Riyadh Blood Banks Distribution System
SELP695 – System Engineering Integrative Project

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How The Idea Came Out?

Daily, 2-3 hours on Twitter.

A desire to fix a problem using problem-solving steps.

Inspired by “Engineers do things, but industrial engineers make things better.”
Problem Definition & Background Information

- **Hospitals sectors in Riyadh:** public, private, and military. *(Different sizes)*
  - e.g. King Saud Medical Complex
- $54 million as financial support for investment in the private sector.
  - e.g. Dr. Sulaiman Alhabib Medical Group
- **Isolated units, but few medical doctors exchange programs among public hospitals.**
**Problem Definition & Background Information**

- **Study results for blood types population of 57396 donors (1995-1999)**

![Pie chart showing blood type distribution]

<table>
<thead>
<tr>
<th>Type</th>
<th>Give Blood To</th>
<th>Giving POP%</th>
<th>Receive Blood From</th>
<th>Receiving POP%</th>
</tr>
</thead>
<tbody>
<tr>
<td>O+</td>
<td>O+ A+ B+ AB+</td>
<td>93%</td>
<td>O+ O-</td>
<td>52%</td>
</tr>
<tr>
<td>A+</td>
<td>A+ AB+</td>
<td>28%</td>
<td>A+ A- O+ O-</td>
<td>78%</td>
</tr>
<tr>
<td>B+</td>
<td>B+ AB+</td>
<td>21%</td>
<td>B+ B- O+ O-</td>
<td>70%</td>
</tr>
<tr>
<td>AB+</td>
<td>AB+</td>
<td>4%</td>
<td>Everyone</td>
<td>100%</td>
</tr>
<tr>
<td>O-</td>
<td>Everyone</td>
<td>100%</td>
<td>O-</td>
<td>4%</td>
</tr>
<tr>
<td>A-</td>
<td>A+ A- AB+ AB-</td>
<td>66.3%</td>
<td>A- O-</td>
<td>6%</td>
</tr>
<tr>
<td>B-</td>
<td>B+ B- AB+ AB-</td>
<td>22.3%</td>
<td>B- O-</td>
<td>5%</td>
</tr>
<tr>
<td>AB-</td>
<td>AB+ AB-</td>
<td>4.3%</td>
<td>AB- A- B- O-</td>
<td>7.3%</td>
</tr>
</tbody>
</table>
Problem Definition & Background Information

- **Blood Banks are struggling.**
  e.g. King Khaled University Hospital

- **Disaster Case.**
  e.g. Riyadh Gas Truck Explosion. 2012
40% voluntary donations, 60% is compensatory blood.*

- Dr. Salwa Hindawi. King Abdulaziz University, Director of Blood Transfusion Services.
  
  "the ratio of volunteer blood donors should be 100% voluntary donations"

- Dr. Farjah Al Gahtani. King Saud University - Blood Banks Director.
  
  "the available blood is just enough only for daily uses"

- World Health Organization (WHO) recommends to have a blood bank system of 100% voluntary donations. (e.g. Canada, U.S, and Australia)*
WHO recommends that every country should put in place policies, systems and structures to ensure the safety, quality, accessibility and timely availability of blood and blood products to meet the needs of all patients who require transfusion.*

*Data since 2006 from 17 countries are used

- Red: ≤5
- Yellow: 5-9.9
- Light yellow: 10-19.9
- Light olive: 20-29.9
- Green: ≥30
- Gray: Data not available
World Examples of Best Blood Community

- Provides half of the U.S. blood supply and operates more than 600 blood donor collection sites (19,000 pints collected daily, 1 pint = 1 pound)
- Provides blood products to more than 3,500 hospitals across Canada and 45 states in the U.S.
- Responded to disasters. (Oklahoma City and 9/11).

Helps more than 500 hospitals in 18 states (25 millions people).
**Project Objective**

- **Main Objective** is to increase the voluntary blood donations rate from 40% to 100% in the city of Riyadh.

