Julia Marín-Yaseli de la Parra

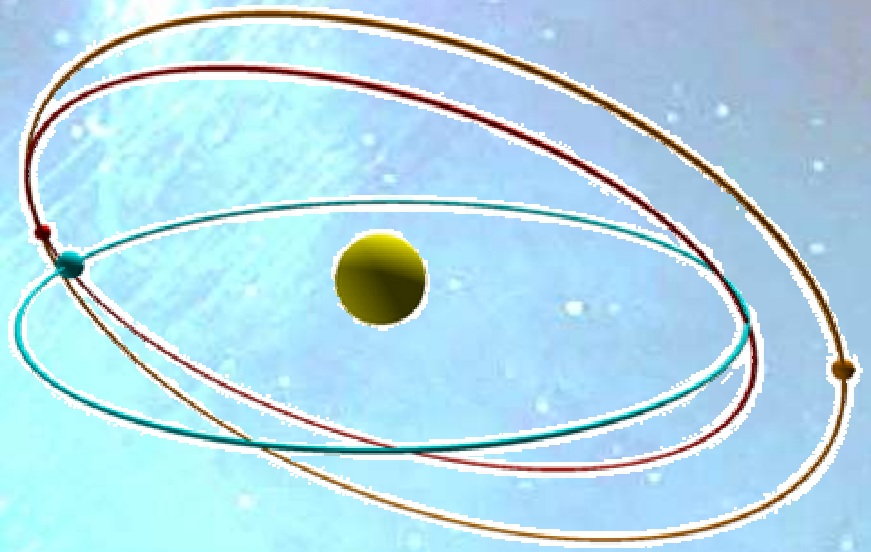
ESAC Trainee project

1st July – 1st September 2010

Trainee Objective:

Main; check the Zenithal attraction

- So…Comparing a 2B-simulator with the zenithal attraction approximation
- How to…developing a powerful tool and see the differences



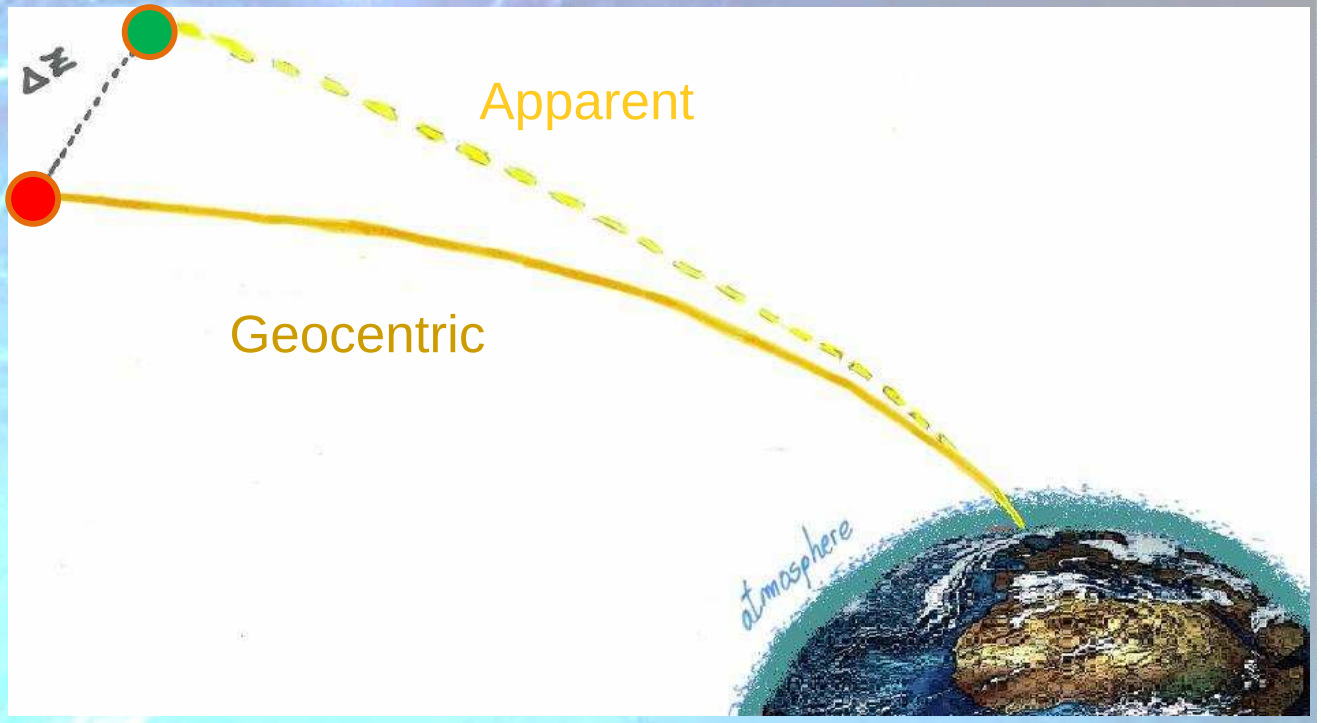
Introduction:

