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System Engineering Analysis of Construction Equipment Operation in the Latin America

Outline

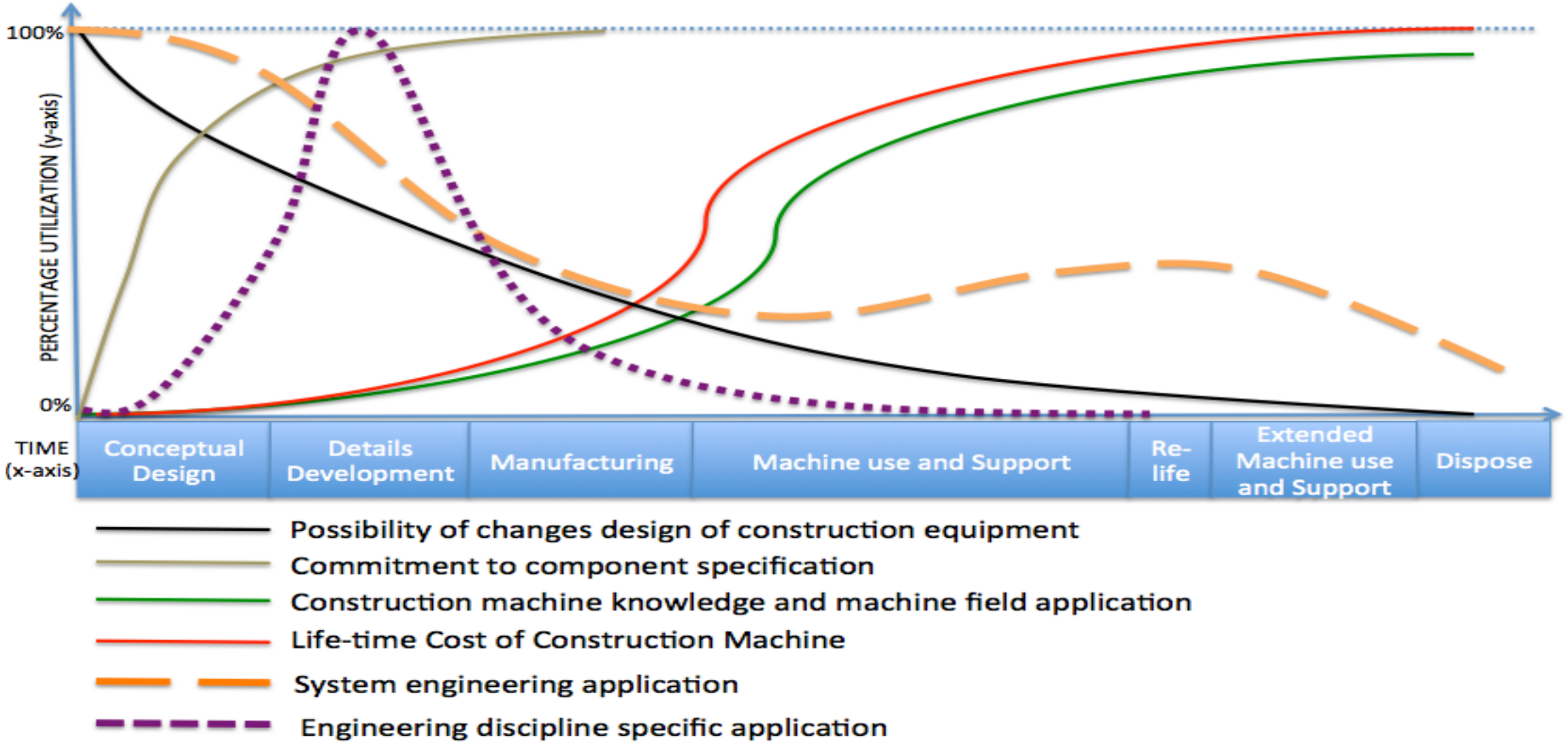
1) Introduction
2) System Engineering Approach
3) Motivation
4) Latin America Construction Market and Geography
5) Methods: Lube Oil Analysis and Other Engineering Data
6) Results
7) Conclusion of the research

1. Introduction

1) What are the engine oil contamination characteristics of diesel engines deployed in Latin America?

2) How does engine oil contamination relate to the environmental factors in Latin America?

