Designing the Next Generation of Pit Emptying Technologies Using a Workshop Approach

Francis L. de los Reyes III
H. Ashinhurst, C. Buckley, J. Choksey, J. Davis, G. Foutch, X. Gras, T. Gurski, J. Heeger, J.R. Inman, A. Innes, S. Kim, H. Kneller, S. Malinga, S. Mercer, J. Neethling, M. Pramanik, J. Radford, J. Shaw, D. van Heerden, J. Williams

[1]Department of Civil, Construction, and Environmental Engineering,
North Carolina State University
BMGF, UKZN, Mott MacDonald, Ashland Pumps, Univ. of Missouri, Practica, Carbyne, Netherlands Red Cross, FloHawks, AGI, Boeing, WFP, PID, MAWTS, Mveza, Jon Shaw and Assoc.

This is the problem

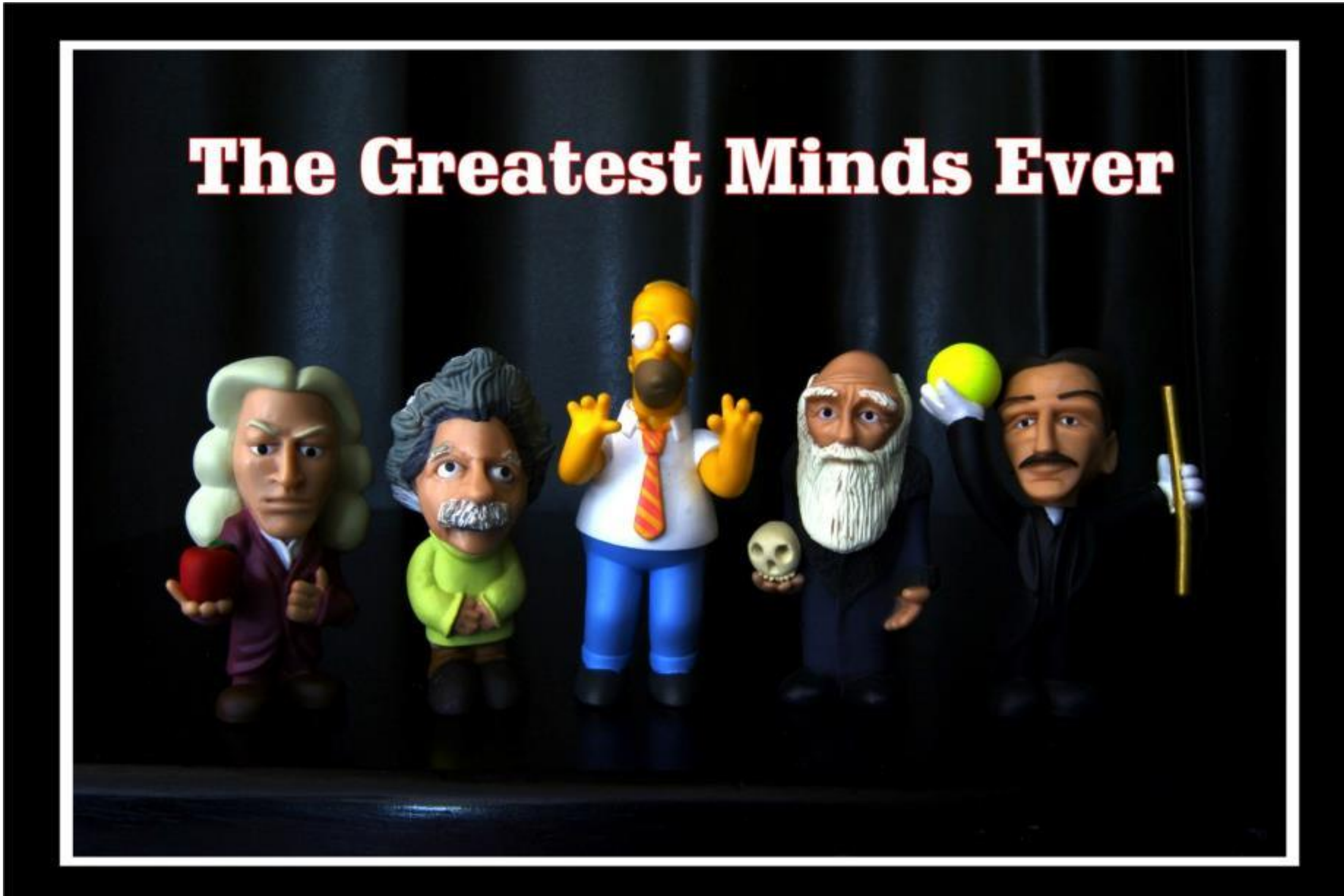
An estimated 1.77 billion people use pit latrines, many need to emptied every 3-5 years

How can we design a mechanical pit emptying device that is…

- Fast
- Reliable
- Safe
- Hygienic
- Robust
- Replaceable parts
- Can access all pits
- Can handle wet and dry pits
- Can handle trash
- Etc
- Etc

Meets specific requirements

Assemble …



Assemble… A bunch of technical people with knowledge, experience, and interest ….

