Amir Bijandi
Mentor: Timothy Davis
Remote-Guided Pickup Drop Off System RGPDOS

Johns Hopkins Whiting School of Engineering
System Engineering Master’s Project
AGENDA

- My Background
- Introduction & need
- Five-minute Video
- CONOPS (initial & final)
- How did we model the RGPDOS?
- Reports: RA, FA, TS, Conceptual design, etc.
- Risk Management
- Recommendations
TECH. BACKGROUND

U.S. MERCHANT MARINER
7+ YEARS OF MARITIME EXPERIENCE
IN BOSCO, VSC, D.C. CRUISES ....
EDUCATION:
BS, MARINE ENGINEERING
BS, NAVIGATION
CURRENTLY STUDING M.S. SYSTEM ENGINEERING
FUN FACTS;
VIOLONIST & COMPOSER
SWIM COACH
LOVE NATURE & READ BOOKS
Introduction

RGPDOS initial concept is a system that:
Improve maritime transportation implementing SE processes.
Decrease TTL cost and needs for personnel
Minimize loss of lives and property
Eliminate the deficiencies and downsides of the current system.

Stakeholders;
Marine pilots
Port Management
VTS Personnel
Ships Crew
AV pilot (System operator)
What is going on?
What is wrong?

- **Spend a night** in the mouth of the Chesapeake Bay waiting for the inbound cargo ships

- VTS must allocate **a noticeable time to schedule** the marine pilots.

- **Delays** in-bound/ out-bound **vessels**

- Climbing up/down the pilot ladders is risky and could jeopardize the marine pilot’s life

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**SLOW**

**UNSAFE**

Launches and Rope ladders
Stakeholders Needs

The objective of this survey is to collect valid information about port of Baltimore piloting operation. The collected data may be used by Johns Hopkins University in order to develop cutting-edge technology to promote port safety and its operational capabilities.

**Personal details**

Name: Nick Nielson  Organizational Rank/position: President of Association of Maryland Pilots

1. How many pilot vessels are operationally running during each shift work? (No matter how many hours each shift work is)
   1. 1 Vessel
e 2. 2 Vessels
   3. 1 or 2 Vessels

2. How many marine pilots are on-call/standing by during routine operations? If you don’t know the exact number, please choose one of the following:
   a. 200 gallons to 500 gallons
   b. 500 gallons to 1000 gallons
   c. More than 1000 gallons

3. How much fuel would be the average monthly consumption of a pilot boat? Less than 200 gallons and about …

4. How much is the yearly maintenance cost for each pilot boat? Not answered – sensitive data

5. Does the port of Baltimore have heliboarding for pilot embarkation/disembarkation operations? If yes, how much does it cost each time? No, it does not

6. On average, how many pilotage operations does the port of Baltimore have per day?

7. What is the maximum speed of a pilot boat? The maximum speed that we operate our launches is 20 Ks.

8. As per local regulations, what is the maximum boarding speed? Not more than 8 Ks

9. How many accidents did you have reported regarding pilot embarkation/disembarkation in the last five years? Not answered – sensitive data How about near accidents? Not

10. Are the bay pilots relieved by the harbor pilots before docking operations? Yes

11. What do you believe is the "hiccup" in the port of Baltimore in terms of pilot embarkation/disembarkation? Please mention technical incapability?

**Q1. Quantity of launches running during…**

<table>
<thead>
<tr>
<th>Vessel</th>
<th>1 Vessel</th>
<th>2 Vessels</th>
<th>1 or 2 Vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>80%</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

**Q2. Marine Pilots on-duty**

<table>
<thead>
<tr>
<th>Persons</th>
<th>10 persons</th>
<th>15 persons</th>
<th>11 persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>80%</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

**Q5. Does Baltimore use heliboarding?**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Q7. Maximum speed for a launch?**

<table>
<thead>
<tr>
<th>20 kn</th>
<th>21 kn</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>90%</td>
</tr>
</tbody>
</table>

**Q11. What is the hiccup to embark/disembark a ship?**

<table>
<thead>
<tr>
<th>Communicating with foreign ships</th>
<th>Climbing up and down rope ladders</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Researchers: Amir Bijandi
## Results

