Utilizing Python in RayStation for Proton Therapy Efficiency and Standardization

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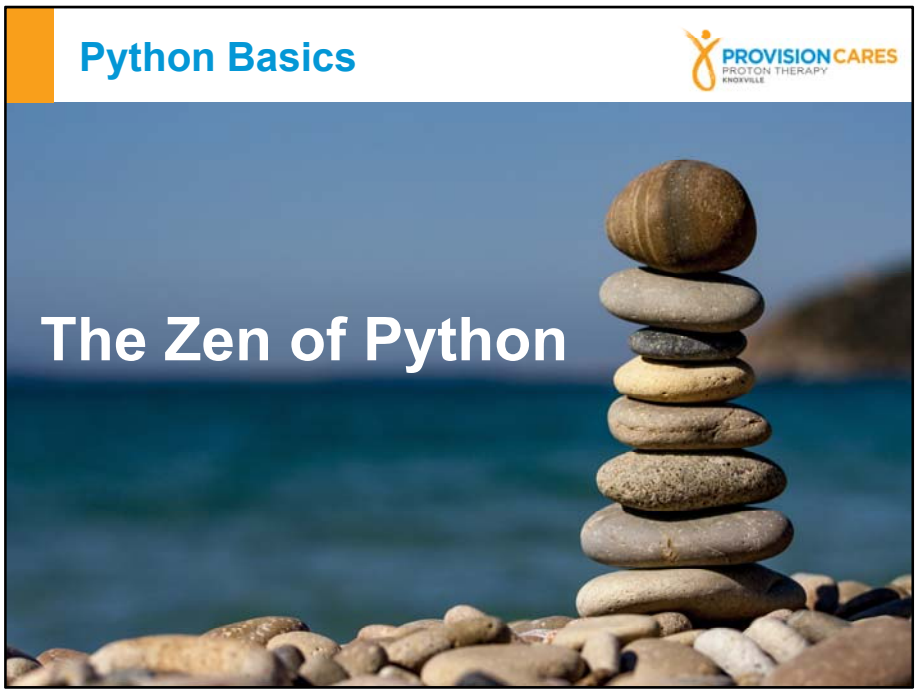
Table of Contents



The Zen of Python, by Tim Peters:

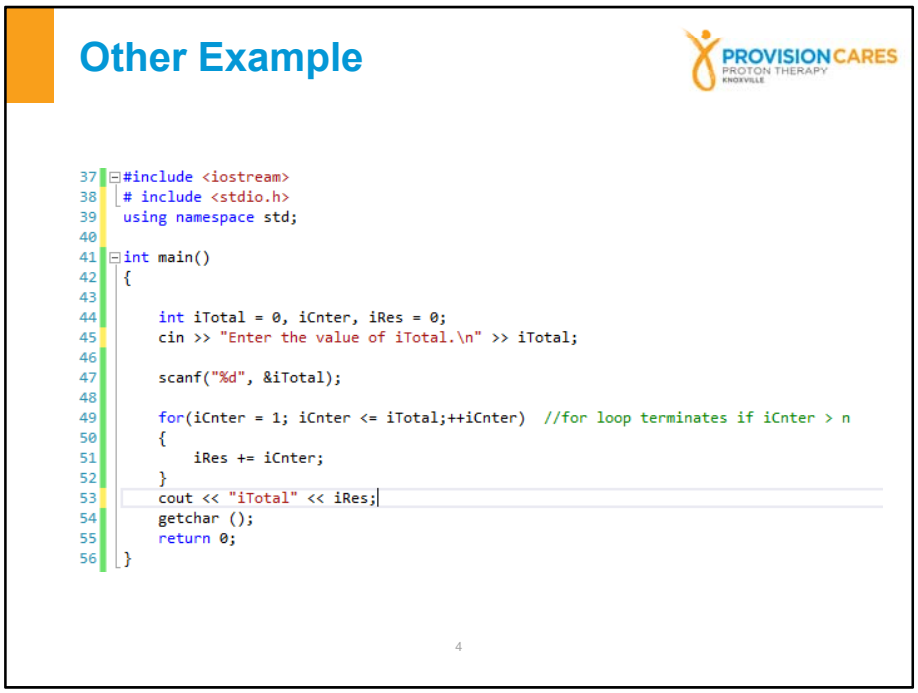
Simple is better than complex.
Complex is better than complicated.

Readability counts.

There should be one-- and preferably only one --obvious way to do it.

If the implementation is hard to explain, it's a bad idea. If the implementation is easy to explain, it may be a good idea.

Other Example



```
#include <iostream>
# include <stdio.h>
using namespace std;

int main()
{

    int iTotal = 0, iCnter, iRes = 0;
    cin >> "Enter the value of iTotal.\n" >> iTotal;

    scanf("%d", &iTotal);

    for(iCnter = 1; iCnter <= iTotal;++iCnter)  //for loop terminates if iCnter > n
    {
        iRes += iCnter;
    }
    cout << "iTotal" << iRes;
    getchar ();
    return 0;
}
```

