on another planet



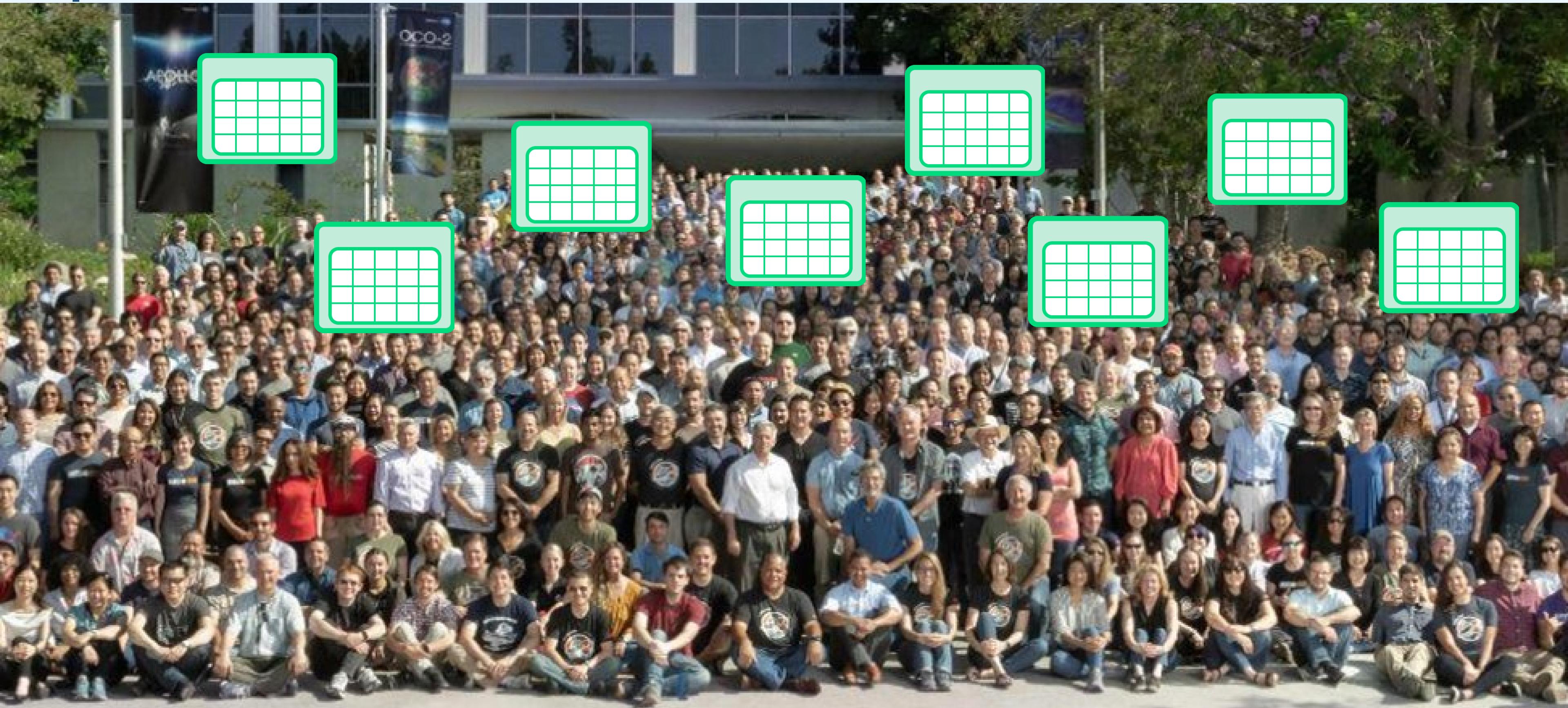
Continuous presence on Mars since 1997 Voyager 1, First interstellar traveler



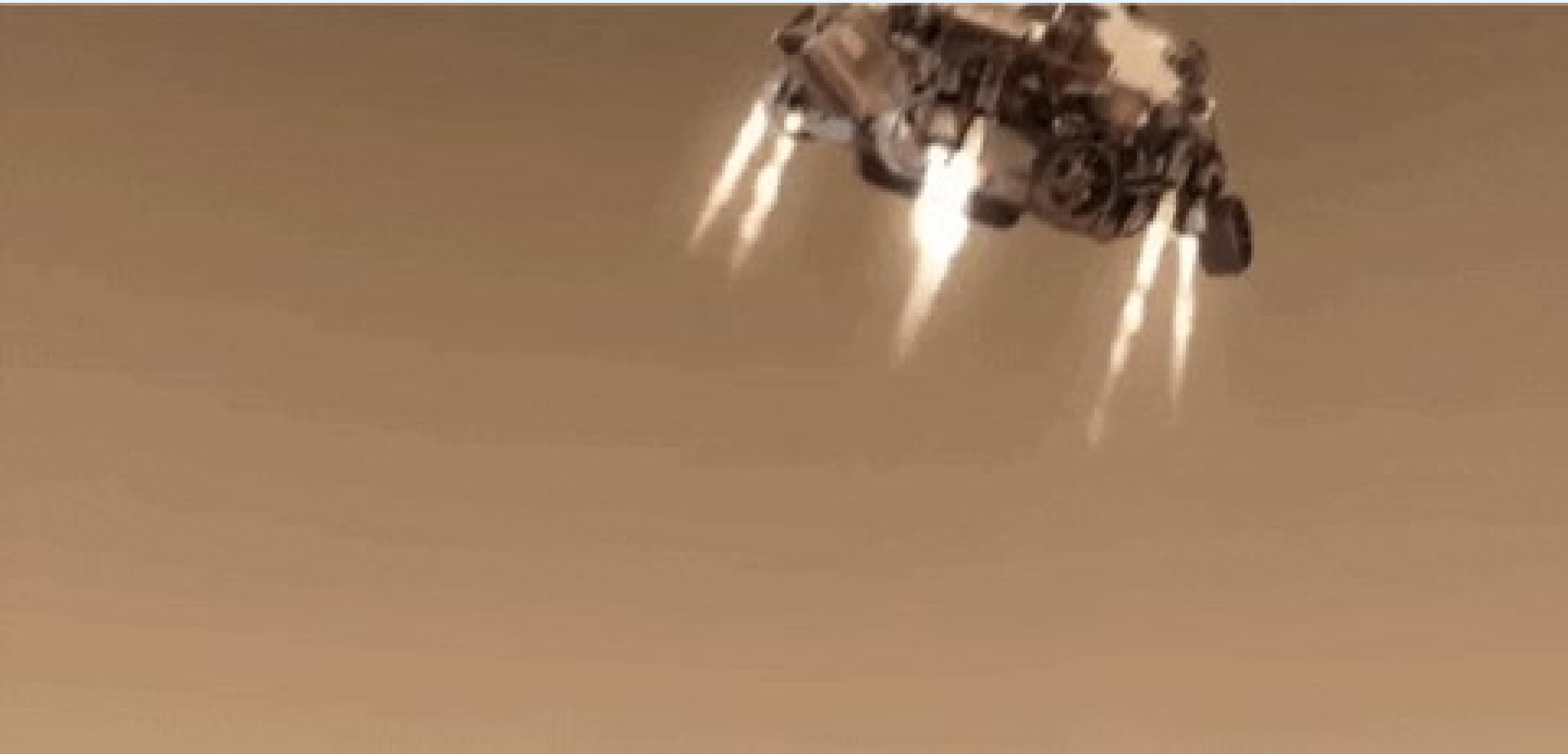
Project teams are large. Lots of people work on one project...



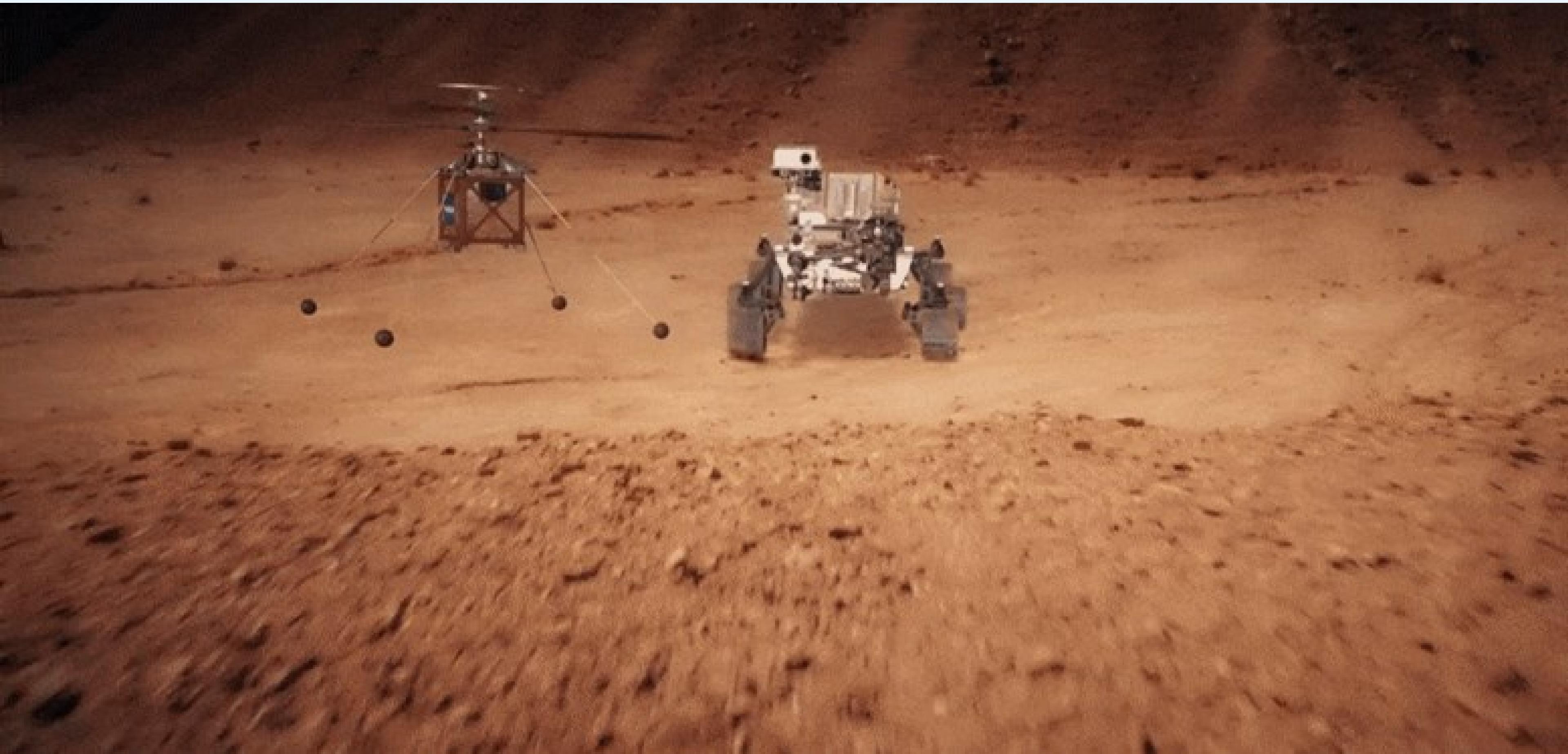
...and they communicate their project needs often through spreadsheets.



