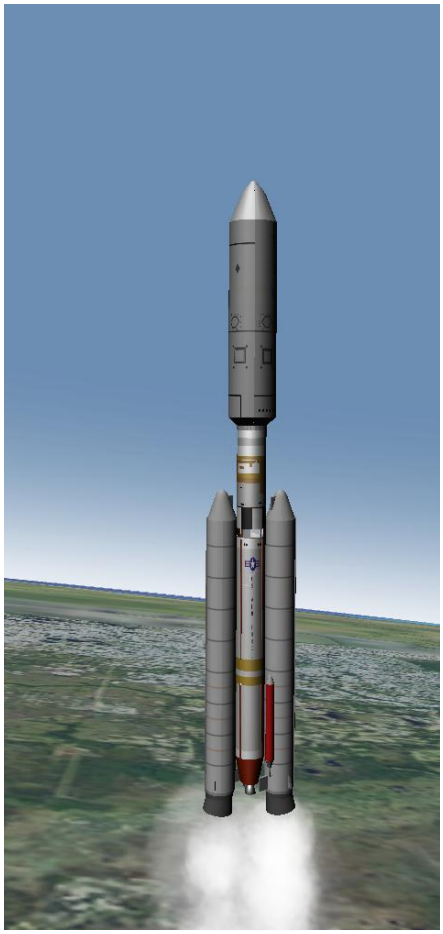
CVEL Titans
Version 1.36



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Titan meshes by Scott Oehlerking and the Project Gemini team

Thanks to:

Hendo and Daver, for the CVE-Lite code on which this is based.

Rob Conley (estar) for the first Titan add-ons, for inspiration, and more.

Scott Oehlerking and the Gemini team for the Titan II first and second-stage meshes, and for the textures thereof, also used here on Titan III.

STS-107, for the Agena and Titan-IVB meshes and textures. The Titan meshes were modified to become the first and second stages of everything that isn't a Titan II.

John Graves (Missileman01) for the Transtage and Titan SRM meshes.

Rjcroy, for the autopilot routine, now with extensive changes.

Christophe Chabot, for the RealExhaust texture. And the XCOR Aerospace team, for original rocket engine and photo. http://www.xcor.com

As of v1.3, RealExhaust also comes with a modified orange-tinted version, “KeroExhaust”, for LOX/Kerosene rockets, and a green-tinted version, “FlourineExhaust”, for LF2/Hydrazine rockets (Chariot).

And, above all, many thanks go to Martin Schweiger, for actually developing the simulator I used to daydream about in astrodynamics classes!

http://www.orbitersim.com

Unpacking:

Use Winzip to put each subfolder in its matching Orbiter folder.

This add-on does not overwrite any Titan meshes from Project Gemini, as the ones used here are located in a separate subfolder. If you also have Project Gemini, you will have two different copies of a few meshes.

Introduction:

Welcome to the CVEL Titans add-on! The intent is to make a versatile, flexible code that allows launching payloads, manned or unmanned, on the wide variety of Titan launchers that have seen service.

After the Titan II ICBM was used to place Gemini capsules in orbit, the derivative Titan III was used as a workhorse space launcher for the next 40 years. By the time the Titan was retired in 2005, it had added a solid-fuel “zero stage” (stage below the first stage) of 5.5-segment SRM's, and later 7-segment SRM's designed for the Titan IIIM and first used on the Titan IVA. (Later still, the Titan IVB would get a different set of SRM's). Upper stages included the Agena, the Transtage, and several Centaur variants. All in all, this was a versatile vehicle seen in many variants.

The CVEL Titans is currently capable of launching Titan's I, II, III, or IV, with the originally proposed 3-segment 100-inch motor, or 5.5-segment (long or short tank), 7-segment, or 8-segment SRM's, or SRMU's (Titan-IVB) or RSRM's (Shuttle SRM's, for the “Growth Titan III”). You can add 2, 4, or 10 small SRM's (Titan 3BAS2, 3BAS4, and Titan IIS, all of which were conjectural). You can employ no upper stage, or an Agena, a Transtage, a Centaur-D, or a Chariot upper stage, and with a choice of many fairings (or none). This pretty much covers all of the workhorse variants, and quite a few proposed or notional ones.

