



MATLAB EXPO

Moonshots: How Engineers and Scientists Are Achieving the Impossible

Dr. Arun Mulpur, MathWorks





Courtesy of NASA



Courtesy of NASA



Courtesy of NASA

Moonshots Foster Emerging Technologies

Heat-resistant alloys



Courtesy of NASA

Fireproof fabrics



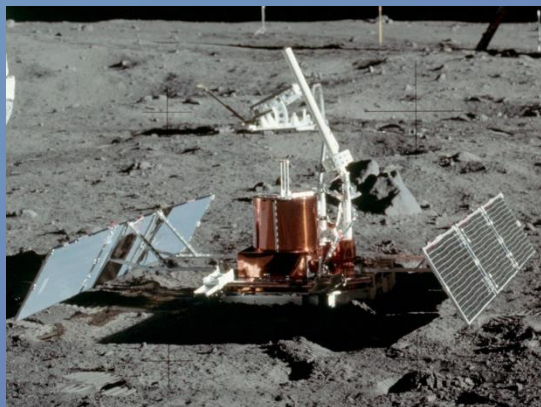
Courtesy of NASA

Freeze-dried foods



Photo by Jurvetson (flickr)
<https://creativecommons.org/licenses/by/2.0/>

Photovoltaic cells



Courtesy of NASA

Integrated circuits

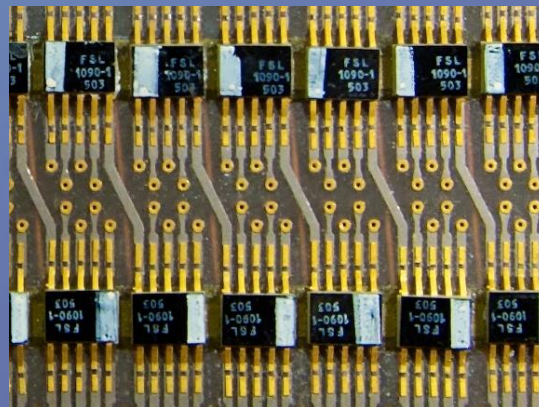


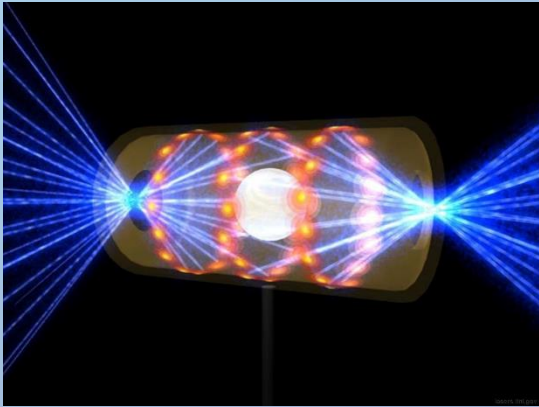
Photo by DDebold (flickr)
<https://creativecommons.org/licenses/by/2.0/>

Computers



Photo by Jurvetson (flickr)
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Moonshots: Projects with lofty and seemingly impossible goals



Moonshot: Unlimited Clean Energy

Global energy consumption will grow by almost 50% between 2020 and 2050

– **CNBC**





Fusion: The ultimate clean energy source

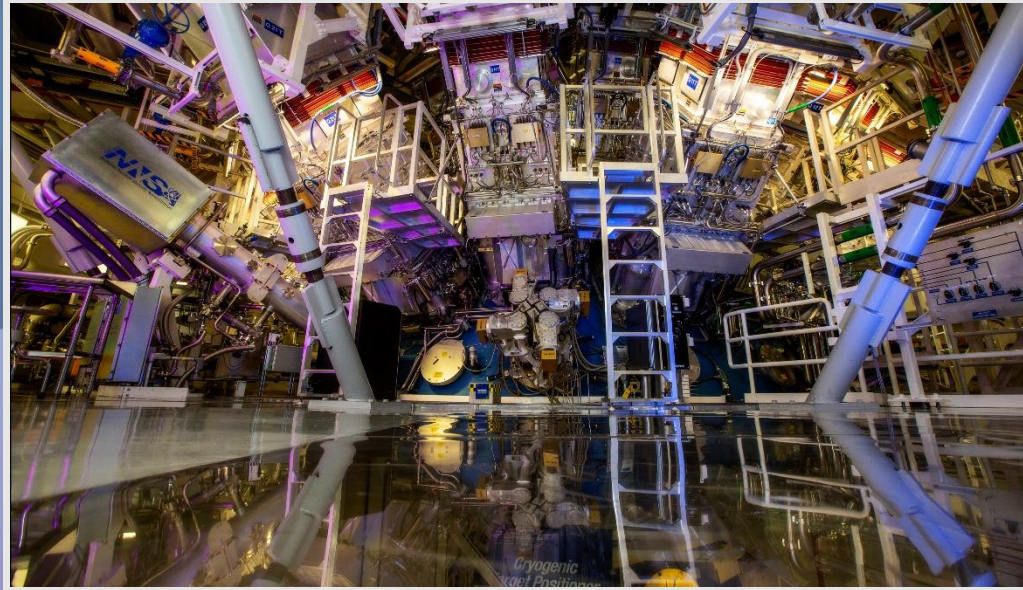
- No CO² or other harmful atmospheric emissions
- Safer than traditional fission reactors
- Abundant fuels

Moonshot: Unlimited Clean Energy



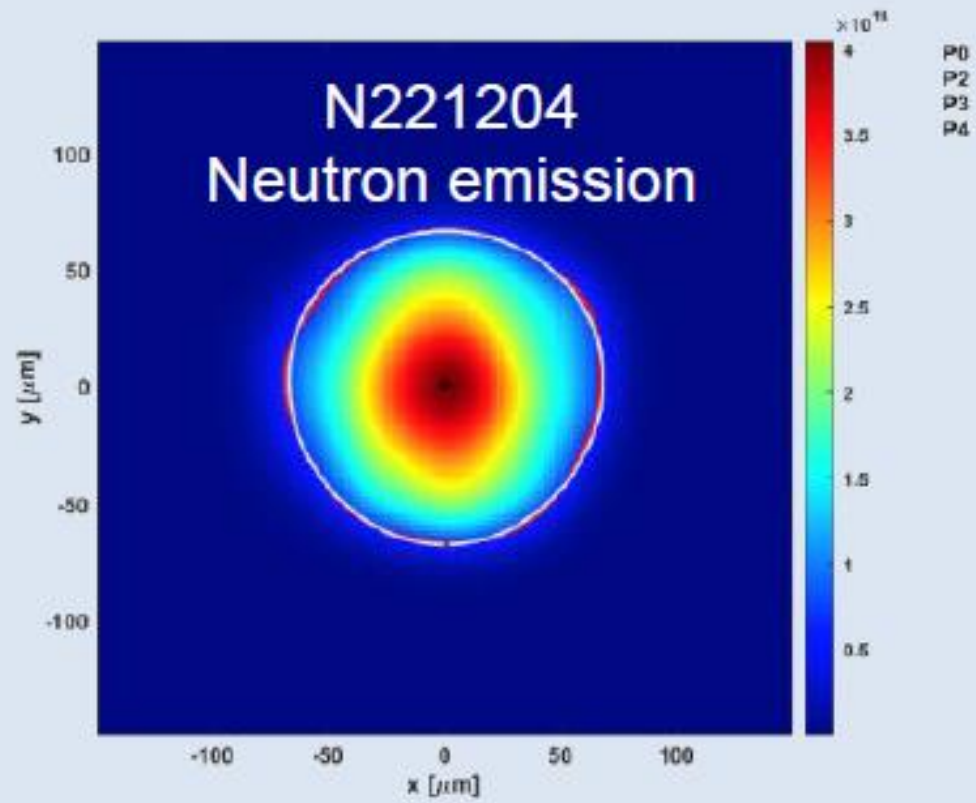
Scientists Achieve Nuclear Fusion Breakthrough With Blast of 192 Lasers

– *The New York Times*



Courtesy of Lawrence Livermore National Laboratory

Fusion Breakthrough



Fusion Breakthrough

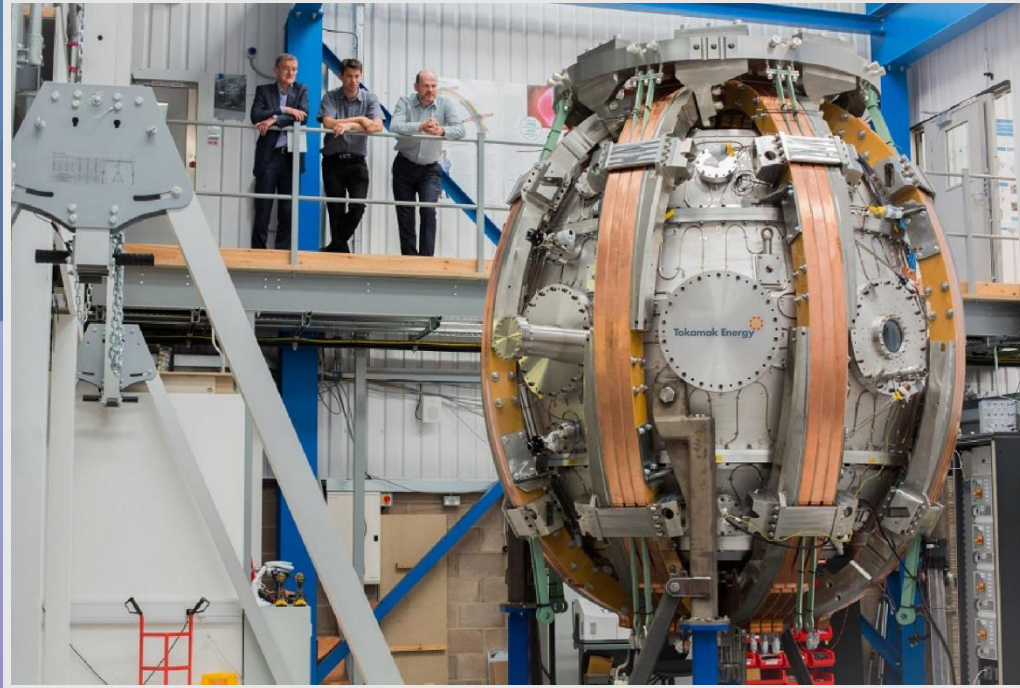
The image displays the MATLAB 7.0.0 (R2008a) software interface, which is divided into several functional areas:

- Development:** The top-left pane shows a file explorer with a project structure including folders like 'Analysis', 'Scripts', and 'Reports'. The main editor window contains MATLAB code for data acquisition and processing, such as `spike from ID9021 resetting +/- 30 sec` and `ans = ans.getPic('HTS-PID', from, until);`.
- Data Analysis:** The top-right pane, titled 'Figure 1', shows a line plot of 'Output V' versus 'Seconds'. The plot displays several data series (TT1, TT2, TT3, TT7) with a sharp peak at approximately 0 seconds. A yellow box labeled 'Data Analysis' is overlaid on this plot.
- Monitoring:** The bottom-left pane shows a workspace window with variables like 'ans', 'ans', 'ans', 'ans', and 'until' listed with their values. A yellow box labeled 'Monitoring' is overlaid on this window.
- Interactive Controls:** The bottom-middle pane shows MATLAB code for histogram generation and fitting, including `h = hist(stestdata(plotMask));` and `fit = fit(stestdata(plotMask), h, 'gauss');`. A yellow box labeled 'Interactive Controls' is overlaid on this code.
- Image Analysis:** The bottom-right pane, titled 'Figure 2', shows a grayscale image of a circular object, likely a fusion chamber. A yellow box labeled 'Image Analysis' is overlaid on this image.

