Week 10 Summary

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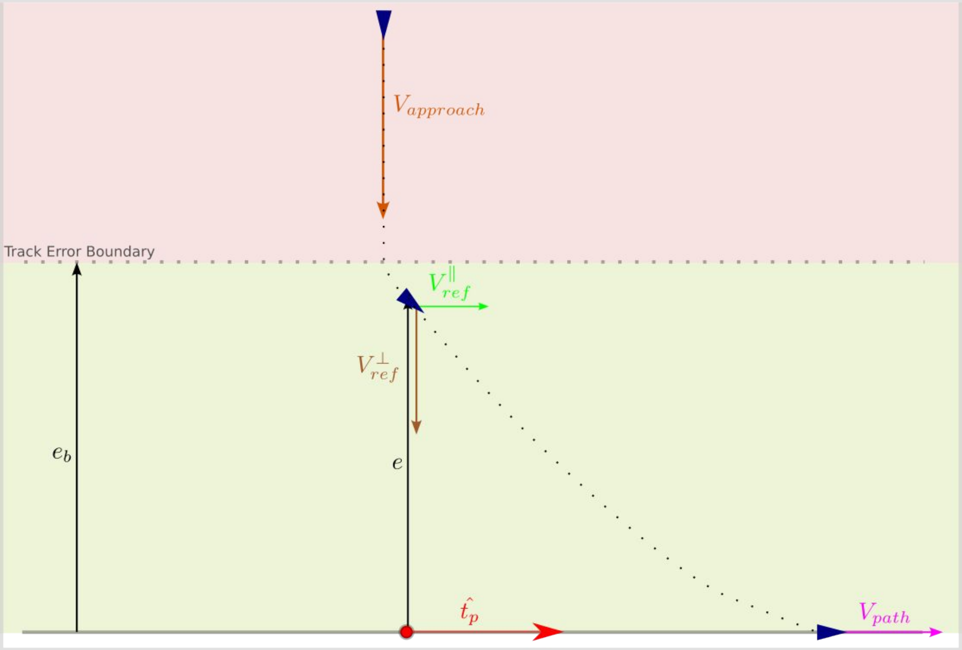
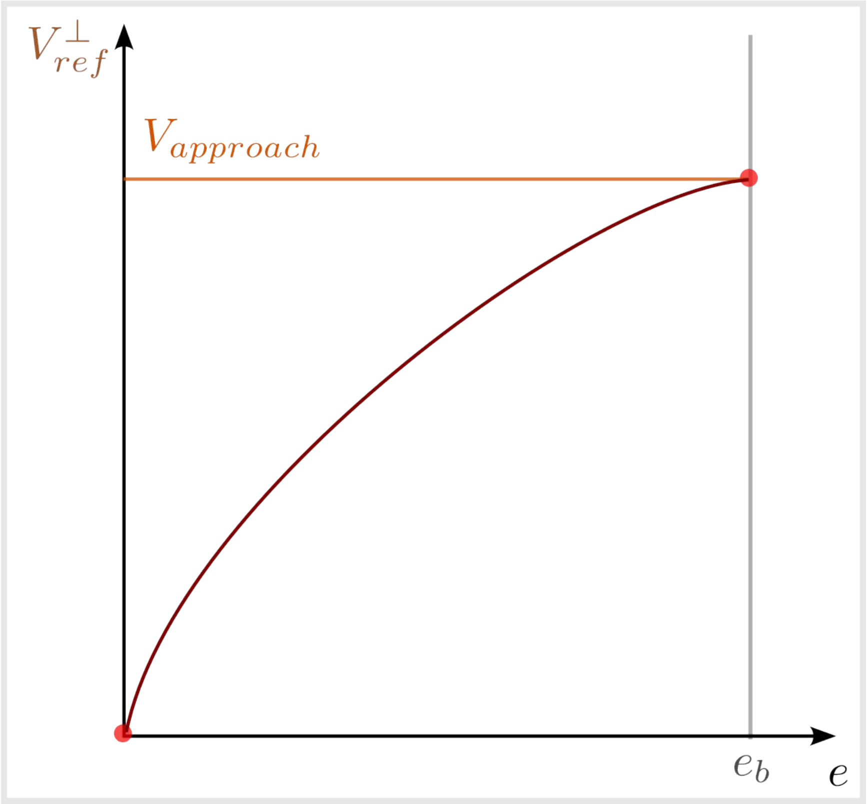
Nomenclature