4

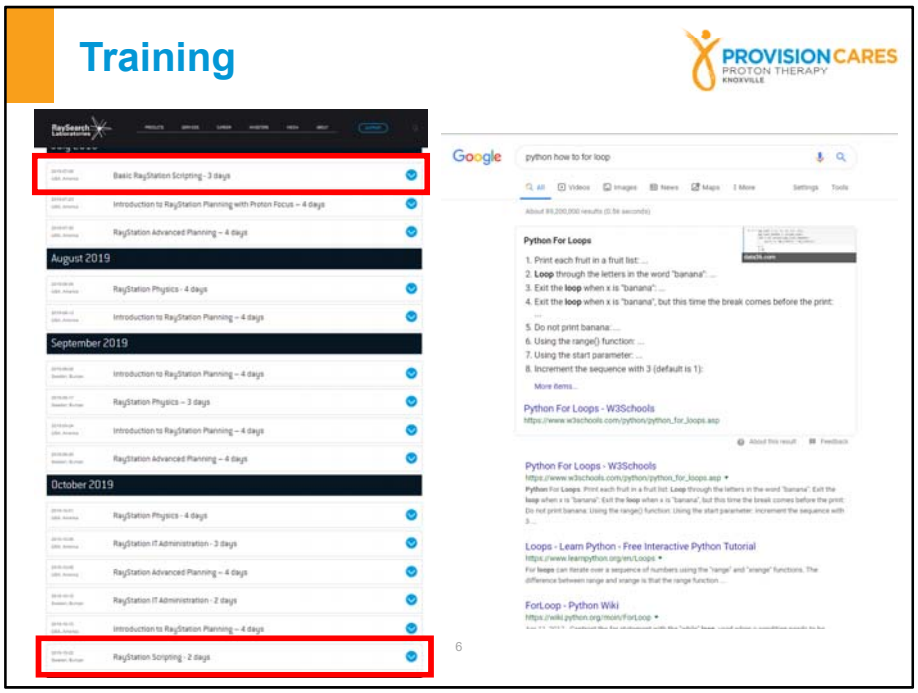
Hard to read, not simple

Python Example

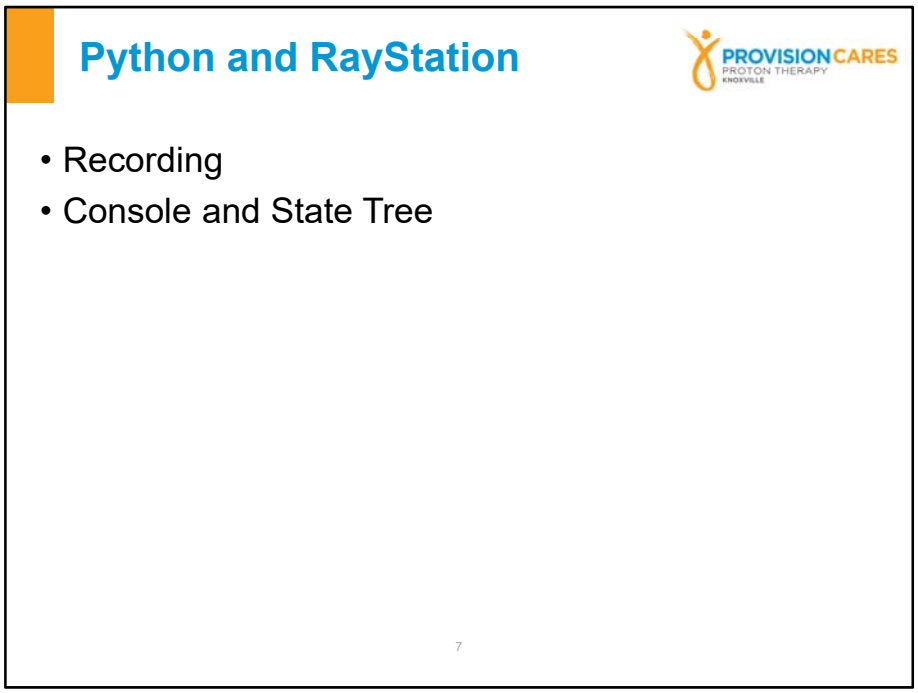
```
x = [1, 2, 3, 4, 5]
y = [6, 7, 8, 9, 10]

nx = len(x)
ny = len(y)

z=[[0 for i in range(nx)] for j in range(ny)]

for i in range (0, nx):
    for j in range (0, ny):
        z[i][j] = x[i] * y[j]

for i in range (ny):
    for j in range (nx):
      print('{0:4d}'.format(z[i][j]),end=' ')
    print()
```