SMEs and non-SMEs, practitioners, researchers, engineers, optimists

Tremendous Insight No. 1

If we really want to solve a problem, we must:

Really harness the diversity of minds, experiences, and ideas of the right mix of people

Corollary:

The ways we do our normal work with other people (meetings, brainstorming) are probably not the most effective

Process matters!!!

- Problem Definition
  - Problem Statement
  - Scope
  - Inviolables
- Field Visits
- Review Pit Observation Sheets

Problem Definition- "I think the problem is…"

Technical:

There is currently no technical emptying solution that adequately mitigates the wide variety of trash and debris found in pits

Health and safety- pit emptying is often performed by hand

Pits can be difficult to access by mechanized means

Access to the pit

Water availability

Mechanized solutions to the FSM chain are too energy intensive (fuel, cost)

We're trying to create one solution that works in every pit

Don't have a solution to clear debris in an effective way

~~We don't know what to do with sludge~~ there are limited options available for appropriate disposal of waste

We have to move sludge against gravity

Technical solutions are too big- difficult to design technical solutions that are small enough to access pits

Vibration can cause collapse of unlined pits

"A problem well stated is a problem half-solved"

-Charles Kettering

Jon Shaw & Associates, LLC

Economics:

We don't how to make pit emptying profitable/less expensive than digging new pit

Established mainstream industrial equipment is too expensive for certain entrepreneurial markets

Existing pumps are too expensive

We don't understand the whole timing aspect of business process of emptying

We don't understand market segmentation

Favorable financing is not available

Access to financing in developing countries is poor generally

Supply chain issues in developing countries

Lack of clarity as too\ who owns this problem (private sector? Public sector?)

The people that need this solution have little income

Availability of spare parts

Cost of importing parts

Availability of skills

The "do-nothing" or partial emptying solution is viable

Ambiguity in facility ownership

Enabling environment/regulations:

We don't have all of the data around pit make-up/ a lot of the data is questionable

Sludge contains pathogens, is dangerous

Disposal sites are too far away too crowded or non-existent

We don't have a safe, sustainable technical solution(s) that is supported by a viable business model in disadvantaged communities

Social/Cultural:

We're trying to come up with a mechanical solution to a cultural problem

We don't know how to overcome the social/cultural issues

People are not sufficiently concerned about the status quo hand emptying processes

We don't understand how to influence private sector and authorities to change processes (moving from hand-emptying)

Not sufficient worker safety regulations in place

Pit emptiers are often the most vulnerable member of society

Do the people that would benefit understand the need

We don't have sustainable technical solutions that protect public health and economically empty wet and dry urban pit latrines of various designs

Scope

What is in?

- Pit emptying and transport
- Dealing with trash in pits
- Ancillary existing pit modification

What is out?

- Treatment of faecal sludge
- New pit designs
- Availability of financing for operator and customer
- Regulatory environment
- Behavior change

Inviolates

What concepts, rules and processes specific to this problem are ***considered*** immovable, unchangeable or off-limits from change?

- How people defecate
- The location and legality of where people live
- Public and environmental health
- Health and safety of workers
- Dignity of people