Courtesy of Lawrence Livermore National Laboratory

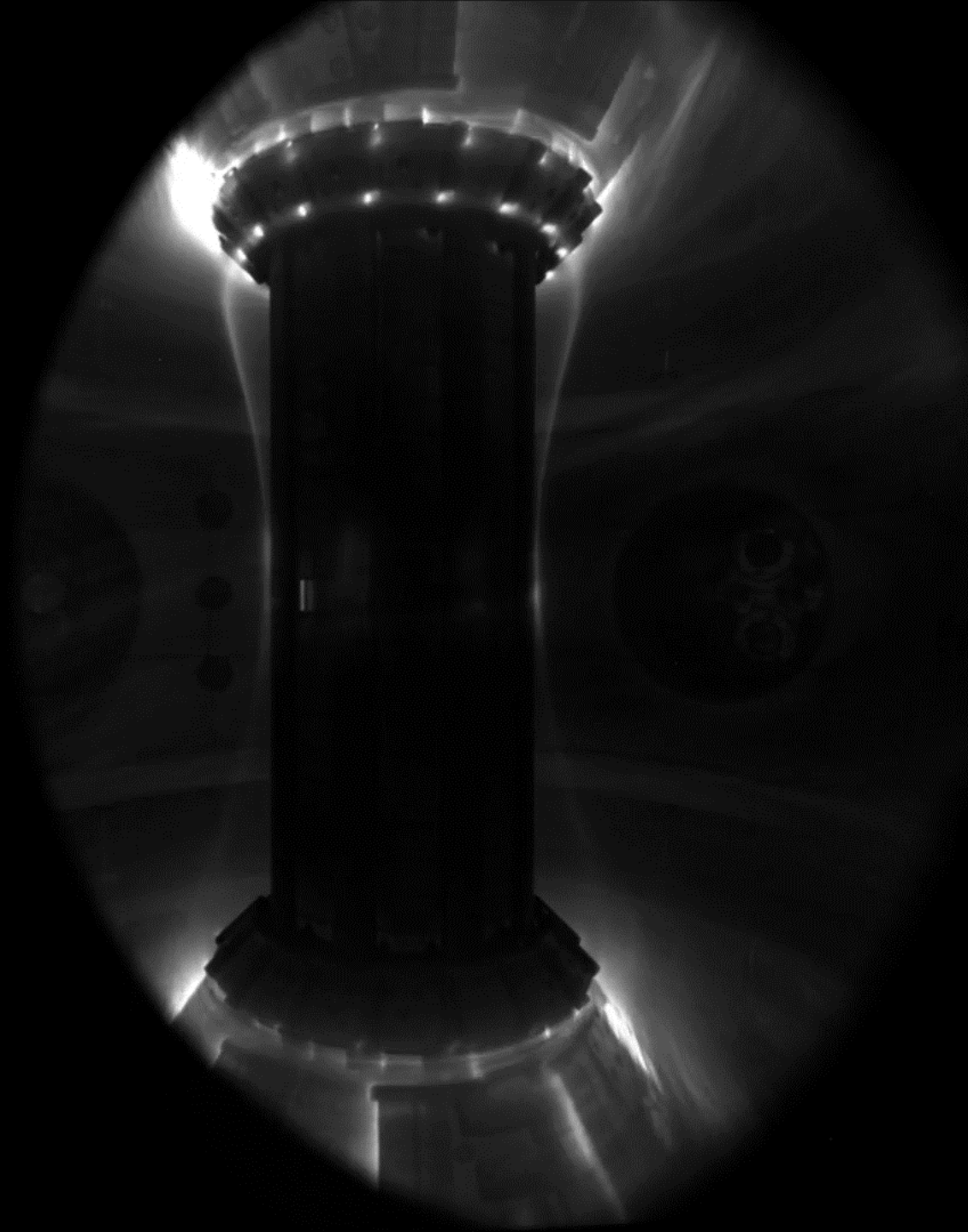
This Compact Tokamak Is on the Verge of Commercial Energy Production

– *Popular Mechanics*



Courtesy of Tokamak Energy

ST40 #10014



Achieving 100M° Celsius

Simulink and Simulink Coder for developing and deploying plasma control algorithms

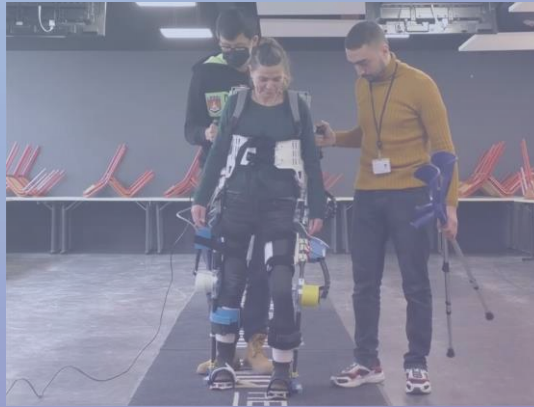
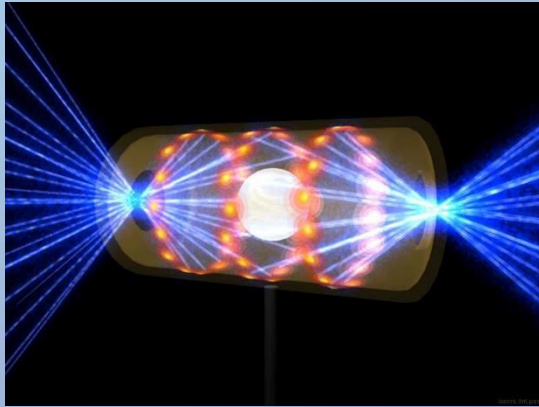
MATLAB for real-time and post-pulse data analysis