Zenithal attraction formula

$$\Delta Z = 2 \arctan \left[\frac{W - V_g}{W + V_g} \tan \frac{Z_o}{2} \right]$$

Two body simulator

- Kepler



Previous Analysis:

- Feasibility of the software;

Software	Gravity simulator Tony Dunn	GMAT NASA	STA ESA	JAQAR ESA spin off	STK Private (AGI)	Own Me
Assessment	Bad	Good	Good	Regular/Bad	Good	The best
Best points	None	Better integrators	Better interfaces	OP conversions	Very well validated	Most suitable
Worst points	All	No able to introduce automatic inputs !	Only TLE's format available Not completely validated !	Designed to transference orbits	Very expensive licenses… $	Long time to develop it Validation

SPIC	Good assesment	Very powerfull tool	Hard to understand ?

E

Analysis:

RAdiant N-Body Orbit Tool

RANBO software

Julia M. de la Parra

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- Purpose; to create an accurate software, freeware and being able to be integrated as a module into VMO.
  - Code; C++
  - compiler; Dev C++
  - Integrator; Runge Kutta
  - Divided into modules

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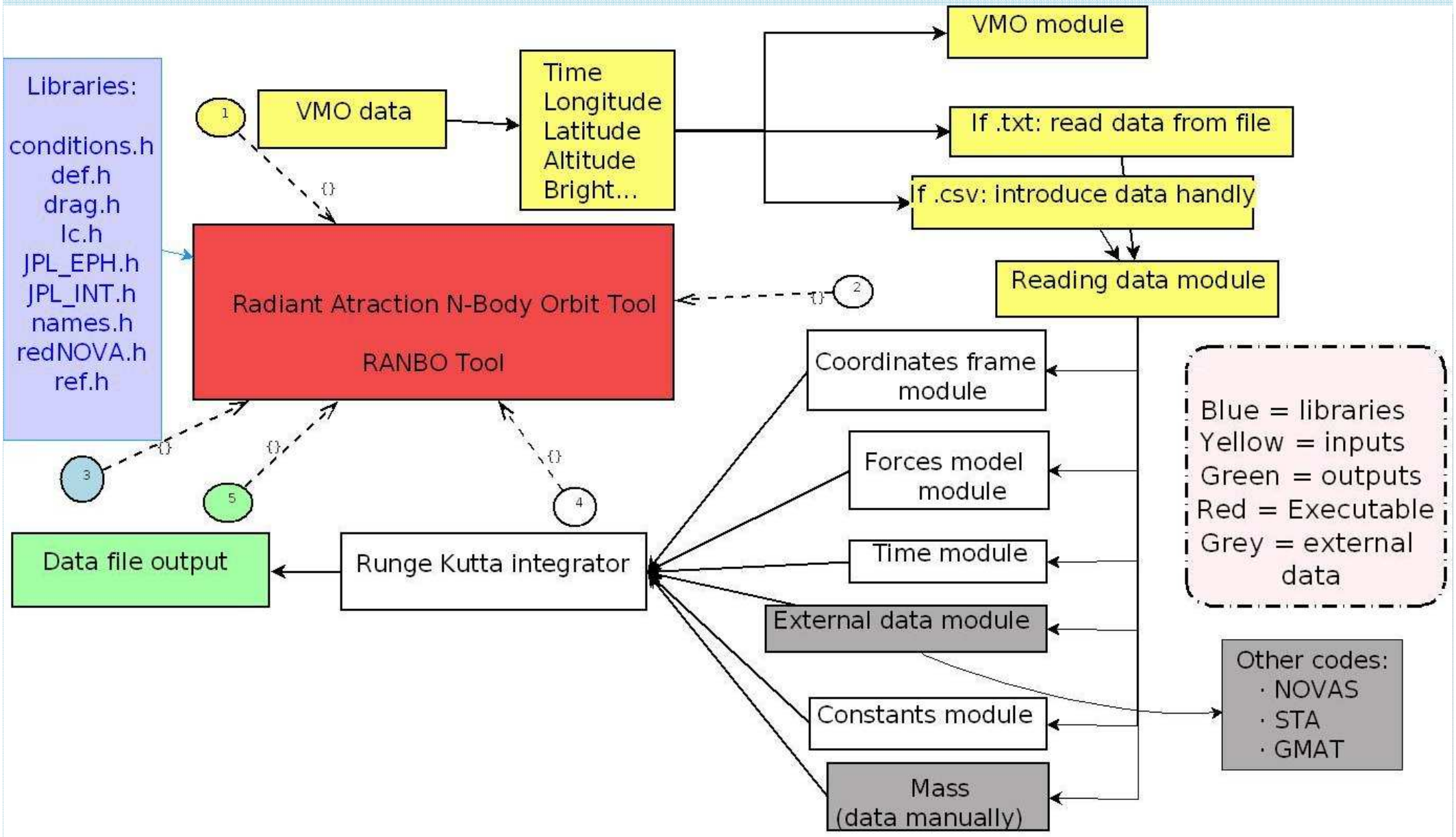
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VMO data
Time
Longitude
Latitude
Altitude
Bright...
VMO module
If .txt: read data from file
If .csv: introduce data handly
Reading data module
Radiant Atraction N-Body Orbit Tool
RANBO Tool
2
3
5
4
Data file output
Runge Kutta integrator
Coordinates frame module
Forces model module
Time module
External data module
Constants module
Mass (data manually)
Blue = libraries
Yellow = inputs
Green = outputs
Red = Executable
Grey = external data
Other codes:
· NOVAS
· STA
· GMAT

