

An Autonomous Nuclear Waste Monitoring System - a Design Challenge

KNOO Annual Meeting

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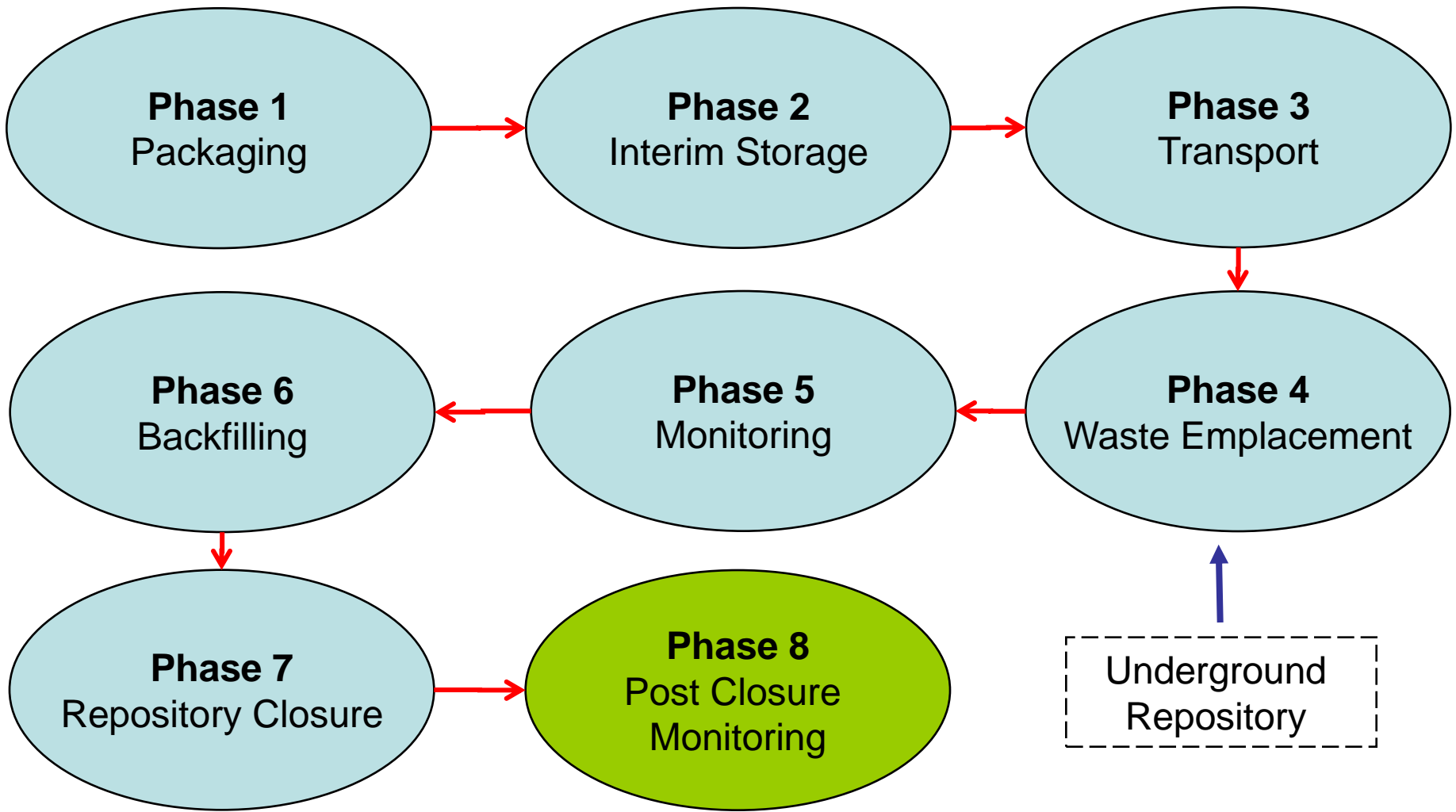
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Overview

- Nuclear Waste – The phase disposal concept
- Objective / Monitoring concept
 - System Architecture
 - Design Challenges
- Energy Source
 - Concept Selection Process
 - Chosen topology
 - Preliminary Results
- Summary