To eventually do this...

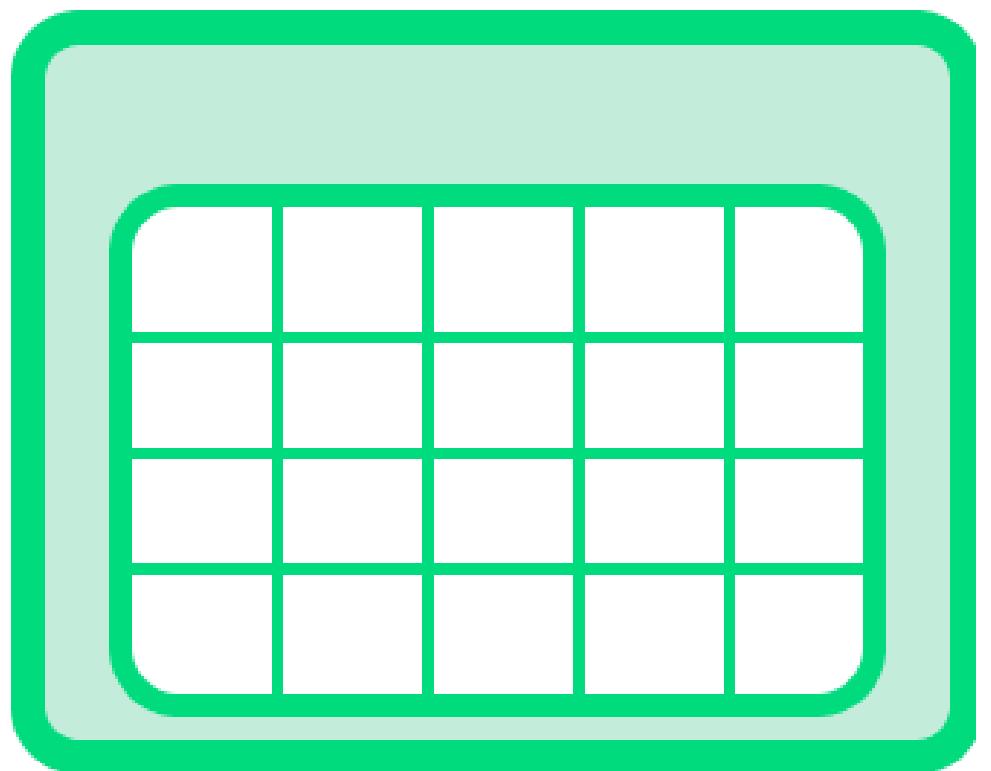


And this. But it takes a lot to get here.

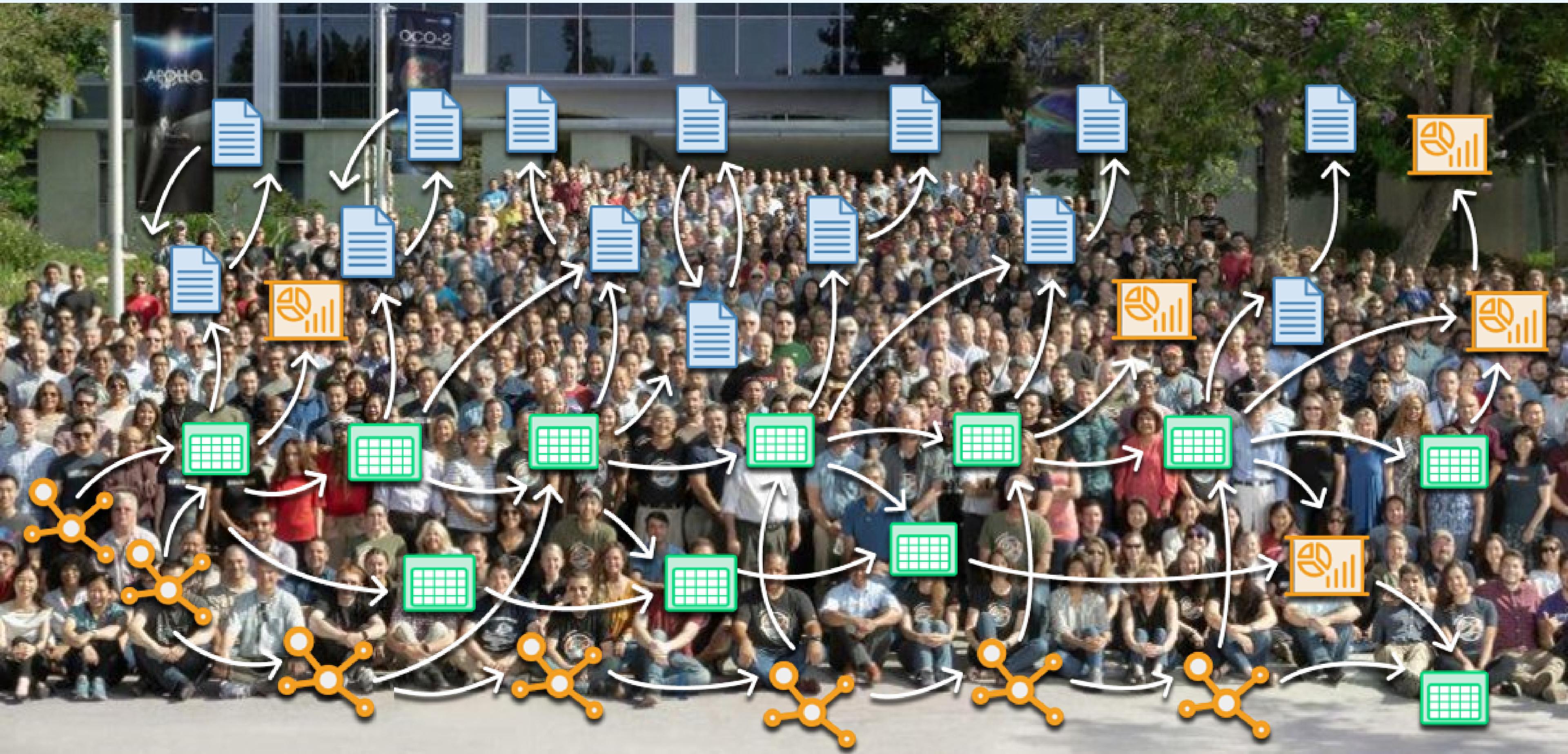


**So how do we get from
this...**

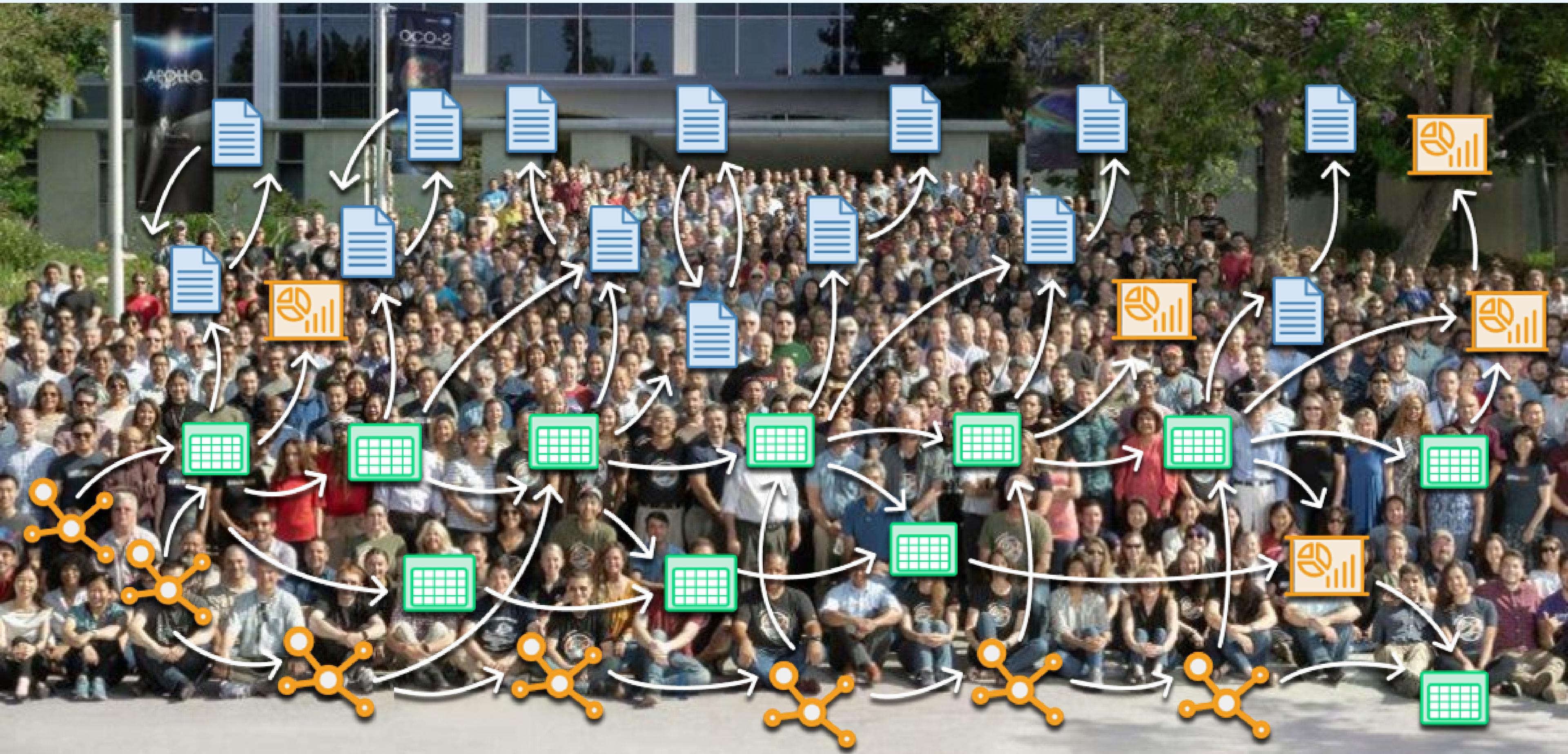
to this?



It takes people, and requirements, and spreadsheets, and documents, and processes, and workflows, and tests...



Unfortunately, all of these things create silos of information that lead to miscommunication and duplicate work.



A project starts simple.



Engineers iterate on their models.