2. System Engineering Approach



3. Motivation

Users' needs:

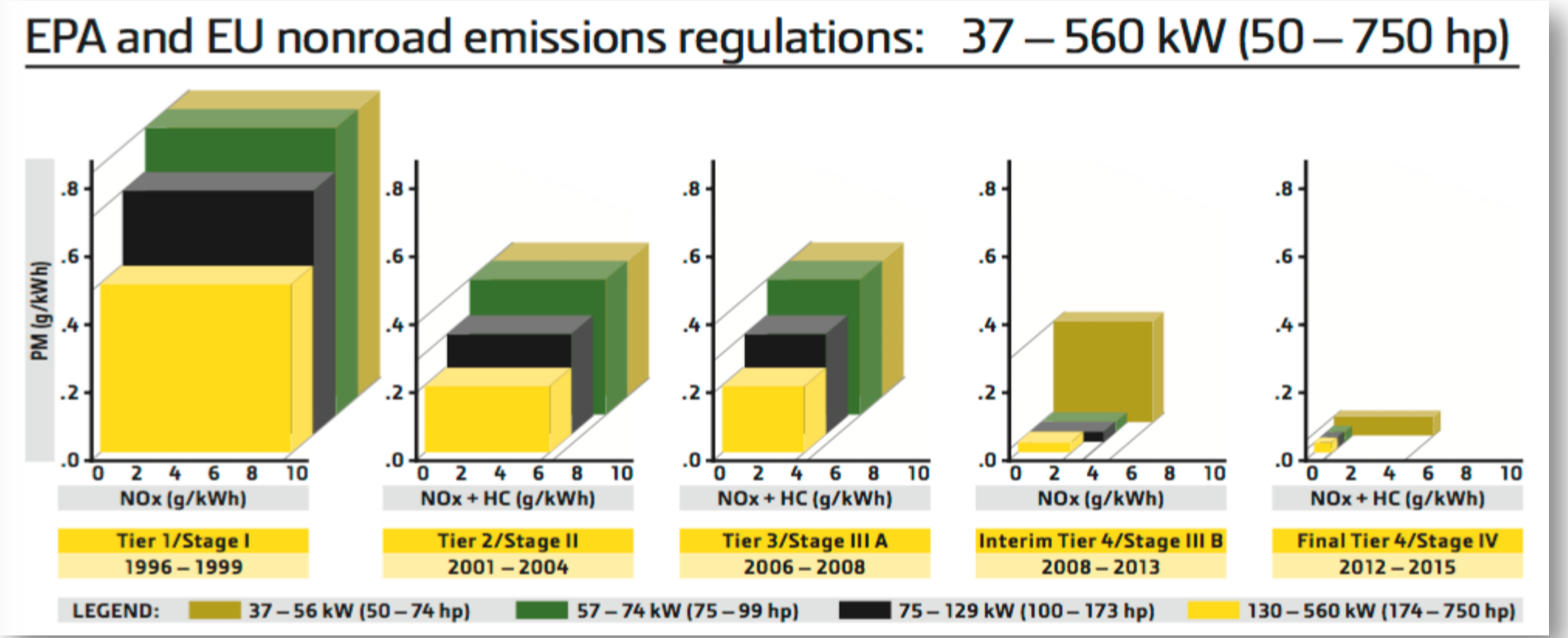
1) Reliability
2) Parts availability
3) Durability
4) Maintenance and repair costs
5) Performance
6) Fuel economy
7) Dealer support
8) Operator comfort

Manufacturers' needs:

1) Return on the investment
2) "Global" product platform
3) Lower production cost
4) Less parts variability
5) Higher durability
6) Greater competitive performance

3. Motivation

Rationale:



Source: Off-Highway Diesel Engines Ratings Tier 3 / State III A. John Deere (2003, September).