Nuclear Waste – Phase Disposal Concept*

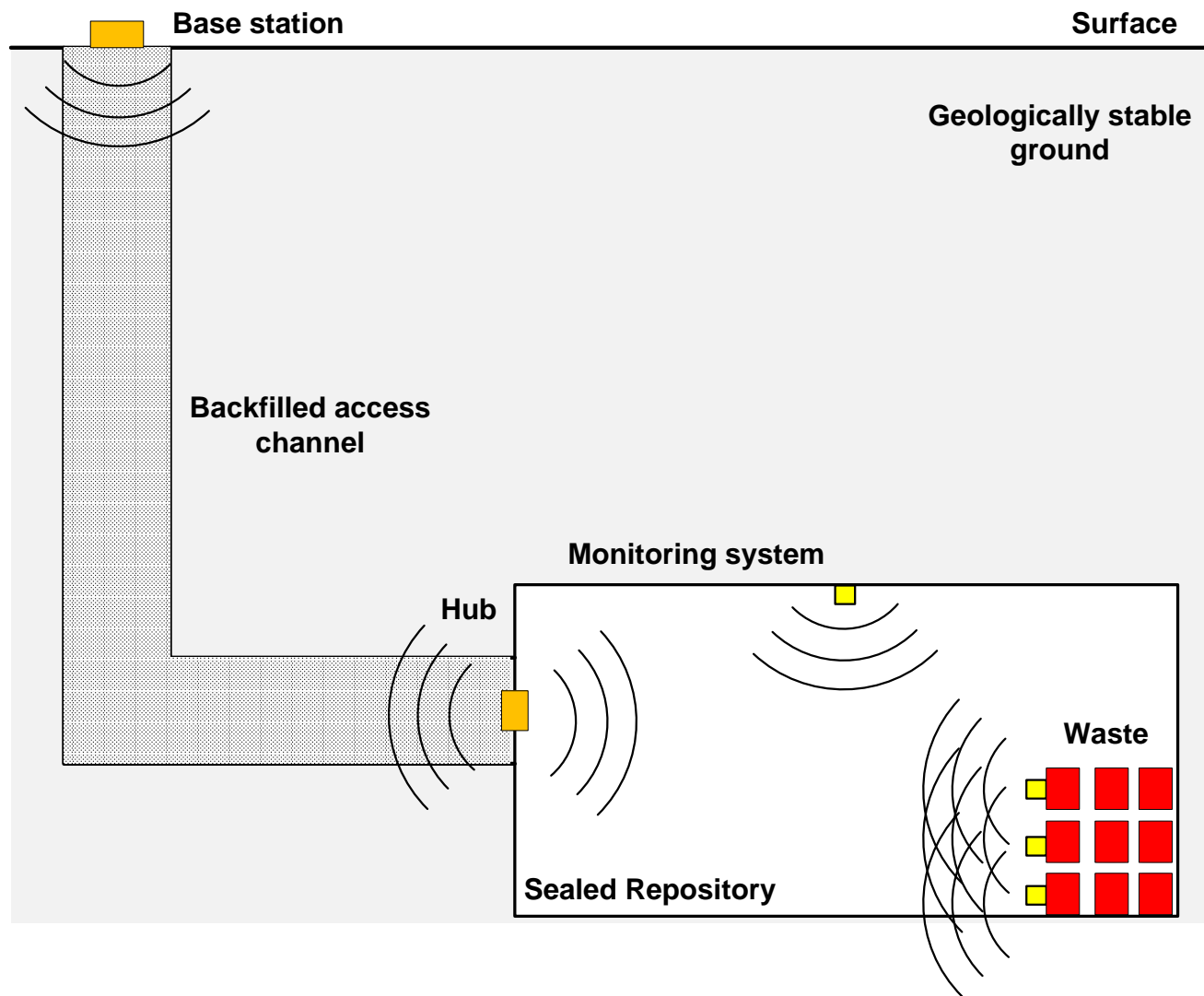


Objective – the egg

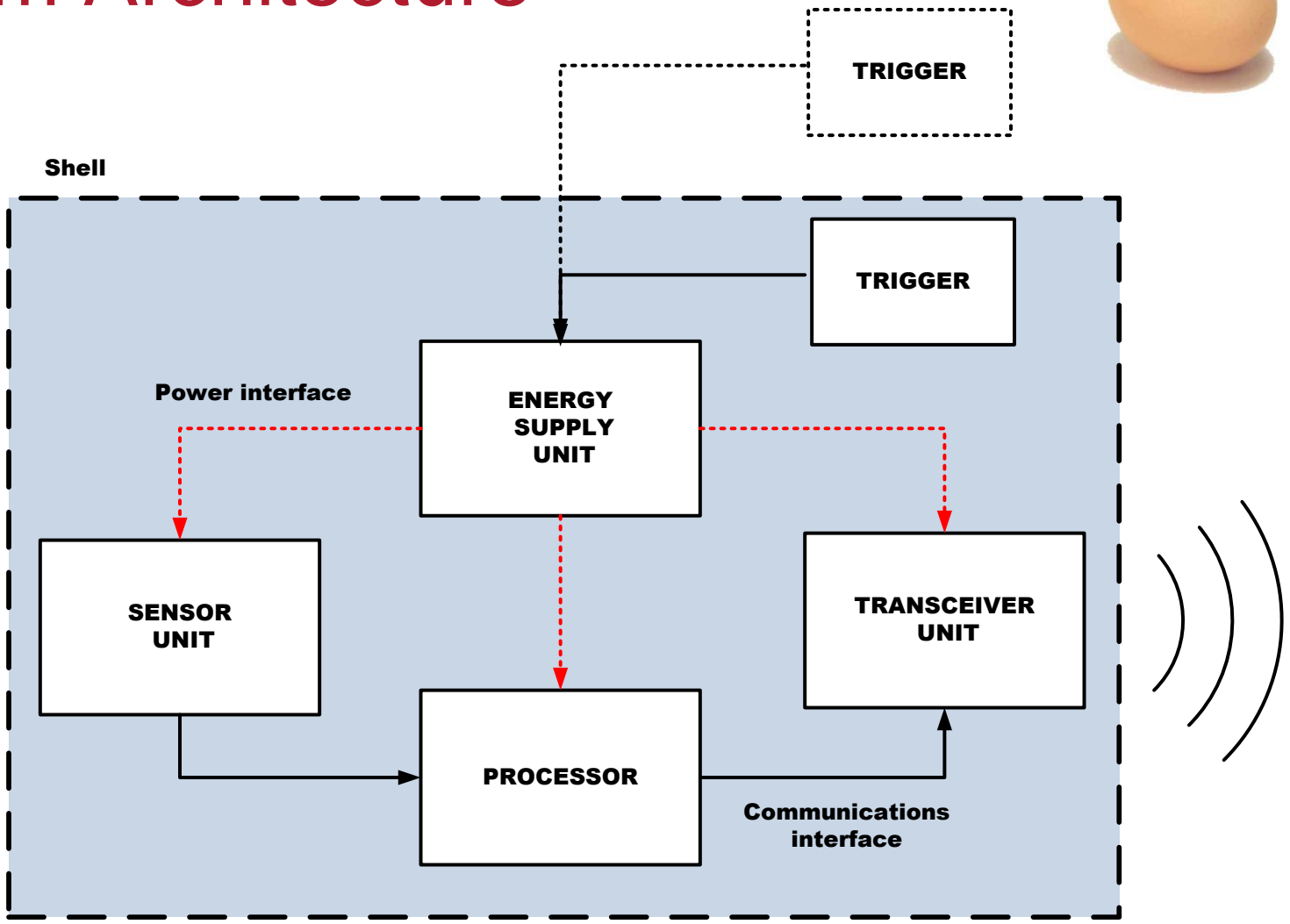


- To develop an autonomous monitoring system that will acquire and transmit data (at least once) about the environment from a sealed underground repository to a surface base-station after a duration of 50-100 years.
- System will lay dormant for 50 years, wake-up (hatch) and collect data. It will then ‘die’.