The “Clustered Titan” replaces the SRM's instead with four Titan I first stages welded together. This oddball 1959 proposal tried to compete with the Saturn I.

Add the CVEL IUS and the CVEL Centaur-G add-ons to cover the upper stages that I haven't included with this package. Adding the CVEL Star-37 will allow you to add the most common payload kick motor, as well. And of course it's CVE-Lite compatible, so it will launch whatever you like!

Note that there are few “missions” as such included with the CVEL Titans add-on (the Titan-Agena launch of seven Vela Hotel satellites and the DMSP launch are conspicuous exceptions). Most scenarios push a generic probe with an artificially high mass, to demonstrate the payload capability. That's because CVEL-Titans is intended as a playground for YOUR enjoyment, to launch whatever strikes your fancy! Besides, a “typical” Titan III/IV payload was classified...we don't even know what it looked like! That makes it harder to model....

Titan Operation:

Launch the CVEL Titan using the scenario provided.

You can attach a payload to the Titan in one of two ways: using CVEL extensions (which see), or by using the PAYATCH parameter, see below. The PAYATCH parameter grabs another vessel, sticks an attach point on it, and calls it a child attachment. In this case, if your payload has a panel (say, NASSP), you might prefer to ride to orbit with the focus in that vehicle. To support this, the autopilot will engage if any thrust is applied by the payload.

(For NASSP: switch the SPS to ON, blip the power for an instant, and turn the SPS back to off. You'll take off 10 seconds later.)

CVEL Titan Keys:

U - Set a new launch azimuth for the autopilot, replacing the one specified in the scenario file. Ineffective after launch.

O - Start the autOpilot.

J - Jettison the next stage or payload. (Ineffective while SRM's are burning, unless your SRM's have thrust termination ports).

CTL-E - Eject! Separates the first payload from the launcher in whatever stage it's in. Used for launch aborts of manned vehicles. The payload is responsible for recognizing that it's been invoked in an abort situation and for taking the proper action.

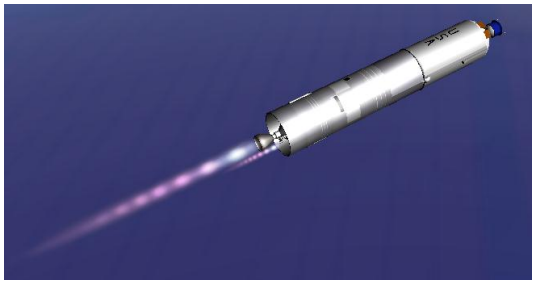
The CVEL Titan has attitude jets on the upper stage (Agena, Transtage, Centaur, or Chariot) only, and doesn't even use those for the autopilot. (Exception: an optional RCS for the second stage can be set by the scenario file. The autopilot won't make use of it either.) All steering on ascent, then, is done by thrust-vectoring. For ease of use, the thrust-vectoring routine will bias slightly against any rotation – in essence, a rate gyro is used to try gently to null the rates at all times. This gives a more useful “airplane-like” feel to the controls, which is vastly more pilot-friendly than one that keeps rates going forever. It also mimics the manual-reversion mode of the X-20 and MOL launchers. However, KILLROT will have no additional effect.

The first stage is normally the “zero stage” of the Titan IIIC – a pair of big SRM's. Those achieve thrust vectoring by injecting liquid (N_2O_4) from the big red side tank into the nozzle throat at one of several locations, depending on where the thrust needs to be vectored. (The SRMU's of the Titan IVB use the more-familiar flexible nozzle). The SRM's are truly a “zero stage” -- the liquid core stage is not firing while the SRM's are. Not all Titan III configurations had the “zero stage” -- set CONFIGURATION to 1 in the .SCN file to skip it.

The next stage is always the “first stage” in Titan parlance. It's the 10-foot-diameter core that made up the first stage of the Titan II ICBM, adapted and stretched several times since. Thrust-vectoring is straightforward engine gimbaling, with differential gimbaling for roll.