Tremendous Insight No. 2

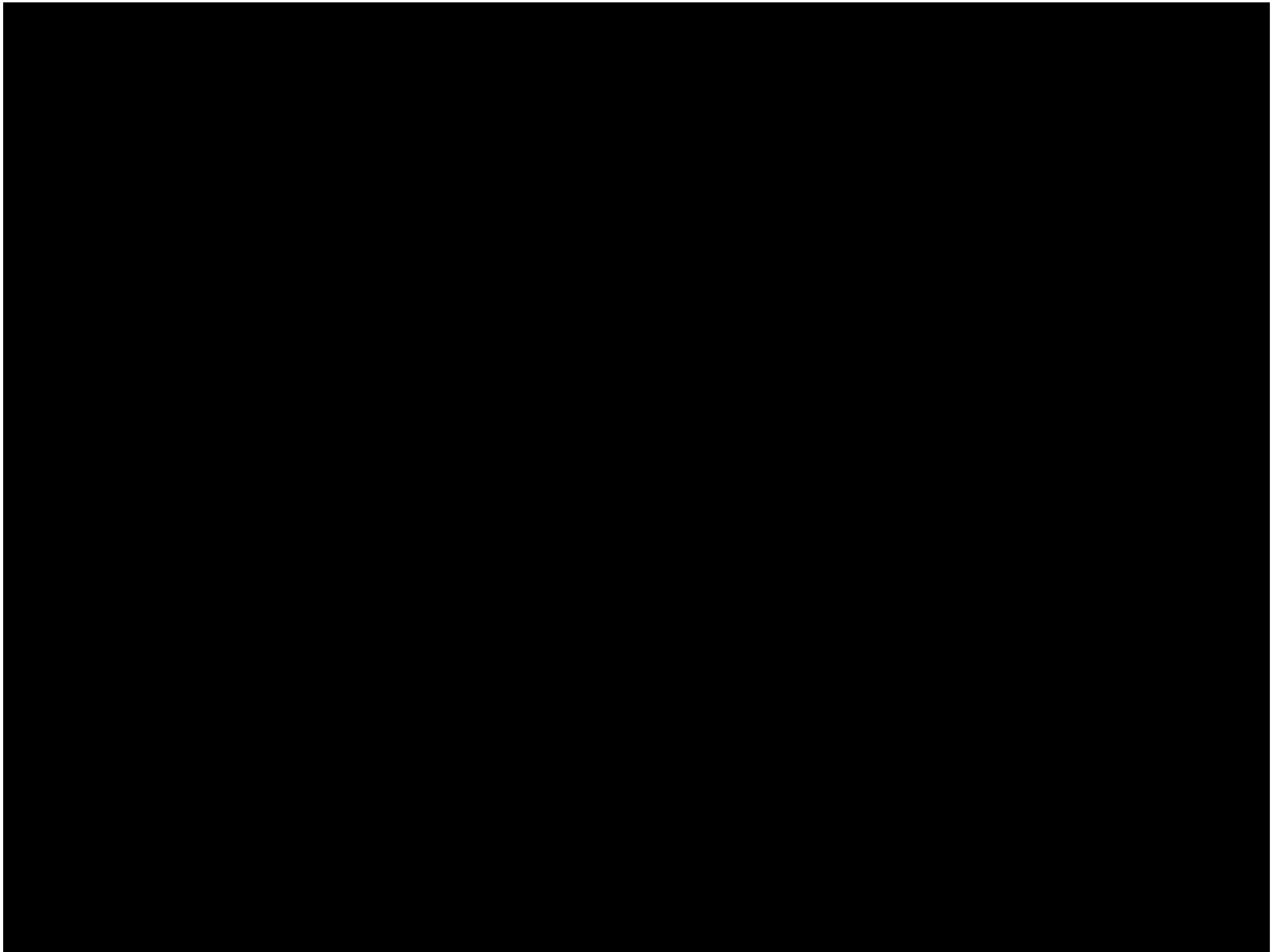
You have to agree on WHAT the problem is

Idea Generation

WHAT: Identify all potential solutions
HOW: Use variety of IG techniques
OUTPUT: Catalog of solutions

- Brainstorming
- Group
- Systematic Inventive Thinking
- Concept mapping
- Structured group prompts

Idea Generation



Tremendous Insight No. 3

Brainstorming mantras

“Not a sprint, but a marathon, and it should HURT accordingly”

“Don’t own any one idea, own ALL the ideas”

“Beware structural fixedness”

“Applaud audaciousness, beware doubt”

“Use other ideas as springboards”

- Morphological chart – dealing with trash, pumping, safety, etc.
- Evaluation – each idea quickly described and rated as “feasible-infeasible”
- Sub Teams – pick from all the ideas, with focus areas, e.g., Universal solution, Lowest Cost, etc.

Team Name: ~~One~~ Dead Ringers

Emphasis: ① Universal Solution

Project Manager: Jamie

Team Members: Dale, Jason, Chris

Solution Elements:

Wet/dry Vac	HP Pump	Cons-Lids
Lance + nozzle	hose + Valve	Trolley
Trailer	[4x4 Horse]	Pick, spade, cement
Disinfectant	Power Unit	Elephant

Funnel/Clean...

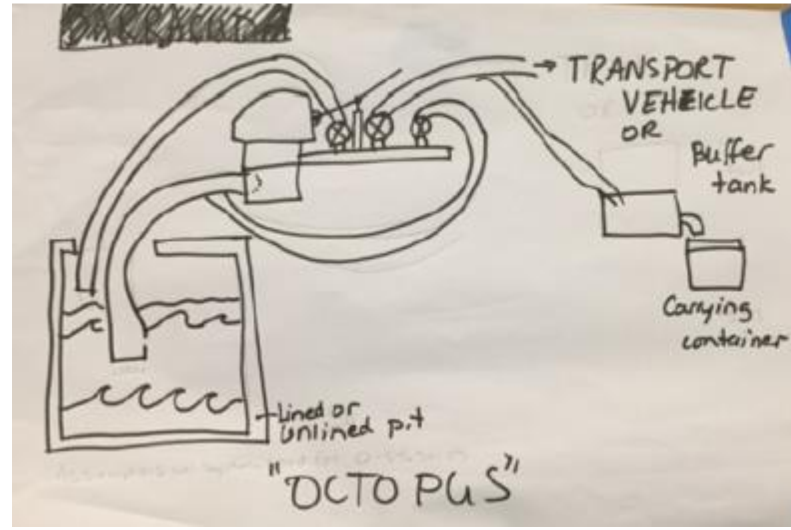
Evaporator Pit...