Monitoring Concept



System Architecture

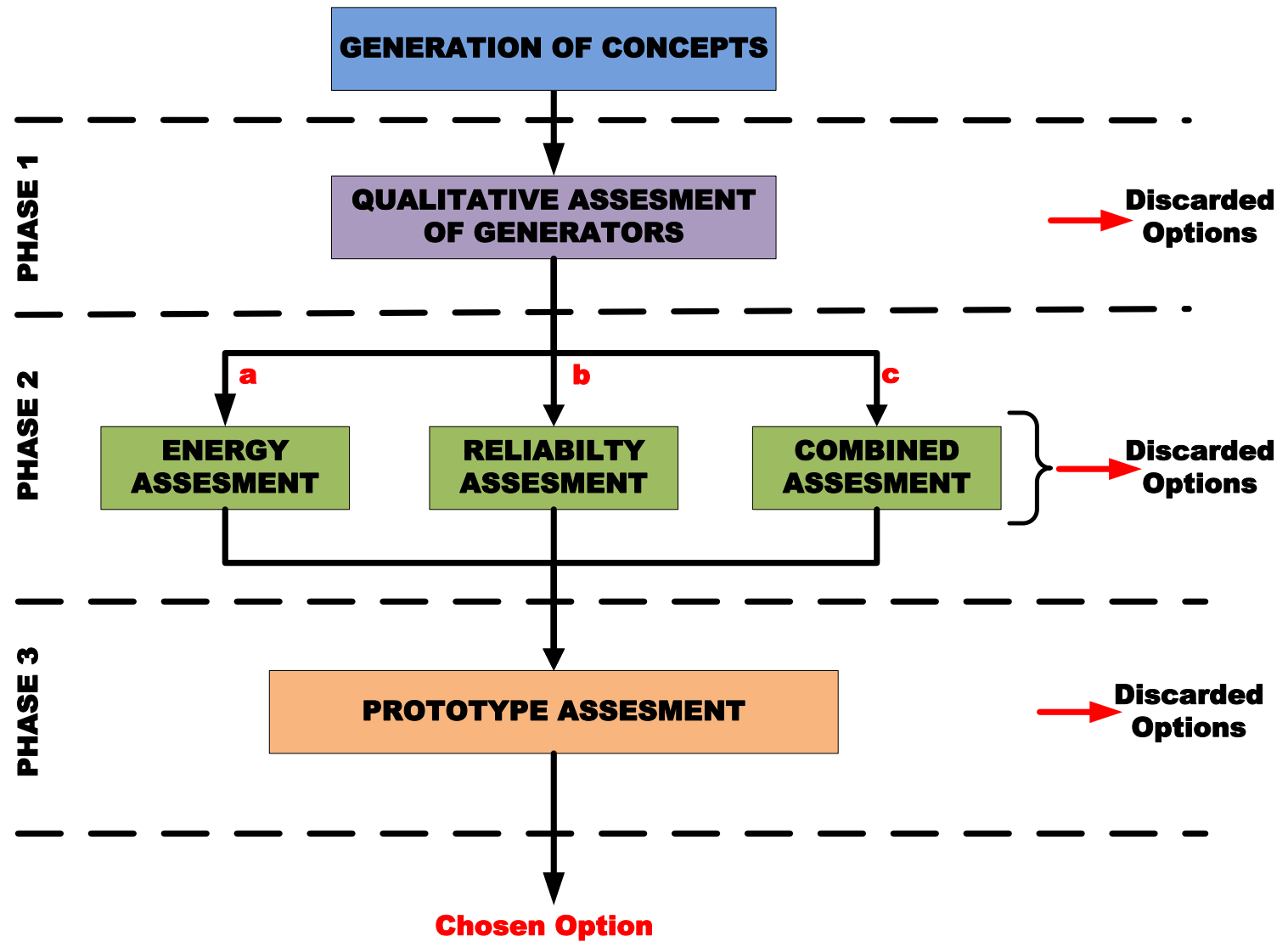


Challenges

- Shell design: must protect monitoring system from nuclear radiation
 - Borosilicate glass has been shown to be a suitable candidate
- Energy Supply Unit
 - Sufficient energy capacity
 - Retainment of energy for long durations of time
- Trigger
 - How do we activate the device ?
 - e.g. RFID technology / mechanical timer ?



