LOW	HIGH

Gleichungen für SMA

$$SMA_z = \left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)} \right) \qquad SMA = \sqrt[3]{\frac{T^2 \mu}{4\pi^2}}$$

SMA = Semi-Major-Axis
T = Orbital Period
n = number of satellites must be ⩾ 2
k = max com range of antenna
μ= gravitational parameter (G*M)

LOW	HIGH
$SMA_{tl} = \sqrt[3]{\frac{\left(\left(\frac{n-1}{n}\right)T_z\right)^2 * \mu}{4\pi^2}}$	$SMA_{th} = \sqrt[3]{\frac{\left(\left(\frac{n+1}{n}\right)T_z\right)^2 * \mu}{4\pi^2}}$
$SMA_{tl} = \sqrt[3]{\frac{\left(\left(\frac{n-1}{n}\right)\left(2\pi\sqrt{\frac{\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^3}{\mu}}\right)\right)^2 * \mu}{4\pi^2}}$	$SMA_{th} = \sqrt[3]{\frac{\left(\left(\frac{n+1}{n}\right)\left(2\pi\sqrt{\frac{\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^3}{\mu}}\right)\right)^2 * \mu}{4\pi^2}}$
$SMA_{tl} = \sqrt[3]{\frac{(Ttl)^2 * \mu}{4\pi^2}}$	$SMA_{th} = \sqrt[3]{\frac{(T_{th})^2 * \mu}{4\pi^2}}$
$SMA_{tl} = \sqrt[3]{\frac{\left(\frac{(n-1)(2\pi)\sqrt{\left(\frac{k}{2}\right)^3}}{(n)\sqrt{(\mu)\left(\sin\left(\frac{180^\circ}{n}\right)\right)^3}}\right)^2 \mu}{4\pi^2}}$	$SMA_{th} = \sqrt[3]{\frac{\left(\frac{(n+1)(2\pi)\sqrt{\left(\frac{k}{2}\right)^3}}{(n)\sqrt{(\mu)\left(\sin\left(\frac{180^\circ}{n}\right)\right)^3}}\right)^2 \mu}{4\pi^2}}$
$SMA_{tl} = \sqrt[3]{\frac{(n-1)^2\left(\frac{k}{2}\right)^3}{(n)^2\left(\sin\left(\frac{180^\circ}{n}\right)\right)^3}}$	$SMA_{th} = \sqrt[3]{\frac{(n+1)^2\left(\frac{k}{2}\right)^3}{(n)^2\left(\sin\left(\frac{180^\circ}{n}\right)\right)^3}}$
$\boxed{SMA_{tl} = \sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}$	$\boxed{SMA_{th} = \sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}$

Gleichungen für Periode

$$T = 2\pi\sqrt{\frac{SMA^3}{\mu}} \qquad T_z = 2\pi\sqrt{\frac{SMA_z^3}{\mu}} \qquad T_z = 2\pi\sqrt{\frac{\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^3}{\mu}}$$

$$T_{tl} = 2\pi\sqrt{\frac{SMA_{tl}^3}{\mu}}$$

$$T_{tl} = 2\pi\sqrt{\frac{\left(\frac{\left(\left(\frac{n-1}{n}\right)\left(2\pi\sqrt{\frac{\left(\frac{\frac{k}{2}}{\sin\left(\frac{180}{n}\right)}\right)^3}{\mu}}\right)\right)^2 * \mu}{4\pi^2}\right)}{\mu}}$$

$$T_{tl} = \frac{(n-1)(2\pi)\left(\frac{k}{2}\right)^{\frac{3}{2}}}{(n)\left(\sqrt{\mu}\right)\left(\sin\left(\frac{180^\circ}{n}\right)\right)^{\frac{3}{2}}}$$

$$T_{tl} = 2\pi\left(\frac{n-1}{n}\right) * \sqrt{\frac{\left(\frac{k}{2}\right)^3}{(\mu)\left(\sin\left(\frac{180^\circ}{n}\right)\right)^3}}$$

$$T_{th} = 2\pi\sqrt{\frac{SMA_{th}^3}{\mu}}$$

$$T_{th} = 2\pi\sqrt{\frac{\left(\frac{\left(\left(\frac{n+1}{n}\right)\left(2\pi\sqrt{\frac{\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^3}{\mu}}\right)\right)^2 * \mu}{4\pi^2}\right)}{\mu}}$$