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
<th>Mean result</th>
<th>Result considered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of launches are currently used</td>
<td>1.9</td>
<td>2 Launches</td>
</tr>
<tr>
<td>2</td>
<td>How many marine pilots are needed</td>
<td>10.6</td>
<td>11 pilots</td>
</tr>
<tr>
<td>3</td>
<td>The average consumption of a pilot boat</td>
<td>Sensitive information</td>
<td>100 gph (50 gph for each launch)</td>
</tr>
<tr>
<td>4</td>
<td>Yearly maintenance cost of a pilot boat in the port of Baltimore</td>
<td>Sensitive information</td>
<td>$55k</td>
</tr>
<tr>
<td>5</td>
<td>Any alternative system is currently used</td>
<td>NA</td>
<td>NO</td>
</tr>
<tr>
<td>6</td>
<td>How many pilot operations per day</td>
<td>Sensitive information</td>
<td>18 operation per day</td>
</tr>
<tr>
<td>7</td>
<td>Maximum traveling speed of the current system</td>
<td>20</td>
<td>20kn</td>
</tr>
<tr>
<td>8</td>
<td>Maximum boarding speed</td>
<td>8</td>
<td>8 kn</td>
</tr>
<tr>
<td>9</td>
<td>Number of incidents related to the current system</td>
<td>Sensitive data</td>
<td>46% of all incidents</td>
</tr>
<tr>
<td>10</td>
<td>If the bay pilots relieved by the harbor pilots</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>What is the most noticeable downside with the present system</td>
<td>70% mentioned, Climbing up and down rope ladders</td>
<td>Climbing up and down rope ladders</td>
</tr>
</tbody>
</table>
Initial ConOps

Utilize VTOL capabilities to transfer MPs

Autonomously Schedule MP

Autonomously picks the fastest available RGAV

Autonomously charge/refuel RGAV

Comply with Safety/Security measures (ISPSS Code, FAA Rules, IMO Regulations,...)

Cost-effective comparing to Launches and rope ladder

Faster and Safer
LET’S WATCH THE VIDEO
How We Modeled?

MBSE
Methodology
Tool
Language
System of Interest

Direct Composition
High-level context diagram (Black box)
Use case #1: Embark a ship

**Actor:** The marine pilot

**Description:** Command “embark the ship” when the encrypted landing signal is received.

**Input:** The encrypted landing signal

**Source:** GCS

**Output:** The RGAV starts landing on the helideck

**Destination:** RGAV

**Action:**
- No embarkation will be allowed if the command “embark the ship” is received, the RGAV confirmation signal is not received back to the GCS.

**Requires:**
- No command can be executed unless the Helideck is clear of any obstruction vessel identification is confirmed. The Real Time and real-time data stream is being received.

**Precondition:**
- The Helideck is clear of any obstruction vessel identification is confirmed. The Real Time and real-time data stream is being received.

**Postcondition:**
- The Marine pilot gets off the RGAV and receives the embarkation call.
Requirement Development

USER NEEDS

TECH. GAPS

USE CASE

CAUSALITY DIAG.

AMBIENT ENVIRONMENT

CONOPS

MNS

FUNCTIONAL REQ.

OPERATIONAL REQ.

NON-FUNCT. REQ.
<table>
<thead>
<tr>
<th>Req . ID</th>
<th>Requirements Title</th>
<th>Requirement Text</th>
<th>Threshold</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>System availability</td>
<td>The RGPDOS shall have a system availability ≥99.8%.</td>
<td>System availability of 99.8%</td>
<td>System availability of 100%</td>
</tr>
<tr>
<td>1.2.1</td>
<td>Fast transportation Harbor to PBA</td>
<td>The RGPGOS shall transfer marine pilots from harbor to PBA in less than 2 h(T)</td>
<td>2h</td>
<td>1h</td>
</tr>
<tr>
<td>1.2.2</td>
<td>Fast transportation PBA to Harbor</td>
<td>The RGPGOS shall transfer marine pilots from PBA to harbor in less than 2 h.(T)</td>
<td>2h</td>
<td>1h</td>
</tr>
<tr>
<td>1.2.3</td>
<td>Fast transportation</td>
<td>The RGPGOS shall transfer marine pilots from a ship to a ship in the PBA in less than 0.5h(T)</td>
<td>30 min</td>
<td>15min</td>
</tr>
<tr>
<td>1.27</td>
<td>Retrieval of information</td>
<td>The system shall enable retrieval of information about marine pilot transportations as needed by the port administration.</td>
<td>Data available for ≥ 6 months</td>
<td>Data available since system inception</td>
</tr>
<tr>
<td>3.22</td>
<td>Clean source of energy</td>
<td>The RGPDOS shall use a clean source of energy in order to comply with 40 CFR-part 87, CONTROL OF AIR POLLUTION FROM AIRCRAFT AND AIRCRAFT ENGINES.</td>
<td>comply with 40 CFR-part 87, CONTROL OF AIR POLLUTION FROM AIRCRAFT AND AIRCRAFT ENGINES.</td>
<td>Zero emission and no air pollutant.</td>
</tr>
</tbody>
</table>
## 1.0 OPERATIONAL REQUIREMENTS