Energy Supply Unit: Design Selection Process



Concept Generation

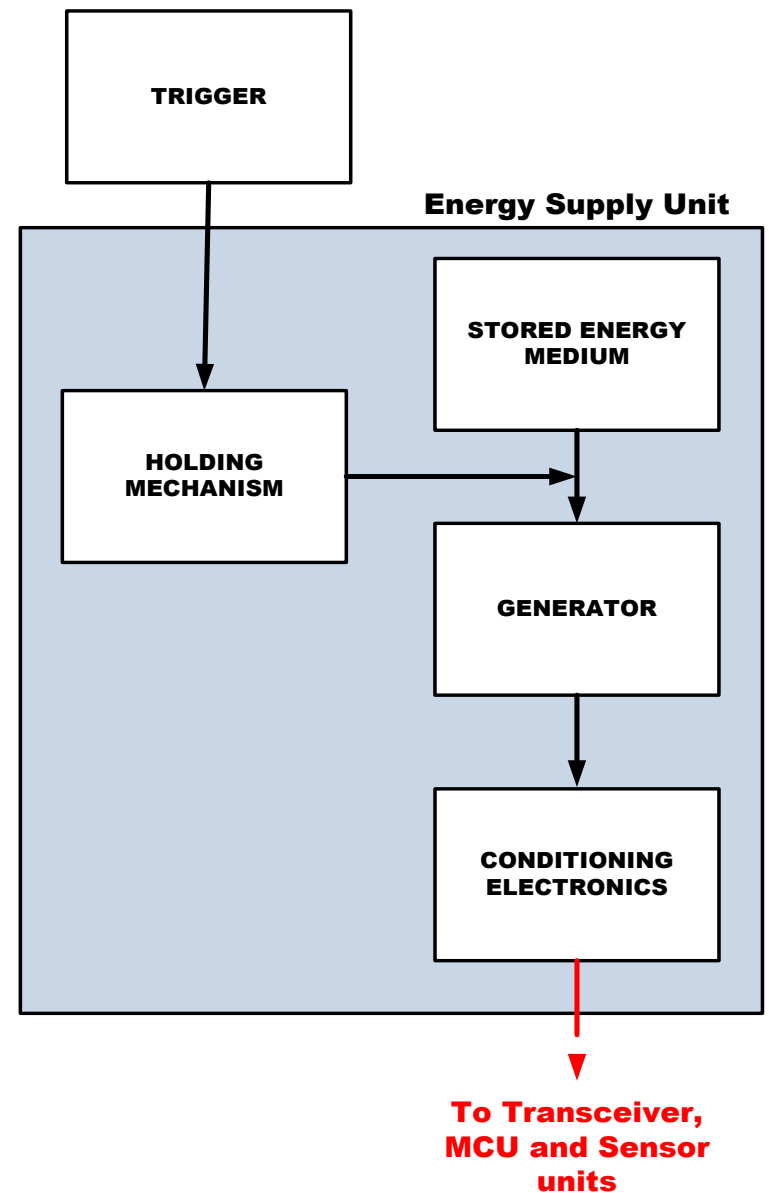
- Generation of concepts
 - Round table 'brain storming' session.
- Resulting options comprise:
 - Energy harvesting
 - Chemical batteries
 - Mechanical batteries
 - Compressed Springs
 - Clock work radio springs
 - Gravitational Potential energy

Phase 1: Qualitative Elimination

- Process: Qualitative Assessment around table
- Batteries
 - Degrade with time and environment.
 - Effects of chemicals in a nuclear environment is unknown.
- Energy Harvesting
 - Thermal – a temperature gradient
 - Nuclear – prior work demonstrated that harvested power is small.
 - Environment is relatively unknown.
- **Mechanical Options remain**

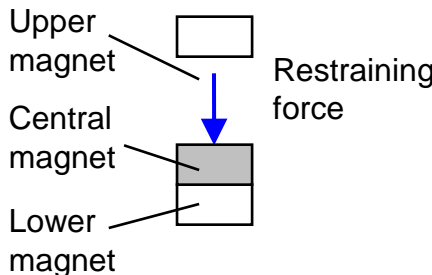
🔥 Energy Supply Unit

- Storage Medium
- Holding Mechanism
 - Retains source in a 'charged' state
- Generator
 - Converts mechanical energy to electrical energy
- Conditioning
 - Converts raw electrical energy to rated form