The payload fairings, if any, are a separate “configuration” (Configuration 2) between stage 1 and 2; they stage when dynamic pressure is low enough. If the first stage is emptied before reaching this condition, it will drop the fairing and go to the next stage, even though dynamic air pressure might damage the payload. It would take an absurdly heavy payload on a Titan without SRM's to reach this condition, though.

The next stage (always the “second stage”) has a single thrust chamber. This would ordinarily make it impossible to roll the stage, but the designers had a clever solution. The gas-generator which drives the pump exhausts a significant amount of heat and pressure; by forcing that through a vectorable nozzle, the second stage gets a little thrust and an off-center nozzle that allows vectoring for roll. It's slow, but it works.



Finally, optionally, there is an “upper” stage – a Transtage (a versatile storable-propellant stage with an interesting asymmetrical tank arrangement) or a Centaur (basically identical to the one on the Atlas-Centaur that took Surveyor to the moon), or the Agena (functionally similar to a Transtage, but one engine, and only 5 feet diameter), or the Chariot (a higher-energy stage than any of them, but dependent on the poisonous propellants of Fluorine and Hydrazine. For this reason, Chariot never flew).

The autopilot makes use of a dumb little algorithm that pitches you over early if your payload is light, and later if it's heavier. In addition, once your apogee exceeds 140 km, it will pitch down to keep from shooting well past that altitude. It's not perfect, but it does a creditable job with a wide variety of configurations and weights.

The autopilot is not smart enough to compensate for unusual launch azimuths – if you're launching retrograde, you may have to make a few pitch inputs for everything to work out right.

Note: if you have an unusually heavy payload that the Titan is unable to put in orbit, the autopilot will attempt to put it in a decent suborbital lob from which you can circularize – it assumes your heavy payload includes some propellant. This would be the case if, for example, you set “UPPER STAGE 0” and then include a CVEL-CentaurD stage as payload. It's the same as if you set “UPPER STAGE 2”, except the autopilot knows nothing about the Centaur, so the autopilot will end at that (suborbital) point. The same happens with the X-20 add-on, which includes its own modified Transtage stage, which is treated as part of the X-20 and not the Titan.

Care and Feeding:

At the broadest level, the CVEL Titans routine can be invoked by one of several .CFG files. These tell it how stretched the “zero” and first stages are, if any. These are:

CVELTitan – The “standard” is the early Titan III – Titan II length core, 5.5-segment SRM's.

CVELTitanII – This configuration is precisely the same as above, except that it goes to the trouble of forcing CONFIGURATION to 1, so that there will be no SRM's. Historically, Titan II's had no upper stages either (adding one is what MAKES it a Titan III) but I have included no program logic prohibiting this; you can also change CONFIGURATION back to 0 in the .SCN file.

CVELTitanI – Much like the Titan II, except with lower thrusts and weights and Isp's. The Titan I burned kerosene and LOX; all later models used N2O4 and hydrazine for better storability. Use of an upper stage is not recommended; there is no internal logic to include an adapter from the Titan I's 8-foot stage to an upper-stage of 10 feet diameter. The Titan I was never used as a space launcher.

CVELTitanCluster – An oddball proposal to weld four Titan I first stages together as a bottom stage; a Titan I first stage would then be the next stage. This command sets the configuration to 0 (4-barrel cluster stage); this make it impossible to also use SRM's. There should be no second stage or upper stage with this vehicle.

CVELTitan34 – The first “stretch” of the core first and second stages. SRM's remain the same at 5.5 segments. The Titan34 stretch was actually developed for the Titan IIIM-MOL, and introduced after its cancellation for improved capability.

CVELTitanIIIM – The MOL launcher version. Included the Titan34 stretch, and 7-segment SRM's. Never flown.

CVELTitanIV – This is the Titan IVA, circa 1989 or so. It uses the 7-segment SRM's originally developed for the MOL program. The core is stretched again (to the Titan45 configuration).

CVELTitanIVB – The Titan IVB adds the SRMU (Solid Rocket Motor Upgrade). In addition to being a bit larger and more efficient than the 7-segment SRM's developed for the Titan IIIM, they have a significantly lower empty weight, increasing payload weight significantly.