$$T_{th} = \frac{(n+1)(2\pi)\left(\frac{k}{2}\right)^{\frac{3}{2}}}{(n)\left(\sqrt{\mu}\right)\left(\sin\left(\frac{180^\circ}{n}\right)\right)^{\frac{3}{2}}}$$

$$T_{th} = 2\pi\left(\frac{n+1}{n}\right) * \sqrt{\frac{\left(\frac{k}{2}\right)^3}{(\mu)\left(\sin\left(\frac{180^\circ}{n}\right)\right)^3}}$$

Gleichungen für c, f und e

$$2b = \sqrt{(p+q)^2 - f^2} \qquad p = SMA_z \qquad f = 2c$$

$$c = \sqrt{SMA^2 - b^2} \qquad c = SMA*e$$

$$e = \sqrt{1 - \left(\frac{b}{SMA}\right)^2}$$

p = Abstand von Fokuspunkt 1 zu einem Punkt P auf der Ellipse
q = Abstand von Fokuspunkt 2 zu einem Punkt P auf der Ellipse
b = Semi-Minor-Axis
c = lineare Exzentrizität
f = Abstand der beiden Fokuspunkte voneinander

$$q = SMA_z - f \qquad c = SMA_z - SMA_{tl}$$

$$q = SMA_t - c$$

$$f = 2\left(SMA_z - SMA_{tl}\right)$$

$$f_{tl} = 2\left(\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right) - \left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)\right)$$

$$c_{tl} = \left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right) - \left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)$$

$$e_{tl} = \frac{c}{SMA_{tl}}$$

$$e_{tl} = \frac{\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right) - \left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)}{\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180}{n}\right)}}$$

$$e_{tl} = \frac{\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}{\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180}{n}\right)}} - \frac{\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}{\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180}{n}\right)}}$$

$$e_{tl} = \sqrt[3]{\frac{(n)^2}{(n-1)^2}} - 1$$

$$q = SMA_z - f \qquad c = SMA_{th} - SMA_z$$

$$f = 2\left(SMA_{th} - SMA_z\right)$$

$$f_{th} = 2\left(\left(\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right) - \left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)\right)$$

$$c_{th} = \left(\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right) - \left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)$$

$$e_{th} = \frac{c}{SMA_{th}}$$

$$e_{th} = \frac{\left(\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right) - \left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)}{\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}$$

$$e_{th} = \frac{\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}{\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}} - \frac{\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)}{\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}$$

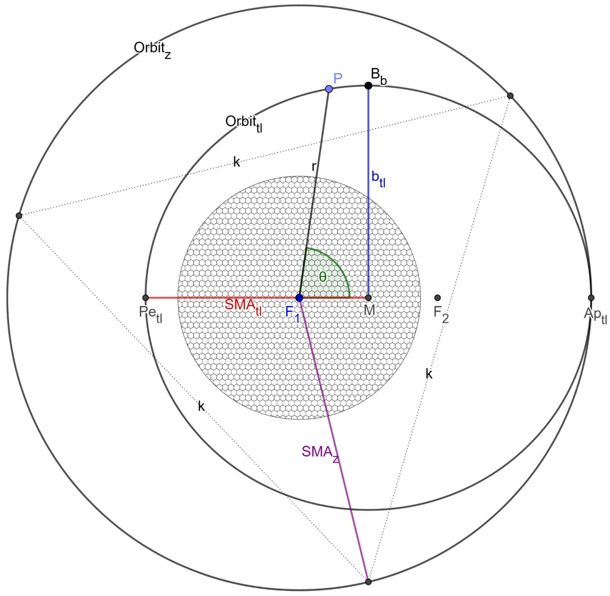
$$e_{th} = 1 - \sqrt[3]{\frac{(n)^2}{(n+1)^2}}$$