5

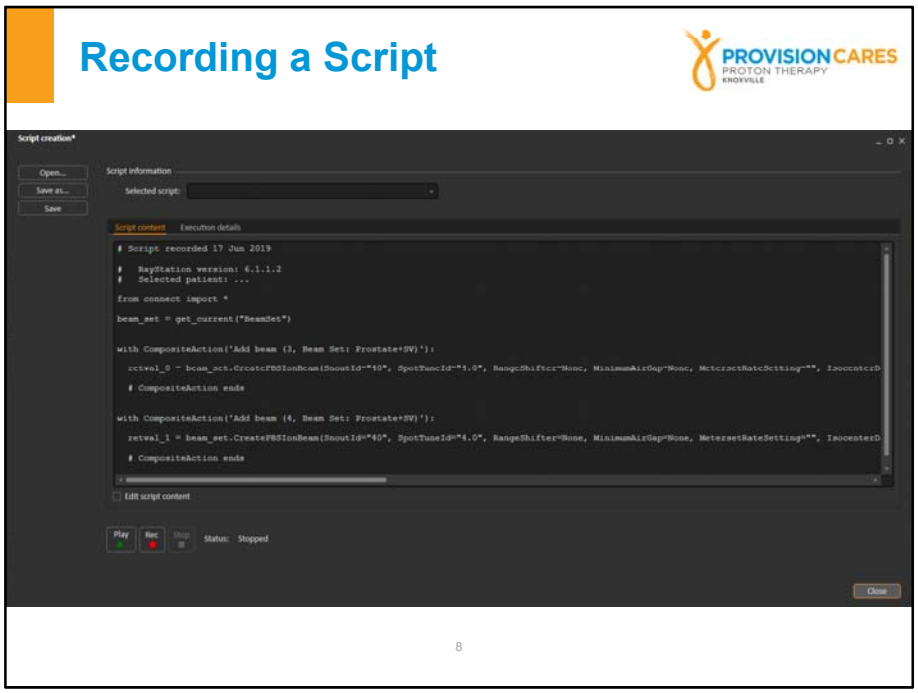
Easier to read, simple



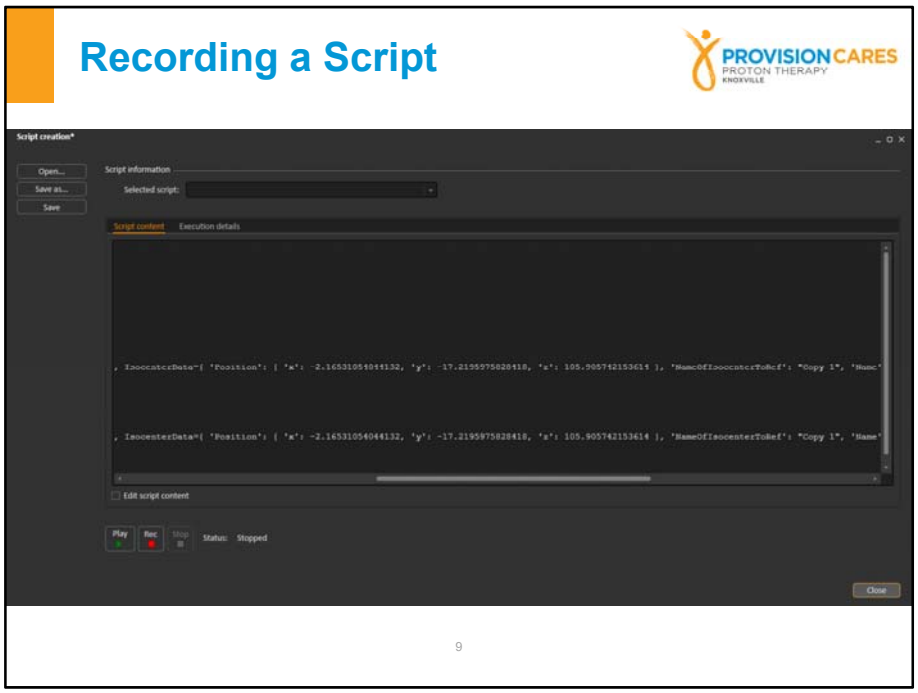
I have no formal training, I learned through the Manual and google.
I trained in Fortran, which is like learning Latin, it's a dead language



Python is expanding, it's already used in RayStation and it's starting to be adopted in other planning systems, like Eclipse
Python and RayStation allow the script to write to the database, not just read.
Opens up a huge world of automation

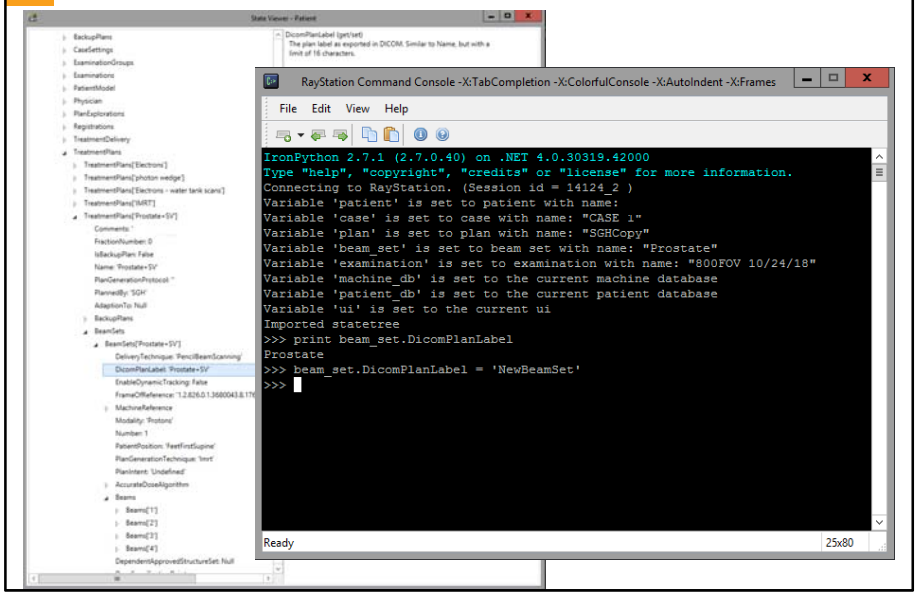


Recording a script allows you to visualize the lines of code necessary to accomplish the goal you just did through button clicks
Very useful for getting started



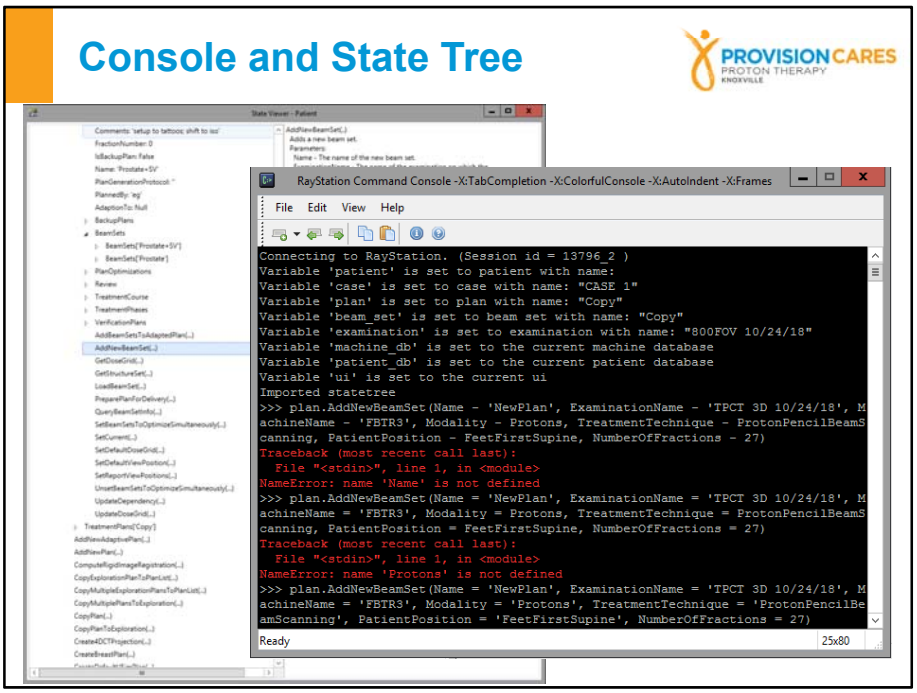
Recording has limitations
It hardcodes things like plan names, beam names, isocenter locations, etc
The scripter has to figure out how to make these parameters more generic and apply to a broader environment

Console and State Tree



State Tree is the “behind the scenes” of RayStation’s use of Python
Uses a hierarchy, from Case to Patient to Plan to Beamset to Beam
Can access functions well beyond recording scripts