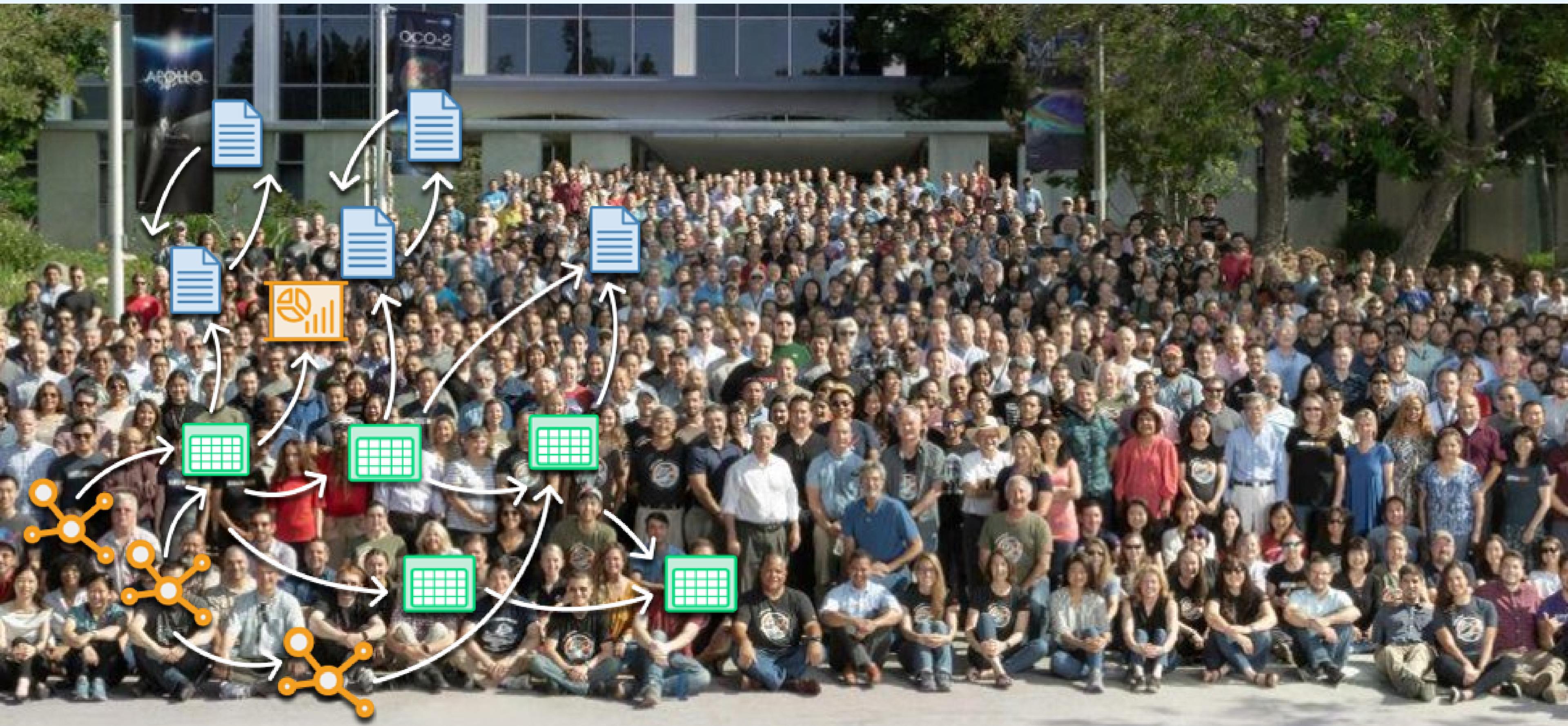
They add it to a spreadsheet to track it over time.



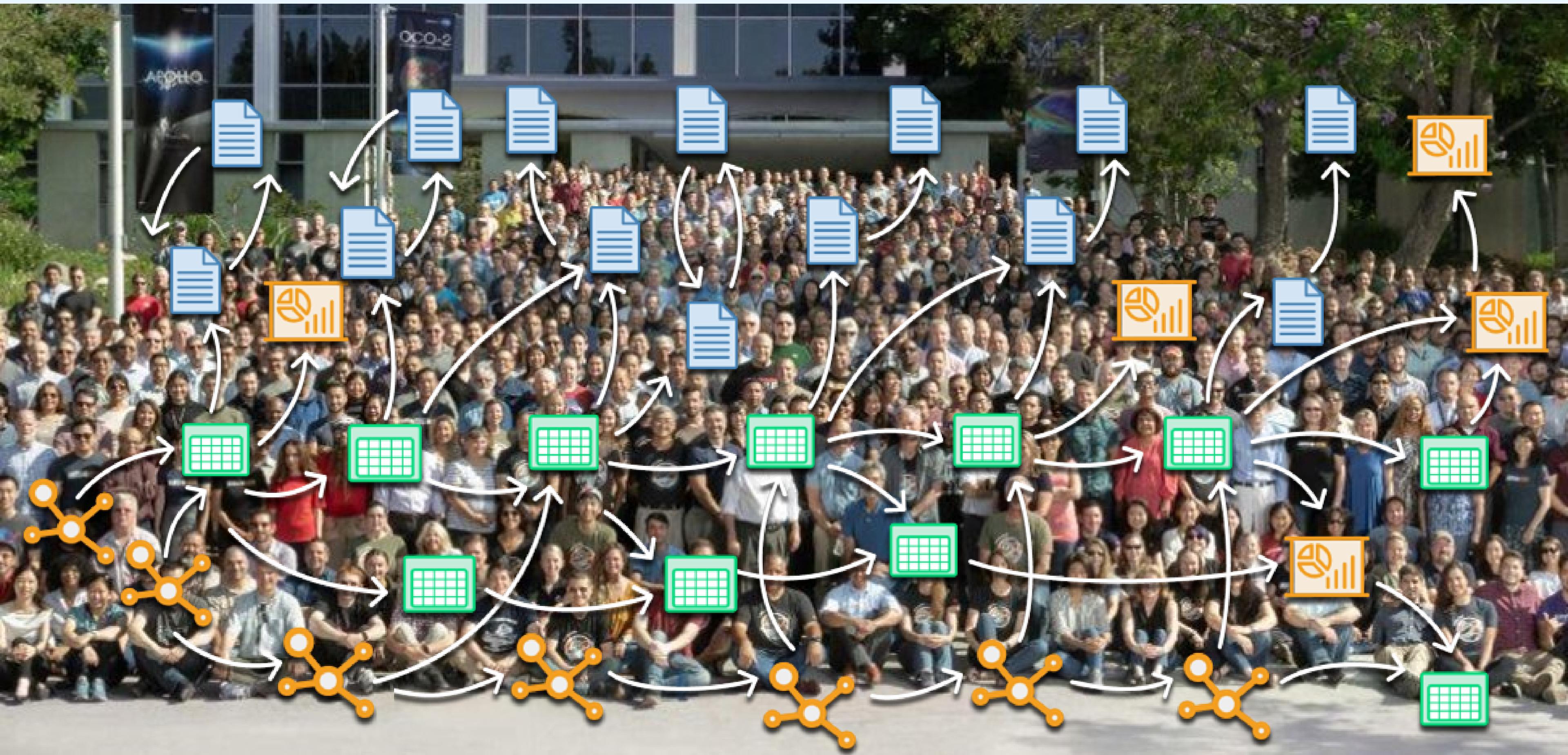
They add it to a document.



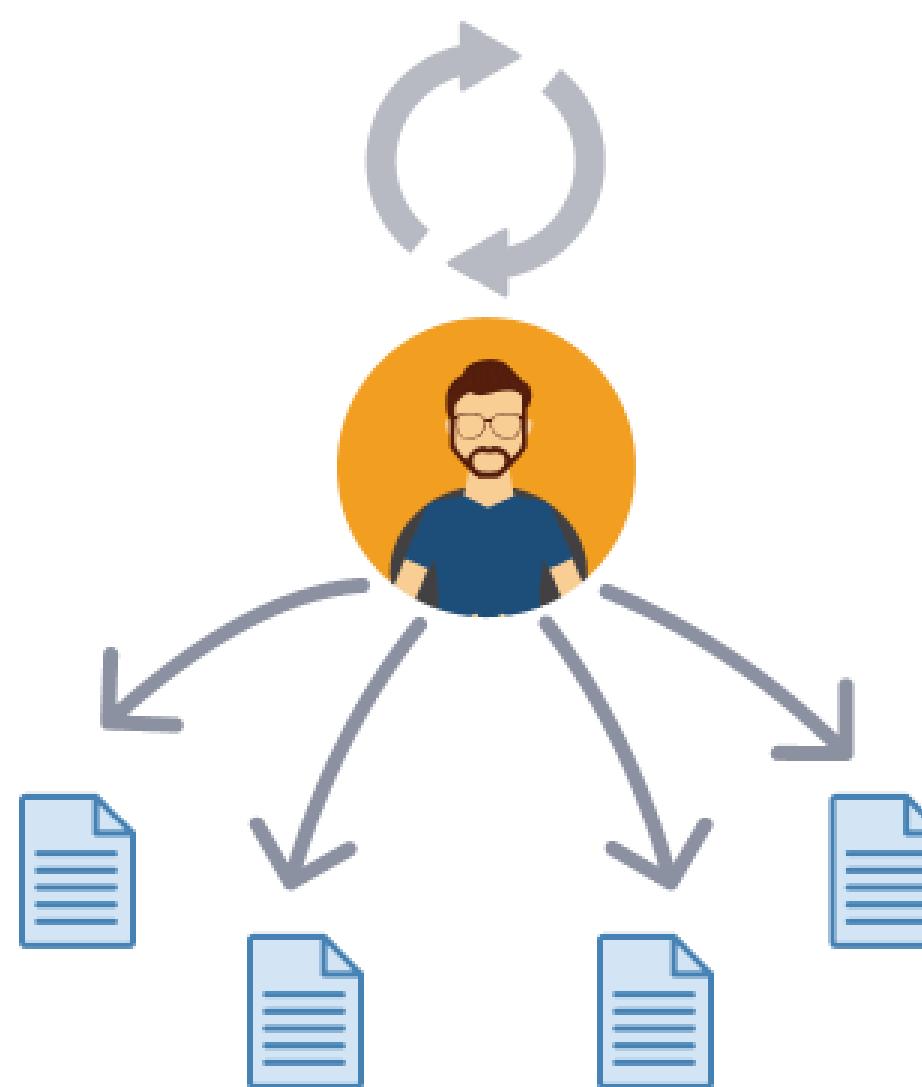
And get input from others.



And it gets complicated pretty quickly...