Achieving 100M° Celsius

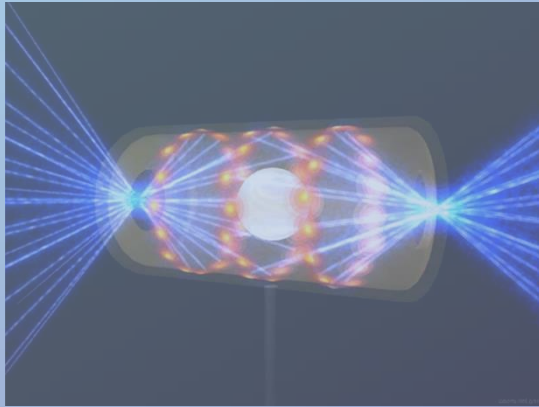


Courtesy of Tokamak Energy

Moonshots: Projects with lofty and seemingly impossible goals



Moonshots: Projects with lofty and seemingly impossible goals

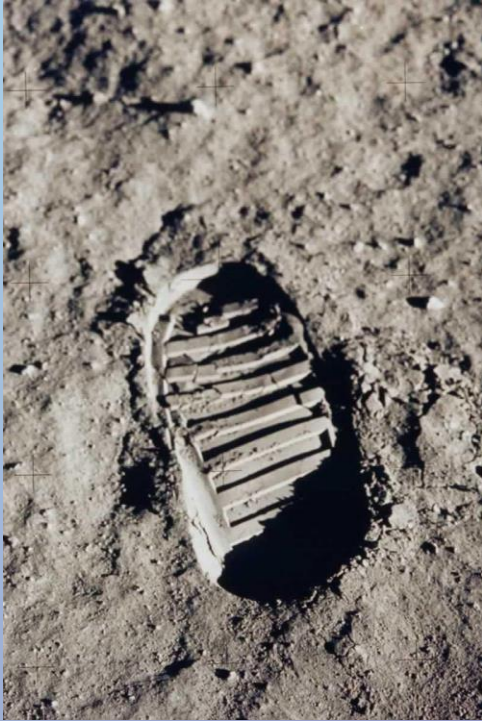




Moonshot: Improving Quality of Life through Healthcare



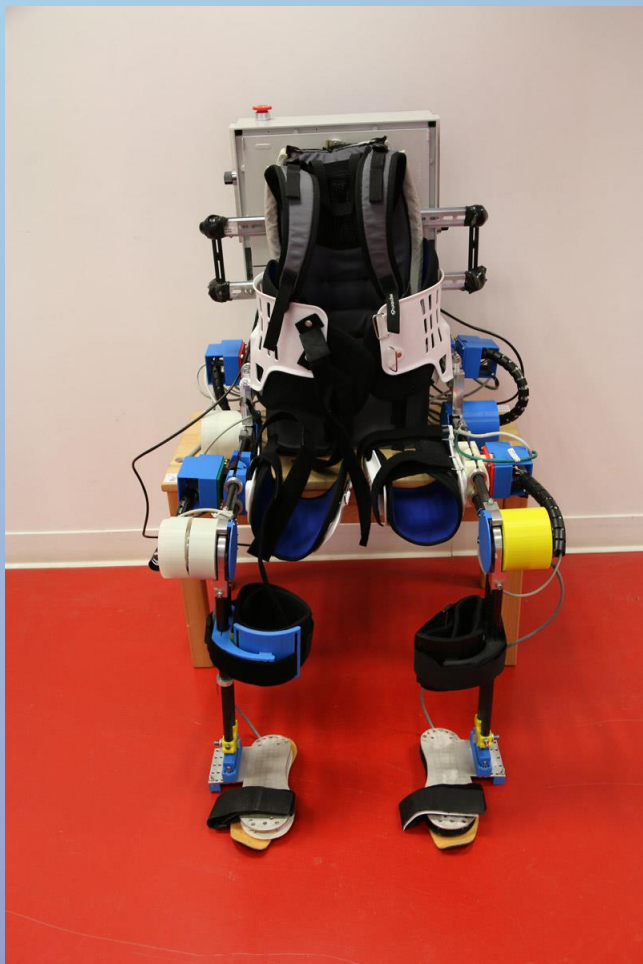
Empowering Children to Walk



Courtesy of NASA

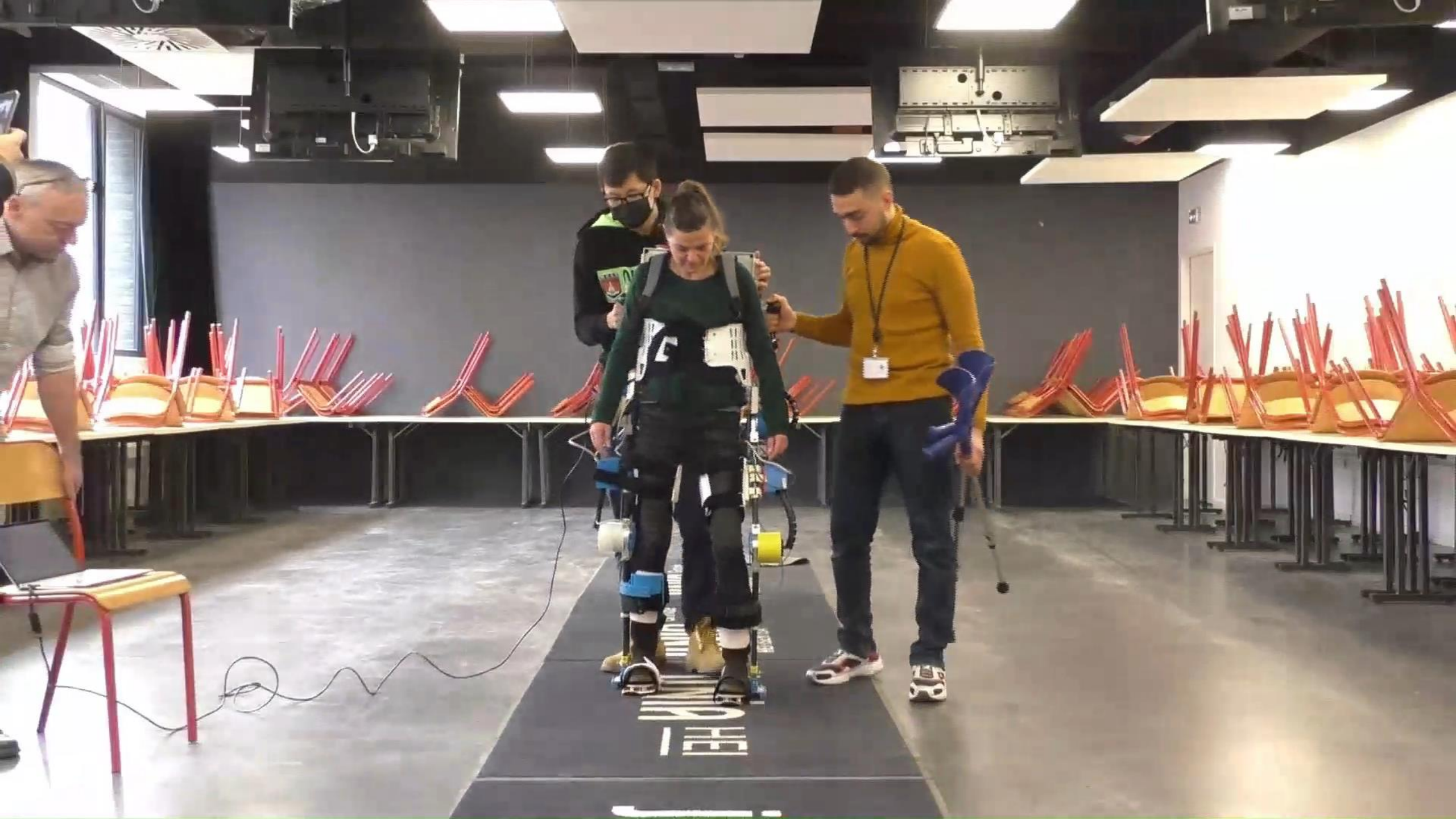


Empowering Children to Walk



Empowering Children to Walk

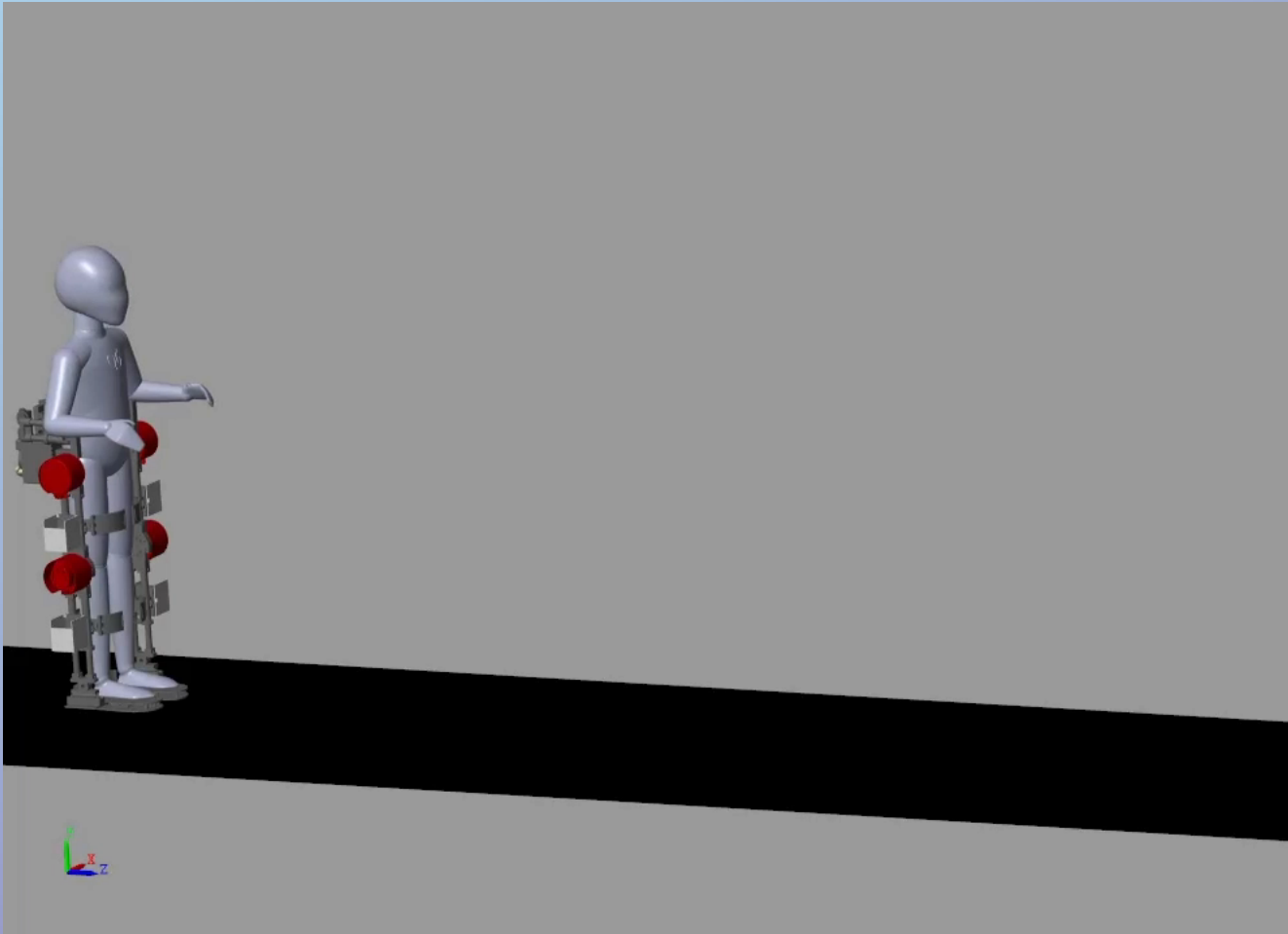




“Designing in C++, you have a lot of code to enter to realize one functionality. Model-Based Design with MATLAB and Simulink was really a **timesaving tool** for us.”