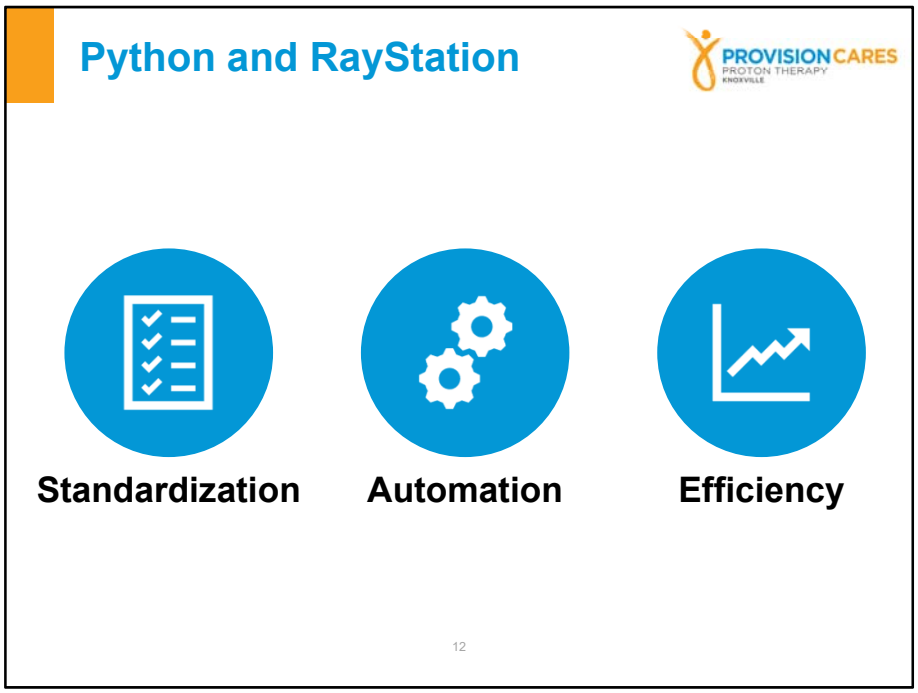
Console and State Tree



Console is used for trial and error

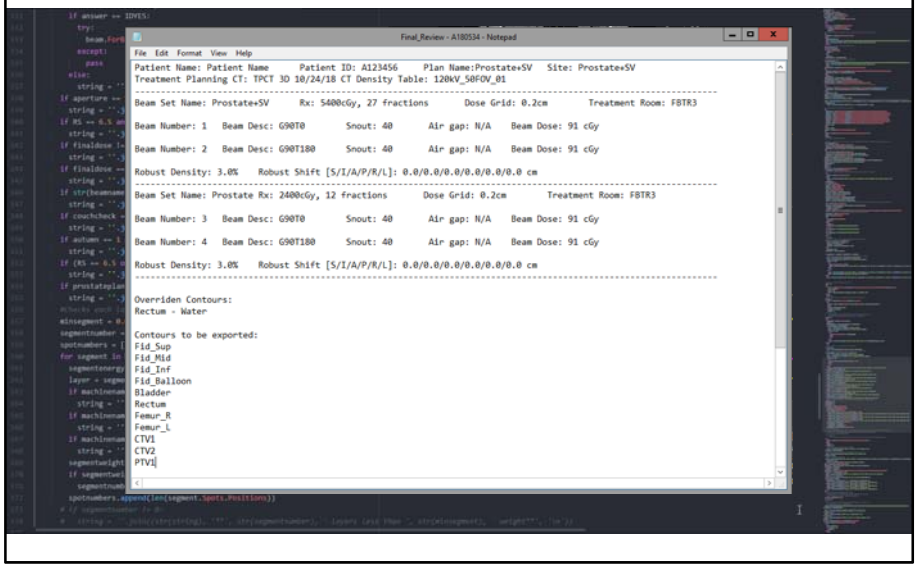
In my example, I thought you used a “-” to fulfill the necessary information but it required an “=“

In the second attempt, I was missing quotation marks are necessary information

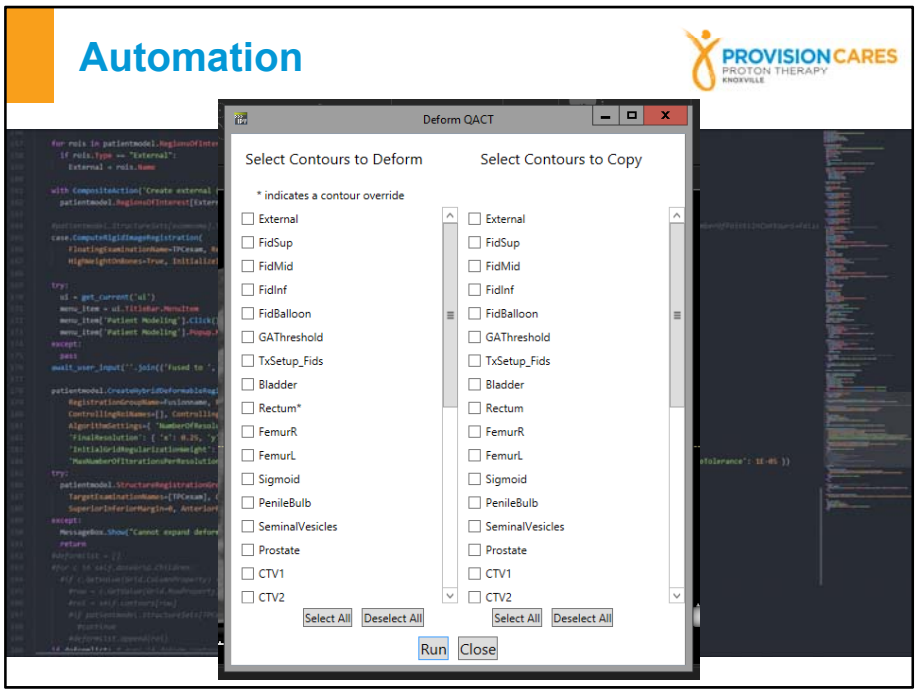


Scripting can be used for automation, standardization and efficiency
The only thing it can't be used for is MD approval (mostly kidding)