- **Minor Objectives:**
  - To design a unique system with the goal of supporting all Riyadh hospitals with blood 24/7
  - To ensure blood safety and blood products.
  - To raise attention towards the blood shortage in Riyadh, and promote for the culture of voluntary blood donations.
  - To provide alternative approaches to handle several types of shortage.
  - To improve workers skills.
Stakeholders Description

Ministry of Health (MoH).
General Department of Laboratories and Blood Banks (GDLBB).

Medical Services Department –Ministry of Defense–.

Medical Services Department –Ministry of Interior–.

Blood Banks (34).

Saudi Red Crescent Authority (SRCA).

People (donors, patients, families)
System Requirements

- **Top-level Requirement** is to provide blood safely to all needed medical centers across Riyadh.

- **Second-level Requirements:**
  - The system shall reduce the shortage of blood.
  - The system shall be responsible for communication between blood banks.
  - The system shall distribute blood units regularly and on demand to all public, private and military hospitals.
  - The system shall have a variety of voluntary donation programs.
  - The system shall forecast events such as Eid Alfitr and Aldha’a days.
  - The system shall have integrated communication channels with other governmental departments and societal organizations such as Medical Services Department at MOD.
  - The system shall be responsible for training all workers at blood banks.
Proposed Alternative Approaches

1- The Status-quo System.
2- The Sector-based System.
3- The Collective Blood Banks System.
Analysis of the Proposed Alternatives Approaches

- AoA should focus on three steps defined in the *INCOSE Systems Engineering Handbook (v3.2.2)*:
  - Identify alternative solutions: the status-quo system and two candidate solutions.
  - Define measures to assess alternatives, including Measures of Effectiveness (MoEs).
  - Assess each alternative versus measures.
Measure of Effectiveness (MoEs)

- **Communication & Coordination**: the system’s ability to communicate and coordinate between the blood banks.
- **System Reliability**: the system’s ability to work and be available to perform constantly.
- **System Robustness**: the system’s ability to manage and recover from all external impacts.
- **System Upgradeability**: the system’s ability to evolve.
- **Uninterrupted Service**: the system’s ability to provide a service during technical mishaps.
- **System Safety**: the system’s ability to remain safe and secured.

<table>
<thead>
<tr>
<th>MOE</th>
<th>The Status-Quo System</th>
<th>The Sector-Based System</th>
<th>The Collective Blood Banks System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication &amp; Coordination</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>System Reliability</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>System Robustness</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>System Upgradeability</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Uninterrupted Service</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>System Safety</td>
<td>High</td>
<td></td>
<td>High</td>
</tr>
</tbody>
</table>

- **Best Solution**
- **Regular Solution**
- **Worst Solution**
GDLBB Units Structure

GDLBB Context

- Planning & Development Unit
- Human Resources Management
- Statistics Management
- Training Management

- Blood Banks Unit
- Medical National Programs Management
- Supplies & Medical Devices Management
- Infectious Diseases Management
- Non-Communicable Diseases Management

- Medical Services Unit

- Information Technology Unit
- Information System Management
- Network Management
- Data Analysis Management
- Technical Support Team

- Education Management
- General Management & Relationships
- Plasma Components Management

- Public Hospitals Management
- Military Hospitals Management
- Private Hospitals Management
User-oriented Operation Description

- Education
- Collection
- Storage and Segmentation
- Data-Entry
- Transfer and Distribution
Operational Environment

- Requirements: Use Case Viewpoint

Diagram:

- **GDLBB Context**: GDLBB
- **Requirement**: GDLBB shall reduce blood shortage
- **Requirement**: GDLBB be responsible for communication between blood banks
- **Communication between Stakeholders**
  - **GDLBB**: Responsible for Communication
  - **Activity**
    - Calls
    - E-mail
    - Electronic
    - Network
- **Donor**: receives, makes
- **Organization**: receives, sends
- **SRCA**: sends, receives
- **Blood Banks**: 1, 2, 3, 4
Operational Needs

- Mobile Blood Bank Caravan.
- Transferring Blood Vehicle.
- Blood Bank Room.
- Medical Equipment (e.g. Cell Washer and Tube Centrifugation)
- Private Network.
Activity Diagram