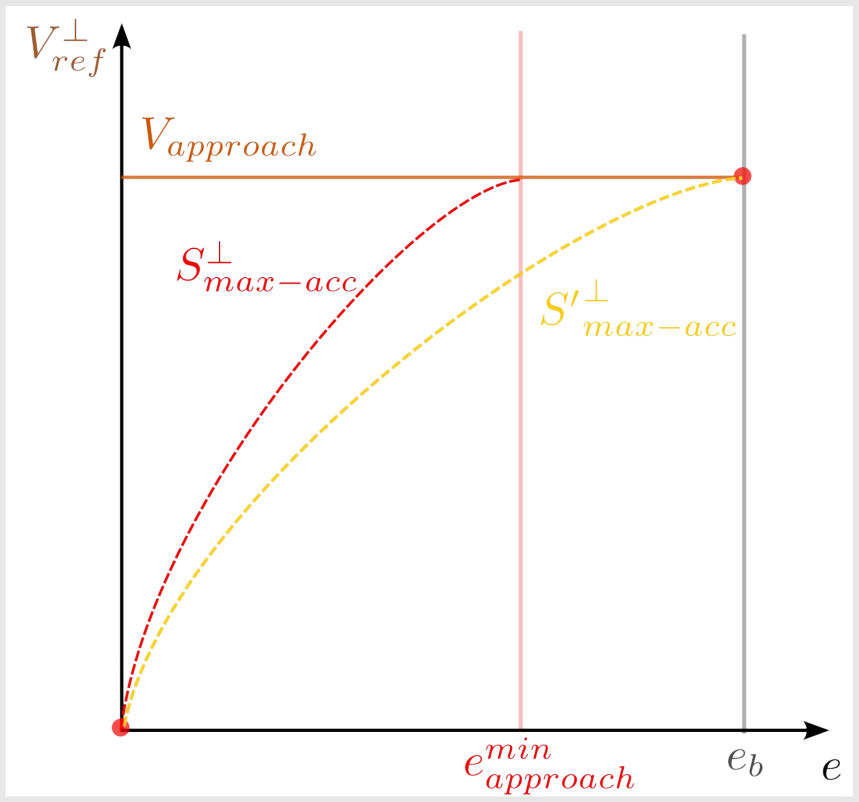
Nomenclature

V_{max}	Maximum Speed vehicle can achieve
V_{min}	Minimum Speed Vehicle can achieve
V_{nom}	Nominal Speed Vehicle can achieve (cruise speed for Fixed Wing)
V_{path}	Desired speed on path
$V_{approach}$	Desired approaching speed orthogonal to path (outside track error boundary)
$V_{ref}^{\perp}$	Orthogonal component to path, of the reference (target) velocity
$V_{ref}^{\|\|}$	Parallel component to path, of the reference (target) velocity
e	Cross track error distance to the path
e_b	Track error boundary
$\hat{t_p}$	Unit tangent vector of the path segment