CVELTitanC – The Titan-C stands for Cryogenic second stage, and should not be confused with a Titan IIIC, or a Titan Cluster. The LR87 first-stage engine of the Titan was very versatile; in addition to being adapted from burning kerosene to hydrazine (Titan I to Titan II, respectively), it was also adapted and test-run while burning liquid hydrogen. A single LR87 in a 4-meter stage was proposed to upgrade the payload of the Titan launcher. This was seen as competition for the Saturn Ib and was eventually cancelled. Titan-C was cancelled before the 5.5-segment SRM's were proposed for the Titan, so historically you couldn't put SRM's on a Titan-C. But there's no

internal logic preventing you from doing so.

Once the Titan is invoked with these higher-level commands, more configuration occurs in the .SCN file. The highlights:

CONFIGURATION –
- 0 Has the large SRMs
- 1 Core stage, no SRMs
- 2 Payload fairing jettisoned
- 3 Second stage
- 4 Upper stage only

SRM_TYPE – Overrides the SRM set above, of course. Set it to:
- 0 None
- 1 Original proposal 100-inch SRM with 3 segments
- 2 Early UA1205 with bigger N2O4 tanks (As #3, but slightly higher dry weight)
- 3 UA1205 5.5-segment motors (Titan III)
- 4 UA1207 7-segment motors (Titan IIIM, Titan IVA)
- 5 UA1208 8-segment motors (proposed, not flown)
- 6 SRMU motors (Titan IVB)
- 7 156-inch solids (RSRM, shuttle SRB's, for Growth Titan III)

SECOND STAGE – 0 for none, 1 to have one.
UPPER STAGE – 0 for none
1 for Transtage
2 for Centaur-D
3 for Agena
4 for Chariot

NUM_SRMS – The number of small SRM's used to supplement takeoff thrust. You can have 2 or 4, or you can have 10 (6 lighting at takeoff, the other 4 when the first 6 are expended). No Titan with small SRM's was ever flown, but there were many proposals. Small SRM's are Algol motors, unless on a Titan II, in which case they are the very similar Castor IV's.

FAIRING – Fairings have been redesignated. They come in several classes:

```
                501
               /  | |
  Size (dia)   | |
0 = none       |  \
1 = 5'         |   Length
2 = 8'          \
3 = 10'          0 = 2-part fairing, 1 = 3-part
4 = 11.5'
5 = 4m (13.1')
6 = 5.08m (16.7')
```

Special exception fairings:
0 = No fairing, of course
300 = Titan 3C nose cone
500 = 2-part fairing meant to be used on dual-payload Titan III (it's 4m with no neck-down at the bottom). Use 2PLCarr and 2PLPAF meshes with it. Also works well on Titan-C

FAIRLOC – Z-offset (in meters) where you want the fairing (if any) placed. You'll probably need to experiment.

TGT_HEADING – The azimuth heading the autopilot should take after launch. Degrees.

AUTO LEO – 1 if the autopilot should stop when in a LEO parking orbit. If it's 0, the engines will burn to depletion instead.

SHIFTFOCUS – Which payload (of available payloads) the focus should transfer automatically to when jettisoned. 0 if the focus is never automatically shifted. Normally 1, to shift focus to your

primary payload (especially if it's a manned payload). Might be 6 if you're going to plop a half-dozen Vela Hotel satellites in a high earth orbit and you want to shift to controlling the final one after you've jettisoned them all. An LES doesn't count as a jettisoned payload and can't be shifted to using this parameter.

STG2_RCS – Normally 0, set to 1 to add an RCS to the second stage. The Titan IIS was to have a second-stage RCS added. No RCS-equipped second stage ever actually flew.

THRUST_TERM – Normally 0, set to 1 if there are thrust termination ports on the solid rocket motors, effectively permitting them to be "shut down" for an abort. Used for manned payloads.

PADBIAS – Z-offset (in meters) for the entire vehicle stack's touchdown points. Used to set the vehicle properly on different pad meshes.

LAUNCH MJD – Set a launch time for automatic launch!