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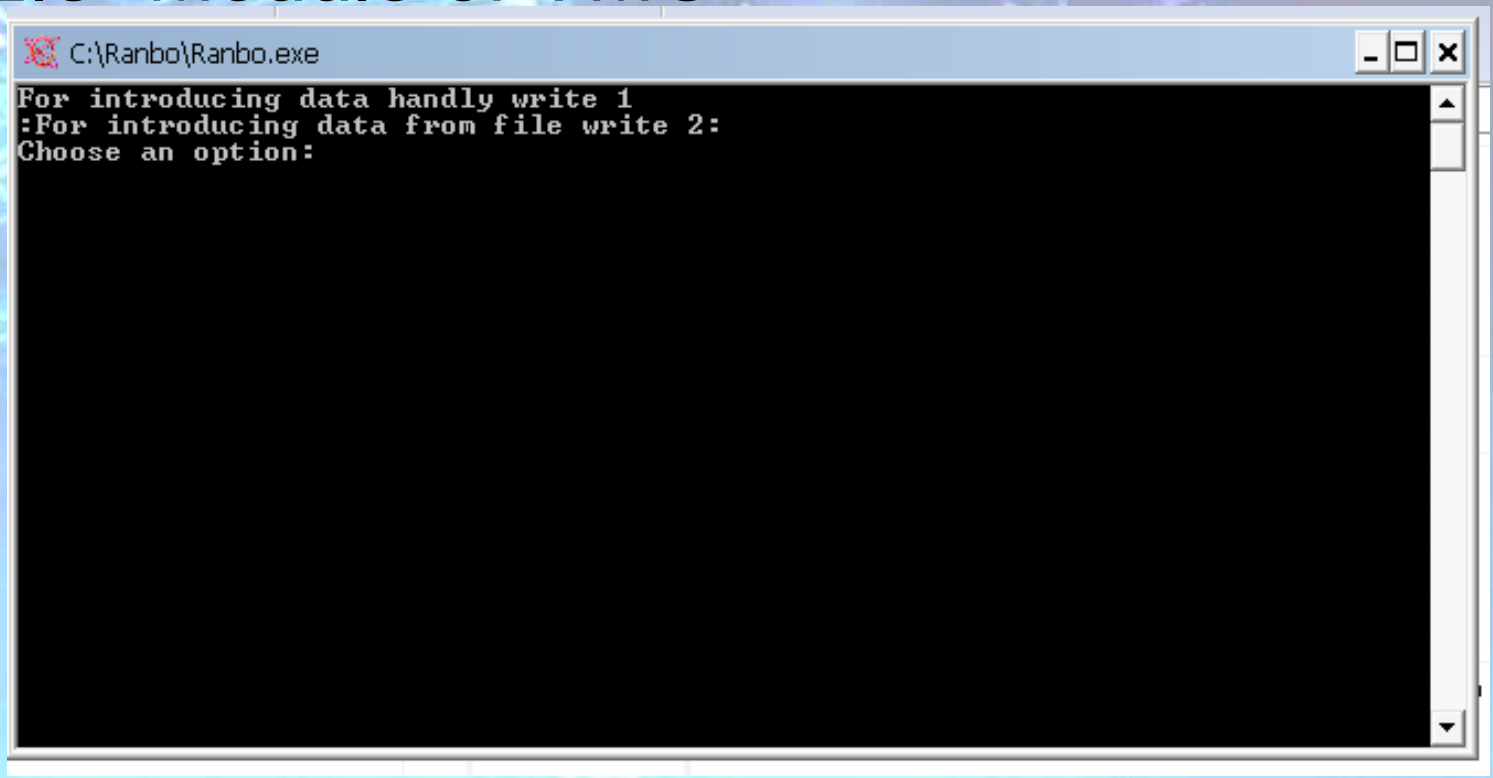
- Inputs
  - o 1.1 - Reading VMO data file
  - o 1.2- Reading data manually
  - o 1.3- Module of VMO