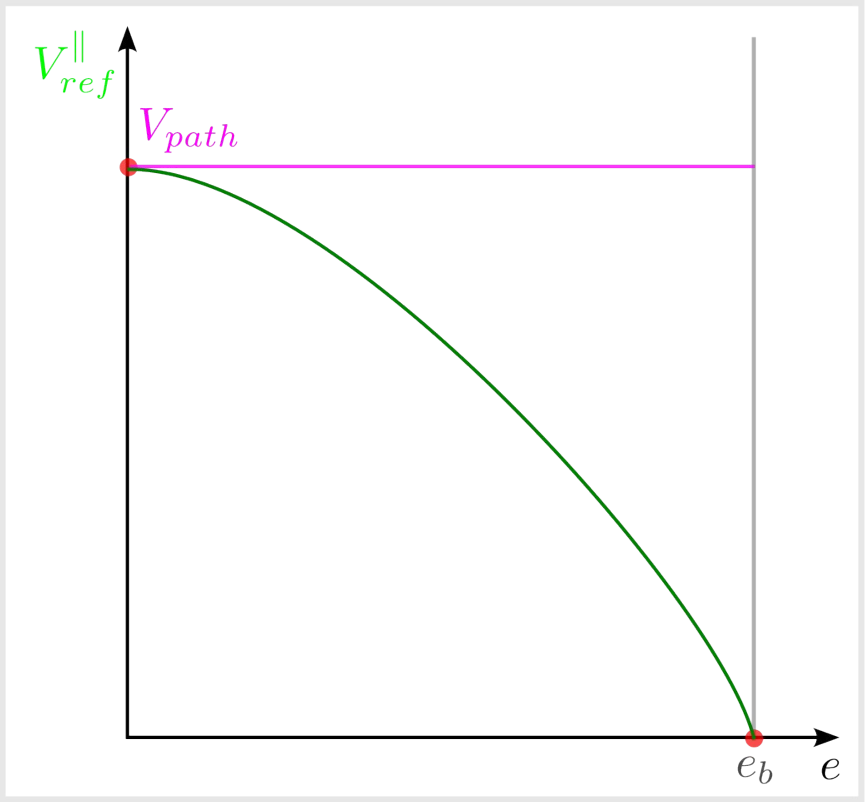
Orthogonal velocity curve



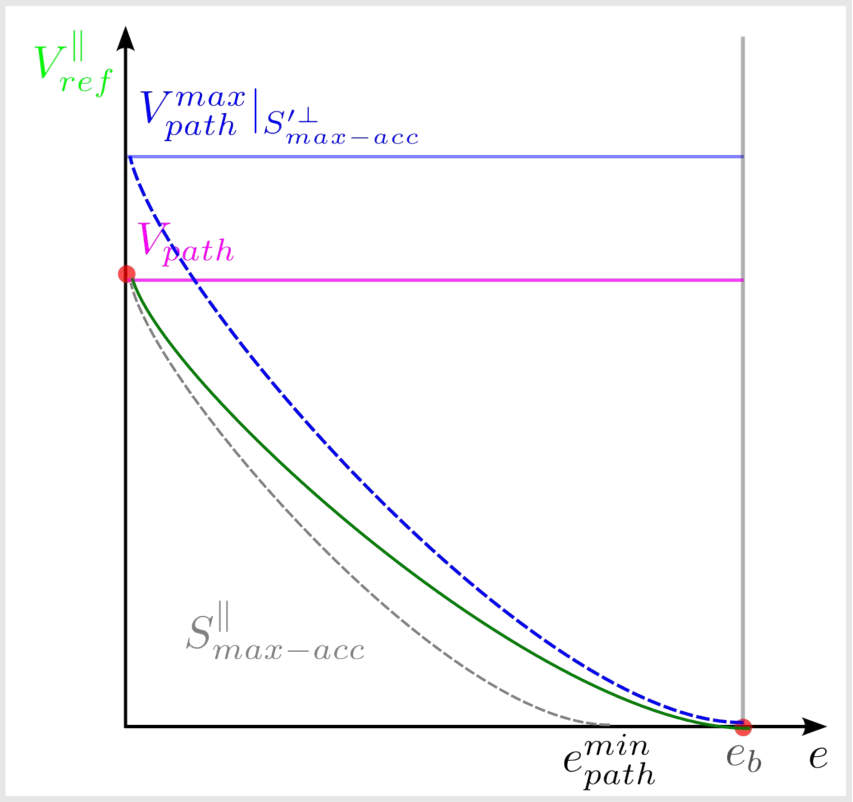
Orthogonal velocity curve with Acceleration limit



Parallel Velocity Curve



Parallel Velocity Curve with Acceleration Limit



Monotonicity Constraint

3.3 Velocity norm Monotonicity

Another constraint is to make sure vehicle doesn't brake and accelerate, but rather have a constantly decreasing velocity norm profile when approaching path. This is desired since it gives a smooth speed curve, which can have higher efficiency (to be clarified), and more intuitive path following behavior.

$$|\dot{V_{ref}}| \leq 0 \tag{21}$$

Since derivative of the velocity curves against track error (e), when multiplied by $-V_{ref}^{\perp}$ gives the derivative against time, this can be formulated as:

$$\begin{aligned}
|\dot{V_{ref}}| &= \dot{\sqrt{{V_{ref}^{\|}}^2 + {V_{ref}^{\perp}}^2}} \\
&= \frac{1}{|V_{ref}|} * (\dot{V}_{ref}^{\|} + \dot{V}_{ref}^{\perp}) \\
&= \frac{-V_{ref}^{\perp}}{|V_{ref}|} * (\frac{dV_{ref}^{\|}}{de} + \frac{dV_{ref}^{\perp}}{de}) \\
\text{Therefore, } & \frac{dV_{ref}^{\|}}{de} + \frac{dV_{ref}^{\perp}}{de} \geq 0
\end{aligned} \tag{22}$$

3.3.1 Monotonicity constraint on relaxed curves

Using Equation 10 and Equation 20:

$$\frac{dV_{ref}^{\|}}{de} + \frac{dV_{ref}^{\perp}}{de} = \frac{V_{approach} - V_{path}}{\sqrt{e_b}} * \frac{1}{2\sqrt{e}} \geq 0 \tag{23}$$

This indicates that for our relaxed curves to satisfy monotonically reducing velocity form as it approaches the path, the approach velocity must be bigger than velocity on path.