Standardization

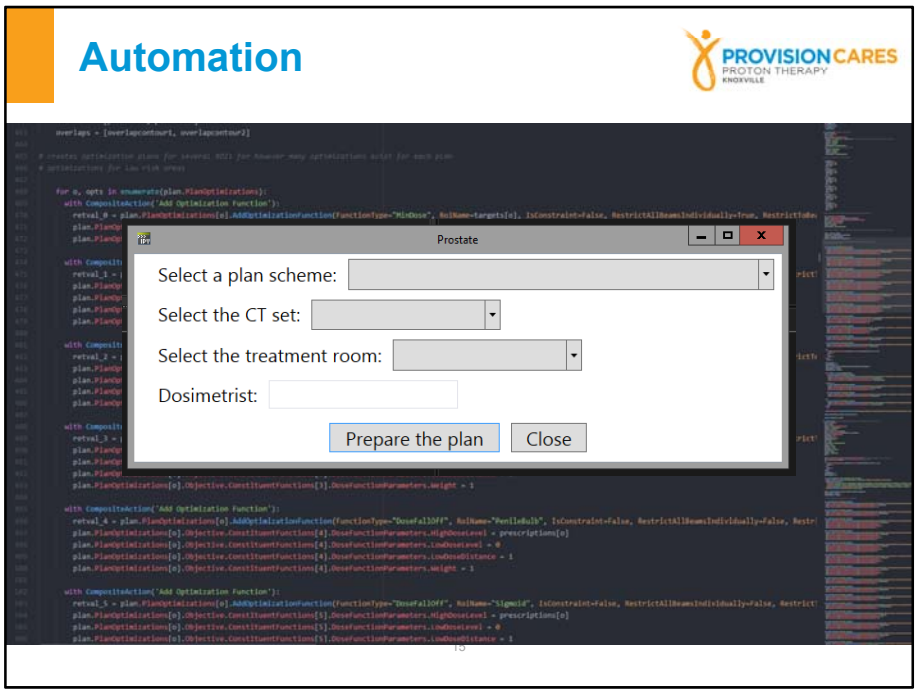


Plan Check



QACT import:

- Proton therapy requires periodic CTs during treatment to evaluate setup consistency, weight loss, tumor changes, etc
- These QACTs are tedious to evaluate, with a lot of button clicks
- Script will rename CT, apply density table, fuse with TPCT, deform OAR contours, copy target contours, calculate dose
- User has to check the contours and evaluate the dose on the QACT



Treatment planning:

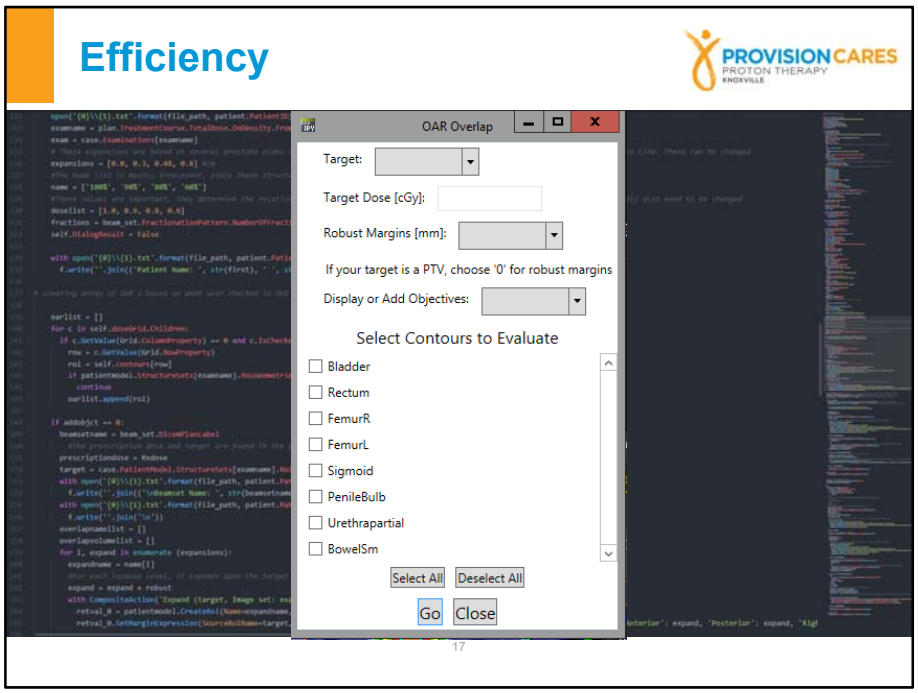
- Some treatment sites, like head and neck, prostate, and breast, have standard beam angles and dose schemes
- Allows user to choose dose/fractionation, Treatment Planning CT, treatment room, and add their initials
- Creates new plan, creates isocenter, adds beams, adds objectives, adds clinical goals, runs optimization, pauses for review, runs perturbations, runs report

Automation

PROVISION CARES PROTON THERAPY KNOXVILLE

You can automate DVH export

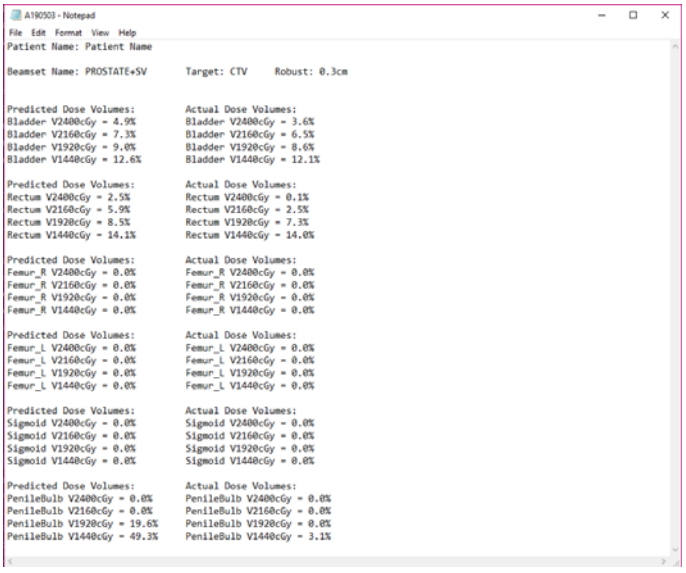
- Script reads a file with patient ID numbers
- User chooses which contours to export
- Script finds the approved plan and selected contours
- Exports DVH to a CSV