Bad Ratio of Real engineering vs. overhead



Repetitive Data Entry

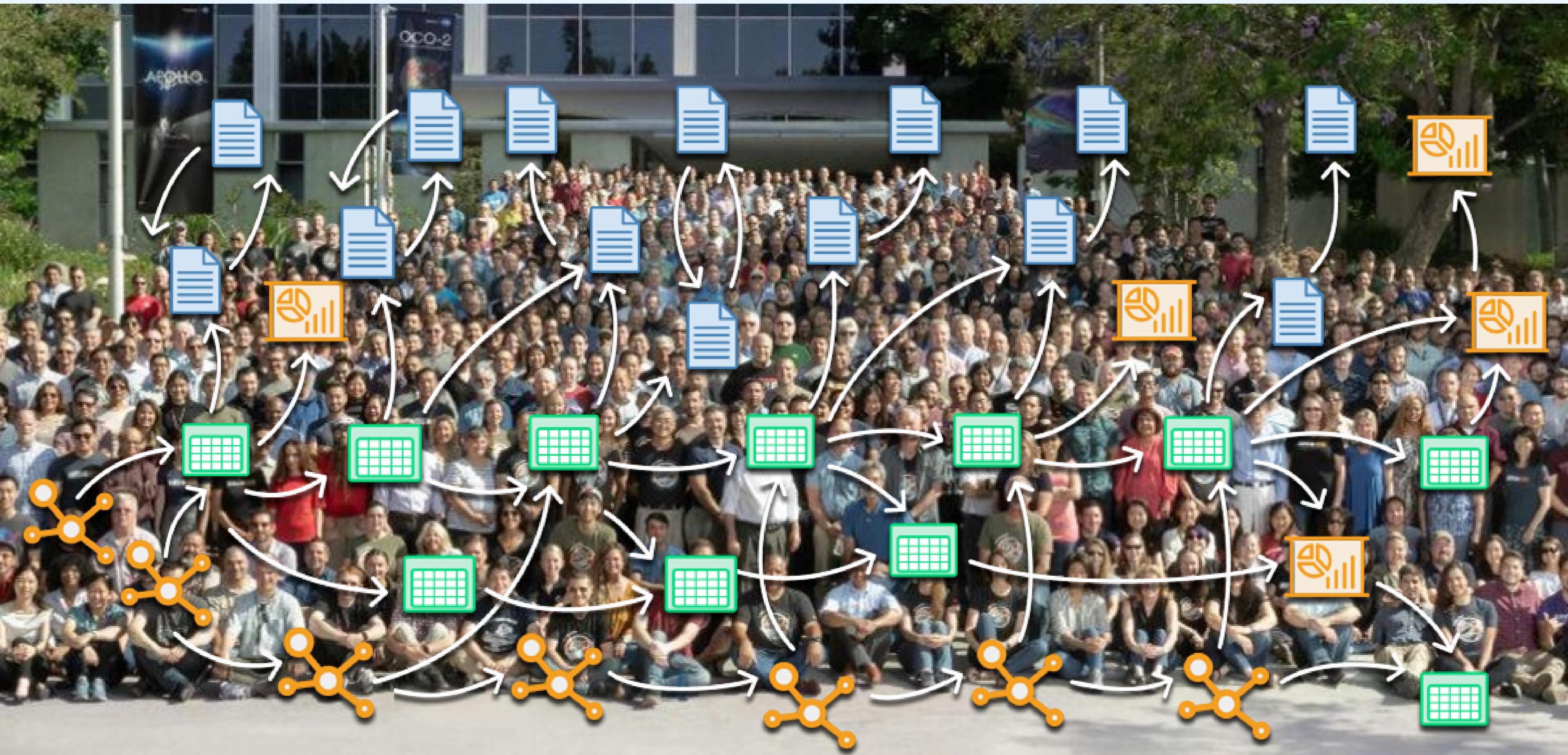


Version Confusion



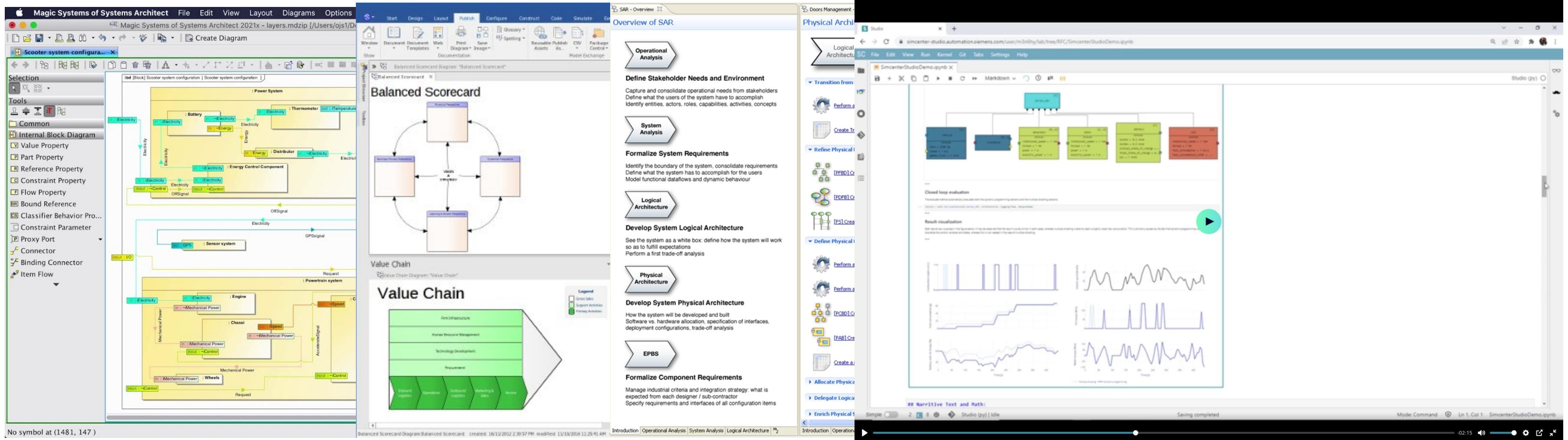
Constant Searching

How do we connect all of these things together?



Model Based Systems Engineering (MBSE)

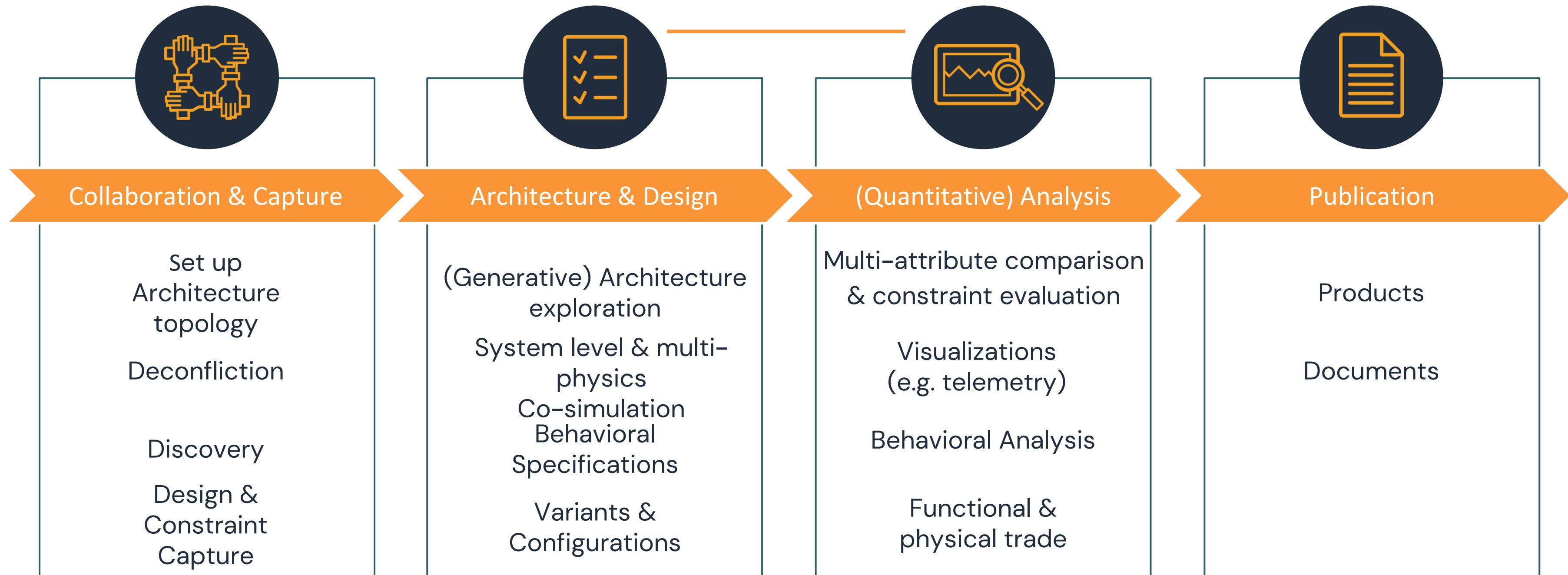
- MBSE is the formalized application of modeling techniques to support system requirements, design, analysis, verification, validation and documentation activities
- MBSE expresses a system using a Systems Modeling Language (e.g. SysML, Modelica)
- MBSE is often applied with a method like Object Oriented System Engineering Method (OOSEM)





Iterative

Workflow across product lifecycle



Issue Management

Continuous Integration

Process Orchestration



Process (Traceable, Auditible, Repeatable)

