

Agile Project Management in Scalable Team-Based Senior Capstone Design Experiences

Wouter Deconinck, William & Mary

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Physicists Find Careers Primarily Outside Academic Research

PHYSICS TRENDS

Spring 2019

Common Job Titles of New Physics Bachelors



Source: AIP Follow-up Survey of Physics Bachelors, classes of 2015 and 2016.

AIP Statistics

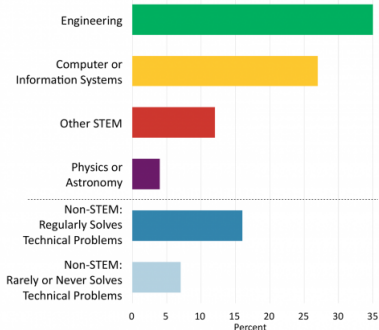
@AIPStatistics

aip.org/statistics

PHYSICS TRENDS

Fall 2017

Field of Employment for New Physics Bachelors Employed in the Private Sector



- STEM refers to natural science, technology, engineering and mathematics.
- Regularly solving technical problems includes respondents who selected "Daily", "Weekly", or "Monthly" on a four-point scale that also included "Rarely or Never".
- Almost half of new physics bachelors entered the workforce after receiving their degree, two-thirds of which were working in the private sector.
- Data are from AIP's Follow-up Survey of Physics Bachelors, classes of 2015 & 2016 combined.

AIP Statistics

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Physicists Find Careers Primarily Outside Academic Research

What skills are physicists missing?¹

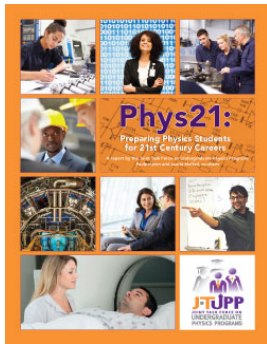
- Ability to design a system, component or process to meet a specific need
- Ability to function on multi-disciplinary teams
- Ability to recognize value of diverse relationships (customers, supervisors, etc)
- Leadership skills
- Familiarity with basic business concepts (i.e. cost-benefit analysis, funding sources, IP, project management)
- Communication skills (oral and written), esp. how to tailor message to audience
- Real-world experience in companies before graduation
- Awareness of career paths outside of academia

¹Sources: ABET Survey of Applied and Engineering Physics Graduates, Kettering University; APS Workshop on National Issues in Industrial Physics, Industrial Physics Lunches.

Joint Task Force on Undergraduate Physics Programs

Findings

- “The overwhelming majority of physics bachelor’s recipients are employed outside academia for all or part of their careers.”
- “Since only about one-third of physics Ph.D. recipients end up in academic careers, even students who plan to obtain graduate degrees will benefit from developing skills and knowledge that are valued outside the academic community.”



Promote career readiness: Scientific and technical skills

- “Competencies in instrumentation, software, coding, and data analytics.”
- “Introduce students to industry-standard tools and software packages.”

Initiatives in Team-Based Physics Design Courses I

Context at W&M

- Liberal-arts, no eng/med, subset of depts have graduate programs
- Physics department is largest STEM graduate research department
- Regional partners: NASA Langley, Jefferson Lab, Virginia Institute of Marine Science

Robo-Ops: Design and development of tele-robotic rover (2016)

- Semester-long class of 15 students (50% physics majors), 3 sub-teams
- Single project, agile project management (with many lessons learned)
- Co-supervisor: flight engineer at NASA Langley
- Outcome: third place on competition at Johnson Space Center

Initiatives in Team-Based Physics Design Courses II

Agile Innovation: NASA's Lab77 technology incubator (2017)

- Semester-long class of 15 students (30% physics majors)
- Problem finding, ideation, prototyping into minimum viable product
- Outcomes: mental health startup and novel drone-borne bacterial sampling system

Agile Project Management Senior Design Course (2018-19)

- Year-long senior project with 5 graduating physics majors
- Project entirely outside area of expertise of adviser
- Co-supervisors: mission engineer at NASA Langley, agile consultant
- Outcome: MVP of ejectable data recorder for NASA mission

Project Management: Waterfall vs. Agile

Waterfall model

- DOE/DOD/NASA: WBSes, gantt charts
- Large projects, extensive planning
- Reqs drive cost and schedule

Agile model

- Start-ups and collections of small teams, changing reqts
- Current cost and schedule drive features/priority iteratively