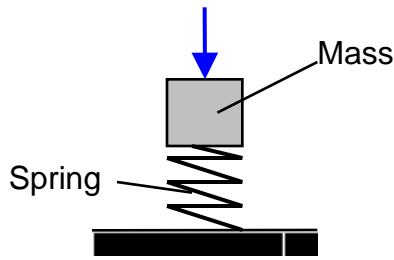


🔥 Mechanical Batteries

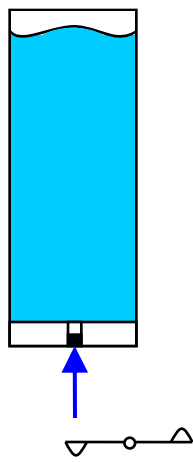
a) Magnetic suspension



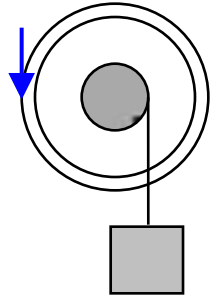
b) Helical spring



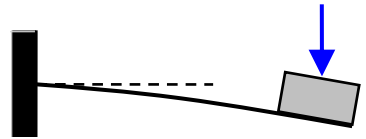
e) – Falling fluid



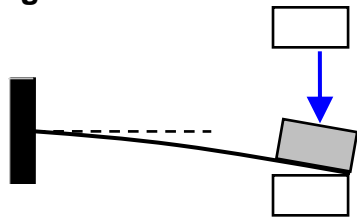
f) – Falling mass



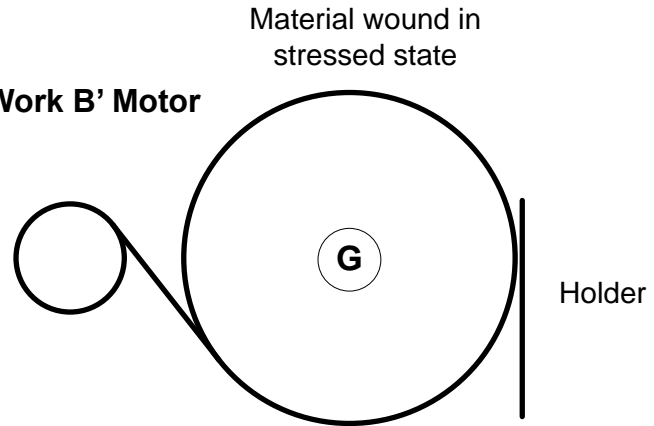