—Yang Zhang, postdoctoral researcher at JUNIA HEI

Empowering Children to Walk



Moonshot: Improving Quality of Life through Healthcare





Fighting Parkinson's Disease with AI

More than 10 million people worldwide with Parkinson's disease



20
uV/D Dep. Gain: 20 uV/D

Plan 1

Center

0.00

0.00
0.00

20 uV

Play

DD

DT

Segment 1

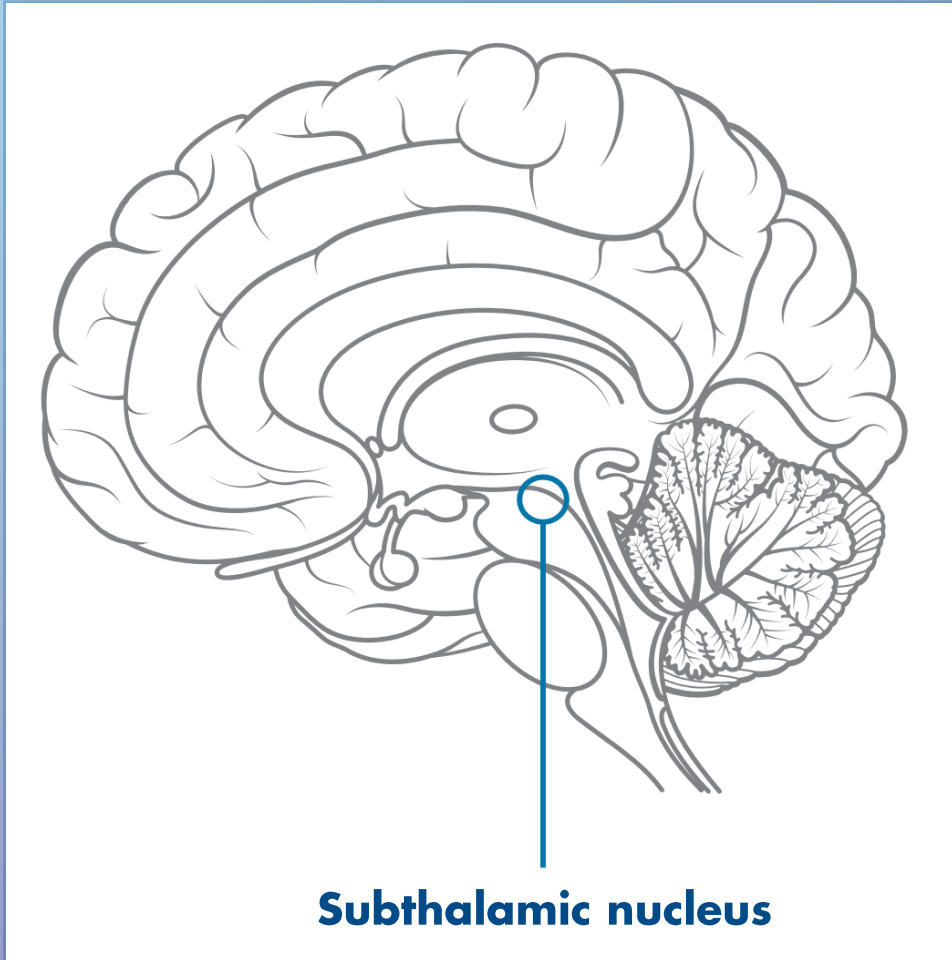
Center

10.0

8.0



Fighting Parkinson's Disease with AI



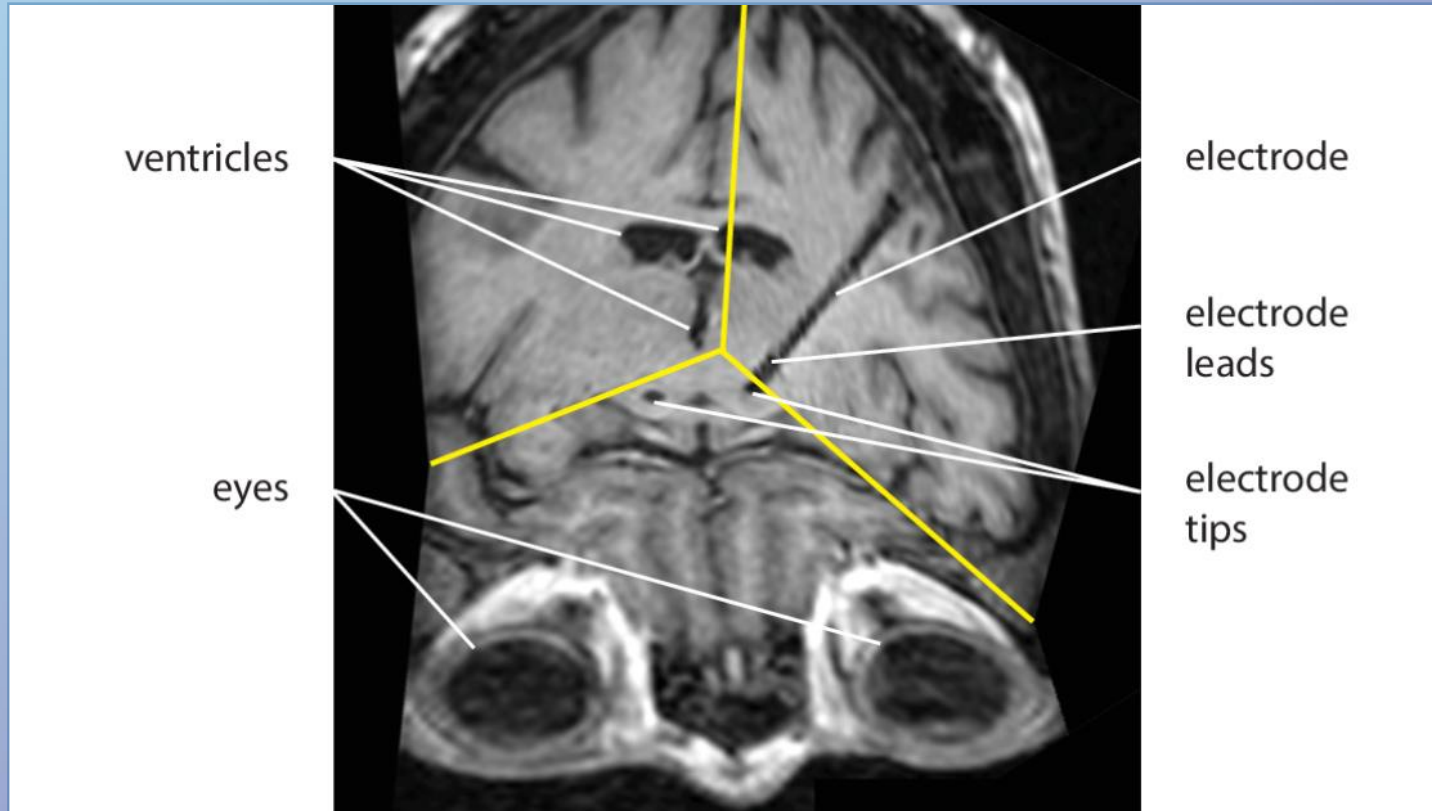
“A **neurological minefield** surrounds the subthalamic nucleus. If you put the electrode in the wrong spot, it can severely alter the patient’s emotions.”