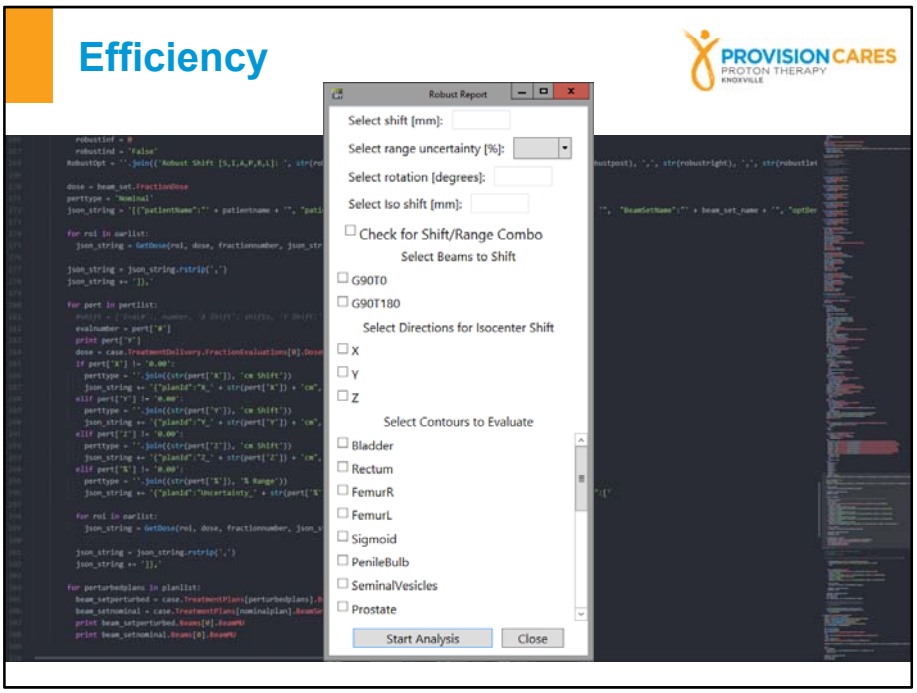
Predict DVH:

- Uses overlap of contours and targets to predict OAR sparing
- Allows the user to choose margins for robust planning or no margin for PTV planning
- Use “Display” to check your plan and see how well you met the predictions or
- Use “Add objectives” to add DVH objectives to your plan before you start planning

Efficiency

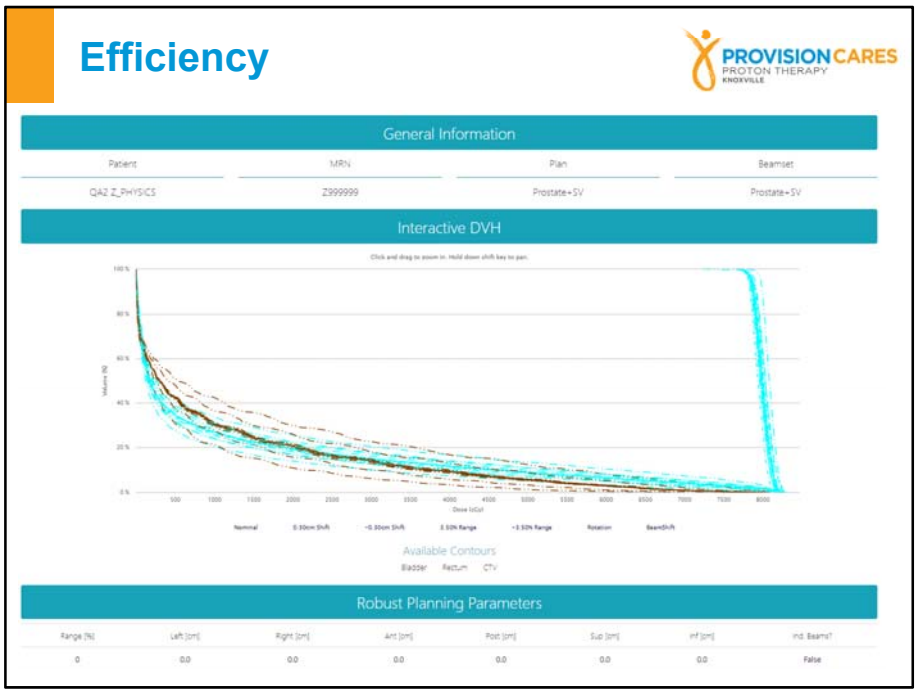


Predict DVH



Robust report:

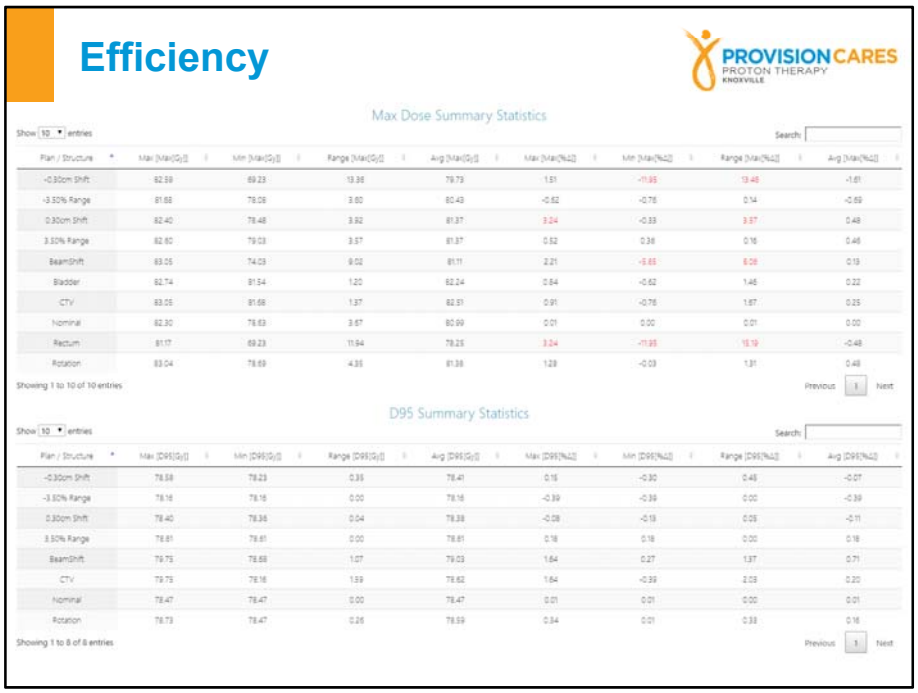
- Runs up to 18 perturbations, possibly more for additional beam isocenter shifts or combination perturbations
- Don’t necessarily need to shift beams independently in all directions, choose fewest necessary
- Recommend outputting CTV targets and serial organs, e.g. Spinal Cord, Brainstem, etc
- Allows the dosimetrist to evaluate robustness before sending to physics, thus reducing failures and wasted time
- Allows the physicist to have an overall view of robustness before evaluating nominal dose