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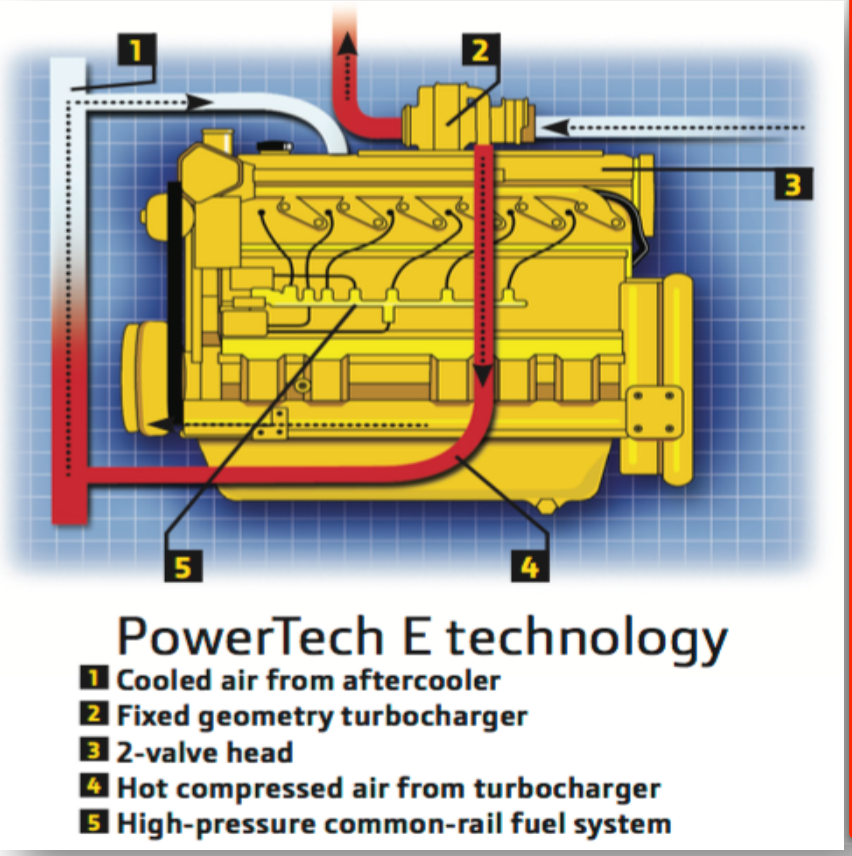
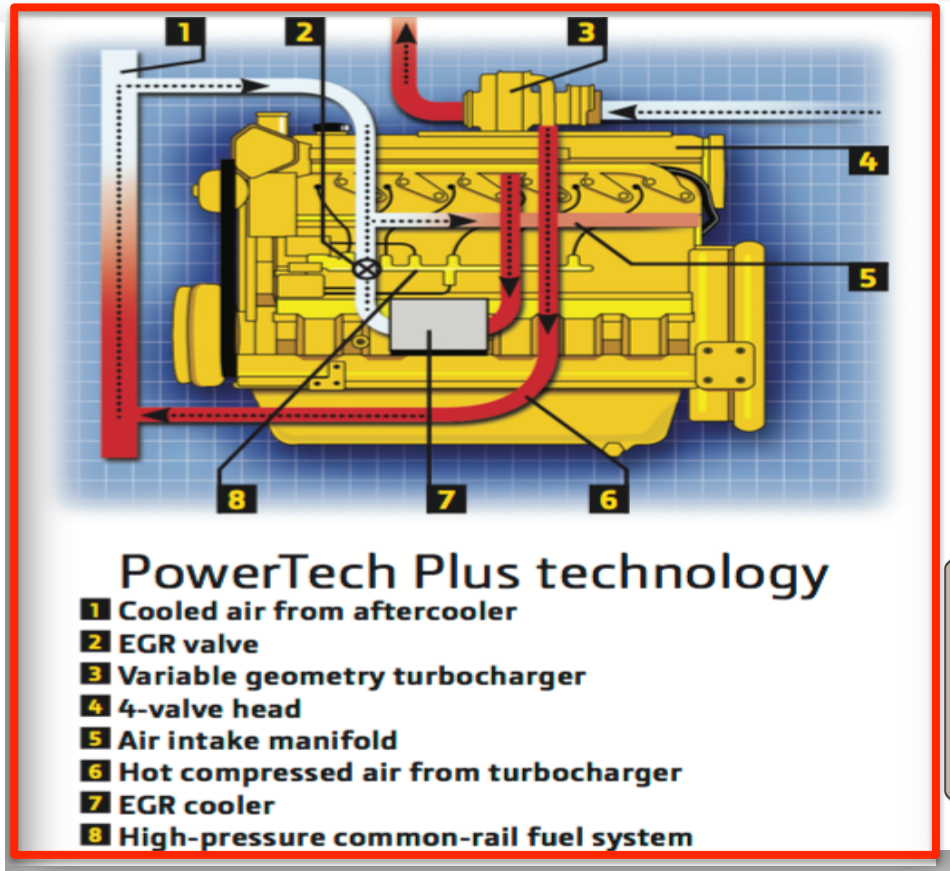
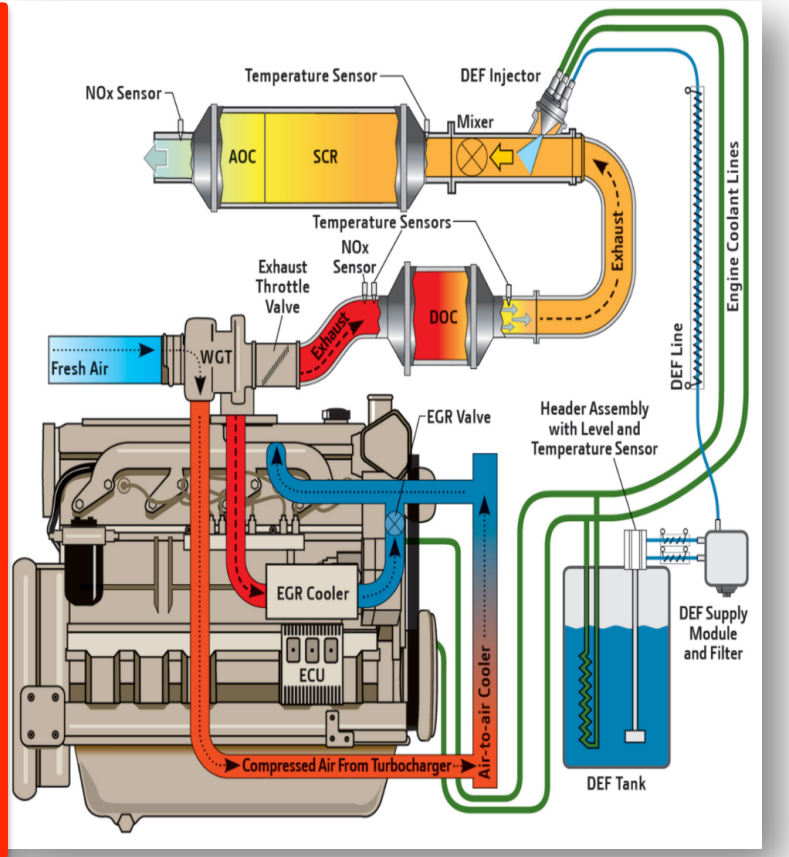
3. Motivation