Gleichungen für Apsiden

$$r_{(\theta)} = \frac{SMA\left(1 - e^2\right)}{1 \pm e\cos\theta} \qquad r_{(\theta)} = \frac{SMA\left(1 - e^2\right)}{1 - e\cos\theta}$$

$$r_{Ap} = \frac{SMA\left(1 - e^2\right)}{1 - e} \qquad r_{Pe} = \frac{SMA\left(1 - e^2\right)}{1 + e}$$

$$r_{max} = SMA\left(1 + e\right) \qquad r_{min} = SMA\left(1 - e\right)$$



$$r_{Aptl} = SMA_{tl}\left(1 + e_{tl}\right)$$

$$r_{Aptl} = \left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)\left(1 + \left(\sqrt[3]{\frac{(n)^2}{(n-1)^2}} - 1\right)\right)$$

$$r_{Aptl} = \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)} = SMA_z$$

$$r_{Petl} = SMA_{tl}\left(1 - e_{tl}\right)$$

$$r_{Petl} = \left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)\left(1 - \left(\sqrt[3]{\frac{(n)^2}{(n-1)^2}} - 1\right)\right)$$

$$\boxed{r_{Petl} = \frac{\frac{k}{2}\left(2\sqrt[3]{(n-1)^2} - \sqrt[3]{n^2}\right)}{\sqrt[3]{n^2} * \sin\left(\frac{180^\circ}{n}\right)}}$$

$$r_{Apth} = SMA_{th}\left(1 + e_{th}\right)$$

$$r_{Apth} = \left(\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)\left(1 + \left(1 - \sqrt[3]{\frac{(n)^2}{(n+1)^2}}\right)\right)$$

$$\boxed{r_{Apth} = \frac{\frac{k}{2}\left(2\sqrt[3]{(n+1)^2} - \sqrt[3]{n^2}\right)}{\sqrt[3]{n^2} * \sin\left(\frac{180^\circ}{n}\right)}}$$

$$r_{Peth} = SMA_{th}\left(1 - e_{tl}\right)$$

$$r_{Peth} = \left(\sqrt[3]{\frac{(n+1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)\left(1 - \left(1 - \sqrt[3]{\frac{(n)^2}{(n+1)^2}}\right)\right)$$

$$r_{Peth} = \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)} = SMA_z$$

Gleichungen für relative Geschwindigkeiten

$$V = \sqrt{\mu\left(\frac{2}{r} - \frac{1}{SMA}\right)} \qquad V_z = \sqrt{\frac{\mu}{SMA_z}} \qquad V_z = \sqrt{\frac{\mu}{\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}} = \sqrt{\frac{2\mu \sin\left(\frac{180^\circ}{n}\right)}{k}}$$

$$V_{Petl} = \sqrt{\mu\left(\frac{2}{r_{Petl}} - \frac{1}{SMA_{tl}}\right)}$$

$$V_{Petl} = \sqrt{\mu\left(\frac{2}{\frac{\frac{k}{2}\left(2\sqrt[3]{(n-1)^2} - \sqrt[3]{n^2}\right)}{\sqrt[3]{n^2} * \sin\left(\frac{180^\circ}{n}\right)}} - \frac{1}{\sqrt[3]{\frac{(n-1)^2}{(n)^2} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}}\right)}$$

$$V_{Apth} = \sqrt{\mu\left(\frac{2}{r_{Apth}} - \frac{1}{SMA_{th}}\right)}$$

$$V_{Apth} = \sqrt{\mu\left(\frac{2}{\frac{\frac{k}{2}\left(2\sqrt[3]{(n+1)^2} - \sqrt[3]{n^2}\right)}{\sqrt[3]{n^2} * \sin\left(\frac{180^\circ}{n}\right)}} - \frac{1}{\sqrt[3]{\frac{(n+1)^2}{(n)^2} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}}\right)}$$

$$V_{Aptl} = \sqrt{\mu\left(\frac{2}{r_{Aptl}} - \frac{1}{SMA_{tl}}\right)}$$

$$V_{Aptl} = \sqrt{\mu\left(\frac{2}{\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}} - \frac{1}{\sqrt[3]{\frac{(n-1)^2}{(n)^2} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}}\right)}$$

$$V_{Aptl} = \sqrt{\mu\frac{2\sin\left(\frac{180^\circ}{n}\right)}{k}\left(2 - \frac{\sqrt[3]{n^2}}{\sqrt[3]{(n-1)^2}}\right)}$$