Robust report:

- Interactive DVH allows user to turns contours on and off to only see 1 OAR at a time for evaluation
- Interactive DVH allows user to turn perturbations on and off
    - Range uncertainty is likely occurring every day, so I'm going to evaluate the range perturbations more seriously than shifts
    - Independent beam isocenter shifts indicate gradient within the plan, so I evaluate it more closely because it can predict sensitivity to weight loss/tumor change/setup changes

Efficiency



Max Dose Summary Statistics

Show 10 entries Search:

Plan / Structure	Max [Max][Gy]	Min [Max][Gy]	Range [Max][Gy]	Avg [Max][Gy]	Max [Max][%Δ]	Min [Max][%Δ]	Range [Max][%Δ]	Avg [Max][%Δ]
-0.30cm Shift	82.99	69.23	13.76	79.73	1.51	-11.95	13.46	-1.61
-3.50% Range	81.68	78.08	3.60	80.43	-0.62	-0.76	0.14	-0.69
0.30cm Shift	82.40	78.48	3.92	81.37	0.24	-0.33	0.57	0.48
3.50% Range	82.60	79.03	3.57	81.37	0.52	0.36	0.16	0.46
BeamShift	83.05	74.09	9.02	81.11	2.21	-5.65	8.09	0.19
Bladder	82.74	81.54	1.20	82.24	0.84	-0.62	1.46	0.22
CTV	83.05	81.68	1.37	82.51	0.91	-0.76	1.67	0.25
Nominal	82.30	78.63	3.67	80.99	0.01	0.00	0.01	0.00
Rectum	81.17	69.23	11.94	78.25	0.24	-11.95	12.19	-0.48
Rotation	83.04	78.69	4.35	81.38	1.28	-0.03	1.31	0.48

Showing 1 to 10 of 10 entries Previous 1 Next

D95 Summary Statistics

Show 10 entries Search:

Plan / Structure	Max [D95][Gy]	Min [D95][Gy]	Range [D95][Gy]	Avg [D95][Gy]	Max [D95][%Δ]	Min [D95][%Δ]	Range [D95][%Δ]	Avg [D95][%Δ]
-0.30cm Shift	78.58	78.23	0.35	78.41	0.16	-0.30	0.46	-0.07
-3.50% Range	78.16	78.16	0.00	78.16	-0.39	-0.39	0.00	-0.39
0.30cm Shift	78.40	78.36	0.04	78.38	-0.08	-0.13	0.05	-0.11
3.50% Range	78.81	78.81	0.00	78.81	0.18	0.18	0.00	0.18
BeamShift	79.75	78.68	1.07	79.03	1.64	0.27	1.37	0.71
CTV	79.75	78.16	1.59	78.62	1.64	-0.39	2.03	0.20
Nominal	78.47	78.47	0.00	78.47	0.01	0.01	0.00	0.01
Rotation	78.73	78.47	0.26	78.59	0.34	0.01	0.33	0.18

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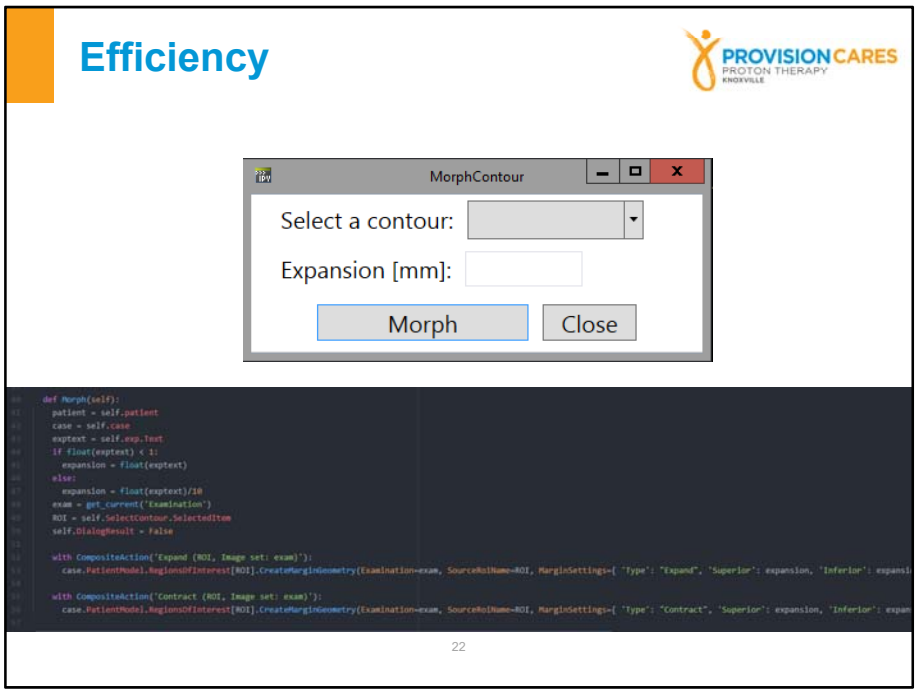
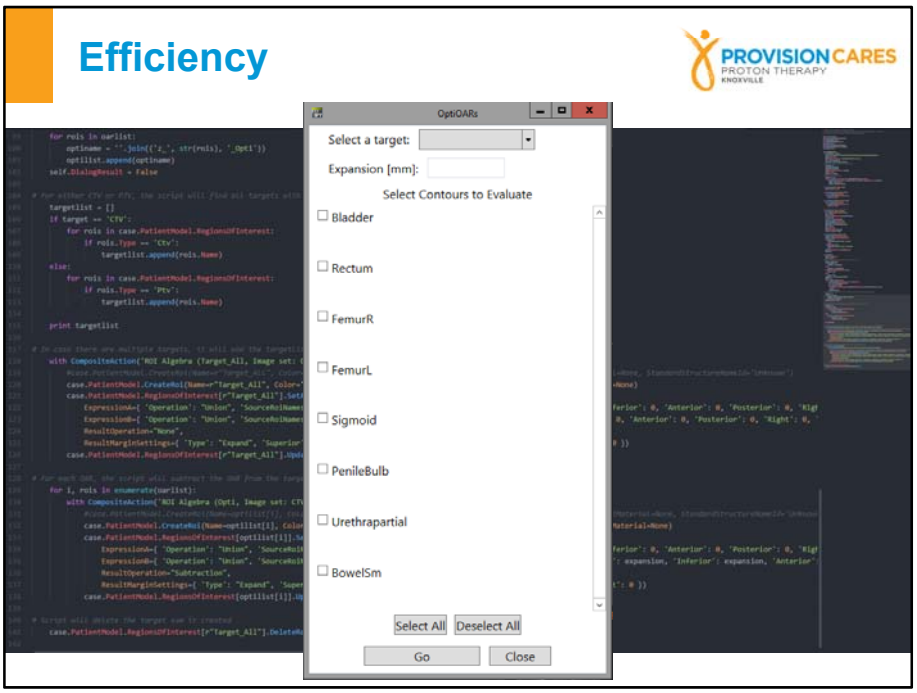
Robust report:

