The Agile Development of SPORT Spacecraft

Prof. Dr. Luis Eduardo Vergueiro LOURES da Costa
SPORT Mission
## SPORT Mission Measurements

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma motion</td>
<td>RPA/Drift meter</td>
</tr>
<tr>
<td>Plasma density / density profiles</td>
<td>GPS Occultation</td>
</tr>
<tr>
<td>Small scale structures and waves</td>
<td>Langmuir</td>
</tr>
<tr>
<td>Scintillation Index</td>
<td>Impedance</td>
</tr>
<tr>
<td>Magnetic field structure</td>
<td>E-Field</td>
</tr>
<tr>
<td>Plasma temperature</td>
<td>Magnetometer</td>
</tr>
</tbody>
</table>

[Diagram showing instruments and spacecraft components: Impedance Probe, GPS Occultation Patch Antenna, Floating Potential, E-field/Wave, Star Camera, Ion Velocity Meter, Magnetometer, Velocity, Nadir, Langmuir.]
Waterfall Approach?

Conception → Initiation → Analysis → Design → Construction → Testing → Implementation → Operation → Discharge
But: Development Uncertainties

- Experiments complexity
- Number of experiments and teams: many interactions needed
- Insufficient competence of the design team
- Unknown design practices from NASA
- New NASA design approaches for CubeSats
- Lack of information: NO Umbrella Agreement between Brazil and United States
Agile Manifesto

• **Individuals and interactions** over processes and tools
• **Working software (model)** over documentation
• **Customer collaboration** over contract negotiation
• **Responding to change** over following a plan

Source: www.agilemanifesto.org
Principles behind the Agile Manifesto

• Our highest priority is to satisfy the customer
• Welcome changing requirements, even late in the development
• Deliver working software (model) frequently
• Business people and workers must work together daily
• Build project around motivated individuals
• Face-to-face conversation
• Working software (model) is the primary measure of progress
• The sponsors, developers, and users should be able to maintain a constant pace
• Attention to technical excellence
• Simplicity is essential
• Best architectures, requirements and designs emerge from self-organizing teams
• The team reflects on how to be more effective: tunes and adjusts its behavior accordingly

Source: www.agilemanifesto.org
Principles behind the Agile Manifesto

- Satisfy the customer: UTD, NASA Goddard, USU, Aerospace, NASA Marshall
- Changing requirements: happening when necessary, example: pointing accuracy
- Deliver working model frequently: CAD, Thermal, Electrical, Radiation, Orbital, Control
- Business people and workers must work together: NASA HQ, Brazilian Congress, COMAER
- Motivated individuals: team was liberated from work, but EVERYONE came to work
- Face-to-face conversation: videoconference 3x or 2x per week
- Working model as measure of progress: frequent presentations
- Group should be able to maintain a constant pace indefinitely: happening
- Attention to technical excellence: three forms of risk management
- Simplicity is essential: KISS strategy
- Best architectures, requirements and designs emerge from self-organizing teams: we have
- The team tunes and adjusts its behavior accordingly: more or less
SPORT Development Strategy

4th Design Loop
3rd Design Loop
2nd Design Loop
1st Design Loop

Simplified diagram from System Engineering Analysis, Design and Development
First Loop (2 months)

• Stakeholder analysis
• Field Data
• Mission Need, Goals and Objectives:
• Mission Concept
• Operational Modes Definition

The results of the first loop were presented on the bi-weekly meeting
Concept similar to ITASAT
Second Loop (3 months)

- Mission requirements
- Scenarios Specification
- Concept of Operations
- Mission Event Timeline
- Risk Analysis: Mission level
- Review of Operational Modes

The results of the second loop were presented on the bi-weekly meeting.
LOOP 2

Star Tracker

Reaction Wheels
Third Loop (3 months)

- System and Subsystem Requirements
- Operational Scenarios
- Preliminary System Architecture and Budget (power, mass and data)
- Mission Event Timeline
- Risk Analysis: System level
- Preliminary Systems Interface definition
- Sport State, Modes and Use Cases
- Attitude Control Model
- Mechanical Model
- Power Generation Simulation

The results were presented on the Sport Workshop on September 2017
Fourth Loop (6 months)

- Updated CONOPS
- Mission and System Requirements
- Preliminary Mechanical Analysis
- Preliminary Thermal Analysis
- Functional Analysis and Description
- Preliminary Systems Architecture
- Risk Analysis: subsystem level
- Preliminary Software Architecture

- Preliminary Electrical Diagram
- Preliminary Harness Identification
- Power, Mass and data Budget
- Power Generation Analysis
- Mission Event Timeline Update
- Sport State, Modes & Use Cases update

The results were presented on the CSR/PDR of Sport Project on April 2018
Deployable Panels

Shield for radiation in Aluminum
## Fifth Loop (4 months)

<table>
<thead>
<tr>
<th>Requirements and Analysis</th>
<th>Modules and System Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mission and System Requirements Review NASA approach)</td>
<td>• Spacecraft Physical Architecture Definition</td>
</tr>
<tr>
<td>• Subsystem requirements (NASA approach)</td>
<td>• Orbit Decay Analysis</td>
</tr>
<tr>
<td>• Detailed Thermal Analysis</td>
<td>• Mission Event Timeline Update</td>
</tr>
<tr>
<td>• Software Analysis and Development (System Modelling)</td>
<td>• Sport Sates, Models and Use Cases Update</td>
</tr>
<tr>
<td>• Detailed Software Architecture</td>
<td>• Parts Procurement</td>
</tr>
<tr>
<td>• Risk Analysis: Subsystem update</td>
<td>The results were presented on the Sport Equipment's CDR on August 2018</td>
</tr>
<tr>
<td>• Detailed Electrical Diagram</td>
<td></td>
</tr>
<tr>
<td>• Pointing Budget</td>
<td></td>
</tr>
<tr>
<td>• Power, Mass and Data Budgets Review</td>
<td></td>
</tr>
</tbody>
</table>

The results were presented on the Sport Equipment's CDR on August 2018
Sixth Loop (present)

- Mission and System Requirements baselined
- Detailed Mechanical Analysis
- Detailed Thermal Analysis
- Software Analysis and Development (emulators definition and development)
- Detailed System Architecture (interfaces and functional tests with emulators and simulators)
- Risk Analysis: Subsystem follow-up
- Detailed Electrical Diagram
- Detailed Software Architecture
- Spacecraft Physical Architecture update
- Power, Mass and Data budget review
- Pointing budget update
- Mission Event Timeline Update
- Sport Sates, Models and Use Cases Update
- Parts Procurement
- Verification and Validation strategy

The results will be presented on the Spacecraft emulators test with the instruments on November 2018
LOOP 6

Detail of Structure and Deployable Panel in progress
Conclusions

- In the SPORT bus design an evolutionary approach was used: Agile
- It was necessary due to the uncertainties in the project as a whole
- It was possible because of a multi-disciplinary self-organizing team
- This allowed a highly iterative development with the Stakeholders
- Which produced a close collaboration between developers and Stakeholders
- Each iteration worked with four architectures at the same time
- Which allowed a cross-fertilization in the development
- Results were presented constantly to the Stakeholders
- These results were based on working models rather than documents