—Dr. Konrad Ciecierski, assistant professor at NASK

Fighting Parkinson's Disease with AI

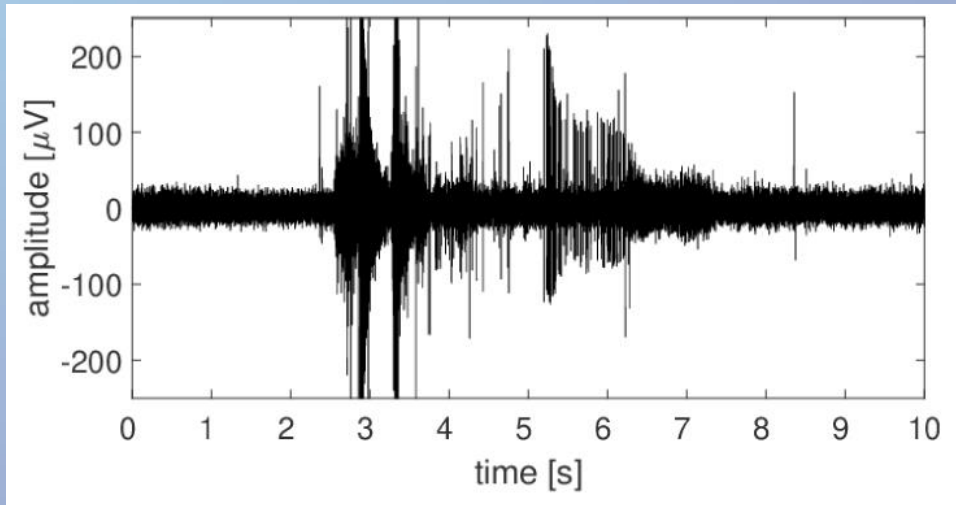


Fighting Parkinson's Disease with AI



Fighting Parkinson's Disease with AI

Original
Signal



Fighting Parkinson's Disease with AI

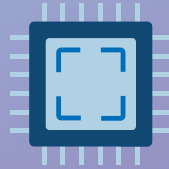
Data Cleansing
and Preparation



AI Modeling
and Tuning

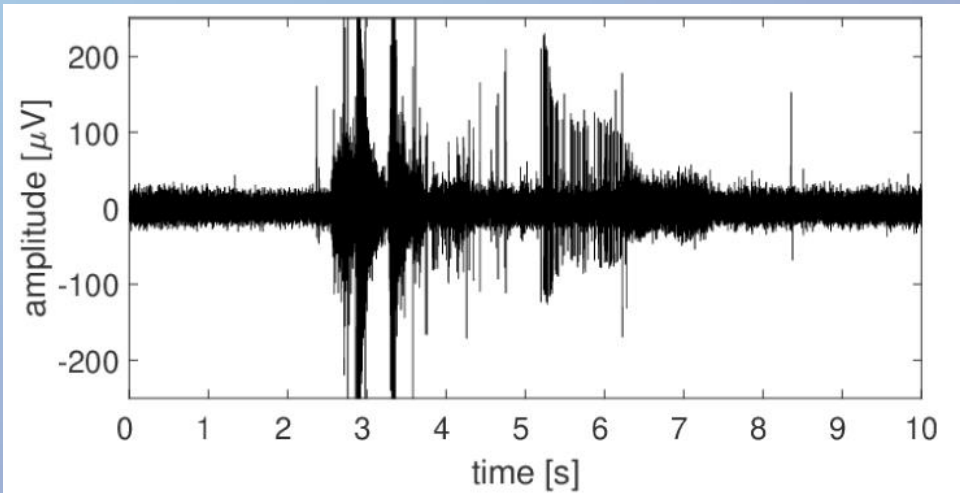


Deployment

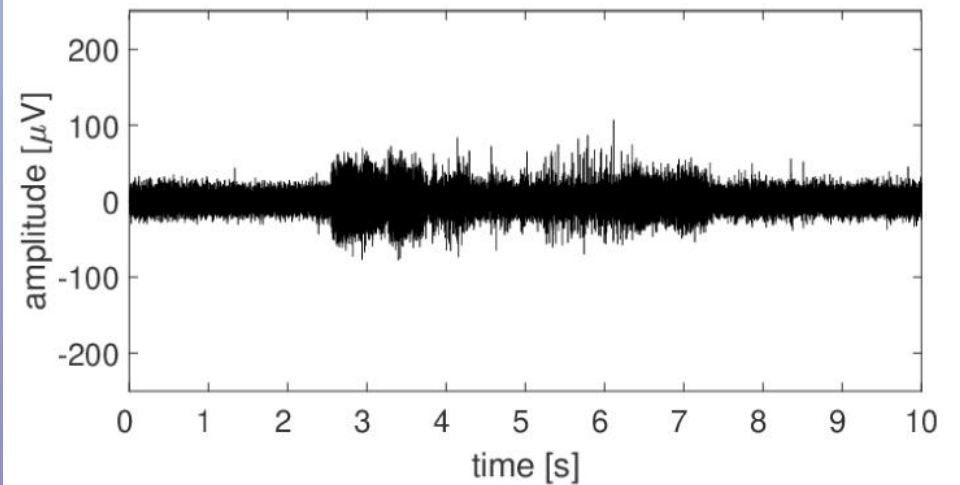


Fighting Parkinson's Disease with AI

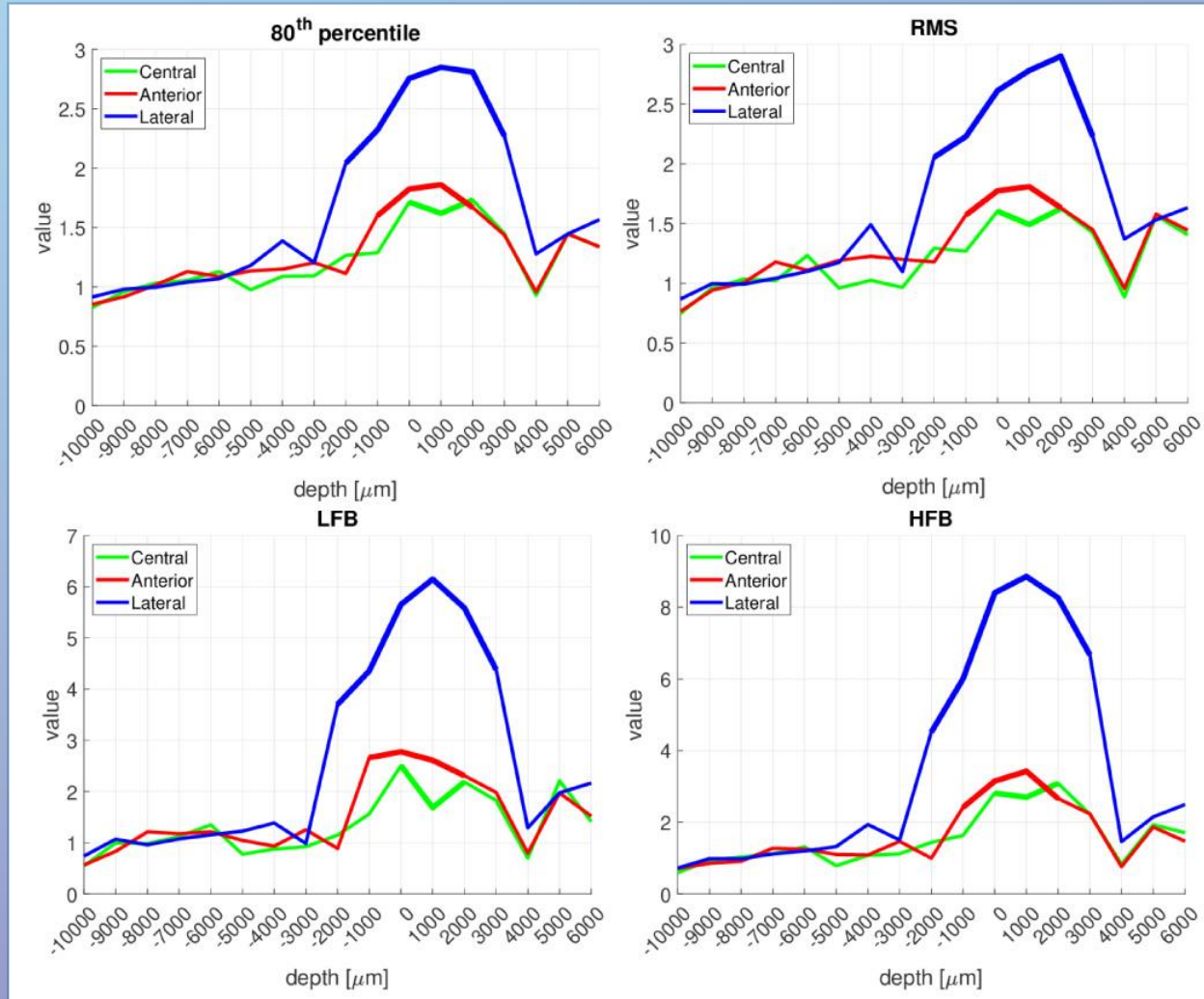
Original
Signal



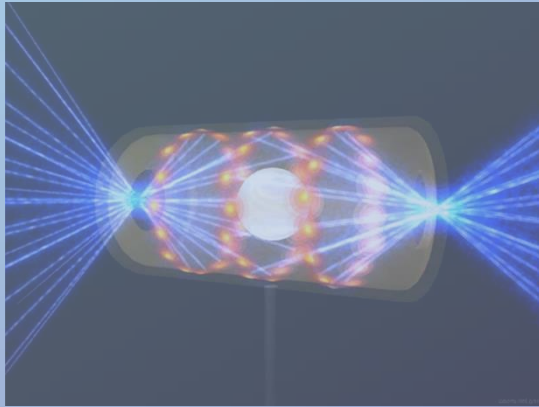
Filtered
Signal



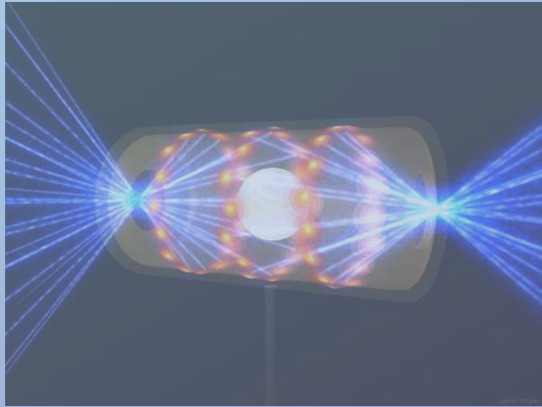
Entire process takes only 2 minutes
and is 97% accurate



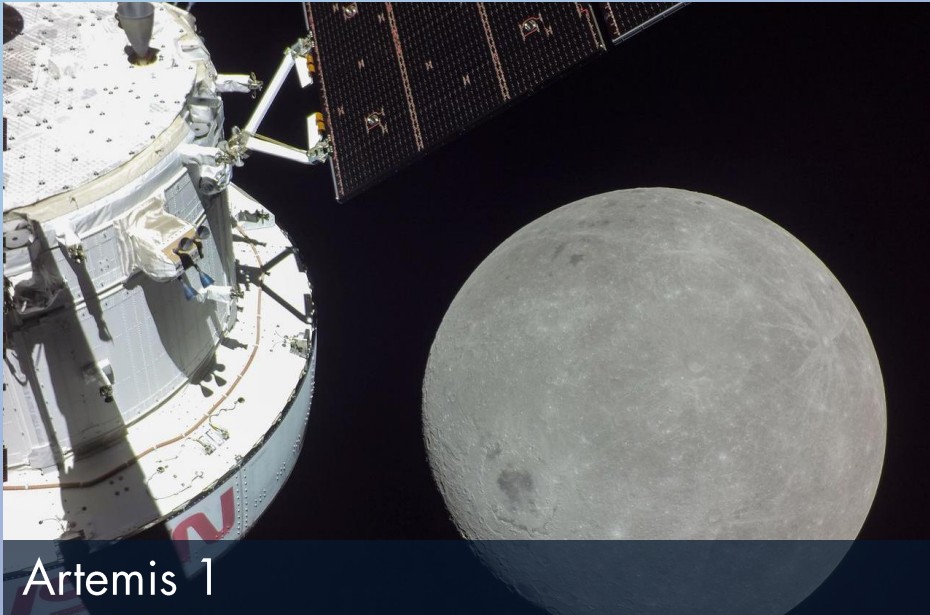
Moonshots: Projects with lofty and seemingly impossible goals



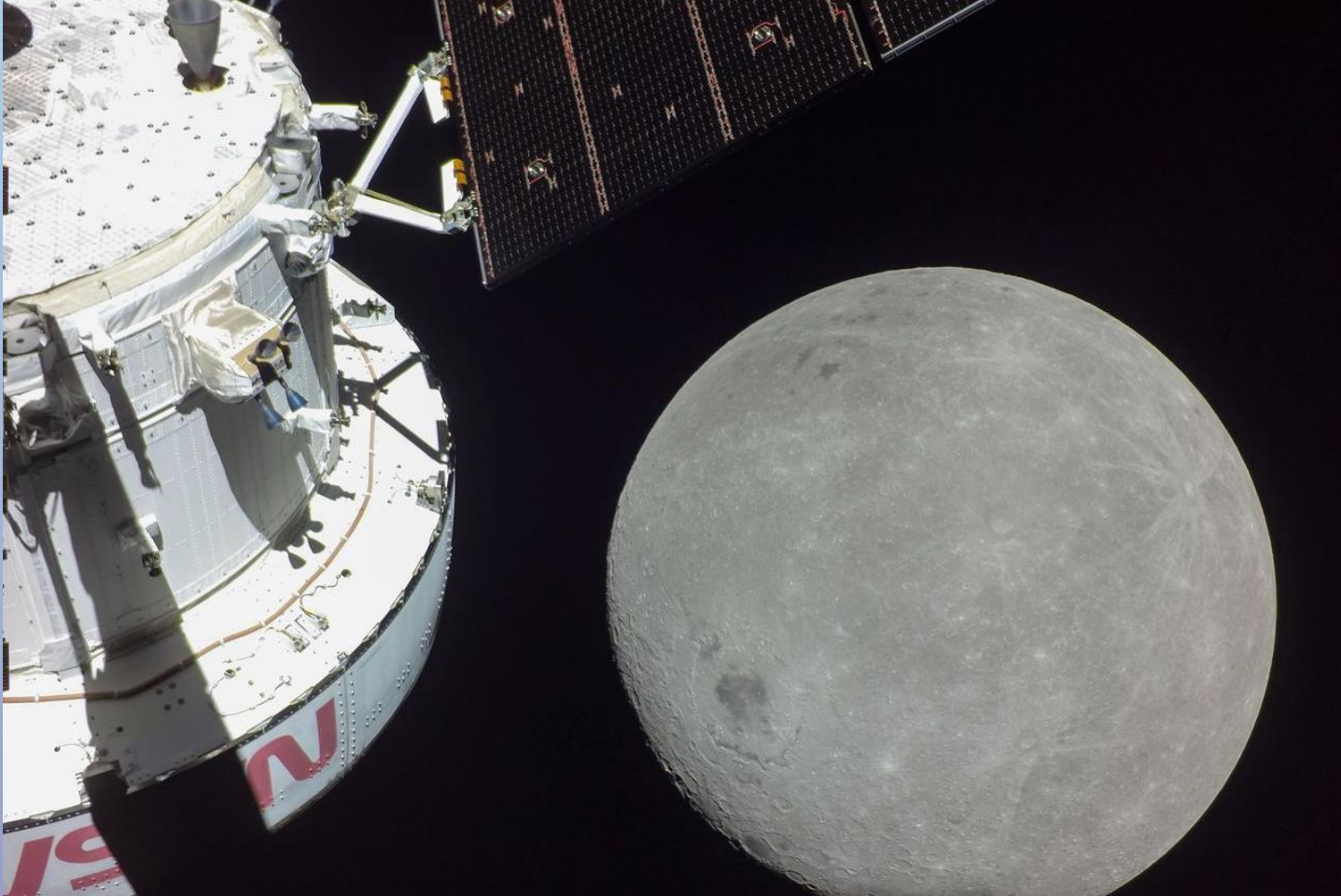
Moonshots: Projects with lofty and seemingly impossible goals