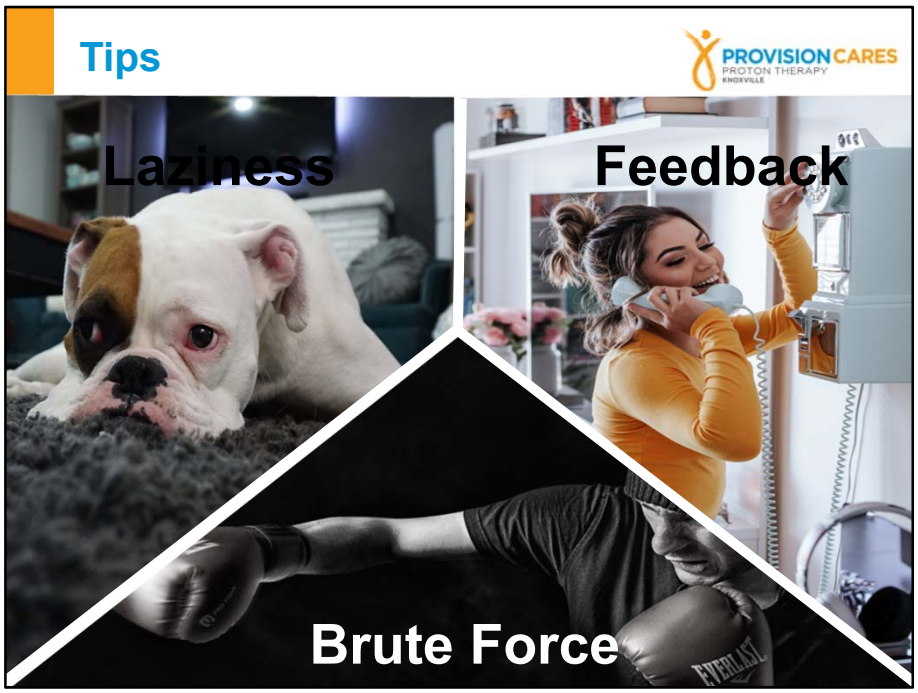
- Tables summarize change in D95% for targets
- Tables summarize change in Dmax for OARs



Not every script has to be huge or involved
Sometimes the simplest scripts can be big time-savers
This script is barely more than 2 lines of actual work, but it is used nearly every day



This fairly simple script saves a lot of time and button clicks
Simple to write, nearly fully recordable



Laziness:

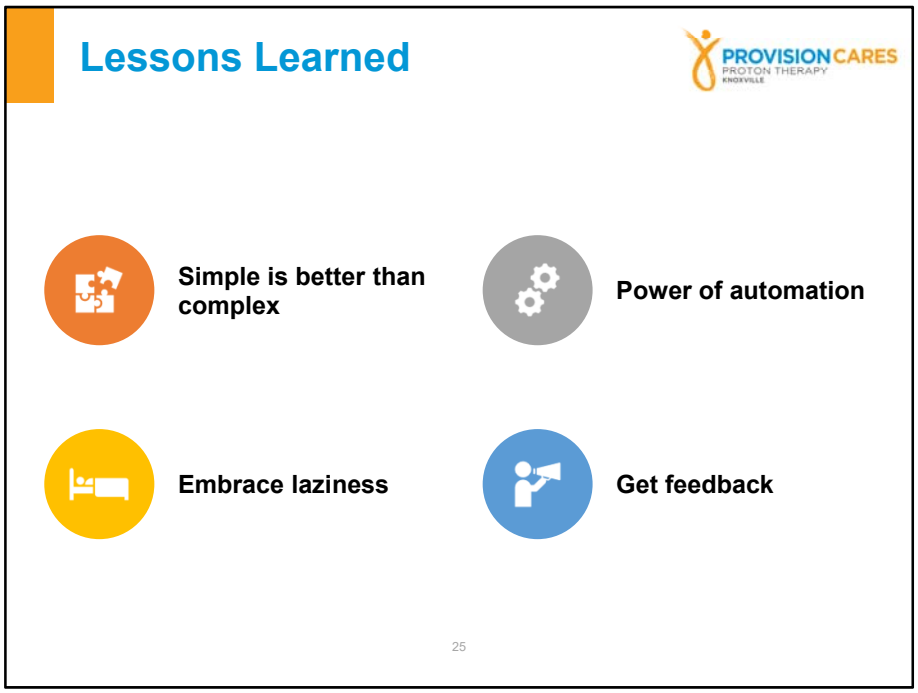
- I find a lot of script ideas doing processes I don't normally do, e.g. creating a prostate plan
- It's a lot of clicks that I just don't want to do, so I automate it
- When writing up a plan, I don't want to remember all the required isodoses, contours, etc, so I automate it
- Dosimetrists aren't necessarily going to give you ideas to script them out of a job
- Laziness = improved efficiency

Brute Force:

- When I'm testing lines of code in the Console, I use the brute force method
- I plan out what I want the script to do, but not necessarily how I'm going to do
- It's not elegant, but it's effective

Feedback:

- I once watched a dosimetrist use the automate prostate plan and then systematically delete all the objectives the script just loaded
- Encourage users to embrace standardization, but understand why they're not using the standards
- Get constant feedback to find bugs and improve



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Power of automation
Embrace laziness
Get feedback


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