$$V_{Peth} = \sqrt{\mu\left(\frac{2}{r_{Peth}} - \frac{1}{SMA_{th}}\right)}$$

$$V_{Peth} = \sqrt{\mu\left(\frac{2}{\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}} - \frac{1}{\sqrt[3]{\frac{(n+1)^2}{(n)^2} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}}}\right)}$$

$$V_{Peth} = \sqrt{\mu\frac{2\sin\left(\frac{180^\circ}{n}\right)}{k}\left(2 - \frac{\sqrt[3]{n^2}}{\sqrt[3]{(n+1)^2}}\right)}$$

$$\Delta V_{tl\text{-}Insertion} = V_z - V_{Aptl}$$

$$\Delta V_{tl\text{-}Insertion} = \sqrt{\frac{2\mu\sin\left(\frac{180^\circ}{n}\right)}{k}} - \sqrt{\mu\frac{2\sin\left(\frac{180^\circ}{n}\right)}{k}\left(2 - \frac{\sqrt[3]{n^2}}{\sqrt[3]{(n-1)^2}}\right)}$$

$$\Delta V_{tl\text{-}Insertion} = \sqrt{\frac{2\mu\sin\left(\frac{180^\circ}{n}\right)}{k}}\left(1 - \sqrt{2 - \sqrt[3]{\left(\frac{n}{n-1}\right)^2}}\right)$$

$$\Delta V_{th\text{-}Insertion} = V_{Peth} - V_z$$

$$\Delta V_{th\text{-}Insertion} = \sqrt{\mu\frac{2\sin\left(\frac{180^\circ}{n}\right)}{k}\left(2 - \frac{\sqrt[3]{n^2}}{\sqrt[3]{(n+1)^2}}\right)} - \sqrt{\frac{2\mu\sin\left(\frac{180^\circ}{n}\right)}{k}}$$

$$\Delta V_{th\text{-}Insertion} = \sqrt{\frac{2\mu\sin\left(\frac{180^\circ}{n}\right)}{k}}\left(\sqrt{2 - \sqrt[3]{\left(\frac{n}{n+1}\right)^2}} - 1\right)$$

notizen

$$e = \sqrt{1 - \left(\frac{b}{SMA}\right)^2} \quad e_{tl} = \sqrt[3]{\frac{(n)^2}{(n-1)^2}} - 1$$

$$c = \sqrt{SMA^2 - b^2}$$

$$e_{tl}^2 = 1 - \frac{b^2}{SMA_{tl}^2}$$
$$e_{tl}^2 SMA_{tl}^2 = SMA_{tl}^2 - b^2$$
$$b = \sqrt{SMA_{tl}^2 - \left(e_{tl}^2 SMA_{tl}^2\right)}$$

$$c = \sqrt{SMA^2 - b^2}$$
$$c_{tl}^2 = SMA_{tl}^2 - b^2$$
$$SMA_{tl}^2 - c_{tl}^2 = b^2$$
$$b = \sqrt{SMA_{tl}^2 - c_{tl}^2}$$

b aus c

$$b_{tlc} = \sqrt{\left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^2 - \left(\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right) - \left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)\right)^2}$$

b aus e

$$b_{tle} = \sqrt{\left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^2 - \left(\left(\sqrt[3]{\frac{(n)^2}{(n-1)^2}} - 1\right)^2 * \left(\sqrt[3]{\frac{(n-1)^2}{(n)^2}} * \frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^2\right)}$$

$$SMA_{maxcom} = \sqrt{\left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^2 - \left(\frac{k}{2}\right)^2} + \sqrt{k^2 - \left(\frac{k}{2}\right)^2}$$

$$SMA_{maxcom} = \frac{k}{2}\left(\cot\left(\frac{180^\circ}{n}\right) + \sqrt{3}\right)$$

$$r_{(\theta)} = \frac{SMA_{tl} Number\left(1 - e_{tl}^2\right)}{1 \pm {}_{tl}e \cos(\theta)}$$

μ

$$SMA_{mincom} = \sqrt{k^2 - SMA_z^2}$$

$$SMA_{mincom} = \sqrt{k^2 - \left(\frac{\frac{k}{2}}{\sin\left(\frac{180^\circ}{n}\right)}\right)^2}$$

$$SMA_{mincom} = k\sqrt{1 - \frac{1}{\left(2\sin\left(\frac{180^\circ}{n}\right)\right)^2}}$$