c) – Cantilever



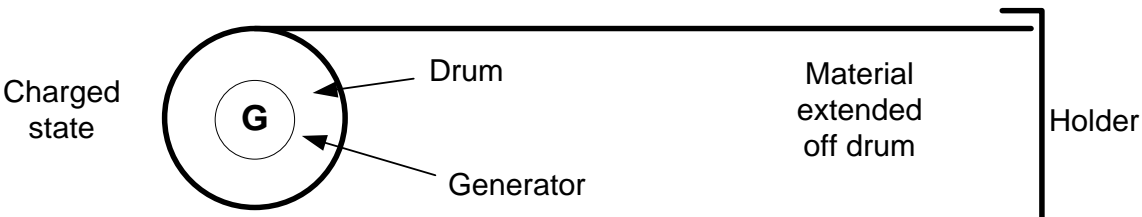
d) – Hybrid – cantilever / magnetic

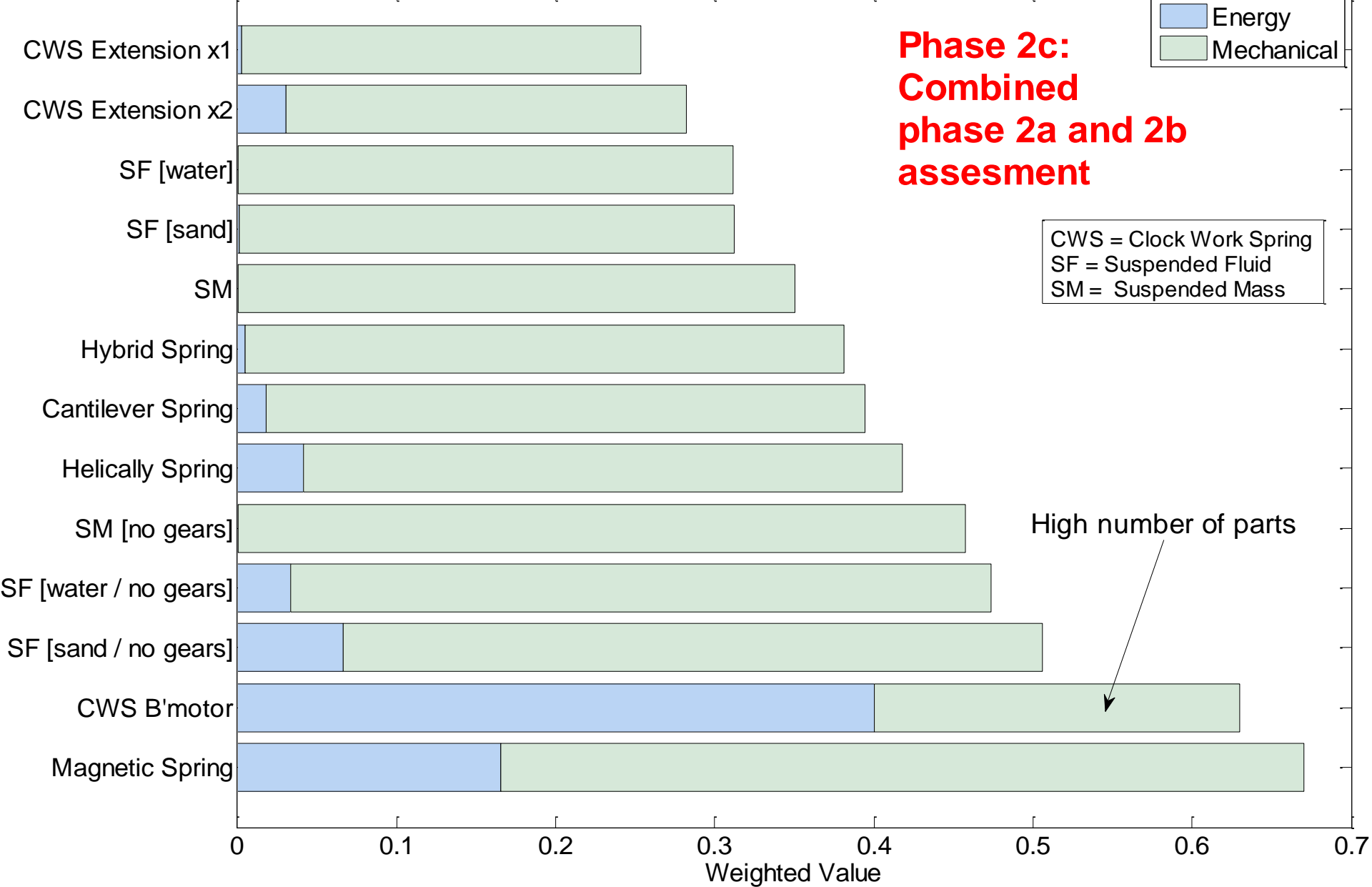


g) – Clock Work B' Motor

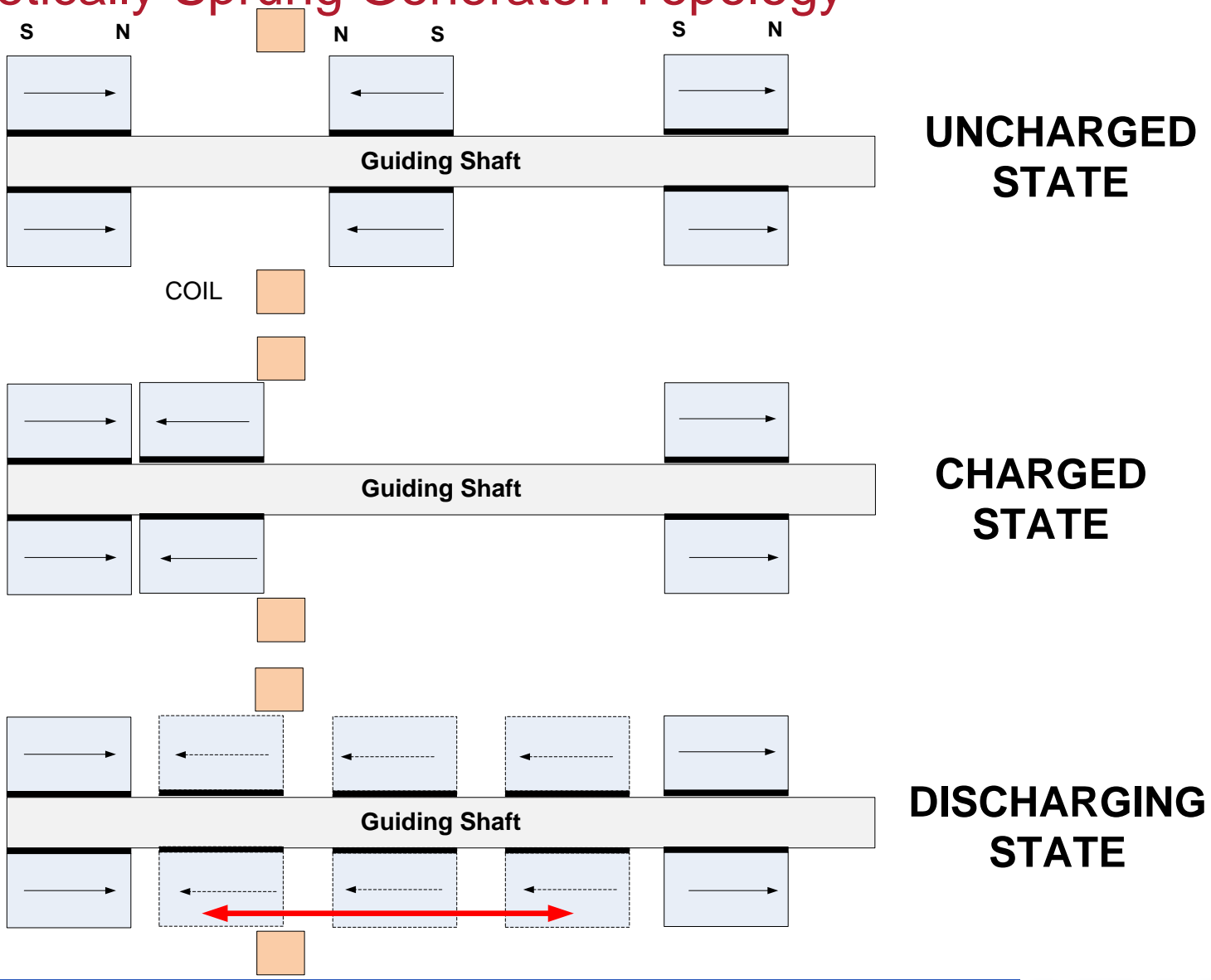


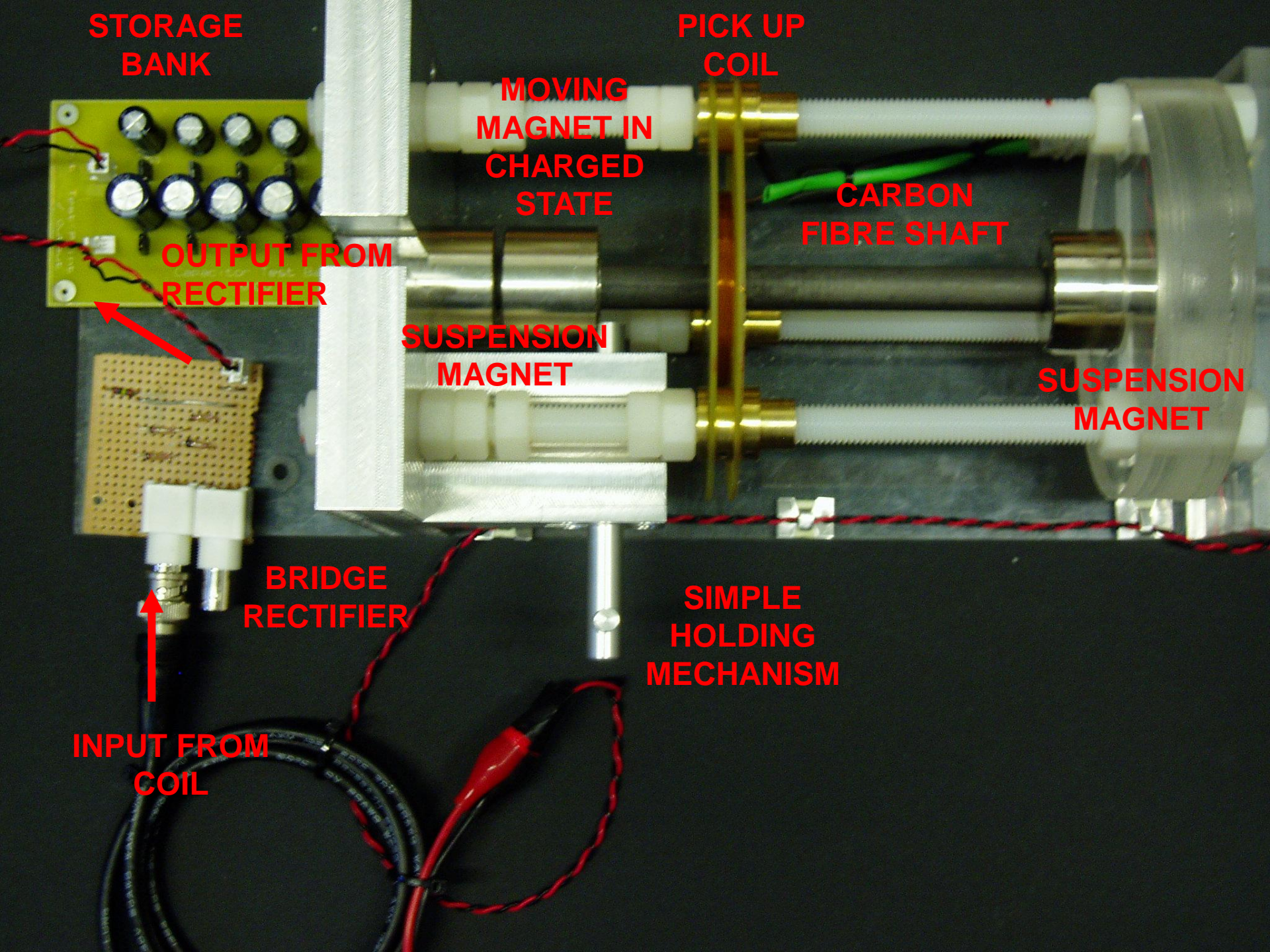
h) – Clock Work Extension





Magnetically Sprung Generator: Topology





STORAGE BANK