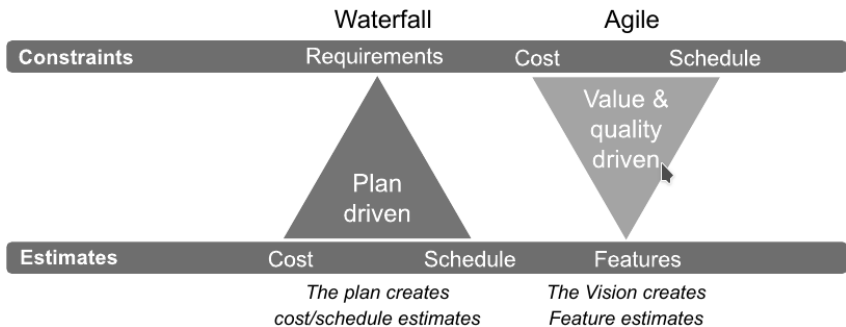


Image credit: Scaled Agile Inc.

Project Management: Waterfall vs. Agile

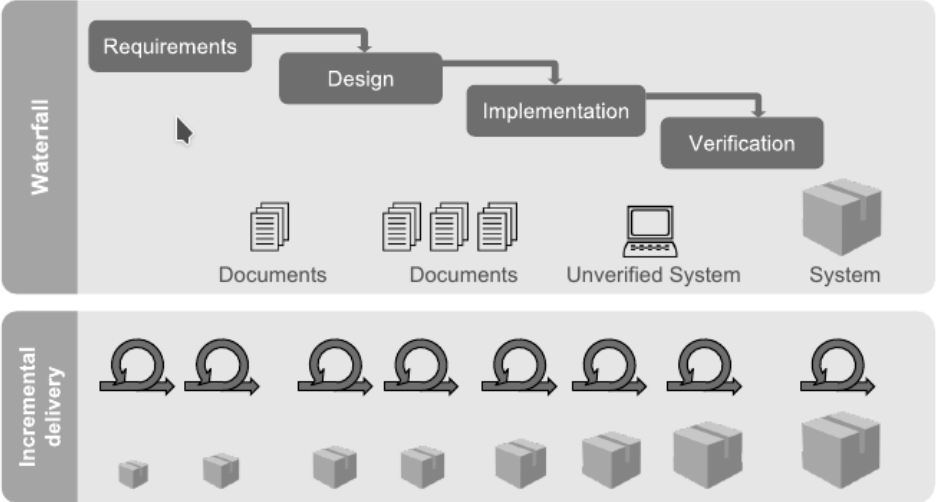


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Project Management: Waterfall vs. Agile

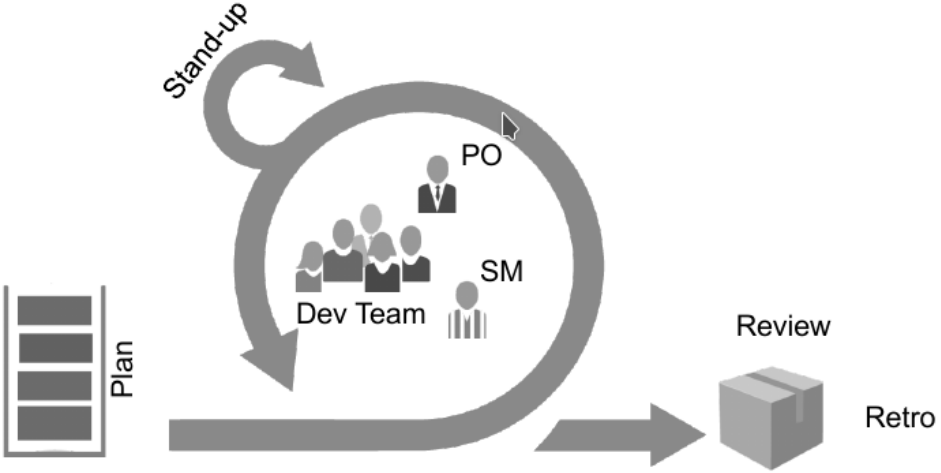


Image credit: Scaled Agile Inc.

Agile Values and Principles

Agile Manifesto

- Individuals and interactions over processes and tools
- Working products over comprehensive documentation^a
- Customer collaboration over contract negotiation
- Responding to change over following a plan

That is, while there is value in the items on the right, we value the items on the left more.

^aProducts: software, hardware,...

