



ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS

Zvi Zaphir and Moshe Halfon
Israel Aircraft Industries Ltd.
MLM Division



ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



- IAI-MLM designs and manufactures solar panels.
- The present analysis was conducted within one of our current projects.
- Satellite solar arrays need to have
 - Minimal weight - on one hand and
 - Stiff structure with high natural frequencies - on the other.
- Conventional deployment systems are usually kinematic.
- Displacements, speeds and sequence are controlled a priori.



ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



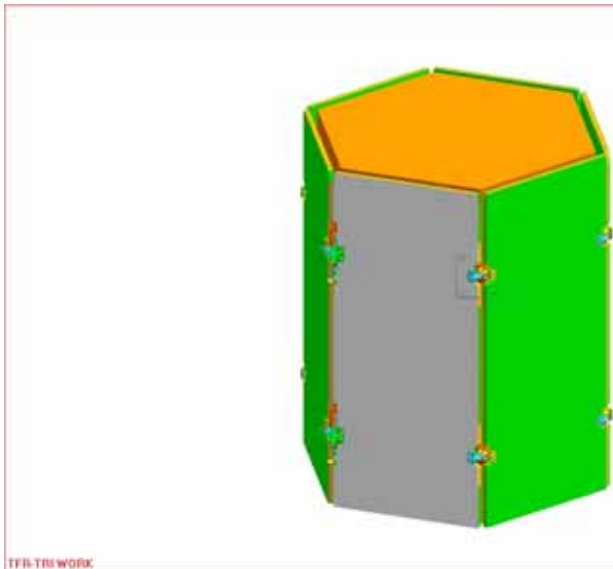
- The present system is dynamic
 - Springs energy converted to kinetic panel movement
 - On locking absorbed by impact and panel oscillations
- The system is simple, small and low weight, but needs to overcome two contradicting requirements
 - Sufficient energy to ensure the deployment
 - Withstanding the locking impacts
- Also trajectory is not predetermined
- Problems may arise as shown further-on



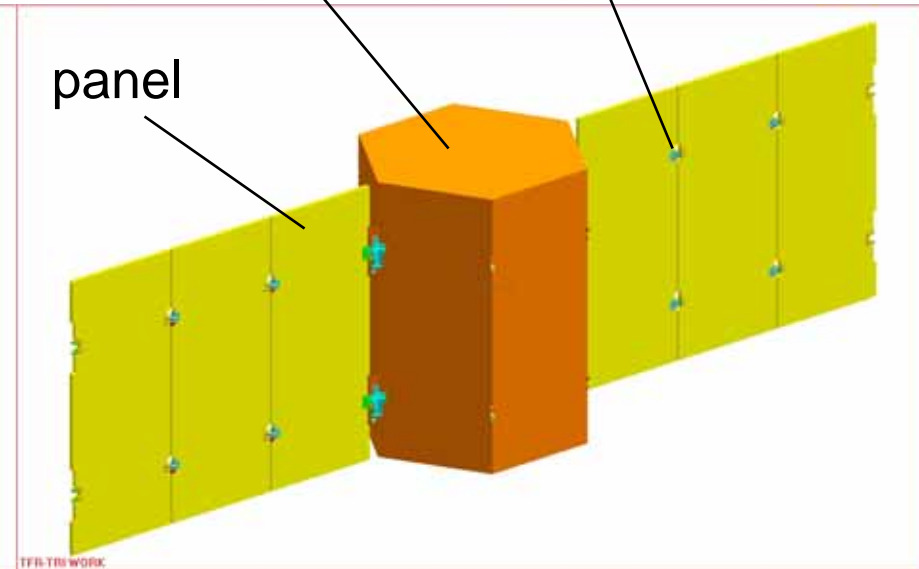
ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