Start

Planning
- For promotion donations
  by: General Management & Relationships + Statistics Management

Communication
- With colleges, companies, factories
  by General Management & Relationships

Prepare & Provide Reports
- by Statistics Management

Coordinating
- for the drive
  by Hospitals Management

Try Again

No Response

Contact donor
- by Infectious Disease Management

Unsafe

Screen & Test
- All gathered blood
  by a medical assistant

Collection
- by a special team

Assign Team
- by a blood bank

Separating
- Blood into components of plasma and platelets
  by a medical team

Storing
- Blood in cooling refrigerators
  by a medical team

Data-Entry
- On collected safe-blood into the Private Network
  by data-entry person

Transfusion
- To a patient
  by a physician and nurse

Distribution
- To another blood bank using blood vehicle
  by the original blood

End
Operational Scenarios

Scenario 1: Rare Blood Types

- The Statistics Management should conduct studies on how many people in Riyadh have rare blood types and attain their full information about type, age, gender, address, and contact number.
- The GDLBB System should develop an overarching plan with the help of teams from all local hospitals.
- The GDLBB System should emphasize in early plans of the best methods to encourage and motivate people to donate blood.
- The GDLBB System should provide all rare types of blood to patients for regular and urgent cases.
- Large specialized hospitals in need of blood should be assisted by other hospitals, especially in case of emergency.
- The GDLBB System should be responsible for communication between all blood banks.
- The GDLBB System should allow any hospital to request rare blood through the Private Network.
- The GDLBB System should deliver rare types of blood to other blood banks when needed immediately.
Operational Scenarios

Scenario 2: Disasters

- The Statistics Unit should conduct studies on defining each expected disaster that may occur in Riyadh.
- The GDLBB System should develop an overarching plan with the help of teams from hospitals.
- **The SRCA should inform hospitals about the number of people affected during evacuations.**
- The GDLBB System should emphasize in early plans of the best methods to encourage and motivate people to donate blood.
- The GDLBB System should provide all blood types to patients on urgent cases.
- Large specialized hospitals in need of blood should be assisted by other hospitals in case of emergency.
- **The GDLBB System should be responsible for communication between all blood banks, the SRCA, and volunteer donors.**
- The GDLBB System should manage the rescue methods and know the nearest hospitals where to place injured citizens in the affected areas.
- **The GDLBB System should prepare for an updated plan to replenish the lack of blood caused by the disaster.**
Heuristics Approach

- **Heuristics Approach Definition:**
  It is considered as an experience-based technique for learning, problem solving and discovery that helps provide an optimal solution and predict the potential solution effectiveness.

**By Tom Gilb:**
- Don’t ever try to build it all at once – evolve the system based on highest value early, and rapid learning about realities.
- System models cannot be relied on, and their only justification is when there is no more realistic way to economically represent the future system.
- Systems need to be built to tolerate change and expansion beyond current stakeholder needs.
- We don’t really know what works until we try it.
## Lean Implementation

### Principle 1: Identify Customer and Specify Value.

<table>
<thead>
<tr>
<th>Customer</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDLBB Department (MOH)</td>
<td>Blood is available during disaster cases and on demand</td>
</tr>
<tr>
<td>People</td>
<td>Ensure blood availability for patients</td>
</tr>
<tr>
<td>Blood Banks</td>
<td>- Blood is available at each bank and using GDLBB System.</td>
</tr>
<tr>
<td></td>
<td>- Improve workers skills.</td>
</tr>
<tr>
<td></td>
<td>- Share lessons &amp; expertise with other blood banks.</td>
</tr>
<tr>
<td></td>
<td>- Increase the awareness of blood donations.</td>
</tr>
</tbody>
</table>
Lean Implementation