PICK UP COIL

MOVING MAGNET IN CHARGED STATE

CARBON FIBRE SHAFT

OUTPUT FROM RECTIFIER

SUSPENSION MAGNET

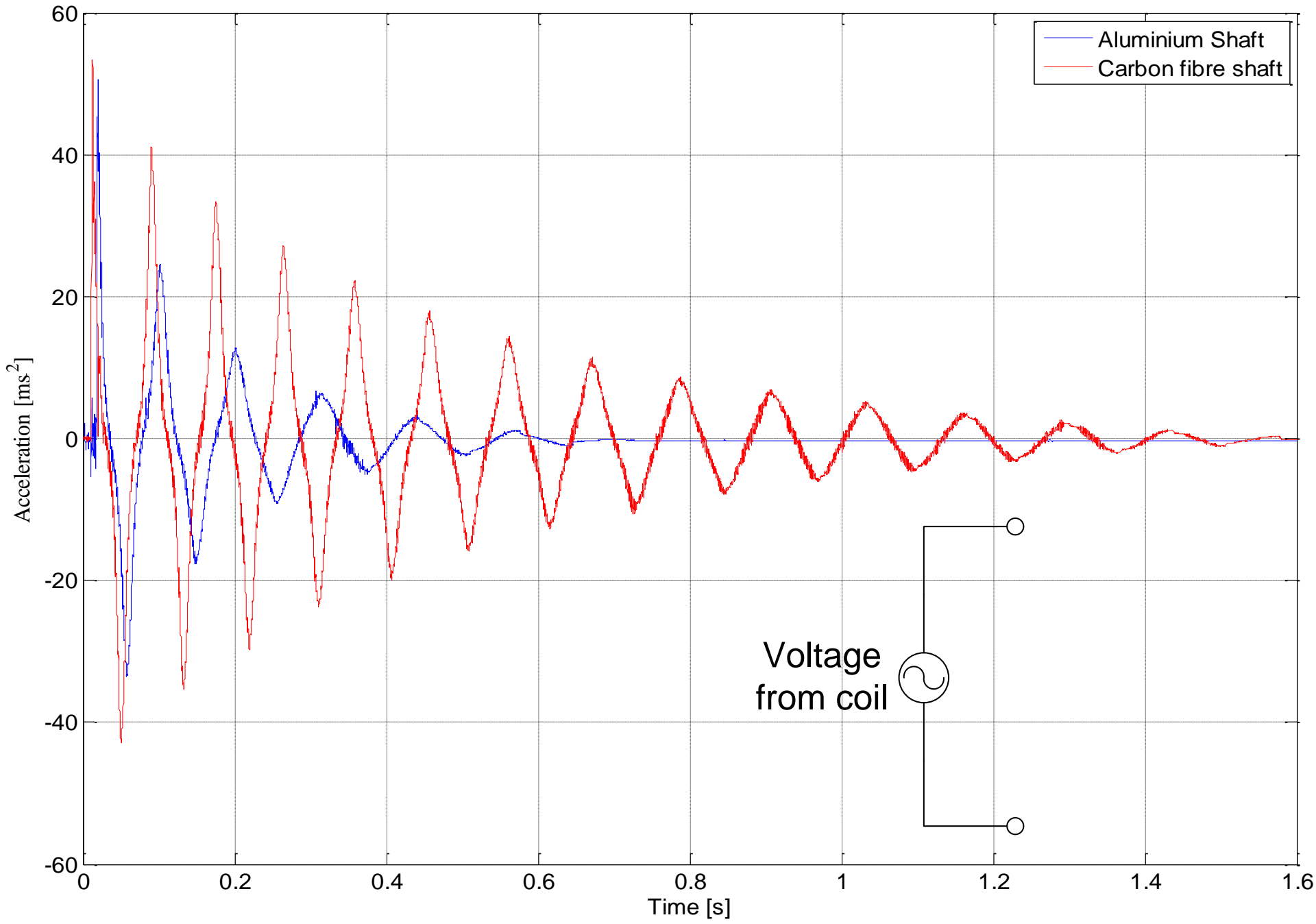
SUSPENSION MAGNET

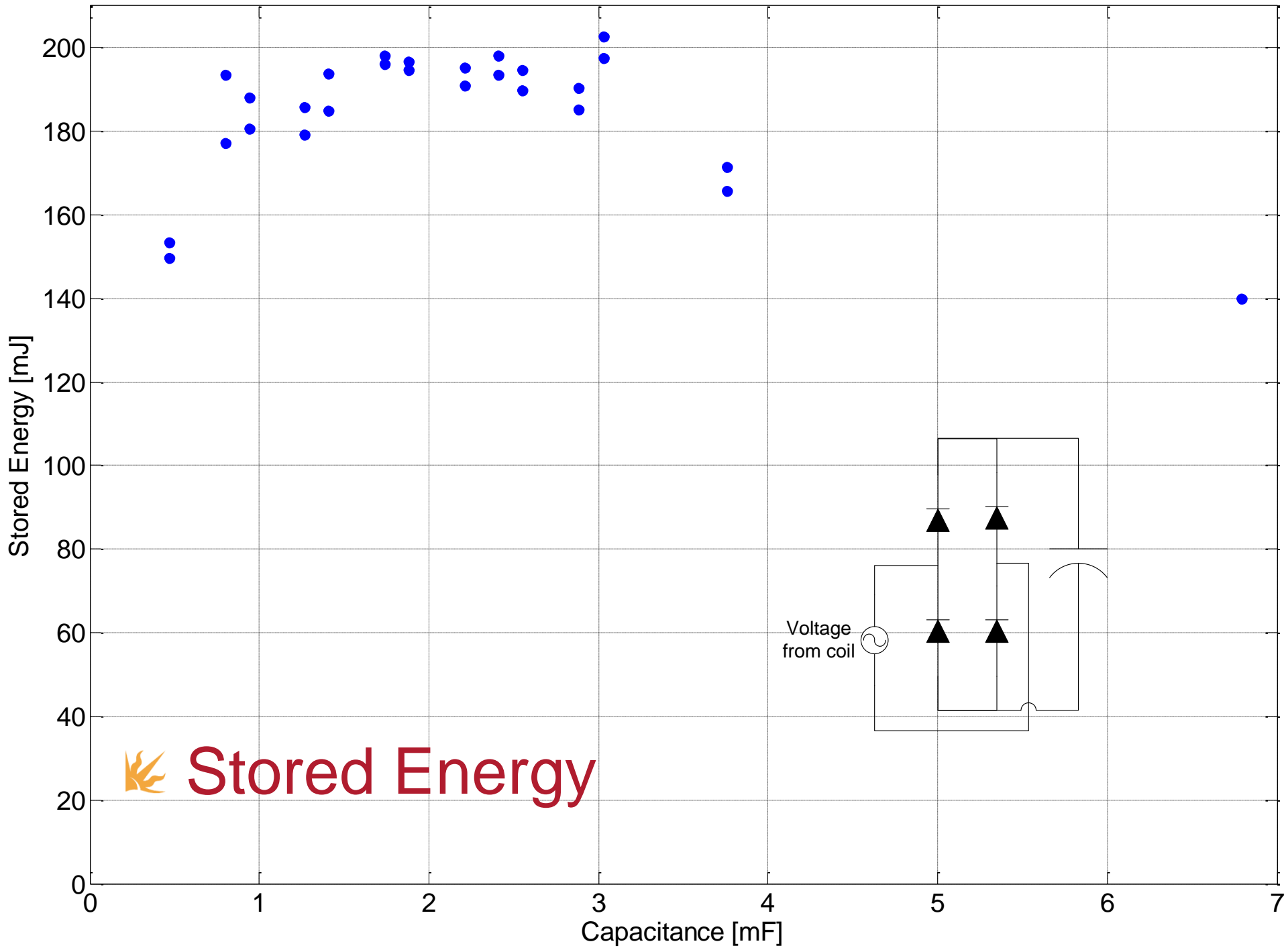
BRIDGE RECTIFIER

SIMPLE HOLDING MECHANISM

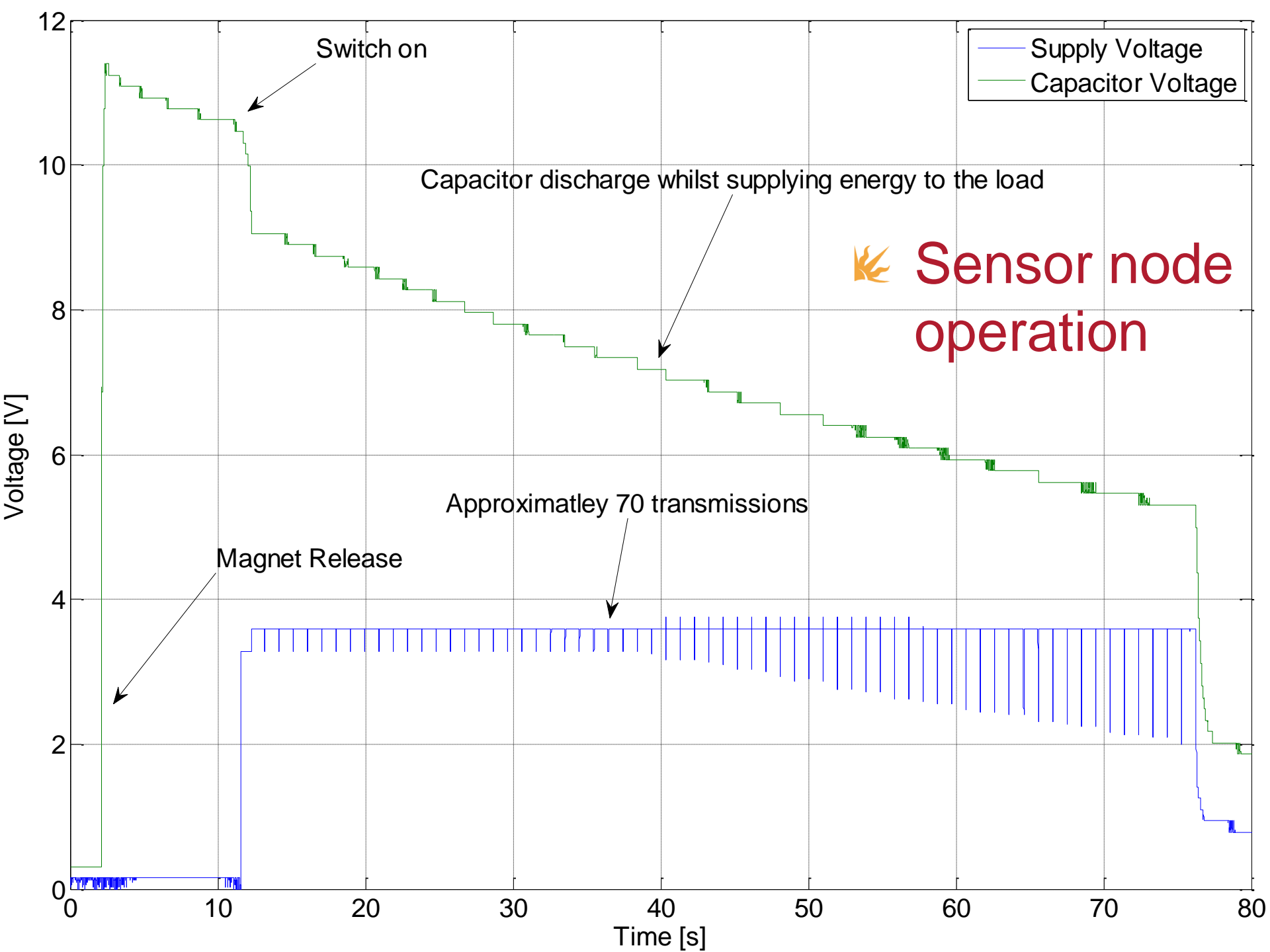
INPUT FROM COIL

Preliminary results: initial shaft selection





Stored Energy



Summary

- A design selection process revealed that the magnetically sprung device is best option.
- To date an un-optimised device has demonstrated ~200mJ energy transfer from the mechanical to the electrical domain.
- Demonstrated operation of sensor node from a magnetically sprung device.



Prototype will be on display at coffee