Moonshot: Space Exploration



To the Moon and Beyond

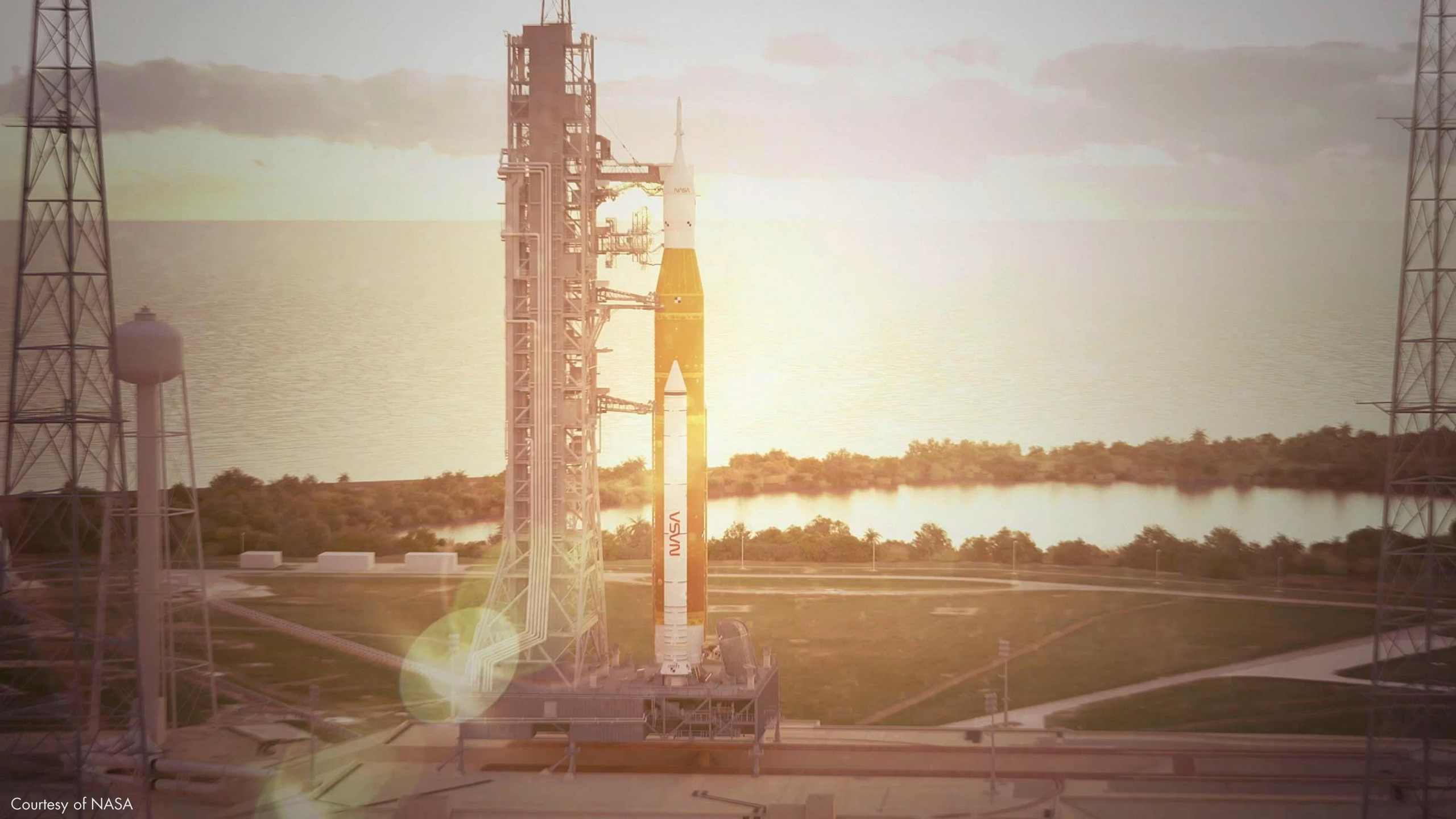


Courtesy of NASA

To the Moon and Beyond



Courtesy of NASA









Orion Power System
Analysis

Simscape Electrical

Mission Management
Algorithm Validation

Stateflow

Orion Guidance, Navigation
and Controls Design

MATLAB

Simulink

Embedded Coder

Launch Tower Modeling

Simscape

Simscape Fluids



Courtesy of NASA

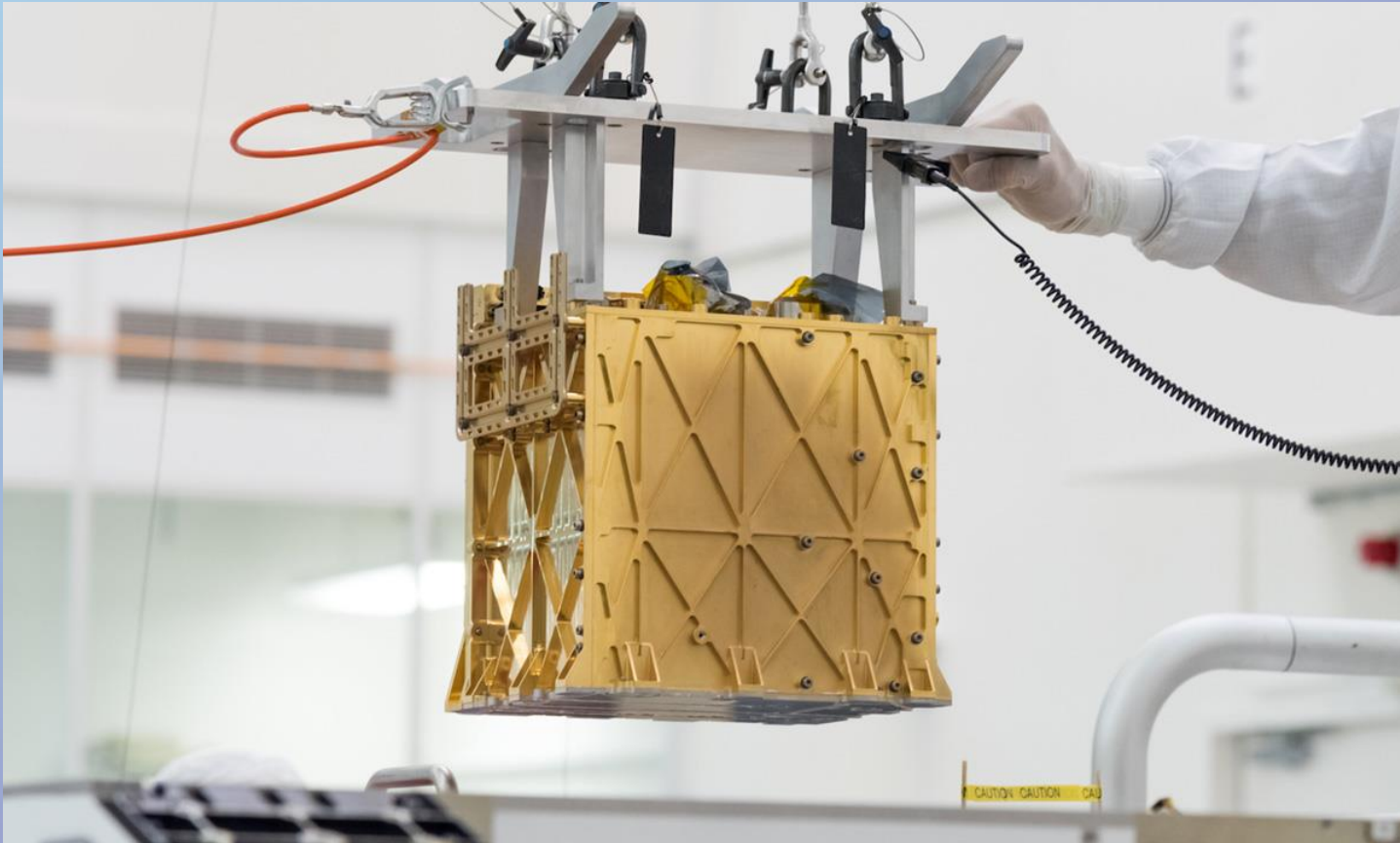


Making Oxygen on Mars

Challenge: 25 metric tons of oxygen required to support a four-person crew, costing billions

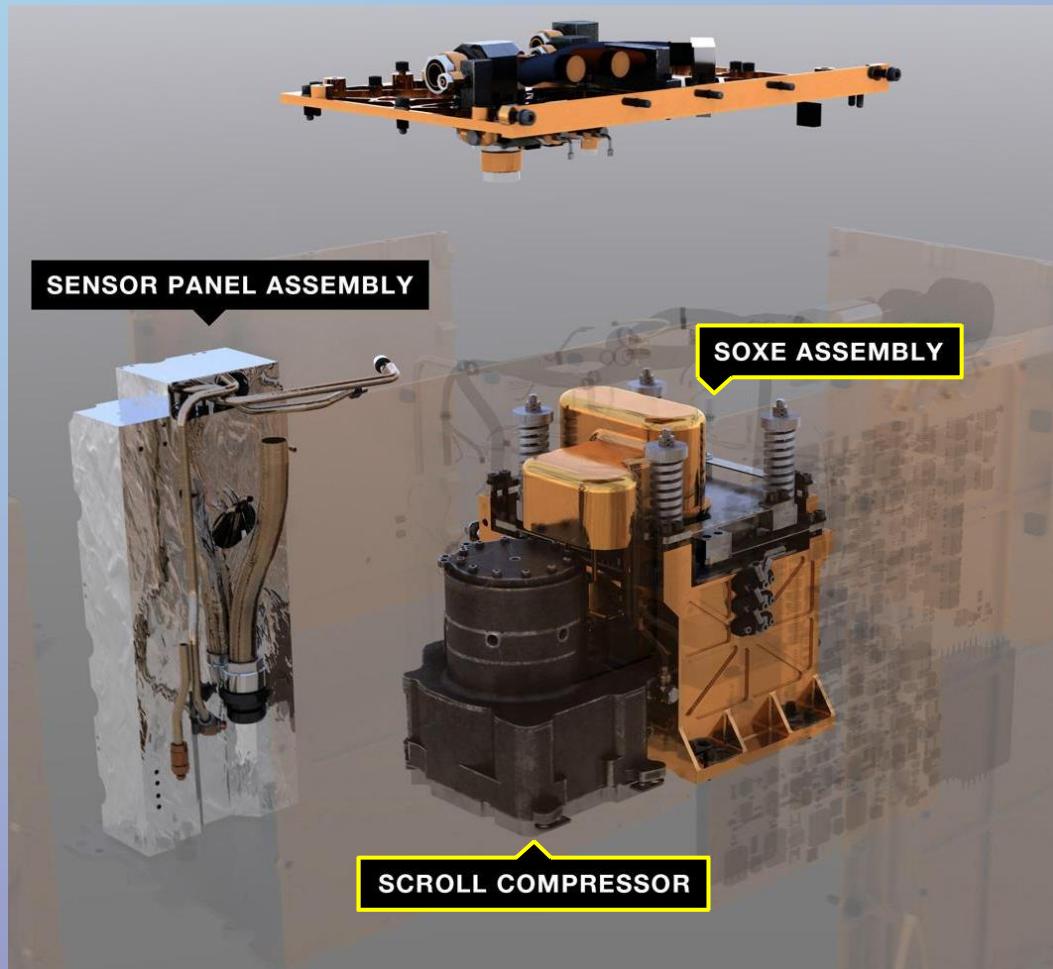
Solution: Extract oxygen from the atmosphere by separating it from carbon dioxide

Making Oxygen on Mars



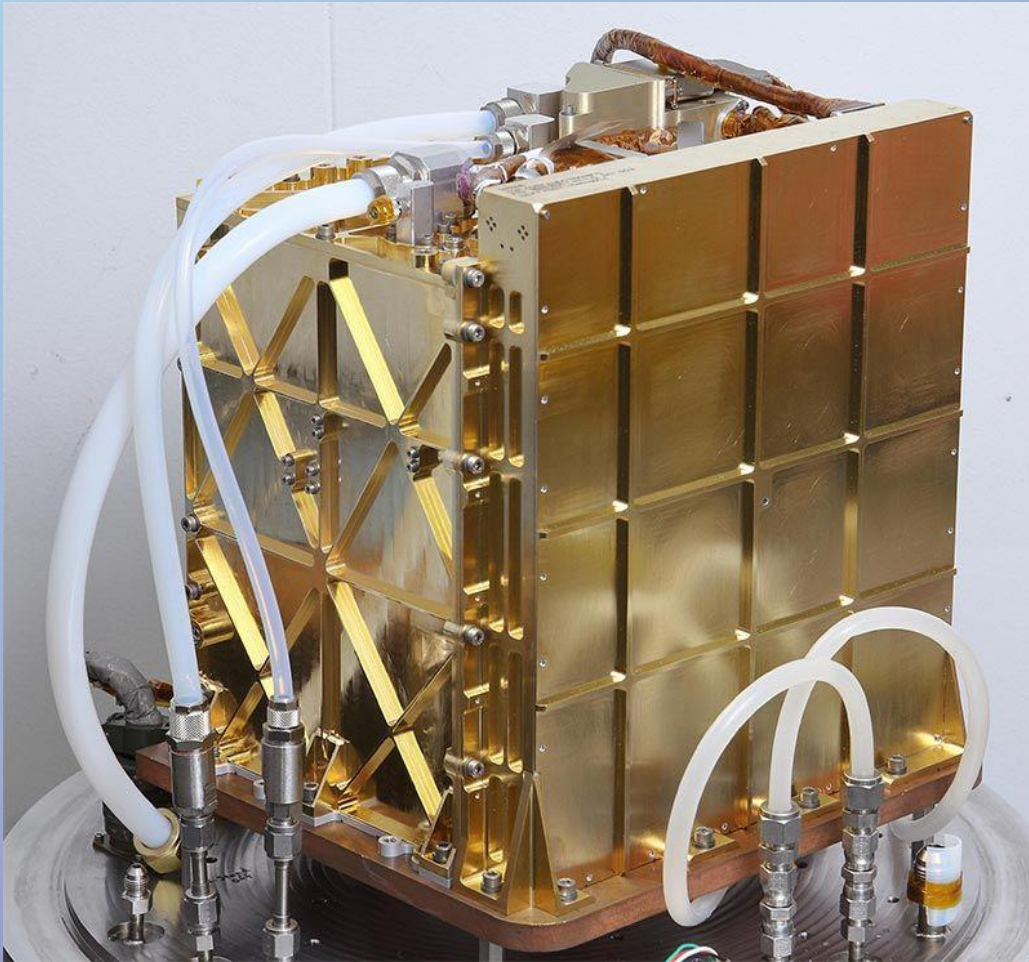
Courtesy of NASA

Making Oxygen on Mars



Courtesy of NASA

Making Oxygen on Mars




Courtesy of NASA


Making Oxygen on Mars

MOXIE Simulation Controller

MOXIE Simulation Controller File View Hardware Model I/O RCT Help



MOXIE Simulation Controller | MARS 2020



MOXIE Flight Dynamics Systems Model Primary Inputs

Mars Parameters

Input Mars Parameters By:
Location Atmospheric Conditions

Input Location
Use Pre-created MCD Dataset? Yes No

Location

Latitude °

Longitude °

Sol of Year

Time of Sol

Weather Event

Visualize Location on Mars Map

MOXIE Parameters

Compressor RPM Offset

SOXE Parameters

Temperature (°C)