Rationale:







Source: Off-Highway Diesel Engines Ratings Tier 3 / State III A. John Deere (2003, September).

Source: John Deere Expands Final Tier 4/Stage IV Offering with No-DPF 4.5L Engine (2013)

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3. Motivation

Rationale:

Source: Azevedo Field trip (2014)

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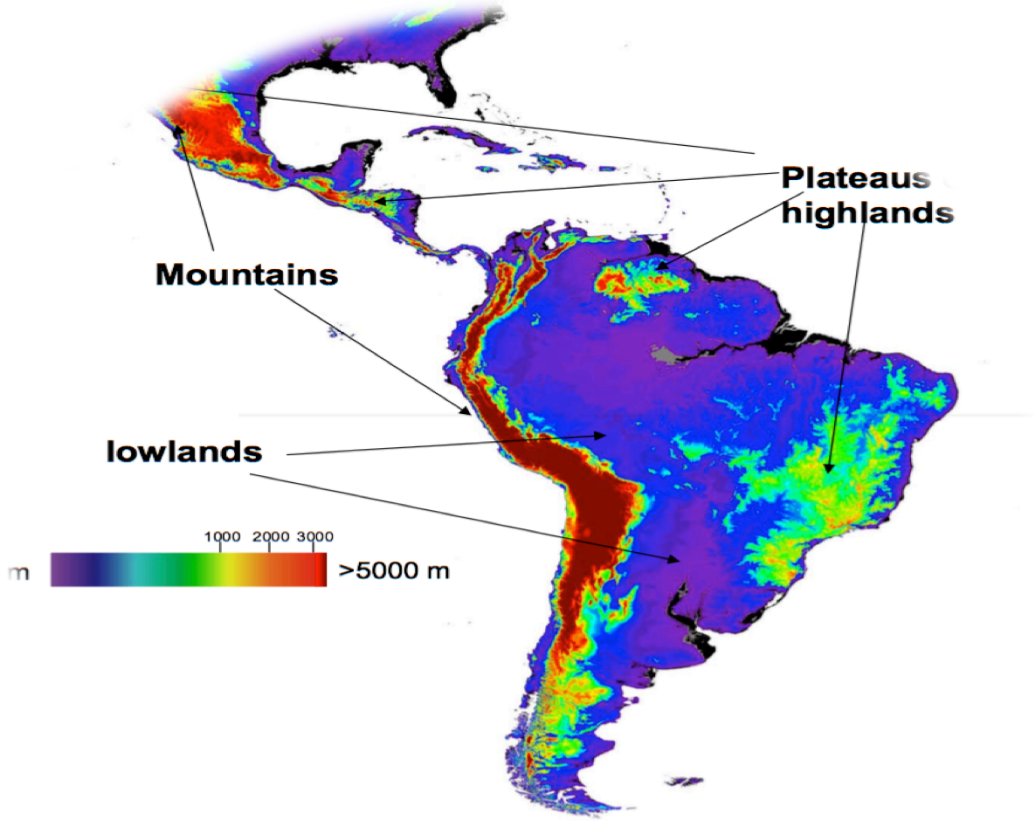
3. Latin America Construction Market and Geography