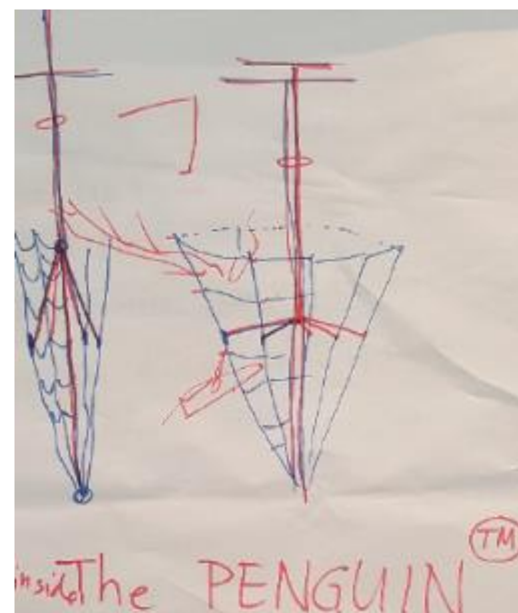
Universal pit emptying solution to economically empty 95% of pits using proven technology that is easy to operate and maintain

Pros: off-the-shelf; easy to operate, Original, (high costs) unskilled labour (local) low cost; scalable

Cons: untested, LID NOT OTS, Heavy sludge + debris

Actions: Schematic/Outline sketch → Jason
Process map + timings
Shopping list for Fri.
Review IRCWD data → JTR
Capex estimate + Opex (per pit) Dale





Solution

Components, costs, 40+ criteria

Criteria:	Estimate	Comments
1. No. of workers	3	
2. No. of parts	15	
3. $ per unit emptied	21.5 USD / pit 1.5 USD for fuel 10 USD for labor (3 trained operators) 10 USD for CAPEX amortized over 7 years & financing 20% interest	1 hour per pit emptying
4. Liters of fuel/unit emptied	2 liters	
5. Liter of water per unit emptied	5 gal	
6. kW/liter of unit emptied		
7. No. of pits per day	6	
8. Meters from pit horizontal	100 meters	
9. Meters from pit vertical	40 meters	
10. Number of minutes to set up	15 metric minutes	dependent on distance (estimate based on distance of 25 meters between pit to road)
11. Number of minutes for teardown	20 metric minutes	
12. Number of operation steps	12 steps	
13. Weight of unit in kg for RSU	1800 kg	empty weight
14. Weight of PSU	100 kg	
15. Operation space required	2.9 X 2.9 m = <9 m2	
16. Number of COTS parts	~40% by value	
17. % of COTS parts	see above	
18. % of wear parts	~10%	hoses, chain saw blade, etc....
19. Capital Cost	36,200 USD	
20. Unit Cost ($ per pit emptied per year)		
21. Hours of training for operations	40 metric hours	
22. Hours of training for maintenance	24 metric hours	assumes the start is trained mechanic.
23. % of local manufacture	50%	
24. Risk priority number	M	
25. Cost of service delivery	M	

26. Life expectancy in months
27. Minutes cleaning between operation
28. Skill level to operate
29. Max. depth capability (m)
30. Max. horizontal reach (m)
31. Mean time between failures
32. Likelihood of damaging unlined pits
33. Odor impact
34. % of spillage per operation
35. Time to gain access for emptying
36. Min. hole size allowing access to
37. Number of different content types addressed
38. Range of solids content
39. Propensity to clog
40. Time to clear blockage (min)

41. Grams per contamination
42. Mean time between blockages
43. Empting rate per second
44. Human output per operation
45. Min. residual operational depth
46. Operational noise levels (dB)
47. Particulate emissions per operations
48. Maintenance oil used for operation

- Evaluation/Prioritization

Teamwork – Ranking of "mock-ups"

	1= bad	2=ok	3=good						
	$/m3	CapX	Trash handling	Wet sludge removal rate	Dry sludge removal rate	Cleanli-ness	Technical risk	Ease of use	Avg

Lessons learned

- Value of innovation process tools and techniques
- Learning: challenges in pit emptying, variability, learning from each other
- A single pit emptying machine?
- Challenges: time for evaluation, review; follow-up and steps forward