OpenCAE



Iterative

```
system simple_rover:
  owns:
    Chassis
    Wheel
    PowerSupply
    Terrain

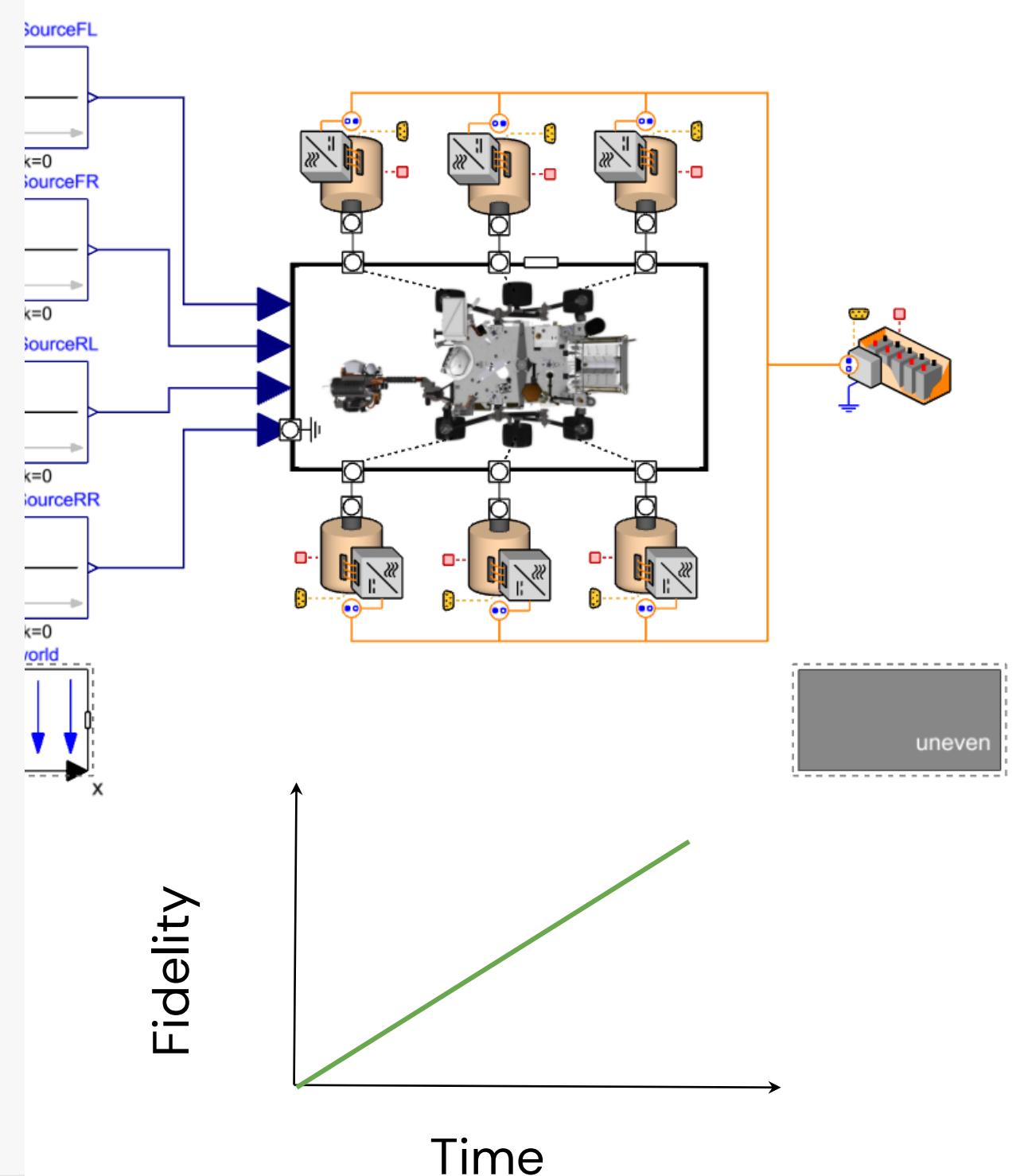
  component Chassis:
    ports::group wheels:
      out::wheel_structure w1
      out::wheel_structure w2
      out::wheel_structure w3
      out::wheel_structure w4
      (out)::wheel_structure w5
      (out)::wheel_structure w6
    ports:
      out::power_structure p1

  component Wheel:
    properties:
      multiplicity = 4..6
    ports:
      in::wheel_structure w1
      out::terrain t1

  component PowerSupply:
    ports:
      in::power_structure p1

  component Terrain:
    ports::group terrains:
      in::terrain t1
      in::terrain t2
      in::terrain t3
      in::terrain t4
      (in)::terrain t5
      (in)::terrain t6
```

Collaboration & Capture



System model

Multi-physics model

Wiki



Collaboration & Capture

Set up Architecture topology

Deconfliction

Discovery

Design & Constraint Capture

[Pages](#) / ... / CAE Systems Environment Wiki and Discussion

Engineering Document

Created by Robert Karban just a moment ago

This document captures the design and analysis of a rover.

MEL

Component	Mass
Chassis	500 kg
Wheel	10 kg
PowerSupply	50 kg

Architectures

Analysis of attributes



Iterative

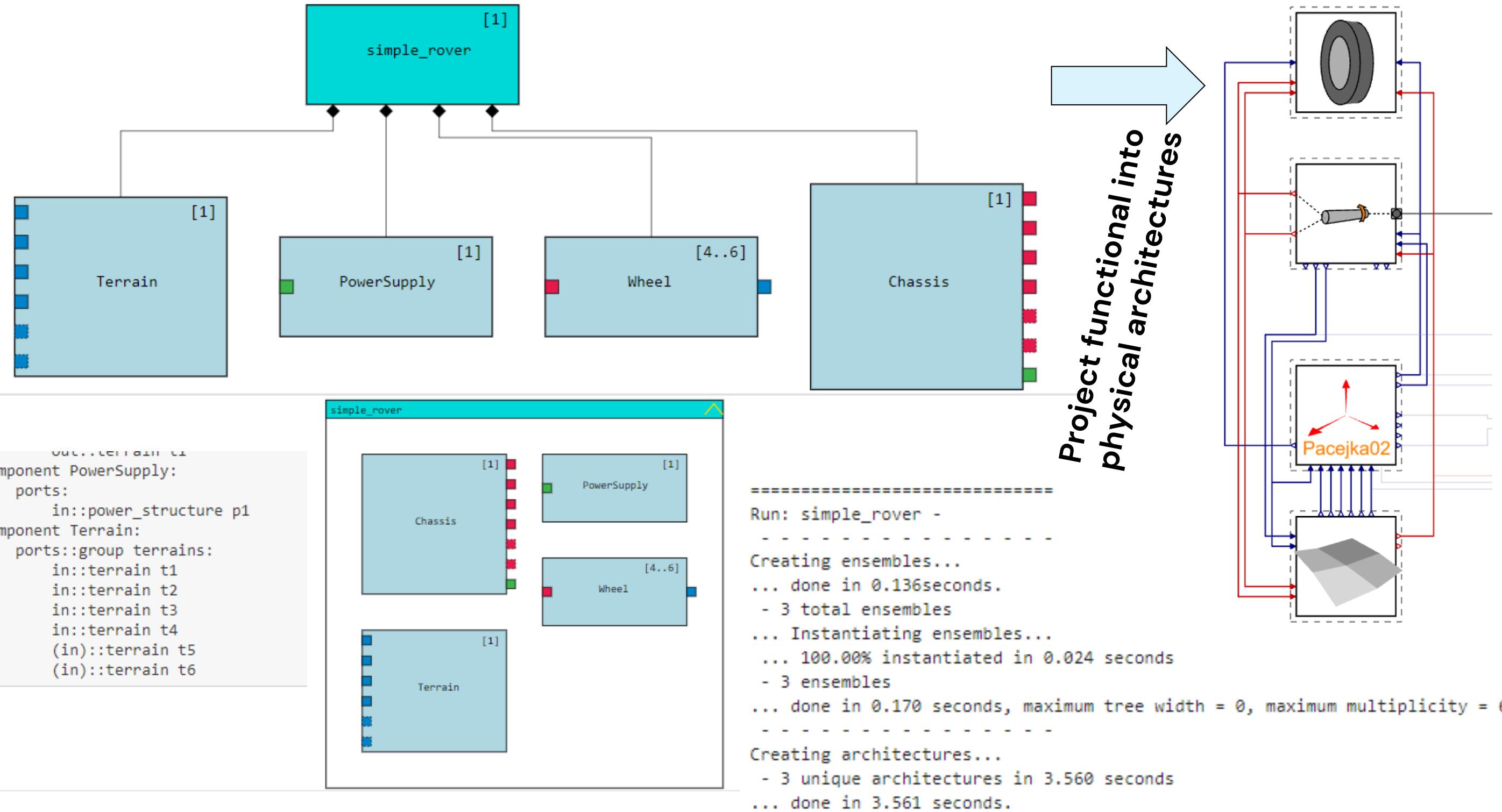
Architecture and Design



Architecture & Design

(Generative) Architecture exploration
System level & multi-physics
Co-simulation
Behavioral Specifications
Variants & Configurations

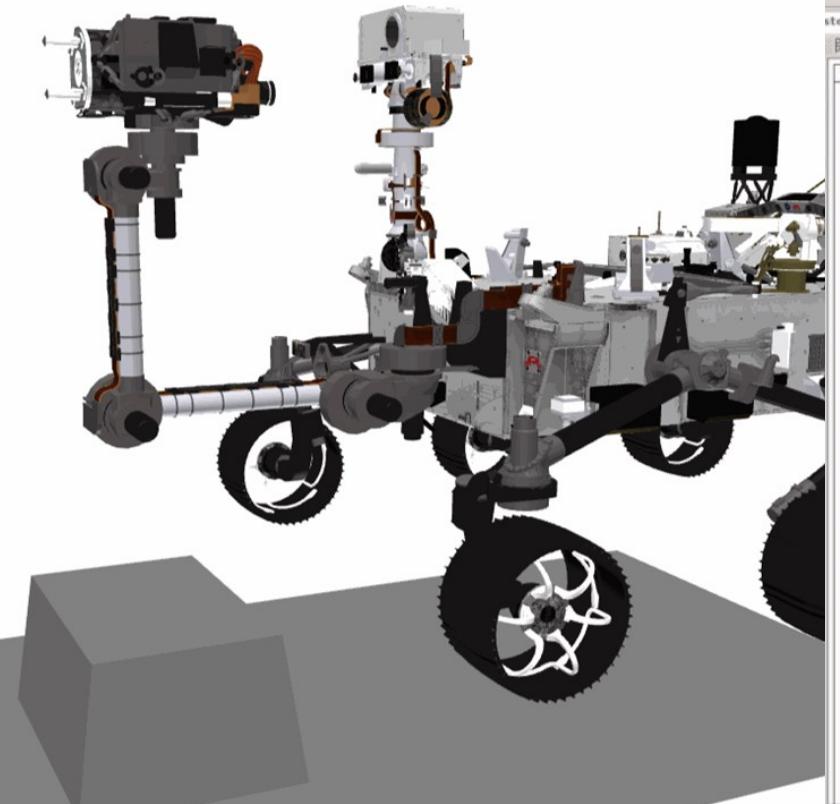
- Articulation of Design Space
- Determine required connectivity constraints