Principle 2: Identify Value Stream Mapping

Current State -VSM-:
Lean Implementation

Principle 2: Identify Value Stream Mapping

Future State -VSM-:
Lean Implementation

**Principle 3: Create Flow Streamlining**

- A blood bank hires and continuously trains workers. (e.g. Exchange Workers Program)
- Continuous follow-up for achieving GDLBSS's objectives.
- Educational programs. *(the more you educate people, the more they donate)*
- Each blood bank is required to make a donation drive three times or more monthly depending on goals and statistics.
- A blood bank is to effectively contribute and assist other banks by making blood drives.
- The Private Network & medical equipment should be always available and maintained.
- A blood bank requests blood from the nearest blood bank.
Lean Implementation

Principle 4: Pull

- A blood bank doesn’t push blood to other banks unless it is requested through the Private Network.
- Within 15-25 minutes.
Lean Implementation

Principle 5: Pursuit of Perfection

- Work on small improvements day by day.
- Every process has value to the system.
- 5S.
Lean Implementation

Principle 6: Respect for People

- Promote for "how can I help you?" rather than "the blame and shame culture".
- Adherence to salary monthly.
- Provide a safe environment at work.
- Racism. (e.g. promotion based on relations & tribe)
## Improvement Summary

<table>
<thead>
<tr>
<th>Item</th>
<th>Current State</th>
<th>Future State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Drive (each blood bank)</td>
<td>Once a month</td>
<td>3 or more monthly</td>
</tr>
<tr>
<td>Blood availability for rare types and when disasters</td>
<td>Unstable</td>
<td>Stable</td>
</tr>
<tr>
<td>Training</td>
<td>One time before hiring</td>
<td>Continuous</td>
</tr>
<tr>
<td>Average waiting time for blood donation</td>
<td>More than one hour</td>
<td>40 minutes</td>
</tr>
<tr>
<td>Communication between blood banks</td>
<td>Ineffective</td>
<td>Effective</td>
</tr>
<tr>
<td>Sharing lessons and experiences</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Lean Enablers

- **1.2.2.** Ensure that everyone can see how their own contributions contribute to the overall success of the program vision.

- **2.6.** Actively minimize the bureaucratic, regulatory and compliance burdens on the program and subprojects.

- **4.10.1.** Make work progress visible and easy to understand to all, including external customers.

- **6.2.3.** Set up a Lean management training infrastructure so that mid-level and project managers can better train and motivate their teams.

- **6.4.1.** Create mechanisms to capture, communicate, and apply experience.
Project Management: Organizing Event

- **Business:** includes corporations of large, medium, and small size (e.g. STC: 5,000 employees)
- **Governmental Departments:** includes all departments and branches (e.g. Ministry of Labor)
- **Educational Institutes.** (e.g. King Saudi University: 35,800 students)
- **Community Organizations:** includes all civic and social organizations, such as the Prince Salman Social Center (PSCC)
- **Faith-based Organizations:** includes all religious centers and mosques (e.g. Alrajhi Grand Mosque)
Organizing Event: Blood Drive Timeline

- Establish goals.
- Select planning committee.
- Event theme.
- Date/time/location.
- Budget and resources.

3 months before event

- Written approvals.
- Assign workers.
- Develop posters.
- Order educational material.

2 months before event

- Review Statistics reports.
- Print evaluation forms.
- Publicize the event.

1 month before event

2 weeks before event

- Review progress and strategy.
- Obtain medical supplies.

Event Follow-up

- Thanks letters.
- Evaluate event.
- Lessons learned
- Transferring blood.
- Data into the Private Network.

1 day before event

- Set up the vehicle at the location and check out the place.

1 week before event

- Call/email for event confirmation.
- Confirm staff.
- Finalize preparation.
- Obtain blood vehicle.
Financial Responsibility & Cost

- Blood banks to provide equipment, while (MoH) to pay and operate the Private Network.