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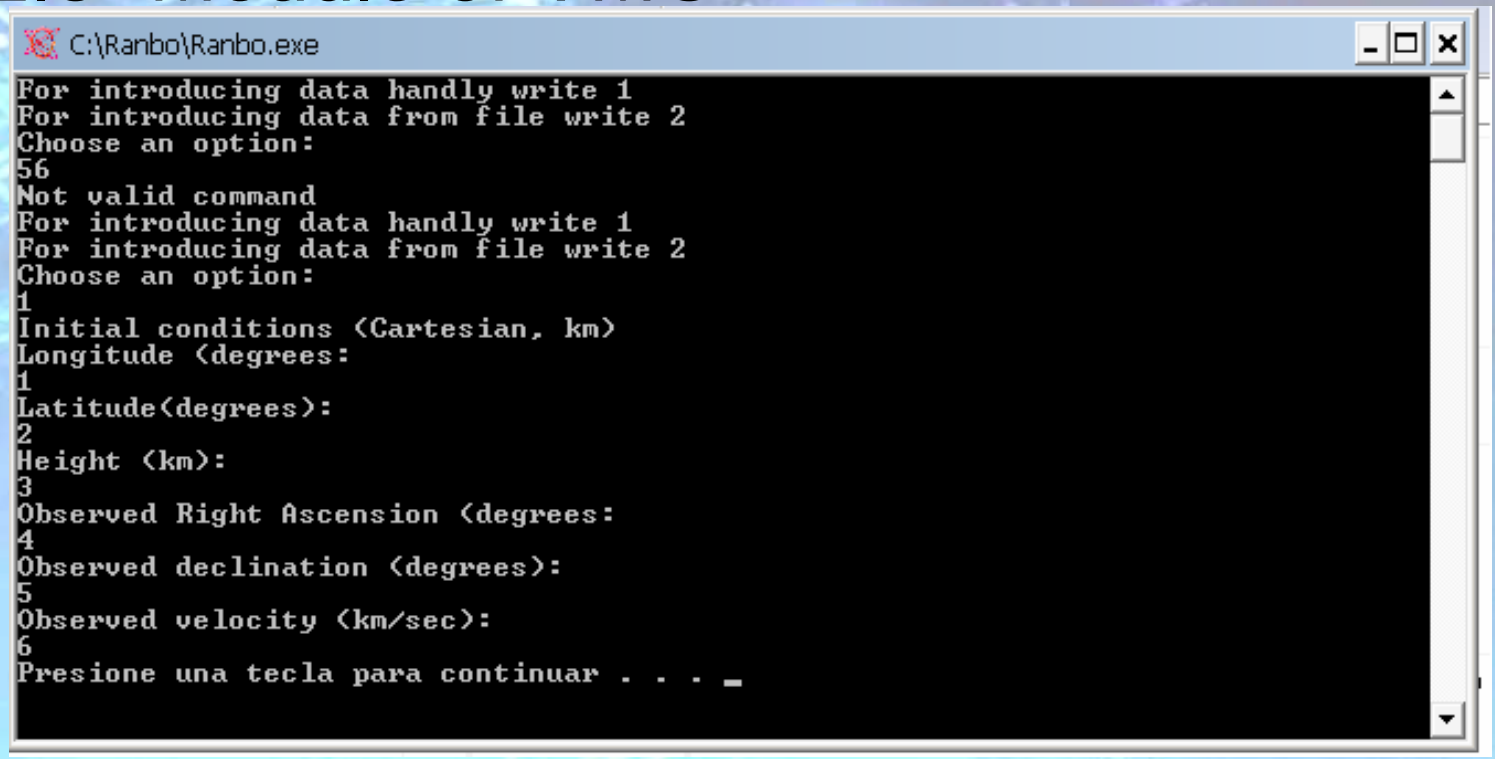