Operating Current (A)

Run Simulation

Simulation Time (s)

Off On Optimize Performance

Extracted Mars Parameters

Ambient CO Fraction	<input type="text"/>	Ambient O2 Fraction	<input type="text"/>
Temperature (C)	<input type="text"/>	Pressure (mbar)	<input type="text"/>

Outputs 3/6 | Outputs 4/6 | Outputs 5/6 | Outputs 6/6 | Summary: Maxes/Averages

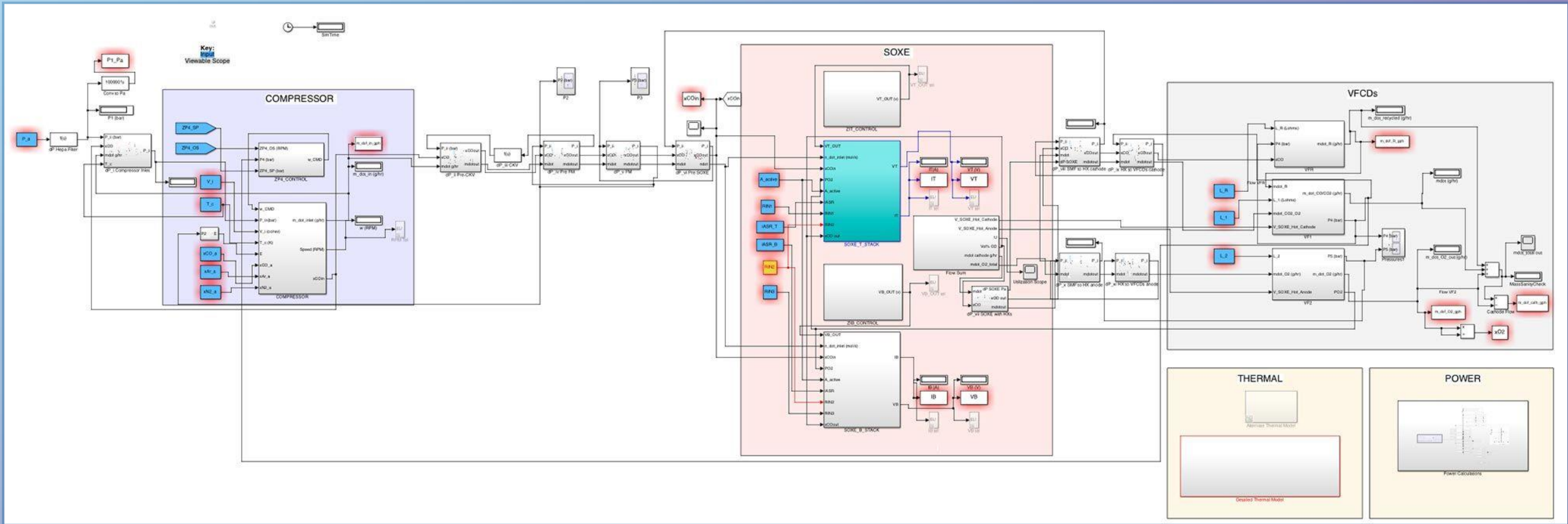
Cell Temperature (Across Cells 1-10)

Temperature (T) vs Time (s)

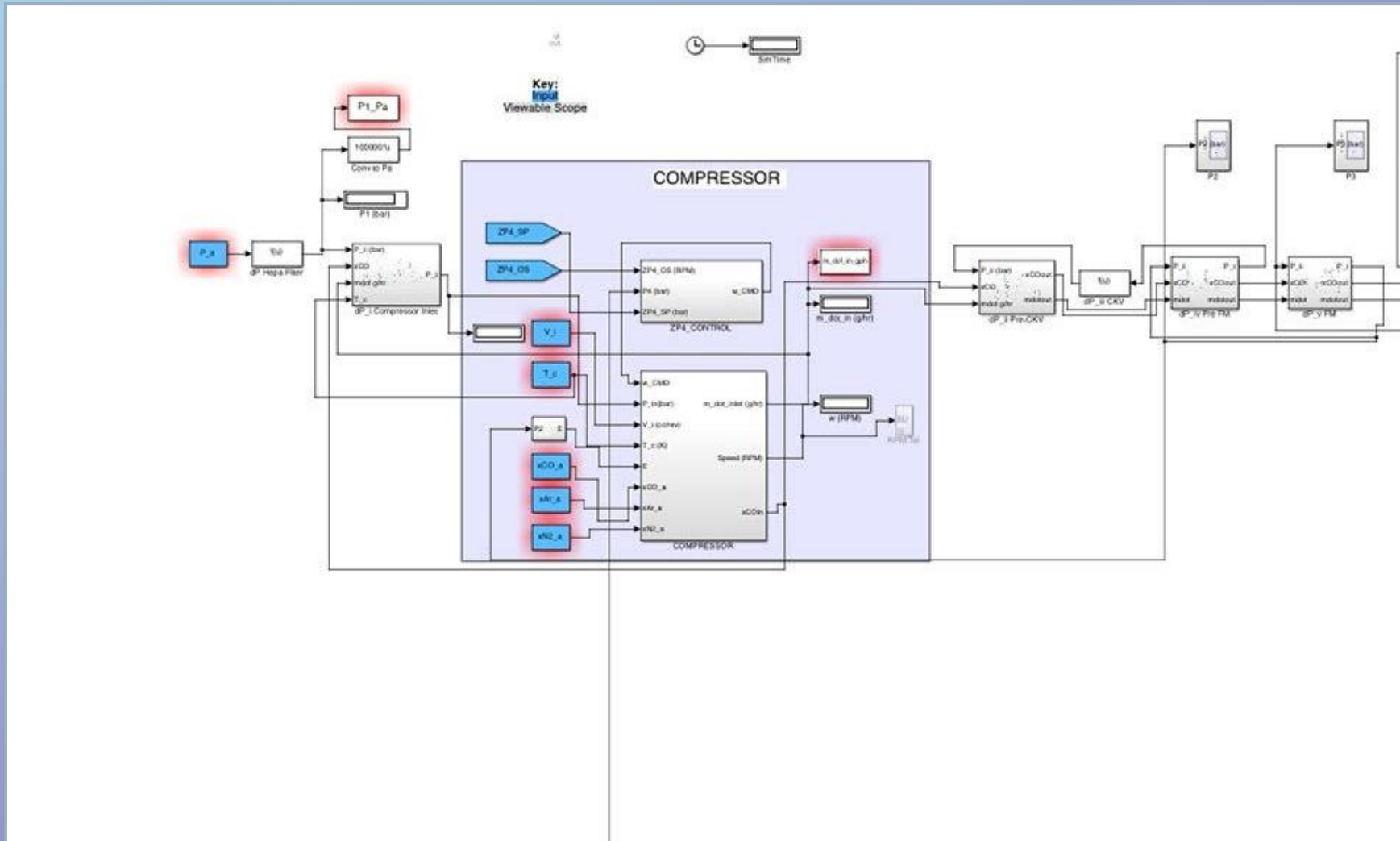
Oxygen Production Rate

Production (g/hr) vs Time (s)