- Medical Equipment (average costs):
  - Infectious Diseases Detector: $11,500
  - Cooling Refrigerator: $8,500
  - Cell Washer and Tube Centrifugation: $9,000
  - Hematology Analyzer: $7,500
  - Plasma Freezer: $8,000
  - Plasma Thawing Bath: $350
  - Platelet Incubator: $1000
  - Platelet Shaker: $400
Financial Responsibility & Cost

- **The Private Network:**
  - Virtual Private Network (VPN): $10,600 (main: 68 Mbps), $25,160 * 34 (each branch: 2 Mbps): total= $35,760 monthly
  - Modem: $600 * 34 = $20,400 one-time charge
  - Cisco Router: $800 * 34 = $27,200 one-time charge
  - Computer: $1000 * 34 = $34,000 one-time charge
## Risk Management

<table>
<thead>
<tr>
<th>No.</th>
<th>Risk</th>
<th>Likelihood</th>
<th>Impact</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Private Network availability</td>
<td>Low</td>
<td>High</td>
<td>Having a backup connection</td>
</tr>
<tr>
<td>2</td>
<td>Public hospitals' blood banks have less-features equipment</td>
<td>Low</td>
<td>Low</td>
<td>The GDLBB System has specific standards for equipment.</td>
</tr>
<tr>
<td>3</td>
<td>Small vehicle is not available for distribution</td>
<td>Medium</td>
<td>Medium</td>
<td>If it is an urgent case, the requesting blood bank sends its vehicle or asking from a different blood bank</td>
</tr>
<tr>
<td>4</td>
<td>High level of bureaucracy is applied</td>
<td>Medium</td>
<td>High</td>
<td>Develop a general policy of empowering and rewarding the bottom-up culture</td>
</tr>
<tr>
<td>5</td>
<td>a blood bank fails to reach the 100% collected blood plan</td>
<td>Medium</td>
<td>High</td>
<td>The Blood Banks Unit and Planning &amp; Development Unit should continually make follow-up plans with all blood banks</td>
</tr>
<tr>
<td>6</td>
<td>Workers feel belonging to either the GDLBB System or hospitals</td>
<td>Low</td>
<td>Medium</td>
<td>Develop and execute a clear communications plan that covers the entire value stream and stakeholders</td>
</tr>
<tr>
<td>7</td>
<td>Lack of cooperation between blood banks</td>
<td>Low</td>
<td>High</td>
<td>Developing a plan that implements the system policy and ensures accountability within the entire teams in communications, coordination, and decision making methods at the planning beginning</td>
</tr>
<tr>
<td>8</td>
<td>Blood in refrigerators stored for more than 42 days</td>
<td>Low</td>
<td>Medium</td>
<td>After twenty days, the blood should be distributed to other blood banks</td>
</tr>
</tbody>
</table>
Risk Matrix

![Risk Matrix Diagram]

- Low
- Medium
- High

Legend:
- 5: Highest Level
- 4: High Level
- 3: Medium Level
- 2: Low Level
- 1: Lowest Level

The diagram illustrates a risk matrix with axes for Likelihood and Severity, where the risk levels are color-coded as follows:
- Green: Low
- Yellow: Medium
- Red: High

The cells are labeled with numbers indicating the risk levels, with combinations like (1), (2), (3), (4), etc., for different risk scenarios.
Verification & Validation Methods

- V&V are methods to ensure that an engineering system meets requirements and specifications, and that it fulfills its intended purpose.

- Verification includes four activities: inspection, analysis, demonstration, and testing.

- Examples.
Lessons Learned

- **Changing from the status-quo limited system to a bigger improved system under the umbrella of the Ministry of Health is a significant challenge.** (e.g. bureaucracy)
- **Raising big questions often leads to good decisions.** (e.g. what impacts could we have if we have not engineered the blood banks system?)
- **As it is said “one hand can’t clap alone.”** Medical societies and organizing groups (e.g. Saudi Society of Hematology) are important to increase the value to the system.
Conclusion

The GDLBB System is to solve the lack of blood problem by increasing blood collected by blood banks to 100% availability. Moreover, the system will distribute blood to each needed blood bank regardless of its type-based using the Private Network in regular needs, rare blood types, and disasters cases. Also, this engineering system is promising to increase the level of awareness of the importance of blood donations. Through applying Systems Engineering discipline, the GDLBB System will hopefully yield better results than the current model.
Thank You,