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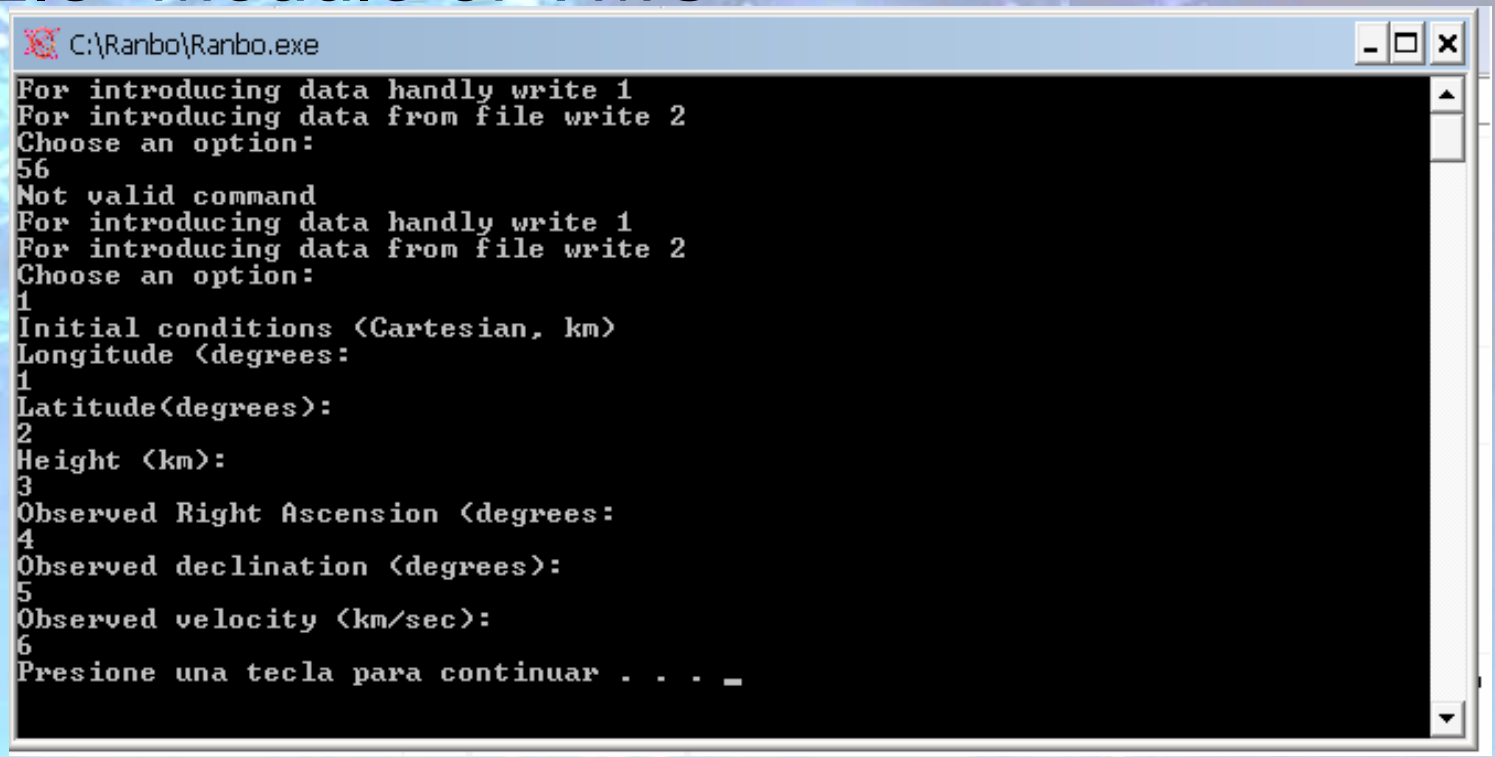

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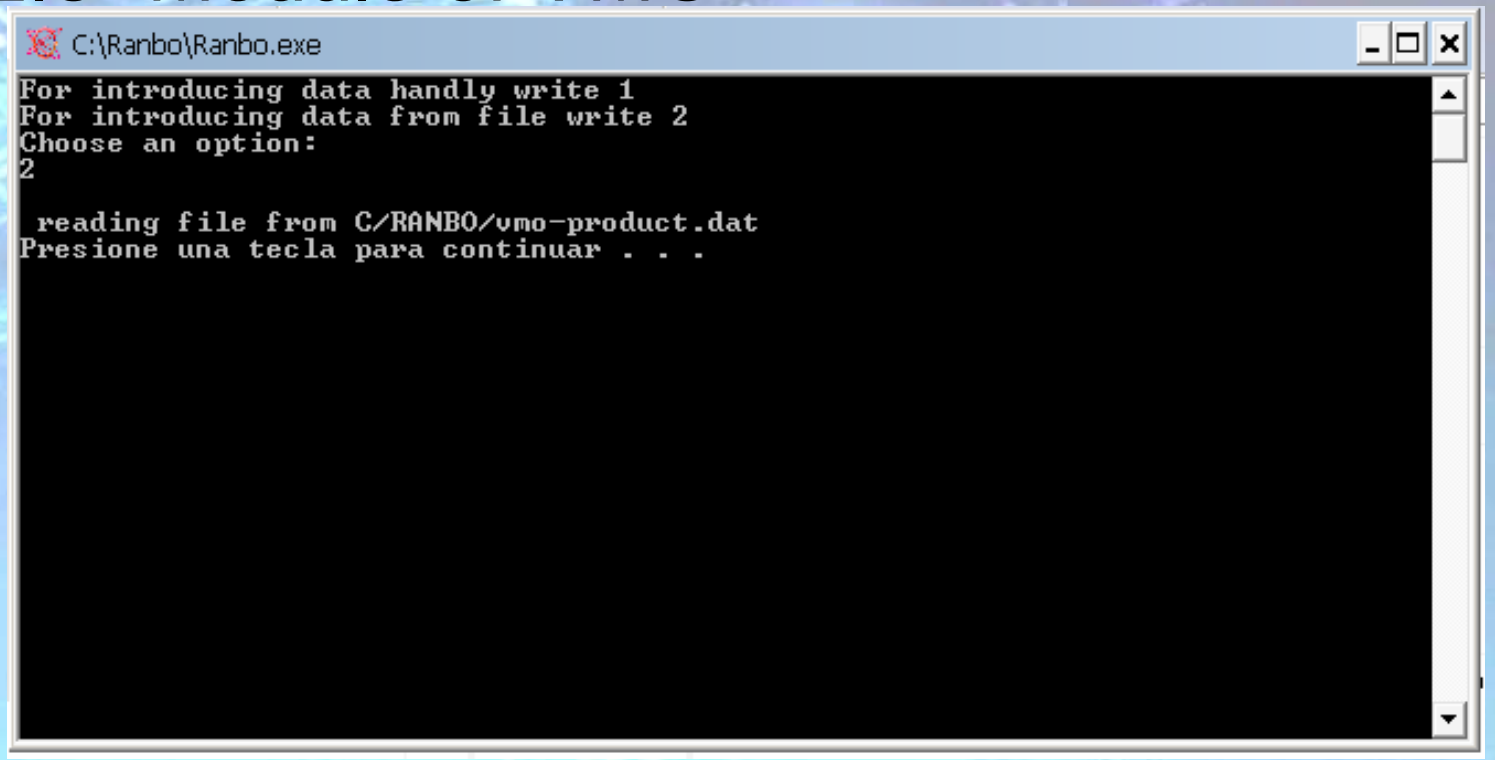