Agile Senior Research Capstone Course

Implementation

- Assigned roles: SM, scribe, archivist, ambassador, devil's advocate
- Scrum, but students are part-time researchers so slower paced
- Stand-up meeting (15 mins) led by SM every 1-2 days, at university
- Sprint demonstration (1 hour) with PO every 1-3 weeks, on location
- Followed by retrospective (30 mins) and next sprint planning (1 hour)
- Physical support tools: shared office/workspace, whiteboards, post-its
- Online support tools: Trello (kanban board), Slack (virtual space), Zoom

Sprint Planning

From Goals to Tasks

- Start with overall goals: “At the next demo, we would like to see functionality X” (largely driven by PO)
- Develop list of tasks that can be completed by single person in a single setting (by entire team)
- Three C’s: Card, Conversation, Confirmation (or Criteria)

Tasks based on Card Template

- “As a <role>, I want <activity> so that <value>”
 - e.g. “As a NASA LOFTID mission planner, I want to recover the payload after reentry so that stored data can be analyzed.”
- All cards assigned a Fibonacci score: 1, 2, 3, 5, 8 (a.u., equates roughly to hours), longer must be split up in parts

Agile Project Student Evaluation

The screenshot shows a Trello board titled "NASA EDR Conceptual Design" with a team of five members. The board is organized into five columns representing different stages of the project:

- To Do (Sprint Backlog) (26 left)**:
 - Order a print of the Drill in Windform. (1 - HIGH) [AS]
 - Print new 45 degree angle full size Dreidel/Pill shell shape (2 - HIGH) [GD]
 - Construct full potted/sealed shell shape with electronic components. (3 - MEDIUM)
 - Put completed and full shell shape in water to see if it is buoyant. (1 - HIGH)
 - Print the Drill in Onyx with kevlar fibers on the Markforges. (2 - MEDIUM)
 - Cut/drill the syntactic foam core (as many as possible). (3 - MEDIUM)
 - + Add another card
- In Progress - WIP: 1-2 / person - "pair" (2 people) on tasks where possible**:
 - Decide on a height for the Tungsten, so that we know where to cut the syntactic foam. (1 - HIGH) [GD]
 - Determine mass of EDR without tungsten mass. (1 - HIGH) [GD, NM]
 - Contact CRP about a Windform print of the final shell (with electronics mounts and seal). (3 - MEDIUM) [AS]
 - Set date for launch, talk to WM campus police. (1 - HIGH) [W]
 - Order a 9-axis accelerometer on the Matoaka launch? (1 - HIGH)
 - + Add another card
- Sprint 9: Done**:
 - Modify CAD design of the Drill (see description). (1 - HIGH) [NM]
 - Buy PVC and appropriate connectors for 4" spud gun. (1 - HIGH) [RW, W]
 - Order 2-part potting epoxy for Tungsten mass. (1 - MEDIUM)
 - Bring into office the Feather M0's and breadboards, as well as gifts from Carrie. (1 - HIGH) [W]
 - Find dimensions of the electronic components in one package. (1 - MEDIUM)
 - Print a sample of Onyx (1 - HIGH)
 - + Add another card
- Hold (Stretch Goals)**:
 - (HIVIZ) Decide on type of location device.
 - Perform Parabolic Spud Gun Launch Test (3 - HIGH)
 - Perform Parabolic Test Data Analysis (1 - MEDIUM)
 - Make code for parabolic test (5 - MEDIUM)
 - Get polyethylene spray?
 - Re-solder the feather and GPS that will go into the test shell. (1 - MEDIUM) [GD]
 - + Add another card
- Won't Do**:
 - Modify the spud gun to 4in diameter ([W]
 - Get Wouter to make a 4 inch diameter spud gun. (1 - HIGH) [W]
 - Buy filler foam (1 - LOW) [GI]
 - Get shaped tungsten mass through McMaster. (5 - MEDIUM) [NI]
 - Research mechanical seal interface (3 / low) []
 - Model center of buoyancy and center of mass for change we are []
 - + Add another card

Lessons Learned: Retrospective I

Based on feedback from students during the past year.

Participation of External Partners

- Strong motivator for students (even if not with name recognition and job prospects of NASA)

Consultants and Mentorship

- Benefited from industry partner (Adam Beck, Berkana Enterprise Consulting)
 - Agile coach, called in during half of the stand-ups, attended nearly all demos and team retrospectives (often virtually)
 - Provided optional parallel agile scrum master training for the teams (one current team member interviewed for agile project manager jobs based on this experience)
 - Opportunities for mentorship exist at many companies

Lessons Learned: Retrospective II

Additional Formal Training

- Agile workshop at start of year, may have been too early to be useful

Evaluation of Students

- Looking for tools beyond Trello that automatically determine velocity, burndown rate, individual contributions