CAMERA – Position the camera by entering a vector here.

LES – Followed by the number of seconds after launch the Launch Escape System is jettisoned. The LES is assumed to be the first CVEL payload, and is jettisoned, smoke added, and thrust level set to full. This system allows realistic flights of manned rockets with escape towers. May not work properly with CTL-E Escape/Abort key.

PAYATCH – Attaches a payload directly to the launcher, rather than using CVEL extensions. Advantageous for payloads that don't invoke properly under CVEL. Example:

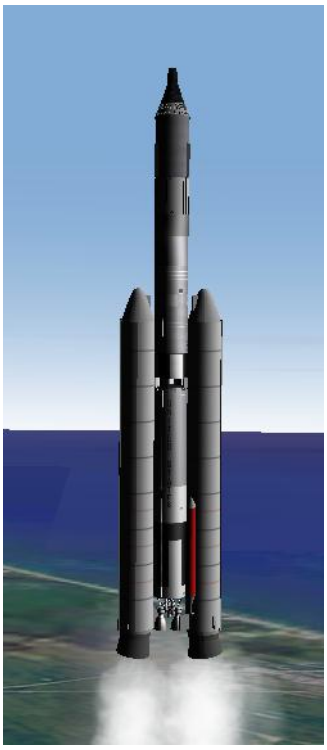
PAYATCH Apollo-24 0.0 0.0 -5.85 0.0 1.0 0.0

This attaches Apollo-24 as a payload. Apollo-24 must be a vessel defined later in the .SCN file. Its attach point is set at _V(0,0,-5.85), which is a point on Apollo-24 where it will attach to the front of the Titan. Orientation is _V(0,1,0), which means Y is up, as you'd expect. Other orientations are possible, though; try _V(0,-1,0) to put something on upside down. If a payload is defined through PAYATCH, it is always jettisoned first (exception: LES).

Less well documented configuration settings:
(Probably made obsolete by the PAYATCH parameter)

DRAWAGEMINI – Normally 0 for none. If it's set to 1 or 2, draws a Gemini! (1 for just the capsule, 2 for the capsule and equipment and adapter modules). The Titan III was proposed for a number of Gemini derivative vehicles. In Orbiter we have a fine set of Gemini meshes, but no all-up mesh of the Gemini capsule. The meshes were of several parts intended to be assembled by the code, and are not really suitable for treatment as a CVEL payload. I've kludged a workaround for this by including Rob Conley's code for drawing the complete Gemini capsule in place atop the rocket! The drawn Gemini has no mass or physical existence, and disappears when the first payload is jettisoned. Also, the distribution file doesn't include the Gemini meshes, so to use this option, you'll need the Gemini 4.2 (or later) add-on. Finally, the maker of your payload add-on will need to make a mesh WITHOUT the Gemini (the DRAWAGEMINI routine will virtually put one in place on top), and then smoothly transition to a module which draws the Gemini in place on its own. (I have a MOL and Lunar Gemini in work, and this works for them. Your mileage may vary).

GEMINIZ – Z-offset for the drawn Gemini.



Titans:

To clear up which Titan goes where and does what, here's a brief table.

Payloads are in Kg to the various orbits. Note that these are from the payload planner's guide. While they match up pretty well with what can be achieved under Orbiter, some values may vary.

This list only includes “real-world” Titans; conjectural aren't listed.

LEO is Low Earth Orbit; 160 km altitude, due east.

Polar means sun-synchronous orbit, about 90 degrees and 600 km altitude.

GTO is a transfer orbit to GEO; perigee at LEO, apogee at GEO.

GEO is Geosynchronous Earth Orbit; 24-hr period.