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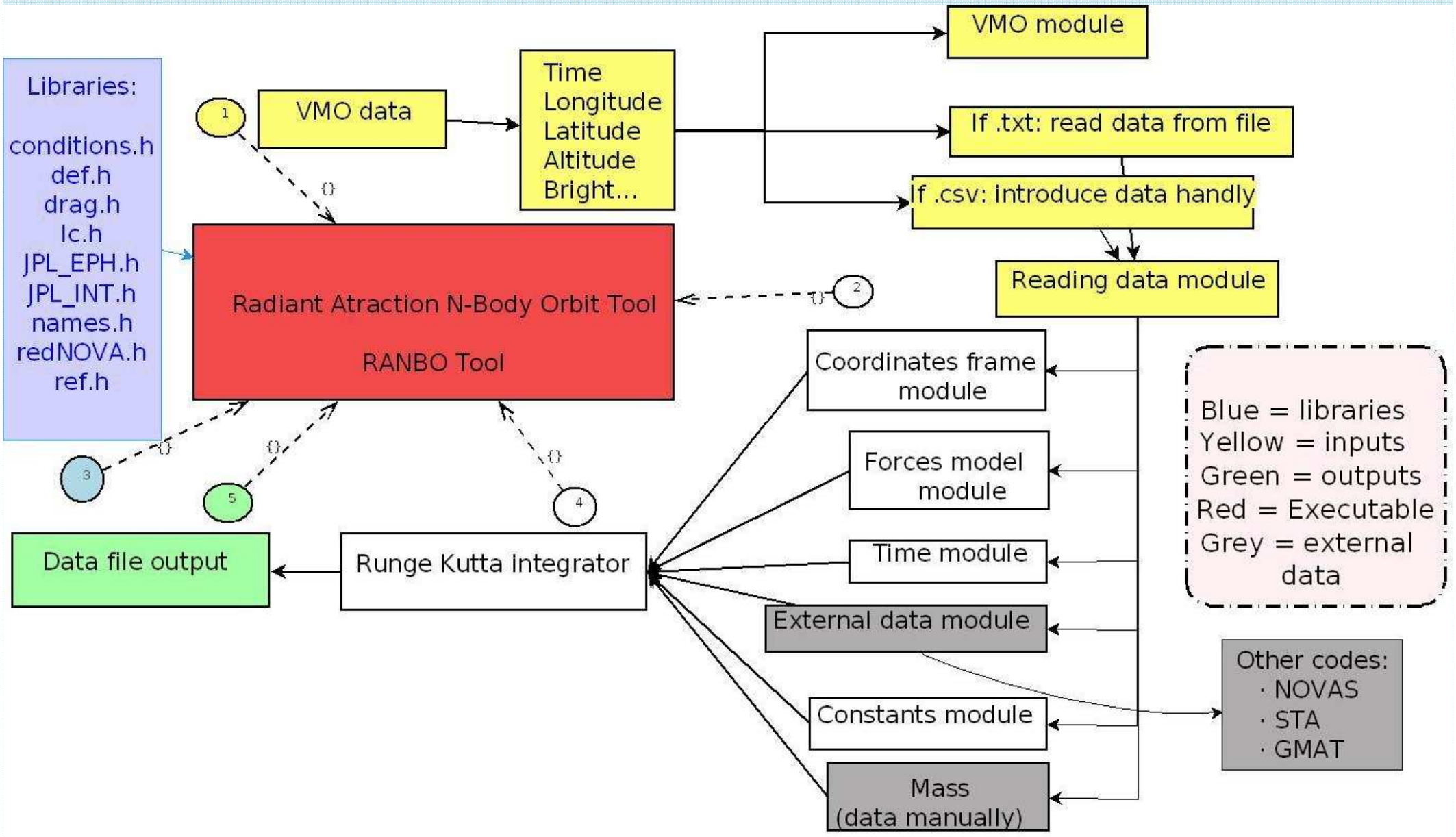
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- Integrator
  - **Runge–Kutta–Fehlberg method**; algorithm of numerical analysis
    - Error; Can be **estimated and controlled** and an appropriate step size can be determined automatically.
    - **Efficient** for ordinary problems of automated numerical integration