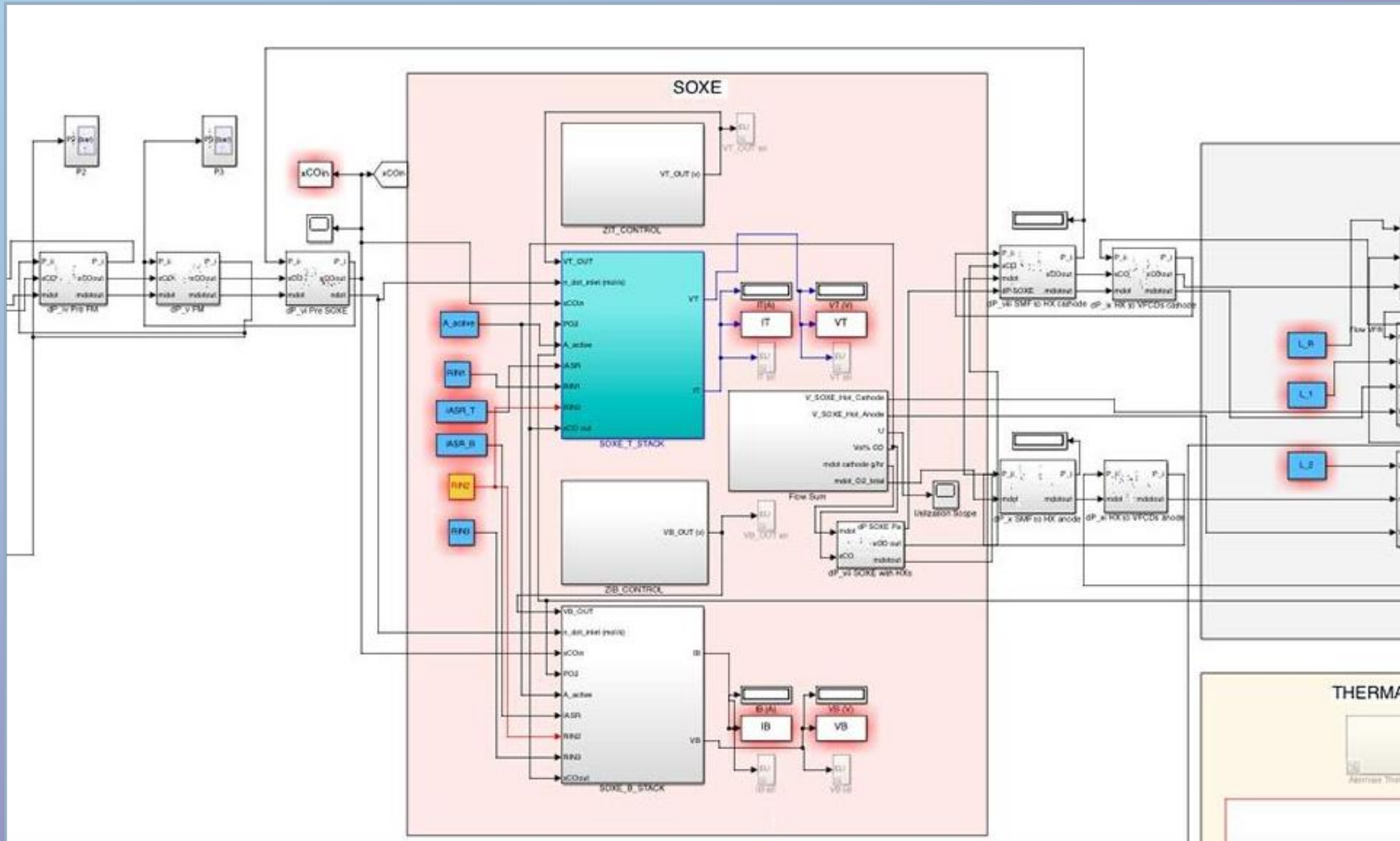
Simulink Model for MOXIE



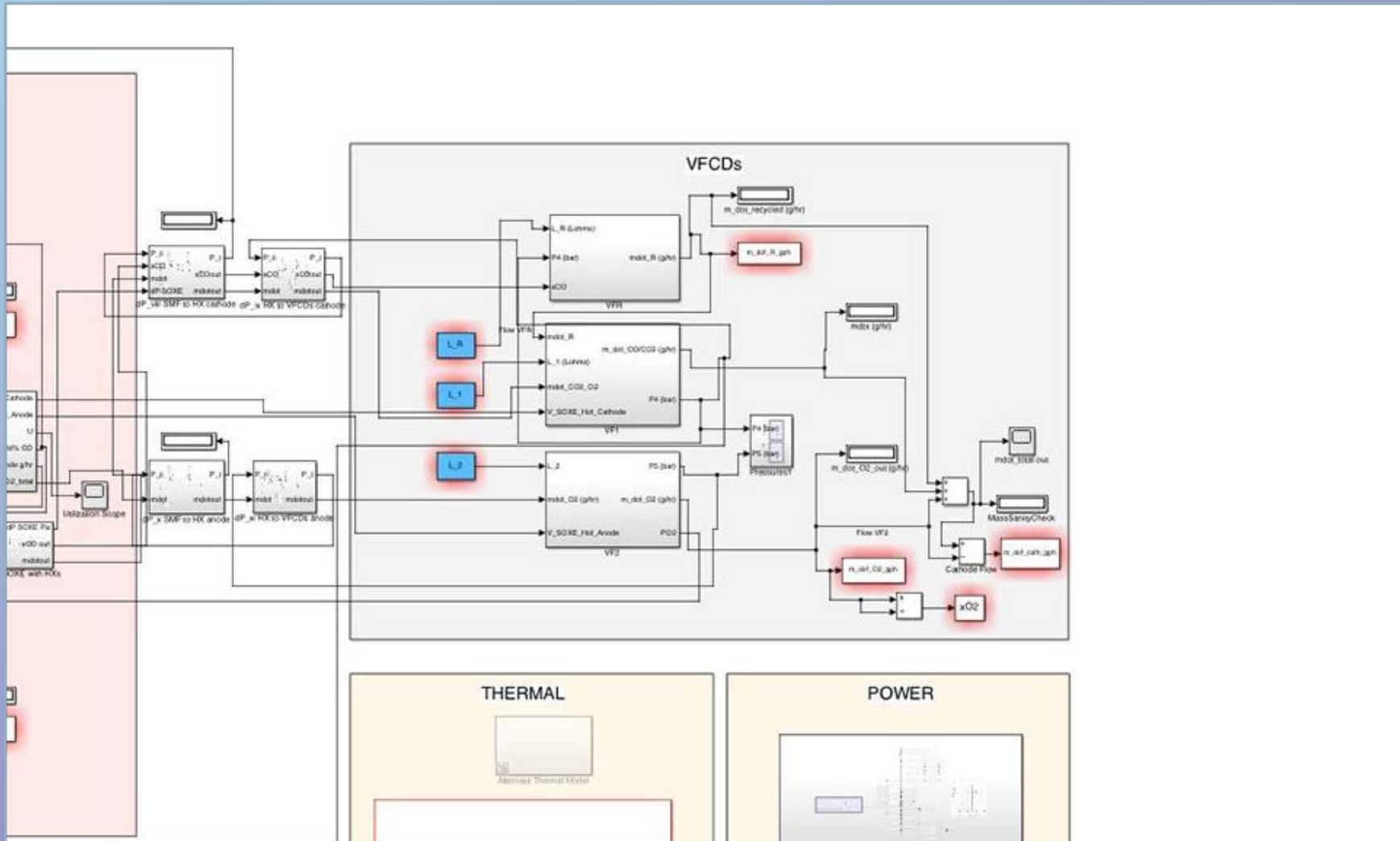
Simulink Model for MOXIE



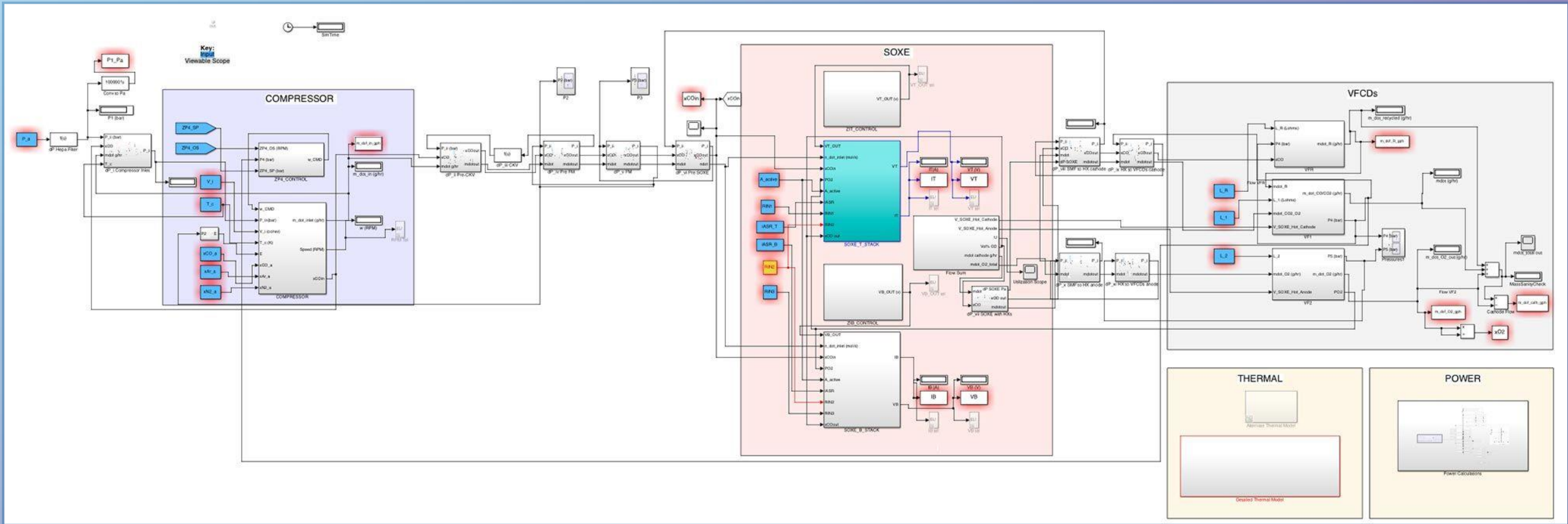
Simulink Model for MOXIE



Simulink Model for MOXIE

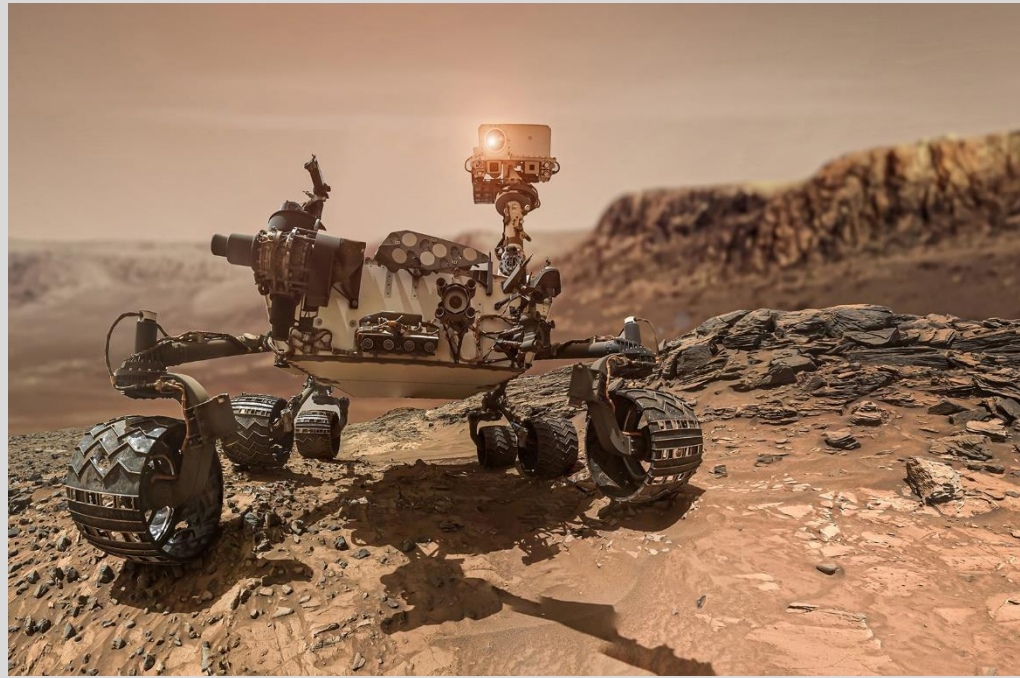


Simulink Model for MOXIE



Perseverance rover just made oxygen on Mars

– CNN



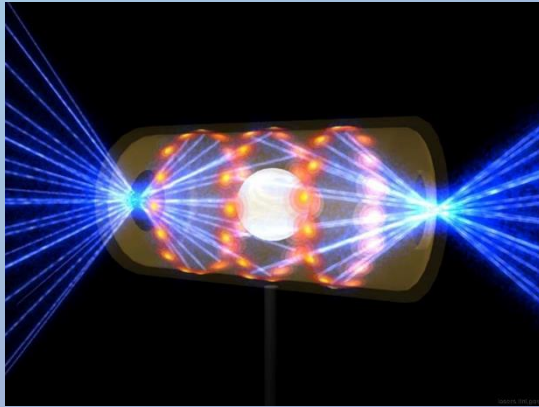
Making Oxygen on Mars

Simulink for modeling three control loops: internal pressure, temperature, and voltage

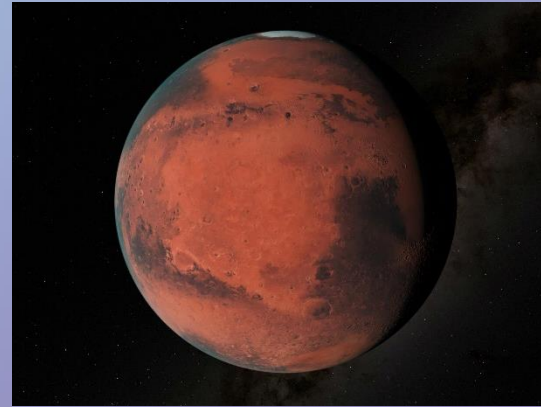
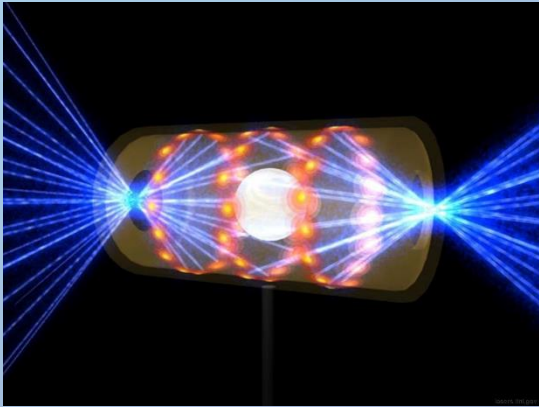
MATLAB for optimizing hardware layout, minimizing mass, and simulating conditions



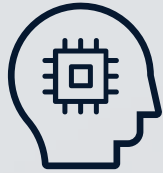
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MATLAB EXPO



AI



Algorithm Development
and Data Analysis



Autonomous Systems and
Robotics



Cloud, Enterprise, and
DevOps



Electrification



Modeling, Simulation,
and Implementation



Preparing Future Engineers
and Scientists



Wireless Connectivity
and Radar

MATLAB EXPO

Thank you



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