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement Name</th>
<th>Requirement Statement</th>
<th>Tractability</th>
<th>Verification</th>
<th>Function ID</th>
<th>Function Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>System availability</td>
<td>The RGPDOS shall have a system availability of ≥99.80%</td>
<td>7.0</td>
<td>X</td>
<td>7.8.3</td>
<td>Support maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Switch to EP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Switch back to main power</td>
</tr>
<tr>
<td>1.2.1</td>
<td>Fast Transportation</td>
<td>The RGPGOS shall transfer marine pilots from harbor to PBA in less than 2 h(T)</td>
<td>0.1</td>
<td>X</td>
<td>5.0</td>
<td>Transfer MP</td>
</tr>
<tr>
<td>1.2.2</td>
<td>Fast transportation PBA to Harbor</td>
<td>The RGPGOS shall transfer marine pilots from PBA to harbor in less than 2 h(T)</td>
<td>0.1</td>
<td>X</td>
<td>5.0</td>
<td>Transfer MP</td>
</tr>
<tr>
<td>1.26</td>
<td>Encrypted communication</td>
<td>The internal communication of the system with mobilized component(s) used to transport the marine pilot shall be encrypted by 128 bit(T)/256bit(Q)</td>
<td>0.5</td>
<td>X</td>
<td>5.1.3.2</td>
<td>Encrypt real-time codes</td>
</tr>
<tr>
<td>1.27</td>
<td>Retrieval of information</td>
<td>The system shall enable retrieval of information about marine pilot transportation and access to the system pertaining to the last 180 days as needed by the port administration.</td>
<td>0.9</td>
<td>X</td>
<td>12.0</td>
<td>Archive data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Store data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Compress data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Format data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Save data</td>
</tr>
</tbody>
</table>

## 2.0 Functional Requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement Name</th>
<th>Requirement Statement</th>
<th>Tractability</th>
<th>Verification</th>
<th>Function ID</th>
<th>Function Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.112</td>
<td>Flight range</td>
<td>The system shall be able to accomplish a flight range ≥150(O) nm/145nm(T). Flight range is the maximum distance that the RGAV can fly without stopping while at maximum carrying capacity.</td>
<td>1.5</td>
<td>T</td>
<td>5.4.2.5</td>
<td>Fly a required flight path while carrying a payload</td>
</tr>
</tbody>
</table>

**Note**: The table includes various requirements and their associated functionalities and IDs.

---

**Requirements Sample**

---
## Requirement Development

<table>
<thead>
<tr>
<th>Project Stage</th>
<th>Total</th>
<th>Quantitative</th>
<th>%</th>
<th>Binary</th>
<th>Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements Analysis Report</td>
<td>144</td>
<td>61</td>
<td>42</td>
<td>28</td>
<td>55</td>
</tr>
<tr>
<td>Functional Analysis Report</td>
<td>184</td>
<td>83</td>
<td>45</td>
<td>35</td>
<td>67</td>
</tr>
<tr>
<td>Trade Study</td>
<td>190</td>
<td>87</td>
<td>46</td>
<td>36</td>
<td>67</td>
</tr>
<tr>
<td>Conceptual Design Report</td>
<td>195</td>
<td>90</td>
<td>46</td>
<td>37</td>
<td>68</td>
</tr>
<tr>
<td>System Specifications</td>
<td>239</td>
<td>173</td>
<td>72</td>
<td>66</td>
<td>0</td>
</tr>
<tr>
<td>Risk Management</td>
<td>240</td>
<td>174</td>
<td>73</td>
<td>66</td>
<td>0</td>
</tr>
<tr>
<td>Test Plan</td>
<td>245</td>
<td>179</td>
<td>73</td>
<td>66</td>
<td>0</td>
</tr>
<tr>
<td><strong>Final</strong></td>
<td><strong>245</strong></td>
<td><strong>179</strong></td>
<td><strong>73</strong></td>
<td><strong>66</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>
Functional Development

Use Case

ConOps

Functional Context

Zero-Level Functional flow

Black Box

Lower-Level Functional flow

Functional Req.

\[ N^2 \]
Functional Context Diagram
Functional flow Diagram
(Level Zero)
Trade Study

Formal:
What technology can be the best ???
VTOL capability & point-to-point transport

Informal:
- Cost-effective Energy source
- Charging stations functionalities.
- High-range wireless communication
CRITERIA

Max. Range

Reliability

Max. Takeoff Weight

Cruise Speed

Efficiency

Max. Capacity

R ID: 2.11.1
KPP: YES
Requirement Name: Flight Range
Statement: The system shall be able to accomplish a flight Range $\geq 145 \text{ nm}$ when the reported wind is no greater than 5Kn.
e VTOL BARTINI wins

1. Lilium jet
2. Bartini
3. City hawk
4. Helicopter R-22

Utility Scores
TTL Cost
Combined Scores

Sensitivity Analysis

Trade Space

$N^{th}$ root
FINAL CONCEPT
DOD RISK MANAGEMENT GUIDELINE

- Risk Identification
  What can go wrong?