- The present solar system



stowed



deployed

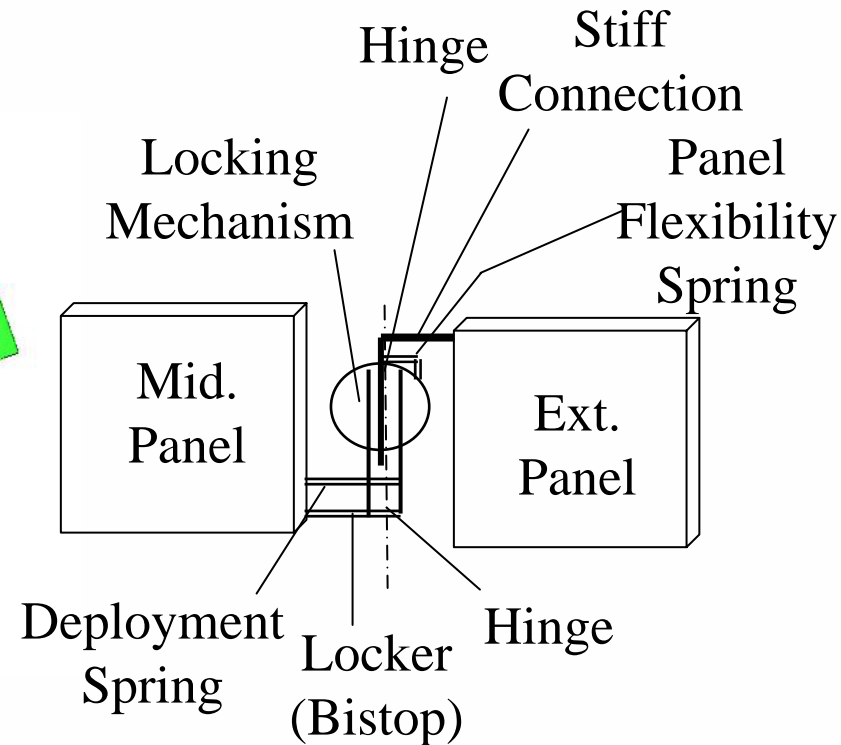
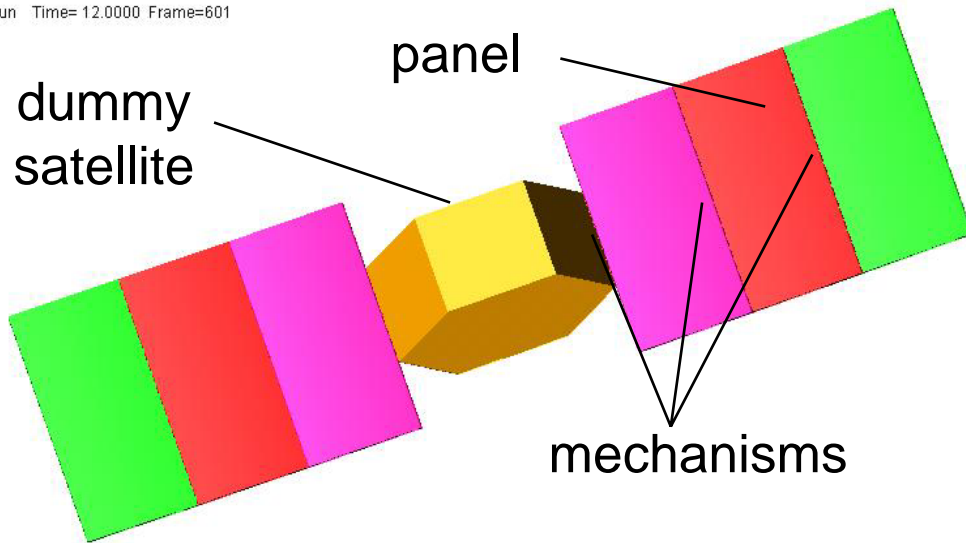


ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS ASSUMPTIONS AND IDEALIZATIONS



- The model is planar – xy plane
- Hinges, mechanisms and springs combined into a central single system with double stiffness.

Last_Run Time= 12.0000 Frame=601



PRODUCT DEVELOPMENT CONFERENCE



ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



- Panel flexibility springs correlate with MSC.Nastran results.
- Bistop activation conditioning
 - At the beginning - deactivated
 - Activation related to angle between adjacent panels
 - Conditioned – once activated, deactivation cannot be applied

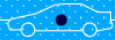


ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



DEPLOYMENT SIMULATION CONDITIONS

- On Ground
 - Without gravity-relief device (zero-g)
 - With gravity-relief device
- At space – No gravity, Satellite free to rotate
- Emergency – deployment with satellite spinning.



ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



RESULTS

- SIMULATIONS FOLLOWED MSC.Nastran (Dyn., LGDISP=1) PROVIDING SIMILAR RESULTS
- MANY ASPECTS ANALYZED I.e. Forces, Ang. Velo., Impacts, Etc.
- Focus - Program on-line simulation and animation capability.
- Enables to detect problems leading to design modifications.



ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



GROUND DEPLOYMENT SIMULATIONS

- Deployment sequential
- High friction loads
- Aerodynamic Drag
- Many increments needed, especially in locking.
- 2 wings simultaneously with and without air-drag
(9.62 Sec. And 8.95 Sec. Respectively)

Video - panels_min_ground222b.avi

Video – 2s_gr_n.wmv, 2s_zg_n.wmv

PRODUCT DEVELOPMENT CONFERENCE



ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS

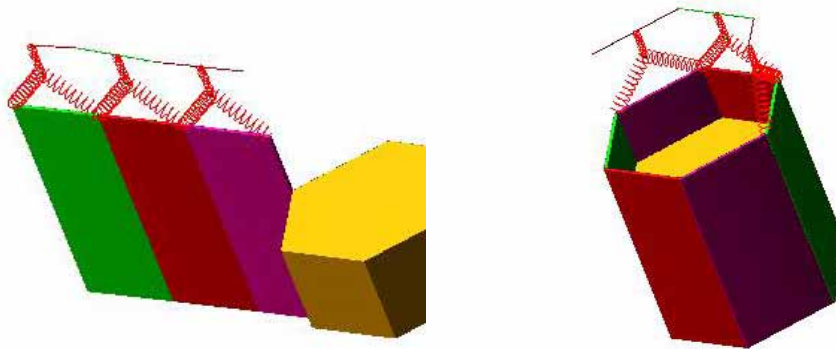


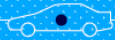
GROUND DEPLOYMENT – SINGLE ROOT SPRING

- Half stiffness and preload
- 2 wings simultaneously with and without gravity-release

Video - ground_1s_gravrel.avi

Video – 1_s-gr_n.wmv, 1s_zg.wmv





ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



DEPLOYMENT IN SPACE

- BEFORE MODIFICATION

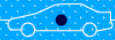
NO SPIN -Video - panels_new7_sep.avi

20 d/s SPIN - panels_new7_sep20x.avi

- AFTER MODIFICATION – ANGLE LIMITER ADDED

NO SPIN - Video – panels_new7x_sep.avi

20 d/s spin - panels_new7x_sep-20.avi



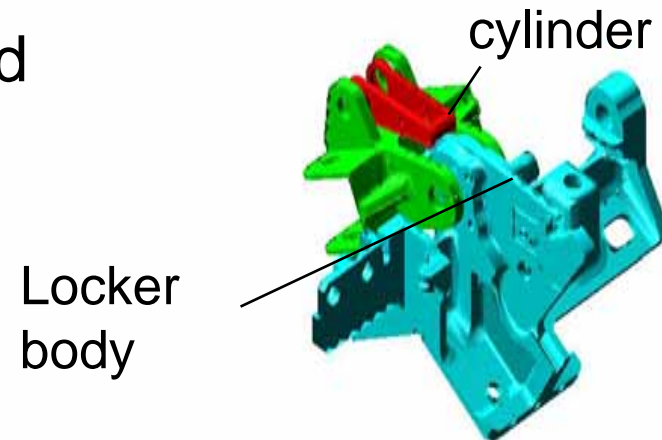
ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



LOCKING ANALYSIS OF ROOT MECHANISM

- Geometry created by UG and imported as parasolid
- Hinge and rotational springs added
- Contact determined between the cylinder and locker body
- Inertia of deployed array added

video - root_mech.avi



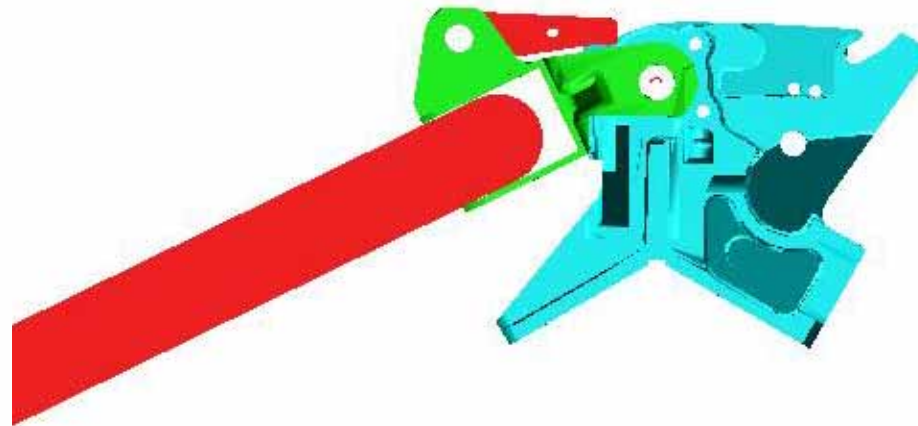


ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



CONSIDERING LOCKING OSCILLATIONS

- A link added, representing deployed array flexibility
video root_mech1.avi, root_mech_6fr.avi





ANALYSIS OF A SATELLITE SOLAR ARRAY DEPLOYMENT BY MSC.ADAMS



CONCLUSION

- Simulating gravity-free space conditions by ground-testing is not easy to achieve and not always realistic.
- Analytic simulation with animation capability could be very helpful for this case.