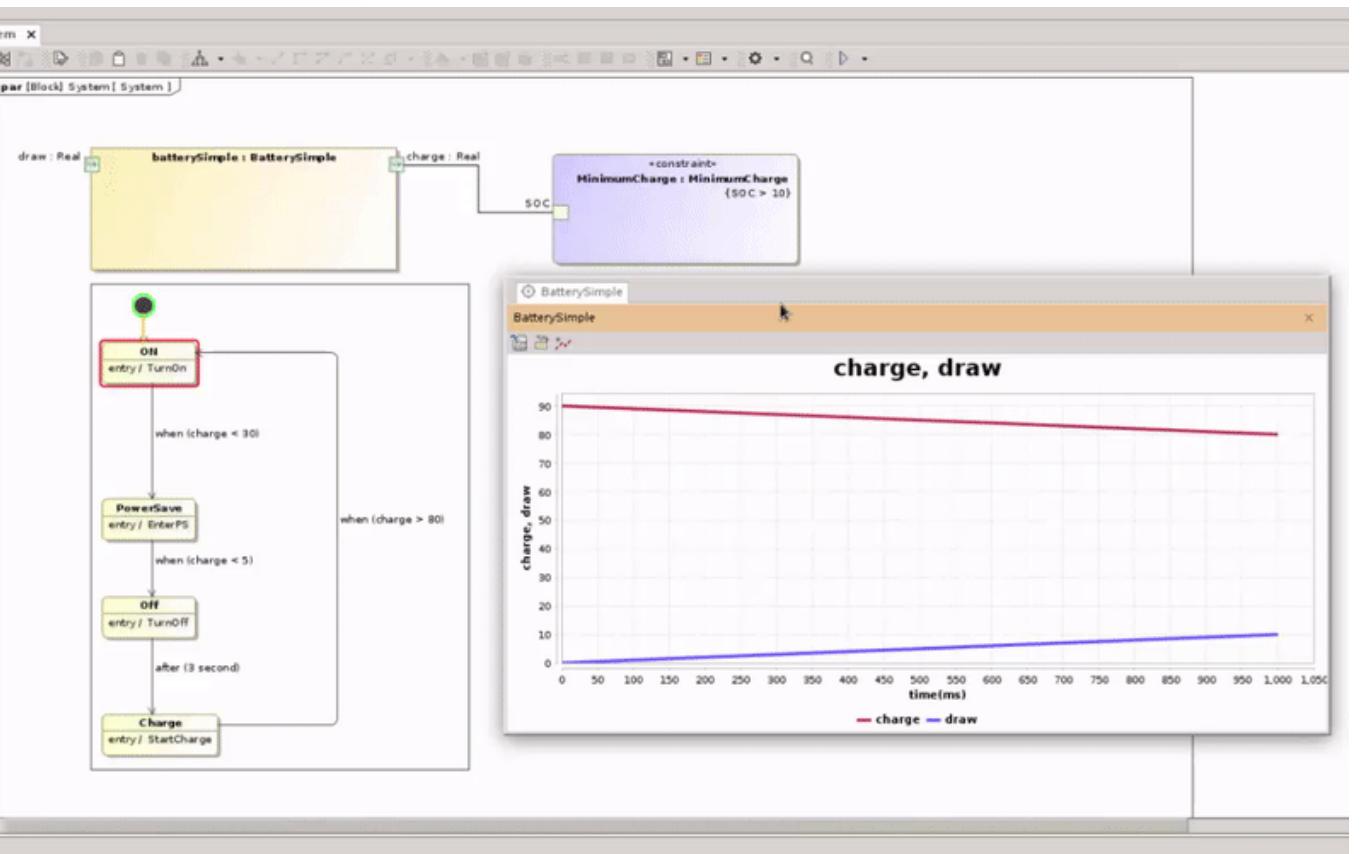
Quantitative Analysis

- Baseline Analysis
- Adding new Components
- Swapping Components

Guided Architecture Selection in an integrated engineering environment

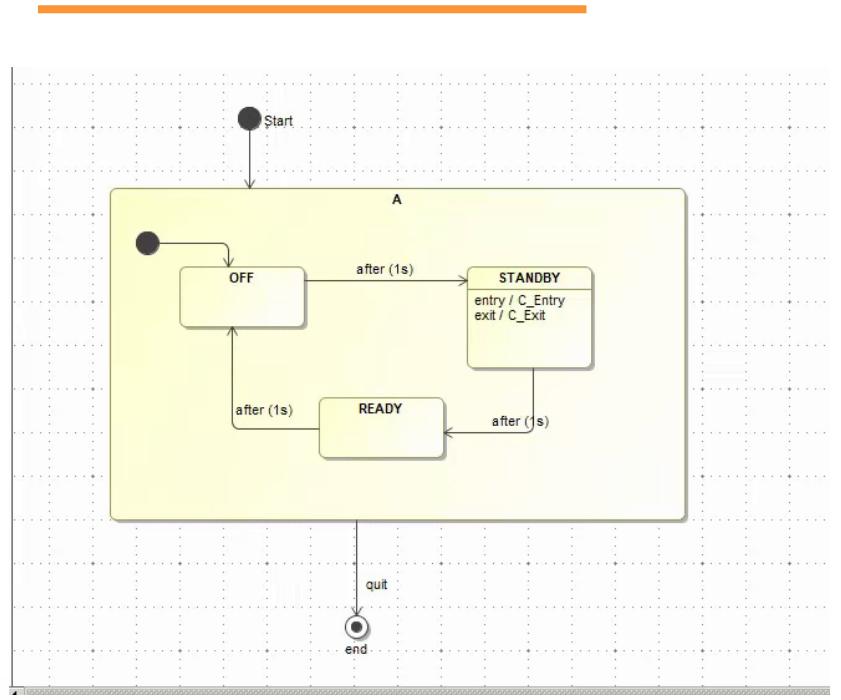


**System –
Multi-physics
Co-simulation**



**Constraint
evaluation**

<https://github.com/Open-MBEE/perseverance-modelica>



**FSW
simulation**

Quantitative Analysis

Multi-attribute comparison & constraint evaluation

Visualizations (e.g. telemetry)

Behavioral Analysis

Functional & physical trade



Publication

People Calendars Create ...

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Engineering Document

Created by Robert Karban, last modified by Myra A Lattimore just a moment ago

This document captures the design and analysis of a rover.

MEL

Component	Mass
Chassis	500 kg
Wheel	10 kg
PowerSupply	50 kg

Architectures

```
graph TD; simple_rover[1] simple_rover --- Terrain[1] Terrain --- PowerSupply[1]; simple_rover --- Wheel[4..6] Wheel --- Chassis[1] Chassis
```

The architecture diagram illustrates the composition of the 'simple_rover' system. It consists of four main components: 'Terrain' (with a count of [1]), 'PowerSupply' (with a count of [1]), 'Wheel' (with a count range of [4..6]), and 'Chassis' (with a count of [1]). The 'simple_rover' component is shown at the top, with arrows pointing down to each of its constituent parts.

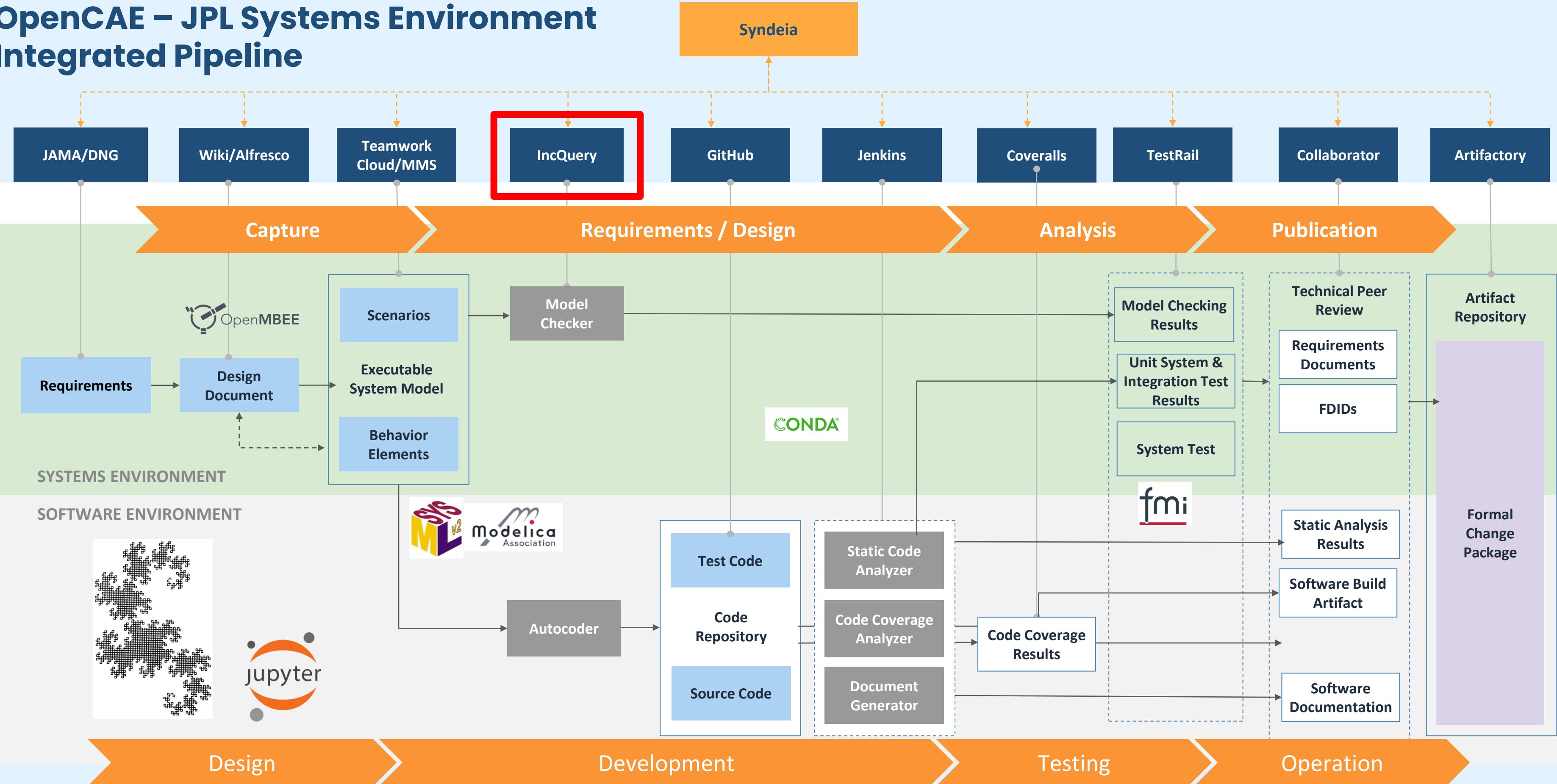


Engineering documents aggregate design specification, definition, and analysis results

