UAV operational challenges in underground mines

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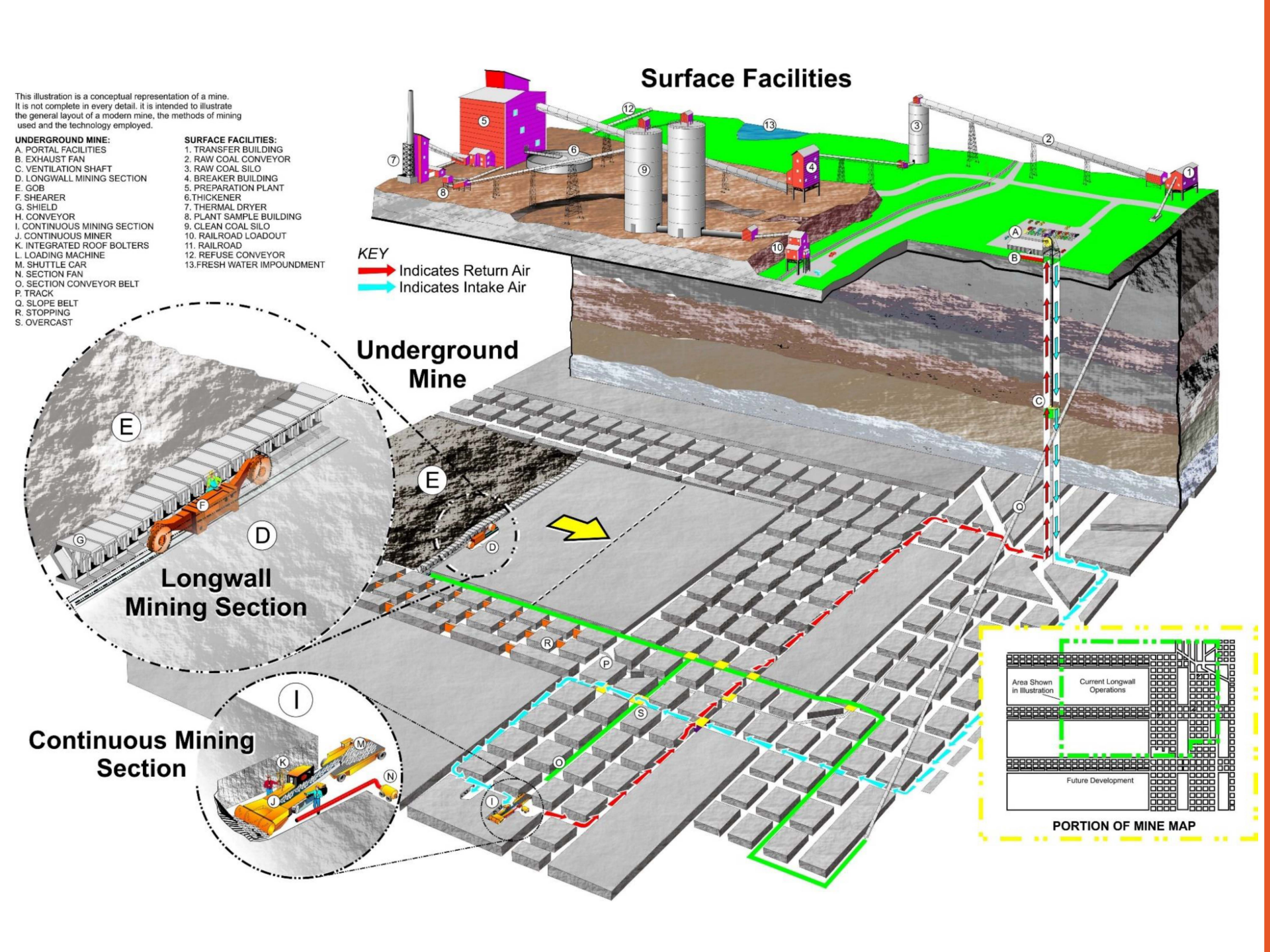
This illustration is a conceptual representation of a mine.
It is not complete in every detail. it is intended to illustrate
the general layout of a modern mine, the methods of mining
used and the technology employed.
UNDERGROUND MINE:
A. PORTAL FACILITIES
B. EXHAUST FAN
C. VENTILATION SHAFT
D. LONGWALL MINING SECTION
E. GOB
F. SHEARER
G. SHIELD
H. CONVEYOR
I. CONTINUOUS MINING SECTION
J. CONTINUOUS MINER
K. INTEGRATED ROOF BOLTERS
L. LOADING MACHINE
M. SHUTTLE CAR
N. SECTION FAN
O. SECTION CONVEYOR BELT
P. TRACK
Q. SLOPE BELT
R. STOPPING
S. OVERCAST
SURFACE FACILITIES:
1. TRANSFER BUILDING
2. RAW COAL CONVEYOR
3. RAW COAL SILO
4. BREAKER BUILDING
5. PREPARATION PLANT
6.THICKENER
7. THERMAL DRYER
8. PLANT SAMPLE BUILDING
9. CLEAN COAL SILO
10. RAILROAD LOADOUT
11. RAILROAD
12. REFUSE CONVEYOR
13.FRESH WATER IMPOUNDMENT
Surface Facilities
KEY
Indicates Return Air
Indicates Intake Air
Underground Mine
Longwall Mining Section
Continuous Mining Section
Area Shown in Illustration
Current Longwall Operations
Future Development
PORTION OF MINE MAP

General challenges in large underground mines

- Size and limited access points – tens of miles in geographic extent, hundreds of miles of tunnels. GPS not available for initialization.
- Limited radio communications range – UAV needs to be autonomous to explore distance beyond a few thousand feet
- Ventilation – sudden air pressure changes, stoppings. Barometric readings cannot be used for positioning or altitude determination.
- Equipment – large machines with magnetic signatures. Magnetometer readings may not be reliable.
- Infrastructure – cables, supports, and other small obstructions
- Electrical currents – electromagnetic fields, interference sources
- Limited visual cues - large areas all look the same

Challenges unique to coal mines:

- Rock Dust
- Explosion Protection requirements – electronic equipment has to be designed and certified to operate in an explosive environment

Navigational aid opportunities from unexploited constraints

- Limited directions – at any given location the UAV generally has four or less directions to go without hitting the ribs (walls), roof, or floor.
- Very good maps – maps are made to survey grade accuracy. Center line maps, which represent the logical navigational path for the UAV are often made.
- Opportunities for visual and non-visual markers – identifiers could be added by mine personnel in most areas of the mine if there were a compelling reason to do so.

Mine disasters – age old problem

- Mine disasters create the difficult decision of committing rescue teams to explore underground.
- Having a UAV that can help minimize the risk to rescue teams could be a huge improvement in rescue team safety and rate of advance.
- There would be limited demand for such a special purpose UAV.
- We are hoping that the efforts of DARPA and others will someday result in a feasible and affordable solution.

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