Titan	Upper Stage	Set-up	Payload LEO	Polar	GTO	GEO	Comments
No SRMs (Configuration1):							
II	0 -	CVELTitanII	3600	2000			Gemini, DMSP
IIIA	1 Transtage	CVELTitan	4100				
IIIB	2 Agena	CVELTitan		3700			Vela Hotel
5.5-segment SRMs (Configuration 0):							
IIIC	1 Transtage	CVELTitan	13300				DSCS
IIID	0 -	CVELTitan		11200			KH-9,11
IIIE	2 Centaur	CVELTitan	13800				Viking, Voyager
34D	1 Transtage	CVELTitan34	15350	12550	4310	2500	
34D	IUS						Intelsat
7-segment SRMs (Configuration 0):							
IVA	0 -	CVELTitanIV	17700	14110	6350		KH-12
IVA	IUS					2380	DSP
IVA	Centaur-G					4540	Milstar
IVB	0 -	CVELTitanIVB	21640	18600			
IVB	Centaur-G					5760	

Known issues:

Scenarios with too many Titans (and some are included in this distribution!) may bog down or otherwise not work quite right when they're all launched, depending on your machine's performance. If you have this problem, free up some memory, or eliminate some of the launchers.

Small SRM's stand off a bit from the 100-inch SOLTAN motor. I probably won't fix this, as it's too unlikely a combination of mixed what-might-have-beens.

Autopilot is a bit over-sensitive when launching without SRM's (CONFIGURATION 1).

Autopilot doesn't get the job done quite right in all cases, but I keep working on it.

No ability to support add-ons with panels during launch, of course, except by compiling a special CVELTitan version with panel code. Or, you could use the PAYATCH attachment, and hop back and forth between the rocket and payload. Source code is included, though!

No support for even weirder conjectural Titans (12-foot core, 15-foot core, Zenith Star Launcher). Maybe someday, but those should probably be separate projects.

Small SRM's not supported on Clustered Titan (they'll appear on stage 1; it'll look weird).

NASSP Apollo flies to orbit with the high-gain antenna out.

Bibliography:

Web:
Astronautix, of course, with many Titan variants: http://www.astronautix.com

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Version history:

V1.36
Bugfix: manual thrust vectoring not working on some installations under Orbiter 2010.
v1.35
Re-compile for Orbiter 2010

v1.34
Bugfix: second-stage no longer yaws on manual control
Spread out exhaust slightly for SRM's (Except SRMU and RSRM)
Added fairings 401 and 402 (11.5' diameter)

v1.33
Bugfix: second-stage thrust is back to the CORRECT corrected values

v1.32
Bugfix: scenario saved PAYATCH when not appropriate; prevented re-start from saved .SCN
Added support for 100-inch SOLTAN motor

v1.31
Bugfix: some .cfg files were missing in v1.3 release

v1.3
Added support for 5.5-segment “long tank” SRM's, 8-segment SRM's, and 156-inch solids
Added “Clustered Titan”
Added optional second-stage RCS
Added DMSP launch scenario
Added Chariot upper stage
Added LES and CAMERA settings
Added PAYATCH attachment method
Added correct engine values for 34-length (and 45-length) stages 1 and 2
Worked autopilot some more
Bugfix: Small SRM's quicksave properly
Bugfix: Azimuths 270-360 work properly
Bugfix: Thrust Termination and aborts work properly
Bugfix: corrected engine values for first and second stage. Stg 2 thrust was half correct value!

v1.2
Recompiled for Orbiter 2006
/Config moved to /Config/Vessels to support Orbiter 2006 Scenario Editor
Large SRM's have separation motors
Small SRM's jettison with velocity and rotation components

v1.11
Bug fix: autopilot was pitching over too early with heavy upper stages. Yet another exception.
Bug fix: jettisoned motors not appearing from 10-strap-on Titans.

v1.1

Added Agena upper stage (thanks STS-107)

Added Titan IVB (thanks again to STS-107)

Adapted STS-107 Titan IV meshes to produce stretched stage 1 + 2 for Titan 34 (with Titan II texture by Scott Oehlerking). Also stage 2 of different diameter for Titan I and Titan C.

Added message passed to CVEL payload if autopilot was on at ejection.

Added small SRM's for conjectural Titan IIS, 3BAS2, etc.

Added many additional payload fairings and tripartite fairing support.

v1.0

First release

Spherical geometry added to autopilot lateral guidance

Launch-on-MJD feature added

Multiple-jettison bug on second stage fixed

v0.9

First beta release