OpenCAE – JPL Systems Environment

Integrated Pipeline

Systems Development Workflow



DevOps - Continuous Integration - Simulation

Process: Issue Management • Continuous Integration • Process Orchestration

JIRA

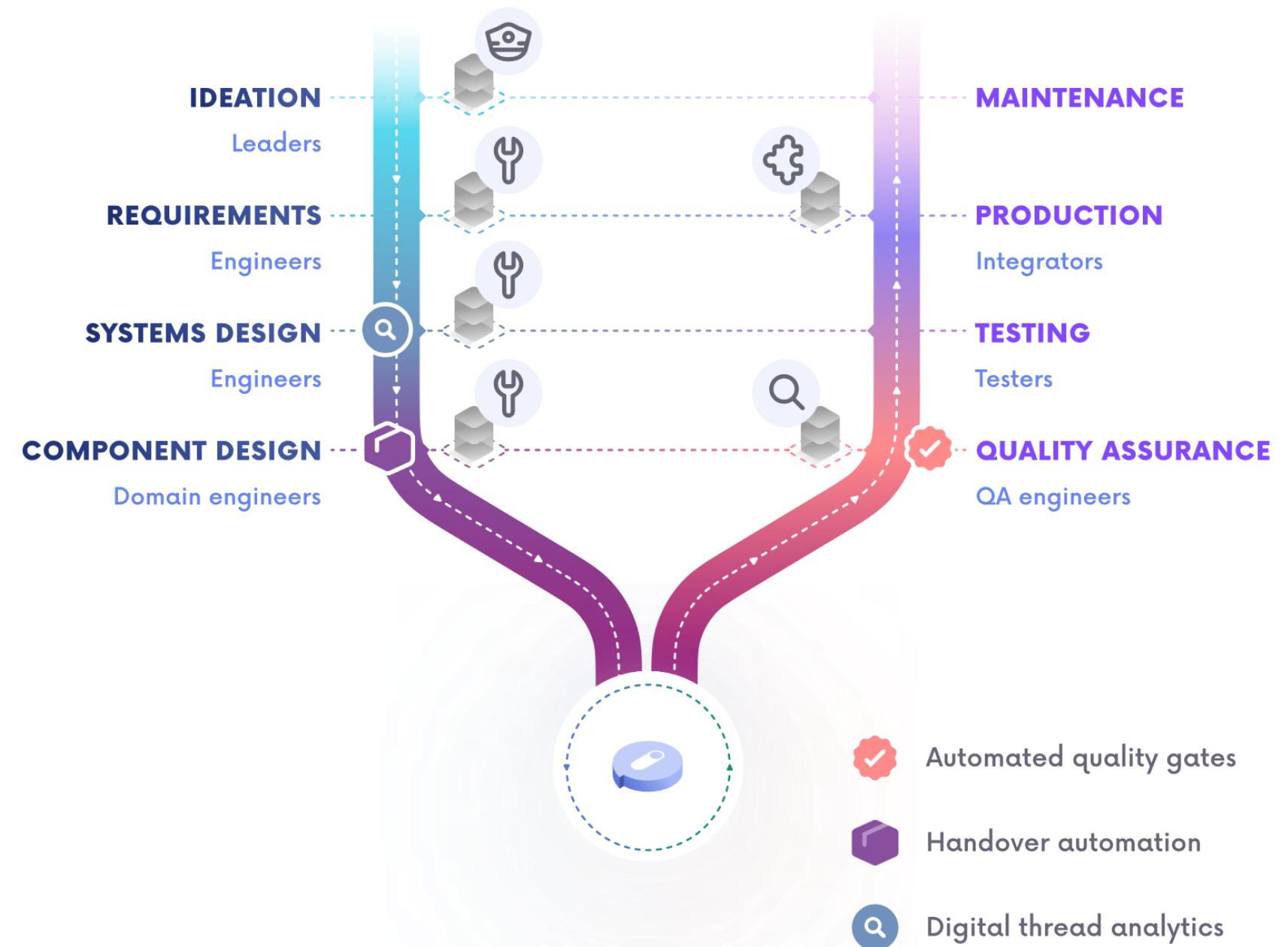
Jenkins

XLRelease

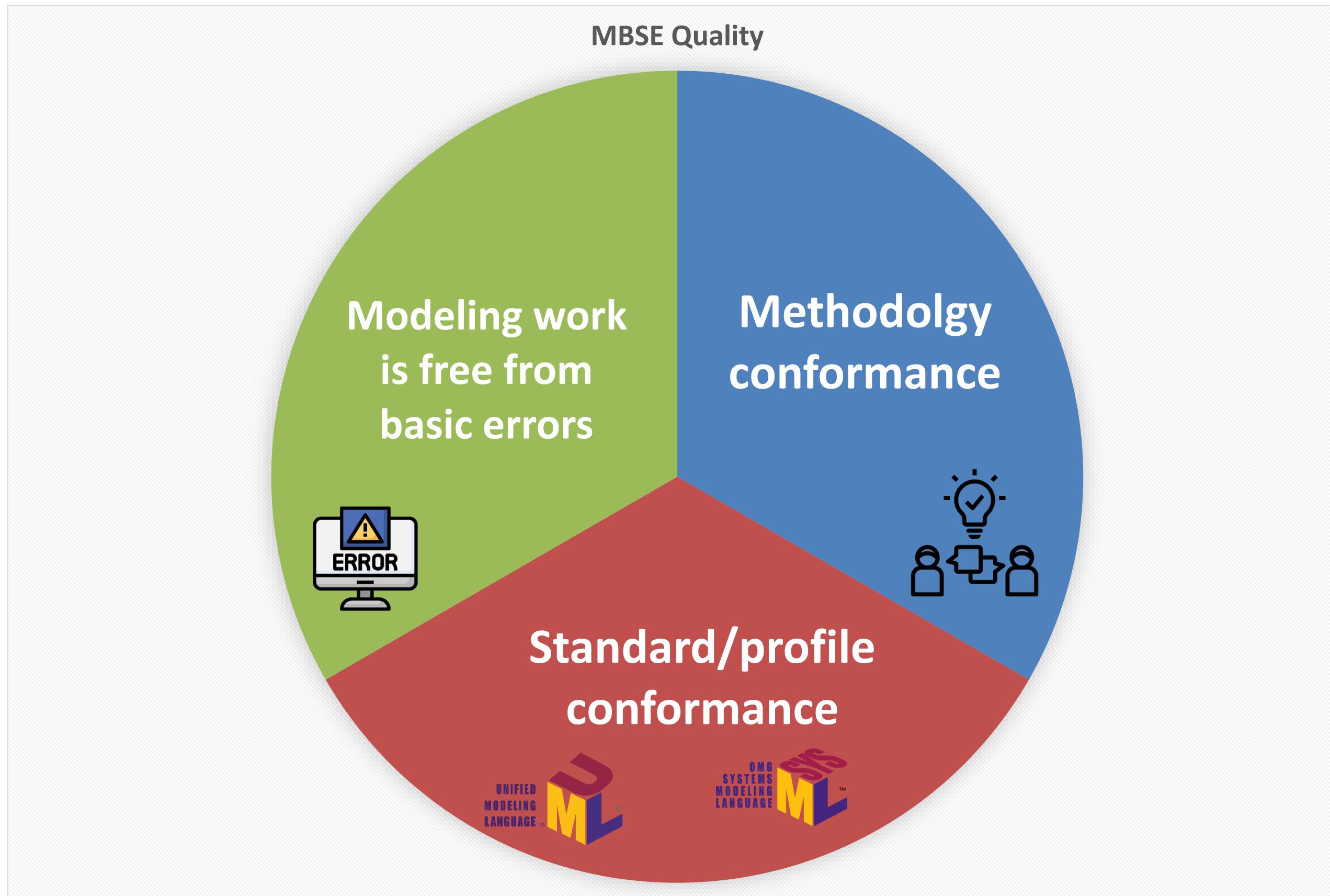
The IncQuery Vision

IncQuery provides a new platform for digital engineering automation.

- Automated Quality Gates to ensure engineering work free of design errors;
- Handover Automation to boost productivity and eliminate document-centric workflows;
- Digital Thread Analytics to break the vendor and data lock-in so you can get the maximum value of your engineering data.



What is model quality?

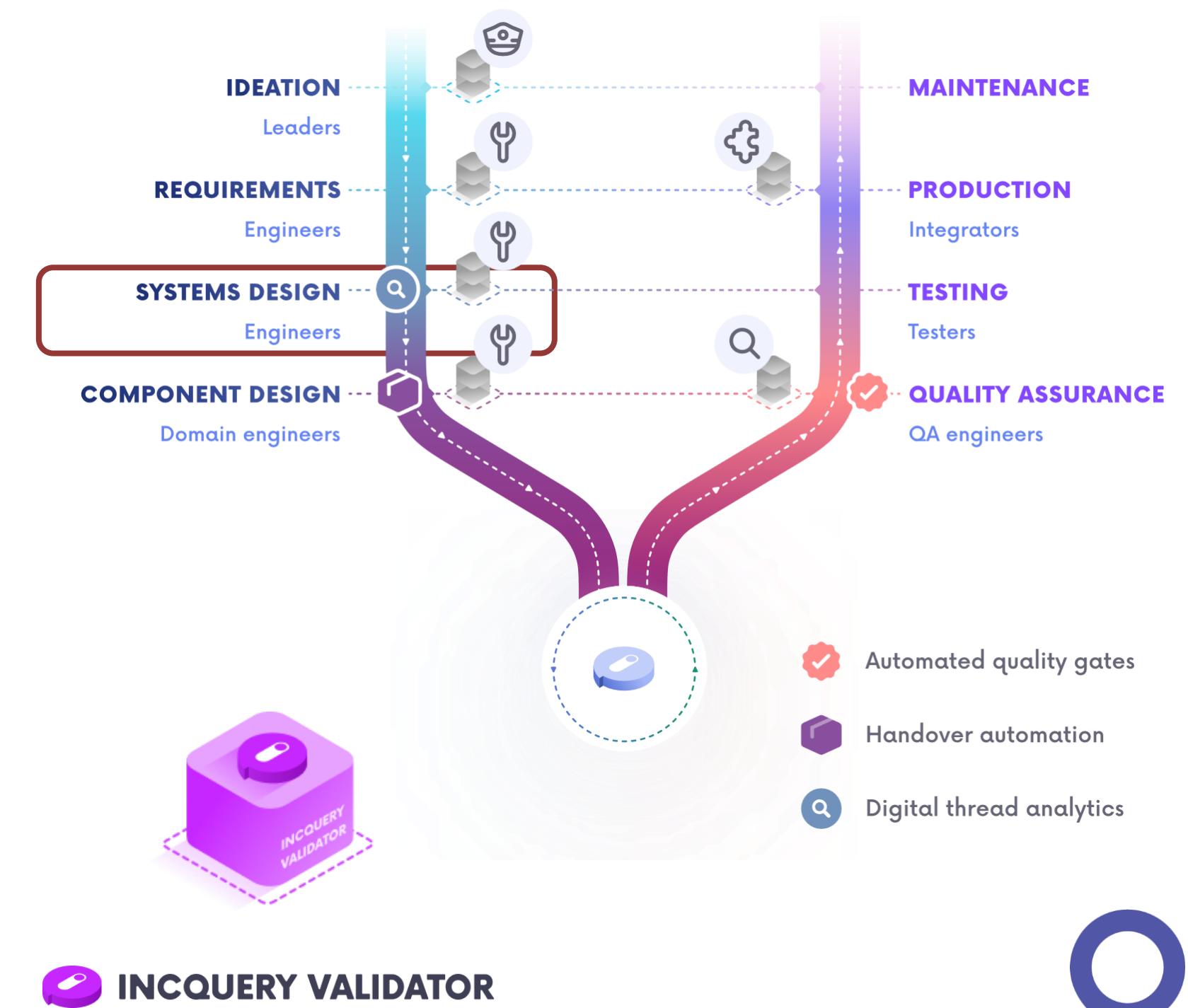


IncQuery Validator

Model Validation

Quality criteria that define well-formedness conditions to ensure authoring success.