- Risk Monitoring
  How has the risk changed?

- Risk Analysis
  What is the likelihood and consequence of the risk?

- Risk Mitigation
  Should the risk be accepted, avoided, transferred or controlled?

Risk Reduction Plan (Risk Control)

<table>
<thead>
<tr>
<th>Execution</th>
<th>Description</th>
<th>Date</th>
<th>Likelihood</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Risk identified and summarized</td>
<td>08/13/19</td>
<td>MOD</td>
<td>SEVER</td>
</tr>
<tr>
<td>2</td>
<td>Define and analyze system functional flow to determine input and output of remote-paired functionality</td>
<td>08/13/19</td>
<td>MOD</td>
<td>SEVER</td>
</tr>
<tr>
<td>3</td>
<td>Define inventory based on RA &amp; FA. Allocate a secondary means of communication to existing guide for RGAV in Computing systems</td>
<td>10/24/19</td>
<td>MOD</td>
<td>MOD</td>
</tr>
<tr>
<td>4</td>
<td>Develop and execute the test plan</td>
<td>11/20/19</td>
<td>MOD</td>
<td>MIN</td>
</tr>
</tbody>
</table>

Likelihood: LOW, MOD, HIGH
Impact: MIN, MOD, SEVER
<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Title</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R001</td>
<td>GCS to RGAV Communication loss</td>
<td>If GCS lose communication with RGAV, the AV will not be remotely guided any longer.</td>
<td>Technical</td>
</tr>
<tr>
<td>R002</td>
<td>RGAV start-up failure on the cargo ship</td>
<td>If RGAV fails to start up for any reason when it is already landed on the cargo ship, the marine pilot will not be able to disembark, and the outband vessel will take it away.</td>
<td>Technical</td>
</tr>
<tr>
<td>R003</td>
<td>RGAV subsystem failure</td>
<td>If RGAV technically fails, the Air Vehicle will crash.</td>
<td>Technical</td>
</tr>
<tr>
<td>R004</td>
<td>The VTS Communication loss</td>
<td>If the RGPDOS cannot communicate with VTS, the pilotage operation will be stopped.</td>
<td>Technical</td>
</tr>
<tr>
<td>R005</td>
<td>Charging station malfunction</td>
<td>If malfunction with the charging stations (out of power etc.), RGVA will not be charging.</td>
<td>Technical</td>
</tr>
<tr>
<td>R006</td>
<td>Course completion in two semesters</td>
<td>Due to taking another course simultaneously, and a full-time job, there is a potential that the completion of the project in two semesters may not be possible.</td>
<td>Project</td>
</tr>
<tr>
<td>R007</td>
<td>ATC communication loss</td>
<td>Loss of communication between the system and ATC makes the operator unable to ask for flight permit.</td>
<td>Technical</td>
</tr>
<tr>
<td>R008</td>
<td>Complexity of the system</td>
<td>If the complexity of RGPDOS is underestimated, the project might not be doable within budget and schedule.</td>
<td>Technical</td>
</tr>
<tr>
<td>R009</td>
<td>Security breach</td>
<td>Unknown trojans and hacker attacks may cause system down.</td>
<td>Technical</td>
</tr>
<tr>
<td>R010</td>
<td>Fatal crash</td>
<td>If the RGAV for any reason crashes the Marine pilots risk their lives.</td>
<td>Technical</td>
</tr>
<tr>
<td>R011</td>
<td>Unknown unknown</td>
<td>Unknown changes, threats, regulations are not identified in the preliminary risk assessment might urge along the path of project.</td>
<td>Technical</td>
</tr>
<tr>
<td>R012</td>
<td>Local power outage</td>
<td>If any residential power outage, system power shut down.</td>
<td>Technical</td>
</tr>
</tbody>
</table>
Nov 3rd  
BCWB-BCWS =  
$4860 - 5520 = -660$ 
Behind Schedule 

Dec 1st  
Behind schedule 
$240$
LESSONS LEARNED

1. Trade space is larger during early SE phase.
2. Information gathering in the need analysis stage is a risky task in terms of the schedule.
3. Coupling and cohesions to cope with possibly unknown changes.
4. Trade Study processes are not only used for simple market decisions.
5. Magic Draw NOT support $N^2$ diagrams.
6. Error#400 with magic draw means that the modeling tools does not have enough memory allocated to work properly.
7. So at the early stage of the SE process, we do not want to unnecessarily constrain our design.
8. Everything is linked to cost.
Recommendations

- Include coding in both M.S. SE program and capstone project
- Establish correspondence with agencies and incorporations
- Require SE student to use the Lab facility to conduct at least one test case scenario
- Include MBSE course in the core courses.
- Award the best project of each semester
- Individual project propelled me to apply SE processes from NA to SSR for the first time.