$$
\begin{aligned}
k_1 &= h \cdot f(x_k) \\
k_2 &= h \cdot f(x_k + \tfrac{1}{4}k_1) \\
k_3 &= h \cdot f(x_k + \tfrac{3}{32}k_1 + \tfrac{9}{32}k_2) \\
k_4 &= h \cdot f(x_k + \tfrac{1932}{2197}k_1 - \tfrac{7200}{2197}k_2 + \tfrac{7296}{2197}k_3) \\
k_5 &= h \cdot f(x_k + \tfrac{439}{216}k_1 - 8k_2 + \tfrac{3680}{513}k_3 - \tfrac{845}{4104}k_4) \\
k_6 &= h \cdot f(x_k - \tfrac{8}{27}k_1 + 2k_2 - \tfrac{3544}{2565}k_3 + \tfrac{1859}{4104}k_4 - \tfrac{11}{40}k_5) \\
x_{k+1} &= x_k + \frac{16}{135}k_1 + \frac{6656}{12825}k_3 + \frac{28561}{56430}k_4 - \frac{9}{50}k_5 + \frac{2}{55}k_6
\end{aligned}
$$

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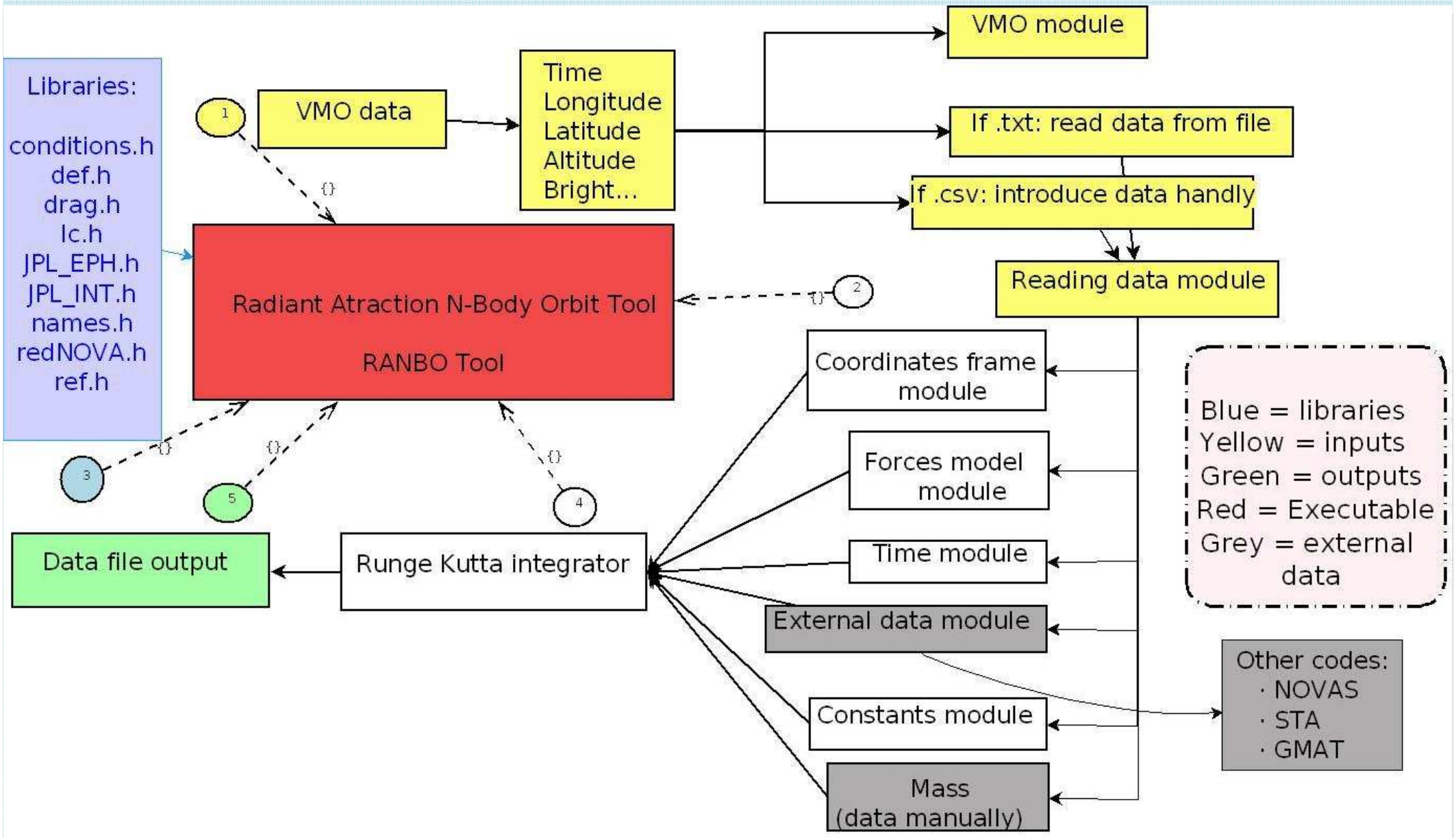
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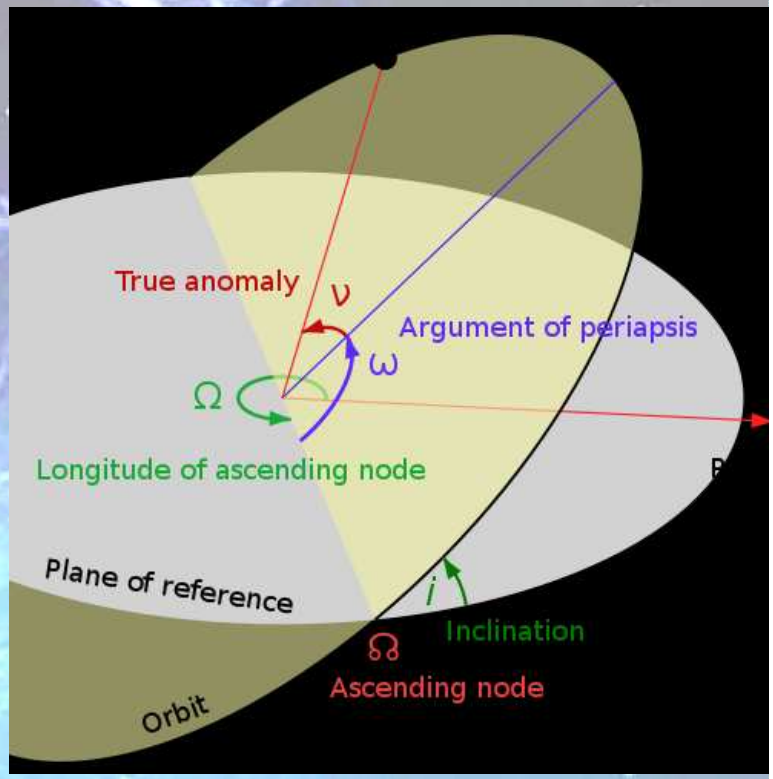
- Results