- Goal: make errors visible and fixable inside the modelling tool



IncQuery Validator

INC**QUERY**

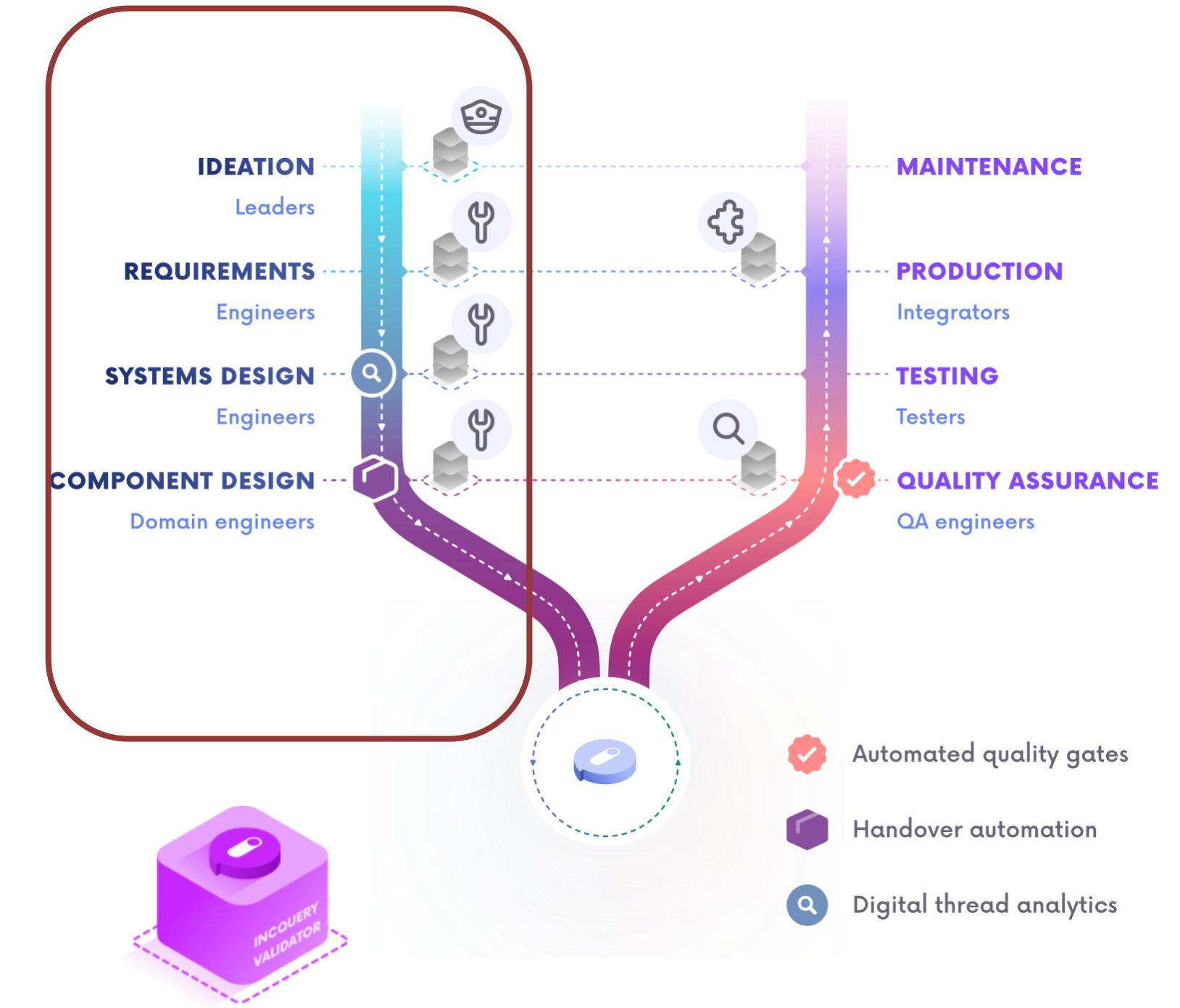
Model Governance

Quality criteria that define the preconditions for data exchange.

Enforce policies (style guidelines) across several stakeholders (organizations).

Make sure that models are

- Consistent in style;
- Understandable across several teams;
- Free of common mistakes & anti-patterns;
- Complete.



INCQUERY VALIDATOR



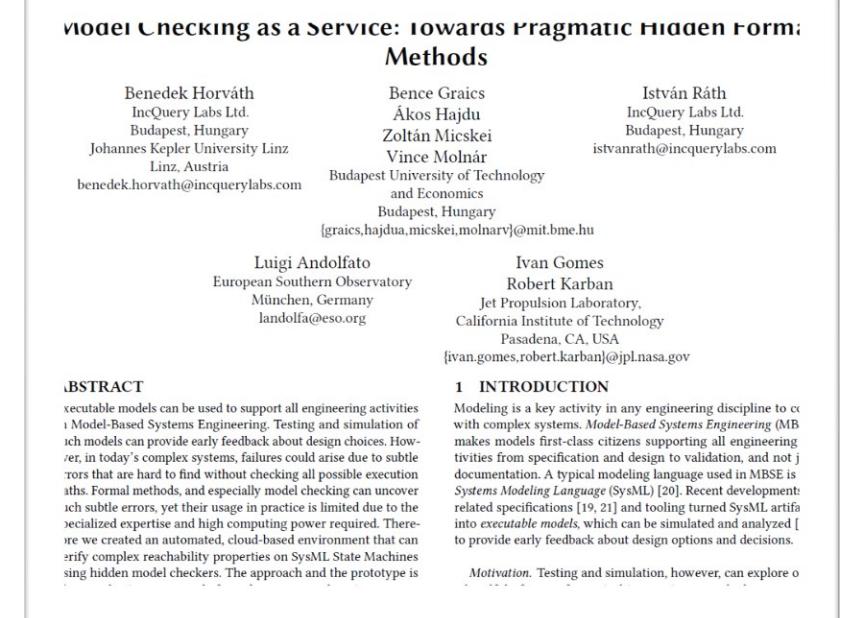
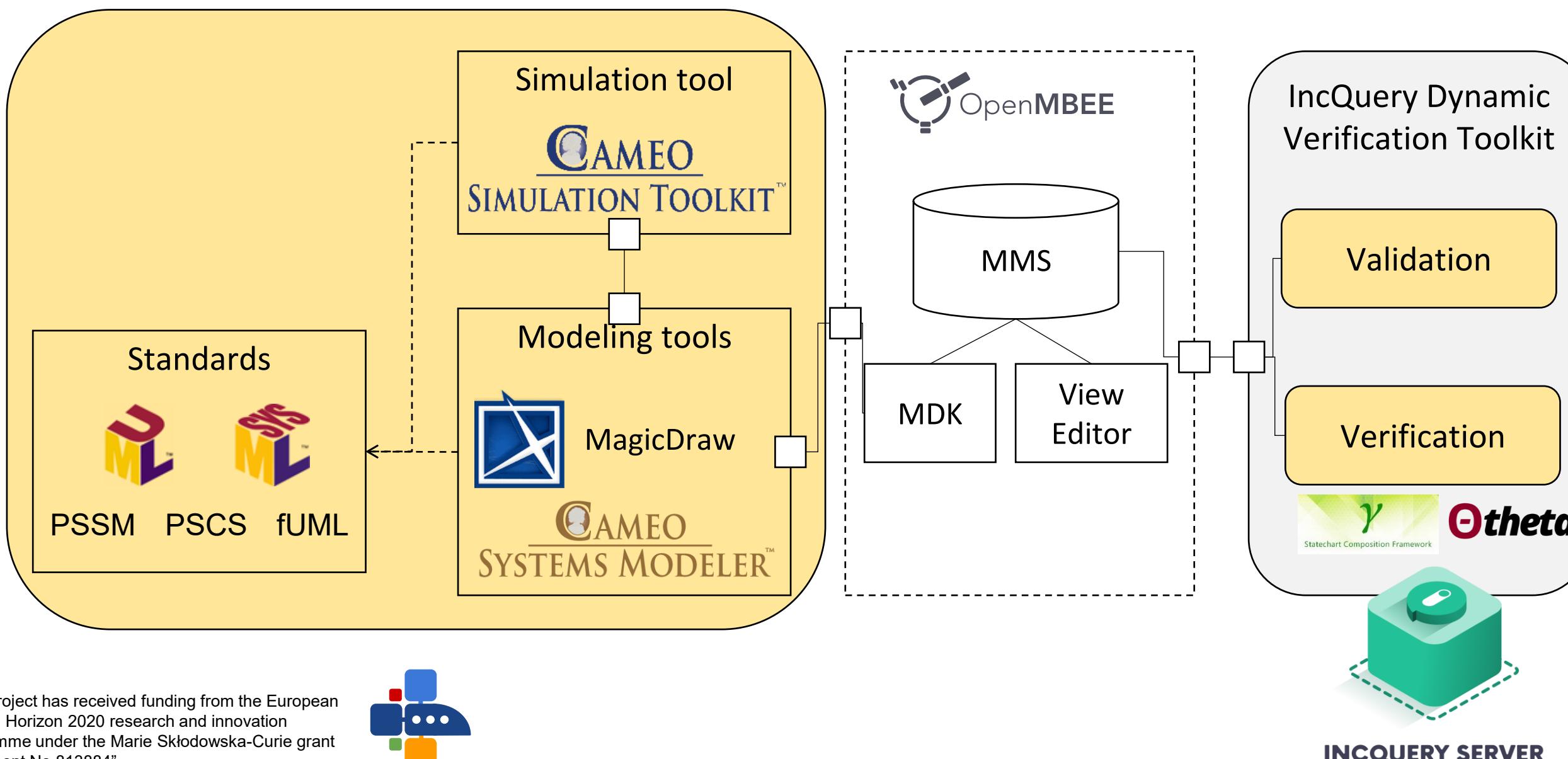
Simonyi Konferencia

Magyarország legnagyobb egyetemi
hallgatók által szervezett éves technológiai
konferenciája.

24. 03. 19.

Research collaboration: Pragmatic Verification of SysML

- Simulation, testing may not find every error
- "Holy grail" of hidden formal methods
 - Systematically checks the model by traversing state space
 - Automated bidirectional translation between engineering domain (SysML) and formal domain (timed automata)



B. Horváth, B. Graics, Á. Hajdu, Z. Micskei, V. Molnár, I. Ráth, L. Andolfato, I. Gomes, R. Karban: Model checking as a service: towards pragmatic hidden formal methods. MoDELs 2020: 37:1-37:5.

<https://doi.org/10.1145/3417990.3421407>



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Thank YOU

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