System Engineering Application: Environmental definition of Latin America Construction Market

1) Latin American countries offer a unique operating environment for construction equipment and their diesel engines

2) High altitude environmental operations lead to increased particulate matter resulting from inefficient diesel combustion.



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Source: Pujana, I. (n.d.).

4. Methods: Lube Oil Analysis

Instrumentation:

1) On Site Analysis Microlab (OSA3 Equipment)

2) On Site Latin America Database

3) 4,000 thousands of engine oil samples from four years

FLUID CHEMISTRY	VISCOSITY	PARTICLE COUNT	ELEMENTAL ANALYSIS
Infrared Spectrometer; tests for TBN, oxidation, soot, water, and glycol	Kinematic Viscometer; tests for viscosity 40C & 100C	Light Blockage Particle Counter; tests for particle count and ISO particle size	OES Spectrometer; tests for 20 wear metals

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4. Methods: Engineering Data

1) Diagnostic Trouble Codes (DTCs)

2) Engine Control Unit (ECU) Data

5. Results

Oil Analysis Results:

Countries	ABNORMAL	NORMAL
Bolivia	40%	60%
Colombia	46%	54%
Costa Rica	39%	61%
Dominican Republic	18%	82%
Ecuador	53%	47%
Guatemala	34%	66%
Honduras	22%	78%
Mexico	33%	67%
Paraguay	40%	60%
Peru	51%	49%
Uruguay	77%	23%

5. Results

Oil Analysis Wear Component Correlation Analysis:

- Cooper and Aluminum
- Lead and Aluminum
- Lead and Silicone
- Lead and Sodium
- Aluminum and Silicone
- Aluminum and Sodium

Wear Metals Results

	Fe	Cr	Cu	Pb	Al	Sn
Abnormal	34.33%	30.51%	22.84%	7.01%	6.75%	42.73%

Contaminants Results

	Si	Na	K
Abnormal	33%	23%	38%

5. Results

Machine Diagnostic Trouble Codes:

- **Paraguay:**
  - 46% - low level of coolant
  - 33% - water in the fuel
  - 8% - extremely high coolant temperature
- **Uruguay:**
  - 34% - low engine oil pressure
  - 25% - water in fuel
  - 13% - high engine temperature
- **Bolivia**
  - 49% - extremely low coolant levels
  - 32% - water in the fuel
  - 14% - extremely high exhaust manifold temperatures
- **Colombia**.
  - 59% - water in the fuel
  - 17% - high engine coolant temperatures
  - 12% - low coolant levels
- **Costa Rica**.
  - 61% - water in the fuel
  - 14% - extremely restricted engine air filters
  - 13% - low coolant

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6. Conclusion of research

- Abnormal oil result significantly higher than United States
- Machine operating altitude is impacting engine durability in Latin America
- Evidence of environmental (dirt or cross-system) contamination
- DTCs data indicates the cooling system failure and oil degradation
- The high correlation of sodium, silicone, and aluminum indicates dirt environmental contamination

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