Paramete	Zenital Attr.	2-Body	N-Body
a (AU)	6.207	6.438	?
e	0.848	0.853	?
i (deg)	113.01	113.45	?
ω (deg)	148.20	147.89	?
Ω (deg)	139.79	139.79	?
v (deg)	/	/	?



❖ Data from: ORB-BARGE-PER2007_100-M007 Comparing MOTS 2.0 with FirBal (Ceplecha 1987) D. Koschny, J. Borovicka

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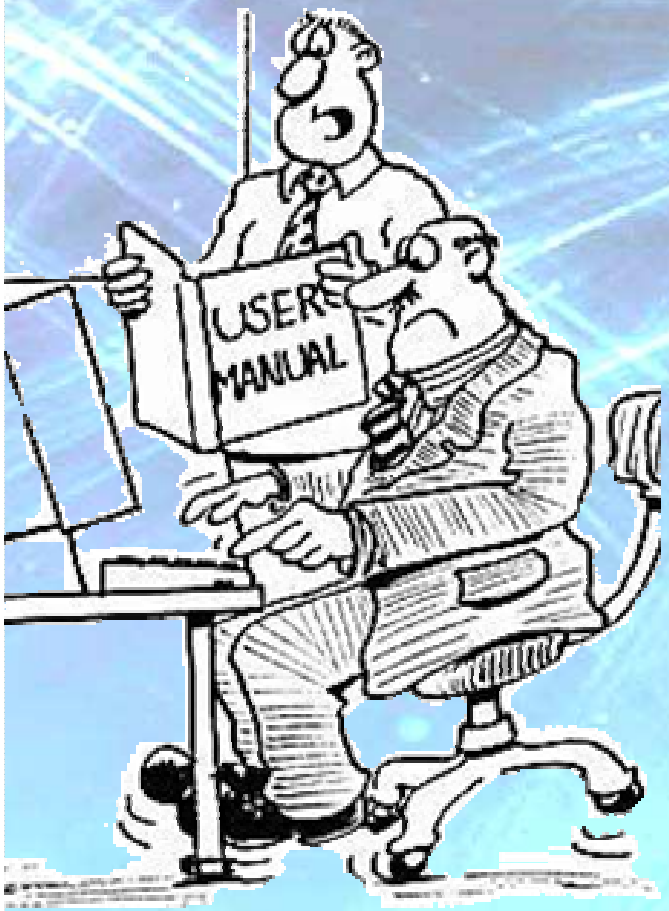

- Test plan (TBD)
- Last, but not least…User Manual

  - Make it simple!!

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- Next steps;
  - Software improvements
  - Software validation
  - Documentation :S
  - Comparison btw methods

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Thank you very much !

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